C/041/002 Incoming ✓

#5445

Canyon Fuel Company, LLC
A Subsidiary of Bowie Resource Holdings, LLC

Sufco Mine
[illegible]

May 7, 2018

Permit Supervisor, Utah Coal Regulatory Program
Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
PO Box 145801
Salt Lake City, UT 84114-5801

Re: Clean Copies of Revision to M&RP to Add Greens Hollow Lease Tract, Task ID# 5445, Sufco Mine, Canyon Fuel Company, LLC, Permit Number C/041/0002

Dear Sirs:

Please find enclosed with this letter a revised version of the M&RP which includes, text, plates and appendices. The PHC (Appendix 7-28) has also been revised. The pagination in the text has been adjusted and the table of contents updated when appropriate.

The Greens Hollow Plate 7-10 was created to show the location of operational water monitoring sites. The plate previously submitted as 7-10 (confidential) with the clean copies of the 4 Right 4 East submittal has been renumbered. No changes have been made to the drawing except that a "C" has been added to the plate number (Plate 7-10C). A copy of Plate 7-10C is included with this submittal and should replace the same plate in the confidential folder.

If you have questions or need addition information please contact Vicky Miller at (435)286-4481.

CANYON FUEL COMPANY, SUFCO Mine

Vicky S Miller
for

John D. Byars
General Manager

Encl.
cc: DOGM Correspondence File

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APPLICATION FOR COAL PERMIT PROCESSING

Permit Change X New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: Canyon Fuel Company, LLC
Mine: Sufco Mine **Permit Number:** C/041/0002
Title: Clean Copies of Revision to M&RP to Add Greens Hollow Lease Tract, Task ID#5445
Description, Include reason for application and timing required to implement:

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

X Yes ☐ No 1. Change in the size of the Permit Area? Acres: Disturbed Area: _____ ☒ increase ☐ decrease.
☐ Yes X No 2. Is the application submitted as a result of a Division Order? DO# _____
X Yes ☐ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
X Yes ☐ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes X No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes X No 6. Does the application require or include public notice publication?
X Yes ☐ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes X No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes X No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes X No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes X No 11. Does the application affect the surface landowner or change the post mining land use?
X Yes ☐ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
X Yes ☐ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes X No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes X No 15. Does the application require or include soil removal, storage or placement?
☐ Yes X No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes X No 17. Does the application require or include construction, modification, or removal of surface facilities?
X Yes ☐ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
X Yes ☐ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes X No 20. Does the application require or include subsidence control or monitoring?
☐ Yes X No 21. Have reclamation costs for bonding been provided?
X Yes ☐ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes X No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach one (1) review copy of the application.

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

Jacob D. Smith
Print Name

Sign Name, Position, Date: Engr. Mgr., 5/7/18

Subscribed and sworn to before me this 7 day of May, 2018

Notary Public

My commission Expires: _____, 20___ }
Attest: State of _____ } ss:
County of _____

JACQUELYN NEBEKER
Notary Public
State of Utah
My Commission Expires 03/24/2019
COMMISSION NUMBER 681827

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining
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APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

Permittee: Canyon Fuel Company, LLC
Mine: Sufco Mine **Permit Number:** C/041/0002
Title: Clean Copies of Revisions to M&RP to Add Greens Hollow Lease Tract, Task ID# 5445

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

			DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☐ Add	☒ Replace	☐ Remove	Chapter 1
☒ Add	☐ Replace	☐ Remove	Appendix 1-1, add to existing data
☐ Add	☒ Replace	☐ Remove	Chapter 2, 2-1 thru 2-9 and 2-30
☐ Add	☒ Replace	☐ Remove	Plate 2-3
☐ Add	☒ Replace	☐ Remove	Chapter 3, TOC, Pages 3-1 thru 3-18, 3-28 thru 3-40 and 3-59
☐ Add	☒ Replace	☐ Remove	Plates 3-1, 3-2 amd 3-3
☒ Add	☐ Replace	☐ Remove	Appendix 3-16
☐ Add	☒ Replace	☐ Remove	Chapter 4
☐ Add	☒ Replace	☐ Remove	Plate 4-1C
☒ Add	☐ Replace	☐ Remove	Appendix 4-5 and 4-6, add to existing data
☐ Add	☒ Replace	☐ Remove	Chapter 5, TOC, Pages 5-1 thru 5-21, 5-24 thru 5-30, 5-40 thru 5-43
☐ Add	☒ Replace	☐ Remove	Plates 5-1, 5-2C, 5-5, 5-6, 5-7, 5-8, 5-10, 5-11
☐ Add	☒ Replace	☐ Remove	Chapter 6, TOC, Pages 6-1 thru 6-13 and 6-22
☐ Add	☒ Replace	☐ Remove	Plate 6-1
☒ Add	☐ Replace	☐ Remove	Appendix 6-5, add to existing data
☒ Add	☒ Replace	☐ Remove	Chapter 7, Figures were removed from text and placed under separate tab
☐ Add	☒ Replace	☐ Remove	Plates 7-2, 7-3
☒ Add	☒ Replace	☐ Remove	Plate 7-10
☒ Add	☐ Replace	☐ Remove	Appendix 7-1 add to exisiting data, Appendix 7-17 - add to existing data
☒ Add	☐ Replace	☐ Remove	Appendix 7-27 and Appendix 7-28
☐ Add	☒ Replace	☐ Remove	Chapter 8, TOC, Pages 8-6, 8-9
☐ Add	☒ Replace	☐ Remove	Chapter 9, TOC, Pages 9-1 thru 9-7
☐ Add	☒ Replace	☐ Remove	Plate 9-1
☐ Add	☐ Replace	☐ Remove	CONFIDENTIAL
☐ Add	☐ Replace	☐ Remove	Appendix 3-4, including Raptor Nest Plate
☒ Add	☐ Replace	☐ Remove	Appendix 4-2 - add to existing data
☒ Add	☒ Replace	☐ Remove	Plate 5-10C and Add plate 7-10C
☒ Add	☐ Replace	☐ Remove	Appendix 6-1, add to existing data

Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.

May 7, 2018

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CHAPTER 1

GENERAL CONTENTS

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CHAPTER 1
GENERAL CONTENTS

110 Minimum Requirements for Legal, Financial, Compliance and Related Information

111 Introduction

For information pertaining to this section(s) refer to the General Chapter 1 binder for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine, SUFCO Mine, Skyline Mines, Banning Loadout and other operations.

112 Identification of Interests

112.100 Business Entity

For information pertaining to this section(s) refer to the General Chapter 1 binder for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine, SUFCO Mine, Skyline Mines, Banning Loadout and other operations.

112.200 Applicant and Operator

For information pertaining to this section(s) refer to the General Chapter 1 binder for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine, SUFCO Mine, Skyline Mines, Banning Loadout and other operations.

112.300 Control Persons

For information pertaining to this section(s) refer to the General Chapter 1 binder for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine, SUFCO Mine, Skyline Mines, Banning Loadout and other operations.

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LIST OF APPENDICES

(Appendices appear in Volume 4)

Appendix

1-1 Legal Right-of-Entry Documents
1-2 Lease Documents
1-3 Newspaper Advertisement
1-4 Filing Fee Receipt

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112.400 Coal Mining and Reclamation Operation Permit Applications Previous, Current or Pending

The following list describes permits held by Canyon Fuel Company, LLC, pending applications for permits, and permits recognized as necessary in the future for which no application has been filed. Identification numbers of applications or permits are contained in the following list. Many of the agencies listed, however, have review responsibility only and may not have submitted a numbered permit.

Permit	Issuing Authority	Approval Status/ Identification No.
Mining and Reclamation Permit C/041/002	State of Utah Department of Natural Resources Division of Oil, Gas and Mining Department of Interior U.S. Geological Survey and Office of Surface Mining Department of Agriculture U.S. Forest Service Fishlake National Forest and Manti La Sal National Forest	Approved
U.P.D.E.S. Permit UT-0022918	Environmental Protection Agency and Utah D.E.Q.	Approved
Disposal for Water Discharge	Utah Department of Health	Approved
Business License	Sevier County	Approved
Mine Health and Safety Permits 42-00089	Mine Safety and Health Administration - Utah	Approved
ID No. 1211-UT-09-00089-01	Mine Safety and Health Administration	Waste Rock Disposal Area Construction Plan
Radio Permits	Federal Communications Commission	Approved

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Certificate of Insurance and Authorization to do Business in State	State Industrial Development Commission	Approved
Public Water Supply Permit #21020	State of Utah Department of Health Division of Environmental Health	Approved
Radiation Control	State of Utah Department of Environmental Quality, Division of Radiation Control	Approved
Special Use 4078-2	U.S. Forest Service Fishlake National Forest	Approved
Air Quality Approval Orders	State of Utah Utah Air Conservation Committee Department of Health Division of Environmental Health	Approved
Water Rights	State Engineer	Approved

A table of the Canyon Fuel Company, LLC mining permits and operations is located in General Chapter 1.

SUFCO Mine C/041/002

The issuing authority for the Canyon Fuel Company, LLC permits is the UDOGM.

Operations held by Canyon Fuel Company, LLC and corporate structure are presented on Figure 1-1 in the General Chapter 1 for Canyon Fuel Company, LLC. Facility names, mailing addresses and permit numbers for these operations are provided in either Table 1-1 and/or Table 1-2. For additional information refer to the General Chapter 1 binder for Canyon Fuel Company, LLC.

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112.500 Legal or Equitable Owner of the Surface and Mineral Properties

Owner of the surface under Federal Coal Leases U-062453, SL-062583, U-0149084, U-047080, U-063214, U-28297, UTU-76195, UTU-84102 and State of Utah Coal Lease ML 49443-OBA is:

United States of America
Department of Agriculture
U.S. Forest Service
Fishlake National Forest
115 East 900 North
Richfield, Utah 84701

United States of America
Department of Agriculture
U.S. Forest Service
Manti-La Sal Forest
599 West Price River Drive
Price, Utah 84501

United States of America
Department of Interior
Bureau of Land Management
Price Coal Office
125 South 600 West
Price, Utah 84501

Lessee for the Federal Coal Leases and State of Utah Coal Lease is:

Canyon Fuel Company, LLC
225 North 5th Street, 9th Floor
Grand Junction, CO 81501
Telephone: (970) 263-5130

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The Bureau of Land Management owns the mineral rights for the Federal Coal Leases and the State of Utah owns the mineral rights for the State Coal Lease.

United States of America
Department of Interior
Bureau of Land Management
Price Coal Office
125 South 600 West
Price, Utah 84501

State of Utah
School and Institutional Trust Lands Administration
675 East 500 South, Suite 500
Salt Lake City, Utah 84102-2818

The Applicant owns 640 acres of coal within the lease area. Surface ownership of these acres is listed below:

Neal J. Mortensen
c/o UNELCO, Inc.
Aurora, Utah 84620

Roger E. Nielsen and Ruth Nielsen
515 East 240 North
Salina, Utah 84654

Canyon Fuel Company, LLC
225 North 5th Street, 9th Floor
Grand Junction, CO 81501
Telephone: (970) 263-5130

A property ownership map of the permit area and adjacent area is presented as Plate 5-6. The Greens Hollow Lease tract contains approximately 79 acres of Fishlake National Forest, the remainder of the tract's surface is managed by the Manti-La Sal Forest.

No area within the lands to be affected by surface operations and facilities or within the area of coal to be mined is under a real estate contract.

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Coal mining and reclamation operations are listed on Table 1-1 and the corporate structures is presented on Figure 1-1 in the General Chapter 1 binder.

112.600 Owners of Record of Property Contiguous to Proposed Permit Area

The following list contains the names and addresses of all owners of surface lands contiguous to the permit boundary:

United States of America
Department of Agriculture
U.S. Forest Service
Fishlake National Forest
115 East 900 North
Richfield, Utah 84701

United States of America
Department of Agriculture
U.S. Forest Service
Manti-La Sal National Forest
599 West Price River Drive
Price, Utah 84501

State of Utah
School and Institutional Trust Lands Administration
675 East 500 South, Suite 500
Salt Lake City, Utah 84102-2818

United States of America
Department of Interior
Bureau of Land Management
Price Coal Office
125 South 600 West
Price, Utah 84501

The following list contains the names and addresses of the owners of mineral acreage contiguous to the permit boundary:

State of Utah
School and Institutional Trust Lands Administration
675 East 500 South, Suite 500
Salt Lake City, Utah 84102-2818

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United States of America
Department of Interior
Bureau of Land Management
Price Coal Office
125 South 600 West
Price, Utah 84501

112.700 MSHA Numbers

Mine ID No. 42-00089, Waste Rock ID No. 1211-UT-09-00089-01.

112.800 Interest in Contiguous Lands

The applicant owns or controls, directly or indirectly, no legal or equitable interest in any lands contiguous to the permit area.

112.900 Certification of Submitted Information

Canyon Fuel Company, LLC hereby attests that the information contained in this permit document is true and correct to the best of their knowledge.

113 Violation Information

For violation information refer to Table 1-2 in the General Chapter 1 binder for Canyon Fuel Company, LLC prepared for the operations.

114 Right-of-Entry Information

Copies of documents granting the legal right to enter and begin underground coal mining activities have not changed with the acquisition. They can be found in Appendix 1.1 Mining and Reclamation Plan for the SUFCO Mine, which is unmodified by this Notice of Change in Ownership and Control Information.

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The right to enter the leaseholds conveyed by the Federal Coal Leases is conferred to the lessee by the Mineral Leasing Act of 1920 and the leases themselves. Copies of Federal Coal Leases U-47080, U-28297, U-62453, U-149084, U-63214, UTU-76195, UTU-91108 (ROW) ,SL-062583, UTU-84102 and State of Utah Coal Lease ML 49443-OBA which grant the right to enter and conduct underground mining operations on the leased premises are presented in Appendix 1-2 Mining and Reclamation Plan for the SUFCO Mine. Appendix 1-2 is unmodified by this Notice of Change in Ownership and Control Information.

Federal Coal Lease SL-062583 grants the right to use lands for the construction and utilization of surface facilities necessary for underground coal mining.

BLM Lease UTU-84102 is in the process of being issued to Sufco. Once the lease/tract is issued to Canyon Fuel Company, LLC a copy of the documents will be incorporated into Appendix 1-2.

The legal description of the SUFCO coal leases:

Federal Coal Lease U-28297 - (716.51 acres +/-) - Approved January 1979
Modified January 2012

T. 21 S., R. 5 E., SLM, Utah
Sec. 32, lot 1, N1/2S1/2
Sec. 33, NW1/4SW1/4
T. 22 S., R. 5 E., SLM, Utah
Sec. 5, W1/2W1/2;
Sec. 7, S1/2NE1 /4, E1/2SW1/4, W1/2SE1/4;
Sec. 8, W1/2NW1/4.

Federal Coal Lease U-062453 - (480 acres +/-) - Approved March 1962
T. 21 S., R. 5 E., SLM, Utah
Sec. 28, SW1/4SW1/4
Sec. 29, SE1/4SE1/4
Sec. 32, N1/2

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Sec. 33, W1/2NW1/4

Federal Coal Lease U-0149084 - (240 acres +/-) - Approved June 1966

T. 22 S., R. 4 E., SLM, Utah

Sec. 12, NE1/4 and N1/2SE1/4

Federal Coal Lease SL-062583 - (3,079.83 acres +/-) - Approved September 1941

Modified January 1973, December 2009

T. 21 S., R. 4 E., SLM, Utah

Sec. 36, S1/2

T. 21 S., R. 5 E., SLM, Utah

Sec. 31, all;

T. 22 S., R. 4 E., SLM, Utah

Sec. 1, lots 1 to 4, S1/2N1/2, S1/2

Sec. 2, SE1/4, S1/2SW1/4;

Sec. 3, SE1/4SE1/4;

Sec. 10, E1/2NE1/4, NE1/4SE1/4;

Sec. 11, N1/2, N1/2S1/2;

Sec. 12, NW1/4

T. 22 S., R. 5 E., SLM, Utah

Sec. 6, all;

Sec. 7, N1/2NE1/4, E1/2NW1/4

Federal Coal Lease U-47080 - (1,953.73 acres +/-) - Approved October 1981

Modified December 2009

T. 21 S., R. 4 E., SLM, Utah

Sec. 25, all;

Sec. 35, E1/2, E1/2SW1/4;

Sec. 36, N1/2.

T. 21 S., R. 5 E., SLM, Utah

Sec. 30, lots 2-4, W1/2SE1/4

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T. 22 S., R. 4 E., SLM, Utah

Sec. 2, lots 1-4, S1/2NE1/4, S1/2NW1/4, N1/2SW1/4;

Sec. 3, NE1/4SE1/4

Federal Coal Lease U-63214 - (6336.34 acres +/-) - Approved July 1989

Modified June 1999, December 2009, May 2011, January 2017

Tract 1:

T. 21 S., R. 4 E., SLM, Utah

Sec. 12, E1/2SE1/4

Sec. 13, E1/2NE1/4, S1/2

Sec. 14, E1/2SW1/4, SE1/4

Sec. 23, E1/2, E1/2W1/2

Sec. 24, all.

T. 21 S., R. 5 E., SLM, Utah

Sec. 16, W1/2NW1/4, W1/2SW1/4, W1/2E1/2NW1/4, W1/2E1/2SW1/4

Sec. 17-19, all

Sec. 20, NE1/4, W1/2 SE1/4, SW1/4, NW1/4

Sec. 21, W1/2NW1/4, W1/2E1/2NW1/4

Sec. 26, W1/2NW1/4SW1/4, SW1/4SW1/4

Sec. 27, NE1/4, SE1/4, S1/2SW1/4, S1/2N1/2SW1/4

Sec. 28, S1/2SE1/4, S1/2N1/2SE1/4, S1/2N1/2SW1/4, SE1/4SW1/4

Sec. 29, S1/2NE1/4SE1/4

Sec. 30, lot 1, N1/2NE1/4

Sec. 33, NE1/4, E1/2NW1/4, NE1/4SW1/4, N1/2SE1/4

Sec. 34, NW1/4NE1/4, NW1/4, NW1/4SW1/4.

Tract 3:

T. 21 S., R. 4 E., SLM, Utah

Sec. 26, E1/2, E1/2SW1/4;

Sec. 35, NW1/4, W1/2SW1/4.

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Federal Coal Lease UTU-76195 - (4,148.15 acres +/-) - Approved October 1999
Modified December 2006, January 2017

T. 21 S., R. 5 E., SLM

Sec. 2, lots 3,4, S1/2SW1/4, SW1/4SE1/4
Sec. 10, NE1/4NE1/4
Sec. 11, NE1/4, SE1/4, NW1/4NW1/4, NE1/4NW14,
SE1/4NW1/4, N1/2SW1/4NW1/4, SW1/4SW1/4NW1/4,
E1/2SW1/4, E1/2NW1/4SW1/4,SE1/4SW1/4NW1/4
Sec. 12, S1/2SW1/4, NW1/4SW1/4
Sec. 13, NW1/4, S1/2
Sec. 14, NE1/4, E1/2NW1/4, E1/2E1/2SE1/4
Sec. 22, S1/2S1/2SE1/4
Sec. 23, SE1/4, E1/2SW1/4, S1/2SW1/4SW1/4, S1/2SE1/4NW1/4,
SE1/4NW1/4NE1/4, S1/2NE1/4NE1/4, NE1/4NE1/4NE1/4,
S1/2SW1/4NE1/4, NE1/4SW1/4NE1/4, SE1/4NE1/4
Sec. 24, all
Sec. 25, N1/2, N1/2S1/2
Sec. 26, N1/2, NE1/4SW1/4, E1/2NW1/4SW1/4, SE1/4

T. 21 S., R. 6 E., SLM

Sec. 19, lots 3-4, E1/2SW1/4
Sec. 30, lots 1-3, E1/2NW1/4, NE1/4SW1/4

Federal Coal Lease UTU-84102 - (6,175.39 acres) - Effective April 1, 2017

T. 20 S., R. 4 E., SLM

Sec. 36, lot 4, E1/2NE1/4, NE1/4SE1/4

T. 20 S., R. 5 E., SLM

Sec. 19, lots 5-8, E1/2SW1/4, SE1/4
Sec. 20, S1/2
Sec. 21, W1/2SW1/4
Sec. 28, W1/2

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Sec. 29, all

Sec. 30, all

Sec. 31, all

Sec. 32, N1/2, N1/2S1/2

Sec. 33, NW1/4NW1/4

T. 21 S., R. 4 E., SLM

Sec. 1, all

Sec. 2, SE1/4

Sec. 11, E1/2, E1/2W1/2

Sec. 12, NE1/4, W1/2, W1/2SE1/4

Sec. 13, W1/2NE1/4, NW1/4

Sec. 14, NE1/4, E1/2NW1/4

T. 21 S., R. 5 E., SLM

Sec. 6, all

BLM Right-of-Way UTU-91108 (70 Acres +/-) - Approved June 4, 2015

T. 21 S., R. 4 E., SLB&M

Sec. 1, E1/2SE1/4SE1/4, SE1/4NE1/4SE1/4

Sec. 12, E1/2E1/2NE1/4

State of Utah Coal Lease ML 49443-OBA - (2,294.19 acres +/-) - Approved October 2004
Modified June 2015, February 2017

T. 20 S., R. 5 E., SLB&M

Sec. 32: S1/2S1/2

T. 21 S., R. 5 E., SLB&M

Sec. 4: lots 1- 4, S1/2S1/2

Sec. 5: lots 1- 4, S1/2S1/2

Sec. 7: lots 1- 4, NE1/4, SE1/4,

Sec. 8: All

Sec. 9: All

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Canyon Fuel Company, LLC acquired the right to entry on these properties in the merger described in Section 111 herein above.

In addition, the SUFCO Mine permit area includes certain fee lands owned by Canyon Fuel Company, LLC as follows:

T. 21 S., R. 5 E., SLB&M, Utah
Sec. 29, SW1/4, NW1/4, W1/2NE1/4, W1/2SE1/4
Sec. 30, S1/2NE1/4, E1/2SE1/4
containing 640.00 acres +/-
T. 22 S., R. 4 E., SLB&M, Utah
Sec. 18, NE1/4, SE1/4NW1/4, NE1/4SE1/4
containing 240 acres +/-

The name of the owner of these fee lands changed from Coastal States Energy Company to Canyon Fuel Company, LLC as a result of the merger transaction described in Section 111 hereinabove.

The SUFCO Mine also uses certain Forest Service lands in its operation for a spring collection system, pumphouse, water transmission line, sanitary discharge line, sanitary drainfield, access road to the sediment pond, and 25 KV powerline. These USFS special use permit areas are shown on Plate 5-6 through portions of:

T. 22 S., R. 4 E., SLB&M, Utah
Sec. 12, S1/2
containing 28.5 acres

The name of the permittee changed from Southern Utah Fuel Company to Canyon Fuel Company, LLC pursuant to the merger described in Section 111 herein above.

The total lease area includes 23,129.95 acres of Federal coal leases, 70 acres of BLM R-O-W, 2,294.19 acres of State of Utah coal leases, 640 acres of fee coal leases, the 240

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acres waste rock disposal site and 28.5 acres under U.S. Forest Service special use permit for a total of 26,402.64 acres.

115 Status of Unsuitability Claims

To the best knowledge of Canyon Fuel Company, LLC, no portion of the area to be permitted is designated, or under study for being designated, unsuitable for mining.

Since the SUFCO Mine was in production before passage of the Surface Mining Control and Reclamation Act of 1977, the unsuitability criteria were not applied to the existing surface facilities.

Canyon Fuel Company, LLC does not propose to conduct coal mining or reclamation operations within 300 feet of any occupied dwelling. Coal mining and reclamation operations have been or will be conducted within 100 feet of a public road, see Section 5.2.1.1 for details. Forest Service approval to conduct coal mining and reclamation operations within 100 feet of the Link Canyon forest service road is located in Appendix 1-1 and the newspaper advertisement for public comment is located in Appendix 1-3.

116 Permit Term

The following information is presented to identify permit term requirements and stipulations. Canyon Fuel Company will be operating the SUFCO Mine with continuous miner and longwall mining methods. The estimated number of total surface acres to be affected over the entire mining operation is 96.42 acres +/- .

PERMITTED DISTURBED AREA BOUNDARY	ACTUAL AREA CURRENTLY DISTURBED TO BE RECLAIMED	SITE DESCRIPTION
30.210	17.405	Mine Site, East Spring Canyon
0.967	0.39	Spring Collection Field, Convulsion Cyn.
0.220	0.075	Pump House, Convulsion Canyon

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0.784	0.40	Leach Field, Convulsion Canyon
1.595	0.193	Water Tank, East Spring Canyon
0.286	0.017	3 East Portals
1.774	0.70	4 East Portals
0.302	0.017	South Portals
0.396	0.017	Quitchupah Portals
0.287	0.18	Link Canyon Substation No. 1
0.245	0.12	Link Canyon Substation No. 2
0.380	0.18	Link Canyon Portal
0.45	0.351	Sinkhole
58.52	28.78	Waste Rock Disposal Site*
96.416	48.825	Totals Acres +/-

*Includes acreage from pre-expansion disturbance and Phase 1 and 2 construction disturbance

The legal description of the SUFCO permit area:

Mine Site Facility, Water Tank, South Portals, Spring Collection Field, Pump House, Pipeline, Leachfield (Approximately 64.40 acres +/-)

T. 22 S., R. 4 E., SLBM, Utah

Section 12: A Portion of the following:
E1/2NW1/4, SW1/4NW1/4NE1/4, S1/2

Portals - 3 East, 4 East, Quitchupah and Link Canyon, Link Canyon Substation No. 1 and No. 2 (Approximately 3.368 acres +/-)

T. 21 S., R. 5 E., SLBM, Utah

Section 26: A Portion of the following:
SE1/4SW1/4SW1/4NW1/4, E1/2NW1/4NW1/4SW1/4
SE1/4NE1/4SW1/4SW1/4

Section 29: A Portion of the following:
NW1/4NW1/4SW1/4SE1/4, NE1/4NW1/4SE1/4SW1/4,
NE1/4NE1/4SE1/4SW1/4

Section 32: A Portion of the following:
NE1/4SW1/4SW1/4NE1/4

Waste Rock Disposal Site (Approximately 81.25 acres +/-)

T. 22 S., R. 4 E., SLBM, Utah

Section 18*: S1/2NW1/4NE1/4, S1/2N1/2NW1/4NE1/4, S1/2S1/2NE1/4NW1/4NW1/4NE1/4, S1/2S1/2NW1/4NE1/4NW1/4NE1/4, W1/2SW1/4NE1/4NE1/4,W1/2E1/2SW1/4NE1/4NE1/4, S1/2SW1/4NW1/4NE1/4NE1/4, S1/2N1/2SW1/4NW1/4NE1/4NE1/4, SW1/4SE1/4NW1/4NE1/4NE1/4, W1/2E1/2SW1/4NE1/4NE1/4,NW1/4SW1/4NE1/4, W1/2NE1/4SW1/4NE1/4, NW1/4SW1/4SW1/4NE1/4, N1/2NE1/4SW1/4SW1/4NE1/4, SW1/4NE1/4NE1/4SW1/4NE1/4, N1/2NE1/4NE1/4SW1/4NE1/4, N1/2NW1/4SE1/4SW1/4NE1/4, NE1/4NE1/4SE1/4NW1/4, SE1/4NW1/4NE1/4SE1/4NW1/4, S1/2NE1/4SE1/4NW1/4, S1/2SE1/4NW1/4SE1/4NW1/4,

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NE1/4SW1/4SE1/4NW1/4, N1/2SE1/4SE1/4NW1/4

* Excluding county/state road(s) and the features associated with the road(s) such as right-of-way, turn-offs and drainage controls such as ditches, culverts, etc.

North Water Mitigation Area (Approximately 542.260 acres +/-)
T. 21 S., R. 5 E., SLBM, Utah

Section 2:	A Portion of the following: SW1/4SW1/4SW1/4
Section 3:	A Portion of the following: S1/2SE1/4
Section 10:	A Portion of the following: NE1/4, N1/2NE1/4SE1/4
Section 11:	A Portion of the following: W1/2NW1/4, W1/2SE1/4NW1/4, E1/2SW1/4, E1/2NW1/4SW1/4, S1/2SE1/4, NW1/4SE1/4, S1/2NE1/4SE1/4
Section 12:	A Portion of the following: W1/2SW1/4
Section 14:	A Portion of the following: W1/2NE1/4, NE1/4NW1/4

Sinkhole (Approximately 0.45 acres +/-)
T.22. S., R.4.E.
Section 2 Portion of the SW1/4NE1/4

PERMITTED AREA BOUNDARIES	SITE DESCRIPTION
64.40	SUFCO Main Facilities Complex
0.286	3 East Portals
1.774	4 East Portals
0.396	Quitchupah Portals
0.287	Link Canyon Substation No. 1
0.245	Link Canyon Substation No. 2
0.380	Link Canyon Portal
81.25	Waste Rock Disposal Site
542.26	North Water Mitigation Area
0.45	Sinkhole
691.728 acres +/-	TOTAL

The permit area boundary, which is shown on Plate 5-6, includes portions of Federal

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coal leases, fee coal leases, the waste rock disposal site and U.S. Forest Service special use permit areas for a total of 691.728acres +/-.

117 Insurance and Proof of Publication

Certificates of Insurance issued to Canyon Fuel Company, LLC are located in the General Chapter 1 binder as prepared for the operations and on file with the Division.

The newspaper advertisement appears in Appendix 1-3. Verification of the advertisement appearing in the appropriate newspapers will be added to Appendix 1-3 and submitted to the Division no later than 4 weeks after publication.

118 Filing Fee

A photocopy of the receipt is presented in Appendix 1-4 as proof of payment of the permit filing fee.

120 Permit Application Format and Contents

The permit application contains clear, concise, current information, in the format required by the UDOGM.

130 Reporting of Technical Data

All technical data submitted in the permit application is accompanied by the names of persons or organizations that collected and analyzed the data. The technical data also contains the dates of collection and analysis of the data, and descriptions of the method used to collect and analyze data. A professional qualified in the subject, planed or directed the technical analyses.

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3 Right 4 East Panel(s)

Mining of this panel(s) will stratle Leases U-63214 and U-62453 which are referred to as the Quitchupah Tract throughout the M&RP in text, appendices and on drawings. Both leases were issued to the permittee in 1989, the tract was originally delineated in 1982. The mine plan is shown on Plate 5-7, mining will occur only in the Upper Hiawatha coal seam. Overburden is approximately 900 feet or more. An environmental assessment was prepared for Lease U-63214 in 1988 and an EIS for the Quitchupah Tract in 1983, a variety of information from these assessments are included in the existing M&RP.

A helicopter survey to locate raptors and migratory bird species was conducted in 1982 and 1988 by UDWR, USFWS, BLM, and USFS. In 1988 ten golden eagle nests were located within the lease boundary, two were active, two were tended and the remaining six were inactive. One active nest and two inactive nests were located in Section 33. Bald eagles annually visit the area during the winter. No other TES species are know to inhabit the tract.

The southern portion of the lease area is considered crucial winter range for deer and elk. The escarpment in the southeastern portion of the triact wich lies between Quitchupah Canyon and Link Canyon is know as a elk migration route, provideing access to th and from the winter range from the plateau top.

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS) . The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text.

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140 Maps and Plans

The maps submitted in this permit application correspond to the format required by the regulations.

Those portions in the mine plan area in which underground coal mining activities occurred before August 3, 1997, and from August 3, 1977 to May 3, 1978 are presented on Plate 5-1.

150 Completeness

CFC believes the information in the permit application for its operations to be complete and correct. Reference the Mining and Reclamation Plans for the Dugout Canyon Mine, Soldier Canyon Mine, Sufco Mine, Gordon Creek Mines, Skyline Mine, Fossil Rock Mine and Banning Loadout operations for additional site specific information.

REFERENCES:

U.S. Department of the Interior, Final Supplemental Impact Statement for Leasing and Underground Mining of the Greens Hollow Federal Coal Lease Tract UTU-84102, Sanpete and Sevier Counties, Utah, February 2015

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APPENDIX 1-1

Legal Right-of-Entry Documents

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Authorization ID: RIC245
Contact ID: CANYON FUEL
Expiration Date: 12/31/2034
Use Code: 521

FS-2700-4 (10/09)
OMB No. 0596-0082

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

SPECIAL USE PERMIT

Authority: ORGANIC ADMINISTRATION ACT June 4, 1897

CANYON FUEL COMPANY, L.L.C. C/O BOWIE RESOURCE PARTNERS, LLC ATTN: SCOTT KEHRER 225 N 5TH STREET, SUITE 900 GRAND JUNCTION CO 81501 (hereinafter "the holder") is authorized to use or occupy National Forest System lands in the Fishlake National Forest of the National Forest System, subject to the terms and conditions of this special use permit (the permit).

This permit covers 28.5 acres or .04 miles in the Sec. 12, T. 22 S., R. 4 E., SALT LAKE MERIDIAN , ("the permit area"), as shown on the map attached as Appendix A. This permit issued for the purpose of:

A storage yard to include sediment ponds, coal storage, coal conveyor systems, access roads to sediment ponds and coal storage, a load out facility including scales and a building, a guard shack, and trash storage area for the temporary storage of refuse. Also including a spring collection system, culinary water storage tanks, water transmission lines, sanitary discharge lines, sanitary drainfield, access roads to utilities, 25 Kv powerline, and a pumphouse. The total permit area is 28.5 acres.

TERMS AND CONDITIONS

I. GENERAL TERMS

A. AUTHORITY. This permit is issued pursuant to ORGANIC ADMINISTRATION ACT June 4, 1897 and 36 CFR Part 251, Subpart B, as amended, and is subject to their provisions.

B. AUTHORIZED OFFICER. The authorized officer is the Forest or Grassland Supervisor or a subordinate officer with delegated authority.

C. TERM. This permit shall expire at midnight on 12/31/2034, approx. 20 years from the date of issuance.

D. RENEWAL. This permit is not renewable. Prior to expiration of this permit, the holder may apply for a new permit that would renew the use and occupancy authorized by this permit. Applications for a new permit must be submitted at least 6 months prior to expiration of this permit. Renewal of the use and occupancy authorized by this permit shall be at the sole discretion of the authorized officer. At a minimum, before renewing the use and occupancy authorized by this permit, the authorized officer shall require that (1) the use and occupancy to be authorized by the new permit is consistent with the standards and guidelines in the applicable land management plan; (2) the type of use and occupancy to be authorized by the new permit is the same as the type of use and occupancy authorized by this permit; and (3) the holder is in compliance with all the terms of this permit. The authorized officer may prescribe new terms and conditions when a new permit is issued.

E. AMENDMENT. This permit may be amended in whole or in part by the Forest Service when, at the discretion of the authorized officer, such action is deemed necessary or desirable to incorporate new terms that may be required by law, regulation, directive, the applicable forest land and resource management plan, or projects and activities implementing a land management plan pursuant to 36 CFR Part 215.

F. COMPLIANCE WITH LAWS, REGULATIONS, AND OTHER LEGAL REQUIREMENTS. In exercising the rights and privileges granted by this permit, the holder shall comply with all present and future federal laws and regulations and all present and future state, county, and municipal laws, regulations, and other legal requirements that apply to the permit area, to the extent they do not conflict with federal law, regulation, or policy. The Forest Service assumes no responsibility for enforcing laws, regulations, and other legal requirements that fall under the jurisdiction of other governmental entities.

G. NON-EXCLUSIVE USE. The use or occupancy authorized by this permit is not exclusive. The Forest Service reserves the right of access to the permit area, including a continuing right of physical entry to the permit area for inspection, monitoring, or any other purpose consistent with any right or obligation of the United States under any law or regulation. The Forest Service reserves the right to allow others to use the permit area in any way that is not inconsistent with the holder's rights and privileges under this permit, after consultation with all parties involved. Except for any restrictions that the holder and the authorized officer agree are necessary to protect the installation and operation of authorized temporary improvements, the lands and waters covered by this permit shall remain open to the public for all lawful purposes.

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H. ASSIGNABILITY. This permit is not assignable or transferable.

I. TRANSFER OF TITLE TO THE IMPROVEMENTS.

1. Notification of Transfer. The holder shall notify the authorized officer when a transfer of title to all or part of the authorized improvements is contemplated.

2. Transfer of Title. Any transfer of title to the improvements covered by this permit shall result in termination of the permit. The party who acquires title to the improvements must submit an application for a permit. The Forest Service is not obligated to issue a new permit to the party who acquires title to the improvements. The authorized officer shall determine that the applicant meets requirements under applicable federal regulations.

J. CHANGE IN CONTROL OF THE BUSINESS ENTITY.

1. Notification of Change in Control. The holder shall notify the authorized officer when a change in control of the business entity that holds this permit is contemplated.

a. In the case of a corporation, control is an interest, beneficial or otherwise, of sufficient outstanding voting securities or capital of the business so as to permit the exercise of managerial authority over the actions and operations of the corporation or election of a majority of the board of directors of the corporation.

b. In the case of a partnership, limited partnership, joint venture, or individual entrepreneurship, control is a beneficial ownership of or interest in the entity or its capital so as to permit the exercise of managerial authority over the actions and operations of the entity.

c. In other circumstances, control is any arrangement under which a third party has the ability to exercise management authority over the actions or operations of the business.

2. Effect of Change in Control. Any change in control of the business entity as defined in paragraph 1 of this clause shall result in termination of this permit. The party acquiring control must submit an application for a special use permit. The Forest Service is not obligated to issue a new permit to the party who acquires control. The authorized officer shall determine whether the applicant meets the requirements established by applicable federal regulations.

K. CONVEYANCE OF LANDS COVERED BY THIS PERMIT. The authorized officer shall give the holder at least 90 days prior written notice of any pending conveyance of the lands covered by this permit. With the holder's consent, the Forest Service may convey the lands covered by this permit without reserving the right-of-way granted by this permit. If the holder does not consent to conveyance without reservation of the right-of-way, the Forest Service may convey the lands covered by this permit only if the lands are subject to the right-of-way granted by this permit.

II. IMPROVEMENTS

A. LIMITATIONS ON USE. Nothing in this permit gives or implies permission to build or maintain any structure or facility or to conduct any activity, unless specifically authorized by this permit. Any use not specifically authorized by this permit must be proposed in accordance with 36 CFR 251.54. Approval of such a proposal through issuance of a new permit or permit amendment is at the sole discretion of the authorized officer.

B. PLANS. All plans for development, layout, construction, reconstruction, or alteration of improvements in the permit area, as well as revisions to those plans must be prepared by a professional engineer, architect, landscape architect, or other qualified professional based on federal employment standards acceptable to the authorized officer. These plans and plan revisions must have written approval from the authorized officer before they are implemented. The authorized officer may require the holder to furnish as-built plans, maps, or surveys upon completion of the work.

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B. CONSTRUCTION. Any construction authorized by this permit shall commence after July 1, 2014 and shall be completed by October 31, 2015.

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III. OPERATIONS.

A. PERIOD OF USE. Use or occupancy of the permit area shall be exercised at least 365 days each year.

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B. CONDITION OF OPERATIONS. The holder shall maintain the authorized improvements and permit area to standards

of repair, orderliness, neatness, sanitation, and safety acceptable to the authorized officer and consistent with other provisions of this permit. Standards are subject to periodic change by the authorized officer when deemed necessary to meet statutory, regulatory, or policy requirements or to protect national forest resources. The holder shall comply with inspection requirements deemed appropriate by the authorized officer.

C. INSPECTION BY THE FOREST SERVICE. The Forest Service shall monitor the holder's operations and reserves the right to inspect the permit area and transmission facilities at any time for compliance with the terms of this permit. The holder's obligations under this permit are not contingent upon any duty of the Forest Service to inspect the permit area or transmission facilities. A failure by the Forest Service or other governmental officials to inspect is not a justification for noncompliance with any of the terms and conditions of this permit.

IV. RIGHTS AND LIABILITIES

A. LEGAL EFFECT OF THE PERMIT. This permit, which is revocable and terminable, is not a contract or a lease, but rather a federal license. The benefits and requirements conferred by this authorization are reviewable solely under the procedures set forth in 36 CFR Part 251, Subpart C, and 5 U.S.C. 704. This permit does not constitute a contract for purposes of the Contract Disputes Act, 41 U.S.C. 601. The permit is not real property, does not convey any interest in real property, and may not be used as collateral for a loan.

B. VALID OUTSTANDING RIGHTS. This permit is subject to all valid outstanding rights. Valid outstanding rights include those derived under mining and mineral leasing laws of the United States. The United States is not liable to the holder for the exercise of any such right.

C. ABSENCE OF THIRD-PARTY BENEFICIARY RIGHTS. The parties to this permit do not intend to confer any rights on any third party as a beneficiary under this permit.

D. SERVICES NOT PROVIDED. This permit does not provide for the furnishing of road or trail maintenance, water, fire protection, search and rescue, or any other such service by a government agency, utility, association, or individual.

E. RISK OF LOSS. The holder assumes all risk of loss associated with use or occupancy of the permit area, including but not limited to theft, vandalism, fire and any fire-fighting activities (including prescribed burns), avalanches, rising waters, winds, falling limbs or trees, and other forces of nature. If authorized temporary improvements in the permit area are destroyed or substantially damaged, the authorized officer shall conduct an analysis to determine whether the improvements can be safely occupied in the future and whether rebuilding should be allowed. If rebuilding is not allowed, the permit shall terminate.

F. DAMAGE TO UNITED STATES PROPERTY. The holder has an affirmative duty to protect from damage the land, property, and other interests of the United States. Damage includes but is not limited to fire suppression costs, damage to government-owned improvements covered by this permit, and all costs and damages associated with or resulting from the release or threatened release of a hazardous material occurring during or as a result of activities of the holder or the holder's heirs, assigns, agents, employees, contractors, or lessees on, or related to, the lands, property, and other interests covered by this permit. For purposes of clause IV.F and section V, "hazardous material" shall mean (a) any hazardous substance under section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9601(14); (b) any pollutant or contaminant under section 101(33) of CERCLA, 42 U.S.C. § 9601(33); (c) any petroleum product or its derivative, including fuel oil, and waste oils; and (d) any hazardous substance, extremely hazardous substance, toxic substance, hazardous waste, ignitable, reactive or corrosive materials, pollutant, contaminant, element, compound, mixture, solution or substance that may pose a present or potential hazard to human health or the environment under any applicable environmental laws.

1. The holder shall avoid damaging or contaminating the environment, including but not limited to the soil, vegetation (such as trees, shrubs, and grass), surface water, and groundwater, during the holder's use or occupancy of the permit area. If the environment or any government property covered by this permit becomes damaged during the holder's use or occupancy of the permit area, the holder shall immediately repair the damage or replace the damaged items to the satisfaction of the authorized officer and at no expense to the United States.

2. The holder shall be liable for all injury, loss, or damage, including fire suppression, prevention and control of the spread of invasive species, or other costs in connection with rehabilitation or restoration of natural resources associated with the use or occupancy authorized by this permit. Compensation shall include but not be limited to the value of resources damaged or destroyed, the costs of restoration, cleanup, or other mitigation, fire suppression or other types of abatement costs, and all administrative, legal (including attorney's fees), and other costs. Such costs may be deducted from a performance bond required under clause IV.I.

3. The holder shall be liable for damage caused by use of the holder or the holder's heirs, assigns, agents,

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employees, contractors, or lessees to all roads and trails of the United States to the same extent as provided under clause IV.F.1, except that liability shall not include reasonable and ordinary wear and tear

G. HEALTH, SAFETY, AND ENVIRONMENTAL PROTECTION. The holder shall promptly abate as completely as possible and in compliance with all applicable laws and regulations any activity or condition arising out of or relating to the authorized use or occupancy that causes or threatens to cause a hazard to public health or the safety of the holder's employees or agents or harm to the environment (including areas of vegetation or timber, fish or other wildlife populations, their habitats, or any other natural resources). The holder shall prevent impacts to the environment and cultural resources by implementing actions identified in the operating plan to prevent establishment and spread of invasive species. The holder shall immediately notify the authorized officer of all serious accidents that occur in connection with such activities. The responsibility to protect the health and safety of all persons affected by the use or occupancy authorized by this permit is solely that of the holder. The Forest Service has no duty under the terms of this permit to inspect the permit area or operations and activities of the holder for hazardous conditions or compliance with health and safety standards.

H. INDEMNIFICATION OF THE UNITED STATES. The holder shall indemnify, defend, and hold harmless the United States for any costs, damages, claims, liabilities, and judgments arising from past, present, and future acts or omissions of the holder in connection with the use or occupancy authorized by this permit. This indemnification provision includes but is not limited to acts and omissions of the holder or the holder's heirs, assigns, agents, employees, contractors, or lessees in connection with the use or occupancy authorized by this permit which result in (1) violations of any laws and regulations which are now or which may in the future become applicable, and including but not limited to those environmental laws listed in clause V.A of this permit; (2) judgments, claims, demands, penalties, or fees assessed against the United States; (3) costs, expenses, and damages incurred by the United States; or (4) the release or threatened release of any solid waste, hazardous waste, hazardous materials, pollutant, contaminant, oil in any form, or petroleum product into the environment. The authorized officer may prescribe terms that allow the holder to replace, repair, restore, or otherwise undertake necessary curative actions to mitigate damages in addition to or as an alternative to monetary indemnification.

I. BONDING. The authorized officer may require the holder to furnish a surety bond or other security for any of the obligations imposed by the terms and conditions of this permit or any applicable law, regulation, or order.

V. RESOURCE PROTECTION

A. COMPLIANCE WITH ENVIRONMENTAL LAWS. The holder shall in connection with the use or occupancy authorized by this permit comply with all applicable federal, state, and local environmental laws and regulations, including but not limited to those established pursuant to the Resource Conservation and Recovery Act, as amended, 42 U.S.C. 6901 et seq., the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 et seq., the Oil Pollution Act, as amended, 33 U.S.C. 2701 et seq., the Clean Air Act, as amended, 42 U.S.C. 7401 et seq., CERCLA, as amended, 42 U.S.C. 9601 et seq., the Toxic Substances Control Act, as amended, 15 U.S.C. 2601 et seq., the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, 7 U.S.C. 136 et seq., and the Safe Drinking Water Act, as amended, 42 U.S.C. 300f et seq.

B. VANDALISM. The holder shall take reasonable measures to prevent and discourage vandalism and disorderly conduct and when necessary shall contact the appropriate law enforcement officer.

C. PESTICIDE USE. Pesticides may not be used outside of buildings to control undesirable woody and herbaceous vegetation (including aquatic plants), insects, rodents, fish, and other pests and weeds without prior written approval from the authorized officer. A request for approval of planned uses of pesticides shall be submitted annually by the holder on the due date established by the authorized officer. The report shall cover a 12-month period of planned use beginning 3 months after the reporting date. Information essential for review shall be provided in the form specified. Exceptions to this schedule may be allowed, subject to emergency request and approval, only when unexpected outbreaks of pests or weeds require control measures that were not anticipated at the time an annual report was submitted. Only those materials registered by the U.S. Environmental Protection Agency for the specific purpose planned shall be considered for use on National Forest System lands. Label instructions and all applicable laws and regulations shall be strictly followed in the application of pesticides and disposal of excess materials and containers.

D. ARCHAEOLOGICAL-PALEONTOLOGICAL DISCOVERIES. The holder shall immediately notify the authorized officer of all antiquities or other objects of historic or scientific interest, including but not limited to historic or prehistoric ruins, fossils, or artifacts discovered in connection with the use and occupancy authorized by this permit. The holder shall leave these discoveries intact and in place until directed otherwise by the authorized officer. Protective and mitigative measures specified by the authorized officer shall be the responsibility of the holder.

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E. NATIVE AMERICAN GRAVES PROTECTION AND REPATRIATION. In accordance with 25 U.S.C. 3002(d) and 43 CFR 10.4, if the holder inadvertently discovers human remains, funerary objects, sacred objects, or objects of cultural patrimony on National Forest System lands, the holder shall immediately cease work in the area of the discovery and shall make a reasonable effort to protect and secure the items. The holder shall immediately notify the authorized officer by telephone of the discovery and shall follow up with written confirmation of the discovery. The activity that resulted in the

inadvertent discovery may not resume until 30 days after the authorized officer certifies receipt of the written confirmation, if resumption of the activity is otherwise lawful, or at any time if a binding written agreement has been executed between the Forest Service and the affiliated Indian tribes that adopts a recovery plan for the human remains and objects.

F. PROTECTION OF HABITAT OF THREATENED, ENDANGERED, AND SENSITIVE SPECIES. The location of sites within the permit area needing special measures for protection of plants or animals listed as threatened or endangered under the Endangered Species Act (ESA) of 1973, 16 U.S.C. 1531 et seq., as amended, or identified as sensitive or otherwise requiring special protection by the Regional Forester under Forest Service Manual (FSM) 2670, pursuant to consultation conducted under section 7 of the ESA, may be shown on the ground or on a separate map. The map shall be attached to this permit as an appendix. The holder shall take any protective and mitigative measures specified by the authorized officer. If protective and mitigative measures prove inadequate, if other sites within the permit area containing threatened, endangered, or sensitive species or species otherwise requiring special protection are discovered, or if new species are listed as threatened or endangered under the ESA or identified as sensitive or otherwise requiring special protection by the Regional Forester under the FSM, the authorized officer may specify additional protective and mitigative measures. Discovery of these sites by the holder or the Forest Service shall be promptly reported to the other party.

G. CONSENT TO STORE HAZARDOUS MATERIALS. The holder shall not store any hazardous materials at the site without prior written approval from the authorized officer. This approval shall not be unreasonably withheld. If the authorized officer provides approval, this permit shall include, or in the case of approval provided after this permit is issued, shall be amended to include specific terms addressing the storage of hazardous materials, including the specific type of materials to be stored, the volume, the type of storage, and a spill plan. Such terms shall be proposed by the holder and are subject to approval by the authorized officer.

1. If the holder receives consent to store hazardous material, the holder shall identify to the Forest Service any hazardous material to be stored at the site. Such identification information shall be consistent with column (1) of the table of hazardous materials and special provisions enumerated at 49 CFR 172.101 whenever the hazardous material appears in that table. For hazard communication purposes, the holder shall maintain Material Safety Data Sheets for any stored hazardous chemicals, consistent with 29 CFR 1910.1200(c) and (g). In addition, all hazardous materials stored by the holder shall be used, labeled, stored, transported, and disposed of in accordance with all applicable federal, state, and local laws and regulations.

2. The holder shall not release any hazardous material as defined in clause IV.F. onto land or into rivers, streams, impoundments, or natural or man-made channels leading to them. All prudent and safe attempts must be made to contain any release of these materials. The authorized officer in charge may specify specific conditions that must be met, including conditions more stringent than federal, state, and local regulations, to prevent releases and protect natural resources.

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H. CLEANUP AND REMEDIATION

1. The holder shall immediately notify all appropriate response authorities, including the National Response Center and the authorized officer or the authorized officer's designated representative, of any oil discharge or of the release of a hazardous material in the permit area in an amount greater than or equal to its reportable quantity, in accordance with 33 CFR Part 153, Subpart B, and 40 CFR Part 302. For the purposes of this requirement, "oil" is as defined by section 311(a)(1) of the Clean Water Act, 33 U.S.C. 1321(a)(1). The holder shall immediately notify the authorized officer or the authorized officer's designated representative of any release or threatened release of any hazardous material in or near the permit area which may be harmful to public health or welfare or which may adversely affect natural resources on federal lands.

2. Except with respect to any federally permitted release as that term is defined under Section 101(10) of CERCLA, 42 U.S.C. 9601(10), the holder shall clean up or otherwise remediate any release, threat of release, or discharge of hazardous materials that occurs either in the permit area or in connection with the holder's activities in the permit area, regardless of whether those activities are authorized under this permit. The holder shall perform cleanup or remediation immediately upon discovery of the release, threat of release, or discharge of hazardous materials. The holder shall perform the cleanup or remediation to the satisfaction of the authorized officer and at no expense to the United States. Upon revocation or termination of this permit, the holder shall deliver the site to the Forest Service free and clear of contamination.

I. CERTIFICATION UPON REVOCATION OR TERMINATION. If the holder uses or stores hazardous materials at the site, upon revocation or termination of this permit the holder shall provide the Forest Service with a report certified by a professional or professionals acceptable to the Forest Service that the permit area is uncontaminated by the presence of hazardous materials and that there has not been a release or discharge of hazardous materials upon the permit area, into surface water at or near the permit area, or into groundwater below the permit area during the term of the permit. This

certification requirement may be waived by the authorized officer when the Forest Service determines that the risks posed by the hazardous material are minimal. If a release or discharge has occurred, the professional or professionals shall document and certify that the release or discharge has been fully remediated and that the permit area is in compliance with all federal, state, and local laws and regulations.

VI. LAND USE FEE AND ACCOUNTING ISSUES

A. LAND USE FEES. The holder shall pay an initial annual land use fee as shown on the bill for collection for the period from January 1, 2015 to December 31, 2015, and thereafter on the date shown on the bill for collection, shall pay an annual land use fee as determined by the market value of the authorized use.

B. MODIFICATION OF THE LAND USE FEE. The land use fee may be revised whenever necessary to reflect the market value of the authorized use or occupancy or when the fee system used to calculate the land use fee is modified or replaced.

C. FEE PAYMENT ISSUES.

1. Crediting of Payments. Payments shall be credited on the date received by the deposit facility, except that if a payment is received on a non-workday, the payment shall not be credited until the next workday.

2. Disputed Fees. Fees are due and payable by the due date. Disputed fees must be paid in full. Adjustments will be made if dictated by an administrative appeal decision, a court decision, or settlement terms.

3. Late Payments

(a) Interest. Pursuant to 31 U.S.C. 3717 et seq., interest shall be charged on any fee amount not paid within 30 days from the date it became due. The rate of interest assessed shall be the higher of the Prompt Payment Act rate or the rate of the current value of funds to the Treasury (i.e., the Treasury tax and loan account rate), as prescribed and published annually or quarterly by the Secretary of the Treasury in the Federal Register and the Treasury Fiscal Requirements Manual Bulletins. Interest on the principal shall accrue from the date the fee amount is due.

(b) Administrative Costs. If the account becomes delinquent, administrative costs to cover processing and handling the delinquency shall be assessed.

(c) Penalties. A penalty of 6% per annum shall be assessed on the total amount that is more than 90 days delinquent and shall accrue from the same date on which interest charges begin to accrue.

(d) Termination for Nonpayment. This permit shall terminate without the necessity of prior notice and opportunity to comply when any permit fee payment is 90 calendar days from the due date in arrears. The holder shall remain responsible for the delinquent fees.

4. Administrative Offset and Credit Reporting. Delinquent fees and other charges associated with the permit shall be subject to all rights and remedies afforded the United States pursuant to 31 U.S.C. 3711 et seq. and common law. Delinquencies are subject to any or all of the following:

(a) Administrative offset of payments due the holder from the Forest Service.

(b) If in excess of 60 days, referral to the Department of the Treasury for appropriate collection action as provided by 31 U.S.C. 3711(g)(1).

(c) Offset by the Secretary of the Treasury of any amount due the holder, as provided by 31 U.S.C. 3720 et seq.

(d) Disclosure to consumer or commercial credit reporting agencies.

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VII. REVOCATION, SUSPENSION, AND TERMINATION

A. REVOCATION AND SUSPENSION. The authorized officer may not revoke or suspend this permit without the consent of the head of the agency that holds this permit.

B. APPEALS AND REMEDIES. Written decisions by the authorized officer relating to administration of this permit are subject to administrative appeal pursuant to 36 CFR Part 251, Subpart C, as amended. Revocation or suspension of this

permit shall not give rise to any claim for damages by the holder against the Forest Service.

C. TERMINATION. This permit shall terminate when by its terms a fixed or agreed upon condition, event, or time occurs without any action by the authorized officer. Examples include but are not limited to expiration of the permit by its terms on a specified date and termination upon change of control of the business entity. Termination of this permit shall not require notice, a decision document, or any environmental analysis or other documentation. Termination of this permit is not subject to administrative appeal and shall not give rise to any claim for damages by the holder against the Forest Service.

D. RIGHTS AND RESPONSIBILITIES UPON REVOCATION OR TERMINATION WITHOUT RENEWAL. Upon revocation or termination of this permit without renewal of the authorized use, the holder shall remove all structures and improvements, except those owned by the United States, within a reasonable period prescribed by the authorized officer and shall restore the site to the satisfaction of the authorized officer. If the holder fails to remove all structures and improvements within the prescribed period, they shall become the property of the United States and may be sold, destroyed, or otherwise disposed of without any liability to the United States. However, the holder shall remain liable for all costs associated with their removal, including costs of sale and impoundment, cleanup, and restoration of the site.

VIII. MISCELLANEOUS PROVISIONS

A. MEMBERS OF CONGRESS. No member of or delegate to Congress or resident commissioner shall benefit from this permit either directly or indirectly, except to the extent the authorized use provides a general benefit to a corporation.

B. CURRENT ADDRESSES. The holder and the Forest Service shall keep each other informed of current mailing addresses, including those necessary for billing and payment of land use fees.

C. SUPERSEDED PERMIT. This permit supersedes a special use permit designated CANYON FUEL COMPANY, L.L.C., RIC98 and RIC407802, dated 01/26/2006 and 7/31/1986.

D. SUPERIOR CLAUSES. If there is a conflict between any of the preceding printed clauses and any of the following clauses, the preceding printed clauses shall control.

E. Improvement Relocation (X33). This authorization is granted with the express understanding that should future location of United States Government-owned improvements or road rights-of-way require the relocation of the holder's improvements, such relocation will be done by, and at the expense of, the holder within a reasonable time as specified by the authorized officer.

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This permit is accepted subject to the conditions set out above.

Date:	**CORPORATE NAME**
(CORPORATE SEAL)	
By: [signature] (Vice) President CHIEF OPERATING OFFICER	
ATTEST: [signature] (Assistant) Secretary	

The following certificate shall be executed by the secretary or assistant secretary of the corporation:

I, Brian Settles, certify that I am the Secretary of the corporation that executed the above permit; that Eugene DiClaudio, who signed said permit on behalf of said Corporation was then of said Corporation; that I know his/her signature on said permit is genuine; and that said permit was duly signed, sealed, and attested to for and on behalf of said Corporation by authority of its governing body.

(CORPORATE SEAL)

(Assistant Secretary)

U. S. DEPARTMENT OF AGRICULTURE
Forest Service

By: _____
(Authorized Officer Signature)

Fishlake National Forest

Allen Rowley, Forest Supervisor

Date: _____

According to the Paperwork Reduction Act of 1995, an agency may not conduct or sponsor, and a person is not required to respond, to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 0596-0082. The time required to complete this information collection is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and, where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at 202-720-2600 (voice and TDD).

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call toll free (866) 632-9992 (voice). TDD users can contact USDA through local relay or the Federal relay at (800) 877-8339 (TDD) or (866) 377-8642 (relay voice). USDA is an equal opportunity provider and employer.

The Privacy Act of 1974 (5 U.S.C. 552a) and the Freedom of Information Act (5 U.S.C. 552) govern the confidentiality to be provided for information received by the Forest Service.

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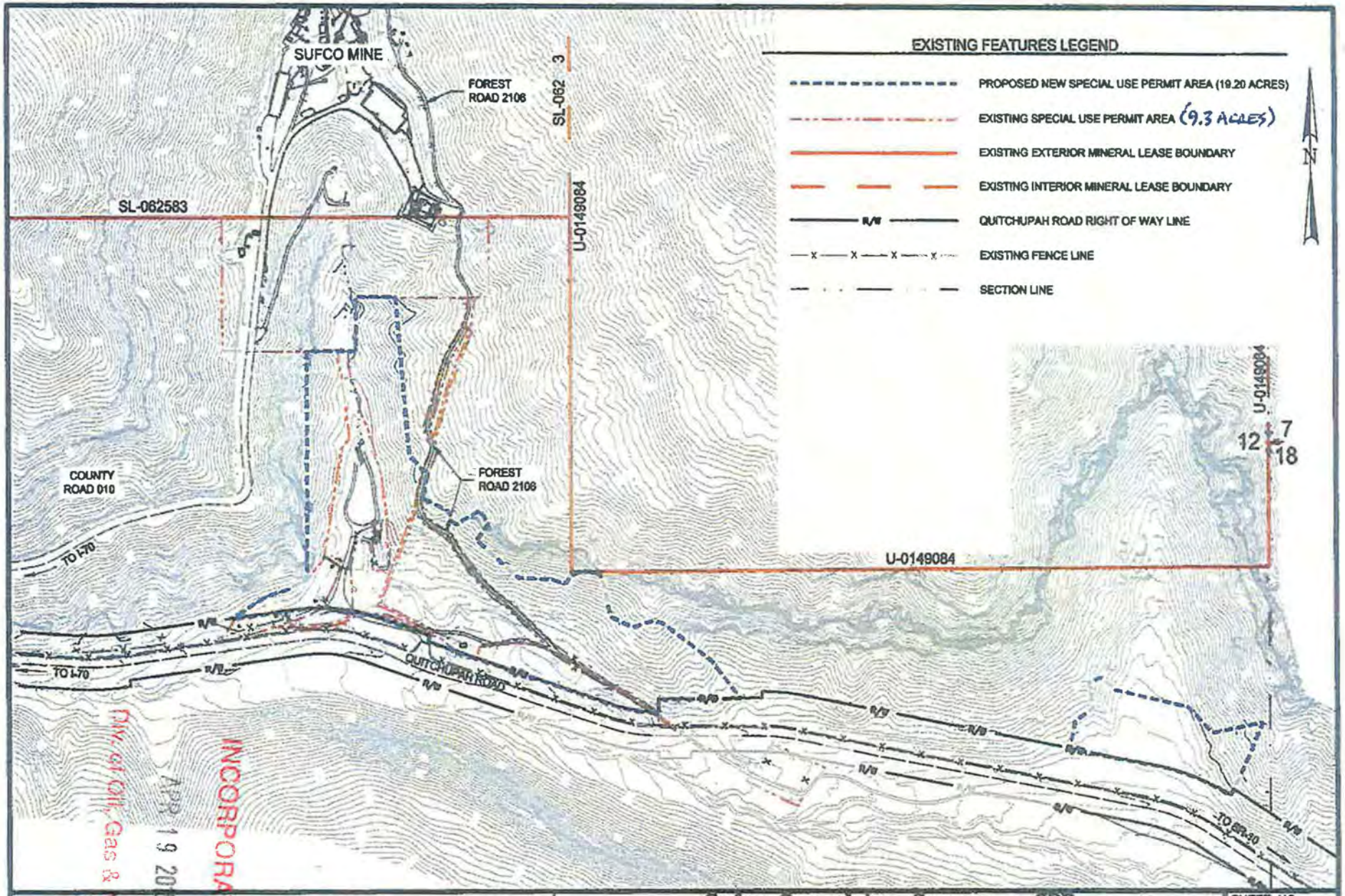


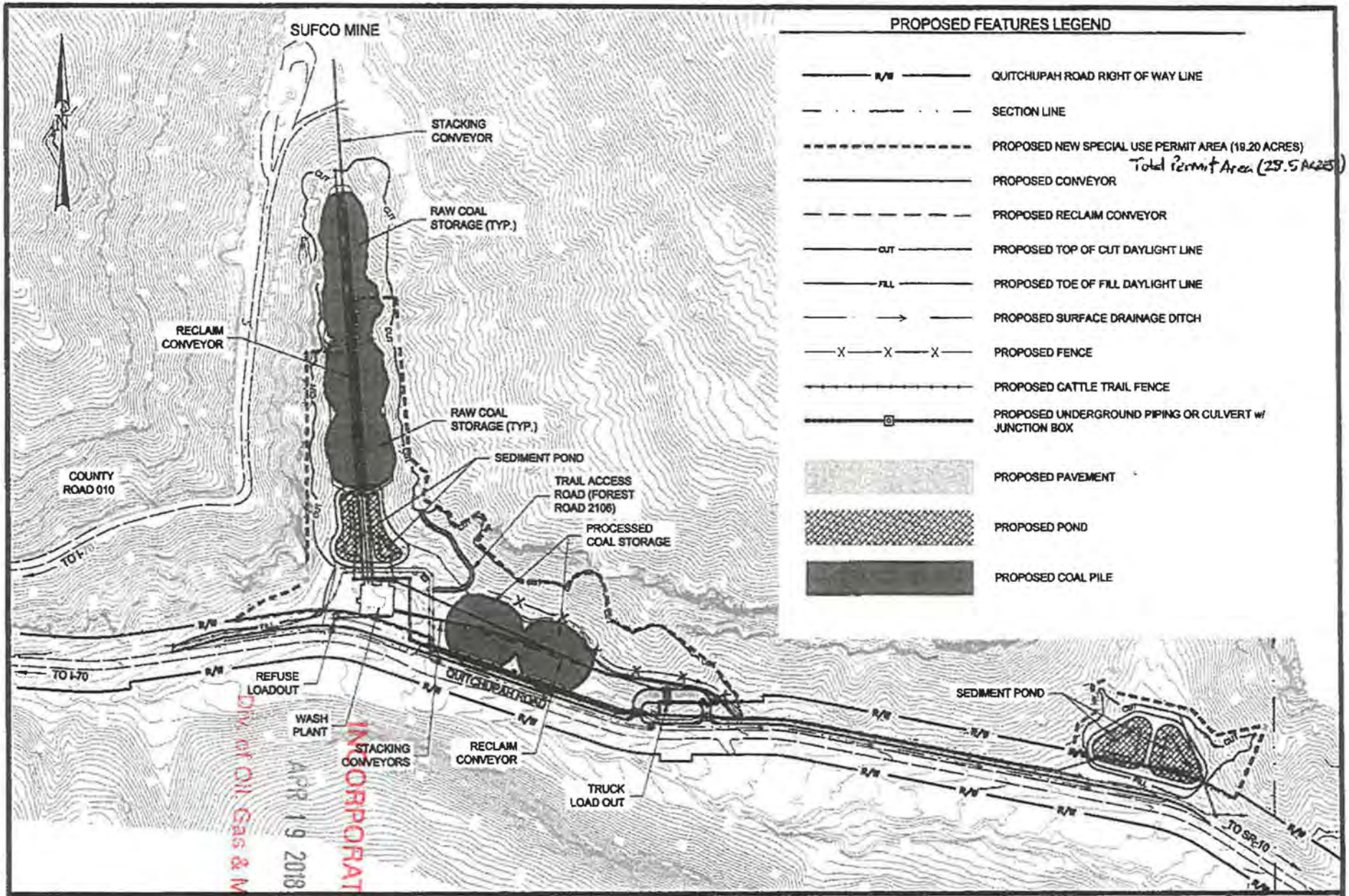
RECEIVED
APR 19 2014
DIV. OF OIL, GAS & MINING

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 - Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

Sufco Convulsion Canyon – CPP		
Special Use Permit Boundary Exhibit – Existing Features		
SCALE: 1" = 500'	DATE: 2/7/2014	DRAWN BY: T.B.\K.B.
ENGINEER: K.B.B.	CHECKED BY: K.B.\J.B.	PROJ: 0114-004
FILE NAME: M:\PROJ\0114-004\dwg\FS-SUP.dwg		

SHEET NO. EX-01

Existing Features



Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 - Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

Sufco Convulsion Canyon – CPP		
Special Use Permit Boundary Exhibit – Proposed Features		
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ENGINEER: K.B.B.	CHECKED BY: K.B.\J.B.	PROJ: 0114-004
FILE NAME: M:\PROJ\0114-004\dwg\FS-SUP.dwg		

SHEET NO. EX-02

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Proposed Features

Greens Hollow Tract

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Form 3400-12
(September 2013)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

COAL LEASE

FORM APPROVED
OMB NO. 1004-0073
Expires: June 30, 2016

Serial Number

UTU-84102

PART 1. LEASE RIGHTS GRANTED

This lease, entered into by and between the UNITED STATES OF AMERICA, hereinafter called lessor, through the Bureau of Land Management (BLM), and *(Name and Address)*

hereinafter called lessee, is effective *(date)* / / , for a period of 20 years and for so long thereafter as coal is produced in commercial quantities from the leased lands, subject to readjustment of lease terms at the end of the 20th lease year and each 10-year period thereafter.

Sec. 1. This lease is issued pursuant and subject to the terms and provisions of the:

☒ The Mineral Leasing Act of 1920, as amended, 30 U.S.C. 181 - 287; or
☐ The Mineral Leasing Act for Acquired Lands, 30 U.S.C. 351 - 359;
and to the regulations and formal orders of the Secretary of the Interior which are now or hereafter in force, when not inconsistent with the express and specific provisions herein.

Sec. 2. Lessor, in consideration of any bonuses, rents, and royalties to be paid, and the conditions and covenants to be observed as herein set forth, hereby grants and leases to lessee the exclusive right and privilege to drill for, mine, extract, remove, or otherwise process and dispose of the coal deposits in, upon, or under the following described lands:

T. 20 S., R. 4 E., SLM, Utah
sec. 36, lot 4, E½NE¼, NE¼SE¼;

T. 21 S., R. 5 E., SLM, Utah
sec. 6, all;

T. 21 S., R. 4 E., SLM, Utah
sec. 1, all;
sec. 2, SE¼;
sec. 11, E½, E½W½;
sec. 12, NE¼, W½, W½SE¼;
sec. 13, W½NE¼, NW¼;
sec. 14, NE¼, E½NW¼;

T. 20 S., R. 5 E., SLM, Utah
sec. 19, lots 5-8, E½SW¼, SE¼;
sec. 20, S½;
sec. 21, W½SW¼;
sec. 28, W½;
sec. 29, all;
sec. 30, all;
sec. 31, all;
sec. 32, N½, N½S½;
sec. 33, NW¼NW¼.

containing 6,175.39 acres, more or less, together with the right to construct such works, buildings, plants, structures, equipment and appliances and the right to use such on-lease rights-of-way which may be necessary and convenient in the exercise of the rights and privileges granted, subject to the conditions herein provided.

PART II. TERMS AND CONDITIONS

Sec. 1. (a) RENTAL RATE - Lessee must pay lessor rental annually and in advance for each acre or fraction thereof during the continuance of the lease at the rate of $ 3.00 for each lease year.

(b) RENTAL CREDITS - Rental will not be credited against either production or advance royalties for any year.

Sec. 2. (a) PRODUCTION ROYALTIES - The royalty will be 8 percent of the value of the coal as set forth in the regulations. Royalties are due to lessor the final day of the month succeeding the calendar month in which the royalty obligation accrues.

(b) ADVANCE ROYALTIES - Upon request by the lessee, the BLM may accept, for a total of not more than 20 years, the payment of advance royalties in lieu of continued operation, consistent with the regulations. The advance royalty will be based on a percent of the value of a minimum number of tons determined in the manner established by the advance royalty regulations in effect at the time the lessee requests approval to pay advance royalties in lieu of continued operation.

Sec. 3. BONDS - Lessee must maintain in the proper office a lease bond in the amount of $. The BLM may require an increase in this amount when additional coverage is determined appropriate.

Sec. 4. DILIGENCE - This lease is subject to the conditions of diligent development and continued operation, except that these conditions are excused when operations under the lease are interrupted by strikes, the elements, or casualties not attributable to the lessee. The lessor, in the public interest, may suspend the condition of continued operation upon payment of advance royalties in accordance with the regulations in existence at the time of the suspension. Lessee's failure to produce coal in commercial quantities at the end of 10 years will terminate the lease. Lessee must submit an operation and reclamation plan for the BLM's approval pursuant to 30 U.S.C. 207(c) prior to conducting any development or mining operations or taking any other action on a leasehold which might cause a significant disturbance of the environment.

The lessor reserves the power to assent to or order the suspension of the terms and conditions of this lease in accordance with, inter alia, Section 39 of the Mineral Leasing Act, 30 U.S.C. 209.

5. LOGICAL MINING UNIT (LMU) - Either upon approval by the lessor of the lessee's application or at the direction of the lessor, this lease will become an LMU or part of an LMU, subject to the provisions set forth in the regulations.

The stipulations established in an LMU approval in effect at the time of LMU approval will supersede the relevant inconsistent terms of this lease so long as the lease remains committed to the LMU. If the LMU of which this lease is a part is dissolved, the lease will then be subject to the lease terms which would have been applied if the lease had not been included in an LMU.

NOT GRANTED
Div. of Oil, Gas & Mining

(Continued on page 2)

Sec. 6. DOCUMENTS, EVIDENCE AND INSPECTION - At such times and in such form as lessor may prescribe, lessee must furnish detailed statements showing the amounts and quality of all products removed and sold from the lease, the proceeds therefrom, and the amount used for production purposes or unavoidably lost.

Lessee must keep open at all reasonable times for the inspection by BLM the leased premises and all surface and underground improvements, works, machinery, ore stockpiles, equipment, and all books, accounts, maps, and records relative to operations, surveys, or investigations on or under the leased lands.

Lessee must allow lessor access to and copying of documents reasonably necessary to verify lessee compliance with terms and conditions of the lease.

While this lease remains in effect, information obtained under this section will be closed to inspection by the public in accordance with the Freedom of Information Act (5 U.S.C. 552).

Sec. 7. DAMAGES TO PROPERTY AND CONDUCT OF OPERATIONS - Lessee must comply at its own expense with all reasonable orders of the Secretary, respecting diligent operations, prevention of waste, and protection of other resources.

Lessee must not conduct exploration operations, other than casual use, without an approved exploration plan. All exploration plans prior to the commencement of mining operations within an approved mining permit area must be submitted to the BLM.

Lessee must carry on all operations in accordance with approved methods and practices as provided in the operating regulations, having due regard for the prevention of injury to life, health, or property, and prevention of waste, damage or degradation to any land, air, water, cultural, biological, visual, and other resources, including mineral deposits and formations of mineral deposits not leased hereunder, and to other land uses or users. Lessee must take measures deemed necessary by lessor to accomplish the intent of this lease term. Such measures may include, but are not limited to, modification to proposed siting or design of facilities, timing of operations, and specification of interim and final reclamation procedures. Lessor reserves to itself the right to lease, sell, or otherwise dispose of the surface or other mineral deposits in the lands and the right to continue existing uses and to authorize future uses upon or in the leased lands, including issuing leases for mineral deposits not covered hereunder and approving easements or rights-of-way. Lessor must condition such uses to prevent unnecessary or unreasonable interference with rights of lessee as may be consistent with concepts of multiple use and multiple mineral development.

Sec. 8. PROTECTION OF DIVERSE INTERESTS, AND EQUAL OPPORTUNITY - Lessee must: pay when due all taxes legally assessed and levied under the laws of the State or the United States; accord all employees complete freedom of purchase; pay all wages at least twice each month in lawful money of the United States; maintain a safe working environment in accordance with standard industry practices; restrict the workday to not more than 8 hours in any one day for underground workers, except in emergencies; and take measures necessary to protect the health and safety of the public. No person under the age of 16 years should be employed in any mine below the surface. To the extent that laws of the State in which the lands are situated are more restrictive than the provisions in this paragraph, then the State laws apply.

Lessee will comply with all provisions of Executive Order No. 11246 of September 24, 1965, as amended, and the rules, regulations, and relevant orders of the Secretary of Labor. Neither lessee nor lessee's subcontractors should maintain segregated facilities.

Sec. 9. (a) TRANSFERS -

This lease may be transferred in whole or in part to any person, association or corporation qualified to hold such lease interest.

This lease may be transferred in whole or in part to another public body or to a person who will mine coal on behalf of, and for the use of, the public body or to a person who for the limited purpose of creating a security interest in favor of a lender agrees to be obligated to mine the coal on behalf of the public body.

This lease may only be transferred in whole or in part to another small business qualified under 13 CFR 121.

Transfers of record title, working or royalty interest must be approved in accordance with the regulations.

(b) RELINQUISHMENT - The lessee may relinquish in writing at any time all rights under this lease or any portion thereof as provided in the regulations. Upon lessor's acceptance of the relinquishment, lessee will be relieved of all future obligations under the lease or the relinquished portion thereof, whichever is applicable.

Sec. 10. DELIVERY OF PREMISES, REMOVAL OF MACHINERY, EQUIPMENT, ETC. - At such time as all portions of this lease are returned to lessor, lessee must deliver up to lessor the land leased, underground timbering, and such other supports and structures necessary for the preservation of the mine workings on the leased premises or deposits and place all workings in condition for suspension or abandonment. Within 180 days thereof, lessee must remove from the premises all other structures, machinery, equipment, tools, and materials that it elects to or as required by the BLM. Any such structures, machinery, equipment, tools, and materials remaining on the leased lands beyond 180 days, or approved extension thereof, will become the property of the lessor, but lessee may either remove any or all such property or continue to be liable for the cost of removal and disposal in the amount actually incurred by the lessor. If the surface is owned by third parties, lessor will waive the requirement for removal, provided the third parties do not object to such waiver. Lessee must, prior to the termination of bond liability or at any other time when required and in accordance with all applicable laws and regulations, reclaim all lands the surface of which has been disturbed, dispose of all debris or solid waste, repair the offsite and onsite damage caused by lessee's activity or activities incidental thereto, and reclaim access roads or trails.

Sec. 11. PROCEEDINGS IN CASE OF DEFAULT - If lessee fails to comply with applicable laws, existing regulations, or the terms, conditions and stipulations of this lease, and the noncompliance continues for 30 days after written notice thereof, this lease will be subject to cancellation by the lessor only by judicial proceedings. This provision will not be construed to prevent the exercise by lessor of any other legal and equitable remedy, including waiver of the default. Any such remedy or waiver will not prevent later cancellation for the same default occurring at any other time.

Sec. 12. HEIRS AND SUCCESSORS-IN-INTEREST - Each obligation of this lease will extend to and be binding upon, and every benefit hereof will inure to, the heirs, executors, administrators, successors, or assigns of the respective parties hereto.

Sec. 13. INDEMNIFICATION - Lessee must indemnify and hold harmless the United States from any and all claims arising out of the lessee's activities and operations under this lease.

Sec. 14. SPECIAL STATUTES - This lease is subject to the Clean Water Act (33 U.S.C. 1252 et seq.), the Clean Air Act (42 U.S.C. 4274 et seq.), and to all other applicable laws pertaining to exploration activities, mining operations and reclamation, including the Surface Mining Control and Reclamation Act of 1977 (30 U.S.C. 1201 et seq.).

INCORPORATED

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Sec. 15. SPECIAL STIPULATIONS -

(Continued on page 3)

Sec. 15. SPECIAL STIPULATIONS (Cont'd.) -

SEE ATTACHED SPECIAL STIPULATIONS

INCORPORATED

APR 19 2018

Div. of Oil, Gas & Mining

THE UNITED STATES OF AMERICA

Canyon Fuel Company, LLC
(Company or Lessee Name)

By Edwin L. Roberson

E. Lindsay
(Signature of Lessee)

Edwin L. Roberson
(BLM)

Chief Operating Officer
(Title)

STATE DIRECTOR
(Title)

3/10/17
(Date)

3-14-2017
(Date)

8 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

(Continued on page 4)

NOTICES

The Privacy Act and 43 CFR 2.48(d) require that you be furnished with the following information in connection with the information requested by this form.
AUTHORITY: 30 U.S.C. 181 - 287 and 30 U.S.C. 351 - 359 permit collection of the information requested by this form.
PRINCIPAL PURPOSE: The BLM will use the information you provide to process your application and determine if you are eligible to hold a coal lease on public lands.
ROUTINE USES: The BLM will only disclose this information in accordance with the provisions at 43 CFR 2.56(b) and (c).
EFFECT OF NOT PROVIDING INFORMATION: Submission of the requested information is necessary to obtain or retain a benefit. Failure to submit all of the requested information or to complete this form may result in delay or preclude the BLM's acceptance of your application for a coal lease.

The Paperwork Reduction Act requires us to inform you that:
The BLM collects this information to evaluate and authorize proposed exploration and mining operations on public lands.
Submission of the requested information is necessary to obtain or retain a benefit.
You do not have to respond to this or any other Federal agency-sponsored information collection unless it displays a currently valid OMB control number.

BURDEN HOURS STATEMENT: The public reporting burden for this form is estimated to average 25 hours per response when the form is used under the authority of 43 subpart 3422 (Lease Sales), or 800 hours per response when the form is used under the authority of 43 subpart 3430 (Preference Right Leases). The estimated burdens include the time for reviewing instructions, gathering and maintaining data, and completing and reviewing the form. You may submit comments regarding the burden estimate or any other aspect of this form to: U.S. Department of the Interior, Bureau of Land Management (1004-0073), Bureau Information Collection Clearance Officer (WO-630), 1849 C Street, Mail Stop 401 LS, Washington, DC 20240.

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APR 19 2018
Div. of Oil, Gas & Mining

SPECIAL STIPULATIONS FOR

COAL LEASE UTU-84102

1. In accordance with Sec. 523(b) of the "Surface Mining Control and Reclamation Act of 1977," surface mining and reclamation operations conducted on this lease are to conform with the requirements f this act and are subject to compliance with Office of Surface Mining regulations, or as applicable the Utah program approved under the cooperative agreement in accordance with sec. 523(c). The United States Government does not warrant that the entire tract will be susceptible to mining.

2. Before undertaking activities that may disturb the surface of previously undisturbed leased lands, the lessee may be required to conduct a cultural resource inventory and a paleontological appraisal of the areas to be disturbed. These studies shall be conducted by qualified professional cultural resource specialists or qualified paleontologists, as appropriate, and a report prepared itemizing the findings. A plan will then be submitted making recommendations for the protection of, or measures to be taken to mitigate impacts for identified cultural or paleontological resources.

If cultural resources or paleontological remains (fossils) of significant scientific interest are discovered during operations under this lease, the lessee, prior to disturbance, shall immediately bring them to the attention of the appropriate authorities. Paleontological remains of significant scientific interest do not include leaves, ferns, or dinosaur tracks commonly encountered during underground mining operations.

The cost of conducting the inventory, preparing reports, and carrying out mitigating measures shall be borne by the lessee.

3. If there is reason to believe that Threatened or Endangered (T&E) species of plants or animals, or migratory bird species of high Federal interest occur in the area, the Lessee shall be required to conduct an intensive field inventory of the area to be disturbed and/or impacted. The inventory shall be conducted by a qualified specialist and a report of findings will be prepared. A plan will be prepared making recommendations for the protection of these species or action necessary to mitigate the disturbance.

The cost of conducting the inventory, preparing reports, and carrying out mitigating measures shall be borne by the lessee.

4. The Lessee shall be required to perform a study to secure adequate baseline data to quantify the existing surface resources on and adjacent to the lease area. Existing data may be used if such data are adequate for the intended purposes. The study shall be adequate to locate, quantify, and demonstrate the interrelationship of the geology, topography, surface and ground water hydrology, vegetation and wildlife. Baseline data will be established so that future programs of observation can be incorporated at regular intervals for comparison.

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Div of Oil, Gas & Mining

5. Power lines used in conjunction with the mining of coal from this lease shall be constructed so as to provide adequate protection for raptors and other large birds. When feasible, power lines will be located at least 100 yards from public roads.

6. The limited area available for mine facilities at the coal outcrop, steep topography, adverse winter weather, and physical limitations on the size and design of the access road, are factors which will determine the ultimate size of the surface area utilized for the mine. A site specific environmental analysis will be prepared for each new mine site development and for major modifications to existing developments to examine alternatives and mitigate conflicts.

7. Consideration will be given to site selection to reduce adverse visual impacts. Where alternative sites are available, and each alternative is technically feasible, the alternative involving the least damage to the scenery and other resources shall be selected. Permanent structures and facilities will be designed, and screening techniques employed, to reduce visual impacts, and where possible achieve a final landscape compatible with the natural surroundings. The creation of unusual, objectionable, or unnatural land forms and vegetative landscape features will be avoided.

8. The lessee shall be required to establish a monitoring system to locate, measure, and quantify the progressive and final effects of underground mining activities on the topographic surface, underground and surface hydrology and vegetation. The monitoring system shall utilize techniques which will provide a continuing record of change over time and an analytical method for location and measurement of a number of points over the lease area. The monitoring shall incorporate and be an extension of the baseline data.

9. The lessee shall provide for the suppression and control of fugitive dust on haul roads, permitted roads, and at coal handling and storage facilities. On National Forest System Roads (NFSR), lessees may perform their share of road maintenance by a commensurate share agreement if a significant degree of traffic is generated that is not related to their activities.

10. Except at locations specifically approved by the Authorized Officer, with the concurrence of the Forest Service, underground mining operations shall be conducted in such a manner so as to prevent surface subsidence that would: (1) cause the creation of hazardous conditions such as potential escarpment failure and landslides, (2) cause damage to existing surface structures, and (3) damage or alter the flow of perennial streams. Where the Forest Service specifically approves exceptions to the above restrictions on subsidence, the lessee shall provide specific measures for the protection of escarpments, and determine corrective measures to assure that hazardous conditions are not created.

11. In order to avoid surface disturbance on steep canyon slopes and to preclude the need for surface access, all surface breakouts for ventilation tunnels shall be constructed from inside the mine, except at specifically approved locations.

12. If removal of timber is required for clearing of construction sites, etc., such timber shall be removed in accordance with the regulations of the surface management agency.

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13. The coal contained within, and authorized for mining under this lease, shall be extracted only by underground mining methods.

14. Existing Forest Service owned or permitted surface improvements will need to be protected, restored, or replaced to provide for the continuance of current land uses.

15. In order to protect big game wintering areas, elk calving and deer fawning areas, sagegrouse strutting areas, and other critical wildlife habitat and/or activities, specific surface uses outside the mine development area may be curtailed during specific periods of the year.

16. No new surface facilities shall be authorized in sage grouse priority habitat management areas.

17. Support facilities, structures, equipment, and similar developments will be removed from the lease area within 2 years after the final termination of use of such facilities. This provision shall apply unless the requirement of Section 10 of the lease form is applicable. Disturbed areas and those areas previously occupied by such facilities will be stabilized and rehabilitated, drainages reestablished, and the areas returned to a pre-mining land use.

18. The Lessee at the conclusion of the mining operation, or at other times as surface disturbance related to mining may occur, will replace all damaged, disturbed, or displaced corner monuments (section corners, quarter corners, etc.) their accessories and appendages (witness trees, bearing trees, etc.), or restore them to their original condition and location, or at other locations that meet the requirements of the rectangular surveying system. This work shall be conducted at the expense of the Lessee, by Bureau of Land Management (BLM) land surveyors, to the standards and guidelines found in the Manual of Surveying Instructions, U.S. Department of Interior.

19. The Lessee, at their expense, will be responsible to replace any surface water and/or developed ground water sources identified in Record of Decision for protection, that may be lost or adversely affected by mining operations, with water from an alternate source in sufficient quantity and quality to maintain existing riparian habitat, fishery habitat, livestock and wildlife use, or other land uses (authorized by 36 CFR 251).

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Table 1. Spring sources identified for protection during mining operations			
Spring Site ID[a]	Elevation	Easting	Northing
M_SP01	8420	465615	4319979
M_SP02	8335	466086	4319977
M_SP04	8812	464246	4319267
M_SP05	8937	464212	4319133
M_SP06	8952	464215	4319121
M_SP08	8820	464754	4317178
M_SP09	8849	464791	4317141
M_SP012	8739	464583	4319397
M_SP015	8811	463884	4316685
M_SP018	8295	465794	4320892
M_SP019	8968	462644	4316124
M_SP020	9395	462191	4316826
M_SP040	9163	463677	4318041
M_SP041	9223	463475	4318025
M_SP045	8505	465156	4319780
M_SP060	8801	462887	4316092
M_SP087	7922	465309	4322427
M_SP100	8975	463616	4316719
M_SP103	8999	463271	4316302
M_SP104	9052	463250	4316335
M_SP105	8971	463233	4316280
M_SP106	8997	462626	4316155
[a] Derived from Table 3.2 in the Greens Hollow Federal Coal Lease Tract Final SEIS			

20. The Licensee/Permittee/Lessee must comply with all the rules and regulations of the Secretary of Agriculture set forth at Title 36, Chapter II, of the Code of Federal Regulations governing the use and management of the National Forest System (NFS) when not inconsistent with the rights granted by the Secretary of the Interior in the license/permit/lease. The Secretary of Agriculture's rules and regulations must be complied with for (1) all use and occupancy of the NFS prior to approval of a permit/operation plan by the Secretary of Interior, (2) uses of all existing improvements, such as Forest Development Roads, within and outside the area licensed, permitted or leased by the Secretary of Interior, and (3) use and occupancy of the NFS not authorized by a permit/operation plan approved by the Secretary of the Interior.

All matters related to this stipulation are to be addressed to:

Forest Supervisor
Manti-LaSal National Forest
599 West Price River Drive
Price, Utah 84501
Telephone No.: 435-637-2817

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who is the authorized representative of the Secretary of Agriculture.

21. The licensee/lessee must comply with the Roadless Area Conservation Rule, 36 CFR Part 294- Special Areas, Subpart B- Protection of Inventoried Roadless Areas, January 12, 2001.

In addition, on lands within inventoried roadless areas any surface disturbance from authorized temporary cross-country motorized access will be restricted to the minimum necessary to safely and efficiently complete surface activities.

22. Notwithstanding the approval of a resource recovery and protection plan (R2P2) by the BLM, lessor reserves the right to seek damages against the operator/lessee in the event (i) the operator/lessee fails to achieve maximum economic recovery [as defined at 43 CFR §3480.0-5(21)] of the recoverable coal reserves or (ii) the operator/lessee is determined to have caused a wasting of recoverable coal reserves. Damages shall be measured on the basis of the royalty that would have been payable on the wasted or unrecovered coal.

The parties recognize that under an approved R2P2, conditions may require a modification by the operator/lessee of that plan. In the event a coal bed or portion thereof is not to be mined or is rendered unminable by the operation, the operator shall submit appropriate justification to obtain approval by the AO to leave such reserves unmined. Upon approval by the AO, such coal beds or portions thereof shall not be subject to damages as described above. Further, nothing in this section shall prevent the operator/lessee from exercising its right to relinquish all or a portion of the lease as authorized by statute and regulation.

In the event the AO determines that the R2P2 as approved will not attain MER as the result of changed conditions, the AO will give proper notice to the operator/lessee as required under applicable regulations. The AO will order a modification if necessary, identifying additional reserves to be mined in order to attain MER. Upon a final administrative or judicial ruling upholding such an ordered modification, any reserves left unmined (wasted) under that plan will be subject to damages as described in the first paragraph under this section.

Subject to the right to appeal hereinafter set forth, payment of the value of the royalty on such unmined recoverable coal reserves shall become due and payable upon determination by the AO that the coal reserves have been rendered unminable or at such time that the lessee has demonstrated an unwillingness to extract the coal.

The BLM may enforce this provision either by issuing a written decision requiring payment of the Office of Natural Resource Revenue (ONRR) demand for such royalties, or by issuing a notice of non-compliance. A decision or notice of non-compliance issued by the lessor that payment is due under this stipulation is appealable as allowed by law.

23. WASTE CERTIFICATION: The lessee shall provide upon abandonment and/or sealing off a mined area and prior to lease termination/relinquishment, certification to the lessor that, based upon a complete search of all the operator's records for the mine and upon their knowledge of past operations, there has been no **hazardous substances** per (40 CFR 302.4) or **used oil** as per Utah State Management Rule R-315-15, deposited within the lease, either on the surface or underground, or that all remedial action necessary has been taken to protect human health and the environment

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with respect to any such substances remaining on the property. The back-up documentation to be provided shall be described by the lessor prior to the first certification and shall include all documentation applicable to the Emergency Planning and Community Right-to-know Act (EPCRA, Public Law 99-499), Title III of the Superfund Amendments and Reauthorization Act of 1986 or equivalent.

24. ABANDONMENT OF EQUIPMENT: The lessee/operator is responsible for compliance with reporting regarding toxic and hazardous material and substances under Federal Law and all associated amendments and regulations for the handling such materials on the land surface and in underground mine workings.

The lessee/operator must remove mine equipment and materials not needed for continued operations, roof support and mine safety from underground workings prior to abandonment of mine sections. Exceptions can be approved by the Authorized Officer (BLM) in consultation with the surface management agency. Creation of a situation that would prevent removal of such material and by retreat or abandonment of mine sections without prior authorization would be considered noncompliance with lease terms and conditions and subject to appropriate penalties under the lease.

25. UNDERGROUND INSPECTION: All safe and accessible areas shall be inspected prior to being sealed. The lessee shall notify the Authorized Officer in writing 30 days prior to the sealing of any areas in the mine and state the reason for closure. Prior to seals being put into place, the lessee shall inspect the area and document any equipment/machinery, hazardous substances, and used oil that is to be left underground.

The purpose of this inspection will be: (1) to provide documentation for compliance with 42 U.S.C. 9620 section 120(h) and State Management Rule R-315-15, and to assure that certification will be meaningful at the time of lease relinquishment, (2) to document the inspection with a mine map showing location of equipment/machinery (model, type of fluid, amount remaining, batteries etc.) that is proposed to be left underground. In addition, these items will be photographed at the lessee's expense and shall be submitted to the Authorized Officer as part of the certification. The abandonment of any equipment/machinery shall be on a case by case basis and shall not be accomplished unless the Authorized Officer has granted a written approval.

LEASE NOTICE:
Portions of federal coal lease UTU-84102 are in an inventoried roadless area (IRA) and may be subject to restrictions on road construction and timber harvest pursuant to rules and regulations of the Secretary of Agriculture pertaining to roadless area management applicable at the time such activities may be proposed on the lease. Locations of any proposed surface use will be verified for relationship to IRA boundaries using site-specific maps if/when surface operations are proposed.

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United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Utah State Office
440 West 200 South, Suite 500
Salt Lake City, UT 84101-1345
http://www.blm.gov/ut/st/en.html

AUG 08 2016

IN REPLY REFER TO
3452
UTU-63214
UTU-76195
(UT-9223)

CERTIFIED MAIL
91 7199 9991 7033 9110 6510

DECISION

Canyon Fuel Company 225 North 5th Street Suite 900 Grand Junction, CO 81501	:	Coal Leases UTU-63214, and UTU-76195

Coal Lease Partial Relinquishments Accepted

On March 27, 2015, partial relinquishments, concerning the above noted federal coal leases, were filed in the office by Canyon Fuel Company.

A determination has been made that the partial relinquishment of U-63214 and UTU-76195 is approved as of the date of filing. The relinquished lands are subject to the continued obligation of the lessee to make payment of all accrued rentals and royalties and to complete the reclamation of the relinquished lands.

The relinquished and retained lands are described as follows:

Coal lease UTU-63214:

Relinquished Lands
T. 21 S., R. 5 E., SLM, Utah
Tract 1:
Sec. 15, W½;
Sec. 16, E½, E½E½W½;
Sec. 20, E½SE¼;
Sec. 21, E½, E½E½NW¼, SW¼;
Sec. 22, W½;
Sec. 27, NW¼, N½N½SW¼;
Sec. 28, N½, N½N½S½;
Sec. 29, E½NE¼, N½NE¼SE¼;

Retained Lands
T. 21 S., R. 4 E., SLM, Utah
Tract 1:
Sec. 12, E½SE¼;
Sec. 13, E½NE¼, S½;
Sec. 14, E½SW¼, SE¼;
Sec. 23, E½, E½W½;
Sec. 24, all;

T. 21 S., R. 5 E., SLM, Utah
Sec. 16, W½E½W½, W½W½;
Secs. 17-19, all;
Sec. 20, NE¼, W½, W½SE¼;
Sec. 21, W½E½NW¼, W½NW¼;
Sec. 26, W½NW¼SW¼, SW¼SW¼;

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Containing 2,493.36 acres

Sec. 27, E½, S½N½SW¼, S½SW¼;
Sec. 28, S½N½S½, SE¼SW¼, S½SE¼;
Sec. 29, S½NE¼SE¼;
Sec. 30, lot 1, N½NE¼;
Sec. 33, NE¼, E½NW¼, NE¼SW¼, N½SE¼;
Sec. 34, NW¼NE¼, NW¼, NW¼SW¼;
Containing 40.00 acres

Relinquished Lands
Tract 2:
T. 21 S., R. 5 E., SLM, Utah
Sec. 10, E½E½SW¼NW¼, SE¼NW¼, E½SW¼, E½E½W½SW¼;

Retained Lands
Tract 2:
None

Relinquished Lands
Tract 3:
None

Retained Lands
Tract 3:
T. 21 S., R. 4 E., SLM, Utah
Sec. 26, E½, E½SW¼;
Sec. 35, NW¼, W½SW¼;

Containing 2,490.00 acres

Containing 6,336.34 acres

Coal lease UTU-76195:
Relinquished Lands
T. 21 S., R. 5 E., SLM, Utah
Sec. 10, W½NE¼, SE¼NE¼, SE¼;
Sec. 11, SW¼SW¼NW¼, W½NW¼SW¼, SW¼SW¼;
Sec. 14, W½NW¼, SW¼, W½NE¼SE¼, W½SE¼, W½SE¼SE¼;
Sec. 15, E½;
Sec. 22, NE¼, N½SE¼, N½S½SE¼;
Sec. 23, NW¼NE¼NE¼, N½NW¼NE¼, SW¼NW¼NE¼, NW¼SW¼,NE¼, N½NW¼, SW¼NW¼, N½SE¼NW¼, NW¼SW¼, N½SW¼SW¼.

Retained Lands
T. 21 S., R. 6 E., SLM, Utah
Sec. 19, lots 3, 4, E½SW¼;
Sec. 30, lots 1-3, E½NW¼, NE¼SW¼;

T. 21 S., R. 5 E., SLM, Utah
Sec. 10, NE¼NE¼;
Sec. 11, E½, N½NW¼, N½S½NW¼, SE¼SW¼NW¼, S½SE¼NW¼, NE¼SW¼, E½NW¼SW¼, SE¼SE¼;
Sec. 12, NW¼SW¼, S½SW¼;
Sec. 13, NW¼, S½;
Sec. 14, NE¼, E½NW¼, E½E½SW¼;
Sec. 22, N½S½SE¼;
Sec. 23,
Sec. 24, all;
Sec. 25, N½, N½S½;
Sec. 26, N½, NE¼SW¼, E½NW¼SW¼, SE¼;

Containing 1,556.51 acres

Containing 4,138.15 acres

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The recoverable coal reserves (RCR) are adjusted as follows due to the partial relinquishment of the lands:

Federal Leases	Existing RCR	Adjusted RCR	New RCR
SL-062583	24,574,745	0	24,574,745
UTU-062453	3,166,863	0	3,166,863
UTU-0149084	1,017,786	0	1,017,786
UTU-28297	3,503,419	0	3,503,419

UTU-47080	16,245,323	0	16,245,323
UTU-63214	91,434,904	26,071,185	65,363,719
UTU-76195	41,850,875	17,258,816	24,592,059
Total LMU	181,793,915	43,330,001	138,463,914

This decision may be appealed to the Interior Board of Land Appeals, Office of the Secretary, in accordance with the regulations contained in 43 CFR, Part 4, and the enclosed Form 1842-1. If an appeal is taken, your notice of appeal must be filed in this office (at the above address) within 30 days after receipt of this decision. The appellant has the burden of showing that the decision appealed from is in error.

If you wish to file a petition (pursuant to regulation 43 CFR 4.21)(58 FR 4939, January 19, 1993)(request) for a stay (suspension) of the effectiveness of this decision during the time that your appeal is being reviewed by the Board, the petition for a stay must accompany your notice of appeal. A petition for a stay is required to show sufficient justification based on the standards listed below. Copies of the notice of appeal and petition for a stay **must** also be submitted to each party named in this decision and to the Interior Board of Land Appeals and to the appropriate Office of the Solicitor (see 43 CFR 4.413) at the same time the original documents are filed in this office. If you request a stay, you have the burden of proof to demonstrate that a stay should be granted.

Standards for Obtaining a Stay

Except as otherwise provided by law or other pertinent regulation, a petition for a stay of a decision pending appeal shall show sufficient justification based on the following standards:

(1) The relative harm to the parties if the stay is granted or denied,
(2) The likelihood of the appellant's success on the merits,
(3) The likelihood of immediate and irreparable harm if the stay is not granted, and
(4) Whether the public interest favors granting the stay.

If you have any further questions, please call Bill Buge of this office at (801) 539-4086.

Jenna Whitlock
Acting State Director
Utah State Office

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cc: Resource Development Coordinating Committee, ATTN: Mineral Leasing Taskforce, 116 State Capital Building, Salt Lake City, Utah 84114

ONRR, ACM, Solid Minerals Staff, Attn: LeeAnn Martin, MS62300B, Box 25165, Denver, CO 80225-0165

Price Field Office

Mr. John Baza, Director, UDOGM, Box 145801, Salt Lake City,Utah 84114-5801

Allen Rowley, Forest Supervisor, Manti-La Sal National Forest, 599 Price River Dr., Price, UT 84501
Tina Garcia, USDA-Forest Service, Southwest Region, 333 Broadway Blvd., SE, Albuquerque, NM 87102

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CHAPTER 2

SOILS

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CHAPTER 2
SOILS

2.10 Introduction

This chapter and Volume 3 of this M&RP contains all pertinent information relating to identification, management, and reclamation activities associated with the soil resources present in the disturbed area of the SUFCO Mine.

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS) . The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text.

2.20 Environmental Description

The SUFCO Mine area lies in central Utah at the southern end of the Wasatch Plateau. Topography is dominated by plateaus separated by deeply incised canyons. Canyon walls are generally composed of laterally continuous (several thousand feet) ledge-forming sandstones, interbedded with slope forming shales and siltstones. Topography in the SUFCO Mine area ranges from 6500 to about 9,000 feet above sea level. Soils are generally not cultivated due to their thin nature, shortage of irrigation water, and a short growing season. Residual and colluvial soils are present at the SUFCO Mine surface facilities area. These soils have formed from residual sandstone and shale particles that mixed as they migrated down slope. Soils are usually very shallow, consisting predominantly of sand and silty sand loams which have high percolation rates. The soils are highly susceptible to wind erosion. The inherent erosion hazard from water is low. Rock outcrops consist of alternating layers of sandstone and shale. Subordinate amounts of coal

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and limestone are also present. The landscape is steep and rocky with massive sandstone ledges, and siltstone/shale slopes. Surface and subsurface layers are often rocky.

2.2.1 Prime Farmland Investigation

No prime farmland exists in the SUFCO Mine disturbed area, Link Canyon disturbed area, or in any of its lease areas. Mining activities will not impact prime farmland. In compliance with R645-302-313, a pre-application investigation was conducted by the Applicant to determine if any prime farmland would be impacted by the project. Based on the federal criteria for determining the presence or absence of prime farmland, the Convulsion Canyon area, Link Canyon, the Pines Tract area, and the SITLA Muddy Tract area cannot be classified as prime farmland. Consultation with Dr. Theron B. Hutchings, State Soil Scientist for the Soil Conservation Service, substantiated the absence of prime farmland in the Convulsion Canyon and Link Canyon areas. (Appendix 2-1).

2.2.2 Soil Survey

A Level I soil survey of the entire SUFCO Mine disturbed area, including the Link Canyon Substations No. 1 and 2 , has been conducted. Soil survey data are presented in Appendix 2-2 for the majority of the permit area, Appendix 2-6 for the Link Canyon Substation areas, and are herein summarized in Sections 2.2.2.1 through 2.2.2.3. Survey data includes the following information: taxonomic classification, horizon name and depth, dry and moist color, texture (percent sand, silt, and clay), class, structure, percent rock fragments and organic matter, pH, effervescence, EC, and solubility of calcium, magnesium, and sodium (Appendices 2-2 and 2-6). A cross-reference list of map unit, soil taxonomic classification, and sample site appears in pages 17 through 19 of Appendix 2-2.

A site specific soil survey will be completed for the Overflow Pond prior to disturbance and this information will be utilized in determining topsoil salvage depth. The results of this soil survey will be included in the as-built addendum to be included in Appendix 2-2.

An Order 2 soil survey has been completed for the Link Canyon Substation No. 1 disturbed area and is included in Appendix 2-2. Additionally, an Order 1 soil survey was conducted of the substation Nos. 1 and 2 pad areas and the results are included in Appendix 2-6.

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An Order 3 soil survey has been conducted for the Pines Tract and the results are included in Appendix 2-8. (Plate 2-2)

An Order 3 soil survey has been conducted for the SITLA Muddy Tract and the results are included in Appendix 2-10. (Plate 2-3). Soils associated with the 70 Acre BLM Right of Way are part of the Order 3 soil survey located in Appendix 2-10.

2.2.2.1 Soils Map

Plates 2-1 and 2-2 delineates the soil types present in the disturbed and adjacent areas.

2.2.2.2 Soil Identification

Soils present in the narrow V-shaped East Spring Canyon, which lie within and immediately adjacent to the disturbed area of the SUFCO Mine have been identified, characterized, and their spatial occurrences documented (Appendix 2-2). Four soil types are present in the disturbed area, and are herein referred to as soil types O, W, T, and X (Plate 2-1). Soil type O is a loamy-skeletal, mixed, frigid Ustic Torriorthent. Soil W is a loamy-skeletal, mixed, frigid Typic Xerothent. Soil type T is a loamy-skeletal, mixed, frigid, Calcixerollic Xerochrept. Soil X is a complex composed of both a clayey-skeletal, mixed, frigid, shallow Lithic Calcixeroll, and a fine, mixed, frigid Mollic Haploxeralf.

Analytical and field methodology utilized in characterizing these soil types and their soil horizons are found in pages 13 and 14 of Appendix 2-2. Soils were classified to family unit using the Soil Conservation Service's classification system (Johnson, 1975).

2.2.2.3 Soil Description

Soil Type O

Soil type O is found at the north end of the disturbed area, in the area of the confluence of the Mud Spring Hollow and East Spring Canyon drainages (Plate 2-1). The taxonomic classifications of Soil O are that of a loamy-skeletal, mixed, frigid Ustic Torriorthent. This soil is found on slopes with grades of 60 percent or greater; consists of well-drained soils that have formed from residuum and

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colluvium; and supports Pinyon, Juniper, and Mountain Mahogany vegetative growth. The water holding capacity is 3.5 inches.

The A soil horizon ranges from 0 to 2 inches in depth and is a sandy clay loam composed of about 52% sand, 22% silt, and 26% clay. The dominant color is a pale brown (10YR 6/3) when dry, and a dark grayish brown (10YR 4/2) when moist. Rock fragments (predominantly gravel) account for 15% by volume of this horizon. A pH of 7.66, EC of 740 mmhos/cm, and organic matter values of 2.22% are present. Solubility values (ppm) of Ca, Mg, and Na, are 116.3, 14.4, and 6.7, respectively.

The AC soil horizon ranges from 2 to 12 inches in depth and is a sandy clay loam composed of approximately 50% sand, 18% silt, and 32% clay. Predominant color is a yellowish brown (10YR 5/4) dry, and a dark grayish brown (10YR 4/2) wet. Rock fragments make up about 45% (15% gravel, 10% cobbles, 20% stones) of the AC horizon by volume. A pH of 7.73, an EC of 940 mmhos/cm, and an organic matter percent of 2.2% are common. Solubility values (ppm) of Ca, Mg, and Na, are 150, 18, and 6, respectively.

The C soil horizon ranges in depth from 12 to 31 inches. This horizon is also a sandy clay loam composed of 45% sand, 23% silt, and 32% clay. Soil color is light yellowish brown (2.5Y 6/4) when wet. Rock fragments account for 30% (20% gravel, 5% cobbles, 5% stones) of the C soil horizon by volume. A pH value of 7.92, EC of 560 mmhos/cm, and an organic matter percent of 0.54 are present. Solubility values (ppm) of Ca, Mg, and Na, are 83, 12, and 9, respectively. Bedrock is encountered at a depth of 31 inches.

Soil Type W

Soil type W is found along the western edge of the disturbed area on an east facing slope with a grade of 60% or more (Plate 2-1). The taxonomic classifications of Soil W are that of a loamy-skeletal, mixed, frigid Typic Xerothent. Soil W supports vegetation consisting of sage-grass and mountain brush in this area. This soil consists of excessively well drained soils that have formed in residuum and colluvium. Rock outcrops comprise 30% of the mapped area containing soil type W.

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The A1 soil horizon occurs from the surface to a depth of 4 inches. This surface soil horizon is a sandy clay loam composed of 53% sand, 21% silt, and 26% clay; rock fragments compose about 80% (40% gravels, 40% cobbles) of its volume. The A1 horizon has a brown to dark brown color (10YR 4/3) when moist. A pH value of 7.5, EC of 3300 mmhos/cm, and a percent organic matter of 1.54 are present. The solubilities of Ca, Mg, and Na, are 430, 118, and 42 ppm, respectively.

The A1 soil is underlain by a brown to dark brown (10YR 4/3) C soil horizon. The C soil occurs between depths of 4 to greater than 60 inches. It is also a sandy clay loam with sand, silt, and clay percentages of 53, 21, and 26, respectively. Rock fragments compose about 45% by volume (25% gravel, 10% cobbles, 10% stones) of this soil horizon. Solubilities of Ca, Mg, and Na are identical to those in the A1 horizon.

Soil Type T

Soil type T is found in the south-central region of the disturbed area and encompasses the original drainage channel of the East Spring Canyon (Plate 2-1). This unit consists of excessively well-drained soils that have formed in colluvium and residuum. Slopes range in excess of 60%. Soil T is classified as a loamy-skeletal, mixed, frigid, Calcixerollic Xerochrept. Rock outcrops comprise 30% of the mapped area containing soil type T. The water holding capacity of the soil is 4 inches. Soil T supports pinyon pine, juniper, and wild rye vegetation.

The surficial A1 soil horizon ranges in depth from 0 to 2 inches. This horizon is a sandy clay loam, composed of 45% sand, 23% silt, and 32% clay. Soil color is yellowish brown (10YR 5/4) when moist. Rock fragments account for only 5% (gravel) by volume. A pH value of 7.57, EC of 1110 mmhos/cm, and an organic matter percent of 5.57% are present. Solubility values (ppm) of Ca, Mg, and Na, are 149, 29, and 8, respectively.

The B1 horizon, a clay loam, occurs between depths of 2 to 12 inches, and is composed of 37% sand, 29% silt, and 34% clay. Rock fragments compose 55% (10% gravel, 5% cobbles, 40% stone) by volume of this soil resource. When moist the B1 horizon is brown to dark brown (10YR 4/3) in color. Geochemical tests reveal a pH of 7.45, an EC of 1340 mmhos/cm, and an organic

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matter percent of 4.07. Solubility values of Ca, Mg, and Na, are 182, 35, and 7.4 ppm, respectively.

The underlying B2 soil horizon ranges from depths of 12 to 24 inches, and is brown (10YR 5/3) in color. It is a clay loam composed of 35% sand, 27% silt, and 38% clay. Rock fragments account for 45% (40% gravel, 5% cobble) by volume of this soil horizon. PH value of 7.66, an EC of 820 mmhos/cm, and organic matter values of 2.63 are present. Ca, Mg, and Na solubility concentrations are 99, 20, and 9 ppm, respectively.

The basal yellowish brown (10YR 5/4) C soil horizon occurs from 24 to 58 inches below ground level. Soil C is also a clay loam, with sand comprising 37%, silt 27%, and clay 35%. Rock fragments make up 50% of this soil horizon, with stones accounting for 40%, gravel 5%, and cobbles 5%. Solubility concentrations of Ca, Mg, and Na are 220, 80, and 37 ppm, respectively.

Soil Type X

Soil X lies along the eastern edge and in the north-central region of the disturbed area (Plate 2-1). This soil is a complex consisting of two soil types: (1) a clayey-skeletal, mixed, frigid, shallow Lithic Calcixeroll, and (2) a fine, mixed, frigid Mollic Haploxeralf. The former soil comprises approximately 70% of the soil cover in this region, the latter soil type accounts for about 20%, with about 10% of the area covered with rock outcrop. Both soil types support pinyon pine and juniper trees.

The Lithic Calcixeroll soil is composed of A1, AC, and Cca soil horizons. The A1 horizon occurs from the surface to a depth of 4 inches below the surface and is dark brown (7.5YR 3/2). It is a clay loam composed of 43% sand, 29% silt, and 28% clay. Rock fragments (gravel) comprise 25% by volume this horizon. An organic matter content of 7%, pH value of 7.44, and an EC of 1280 mmhos/cm are present. Soluble concentrations of Ca, Mg, and Na are 205, 27, and 6.6 ppm, respectively.

The AC soil horizon occurs between 4 to 8 inches below ground level, and is predominately a clay composed of 33% sand, 25% silt, and 42% clay. Its color when moist is dark brown (7.5YR 3/2). Gravel makes up 20% of this horizon, by volume. Organic matter accounts for about 5% of this

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horizon. PH and EC values of 7.9 and 510 mmhos/cm are present. Ca, Mg, and Na soluble concentrations are 73, 19, and 3 ppm, respectively.

The underlying Cca soil horizon extends from 8 inches to depths of about 17 inches, where bedrock is encountered. The Cca horizon is a reddish brown clay. Clay comprises 42% of this horizon; subordinate amounts of sand (35%) and silt (23%) are also present. Rock fragments account for 55% (40% gravel, 15% cobbles) of this zone. EC values of 380 mmhos/cm, along with a pH of 7.97, and an organic matter percent of only 1.21% are present. Soluble concentrations for Ca, Mg, and Na are 10, 10, and 6 ppm, respectively.

The Mollic Haploxeralf soil is characterized by an A, AC, and Cca soil horizons. The surficial A horizon extends to 5 inches below ground level, and is a very dark brown (10YR 2/2) sandy clay loam. It is typically composed of 59% sand, 15% silt, and 26% clay. Gravel accounts for only 5% by volume of this horizon. Percent organic matter is about 7%. A pH of 7.63 and an EC of 1620 mmhos/cm are present. The soluble concentrations (ppm) of Ca, Mg, and Na are 168, 72, and 26, respectively.

The underlying AC soil zone occurs between 5 to 14 inches below the surface, and is a pale brown (10YR 6/3) clay. Clay is the dominant constituent comprising 44% of this zone, silt (39%) and sand (17%) are also present. Rock fragments make up 20% (5% gravel, 15% cobbles) of this horizon, by volume. An organic matter value of 3.8%, a pH level of 7.48, and an EC of 6340 mmhos/cm characterize this soil horizon. Solubilities of Ca, Mg, and Na are 517, 279, and 317 ppm, respectively.

The basal soil horizon, Cca, a light brownish gray clay, typically extends to depths of 34 inches where bedrock is encountered. Cca is composed of 52% clay, 37% silt, and 11% sand. Rock fragments comprise 40% (10% gravel, 20% cobbles, 10% stones) of this horizon. Percent organic matter is only 1.7. PH and EC values are 7.87 and 9590 mmhos/cm, respectively.

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Overflow Pond Soils

A general description of the soils located in the Overflow Pond area will be provided in Appendix 2-2.

Link Canyon Soils

A description of the soils located in the Link Canyon Substation Nos. 1 and 2 disturbed areas is provided in Appendix 2-6.

Link Canyon Mine Portals

A description of the soils located in the Link Canyon Mine Portals area is provided in Appendix 2-9. The description of the soils was prepared by Dan Larsen, a soils scientist with EIS Environmental and Engineering Consultants.

Pines Tract

The general description of the soils within the Pines Tract is provided in Appendix 2-8.

SITLA Muddy Tract and Greens Hollow Tract

The general description of the soils within the SITLA Muddy Tract and Greens Hollow Tract is provided in Appendix 2-10.

3 Right 4 East - Quitchupah Tract

A general description of the soils associated with the Quitchupah Tract is provided in the Supplemental Environmental Assessment prepared by UDOGM October 27, 1989, included in Appendix 2-7. No surface disturbance as in the construction of facilities, etc. is associated with the ming of the 3 Right 4 East panel(s)

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4 Right 4 East - Quitchupah Tract

The general description of the soils associated with the Quitchupah Tract is provided in the Supplemental Environmental Assessment prepared by UDOGM October 27, 1989, included in Appendix 2-7. The soils above the 4 Right panel support sagebrush, grassland, mountain brush and Pinyon/Juniper, with islands of quaking aspen and scattered pines. No other disturbance as in the construction of facilites, etc. is associated with mining of the 4Right 4 East panel.

2.2.2.4 Soil Productivity

In areas where soil disturbance has resulted from mining activities, the soils have lost their native identities. In most cases the soils have been quite thoroughly mixed. As a result, soil textures and horizons have been altered. Textures are now primarily loams and silty clay loams; depths over indurated material or shale are generally greater than 30 inches, except along "cut" slopes of the mountain where geologic strata are exposed.

As a result of this disturbance in "fill" areas, the potential for reclamation has been enhanced. The soils are deeper and the resulting textures are more desirable for plant growth.

Saturation percentages are unavailable. When the original sampling and analyses of soils for the portal yard area were completed, saturation percentage was not required by the regulatory agencies.

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2.50 Performance Standards

2.5.1 Topsoil, Subsoil, and Topsoil Supplements Management

All topsoil, subsoil, and topsoil supplements shall be managed as outlined in Sections 2.30 and 2.40.

2.5.2 Stockpiled Topsoil and Subsoil

All stockpiled topsoil and subsoil will be managed according to plans outlined in Sections 2.30 and 2.40.

REFERENCES:

Johnson, Wm. M., 1975, Soil Taxonomy, A Basic System of Soil Classification For Making and Interpreting Soil Surveys, Supt. of Doc. S.C.S., Washington, D.C.

U.S. Department of the Interior, Final Supplemental Impact Statement for Leasing and Underground Mining of the Greens Hollow Federal Coal Lease Tract UTU-84102, Sanpete and Sevier Counties, Utah, February 2015

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CHAPTER 3

BIOLOGY

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CHAPTER 3
BIOLOGY

3.10 Introduction

This chapter presents a description of the biological resources found on the SUFCO Mine site. The mine is located approximately 30 miles east of Salina, Utah.

Several consultant reports will be referenced in this M&RP, so for simplicity purposes the report titles will appear as the following abbreviations:

EPS - Report of Studies of Vegetation and Soils for SUFCO Mine - 1980 (Appendix 2-2)

INV - Report of 1983 Field Investigations - 1983 (Appendix 3-1)

AQU - Aquatic Resource Inventory of Southern Utah Fuel Company Permit Area - 1980 (Appendix 3-2)

WIL - Wildlife Assessment of the Southern Utah Fuel Company Mining Property and Adjacent Areas - 1980 (Appendix 3-3)

RAP - Raptor and General Avifauna Studies - 1980 (Appendix 3-4)

FSW - Fauna of Southeastern Utah and Life Requisites Regarding their Ecosystems - 1990 (Appendix 3-5)

VWP - Vegetation and Wildlife of the Pines Tract Project - 1999 (Appendix 3-9).

Reports in the appendices are provided only to present Baseline Data in support of the Mining and Reclamation Plan. Proposals or recommendation presented by consultants were duly considered in preparation of the Mining and Reclamation Plan chapter commitments but not all of them were determined to be appropriate or advisable.

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS) . The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference

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specifically is provided as background or baseline for the obligations and commitments within the text.

3.1.1 Vegetative, Fish and Wildlife Resources

Vegetative, fish and wildlife resource conditions in and adjacent to the SUFCO Mine are discussed in Section 3.20.

3.1.2 Potential Impact to Vegetative, Fish and Wildlife Resources

Potential impact to vegetative, fish and wildlife resources and the associated mitigation plan are presented in Sections 3.30 and 3.40 of this application.

3.1.3 Description of Reclamation Plan

The reclamation plan used to restore the vegetative, fish and wildlife resources to a condition suitable for the postmining land use is presented in Section 3.40.

3.20 Environmental Description

3.2.1 Vegetation Information

This section contains the environmental descriptions for the vegetation for the permit and adjacent areas.

3.2.1.1 Plant Communities Within the Proposed Permit Area

"Vegetation changes from one landform to another. On the benches landform, there is a combination of sagebrush-grass community and ponderosa pine stands. Intermixed are patches of low quality Quaking Aspen, Mountain Mahogany, and Manzanita brush. Ground cover is composed of several native grasses, forbs, and low brush species. Density is generally good.

The steep slopes and scarp faces landform is sparsely vegetated. Pinyon, Juniper, and Mountain Mahogany are scattered over the landform. The site is very harsh and ground vegetation is limited to light quantities of native grasses and forbs in cracks and shelves where soil can accumulate. Composition includes a few drought resistant grasses, annual forbs, Mountain Mahogany and other brush.

Narrow stringers in canyon bottoms are the most productive in the area. Vegetation is primarily native grass, low brush and forbs growing together to form a heavy sod. Brush types include

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willow, rose, rabbit brush, sand brush and others. Carex grows in some of the wetter spots. Only an occasional tree occurs in the bottoms.

The rolling hills landform is covered by an occasional small patch of trees which include Ponderosa pine, Douglas-fir, Alpine-fir, Spruce and Aspen. More common are brush species including oak, snowberry, and sagebrush. Grasses and forbs are very sparse and include several native species." (Blumer, 1979)

The plant communities identified within the proposed permit area are (see Plate 3-1):

Sagebrush-grass
Grass-black sagebrush
Mountain Brush (oak, serviceberry, mountain mahogany, etc.)
Aspen
Aspen-oak
Aspen-Douglas fir-limber pine
Mountain mahogany-oak-ponderosa pine
Douglas fir-spruce-limber pine
Pinyon-juniper-mountain mahogany
Limber pine
Ponderosa pine-mountain mahogany-manzanita
Pinyon-juniper-Douglas fir
Wiregrass-foxtail-haplopappus
Douglas fir-spruce-limber pine-aspen
Limber pine-mountain mahogany-serviceberry
Mountain mahogany
Pinyon-juniper
Douglas fir & other
Riparian
Ponderosa pine-douglas fir-aspen-serviceberry
Grassland-perennial forbs
Sagebrush
Mountain brush
Conifer timber
Mixed
Barren ground

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Aspen-deciduous forest

Additional plant communities are designated on Plate 3-1.

Field sampling of these plant communities was initially done in July of 1983 and the findings were documented in the INV report. A Level II riparian inventory has been conducted along portions of East Fork of Box Canyon (USDA-USFS, 1993). The plant communities and reference areas are outlined on Plate 3-1. In 1999, another vegetation (and wildlife) report (VWP) was prepared for the proposed mine expansion called the Pines Tract Project. Vegetation communities were described and shown on a map included in that document, most of which are also listed in the plant communities shown above. The vegetation types in the SITLA Muddy Tract were identified by Cirrus and reported in EIS documents for the entire BLM and SITLA Muddy Tract. The vegetation types in the SITLA Muddy Tract are illustrated on Plate 3-1. This plate will be updated in the appropriate season of 2006 to more clearly indicate types and extent of vegetation in the SITLA Muddy Tract. As of October 2005, the available Forest Service information used to create the map is essentially correct but Sufco has agreed the vegetation boundaries and descriptions can be further refined. The work to be performed in 2006 will include the evaluation of available aerial photos of the area by a qualified person who then will create an updated vegetation map of the tract. The updated version of the plate will be submitted to the Division before the end of 2006.

Greens Hollow. The following is a listing of the approximate coverage of habitat vegetation. Mahogany and mountain brush constitutes the most abundant habitat, covering 27.4 percent of the tract and associated extended analysis area. Sagebrush covers 23.3 percent, aspen and aspen-mixed conifer 17.2 percent, grassland/forbland 11.7 percent, ponderosa pine 5.3 percent , pinyon-juniper 2.9, Rock outcrops/barren 2.1 percent and mixed conifer 1.1 percent. Limber and or/bristlecone pine were in the extended analysis area only covering 1 percent.

A description of the potential impacts of mining on vegetation is included in Section 3.3.3.3 of this permit.

3.2.1.2 Land Productivity Prior to Mining

The land productivity of the mine area was not measured in 1941 when mining began. However, Appendix 2-2 contains a consultant study (EPS, pgs. 45 - 78) compiled in 1980, which states total cover, production pounds per acre and species within the permit area. Additional information was presented in INV Report, August 12, 1983 (Appendix 3-1).

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3.2.2 Fish and Wildlife Information

A summary of the fish and wildlife resource information for the permit and adjacent areas is contained in Sections 3.2.2.1 through 3.2.2.3. As mentioned above, a wildlife report was included with a vegetation report in 1999 (VWP) for the proposed mine expansion called the Pines Tract Project. Fish and wildlife resources in the SITLA Muddy tract are as described in Sections 3.2.2.1 through 3.2.2.3 and in the "Muddy Creek Summary Report - Wildlife" prepared by Cirrus and included as Appendix 3-11. Fish and wildlife resources within the West Coal Lease Modifications and the area of the 2016 sinkhole repair are summarized in Appendix 3-13 and Section 3.2.2.2. A description of the potential impacts and mitigation of impacts of mining on fish and wildlife is included in Section 3.3.3.3 of this permit.

Due to either their small size, intermittent flows, poor habitat or water quality, the surface waters in the lease area are not of game fish quality. The low importance of the streams as a fishery resource, has categorized them as being of little value for extensive study. An inventory of the aquatic resources is located in Appendix 3-2. Aquatic resources of the Pines Tract Project are briefly described in the wildlife section of Appendix 3-9. Aquatic resources within the Muddy Tract are summarized in Appendix 3-11. Aquatic resources within the West Coal Lease Modifications and the area of the 2016 2RWL sinkhole repair are summarized in Appendix 3-13. Aquatic resources for the Greens Hollow Tract are summarized in Appendix 3-16.

3.2.2.1 Level of Detail

The scope and level of detail within this M&RP are sufficient to design the protection and enhancement plan for wildlife and fish in the area.

This assessment of wildlife resources has been compiled pursuant to guidelines issued by the State of Utah Division of Oil, Gas and Mining (UDOGM). Appendices 3-3, 3-4, 3-5, and 3-9 contain wildlife studies related to their resources in the mine area.

3.2.2.2 Site-specific Resource Information

The following information was summarized from the WIL, RAP, AQU, and VWP Reports. Additional information is available in Appendix 3-2 through 3-5, and 3-9.

Reptiles and Amphibians

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Increasing elevation rapidly reduces the number and kind of reptiles and amphibians. Furthermore, in Utah the effects of the more northern latitude reduces the number of reptiles in much the same way as does the increase in elevation.

These geographical and associated climatic factors have eliminated most desert species, leaving species that are adapted either to mountain habitats or montane type habitats developed in the more northern areas.

Literature pertaining to the amphibians and reptiles is extensive; but, much of it refers to species occurring in the desert areas and has only limited reference to forms inhabiting Utah mountains.

Based on the extensive literature review and limited field work it was determined that potentially 8 species of amphibians (Appendix 3-5) inhabit the area of concern which provides substantial value habitat . All amphibians are legally protected, but since the species listed are all widespread throughout the mountains of Utah, none are treated as high-interest species. It is doubtful that the proposed action would seriously impact populations, but localized individuals may be involve in habitat destruction due to subsidence. An exception to this would be if subsidence interrupted underground aquifers and caused drying of present wet habitats essential to reproduction.

Based on the literature search and limited field work, it was determined that potentially 14 species of reptiles (Appendix 3-5) occupy the mine land area, a substantial value habitat for all species. All reptiles are legally protected but since the species listed are all widespread throughout montane habitats in Utah, none are treated as high-interest species and, therefore, are not individually discussed. It is doubtful that the proposed action would seriously impact populations.

Information about reptiles and amphibians specific to the Pines Tract Project area is provided in the VWP report (Appendix 3-9). Information about reptiles and amphibians specific to the Muddy Tract area is provided in the Cirrus report (Appendix 3-11). Information about reptiles and amphibians specific to the West Coal Lease Modifications are summarized in Appendix 3-13.

Wetlands and riparian areas exist within the permit area and have been estimated to represent less than one percent of the total acreage within Pines Tract Project Area and SITLA Muddy Tract. These areas are supported by streams, springs, and seeps located throughout the drainages. Studies in the semi-arid West comparing riparian areas with adjacent uplands showed that riparian zones support up to 400 percent more plant biomass, up to 200 percent more species, and

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contribute to large increases in density and species richness for birds when compared to upland areas.

Between 69% to 92% of all amphibian occur in wetland ecosystems. The scaleless, permeable amphibian skin requires constant moisture to retain body fluids. Both water quantity and quality parameters are of importance to the survival of individual amphibians and ultimately populations of the species.

Reptiles are not nearly as dependent on wetlands since their scaly covering provide resistance to desiccation. Riparian areas are heavily utilized (50% to 72% of all species) for the available drinking water, prey, and vegetative resource (cover). The moist soil characteristic of riparian zones also provide preferred nesting habitat for many reptiles.

The riparian areas for the Pines tract Project Area, Link Canyon, and SITLA Muddy Tract are shown on Plate 3-1. A survey for amphibians and mollusks was conducted in the Link Canyon Portal area in June of 2002. No amphibians or mollusks where found in the portal area nor where any protected or sensitive species found in the area. A copy of a report of the investigation is contained in Appendix 2-9.

Raptors

Only one nest, that of a Cooper's Hawk, was found in 1980 (Appendix 3-4). The one Cooper's Hawk nest found was in an area seemingly less favorable than surrounding canyons. Quitchupah Canyon appeared to be prime habitat, but no nests were found.
Golden Eagles were seen on nearly every survey day during the 1980 survey by Clayton White of Brigham Young University (Appendix 3-4). The presence of two adults accompanied by a juvenile suggest their nearby breeding, however no nests were located.

Appendix 3-4, Table 1 contains a list and the number of sightings for the birds inventoried during the 1980 raptor survey.

A raptor survey conducted April 14, 1987, located three Golden Eagle nests (Appendix 3-4). Two of the nests were tended and contained greenery, the third had an adult eagle incubating eggs.

In October of 1988 an environmental assessment of the Quitchupah Lease area was performed by personnel from the Forest Service and Bureau of Land Management. During the assessment

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6 Golden Eagle nests were located.

The SUFCO Mine portions of the annual raptor surveys conducted by UDWR and others are located in Appendix 3-4 in the Sufco Mine MRP Confidential file. Refer to Section 3.3.3.3 for commitments and other raptor survey information.

The Prairie Falcon has also been reported by U.S. Forest Service and Bureau of Land Management personnel for the planning unit that encompasses the SUFCO Mine area.

The Quitchupah Drainage, of which Link Canyon is a tributary, was identified in the Quitchupah Creek Road DEIS (2001) as not likely to contain Mexican Spotted Owls and dedicated surveys were not necessary. However, the Manti-La Sal National Forest reported that a Mexican Spotted Owl survey of the area was being conducted as part of their Muddy Creek EIS Data Adequacy study. Results of surveys conducted in 2002 and 2003 indicated no Mexican Spotted Owls were found in the Link Canyon Portal area or the Muddy Tract area (Appendix 3-12). Additionally, Sufco does not plan to conduct construction activities during the nesting and rearing times (February 1 through August 31) of the owl.

The lack of permanently running water has an effect on raptors. Many species, such as accipiters, appear to rely on streams and the associated riparian vegetation (Hennessy, 1978).

Known raptor nests are shown on Plate 3-3, refer to Section 3.3.3.3 for additional raptor information.

Information about raptors specific to the Pines Tract Project area is provided in the VWP report (Appendix 3-9). Information about raptors specific to the Muddy Tract area is provided in the Cirrus report (Appendix 3-11). Information about raptors specific to the West Coal Lease Modifications and the area of the 2016 2RWL sinkhole repair are summarized in Appendix 3-13 and Section 3.2.2.2. Raptor surveys conducted in the Greens Hollow Tract are located in Appendix 3-4 and a discussion of raptors and bird species from technical reports prepared by Cirrus Ecological Solutions, LC is located in Appendix 3-16.

3 Right 4 East Panel(s) - Township 21 South, Range 5 East

A helicopter survey to locate raptors and migratory bird species was conducted in 1982 and 1988 by UDWR, USFWS, BLM, and USFS. In 1988 ten golden eagle nests were located within the

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Quitchupah lease boundary, two were active, two were tended and the remaining six were inactive. One active nest and two inactive nests were located in Section 33 (Dry Fork Canyon) during these surveys. During a conversation with Jeff Jewkes it was reported that the raptor nests in the canyon located in Section 33 were surveyed in 2014, 2015 and 2016 by the DWR. One of the three nests in the canyon was active in 2015, and the same nest appeared tended in 2014 and 2016. The other nests were inactive during the three-year survey period. The nests in Dry Canyon were re-surveyed in 2017, in April, May and June, during the surveys the nests were inactive. An application for a "nest take permit" for nests 793, 794 and 795 was submitted to the USFWS prior to the mining of the 3 Right 4 East panel. An e-mail from the USFWS is included in Appendix 3-15, documenting the schedule of review and the potential date of issuance of the "nest take permit." The permittee's intention is to be given permission by the USFWS permit to take the nests, provide and have an approved mitigation plan for the taking of the nests. The permittee will have the obligation of following the requirements of the USFWS permit. The location of the three nests is shown on confidential raptor nest drawing within Appendix 3-15 of this M&RP. Once the "nest take permit" has been granted the Manti-La Sal biologist and the UDOGM biologist will be informed of the requirements and stipulations associated with the"nest take permit" and will be provided a copy. In 2017 during the rapotors surveys of the mine area, including the 3R4E and 4R4E mining panels, the Raptor Survey Guidelines (DOGM, 2010) were followed. The active mining areas with the potential to subside are surveyed in or before the first year of mining and until subsidence movement, as determined by the mine's annual subsidence survey, has ceased. Subsidence survey data is provided to DOGM annually for their files.

Other than golden eagles, no TES species are known to inhabit the area of the panel. According to the DWR in a 1989 assessment the southern portion of the lease area is considered crucial winter range for deer and elk.

Although no surface facilities are planned for construction above the 3 Right 4 East underground panel, as requested by the Manti-La Sal Forest Biologist and Forest Service Supervisor the following standard has been included in the requirements pertaining exclusively to the lands above the 3 Right 4th East underground panel. "To protect sage-grouse habitat, locate new appurtenant surface facilities outside priority habitat management areas, unless no technically feasible alternative exists. If new appurtenant surface facilities cannot be located outside of priority habitat management areas, locate them with and existing disturbed areas, if possible. If location with and existing disturbed area is not possible, the construct new facilities to minimize disturbed area while meeting mine safety standards and requirements in the established mine-plan approval process.

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and locate the facilities in and area least harmful to greater sage-grouse habitat based on vegetation topography, or other habitat features. (Greater Sage-grouse Record of Decision, GRSG-M-CML-ST-093)"

4 Right 4 East Panel - Vegetation Information

At approximately 11:30 am on April 24, 2017 a walking survey of the surface above and immediately adjacent to the panel was conducted by a qualified CFC employee. Vegetation types were documented within the potential subsidence impact area above the 4R4E panel and adjacent areas (See the 4R4E Projected Subsidence Map in Appendix 6-4). The vegetation types found during the survey include pinyon-juniper, sagebrush/grass, and mountain sagebrush types of the desert shrub biome. These findings coincide with data found in an environmental assessment and a supplemental environmental assessment complete in 1988 and 1989 respectively. Appendix 2-7 contains the aforementioned EA and supplemental EA associated with the Quitchupah Lease. Refer to Plates 5-6 and 5-7 of the M&RP for information regarding the location of both the Quitchupah Lease and the 4R4E panel. The findings of the walking survey also coincide with data shown on Plate 3-1.

4 Right 4 East Panel - Raptor Information

The 4R4E panel is located in Sections 27 and 34,Township 21 South, Range 5 East . It is located in Dry Fork Canyon perpendicular and west of the North Fork of Quitchupah Creek. A helicopter survey to locate raptors and migratory bird species was conducted in 1982 and 1988 by UDWR, USFWS, BLM, and USFS. In 1988 ten golden eagle nests were located within the Quitchupah lease boundary, two were active, two were tended and the remaining six were inactive. There were no nest located within a 0.5 mile radius around the current location of the 4R4E panel during these surveys. The nests in Dry Fork Canyon were re-surveyed in April, May and June of 2017. Four inactive Golden Eagle nests were found (793GoEa, 794GoEa, 795Goea, 315GoEa) within a 1.5 mile radius around the 4R4E panel. These surveys show that there are no active or in-active nest within 0.25 miles from the area of potential subsidence above the 4Right 4 East panel (See the 4R4E Projected Subsidence Map in Appendix 6-4). The permittee will perform raptor surveys before, during and after mining as required by the Division. These reports will be submitted annually to the Division. The 2017 raptor survey reports are found in Appendix 3-4 and 3-15. Areas surveyed in these reports designated for the 3 Right 4 East panel also apply to the 4 Right 4 East panel.

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4 Right 4 East Panel - Elk & Mule Deer

The 4R4E panel is located in the southern portion of the Quitchupah Lease (See Plated 5-6 and 5-7 of the M&RP). The panel is located just outside of within what is considered crucial or critical winter range for deer and elk. The escarpment in the southeastern portion of the tract which lies between Quitchupah Canyon and Link Canyon is known as an elk migration route, providing access to and from the winter range from the plateau top (See Plates 3-2 and 3-3 of the M&RP). The permittee is obligated to monitor and mitigate subsidence that poses a risk to livestock and wildlife as soon as feasibly possible. This will be done according to the subsidence monitoring plan (See Section 5.2.5.1) and migration commitments (See Sections 3.3.3.3 and 3.4.1.2) within the MRP. An effort will be made by the permittee to monitor subsidence between 60 and 90 days following completion of the 4R4E longwalll panel or as soon as access is feasible. The permittee recognizes that this time constraint commitment only apples to the 4R4E panel.

4 Right 4 East Panel - Greater Sage-Grouse

Data provided to the public by the Utah Division of Wildlife Resources (UDR) show approximately 30,000 acres of designated sage grouse habitat north of where the 4R4E panel is located. A small portion of the panel is located in this area, but the majority of the panel lies outside of the designated habitat boundary. After consulting with UDWR, Division (DOGM) personnel determined that the proposed 4R4E panel is not likely to have an impact on sage grouse lekking, nesting, or brood rearing activity.

4 Right 4 East Panel - Seed Mix Information

Should a seed mix be required to be used on soil filled subsidence cracks the seed mix previously used for the sinkhole repair and reclamation project will be used. See Section 3.4.1.2 for information regarding the sinkhole project seed mix. Soils used to fill subsidence cracks which receive seed will not receive mulch or fertilizer. Refer to Section 5.2.5.2 (Correction of Material Damage) for additional information.

Elk

The elk herd (#14) is a significant wildlife resource to the citizens of Utah and there is considerable hunting pressure. Winter and summer range is in generally good conditions, but drought is an immediate concern (Big Game Annual Report, 1991).

Although the potential area of impact is not critical to the continued existence and perpetuation of the herd, it is important to maintenance of current population levels, and portions of the entire lease

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area are used annually on a seasonal basis. The aspen areas of Duncan Mountain serve as calving areas for the small herd, (10-20 animals observed during the 1980 summer in that area) but based on pellet counts (WIL, Table 7) the major portion of the lease area is utilized in late fall, winter, and early spring.

In May, while there was still snow on the ground, considerable fresh elk sign (pellets and tracks) was found around the Acord Lakes. By June 5, 1980, when access was available to the other areas, elk tracks were concentrated in the ponderosa, mahogany, aspen and manzanita communities along the ridges and rims of the canyon, plus in the canyons such as Duncan's Draw and Lizonbee Springs. During the summer the elk and elk signs were sighted near the top of Duncan Mountain and at the head of the South Fork of Quitchupah. It seems that the elk in question do not always winter on the rims nor the plateau but in the lower elevation areas to the southeast. This observation was substantiated by a conversation with a local forest ranger out of Richfield. The amount of snow is probably the determinant, with the elk wintering wherever there is available forage from the rim to the low brush areas in the southeast.

The fact that elk utilize the entire area of concern during some time of the year means that all aspects and timing of the actions must be considered. However, since the SUFCO Mine has been operational since the early 1940's and since there are no plans for additional surface facilities other than ventilation portals along the cliffs, there should be little additional disturbance to the elk. The animals have already accommodated the human disturbance associated with the mining and hauling of coal.

Information about elk winter-range and migration routes specific to the Pines Tract Project area is provided in the VWP report (Appendix 3-9). Information about elk winter-range and migration specific to the Muddy Tract area is provided in the Cirrus report (Appendix 3-11). Information about elk winter-range and migration specific to the West Coal Lease Modifications and the area of the 2016 2RWL sinkhole repair are summarized in Appendix 3-13.

3 Right 4 East Panel(s)

The southern portion of the lease area is considered crucial winter range for deer and elk. The escarpment in the southeastern portion of the tract which lies between Quitchupah Canyon and Link Canyon is known as a elk migration route, providing access to and from the winter range from the plateau top.

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Mule Deer

Mule deer on the mine area are considered part of Herd Unit 43 by the UDWR. The animals in the environs of concern utilize the entire assessment area but seasonally concentrate in and more heavily utilize specific habitat types.

During the summer the mule deer generally utilize all of the habitats near watering areas. The most heavily used communities were the sage, mountain brush and the composite of aspen, mountain mahogany, manzanita and ponderosa. This is as expected since there is considerably more browse in these communities than in the others sampled.

With the onset of fall and winter the mule deer latitudinally migrate. Initially (late fall and early winter) they concentrate on the plateau area where they intermingle with the elk but when the snow gets too deep for them to traverse they move into the low elevation sage, and pinyon juniper areas to the southwest. The wintering areas for mule deer make them susceptible to road strikes in the vicinity of the haul and access road for the SUFCO Mine and Interstate 70.

Information about mule deer winter-range and migration routes specific to the Pines Tract Project area is provided in the VWP report (Appendix 3-9). Information about mule deer winter-range and migration specific to the Muddy Tract area is provided in the Cirrus report (Appendix 3-11). Information about mule deer winter-range and migration specific to the West Coal Lease Modifications are summarized in Appendix 3-13.

Cougar

The entire SUFCO Mine area provides substantial value, and year long habitat for cougar. The animal ranges throughout the area as evidenced by a sighting one third of the way down the slope in Quitchupah Canyon, one half mile below the confluence of South Fork, and tracks in the mud near Jack Adley's Monument, Broad Hollow, and in the dust of the road near Acord Lakes. Though animals range throughout the area, their movements are often dictated by migration patterns of their primary food source (mule deer) and human disturbance. Concern must be given to the cougars particularly when the females are accompanied by their young who are learning to hunt and survive. This is considered a sensitive period for cougars and it is best if disturbance is minimized during this time. However, this period in their life cycle is difficult to determine for cougars since they are known to reproduce year round.

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Bobcat

The mine and adjacent areas provide substantial value habitats for bobcats, who were evidenced, by sightings and tracks, to occupy or use all terrestrial habitats on the entire area of potential impact. Sensitive periods would be late February when parturition occurs, May and June when young bobcats are first exploring and learning to hunt. Bobcats are not as secretive as cougar, making them less likely to avoid the high human disturbance areas and making them more vulnerable to open human harassment and illegal killing. Since this is an ongoing mining operation, pressures on bobcats should be unchanged.

Black Bear

Bear tracks were observed in Broad Hollow, but Forest Service personnel indicated to us that most of the bear sightings occurred on White Mountain. At best black bear are not abundant nor are they active year round. Sensitive periods in the life cycle of the black bear are February and March when the cubs are born and when they accompany their mother on initial foraging expeditions during early summer. Since parturition occurs within the winter den and since disturbance in the black bear habitat will be limited to subsidence, this sensitive period will be little impacted by the proposed action.

Mountain Cottontail

The entire mine area provides substantial value, and year long habitats for cottontail rabbits. The young are born between April and July which is considered a sensitive period, but the proposed actions will in all probability not seriously alter the reproductive potential of the population. Hunting pressure will likely not increase, nor will illegal kills. However, this would not matter since hunted rabbit populations are more healthy and stable than non-hunted populations. Subsidence could potentially cause death from caving burrows and disrupt reproduction for a short time.

Snowshoe Hare

The snowshoe hare is present in and dependent upon the limited spruce-fir vegetation habitat of the mine area year round. The sensitive period for reproduction is from April 1 to August 15. Subsidence will not impact the above ground dweller as it does subterranean inhabitants. Little change in snowshoe hare populations will result from the proposed actions. Hunting pressure, legal and illegal, will be the most influential activity of man upon snowshoe hares, but will be of little far reaching impact.

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Fur bearers

Limited portions of the mine and adjacent areas provide substantial value habitats for a few species categorized by management agencies as fur bearers: ermine, long-tailed weasel, badger and the striped skunk. The breeding and rearing activities of these non-migratory species occurs within the area and their dens and burrow systems are important to maintenance of their populations, but it is unlikely that the proposed actions will seriously impact them for any length of time. Subsidence will be localized and new burrows will be built or old ones reconstructed after it occurs. These species are widespread and adaptable to the activities of man.

Small Mammals

Small mammals represent a significant part of the ecosystem. The majority are herbivores and are the primary source of food for higher trophic levels, particularly raptorial birds, canids and felids. The potential exists for caving burrows in and/or changing burrow continuity due to fracturing of the strata. Should this occur, it is likely that young mammals in the nest would be crushed or cut off from parental care. Although this would temporarily alter the population density and age structure, recovery would be imminent and rapid. The 1997 Bat Survey for the SUFCO Mine conducted by J. Mark Perkins & Joshua R. Peterson is included in Appendix 3-8.

Information about small mammals specific to the Pines Tract Project area is provided in the VWP report (Appendix 3-9). General information about small mammals specific to the Muddy Tract area is provided in the Cirrus report (Appendix 3-11). General information about small mammals specific to the West Coal Lease Modifications and the area of the 2016 2RWL sinkhole repair are summarized in Appendix 3-13 and Section 3.2.2.2 and in Appendix 3-16 for the Greens Hollow Tract.

Threatened and Endangered Plant and Wildlife Species. Passage of the Endangered Species Act of 1973 (Public Law 23-20S) provided the legal basis for establishment of lists of endangered and threatened plant species. Such lists were prepared under direction of the Smithsonian Institution, and were published subsequently in the Federal Register (40: 2782 427924, 1975; and 41: 2452 4 24572, 1976). The region under investigation was included in a report on threatened and endangered species of the Central Coal lands of Utah (Welsh 1976). An inventory of endangered wildlife species performed in 1989 by the Division of Wildlife Resources recorded no species within the proposed permit area (conversation with Pamela Hill, DWR, Cedar City, 1991). Table 3-1 provides a list of Federally listed Threatened and Endangered Species that have been

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identified in the Utah counties in which Sufco lies. However, this list does not necessarily indicate these species are found within the mine permit boundaries.

A survey of the literature has failed to indicate the presence of any endangered or threatened plant species in the area. This lack of critical or unique species is supported by the field surveys of the lease areas. The region was searched by walking parallel transects on a quarter-section by quarter-section basis, with each community type within each quarter-section being traversed. No endangered or threatened species were encountered in the lease area or in the adjacent areas.

There are no federally listed threatened or endangered fish species inhabiting the aquatic habitat.

A discussion about threatened, endangered or otherwise sensitive plant and animal species of the Pines Tract Project area is given in Appendix 3-9. A discussion about threatened, endangered or otherwise sensitive plant and animal species of the Muddy Tract area is provided in the Cirrus report (Appendix 3-11). A discussion about threatened, endangered or otherwise sensitive plant and animal species of the West Coal Lease Modifications and the area od the 2016 2RWL sinkhole repair are summarized in Appendix 3-13 and Section 3.2.2.2.

Table 3-1
Federally Listed and Proposed Endangered Species in Utah
Sevier, Sanpete and Emery Counties
April 2, 2013 (2016)

Plants		Status	Present
Barneby Reed-Mustard	Schoenocrambe barnebyi	E	NP
Heliotrope Milk-Vetch	Astragalus montii	T	NP
Jones Cycladenia	Cycladenis humilis var. jonesii	T	
Last Chance Townsendia	Townsendia aprica	T	NP
San Rafael Cactus	Pediocactus despainii	E	NP
Wright Fishhook Cactus	Sclerocactus wrightiae	E	NP
Winkler Cactus	Pediocactus winkleri	T	NP
Dwarf Bear-poppy*	Arctomecon humilis	E	NP
Kodachrome Bladderpod*	Lesquerella tumulosa	E	NP
Autumn Buttercup*	Ranunculus aestivalis (acriformia)	E	NP

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Mammals			
Utah Prairie Dog*	Cynomys parvidens	T	NP
Canada Lynx*	Lynx canadensis	T	NP
Desert Tortoise*	Gopherus agassizii	T	NP
Birds			
Mexican Spotted Owl *	Strix occidentalis lucida	T	NP
Southwestern Willow Flycatcher*	Empidonax traillii extimus	E	NP
Gunnison Sage-grouse*	Centrocersus minimus	T	NP
Western Yellow-billed Cuckoo*	Coccyzus americanus	T	NP
Three-toed Woodpecker	Picoides ridactytus	S	P
Fish			
Bonytail Chub*	Gila elegans	E	NP
Colorado Pikeminnow*	Ptychocheilus lucius	E	NP
Humpback Chub*	Gila cypha	E	NP
Razorback Sucker*	Xyrauchen texanus	E	NP
June Sucker*	Chasmistes liorus	E	NP
Greenback Cutthroat Trout*	Oncorhynchus clarki stomias	T	NP
Lahontan Cutthroat Trout*	Onxhohynchus clarkii henshawi	T	NP
Virgin River Chub*	Gila seminuda (robusta)	E	NP
Woundfin*	Plagopterus aregantissimus	E	NP
Amphibians & Reptiles			
None listed in the Counties			
Snails			
Kanab Ambersnail*	Oxyloma haydeni kanabensis	E	NP

E - Endangered T - Threatened Extirpated - No longer occur in Utah C - Candidate
NP - Not Present (BLM, USFWS, FSEIS) P - Present (BLM, FSEIS)

For additional information contact: U. S. Fish and Wildlife Service, 2078 Administration Building, 1745 West 1700 South, Salt Lake City, Utah 84204-5110 Telephone:(801) 975-3300

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Habitats of Unusually High Value. The area of potential impact contains a variety of important habitats for several species that are considered of "high interest" to various management agencies because these species are of economic or recreational value. There are ten recognizable vegetation habitats from a faunal standpoint: chaparral (ponderosa pine, curl-leaf mountain mahogany, manzanita, aspen), spruce-fir (englemann spruce, douglas fir, sub-alpine fir, white-fir), aspen, sagebrush, mountain brush (oak, curl-leaf mountain mahogany, smooth-leaf mountain mahogany, service berry sagebrush), streamside, pinyon-juniper, ponderosa pine, grass, and scotch pine-spruce. Conifer, aspen, high sage and meadow areas on Duncan Mountain are used as summer range and calving areas for elk and summer range for mule deer. Ponderosa pine along ridge tops are heavily used by elk during the late winter, early spring and occasionally during the summer. The cliff areas harbor mountain lion, bobcat and bear. Mountain brush habitats are heavily utilized by deer and elk during the winter and spring. Deer and elk winter on the lower elevation areas, particularly in the vegetation communities traversed by the access road (WIL, pgs. 2-3, Appendix 3-3).

Literature and field data were summarized for all terrestrial vertebrates of concern, and the species categorized to determine habitat affinities and high interest species status. These results are reported in tabular form (WIL, Tables 3 through 5, Appendix 3-3). They are listed according to their various ecological classifications. All species whose ranges appear to overlap any or all of the potential area of impact are listed. Generally speaking, the project area could potentially be inhabited by 64 mammalian, 8 amphibian and 14 reptilian species (Wasatch Plateau, Appendix 3-5). Some of these are considered high interest species for the habitats and local area of concern.

Since the immediate area of the mine portal, access roads, loading and storage facilities has already been lost as habitat, concern will be given to revegetation with species that will not only benefit, but promote wildlife.

The cliffs in Quitchupah Canyon are habitat for cougar. The observed animals seem to use them for denning activities. Therefore care has been taken to avoid placement of portal openings where there are caves or other natural denning sites. There are a limited number of trails going from the

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was also a part of an Environmental Assessment in 1981as part of the lease application package.

3.2.2.3 Fish and Wildlife Service Review

If requested, the applicant authorizes the release of information pertaining to Section 3.2.2 and 3.3.3 to the U.S. Fish and Wildlife Service Regional and Field office for their review.

3.2.3 Maps and Aerial Photographs

The lease area was mapped by use of a mosaic of aerial photographs and assured by ground inspection. Vegetation sampling locations/reference areas are shown on Plate 3-1.

Greens Hollow. To the best of the applicants knowledge there are no reference areas, monitoring stations for fish and wildlife, habitat features, facilities used to protect and enhance fish/wildlife within the Greens Hollow Lease area. Land Uses for the Greens Hollow Lease are shown on Plate 4-1C.

3.2.3.1 Location and Boundary of Proposed Reference Area

The locations of the vegetative reference areas are found on Plate 3-1. Area 13 shown on Plate 3-1 is to be used as a mapping unit only and not a reference area or validation site. Site 12 will be used as the reference area for the minesite sedimentation pond area.

3.2.3.2 Elevations and Locations of Monitoring Stations

Raptor nest locations and elk and deer range are shown on Plate 3-2 and 3-3. The permit area contains no fish monitoring stations.

3.2.3.3 Facilities for Protection and Enhancement

Sections 3.3.3.3 and 3.5.8.5 contain additional discussion pertaining to protective measures taken by the applicant in behalf of wildlife.

Power lines within the SUFCO Mine permit area were modified during the summer of 1981 to comply with the guidelines of REA Bulletin 61-10, "Power Line Contacts by Eagles and Other Large Birds" (see Plate 5-5 for the power pole locations).

3.2.3.4 Vegetation Type and Plant Communities

Vegetative types and plant communities are outlined on Plate 3-1 of this application.

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Table 3-2

Utah Wildlife Species of Special Interest - Sevier, Sanpete and Emery Counties

October 1, 2015

Mammals		**State Status**
Brown (Grizzly) Bear	Ursus arctos	S-ESA (S,SV)
Black-footed Ferret	Mustela nigripes	S-ESA (E)
Utah Prairie Dog	Cynomys parvidens	S-ESA (S,SV)
Fringed Myotis	Myotis thysanodes	SPC (SV)
Big Free-tailed Bat	Nyctinomops macrotis	SPC (SV
Townsend's Big-eared Bat	Plecotus townsendii	SPC (E,S,SV)
Canada Lynx	Lynx canadensis	S-ESA (E,S,SV)
Kit Fox	Vulpes macrotis	SPC (E,S,SV)
White-tailed Prairie-dog	Cynomys leucurus	SPC (E)
Pygmy Rabbit	Brachylagus idahoensis	SPC (SV)
Birds		
Southwestern Willow Flycatcher	Empidonax traillii extimus	S-ESA
Bald Eagle	Haliaeetus leucocephalus	SPC (E,S,SV)
Ferruginous Hawk	Buteo regalis	SPC (E,S,SV)
Yellow-billed Cuckoo	Coccyzus americanus occidentalis[3]	S-ESA
Spotted (Mexican) Owl	Strix occidentalis[2]	S-ESA
Northern Goshawk	Accipiter gentilis	CS (E,S,SV)
Burrowing Owl	Athene cunicularia	SPC (E,S,SV)
Short-eared Owl	Asio flammeus	SPC (SV)
American White Pelican	Pelecanus erythrorhynchos	SPC (SV
Three-toed Woodpecker	Picoides tridactylus	SPC (S,SV
Greater Sage-Grouse	Centrocercus urophasianus	SPC (E,S,SV)
Long-billed Curlew	Numenius americanus	SPC (S,SV)
Black Swift	Cypseloides niger	SPC (SV)
Lewis's Woodpecker	Melanerpes lewis	SPC (S)
Grasshopper Sparrow	Ammodramus savannarum	SPC (S)

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Fish

Bonytail	Gila elegans	S-ESA (E)
Humpback Chub	Gila cypha	S-ESA (E)
Razorback Sucker	Xyrauchen texanus	S-ESA (E)
Roundtail Chub	Gila robusta	CS (E)
Flannelmouth Sucker	Catostomus latipinnis	CS (E)
Bluehead Sucker	Catostomus discobolus	CS (E,S
Colorado River Cutthroat Trout	Oncorhynchus clarki pleuriticus	CS (E,S,SV)
Bonneville Cutthroat Trout	Oncorhynchus clarki utah	CS (S,SV
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA (E)
Southern Leatherside Chub	Lepicomeda aliciae	SPC (S,SV)

Reptiles and Amphibians

Western (Boreal) Toad	Bufo boreas	SPC (E,S,SV)
Great Plains Toad	Bufo cognatus	SPC (E)

Mollusk

Carinate Glenwood Pyrg	Pyrgulopsis inopinata	SPC (SV)
Otter Creek Pyrg	Pyrgulopsis fusca	SPC (SV)
Smooth Glenwood Pyrg	Pyrgulopsis chamberlini	SPC (SV)
Ninemile Pyrg	Pyrgulopsis nonaria	SPC (S)
South Bonneville Springsnail	Pyrgulopsis transversa	SPC (S)

None of these species are known to be located in the mine lease area.

Key to State Status Field (Table 3-2)

Symbol	Definition
S-ESA	Federally-listed or candidate species under the Endangered Species Act.
SPC	Wildlife species of concern.
CS	Species receiving special management under a Conservation Agreement in order to preclude the need for Federal listing.

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E	Emery County List
S	Sanpete County List
SV	Sevier County List

Utah Division of Wildlife Resources, 1596 West North Temple, Salt Lake City, Utah 84116-3195

Utah Natural Heritage Program's Biodiversity Tracking and Conservation System (BIOTICS)

Table 3-3

USDA-FS Region 4 Sensitive Species - Fishlake and Manti-LaSal

February 2013 Update (June 2016)

Plants		**Status**	**Present**
Link Trail Columbine*	Aquilegia flavescens var. rubicunda	K	NP
Cruetzfeldt-flower Cryptanth*	Cryptantha creutzfeldii	K	NP
Carrington Daisy*	Erigeron carringtoniae	K	NP
Canyon Sweetvetch*	Hedysarum occidentale var. canone	K	NP
Maguire Campion*	Silene petersonii	K/P	NP
Musinea Groundsel	Senecio musinensis	K	NP
Arizona Willow*	Salix arizonica	K	NP
Wonderland Alice Flower*	Aliciella caespitosa	K	NP
Chatterley Onion*	Allium geyeri var. chatterleyi	K	NP
Sweet-flower Rock Jasmine*	Androsace chamaejasme ssp. Carinata	K	NP
Bicknell Milkvetch*	Astragalus consobrinus	K/P	NP
Isely's Milkvetch*	Astragalus iselyi	K	NP
Desert Milkvetch*	Astragalus desereticus	K	NP
Tushar Paintbrush*	Castilleja parvula var. parvula	K	NP
Pinnate Spring-parsley*	Cymopterus beckii	K	NP
Abajo Peak Draba*	Draba abajoensis	K	NP
Mt. Belknap Draba*	Draba ramulosa	K	NP
Creeping Draba*	Draba sobolifera	K	NP
Nevada Willowherb*	Epilobium nevadense	K	NP
Abajo Daisy*	Erigeron abajoensis	K	NP
Kachina Daisy*	Erigeron kachinensis	K	NP
Maquire Daisy*	Erigeron maguirei	K	NP

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LaSal Daisy*	Erigeron mancus	K	NP
Elsinore Buckwheat*	Eriogonum batemanii var. ostlundii	K	NP
Canyonlands Lomatium*	Lomatium latilobum	K	NP
Fish Lake Naiad*	Nafas caespitosa	K	NP
Beaver Mountain Groundsel*	Packera castoreus	K	NP
Little Penstemon*	Penstemon parvus	K	NP
Ward Beardtongue Penstemon*	Penstemon wardii	K	NP
Bicknell Thelesperma*	Thelesperma subnudum var. alpinum	K	NP
Barneby Woody Aster*	Tonestus kingii var. barnebyana	K	NP
Sevier Townsendia*	Townsendia jonesii var. lutea	K	NP
San Rafael Cactus*	Pediocactus despainii	K	NP
Clay Phacelia*	Phacelia argillacea	P	NP
Last Chance Townsendia*	Townsendia aprica	K	NP
Ute Ladies'Tresses Orchid*	Spiranthes diluvialis	K	NP
Heliotrope Milk-Vetch*	Astragalus montii	P	NP
Winkler Cactus*	Pediocactus winkleri	K	NP
Desert Milk-Vetch*	Astragalus desereticus	K	NP

Mammals

Townsend's Western Big-eared Bat*	Corynothinus townsedii townsendii	K	NP
Spotted Bat*	Euderma maculatum	K	NP
Bighorn Sheep*	Ovis canadensis	K	NP
Pygmy Rabbit*	Brachylagus idahoensis	K	NP
Utah Prairie Dog*	Cynomys parvidens	K	NP

Birds

Northern Goshawk*	Accipiter gentilis	K	P
Flammulated Owl*	Otus flammeolus	K	P
Northern Three-toed Woodpecker*	Picoides tridactylus	K	P
Bald Eagle*	Haliaeetus leucocephalus	K	P
Greater Sage-grouse*	Centrocercus urophasianus	K	P
Peregrine Falcon*	Falco peregrinus anatum	K	P
Yellow-billed Cuckoo*	Coccyzus americanus	K/P	NP
Southwestern Willow Flycatcher*	Empidonax traillii extimus	K	NP

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Mexican Spotted Owl*	Strix occidentalis lucida	K	NP
Fish			
Colorado River Cutthroat Trout*	Oncorhynchus clarki pleuriticus	K	NP
Bonneville Cutthroat Trout*	Oncorhynchus clarki utah	K	NP
Southern Leatherside Chub*	Lepidomeda aliciae	K	NP
Greenback Cutthroat Trout*	Oncorhynchus clarki stomias	K	NP
Amphibians			
Columbia Spotted Frog*	Rana luteiventris	K	NP
Boreal Toad*	Bufo boreas	K	NP

K - Known distribution species and or habitat

P - Suspected species or potential habitat NP- Not Present (BLM FSEIS)

USDA-Manti-LaSal National Forest, 599 Price River Dr., Price , Utah 84501

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3.30 Operation Plan

3.3.1 Measures Taken to Disturb the Smallest Practicable Area

No vegetative disturbance is anticipated beyond that encountered during exploratory drilling, portal site construction or that created by subsidence. New operational facilities are kept to a minimum. Only facilities required to maintain the coal operation or satisfy environmental or safety requirements are built.

Revegetation methods to be used to temporarily stabilize are described according to degree of slope angle and accessibility. Interim stabilization is discussed in Section 3.5.2.

The seed mixture (see Section 3.4.1) will be used to revegetate areas disturbed by mining and all associated activities. The climate of the area was reviewed to assess the need for drought-tolerance in the species selected for the seed mixture. The vegetation report (Appendix 2-2) was evaluated to determine seed mixture constituents in light of production, cover, and diversity requirements. The soils report was reviewed to select species adapted to the soil's physical and chemical condition. Plant species were selected on the basis of wildlife needs and requirements. In addition, the operations plan was reviewed to determine the need for species with quick establishment, rapid spreading and high erosion control potentials.

3.3.2 Description of Anticipated Impacts of Subsidence

Surface disturbance associated with certain mining operations and techniques can be extremely detrimental to terrestrial and aquatic vertebrates, but the longwall technique used within the SUFCO Mine minimizes much of the impact. Since no overburden is removed, the major problem is surface subsidence. The acreage that will be undermined may subside up to a maximum of 70 percent of the thickness of the mined coal. Similarly mined areas in comparable habitats in New Mexico have experienced less than 12 percent subsidence with little or no visible disturbance. The existing mined area has subsided and shows minor surface fissures. It is probable that the integrity of the above ground terrestrial vertebrate communities will generally remain status quo, with occurrence of occasional fractures and minor slippages that will not be detrimental to vegetation or wildlife.

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Credibility to this statement comes from the lack of detectable differences in terrestrial vertebrates in comparable habitats in expansion areas.

Subterranean changes, however, are not currently fully understood. There is the possibility that when subsidence occurs, it will disrupt burrow systems and underground aquifers. The loss of the burrow system will destroy the home and habitat of fossorial mammals, reptiles and amphibians and possibly cause death to some species in the immediate area at the time of collapse. If subsidence were to occur simultaneously and non-uniformly over the entire area of concern, this would be a major problem not only for the prey species, but particularly for predators dependent upon the prey base. However, since subsidence will occur systematically and in small areas at a given time, only localized populations will be impacted and only for a short while. Reproductive potential coupled with dispersal will facilitate almost immediate recovery and negate the temporary population reduction. There are no threatened nor endangered species present in the area, so none will be impacted. It has also been observed that burrowing mammals frequently make new dwellings along subsidence induced fractures.

The question of underground aquifer disruption is not easily dismissed. The geology and hydrological system in this area has been studied for several years. Surface waters and habitats are significant resources to elk and deer during the late summer months when water becomes the limiting resource to habitat utilization. Alteration of the groundwater resources would be serious, not to the perpetuation of the population and herds as an entity, but to harvestable productivity. Such habitat loss would also be detrimental to amphibians and aquatic dependent reptiles.

3.3.3 Plan to Minimize Disturbances and Adverse Impacts

In new mine operations it is easy to suggest, provide and implement mitigative measures. But in the case of the SUFCO Mine, preconstruction design and associated mitigation does not apply nor can it be implemented without major additions or modifications. The mine has been operating approximately 55 years, and little can or should now be done to change the design of the portal facilities to lessen the impacts. Any significant change now would increase impacts. Any species inhabiting and utilizing the area of concern have likely habituated to the present facilities and

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consequently adjusted their behavior including migration so that change would be more impacting than status quo.

Construction of additional ventilation portals could potentially cause problems. These portals will be opened to the outside from the underground mine entries. Chainlink fence is placed over the portal opening, to protect wildlife from harm. These portals will be placed so that no major big game migration trails are interrupted and no caves or natural cougar denning or resting ledges are destroyed.

Noise, created from operation of the mine, is not expected to increase in the existing areas of disturbance associated with the mining activity, not even with the addition of any ventilation intake portals along the cliffs. These portals are only for intake air. The present exhaust fans are at the mine site and at the 4 East Portal in Quitchupah Canyon.

Appendix 3-16 contains a sound monitoring report conducted by Tetra Tech, Inc in 2008. The monitoring was conducted to collect baseline data in association with the potential development and operation of a ventilation shaft near Quitchupah Canyon. The data was collected around an existing ventilation fan and at selected sensitive resource location such as Forest System Roads, and Greater Sage-grouse leks. The collected sound level data will be used to determine measures which could reduce sound related impacts associated with the operation of the proposed ventilation fan.

Sound level measurements taken within the resource locations ranged between 27.6 dBA and 70.3 dBA. Sounds from the existing fan were discernable at the leks and forest service roads, however most were at or near the background sound levels. Refer to Table 1 for average, minimum and maximum levels at each location.

Efforts have already been made to minimize wildlife loss and/or harassment associated with operation of the mine. Speed limits are set and posted on the county controlled access road to the mine to alert drivers to the presence of wildlife. Although the danger of road strikes is more harmful to wildlife than transportation vehicles, there is the potential for loss of human life and equipment.

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damage. Therefore avoiding collisions has become a practical company policy. Wildlife crossing areas or sites of limited visibility are adequately marked. The applicant has instituted the use of a commuter bus to reduce traffic and emissions on the access road from Salina, Utah to the mine. SUFCO prohibits the discharge of firearms by employees on the road in East Spring Canyon (portal site). In conjunction with this restriction, the Applicant has initiated an employee education program to reduce harassment and disturbance of wildlife during sensitive stages in their life history.

Perhaps the most promising mitigation action is that of enhancement or maintenance of wildlife habitat. Enhancing wildlife habitat away from the mine area will improve habitat, possibly increase wildlife numbers, and attract wildlife away from impacted areas. Since much of the area is public domain, wildlife habitat enhancement is a viable management tool. However, any such effort should be carefully coordinated among appropriate regulatory agencies. Some examples of these measures include:

1. Development of springs, wells or other water supplies outside the mine area.
2. Fencing of developed water sources to restrict cattle trampling of vegetation, control erosion, and provide non-game habitat;
3. Altered livestock management policies, to avoid potential competition with wildlife.
4. Control of other human-related impacts, including recreation and timber harvest.

Revegetation of disturbed areas, as part of the reclamation effort, will include a mixture of grasses, forbs, shrubs and trees.

The total disturbed area acreage to be revegetated is small enough that fencing is considered to be an economically feasible means of protection, if deemed necessary. If grazing animals do prove detrimental to revegetation attempts, measures will be implemented following consultation with the regulatory authorities.

Water is perhaps the most limiting resource and as mentioned in the subsidence discussion, the present resources must not be decreased. The applicant herein commits to restore stream water resources in addition to previously identified springs which are contaminated, diminished, or

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interrupted as a result of the applicant's underground coal mining activities and which will not obviously be restored naturally within a reasonable period of time.

Potential water depletions from mining operations that may have an effect on endangered fish species identified in pertinent fish recovery programs of the USFWS have been evaluated by the Windy Gap Process as it applies to existing coal mines in the Upper Colorado River Basin.

1. Mining Consumption

   Water used underground to mine coal:

   2.29% moisture added to coal by cutting and dust suppression operations

Projected 2005 tonnage of coal mined	7,605,685 tons
Projected 5-year average tonnage of coal mined	7,510,217 tons
Tons water/year (based on projected 5 yr average)	171,984 tons
Pounds water/yr	343,967,939 pounds
Gallons/year (8.337 lbs/gal of water)	41,257,999 gallons
Acre feet/year	126.62 ac-ft

2. Ventilation Consumption

   33,068 gallons/day (05/02 ventilation survey)

   33,068 gallons/day x 365 days/year = 12,069,820 gallons/year = 37.05 ac-ft/year

3. Coal Producing Consumption

   No washing or processing of coal involving water occurs at the Sufco Mine. Therefore, Coal Producing Consumption = 0 ac-ft/yr

4. Sediment Pond Evaporation

   Mine Site Pond 0.236 acres (surface area)

   Evaporation 18.1 in/yr

   18.1 in/yr = 1.508 ft/yr

   1.508 ft/yr x 0.236 acres = 0.356 ac-ft/yr

   Waste Rock Pond 0.219 acres (surface area)

   Evaporation 18.1 in/yr

   18.1 in/yr = 1.508 ft/yr

   1.508 ft/yr x 0.236 acres = 0.330 ac-ft/yr

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Total Annual Pond Evaporation = 0.686 ac-ft/yr

5. Subsidence Effects on Springs and Seeps

Spring Pines 303 appears to have reduced flow due to mining. Prior to mining, flow appears to have averaged about 2.8 gpm (Pines EIS data). The flow was reduced to 0 gpm by late summer 2001. Flow measured in summer of 2005 indicated the flow is returning at a rate of about 0.17 gpm. Assuming the flow stabilizes at 0.2 gpm, the 2005 reduction of flow is 2.6 gpm. Note: The spring flow may return to its premining rate over time as the drained aquifer recovers. Modification to this calculation will then be required.

2.6 gpm x 1440 min/day x 365 days/yr = 1,366,560 gal/yr

Annual reduction in flow in 2005 = 1,366,560 gal/yr ÷ 325,850 gal/ac-ft = 4.2 ac-ft/yr

6. Alluvial Well Pumpage

Sufco does not pump water from an alluvial well.

7. Alluvial Aquifer Abstractions into Mine

The mine has not created alluvial aquifer abstractions into the mine.

8. Deep Aquifer Pumpage

Sufco does not pump from deep aquifers.

9. Postmining Inflow to Workings

Current data indicates postmining inflows to the mine will be minimal and from aquifers storing water several thousand years old. Inflows will not consist of intercepted surface water or ground water that would discharge to the surface at a perceptible rate.

10. Coal Moisture Loss

8.34% inherent moisture - source Sufco Geologist

Projected Tonnage 2005	7,605,685 tons
Tons water/yr	634,314 tons
Pounds water/yr	1,268,628,258 pounds
Gallons water/yr	152,168,437 = 466.9 ac-ft/yr

* This amount of water is *not* included in the overall calculation of the water removed from the drainage system since it is inherent moisture (water locked in the coal) and is not considered as part of the active or inactive ground water system.

11. Direct Diversions

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Culinary Water - from spring (Water Right 94-87) = 10.50 ac-ft (2004 consumption)

Mine Discharge:

2004 Average 4,948,260gpd = 1,806,114,900 gal/yr = 5544.3 ac-ft/yr.

Consumption Volume from items 1 - 11 above = 179.1 ac-ft/yr

Total mining operations net water gain/loss = 5365.2 ac-ft/yr gain.

Deer regularly migrate through and graze in the surface facilities and down the canyons to lower altitudes during severe winters. Numerous side canyons to Convulsion Canyon have been left undisturbed to allow uninterrupted big game movement.

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3.5.8.4 Replacement of Wetland and Riparian Vegetation

No riparian habitat has been disturbed.

3.5.8.5 Manmade Wildlife Protection Measure

Electric Power Lines. All power lines within the SUFCO Mine permit area were modified during the summer of 1981 to comply with the guidelines of REA Bulletin 61-10, "Power Line Contacts by Eagles and Other Large Birds". Various correspondence regarding the Applicant's modification of power lines is presented in Appendix 3-7. The locations of mine site power poles are shown on Plate 5-5.

Potential Barriers. The mine has been operating approximately 55 years and little should now be done to change the design of the portal facilities to lessen the impacts. The wildlife inhabiting and utilizing the area of concern have likely acclimated to the present facilities and consequently adjusted their behavior including migration so that a modification of the facilities to providing corridors would be more adverse than leaving the facilities as they are.

Pond Protection. Fences or other appropriate methods will be used to exclude wildlife from ponds containing hazardous concentrations of toxic-forming materials. However, at this time the applicant has no ponds containing hazardous concentrations of toxic-forming materials.

REFERENCES:

Blumer, Ralph J., 1979. Environmental Analysis, pp 25-26.

Forest Service. 1981. Lease Application U-47080.

Hennessy, S. P., 1978. Ecological relationships of accipters in northern Utah -- with special emphasis on the effects of human disturbance. MS thesis, unpbl., Utah State Univ., p 66.

USDA, Forest Service, Intermountain Region 1988. Environmental Assessment for SUFCO Mine Coal Lease Application U-63214 Quitchupah Tract.

Utah Division of Wildlife Resources, Department of Natural Resources, 1991. Utah Big Game Annual Report 1991. Publication 91-12.

U.S. Department of the Interior, Final Supplemental Impact Statement for Leasing and Underground Mining of the Greens Hollow Federal Coal Lease Tract UTU-84102, Sanpete and Sevier Counties, Utah, February 2015

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APPENDIX 3-16

Greens Hollow Tract

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Greens Hollow Tract

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WILDLIFE
TECHNICAL REPORT
GREENS HOLLOW COAL LEASE TRACT

Prepared for:
Bureau of Land Management
Price Field Office
125 South 600 West
Price, Utah 84501

Manti-La Sal National Forest
599 West Price River Drive
Price, Utah 84501

Fishlake National Forest
115 East 900 North
Richfield, Utah 84701

Prepared by:
Cirrus Ecological Solutions, LC
965 South 100 West, Suite 200
Logan, Utah 84321

2014

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2.0 Methods

2.1 CONTACTS MADE

The following resource agencies and specialists were contacted over the contract period to obtain data, species lists, and/or discuss survey methods and results:

- Manti La-Sal National Forest, USDA Forest Service
- Fishlake National Forest, USDA Forest Service
- Rocky Mountain Research Station, Flagstaff, Arizona Office, USDA Forest Service
- Price, Utah Field Office, DOI Bureau of Land Management
- Utah Division of Wildlife Resources (UDWR)
- USDI Fish and Wildlife Service
- TetraTech, Inc., Environmental Consulting Firm
- Bruno Engineering, Engineering Consulting Firm
- Utah State University (USU) Graduate Degree Candidate

2.2 SOURCES AND DESCRIPTIONS OF EXISTING INFORMATION

- Muddy Creek Wildlife Technical Report (Cirrus 2004). Prepared by Cirrus Ecological Solutions, LC, 2003.
- Assessment of the Effects of Surface Impacts Resulting from Longwall Mining in the Greens Hollow Tract, Utah (Maleki 2008). Maleki Technologies, April 2008.
- Greens Hollow Sound Study (TetraTech 2008). TetraTech, Inc., October 2008.
- Digital coverage data for mule deer winter and summer range was acquired from the UDWR GIS Data website (UDWR 2013)
- Utah big game annual report – 2011 (Bernales et al. 2012). Publication Number 12-27. UDWR.
- Digital coverage data for elk winter and summer range was acquired from the UDWR GIS Data website (UDWR 2013).
- Sage-grouse data collected by UDWR was acquired from the UDWR Southeastern Region. Digital coverage data of sage grouse habitat was acquired from the UDWR GIS Data website (UDWR 2013).
- Winter and spring lek count data for sage-grouse leks on the MLNF (Forest Service 2013a).
- Intermountain Region Threatened, Endangered, Proposed, and Sensitive Species: Known/Suspected Distribution by Forest (Forest Service 2013b).
- Revised Wildcat Knolls sage-grouse lek boundaries obtained from MLNF, Ferron Ranger District (Forest Service 2008a).

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- List of Federally-listed, Forest Service Region 4 Sensitive, Manti-La Sal National Forest Management Indicator, and Migratory Bird Species to be considered in the Greens Hollow Analysis (Forest Service 2008b).

- Potential presence of species of high federal interest, small-mammals, and non-game birds was predicted by consulting the following resources:
  - Fauna of Southeastern Utah and life requisites regarding their ecosystems (Dalton et al. 1990). Publication No. 90-11 (http://www.wildlife.utah.gov/habitat/sefauna.htm).
  - The Birder's Handbook (Erlich et al. 1988).
  - Utah Big Game Range Trend Studies (UDWR 2007a)
  - Inventory of Sensitive Species and Ecosystems in Utah. Inventory of Sensitive Vertebrate and Invertebrate Species: A Progress Report (UDWR 1997).
  - Colorado GAP Analysis Project website (latest revision), http://ndis1.nrel.colostate.edu/cogap/cogaphome.html/).
  - Utah Conservation Data Center. Utah Division of Wildlife Resources, UCDC website, species information and Utah distribution maps (http://dwrcdc.nr.utah.gov/ucdc/).
  - Birds of Conservation Concern (USFWS 2008)
  - Partners in Flight (Parrish et al. 2002)
  - Utah Comprehensive Wildlife Conservation Strategy (UDWR 2005a)

- Land and Resource Management Plan for the MLNF (Forest Service 1986); 1986 and 2003 amendments.

- Vegetative coverage for the Manti-La Sal National Forest: Manti Division and Sanpitch Divisions (Forest Service 2002).

- Final Environmental Impact Statement for the Pines Tract Project (Forest Service 1999).

- 2008 sage-grouse survey data from Chris Perkins a graduate student with USU (Perkins 2008).

- 2006 MLNF Forest Plan Amendment regarding macroinvertebrates (Forest Service 2006).

2.3 DATA COLLECTION AND ANALYSIS METHODOLOGY

Wildlife surveys and/or habitat assessments were conducted as part of the contract stipulations for the previous, Muddy Creek coal tract evaluation project. This technical report tiers off of the data collected and surveys completed for that report (Cirrus 2004). Where new data is available and management decisions have changed, the information has been updated herein. Data was collected for the 2004 wildlife technical report for the following categories of terrestrial and aquatic wildlife: federally listed threatened and endangered species, and Forest Service sensitive species (TES), management indicator species (MIS), species of high federal interest, amphibians and reptiles, small mammals, and non-game birds. Cirrus personnel conducted field surveys between 2001 and 2003 for the Muddy Creek coal tract analysis and within a 2-mile buffer surrounding the tract. Ongoing field surveys have continued since that analysis was completed. These surveys have been conducted by Forest Service and UDWR biologists. Table 1 summarizes the methods associated with data collection and analysis by species. More detailed discussion of wildlife inventory methods and results is included in section 2.4 below.

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Table 1. Wildlife survey methodology for species considered in this analysis on the Greens Hollow project area, Manti-La Sal and Fishlake National Forests.

Species	Data Collection[1]	Data Analysis
	TES[3]	
Bonytail *Gila elegans* (Federally endangerd)	Existing data acquired from Fish and Wildlife Service. No additional surveys are needed.	Species observations summarized in text.
Colorado pikeminnow *Ptychocheilus lucius* (Federally endangerd)	Existing data acquired from Fish and Wildlife Service. No additional surveys are needed	Species observations summarized in text.
Humpback chub *Gila, cypha* (Federally endangerd)	Existing data acquired from Fish and Wildlife Service. No additional surveys are needed	Species observations summarized in text.
Razorback sucker *Xyrauchen texanus* (Federally endangerd)	Existing data acquired from Fish and Wildlife Service. No additional surveys are needed	Species observations summarized in text.
Bald eagle *Haliaeetus leucocephalus* (R4 Sensitive)	Existing data acquired from UDWR. No additional surveys were needed.	Species presence or absence in the analysis area determined with the use of GIS. No digital coverage was created because no nests were found.
Flammulated owl *Otis flammeollus* (R4 Sensitive)	Presence/absence surveys conducted by Cirrus over two field seasons. UDWR Northern Region forest owl inventory protocol used (UDWR 1992).	Digital coverage of species presence (based on vocal responses) and survey points created with Microsoft Excel and ESRI ArcGIS software.
Greater sage-grouse *Centrocercus urophasianus* (R4 Sensitive)	Presence/absence surveys and lek counts were conducted by Cirrus and UDWR during lekking seasons in 2002 and 2003. Incidental observations also were made. Agency biologists have continued annually since the Muddy Creek effort (Forest Service 2013a).	Digital coverage of species presence and sign, survey areas, and lek sites created with Microsoft Excel and ESRI ArcGIS.
Northern goshawk *Accipiter gentilis* (R4 Sensitive)	Presence/absence surveys conducted by Cirrus from 2001-2003. R4 survey protocol for northern goshawks used (Forest Service 1993). Continued surveys have been conducted through 2010.	Digital coverage of species presence (based on vocal responses and goshawk observations) and survey points created with Microsoft Excel and ESRI ArcGIS software.
Peregrine falcon *Falco peregrinus* (R4 Sensitive)	A falcon was observed during aerial surveys in 2003 (Cirrus 2004). No additional surveys were needed.	Species observations summarized in text.
Pygmy rabbit *Brachylagus idahoensis* (R4 Sensitive – Fishlake only)	FS surveys have been conducted in the past. No additional surveys were needed. Future surveys will continue as habitat is present in the project area.	Species observations summarized in text.
Spotted bat *Euderma maculatum* (R4 Sensitive)	Structural habitat searches were conducted and incidental sightings were recorded by qualified biologists in 2001 and 2002. Survey data from the Utah Natural Heritage Program and the SUFCO mine was acquired and used in this analysis (Toone 1993, Perkins and Peterson 1997).	Digital coverage of species presence (based on audible vocalizations) created with Microsoft Excel and ESRI ArcGIS software.
Three-toed woodpecker *Picoides tridactylus* (R4 Sensitive)	Presence/absence surveys conducted by Cirrus in 2001 and 2002 (Cirrus 2004) UDWR (1992) woodpecker survey protocol used.	Digital coverage of species presence (based on vocal responses and woodpecker observations) and survey points created with Microsoft Excel and ESRI ArcGIS software.

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Table 1. (cont'd) Wildlife survey methodology for species considered in this analysis on the Greens Hollow project area, Manti-La Sal and Fishlake National Forests.		
Species	**Data Collection[1]**	**Data Analysis**
Townsend's big-eared bat *Plecotus townsendii townsendii* (R4 Sensitive)	Conducted habitat assessment surveys using information on mine status. Structural habitat searches also conducted in 2001 and 2002. Survey data from the Utah Natural Heritage Program and the SUFCO mine was acquired and used in this analysis (Oliver 2000, Perkins and Peterson 1997).	Survey results discussed in a narrative.
Colorado River Cutthroat Trout *Oncorhynchus clarkii pleuriticus* (R4 Sensitive)	Collected survey results from UDWR sources (Berg2002a, 2002b, 2002c and Hart and Berg 2003).	Survey results discussed in a narrative.
Bonneville Cutthroat Trout *Oncorhynchus clarki utah* (R4 Sensitive)	Collected survey results from UDWR sources (Berg2002a, 200b, 2002c, and Hart and Berg 2003).	Survey results discussed in a narrative.
MIS		
Rocky Mountain elk *Cervus canadensis* (MLNF, FLNF)	Existing survey and habitat modeling data acquired from UDWR (UDWR 2013). No additional formal surveys were needed.	Digital coverage of winter and summer range created by UDWR and clipped to the project area by Cirrus with Microsoft Access and ESRI ArcGIS software.
Mule deer *Odocoilus hemionus* (MLNF, FLNF)	Existing survey and habitat modeling data acquired from UDWR (UDWR 2013). No additional surveys were needed.	Digital coverage of winter and summer range created by UDWR and clipped to the project area by Cirrus with Microsoft Access and ESRI ArcGIS software.
Northern goshawk *Accipiter gentilis* (MLNF, FLNF)	Presence/absence surveys conducted by Cirrus from 2001-2003. R4 survey protocol for northern goshawks used (Forest Service 1993). Continued surveys have been conducted (Forest Service 2013b).	Digital coverage of species presence (based on vocal responses and goshawk observations) and survey points created with Microsoft Excel and ESRI ArcGIS software.
Golden eagle *Aquila chrysaetos* (MLNF)	Aerial survey for golden eagle nest sites conducted by Cirrus and UDWR in 2002. Additional survey data for the analysis area acquired from UDWR. Ongoing surveys have been conducted since 1998 (UDWR 2007b).	Digital coverage of nest locations created by UDWR and clipped to the project area by Cirrus with Microsoft Access, and ESRI ArcGIS software.
Macroinvertebrates Aquatic insects (MLNF)	No site-specific surveys of aquatic macroinvertebrates have been conducted and no site-specific monitoring is proposed for this project. Monitoring will continue at baseline stations to characterize Forest-wide conditions (Forest Service 2006).	Data analysis will be in cooperation with the Utah Division of Water Quality. Forest sampling stations will be reviewed in relation to DWQ sampling statewide (Forest Service 2006).
Sage nesters (FLNF)	Existing survey and population data obtained from FLNF MIS report (Rodriguez et al 2006) for Brewer's sparrow (*Spizella breweri*), vesper sparrow (*Pooecetes gramineus*), and sage thrasher (*Oreoscoptes montanus*).	Species habitat and populations trends summarized in the text of the document.

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Table 1. (cont'd) Wildlife survey methodology for species considered in this analysis on the Greens Hollow project area, Manti-La Sal and Fishlake National Forests.		
Species	**Data Collection[1]**	**Data Analysis**
Cavity nesters (FLNF)	Existing survey and population data obtained from FLNF MIS report (Rodriguez et al 2006) for hairy woodpecker (*Picoides villosus*), western bluebird (*Sialia mexicana*), and mountain bluebird (*Sialia currucoides*).	Species habitat and populations trends summarized in the text of the document.
Riparian nesters (FLNF)	Existing survey and population data obtained from FLNF MIS report (Rodriguez et al 2006) for Lincoln's sparrow (*Melospiza lincolnii*), song sparrow (*Melospiza melodia*), yellow warbler (*Dendroica petechia*), and MacGillivray's warbler (*Oporornis tolmiei*).	Species habitat and populations trends summarized in the text of the document.
Species of High Federal Interest		
Migratory birds[2]	Presence/absence surveys were conducted in suitable habitat by Cirrus from 2001-2003. Incidental observations also made. Raptor nest data acquired from UDWR. (Cirrus 2004).	Digital coverage of observed territories created with Microsoft Excel and ESRI ArcGIS software.
Other Wildlife Species		
Amphibians	Presence/absence surveys were conducted in suitable habitat by Cirrus from 2001-2003 (Cirrus 2004).	Digital coverage of suitable habitat and species presence created with Microsoft Excel and ESRI ArcGIS.
Reptiles	Incidental sightings recorded (Cirrus 2004). No formal surveys required since construction of mining facilities and roads was not proposed in previous Muddy Creek project. Scope of work for this analysis did not require any new surveys.	Species observations summarized in text.
Small mammals	Incidental sightings recorded (Cirrus 2004) by field biologists while conducting wildlife surveys in the area.	Probability of occurrence analysis conducted using existing literature and other resources. Results summarized in tabular format.
Non-game birds	Incidental sightings recorded (Cirrus 2004) by field biologists while conducting wildlife surveys in the area.	Probability of occurrence analysis conducted using existing literature and other resources. Results summarized in tabular format.
[1]All referenced field survey work was completed for the analysis documented in the 2004 Muddy Creek Wildlife Technical Report. [2]Neotropical migratory bird species considered in this analysis can be found in Table 5.		

Many special status species have been excluded from discussion in Table 1. This is because it was determined by Kevin Albrecht (MLNF, Ferron Ranger District Wildlife Biologist), and Chris Colt (FLNF, Richfield Ranger District Wildlife Biologist), that those species (including all federally-listed threatened and endangered species), either do not occur or have no habitat in the project area. Only species with the potential to be impacted by the Proposed Action are analyzed throughout this document.

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2.4 DESCRIPTION OF INVENTORIES AND DATA COLLECTED BY THE CONSULTANT

A description of field surveys and other forms of data acquisition, including survey methods and results from the previous analysis, is discussed below in sections 2.4.1 - 2.4.4. Order of species described follows that outlined above in Table 1. Summary figures and tables of the previous Muddy Creek study efforts can be found in the Muddy Creek Wildlife Technical Report (Cirrus 2004) in the project record. In addition to the required survey data, general species lists were generated to document incidental wildlife sightings in the analysis area and are included in Appendix C of the Muddy Creek Technical Report (Cirrus 2004).

2.4.1 TES Wildlife Surveys

Lists of federally-listed threatened and endangered, and R4 sensitive species were obtained at the onset of the project analysis period. Updated lists were acquired in 2013 (Forest Service 2013b, USFWS 2013). Each of the species on these lists, and the habitats they utilize, were considered for analysis in this document. However, it was determined by Kevin Albrecht, MLNF, Ferron Ranger District Wildlife Biologist; and Chris Colt, FLNF, Richfield Ranger District Wildlife Biologist; that some species listed (including all federally-listed threatened and endangered species) either do not occur or have no habitat in the project area. Only species with the potential to be impacted by the Proposed Action are analyzed throughout this document. The complete lists of all species (including those dropped from this analysis) can be found in the project record.

2.4.1.1 Bald eagle

Data on bald eagle nest sites was acquired from the UDWR (2005b) and is reported below.

There are only eleven known nesting bald eagle pairs in Utah (UDWR 2009). None are present in the project area or elsewhere on the Manti-La Sal National Forest or vicinity of the project area on the Fishlake National Forest. The closest nest is on private land about 18 miles east of the northeastern boundary of the analysis area, near the town of Castledale. It is unlikely that individuals from this eagle pair would utilize portions of the analysis area for foraging, since suitable habitat is available closer to the nest site. Five bald eagle individuals (3 adults and 2 juveniles) were observed in November 2003 along Cowboy Creek (in the middle of the proposed lease tract), presumably during fall migration (Cirrus 2004). No other observations of this species were made during field visits between March and November, 2001-2003.

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2.4.1.2 Flammulated owl

Surveys for flammulated owls were conducted in suitable foraging and nesting habitat in the analysis area from June 20 to July 19 in 2001, June 7 to June 26 in 2002, and on June 25, 2003 (Cirrus 2004). Survey periods were selected to correspond with the breeding season when male owls were most likely to vocalize to signal their occupied territory. Suitable owl habitat was originally defined as pine woodlands, especially ponderosa pine. After owls were heard in alternative habitat types in the survey area, this definition was expanded to include mixed conifer forest stands that included an aspen and pine component.

Another survey was completed specifically for the area within suitable habitat through which surface disturbance could occur. The survey was completed on July 22, 2008, following accepted protocols for broadcast flammulated owl surveys, beginning at dusk. Calling stations were established on 0.25 mile spacing along the alignment in suitable habitat (Cirrus 2008). Other flammulated owl surveys were conducted in The Pines tract in 2008 by MLNF personnel. This area is directly north and east of the

Wildcat Knolls lek sites. Flammulated owl responses were detected in this area during this survey effort (Jewkes 2008a). Further surveys by MLNF personnel were conducted in the Wildcat Knolls area 2009 through 2011. No flammulated owl responses were detected through these surveys (Forest Service 2013d).

2.4.1.2.1 Survey Methods

A forest owl inventory protocol (UDWR 1992), developed for use in the Northern Region and received from the Utah Department of Natural Resources, was followed to determine the presence of flammulated owls in the analysis area. The survey method employed the use of a conspecific broadcast calling tape of male flammulated owl vocalizations. The same equipment used for the goshawk surveys was used for owl surveys. Surveys consisted of broadcasting repeated sequences of a 30-second adult owl call followed by a 15-second period of silence. Twenty minutes were spent at each survey station. After listening for owls for 3 minutes, calls were broadcast in four directions, rotating 90 degrees every 4 minutes, approximately. Broadcast calling surveys began one-half hour after dusk, and continued throughout the night, as late as 3:30 am. Surveys were aborted or not conducted if it was rainy or windy.

Survey routes were determined using transects and isolated points, drawn on USGS topographic maps over areas containing suitable flammulated owl nesting and foraging habitat. Suitable habitat was determined by examining Forest Service vegetation coverage maps and aerial photos, and by field reconnaissance. Survey calling stations were located at approximately 0.5-mile intervals along transects, and 0.5 miles apart when isolated, to promote effective coverage of suitable habitat.

A digital coverage of the flammulated owl calling points and positive responses was created in Microsoft Excel. The coverage was mapped in ArcGIS and overlaid onto the existing Forest Service vegetation layer to better assess distribution of positive responses in relation to habitat type (see Muddy Creek Wildlife Technical Report; Figure A-3, Appendix A; Cirrus 2004). Results of the surveys are discussed below.

2.4.1.2.2 Survey Results

In 2001, surveys were conducted at 38 calling points. In 2002, calling points that had no response in 2001 were resurveyed, and 15 new points were surveyed to cover additional potential habitat. These new points were resurveyed in 2003 unless a positive response was recorded in 2002. (Cirrus 2004).

Owls responded to broadcast calls at a total of 26 stations in the analysis area over the 3-year survey period. Twelve flammulated owl responses were elicited from surveys conducted in 2001, twenty owl responses in 2002, and one in 2003. A flammulated owl was also heard incidentally along Cowboy Canyon in May 2003, at a location where no response had been recorded during the 2001 and 2002 surveys. At some of the stations, more than one owl responded to calls during the survey visit. The habitat surrounding the stations where positive responses were recorded can be categorized into ponderosa pine, limber pine and aspen, and mixed conifer and aspen forest types. The number of responses does not indicate the number of owl pairs on the tract, as unpaired male flammulated owls are thought to call more during the breeding season than paired owls (Reynolds and Linkhart 1987, UDWR 1992). However, we can assume that numerous pairs are utilizing the survey area based on the high number of male responses and the presence of suitable habitat throughout the tract. In addition to flammulated owls, great-horned owls occasionally responded to the broadcast calls. Calling effort was aborted at these stations once the great-horned owl was heard. A saw-whet owl was also heard calling on the tract during a flammulated owl survey in 2001. For the 2008 survey along the proposed power line alignment that intersects suitable habitat, no flammulated owl responses were detected.

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In summary, two years of surveys were completed for all suitable flammulated owl habitat within the previous Muddy Creek study area during the 3-year survey effort. Positive responses were received at 26 calling stations in the survey area, for a total of 33 responses, as more than one owl responded at some of the stations. Some of these responses were likely from the same individuals as they were received at

adjacent calling stations. It is assumed that several pairs of flammulated owls occur in the analysis area even though no responses were detected in the Greens Hollow survey areas.

2.4.1.3 Greater sage-grouse

Surveys for the greater sage-grouse consisted of visits to known lek sites and searches for grouse sign in suitable habitat that could potentially be used during the breeding season. Grouse sign was in the form of tracks, fecal and cecal pellets. Suitable habitat was defined as plains, foothills, and mountain valleys, where the predominant shrub species is sagebrush, of short to medium stature. Suitable habitat for sage-grouse exists in the area. Forty-eight sage-grouse were transplanted to the southern portion of the Muddy analysis area by UDWR between 1987 and 1990 (UDWR 1997).

2.4.1.3.1 Strutting Ground Surveys

The Forest Service and UDWR have been annually monitoring the strutting ground utilized by reintroduced grouse on the Muddy tract since 1991. This ground, referred to as the Wildcat Knolls lek complex, has received use by 3 to 36 cocks on a given year with the lowest numbers observed in 2003 Forest Service 2013a). Cirrus personnel assisted with the survey in April 2002 and 2003 and also observed three hens in the area in 2002. This lek complex is currently the only one in the analysis area known to be active. In 2003, UDWR and Cirrus personnel also surveyed additional areas identified as potential lek sites by Cirrus in 2002, along the east side of Box Canyon and near Pines Knolls. UDWR observed two cocks and two hens between Box Canyon and the East Fork of Box Canyon in early April 2002, but the birds were not engaged in any lekking displays. No sage-grouse were observed near Pines Knolls. These two sites were revisited by Cirrus later in April 2002, but no grouse were observed. (Cirrus 2004).

Surveys continue to be conducted in the Wildcat Knolls lek complex areas each season. Beginning in 2005, new field equipment was secured (OHVs with track systems), that allowed MLNF biologists to access the lek complex earlier in the year. This has greatly increased that data available and has shown that more grouse use the area than previous years' surveys have recorded. For example, in 2004 when biologists were unable to access the site earlier in the season, the highest lek count observed was 15 total hens and cocks. The following year with additional access to earlier survey, that number grew to 65 in 2005, 80-100 in 2006, and 36 in 2007. Even on a low year such as 2007, greater access is still showing greater than double the usage observed prior to gaining early access (Forest Service 2013a). For more information see Section 2.4.1.3.4 and Table 2.

2.4.1.3.2 Grouse Sign Surveys

Sagebrush habitat potentially suitable for sage-grouse was surveyed for sign by Cirrus. Priority was given to areas with historic grouse use and to those containing a good understory of grasses and forbs, although lesser quality habitat was also surveyed. Survey methods consisted of walking along closely spaced, parallel transects through sagebrush habitat and searching the ground for fecal and cecal pellets, feathers, and tracks. The majority of the survey effort took place in April 2002, although one area not visited at that time was surveyed in June 2002. (Cirrus 2004).

2.4.1.3.3 Survey Results

Surveys for sage-grouse sign within the Muddy analysis area took place from mid to late April 2002 in the following locations: Greens Hollow, The Pines, Julius Flat, the area from Wildcat Knolls north to the tip of Box Canyon, the area west of Box Canyon, and between Box Canyon and Greens Canyon. Additional surveys were conducted in early June 2002 between Box Canyon and East Fork Box Canyon (Cirrus 2004).

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There was no grouse sign observed at Greens Hollow or near Julius Flat reservoir, possibly because the sage in that area was very tall, with minimal understory grasses and forbs. Although the sagebrush was shorter between Greens Canyon and Box Canyon, only a few old piles of grouse pellets were found. As expected, abundant sage-grouse sign was found in the area around the Wildcat Knolls site, clear up to the

intersection of FS roads 044 and 007. Further north from this intersection, on the west side of Box Canyon, there was very little grouse sign. One concentrated area of grouse use was found on the western portion of FS road 028 in The Pines. This area contained numerous patches of sagebrush that had been burned to increase cattle forage, and the grouse pellets were found on the edge between burned and unburned areas (Cirrus 2004). The sage-grouse were probably using the taller sagebrush for roosting and the burned areas for foraging. The most extensive sign of sage-grouse outside of the Wildcat Knolls area was between the East Fork and main fork of Box Canyon. Numerous piles of fecal and cecal pellets and a few feathers were found at the junction of and between FS roads 318 and 058. In addition, 12 roosting adults were flushed near the head of Box Canyon during this survey effort (See Muddy Creek Wildlife Technical Report; Figure A-12, Appendix A, Cirrus 2004). South of this area, near Box Pond, SUFCO Mine personnel also reported seeing over a dozen sage-grouse (adults and chicks) in June 2002.

2.4.1.3.4 Updated Population Counts and Lek Boundaries

Due to the ongoing process of the MNLF Forest Plan revision, many wildlife species range mappings are being re-verified and revised across the Forest to greater reflect new data and land use that has been documented since the previous Forest Plan of 1986. District Biologists on the North Zone of the MLNF have been completing thorough monitoring of sage-grouse since 2002 and have discovered inconsistencies between the lek map and the existing on-the-ground conditions. It has been determined that some areas mapped as suitable lek habitat are in actuality not suitable. Conversely, other areas that are not mapped actually provide quality habitat for sage-grouse. The Wildcat Knolls sage-grouse lek complex near this project's analysis area is one area that has undergone revision to better reflect grouse use and current data. This revision of the lek boundaries in this area of the Forest was completed in early 2008 and the analysis for this project reflects those new lek boundaries based on the best current information (Forest Service 2008a).

No additional sage-grouse surveys were required of Cirrus personnel for this project. However, yearly sage-grouse surveys have been completed by the UDWR and Forest Service biologists since the 2003 survey effort. There are five historic leks on the MLNF. Of these, the Wildcat Knolls lek complex is the most prominent sage-grouse feature in the project area. In 2007, a further revision of the Wildcat Knolls lek complex was completed when a satellite lek was discovered near to and north of this area and integrated into the lek complex. Table 2 below outlines the most recent lek count data available for the Wildcat Knolls lek in the project area as well as the other known leks in the North Zone of the MLNF.

As discussed above, it ought to be noted that although the data appear to show a large increase in grouse use on the leks, these data should be put into perspective. For the 2005 count season and beyond, track-over-snow vehicles allowed surveyors greater access to the lek sites earlier in the year. This is likely the reason for the elevation in count numbers for survey seasons 2005 to 2008. It is assumed that the leks have been receiving this level of use in the past, but it has been impossible to document due to the inaccessibility of lek sites in the late winter and very early spring. Continued monitoring will show whether this assumption is true and lek use remains high as earlier counting brings in new data each year (Forest Service 2013a).

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2.4.1.4 Northern goshawk

Surveys for northern goshawks were conducted in suitable foraging and nesting habitat in the analysis area from June 21 to July 19 in 2001, July 9 to August 1 in 2002, and July 14 to July 17 in 2003 (Cirrus 2004). The survey periods were selected to coincide with portions of the nestling period in 2001 and the post-fledgling dependency period in 2002-2003. Suitable goshawk habitat was defined as gentle to moderate slopes (0 to 30 percent) containing mature conifer stands with closed canopies and open understories. Aspen stringers near perennial streams were also considered suitable nesting habitat, regardless of the grade of the adjacent slopes.

Table 2. Winter and Spring Lek Counts on the North Zone of the MLNF Showing Maximum Number of Cocks Observed By Lek Per Year.[1]				
Dates Monitored	**Wildcat Knolls**	**South Horn South Rim**	**Barbwire Pond SOB Hill**	**North Horn East Rim TV Towers**
1990	0	2	0	3
1991	20	1	0	6
1992	22	4	0	3
1993	0	1	0	2
1994	11	3	0	2
1995	12	0	0	0
1996	20	0	0	0
1997	15	0	0	0
1998	15	0	0	0
1999	16	0	0	0
2000	14	0	0	0
2001	11	0	0	0
2002	8	NV	0	0
2003	3	0	0	0
2004	15	7	0	0
2005	65[2] (12)	9	2	0
2006	80-100[2] (30)	18	14	0
2007	36	17	3	0
2008	17	17	2	0
2009	13	NV	NV	NV
2010	NV	14	NV	NV
2011	28	NV	NV	NV
2012	25	7	NV	NV
2013	24	14	NV	NV

[1]Forest Service 2013a

[2]These numbers are winter counts taken in January and February and represent a total count of hens and cocks. The other numbers in parenthesis represent the actual lek counts and were counted in March through May. Only the highest count in that year is given.

NV=Not Visited

2.4.1.4.1 Survey Methods

Survey methods outlined in the draft Region 4 survey protocol for northern goshawks (Forest Service 1993) were used to determine the presence of goshawks in the analysis area. The method employed the use of a conspecific broadcast calling tape of an adult northern goshawk alarm call and a portable tape player with external speakers capable of broadcasting at 90-100 decibels at one meter from the source. The taped alarm calls were played back as repeated sequences of 10 seconds of alarm calls followed by a 30-second observation period. At each broadcast station, the observer played a total of three sets of the 10 seconds of alarm call/30 seconds of observation sequence, rotating 120 degrees after each set. During all observation periods, the surveyor scanned the area vertically and horizontally for goshawks. Calling surveys were conducted during daylight hours, primarily from sunrise until early afternoon (about 1400 hours). No surveys were conducted in inclement weather (i.e., rain or wind).

Survey routes were determined using transects drawn on USGS topographic maps over areas containing suitable goshawk nesting and foraging habitat. Suitable habitat was determined by examining Forest Service vegetation coverage maps and aerial photos, and by field reconnaissance. Survey calling stations

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were located at approximately 900 feet intervals along transects to promote effective coverage of suitable habitat. Results of the surveys are discussed below.

2.4.1.4.2 Survey Results

In 2001, 110 calling points were surveyed for northern goshawks. In 2002, these calling points were resurveyed and 102 new points were surveyed because of the additional potential habitat identified from vegetation maps or during field visits. In addition, goshawk alarm calls were broadcast at 59 of the stations surveyed for three-toed woodpecker between June 8 and June 23, 2002, to see if a response could be prompted earlier in the breeding season. Of these stations, 52 were resurveyed later in the year as part of the regular goshawk survey effort. In 2003, stations visited for the first time in 2002 were revisited, except where habitat was deemed unsuitable, so that each station with suitable habitat was visited twice over the 3-year study period. (Cirrus 2004). Surveys have continued on the Forest since the Muddy Creek analysis was completed. Goshawk territory occupancy has trended upward in the past five years (2008 to 2012), to the point of 42.4 percent occupancy in 2012 (Forest Service 2013b).

Positive responses were received at three calling stations in the Muddy analysis area in 2001, two calling stations in 2002, and one calling station in 2003. One of the responses in 2002 was at a station where a response was also received in 2001. Goshawk responses were associated with mixed conifer/aspen forest at elevations above 8,650 feet. Positive responses were either silent fly-overs or vocalizations of adult birds. Of the responses in 2001, two were silent fly-overs and the third bird was flushed from a tree. Two of these responses were most likely from the same individual as the goshawk flew from the direction of the last positive calling station within fifteen minutes of the original response. Of the two responses in 2002, one goshawk flew in and vocalized and perched on a tree, the other one vocalized but did not fly in. In 2003, the response consisted of a single alarm call. Four of the responses were in the forested patches west of the tract, inside the buffer, and two were inside the tract. The number of responses observed does not represent the number of individuals. The responses were likely from individuals of one (or possibly two) goshawk pair or family unit. No physical nests were observed, but it was assumed that there was at least one active nest in the area. In addition to the surveys, one incidental visual observation was made in September 2003, when an adult goshawk was seen flying over Black Fork Creek then disappearing into the forest canopy on the other side of the creek, near its confluence with the South Fork Muddy Creek. (Cirrus 2004).

In summary, two years of surveys were completed for all suitable goshawk habitat within the analysis area during the 3-year survey effort. Positive responses were received at five calling stations, including 2 responses at one of the stations, for a total of 6 responses. Researchers spent time searching the area, but were unable to locate nests or juveniles. (Cirrus 2004).

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2.4.1.5 Peregrine falcon

2.4.1.5.1 Survey Methods

Migratory bird surveys were conducted during the 2001 to 2003 field survey effort (both concurrent and in addition to other required surveys) in the following general habitat types: riparian, grassland and forblands, sagebrush, mixed conifer, aspen and aspen mixed conifer, ponderosa pine, mahogany and mountain brush, limber pine, and pinyon pine/juniper. Greater emphasis was given to surveying forested and sagebrush habitat types. Cliff habitat is surveyed annually specifically for golden eagles; incidental falcon sightings are also recorded if observed (Cirrus 2004).

Considerable time was spent traversing coniferous and mixed-coniferous forests and riparian habitats during the breeding season while surveying for sensitive species. Extensive time was also spent traversing shrub-steppe environments during the breeding season while surveying for sage-grouse. Time surveying in grassland habitat in 2001 to 2002 was limited to those areas adjacent to sagebrush habitat, and to the grasslands traversed while traveling to other habitats. In 2003, the survey effort specifically included grasslands.

2.4.1.5.2 Survey Results

A pair of peregrine falcons was observed in the analysis area during the survey effort in 2002. The falcons were encountered while walking along the rim of Muddy Creek Canyon within the 2-mile buffer on the west side of the tract (see Muddy Creek Wildlife Technical Report; Figure A-11, Appendix A, Cirrus 2004). The pair was exhibiting territorial behavior, and it was presumed that a nest was nearby within the cliff faces. One peregrine falcon was observed circling above an inactive golden eagle nest during UDWR aerial surveys in 2003. No falcons were observed in 2001. The FLNF performs surveys each year for peregrine falcons; however, there have been no eyries located on the Forest (Rodriguez et al 2006).

More recent data shows that as of 2008, there are five known peregrine nests on the MLNF. None of these occur within the project area. The closest is approximately 16 miles northeast of the project area in Rock Canyon. This nest was active in 2006 and 2008, but inactive in 2007. From 1999 to 2005 it was not surveyed, but was active in 1998 (Jewkes 2008a).

2.4.1.6 Pygmy rabbit

The pygmy rabbit is a listed sensitive species for the whole of Region 4. However, the region has developed a list of known and/or suspected distribution of such species by forest (Forest Service 2013b). On this list the pygmy rabbit only is listed as possibly occurring on the FLNF and not the MLNF in the project area. With this in mind, all references to pygmy rabbits throughout this document will be assumed that potential populations and habitat occur on the FLNF. The expected subsidence zone of the project area consists of only approximately 81 acres of FLNF-managed land (Figure 1).

2.4.1.6.1 Survey Methods

During the 2003 analysis period and 2001 to 2003 field seasons, pygmy rabbits were not listed as a target species on any list. Thus, they were not specifically surveyed for. Incidental mammal surveys were completed, and although no trapping took place, sixteen species of small mammals were observed incidentally in the project area.

2.4.1.6.2 Survey Results

Although there is some potential habitat in the project area, pygmy rabbits were not observed during the 2001 to 2003 field survey effort. Further, there are no known occurrences of this species in the project area, or the counties wherein the project lies.

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2.4.1.7 Three-toed woodpecker

Surveys for three-toed woodpeckers were conducted in suitable foraging and nesting habitat in the Muddy analysis area from June 21 to July 19 in 2001 and May 24 to June 23 in 2002 (Cirrus 2004). Survey periods were selected to coincide with the nest excavation period. Suitable woodpecker habitat was defined as spruce-fir forests, especially those that had been recently infested by bark beetles.

2.4.1.7.1 Survey Methods

A modification of the northern three-toed woodpecker inventory protocol, received by the Forest Service in 2001 (UDWR 1992) was used to conduct surveys. The method employed the use of a con-specific broadcast calling tape of an adult three-toed woodpecker call plus three intermittent episodes of drumming and silence. The tape was played using a portable tape player with external speakers capable of broadcasting at 90-100 decibels at one meter from the source. The tape was played back as a repeated sequence of 10 seconds of calls and drumming followed by a 30-second observation period. At each survey station, the observer broadcast the call in all four cardinal directions for a total of eight minutes (2 minutes in each direction). During the observation periods, the surveyor scanned the area vertically and horizontally for woodpeckers and listened for drumming responses. Calling surveys were conducted during daylight hours, primarily from sunrise until early afternoon, when it became too warm (about 1400 hours). No surveys were conducted in inclement weather (i.e., rain or wind).

Survey routes were determined using transects drawn on USGS topographic maps over areas containing suitable three-toed woodpecker nesting and foraging habitat. Suitable habitat was determined by examining Forest Service vegetation coverage maps and aerial photos, and by field reconnaissance. The majority of transects traversed for goshawk surveys were used also for woodpecker surveys, because of the similarity of habitat requirements. When the same transects were used for both species, the survey calling stations were located at approximately 900 feet intervals. When transects were used to survey only for woodpeckers, the calling stations were located at intervals ranging between 0.15 and 0.25 miles, depending on terrain and forest density. If surveys were conducted for woodpeckers and goshawks during the same time interval, the woodpecker calls were always broadcast first. Results of the surveys are discussed below.

2.4.1.7.2 Survey Results

In 2001, 98 calling stations were surveyed, which comprised the best habitat in the tract. In 2002, 96 new calling stations were surveyed, which contained a variety of habitat including poor (canyon edges), marginal, and suitable habitats. In addition, 32 calling stations visited in 2001 were resurveyed in 2002 because they were originally surveyed after July 15, towards the end of the nest excavation period. (Cirrus 2004).

Fifteen woodpecker responses resulted at twelve calling stations in 2001. Six of these responses were paired, and one was incidental, occurring in the same location as a prior positive response. One woodpecker responded during the survey effort in 2002, and an additional one was observed incidentally during a goshawk survey in mid-July 2002, when an adult female was observed drumming and flying. No nest sites were found. Positive identifications were made visually and aurally and were associated with dense forested habitats above 8,800 feet that contained patches of snags. Woodpecker responses consisted of drumming or a combination of flying to a few different trees and snags and drumming. All of the responses were in the spruce beetle infested forest habitat within the survey buffer, west of the tract boundary. Although, for a given year, it is difficult to determine the exact number of individuals observed during surveys, it can be assumed that there were at least three, and potentially more, woodpecker pairs nesting on the tract. This assumption is made based on the number of pairs observed, timing of and distance between positive survey responses, and home range size.

In summary, all suitable three-toed woodpecker habitat was surveyed between 2001 and 2002. Responses were received at 13 calling stations in the Muddy analysis area, for a total of 16 responses, as both birds in a pair responded at three stations. Additionally, a female was observed incidentally in the area during a goshawk survey. It is assumed that three or more nesting pairs were present during the survey period.

2.4.1.8 Spotted bat

Surveys for spotted bats were conducted by Cirrus in potential roosting habitat in the Muddy analysis area in 2001 and 2002. Spotted bats have been recorded in a variety of habitats, including open ponderosa pine, desert shrub, pinyon-juniper, and open pastures and hay fields. Foraging occurs in riparian areas and open meadows with wet seeps or wetlands. Roosting habitat is more restrictive, being confined to rock crevices or overhangs associated with large cliff faces (Wai-Ping and Fenton 1989). Roosting habitat for spotted bats is abundant in vertical cracks of the sandstone cliff faces of the steep canyons in the tract. The riparian habitat and forest edges in the tract also provide potential foraging opportunities. (Cirrus 2004).

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2.4.1.8.1 Survey Methods

Surveys for spotted bats in 2001 and 2002 consisted of structural searches of rock crevices or overhangs of cliffs that potentially support roosts sites. Due to the hazards of steep cliff terrain, searches were confined to areas accessible safely by foot. No rock-climbing or repelling gear was used. The following structures were searched for bat roosts in the analysis area: Muddy Canyon east of Box Canyon, Greens

Canyon, the East Fork of Box Canyon, the head of Box Canyon, and the North Fork of Quitchupah Canyon.

In addition to roost site searches, incidental observations of spotted bats were recorded. Spotted bat vocalizations are audible. The only other audible bat species in Utah, Allen's big-eared bat and the big-free-tailed bat, do not occur within the range of the project area. Therefore, when audible bat detections were made, it was assumed that the species heard was the spotted bat. UTM coordinates were recorded for these observations and were used to create the digital coverage provided in conjunction with this report.

2.4.1.8.2 Survey Results

No roosting sites or sign of bats were found during structural searches in the analysis area (Cirrus 2004).

Numerous spotted bats were identified in the survey area by audible vocalizations or a combination of vocalizations and visual detection. Observations were made primarily in conjunction with nighttime flammulated owl survey efforts. A total of 36 spotted bat observations were recorded. Observations were associated with the rocky cliff habitat and ponderosa pine along the east fork and main stem of Box Canyon and along Greens and Cowboy Canyons. Bats were also observed foraging above the North Fork of Muddy Creek, and in the limber pine/Douglas-fir habitat along the jeep trail running west and south of Cowboy Creek.

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See section 2.4.1.10 for results of additional bat surveys conducted by other parties (Perkins and Peterson 1997).

2.4.1.9 Townsend's big-eared bat

Surveys for Townsend's big-eared bat (*Corynorhinus townsendii townsendii*), were conducted by Cirrus in potential hibernacula and roosting habitat in the Muddy analysis area in 2001 and 2002. Townsend's big-eared bats have been recorded in juniper/pine forests, shrub/steppe grasslands, deciduous forests, and mixed coniferous forests. They roost in hibernacula within caves, abandoned mine shafts, and occasionally in old buildings (Perkins and Peterson 1997). Winter hibernacula for big-eared bats are very scarce in the analysis area due to the scarcity of suitable caves and open mine shafts. Cliff overhangs and shelter caves eroded in the sandstone cliffs could provide potential summer roosting habitat.

2.4.1.9.1 Survey Methods

Before surveys were initiated, the status of mines in the area was determined. One inactive mine, the Richie Mine, is present in the survey area. This mine was visited and determined closed because of lack of visible openings. The Link Canyon Mine, just south of the buffer boundary is closed, with the exception of a small magazine, roughly 4 by 4 by 8 feet. One active mine, the SUFCO Mine, is present within and west of the Muddy analysis area, with its operating facilities southwest of the tract buffer boundary.

Surveys for Townsend's big-eared bats in 2001 and 2002 consisted of structural searches of rock overhangs and magazines that potentially support roost sites or hibernacula. These surveys were conducted concurrently with those for spotted bats and included searches of accessible structures in Muddy Canyon east of Box Canyon, Greens Canyon, the East Fork and head of Box Canyon, and the North Fork of Quitchupah Canyon. The Richie Mine and tramway were visited to determine the status of the mine and look for potential hibernacula. A rock overhang exists at the head of Box Canyon and was surveyed for sign of bat roosts. In addition, the magazine at Link Canyon Mine was surveyed for roosting bats. Because big-eared bats are highly susceptible to temperature changes and disturbance, they would not occupy an active mine, thus the SUFCO Mine was not considered for the survey effort.

2.4.1.9.2 Survey Results

No roosting sites, potential hibernacula, or bat sign were found during structural searches in the tract. No substantial caves were observed on the tract and no other structures were considered potentially suitable for Townsend's big-eared bat hibernacula. No mine openings were found at the Richie Mine site after an extensive search of the area, and no bat sign was observed. This mine was considered closed. No bats or bat sign were observed in the magazine in Link Canyon Mine. Because of the disturbance of this opening by cattle and vehicular traffic, it is unlikely that Townsend's big-eared bats would roost there. Since no big-eared bats and little suitable habitat were observed, a digital coverage for this species was not created. (Cirrus 2004).

See section 2.4.1.10 for results of additional bat surveys conducted by other parties(Perkins and Peterson 1997).

2.4.1.10 Additional Bat Surveys

2.4.1.10.1 Cooperative Challenge Cost Share Project

A general inventory was conducted for spotted bats in selected areas on the Ferron Ranger District in 1992 as part of a cooperative challenge cost share project between the MLNF and Utah Natural Heritage Program (Toone 1993). The survey methods employed consisted of listening for spotted bat audible echolocation sounds and categorizing them as a "bat pass" or a "foraging buzz", represented by the rate of echolocation heard, and mist netting. Survey locations were by Quitchupah Creek, just south of the Muddy tract boundary.

No bats were captured in mist nets at Quitchupah Creek, but audible bat detections were made on two occasions during the netting period. Bat activity was noted as low at this site.

2.4.1.10.2 SUFCO Mine Bat Survey

Surveys for spotted and western-big-eared bats were conducted in 1997 in Link, Muddy Creek, and Box Canyons as part of the SUFCO and Dugout Canyon Mine's permit requirements (Perkins and Peterson 1997). Four different survey methods were employed, including structure searches, mist netting, bat detectors, and audible bat transects. The survey area overlapped with the eastern portion of the Muddy tract and buffer, therefore, the SUFCO survey results are likely indicative of the species composition in the analysis area.

Results of the structure searches yielded no bats or bat sign in any shelter caves or in the Link Canyon magazine. No habitat suitable for Townsend's big-eared bats was observed. Mist netting resulted in the capture of California myotis (*Myotis californicus*) and Yuma myotis (*M. yumanensus*) in Link Canyon, and no species at Muddy Creek. The bat detector surveys resulted in the detection of spotted bats, as well as numerous other bat species including California myotis, Yuma myotis, big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagrans*), small-footed myotis (*M. ciliolabrum*), long-eared myotis (*M. evotis*), little brown bat (*M. lucifuus*), western pipistrelle (*Pipistrellus hesperus*), and an unidentified *Myotis* species. No Townsend's big-eared bats were detected. Transect surveys resulted in detection of spotted bat calls in nearly all stations in lower Box Canyon and throughout Muddy Canyon. No calls were heard in the upper reaches of the three canyons or in Link Canyon.

The results of the surveys conducted by Perkins and Peterson (1997) suggest that these canyons do not contain suitable habitat for Townsend's big-eared bats; suitable structures for day roosting and hibernacula are absent. Cliff habitat below the rims of Muddy Creek Canyon and the lower reaches of Box Canyon surveyed by Perkins and Peterson (1997) appear to provide ample habitat for spotted bats.

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2.4.2 Management Indicator Species

2.4.2.1 Rocky Mountain elk

Rocky Mountain elk are an MIS on both the MLNF and FLNF. Data on elk was acquired for the analysis area from UDWR (Bernales et al 2012, UDWR 2013), MLNF (Forest Service 2013b), and FLNF (Rodriguez et al 2006).

The Greens Hollow and surrounding areas contain crucial winter and crucial summer range for elk (UDWR 2013). Quitchupah Canyon is considered general winter range. Although the area is not designated in the MLNF Forest Plan (Forest Service 1986) as general or key winter range for elk, there are both key and general rangelands within miles of the project area. Although not designated as key or general rangelands, habitat in the project is clearly very important both in summer and winter to local deer and elk populations.

No true migration routes have been identified or mapped by the UDWR or Forest Service in the analysis area. Since the area contains both winter and summer range, movements are not extensive, occur between ranges, and follow the seasons. All areas are used, and the animals move from place to place as necessary. In some years they move greater distances than others, depending on the weather and available resources.

Specific calving areas have not yet been identified, studied, reported, or mapped within the Greens Hollow project area. It is assumed that calving potentially occurs in all suitable habitats. In the analysis area, suitable calving habitat coincides with aspen forests and mountain brush and mahogany cover types. Predicted calving areas occur in and around the southwestern portion of the analysis areas, as far north as Julius Flat Reservoir, and as far south as the North Fork of Quitchupah Creek (Hodson 2004). Potential calving habitat was modeled by the MLNF. Modeled habitat coincided with the aforementioned predicted habitat, but also occurred in and around the northwest portion of the analysis area. Modeled calving habitat was associated primarily with aspen and aspen mixed conifer habitat types that were close to water (Jewkes 2004b).

The elk population on the MLNF has remained relatively stable over the past decade (Forest Service 2013b). The elk population for the most part is dependent on the number and type of hunt tags issued by the UDWR annually, and weather cycles and patterns. It appears that due to the large amount of habitat on the Forest, these factors play a larger role in population numbers than do land management practices. The 1986 Forest Plan has a minimum viable population for elk of 2,125. The current population estimate of elk on herd on the Manti Division is 12,500 (Forest Service 2013b, Bernales et al 2012). Figure 3 below illustrates estimated population levels of elk on the Manti Division.

The latest data for the FLNF is from the 2004 to 2005 census. Based on data collected by the UDWR and FLNF biologists, there were approximately 7,225 elk in the winter of 2004 to 2005. This displays a 5,225 head increase since 1986 when the Forest Plan was signed. Overall, on the FLNF, elk population trends continue to increase (Rodriguez et al 2006).

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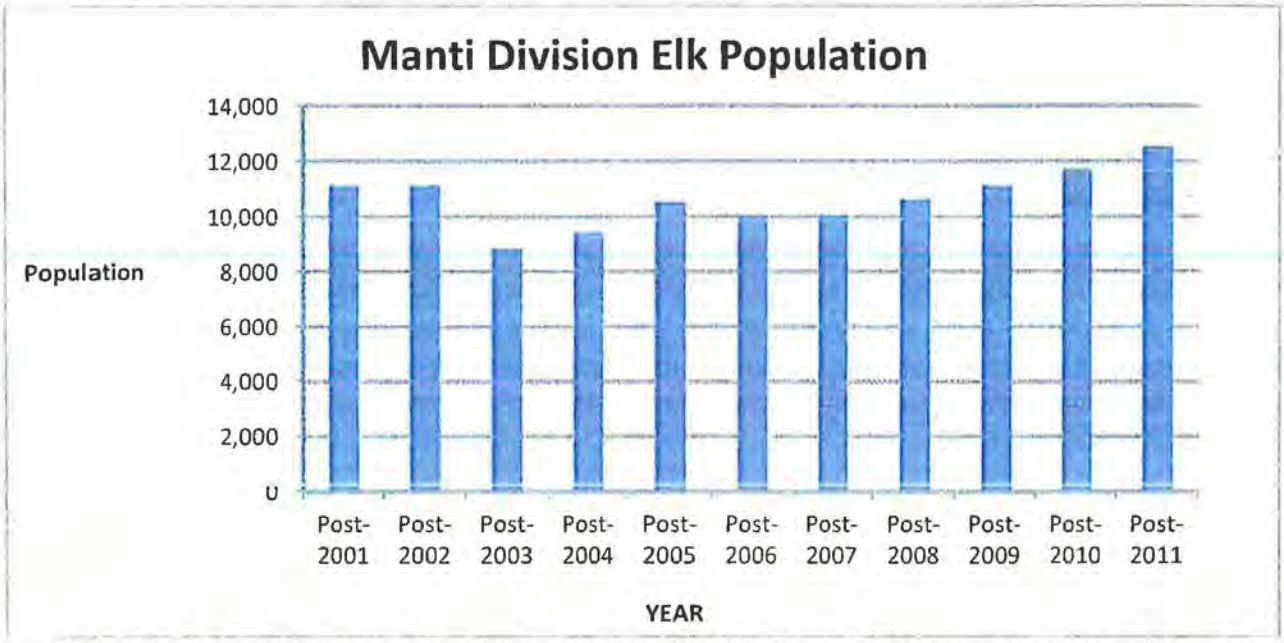

Figure 3. Elk aerial census from 200 to 2011 within the Manti Elk Census Unit (Forest Service 2013b).

2.4.2.2 Mule deer

Mule deer are an MIS on both the MLNF and FLNF. Data on mule deer was acquired for the analysis area from UDWR and Forest Service (Forest Service 2013b, Bernales et al 2012).

The Greens Hollow and surrounding areas contain crucial winter and crucial summer range for mule deer (UDWR 2013). Quitchupah Canyon is considered general winter range. Although the area is not designated in the MLNF Forest Plan (Forest Service 1986) as general or key winter range for deer, there are both key and general rangelands within miles of the project area. Although not designated as key or general rangelands, habitat in the project is clearly very important both in summer and winter to local deer and elk populations.

No true migration routes have been identified by the UDWR or Forest Service in the analysis area. Since the area contains both winter and summer range, movements are not extensive and follow the seasons. All areas are used, and the animals move from place to place as necessary.

Specific fawning areas have not yet been identified, studied, reported, or mapped within the Greens Hollow project area. It is assumed that fawning potentially occurs in all suitable habitats. Generally, suitable fawning habitat coincides with coniferous forests, mixed aspen coniferous forest, young aspen stands, and mountain brush and mahogany cover types, with the latter being preferred because of the protective cover it affords. These habitats occur in the western and southern portions of the analysis area. Deer fawning habitat overlaps elk calving habitat to some degree.

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The mule deer population throughout Utah has fluctuated historically—usually due to drought or severe winter conditions. Populations in eastern Utah declined in the early 1990s, but began to recover in the late 1990s. The mule deer population on the Manti Division, as of 2011, is estimated at about 20,900 individuals (Figure 4), which is below the objective of 38,000 individuals (Forest Service 2013b). Like elk, the mule deer population for the most part is dependent on the number and type of hunting tags issued by the UDWR annually, as well as weather cycles and patterns. It appears that due to the large

amount of habitat on the Forest, these factors play a larger role in population numbers than do land management practices. The 1986 Forest Plan has a minimum viable population for mule deer of 19,820.

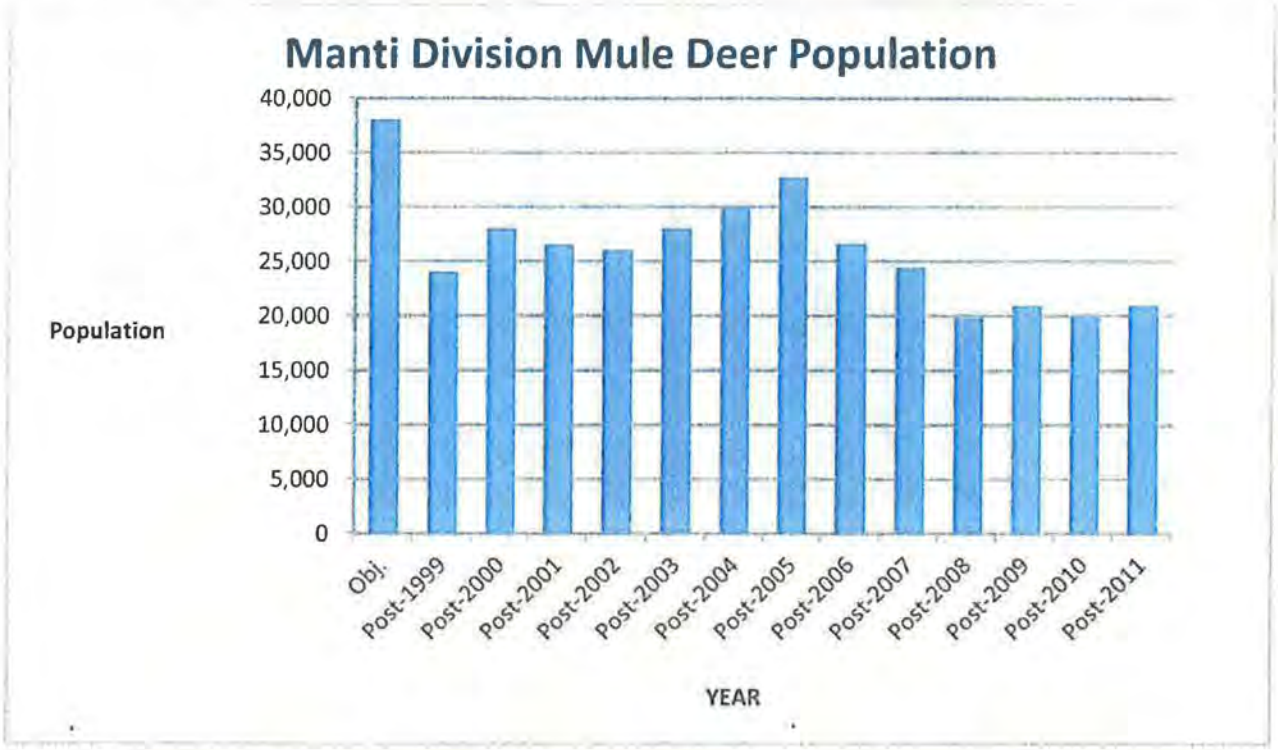

Figure 4. Mule deer population estimates on the Manti Division from 1999 to 2011 (Forest Service 2013b).

2.4.2.3 Northern goshawk

Northern goshawks are an MIS on both the MLNF and the FLNF and data on them was gathered from both Forests. Goshawks are also a R4 sensitive species and as such are discussed above in section 2.4.1.4.

Goshawk populations fluctuate within reproductive seasons, and from season to season. Populations are affected by a number of factors such as drought; cold and wet early spring conditions, low prey densities, significant wind events, fire, modified vegetation in the landscape, and predators (Rodriguez et al 2006). Over the past 12 years goshawk territory occupancy has fluctuated substantially on the MLNF, but has rebounded to near 2000 rates as of 2012 (Figure 5). On the FLNF, goshawks have seen a decline in nesting activity and occupancy in the 26 known territories. This is likely due to the severe drought conditions that southern Utah had experienced in the years leading up to the most current data available (Rodriguez et al 2006). Nesting on the FLNF has averaged 8 to 12 pairs annually with 10 confirmed active in 2004 (Rodriguez et al 2006).

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2.4.2.4 Golden eagle

Golden eagles are an MIS on the MLNF. Surveys for golden eagles were conducted in May 2002 in suitable nesting habitat in the Muddy analysis area with the assistance of UDWR. Additional golden eagle survey data was acquired for this area from UDWR for the period between 1998 and 2003 and from the MLNF for 2004 to 2007. Suitable habitat was defined primarily as tall cliffs and occasionally trees. (Cirrus 2004).

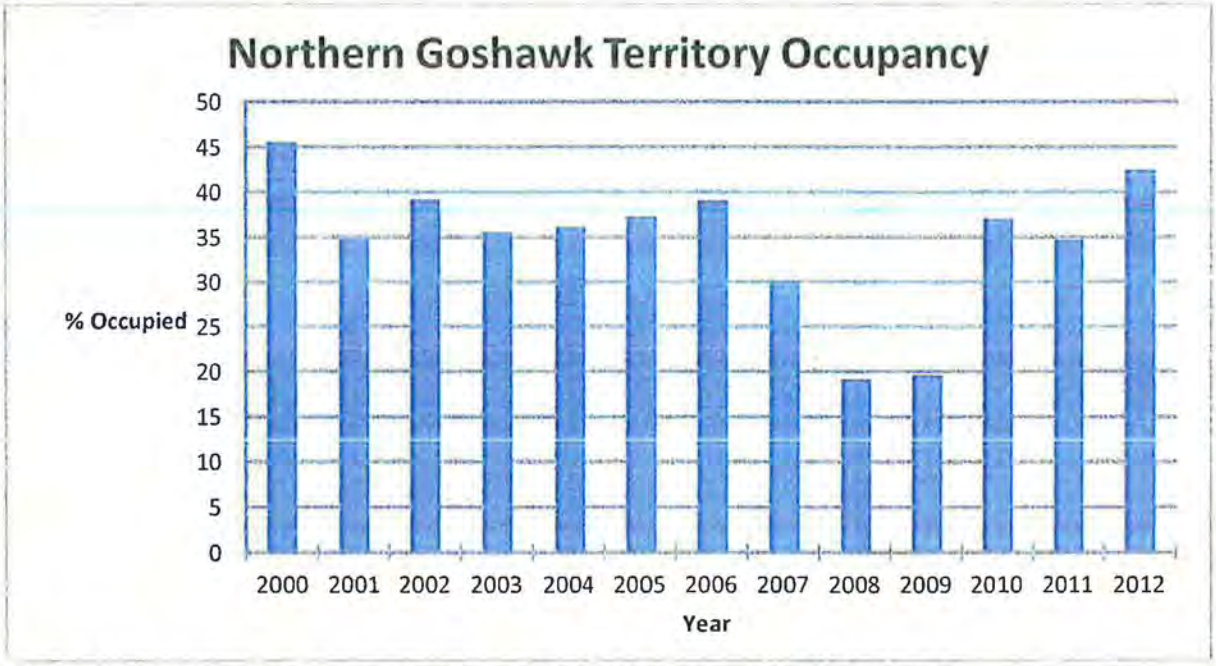

Figure 5. Northern Goshawk occupancy on the MLNF (Forest Service 2013b).

2.4.2.4.1 Survey Methods

Aerial helicopter surveys were conducted annually during the eagle breeding season by UDWR. Survey methods included flight transects over and adjacent to suitable cliff habitat and some forested habitat. When nests were observed, the UTM coordinates of the location were recorded, and the type (species) and status (active, inactive, tended) of the nest were determined, if possible. Cirrus participated with the survey effort in 2002. Results of the surveys are discussed below.

2.4.2.4.2 Survey Results

In 2002, 12 golden eagle nests were known in the analysis area, of which 11 were surveyed. Of these, none were active, two were tended, seven were inactive, one was dilapidated, one was not found, and one was not surveyed. No eagles were seen during this survey effort. In 2003, eight of the known nests were surveyed. Of these, none were reported as active, but two were tended. No new golden eagle nests were identified during this survey effort and no golden eagles were observed. Results from surveys between 1998 and 2003 are found in Table 3, and results from 2007-2013 are found in Table 4. Of all the golden eagle nests in the analysis area, one had been active at least once between 1998 and 2003, and seven additional nests had been tended at least once (Cirrus 2004).

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Table 3. Golden Eagle Surveys Conducted in the analysis area by UDWR, 1998-2003 (Cirrus 2004).

Species	Nest Status	1998	1999	2000	2001	2002	2003
Golden eagle	Active	1	0	0	0	0	0
	Tended	1	1	2	2	2	2
	Inactive	4	4	5	7	7	6
	Dilapidated	1	1	0	0	1	0
	Not found	0	1	0	1	1	0
	Not surveyed	0	2	2	0	1	4
	Total	**7**	**9**	**9**	**10**	**12**	**12**

Table 4. Golden Eagle Surveys Conducted in the analysis area by UDWR and the Forest Service, 2007-2013 (Forest Service 2013c).

Species	Nest Status	2007	2008	2012	2013[1]
Golden eagle	Active	1	0	1	NA
	Tended	0	0	1	NA
	Inactive	6	9	3	NA
	Dilapidated	2	0	1	NA
	Not found	0	0	0	NA
	Not surveyed	3	3	6	NA
	Total	**12**	**12**	**12**	**12**

[1] These sites were surveyed in 2013; however status has not yet been compiled (Jewkes 2013a).

Incidental sightings of golden eagle individuals were made during summer 2002. One observation was made of an eagle soaring over the North Fork Muddy Creek near the junction with the South Fork. The other observation was of a golden eagle perching and vocalizing on a tree and then soaring over the main stem of the Muddy Creek about one mile below the confluence of the South and North Forks. One individual was seen flying over the North Fork of Muddy Creek in July 2003 and several eagle observations were made over the main stem of Muddy Creek in 2002 and 2003 (Cirrus 2004).

Nesting activity appeared to rebound in 2004 and active nesting was above the eight year average in 2005 and 2006 (Forest Service 2013b). Forest Service management practices have not shown to be a factor in dramatic change in the past eight years (2000 to 2007) nests have been surveyed. There has been some variation over the course of the years in nesting (Figure 6). Annual nesting variation is likely a result of precipitation rates which affect prey base (rabbits, prairie dogs etc.), numbers. In spite of this, active nests have been recorded in higher numbers on the MLNF than off the Forest at lower elevations (UDWR 2007b).

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2.4.2.5 Macroinvertebrates

Macroinvertebrates are an MIS group on the MLNF. Aquatic macroinvertebrates include insects, such as mayflies, stoneflies, caddis flies and dipterans (two-winged flies). They provide an ecological link between microscopic prey organisms and fish. Aquatic insects go through a series of life stages in a stream. Insects with incomplete metamorphosis (mayflies and stone flies) go through three stages: egg, nymph and adult. Insects with complete metamorphosis (caddis flies and dipterans) go through four stages: egg, larva, pupa and adult. The majority of their life is spent in the nymph or larva stage. While growing they go through a variety of stages called instars. The nymphs and larva emerge from the water as winged adults. The adults reproduce (lay eggs), completing the cycle.

The most resistant life stage of many aquatic insects is the egg; although, other life stages have shown to be persistent during dewatering events of up to 98 percent flow reductions (James 2008b, Danehy and Bilby 2009). Eggs of many aquatic insects can survive dry conditions for many months, and extended hatching periods are common to many stream insects (Hynes 1972). Aquatic insects also have a variety of life cycles with a few having multiple generations per year, and some take more than a year for each generation. Even with species that have annual generations, there may be overlapping generations (Hynes 1972). These factors increase the likelihood that the more resistant egg stages are present over prolonged periods, reducing the impacts of short-term environmental disturbances. These cyclic and highly variable populations also mean that monitoring of individual taxon populations is not feasible for land management monitoring purposes.

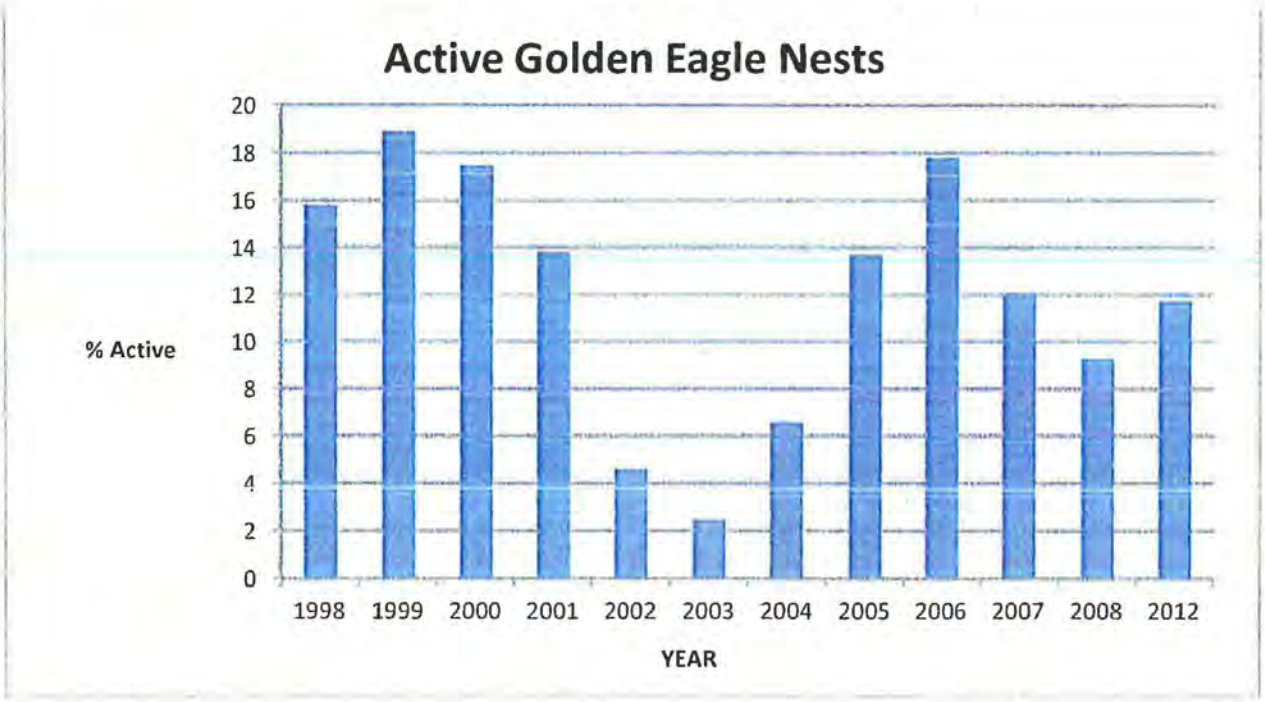

Figure 6. Percentages of active golden eagle nests monitored by the MLNF from 1998 to 2012 (Forest Service 2013b).

2.4.2.5.1 Monitoring Direction Update

The 1986 MLNF Forest Plan monitoring and evaluation program included aquatic macroinvertebrate species as MIS and called for monitoring as needed for select projects at baseline survey stations. This was the direction followed for the 2004 Technical Report (Cirrus 2004). The Forest Plan was amended in 2006 to update the protocols used to collect macroinvertebrate data and to change the method used to analyze the data. The 2006 amendment did not alter the language regarding macroinvertebrate monitoring as an optional technique for selected projects. No site-specific surveys of aquatic macroinvertebrates have been conducted and no site-specific monitoring is proposed for this project (Forest Service 2006). Monitoring will continue at baseline stations to characterize Forest-wide conditions; data analysis will be in cooperation with the Utah Division of Water Quality.

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2.4.2.6 Sage Nesters

Sage nesters are an MIS group for the FLNF. Brewer's sparrows (*Spizella breweri*), vesper sparrows (*Pooecetes gramineus*), and sage thrashers (*Oreoscoptes montanus*) were selected in the 1986 FLNF Forest Plan as MIS to be indicators of the health of sage brush communities. In the Fishlake Forest's MIS reporting, Rodriguez et al (2006), discuss each species separately giving natural history information, population trends, and other information. Below that information is summarized. See that document for full details and natural history information.

Potential Brewer's sparrow habitat has been mapped across the entire FLNF approximating 213, 491 acres of NFS land. However, suitable habitat on the FLNF portion of the project area is minimal. Surveys for avian MIS have been performed since the 1980s, and data has been collected field biologists for the species (on the Forest), from 1994 to 2004. During surveys on the Forest, the population trend appears to increase up to 2004 and then decrease in that year. Then, the population appeared to increase again in 2005 with only preliminary data being reported. Furthermore, the Breeding Bird Survey (35

years of data), and Nature Conservancy status (S4, Apparently Secure), show data that statewide populations (including points on the FLNF), are trending downward. Rodriguez et al (2006) interprets these data such that the population is viable on the FLNF, but the trend is slightly downward.

Potential suitable vesper sparrow habitat is located on all four FLNF ranger districts in the Forest on approximately 213,491 acres. However, suitable habitat on the FLNF portion of the project area is minimal. The Breeding Bird Survey (35 years of data), and Nature Conservancy status (S5, Secure), show data that statewide populations (including points on the FLNF), are slightly trending downward. Surveys for avian MIS have been performed since the 1980s, and data has been collected by professional birders for the species (on the Forest), from 1994 to 2004. Rodriguez et al (2006) interprets these data such that the population is viable on the FLNF, but the trend is slightly downward.

Potential sage thrasher habitat is located on the FLNF. However, suitable habitat on the FLNF portion of the project area is minimal. The Breeding Bird Survey (35 years of data), and Nature Conservancy status (S4, Apparently Secure), show data that statewide populations (including points on the FLNF), are trending downward. The Forest has expanded its efforts to locate populations of sage-related avian species. The sage thrasher has been observed on the Richfield Ranger District—the district in which this project area is located. Very little data is available on the species for the Forest, and additional field surveys and data collection is on-going to fine tune the population status of the species on the Forest.

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2.4.2.7 Cavity Nesters

Cavity nesters are an MIS group for the FLNF. Hairy woodpecker (*Picoides villosus*), western bluebird (*Sialia mexicana*), and mountain bluebirds (*Sialia currucoides*) were selected in the 1986 FLNF Forest Plan as MIS to be indicators of the health of communities containing cavity nesting habitat. In the Forest's MIS reporting, Rodriguez et al (2006), discuss each species separately giving natural history information, population trends, and other information. Below that information is summarized. See that document for full details and natural history information.

Potential hairy woodpecker habitat has been mapped across the entire FLNF approximating 423,432 acres of NFS land. Surveys for avian MIS have been performed since the 1980s, and data has been collected by professional birders for the species (on the Forest), from 1994 to 2004. Further, formal, Forest-wide surveys on the Richfield, Loa, and Beaver Ranger Districts have been conducted by a Brigham Young University graduate student. Additionally, the Breeding Bird Survey (35 years of data), and Nature Conservancy status (S4, Apparently Secure), show data that statewide populations (including points on the FLNF), are stable. Taking all of this data, Rodriguez et al (2006) interprets these data such that the population is stable and viable on the FLNF.

Potential western bluebird habitat is located on all four FLNF ranger districts in the Forest on approximately 423,432 acres. The Breeding Bird Survey (35 years of data), reports data that statewide populations (including points on the FLNF), are significantly increasing, especially since 1985. However, the Nature Conservancy has presented data demonstrating the species in an S2, Imperiled status. Surveys for avian MIS have been performed since the 1980s, and data has been collected by professional birders for the species (on the Forest), from 1994 to 2004. Considering all of this, Rodriguez et al (2006) interprets these data such that the population is viable on the FLNF, but additional monitoring efforts are needed to continue to evaluate the population trend and viability of the species on the Forest.

Potential mountain bluebird habitat is located on all four FLNF ranger districts in the Forest on approximately 423,432 acres. The Breeding Bird Survey (35 years of data), and Nature Conservancy status (S4, Apparently Secure), show data that statewide populations (including points on the FLNF), are stable. The Forest has expanded its efforts (including a Utah State University study in 2001), to locate populations of cavity-nesting avian species. Data is limited on the species for the Forest, and additional

field surveys and data collection is on-going to fine tune the population status of the species on the Forest. However, the data suggest mountain bluebird populations on the FLNF are viable and stable.

2.4.2.8 Riparian Nesters

Riparian nesters are an MIS group for the FLNF. Lincoln's sparrows (*Melospiza lincolnii*), song sparrows (*Melospiza* melodia), yellow warblers (*Dendroica petechia*), and MacGillivray's warblers (*Dendroica petechia*) were selected in the 1986 FLNF Forest Plan as MIS to be indicators of the health of riparian communities. In the Forest's MIS reporting, Rodriguez et al (2006), discuss each species separately giving natural history information, population trends, and other information. Below that information is summarized. See that document for full details and natural history information.

Potential Lincoln's sparrow habitat has been mapped across the entire FLNF on all four ranger districts, approximating 423,432 acres of NFS land and the species is wide-ranging and easily detectable. Surveys for avian MIS have been performed since the 1980s, and data has been collected by professional birders for the species (on the Forest), from 1994 to 2004. Additionally, the Breeding Bird Survey (35 years of data), found that statewide, the species enjoys an upward population trend including survey points on the FLNF. The Nature Conservancy lists its status as S4, Apparently Secure. Taking all of this data into consideration, Rodriguez (2006) interprets it such that the Lincoln's sparrow population is stable and viable on the FLNF.

Potential song sparrow habitat has been mapped across the entire FLNF on all four ranger districts, approximating 423,432 acres of NFS land and the species is wide-ranging and easily detectable. Surveys for avian MIS have been performed since the 1980s, and data has been collected by professional birders for the species (on the Forest), from 1994 to 2004. Additionally, the Breeding Bird Survey (35 years of data), found that statewide, the species enjoys a slight upward population trend including survey points on the FLNF. The Nature Conservancy lists its status as S4, Apparently Secure. Forest specific surveys have shown decreasing numbers, but in these surveys, not all transects were monitored and the sample size was small. Additional sampling and data collection will be required to fine tune the status of the population trend and viability on the FLNF. However, taking all of this data into consideration, Rodriguez (2006) interprets it such that the Lincoln's sparrow population is stable or in a slightly downward trend, but still viable on the FLNF.

Potential yellow warbler habitat has been mapped across the entire FLNF on all four ranger districts, approximating 423,432 acres of NFS land and the species is wide-ranging and easily detectable. Surveys for avian MIS have been performed since the 1980s, and data has been collected by professional birders for the species (on the Forest), from 1994 to 2004. Additionally, the Breeding Bird Survey (35 years of data), found that statewide, the species enjoys a stable to slightly upward population trend including survey points on the FLNF. The Nature Conservancy lists its status as S4, Apparently Secure. Forest specific surveys have shown decreasing numbers, but in these surveys, not all transects were monitored and the sample size was small. Additional sampling and data collection will be required to fine tune the status of the population trend and viability on the FLNF. However, taking all of this data into consideration, Rodriguez (2006) interprets it such that the Lincoln's sparrow population is in a stable trend and still viable on the FLNF.

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Potential MacGillivray's warbler habitat has been mapped across the entire FLNF on all four ranger districts, approximating 423,432 acres of NFS land and the species is wide-ranging and easily detectable. Surveys for avian MIS have been performed since the 1980s, and data has been collected by professional birders for the species (on the Forest), from 1994 to 2004. Additionally, the Breeding Bird Survey (35 years of data), found that statewide, the species enjoys an upward population trend including survey points on the FLNF. The Nature Conservancy lists its status as S4, Apparently Secure. Forest specific surveys have been limited and in these surveys, not all transects were monitored each year. Furthermore, the sample sizes were small. Additional sampling and data collection will be required to fine tune the

status of the population trend and viability on the FLNF. However, taking all of this data into consideration, Rodriguez et al (2006) interpret it such that the Lincoln's sparrow population is in a stable trend and still viable on the FLNF.

2.4.3 Species of High Federal Interest

2.4.3.1 Migratory Birds

The species of high federal interest for the Uinta-Southwestern Utah coal production region of Utah and Colorado includes many species of migratory birds. Kevin Albrecht, MLNF Ferron Ranger District wildlife biologist determined the species on this list that are considered in this analysis (Forest Service 2008b). This list was adapted from the Utah Partners in Flight Avian Conservation Strategy Version 2.0 (Parrish et al 2002) and species were excluded due to habitat and elevation requirements not found in the project area. The final list is located below in Table 5 along with the general habitat types required, elevation range, and predicted occurrence.

Table 5. Migratory birds of high federal interest.

Species[1]	Elevation Range (ft)[2]	Breeding Habitat[3]	Occurrence Expected[4]
Prairie falcon (*Falco mexicanus*)	3,000-14,000	Cliff, high-desert scrub	Observed
Brewer's sparrow[5] (*Spizella breweri*)	7,750-12,100[6]	Shrub steppe, high-desert shrub	Observed
Sage sparrow (*Amphispiza belli*)	4,000-10,000	Shrub steppe, high-desert shrub	Yes
Black-throated gray warbler (*Dendroica nigrescens*)	3,000-9,500	Pinyon-juniper, mountain shrub	Possible
Pinyon jay (*Gymnorhinus cyanocephalus*)	4,500-7,500	Pinyon-juniper, ponderosa pine	Observed
Virginia's warbler (*Vermivora virginiae*)	6,000-9,000	Pinyon-juniper, northern oak	Possible
Gray vireo (*Vireo vicinior*)	3,000-7,800	Pinyon-juniper, northern oak	Observed
Lewis's woodpecker (*Melanerpes lewis*)	3,000-8,000	Pine, mixed conifer, P/J, deciduous	Possible
Three-toed woodpecker[5] (*Picoides tridactylus*)	4,265-9,025	Sub-alpine conifer, lodgepole pine	Observed
Williamson's sapsucker (*Sphyrapicus thyroideus*)	5,500-11,000	Sub-alpine conifer, aspen	Observed
Broad-tailed hummingbird (*Selasphorus platycercus*)	At least to 10,600[6]	Low-land riparian, mountain riparian	Observed

[1]Forest Service 2008b.
[2]NatureServe 2013, Elevation range data is general.
[3]Parrish et al 2002.
[4]Cirrus 2004, Appendix C.
[5]These species are addressed in more detail in additional sections of this report.
[6]Elevation data not complete or very little data (especially state or site-specific data), exists for these species.

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2.4.3.1.1 Survey Methods

Migratory bird surveys were conducted during the previous Muddy Creek analysis survey effort (Cirrus 2004). Formal surveys following protocol for specific species were not performed. Migratory bird presence data collection was conducted as incidental sightings while conducting other surveys throughout

the project area. These surveys were conducted in the following general habitat types: riparian, grassland and forblands, sagebrush, mixed conifer, aspen and aspen mixed conifer, ponderosa pine, mahogany and mountain brush, limber pine, and pinyon pine/juniper. Greater emphasis was given to surveying the forested and sagebrush habitat types. It was determined that additional surveys were not required for this analysis.

Considerable time was spent traversing coniferous and mixed-coniferous forests and riparian habitats during the breeding season while surveying for sensitive species. Extensive time was also spent traversing shrub-steppe environments during the breeding season while surveying for sage-grouse. Time surveying in grassland habitat in 2001 to 2002 was limited to those areas adjacent to sagebrush habitat, and to the grasslands traversed while traveling to other habitats. In 2003, survey effort specifically included grasslands.

2.4.3.1.2 Survey Results

Due to changes in the species list (Forest Service 2008b), not all of the species listed during the previous 2003 Muddy Creek analysis (Cirrus 2004) were analyzed for this project. Further, many of the species listed for this project were not listed and not surveyed for during the 2001 to 2003 survey seasons. This data was collected for the Muddy Creek analysis (Cirrus 2004) and will reflect some of the discrepancies noted above.

Additional migratory bird surveys were completed over approximately 7,800 acres in the Wildcat Knolls area during the 2008 survey season. Several of the species listed above in Table 5 were recorded during these survey efforts (Forest Service 2008c).

Three known prairie falcon nests occur in the Muddy Creek tract buffer and have been surveyed with helicopters intermittently by UDWR since 1998. All three nests were surveyed with the assistance of Cirrus in 2002. Two were inactive and one was not found (Cirrus 2004). Overall, in the six-year survey period (1998 to 2003), including earlier than the 2002 aerial surveys, one of the nests was active twice and another nest was tended twice. The third nest was never recorded as either active or tended. One prairie falcon was observed across the canyon near Buzzard Bench during the 2002 aerial survey effort. No prairie falcons were observed in 2003. Two of these nests occur just east of the Greens Hollow tract boundary between the tract and the Wildcat Knolls lek complex. However, these nest locations are down in the canyon and separated elevationally from the project location.

Since the Muddy Creek Report (Cirrus 2004) was complete, prairie falcon surveys have continued on the nests in the area. Near the current Greens Hollow study area there are two nests that have continuing surveys. One located in Quitchupah Canyon is located approximately 0.2 miles from the project boundary and was not located in 2005 and 2006 and was recorded as inactive in 2008. This nest was not surveyed in 2004 and 2007. The other nest is located northeast of Muddy Creek approximately 2.6 miles from the project area. This nest has been inactive since 2001. (Jewkes 2008a).

Survey efforts in shrub-steppe environments and high-desert shrub where Brewer's and sage sparrows are expected resulted in observations of Brewer's but not sage sparrows (Cirrus 2004 Appendix C). Sage sparrows were expected to use habitat found within the project area and eventually were recorded in the Wildcat Knolls area in 2008. Brewer's sparrows were also observed in 2008. High-desert shrub habitat is located throughout the project area (4,485.3 acres or 13.5 percent) and likely provides ample habitat to support these species. Brewer's sparrows are also a R4 sensitive species and discussed above and in detail in Section 2.4.2.6.

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Black-throated warblers, pinyon jays, Virginia warblers, and gray vireos all utilize pinyon juniper woodlands with another component. This can be mountain shrubs, ponderosa pine, northern oak brush, or a combination of them all. During the surveys for the Muddy Creek analysis (Cirrus 2004 Appendix C),

pinyon jays and gray vireos were observed. During the 2008 surveys pinyon jays, Virginia warblers, and gray vireos were observed. It is possible that black-throated could breed in the project area as well. Pinyon juniper woodlands (977.6 acres or 2.9 percent) are limited in the analysis area but oak brush (1,476.9 acres or 4.4 percent) and particularly mountain shrub (4,485.3 acres or 13.5 percent) are much more prevalent which affords these species additional breeding habitat. All suitable habitat added together provides for a substantial amount of suitable breeding habitat within the project area.

The majority of the forested portions of the analysis area above 9,000 feet, thus it is possible that this habitat is above the elevation usually used by Lewis' woodpeckers. Although these woodpeckers generally use pine (2,098.8 acres or 6.3 percent) and mixed-coniferous (371.3 acres or 1.1 percent) forests, they are also associated with pinyon juniper (977.6 acres or 2.9 percent) and deciduous woodlands (Parrish et al 2002). As was mentioned above, pinyon juniper habitat is sparse in the project area, but there is an abundance of oak brush (1,476.9 acres or 4.4 percent), aspen (2,319 acres or 7.0 percent), and a few other deciduous habitat types available. During the 2001 to 2003 field survey effort for the Muddy Creek analysis, no Lewis' woodpeckers were observed.

One female Williamson's sapsucker was observed while conducting three-toed woodpecker surveys in 2002. It was observed first on a north-facing embankment above a tributary of the North Fork Muddy (Cirrus 2004). The embankment contained a mixture of spruce-fir (39.5 acres or 0.1 percent), aspen (2,319 acres or 7.0 percent) and snags. The sapsucker was then observed entering a nest tree. The nest was in a 14 inch dbh aspen snag within an old beaver pond site. Williamson's sapsuckers were also recorded during the 2008 survey efforts. Three-toed woodpeckers are also a R4 sensitive species and discussed above in greater detail in Section 2.4.1.8.

During the Muddy Creek survey effort from 2001 to 2003, broad-tailed hummingbirds were observed in the project area (Cirrus 2004 Appendix C). Broad-tailed hummingbirds often nest 1 to 4 meters above the ground, and often above water in riparian areas (NatureServe 2013). Although they are known to frequent a variety of habitats, the Utah Partners in Flight Avian Conservation Strategy Version 2.0 (Parrish et al 2002) lists its breeding habitat as low-land and mountain riparian. The project area contains just 47.6 acres (0.14 percent) of riparian habitat.

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2.4.4 Other Wildlife Species

2.4.4.1 Amphibians

Surveys for amphibians were conducted in suitable breeding habitats in the analysis area in 2001, 2002, and 2003. Suitable habitat was defined as natural ponds and wetlands, and pooled habitat adjacent to streams. Man-made water holes and reservoirs containing emergent vegetation were also considered suitable habitat. Potential pond sites were identified from aerial photographs and through field reconnaissance.

2.4.4.1.1 Survey Methods

Amphibian encounter surveys were conducted in June and July 2001 within the analysis area by walking around the periphery of ponds and pools and scanning the area for amphibian adults, larvae, and/or eggs. Visual scans for amphibians were also made in streams where habitat conditions looked favorable. In addition, aural observations of the more vocal amphibian species were made during late afternoon and in the evening. (Cirrus 2004).

Additional amphibian habitat was assessed during the pond monitoring effort conducted for the Utah School and Institutional Trust Land Administration (SITLA) in September 2002. A total of 11 ponds were surveyed for the previous Muddy Creek analysis area. Of these, five were natural basins and six were man-made. The majority of natural basins were dry during the survey effort. In addition to the survey parameters recorded for SITLA, the ponds were visually scanned for the presence of amphibians,

and were assessed for habitat suitability (water depth, presence of emergent vegetation, and livestock disturbance). (Cirrus 2004).

Ponds that were dry during the 2001 and 2002 surveys and appeared to offer suitable habitat for amphibians were revisited in early spring of 2003. As soon as they became accessible, to survey for amphibians and the ponds still held water. Ponds where boreal toads (*Bufo boreas*) had been observed in 2001 were also revisited in 2003, to attempt to confirm those sightings. Additional sites identified from aerial photos were also visited. (Cirrus 2004).

2.4.4.1.2 Survey Results

Four species of amphibians were observed in the analysis area in 2001 (Cirrus 2004). Chorus frogs (*Pseudacris sp.*) were found in a series of ponds in the western portion of the 2-mile buffer, from White Mountain Cabin to Julius Flat Reservoir and in one pond just inside the tract. Chorus frogs were also heard calling in late June at Julius Flat Reservoir. Tiger salamander (*Ambystoma tigrinum*) larvae were abundant in a pond in The Pines, in the eastern portion of the 2-mile buffer of the previous Muddy Creek project area, and were also present in four ponds in the western part of the buffer zone and in one pond just inside the tract. Boreal toad larvae were observed in July 2001 in a pond 1.3 miles west of the current Greens Hollow tract boundary. This pond site is located within the old, 2004 Muddy Creek analysis area and is the only site boreal toads were observed.Great Basin spadefoot toads (*Scaphiopus intermontanus*) were potentially heard calling in the southeast corner of the Muddy Creek buffer zone, in a cattle pond and at the bottom of Box Canyon. However, the elevation of the analysis area may be above that used by this species. Very few amphibians were found inside of the tract boundary, proper, presumably because very little amphibian breeding habitat is present.

No amphibians were observed during the 2002 survey effort, presumably because it was conducted after the breeding season and the majority of the suitable habitat was dry. However, chorus frogs were heard calling at Julius Flat Reservoir. Ponds that were considered suitable amphibian habitat were recorded for future surveys during the breeding season.

In 2003, chorus frogs were observed at eight new ponds and at two ponds where they had already been observed in 2001, and tiger salamanders were observed at three new ponds and at one pond where they had been observed in 2001. All those ponds were located in the western part of the previous Muddy Creek project buffer zone. No boreal toads or Great Basin spadefoot toads were observed in 2003.

In summary, over the three-year survey period, chorus frogs were observed at fifteen ponds, tiger salamanders at nine ponds, and boreal toads at two ponds. Additionally, Great Basin spadefoot toads were possibly heard at two locations. Most of those ponds were located in the western portion of the 2003 Muddy Creek buffer zone, with the exception of the two potential spadefoot toad observations and one salamander pond located in the southeast part of the buffer, and one pond located inside the tract, near its western edge.

2.4.4.2 Reptiles

No formal surveys for reptiles were conducted in the analysis area for the 2003 Muddy Creek project. However, Cirrus personnel traversed abundant habitat at all hours of the day, and performed informal searches on and under rocks and ledges in rock outcrops and sandstone formations. Five species of reptiles were observed incidentally during field visits in the analysis area (eastern fence lizard (*Sceloporus undulatus*), western terrestrial garter snake (*Thamnophis elegans*), tree lizard (*Urosaurus sp.*), sagebrush lizard (*Sceloporus graciosus*), and short-horned lizard (*Phrynosoma hernandesi*)), between 2001 and 2003. Overall, very few reptiles were observed.

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2.4.4.3 Small mammals

No surveys were required for small mammals. Twenty-two species of mammals, including sixteen small mammals, were observed incidentally in the previous Muddy Creek analysis area between 2001 and 2003 (Cirrus 2004). A few additional chipmunks, ground squirrels, and pocket gophers were observed but not identified to species. For the purpose of this analysis, small mammals include shrews, bats, small carnivores (Procyonidae, Bassariscidae, and Mustelidae, with the exception of the wolverine (*Gulo gulo*)), rodents, and lagomorphs. Ungulates and large carnivores (Ursidae, Canidae, Felidae, and the wolverine) will not be addressed in this section.

Since no trapping was conducted, and since the nocturnal nature of many small mammals makes them difficult to observe, probability-of-occurrence analysis was conducted to determine what additional species could potentially occur in the analysis area. Factors used to determine probable occurrence included habitat requirements reported in the literature, habitat presence in the project area, and documented occurrence, through surveys, historic records, and incidental observations of individuals in or near the analysis area. Results of this analysis are discussed generally below, by habitat type, and depicted in the Muddy Creek Wildlife Technical Report; Appendix D (Cirrus 2004).

According to Dalton et al. (1990), 69 species of small mammals are likely present in the Wasatch Plateau area, where the analysis area is located. These species include 5 shrews, 15 bats, 9 small carnivores, 34 rodents, and 6 lagomorphs. However, based on the UDWR inventory of sensitive species in Utah (UDWR 1997), two of these species are not expected to occur in the project area: the red bat (*Lasiurus blossevillii*) and the river otter (*Lontra canadensis*). On the other hand, two additional species, the spotted bat and the grasshopper mouse (*Onychomys sp.*), were observed by Cirrus personnel in the analysis area, and one more species, the Hopi chipmunk (*Tamias rufus*), could also occur there, based on predicted habitat maps found on the UDWR web site (Utah Gap Analysis 1997). This would bring the total number of small mammal species potentially occurring in the analysis area to 70 (5 shrews, 15 bats, 8 small carnivores, 36 rodents, and 6 lagomorphs), of which 16 were observed during the survey effort for the 2003 Muddy Creek analysis (Cirrus 2004).

A comprehensive list of small mammal species and their habitat requirements and relative abundance in the Wasatch Plateau area is presented in the Muddy Creek Wildlife Technical Report; Appendix C (Cirrus 2004). County records of species occurrence, the presence of predicted suitable habitat, and the expected occurrence of individual species in the analysis area are also depicted. Species were included in the table if they were mentioned as occurring in the Wasatch Plateau area by Dalton et al. (1990); or if predicted habitat for these species was present on or near the analysis area, according to the maps on the UDWR web site (UDWR 2013); or if records of the species existed in one or more of the counties in which the analysis area was located. However, some of these species are not expected to occur in the analysis area proper. For instance, Utah prairie dogs (*Cynomys parvidens*) are present in Sevier County but are not expected to occur in the analysis area due to lack of habitat. Predicted habitat for the dwarf shrew (*Sorex nanus*) exists in the analysis area but this species is seemingly very rare, known from only four localities in Utah, and is not expected to occur in the Wasatch Plateau area.

Various habitat types are represented in the analysis area (Figure 7). General types include sagebrush (*Artemesia sp.*), pinyon-juniper, mahogany and mountain brush, grassland and forbland, aspen (*Populus tremuloides*) and aspen-mixed conifers, mixed conifers, ponderosa pine (*Pinus ponderosa*), limber pine (*Pinus flexilis*), rock outcrops and barren areas, and riparian areas, wetlands, and reservoirs. Some wildlife species may occur in only one particular habitat type, while others may use a wide variety of habitats. Riparian and wetland areas are used by the highest number of wildlife species but represent only a very small proportion of the habitat in the analysis area (Cirrus 2004). A general description of species that use each habitat type follows.

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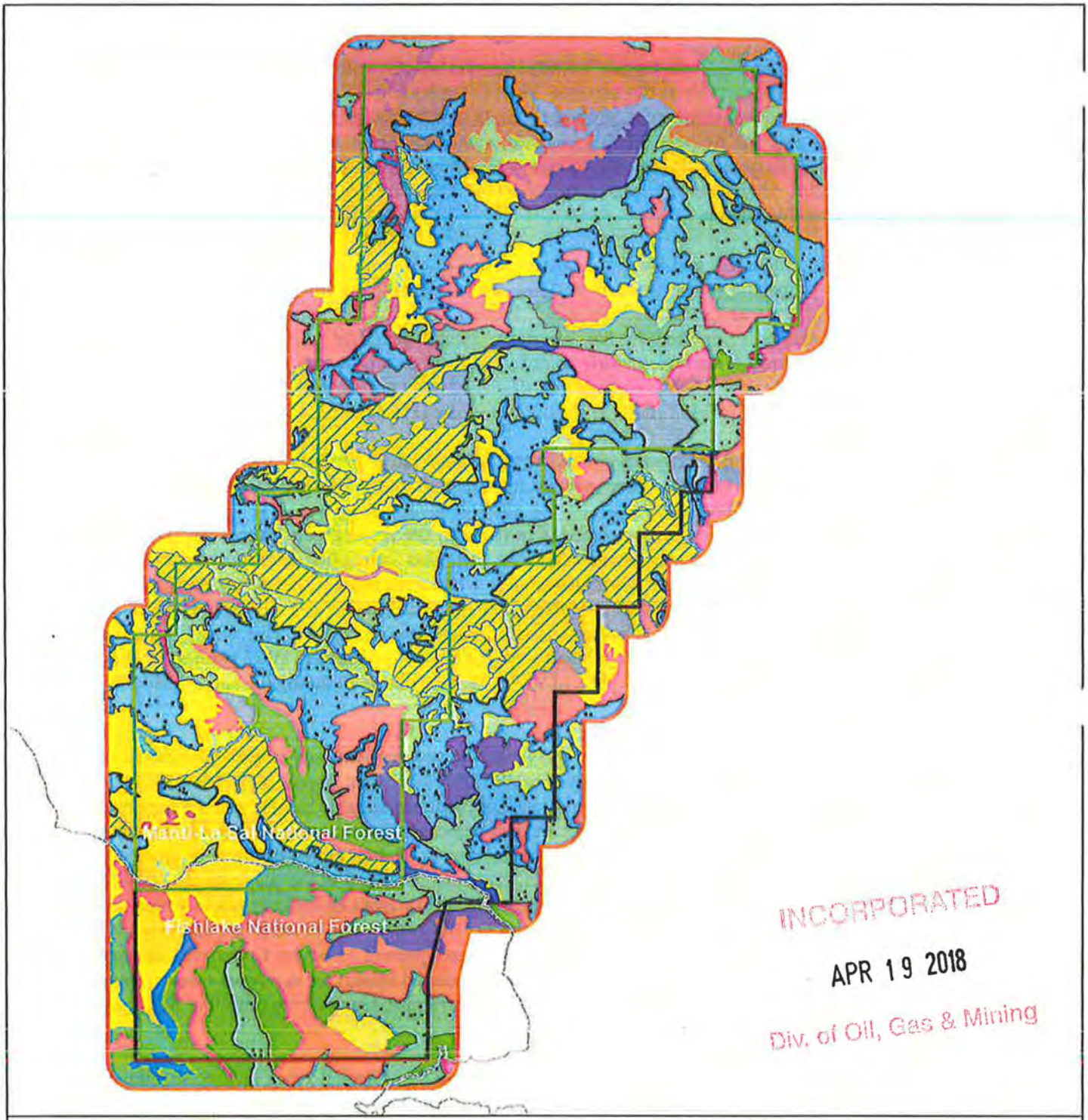

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Figure 7. Habitat types.

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Legend

- Greens Hollow Coal Lease Tract
- Area of Subsidence Mining
- Mining Analysis Area Boundary
- Manti-La Sal/Fishlake Forest Boundary

Vegetation Communities

- Aspen
- Aspen Mixed Conifer
- Barren Rock Outcrop or Ledge
- Basin Big Sagebrush
- Big Mountain Sagebrush
- Black Sagebrush
- Silver Sagebrush
- Cottonwood/Brush
- Curlleaf Mountain Mahogany
- True Mountain Mahogany
- Juniper/Curl-leaf Mohogany
- Limber & or Bristlecone Pine Forest
- Douglas Fir Forest
- Mixed Conifer
- Spruce/Fir Forest
- White Fir Forest
- Ponderosa Pine Forest
- Pinyon Juniper Woodland
- Rocky Mountain Juniper Woodland
- Mountain Brush
- High Mountain Brush
- Oakbrush
- Manzanita
- Perennial Forb Land (high & mid elevation)
- Perennial Forb Land (mid to low elevation)
- Perennial Grassland (low elevation)
- Perennial Grassland (mid elevation)
- Perennial Wetland or Meadow
- Intermittent Wet/Dry Meadow
- Willow Dominated Riparian Area

Sagebrush

Sagebrush is one of the most widespread (19.27 percent) and abundant habitat types in the analysis area. Small mammal species using sagebrush on the Wasatch Plateau include the least chipmunk (*Tamias minimus*), Great Basin pocket mouse (*Perognathus parvus*), long-tailed vole (*Microtus longicaudus*), meadow vole (*Microtus pennsylvanicus*), black-tailed jackrabbit (*Lepus californicus*), white-tailed jackrabbit (*Lepus townsendii*), desert cottontail (*Sylvilagus audubonii*), and mountain cottontail (*Sylvilagus nuttallii*). Both species of jackrabbits and the mountain cottontail were observed in the analysis area. The desert cottontail occurs at lower elevations than the mountain cottontail, generally below 6,000 feet. Since the analysis area is above 6,000 feet, most cottontails present in the area are likely to be mountain cottontails.

Pinyon-Juniper

Pinyon-juniper habitat type is rare (1.78 percent) in the analysis area. Small mammal species found in this habitat on the Wasatch Plateau include the cliff chipmunk (*Tamias dorsalis*), which was observed in the analysis area), Hopi chipmunk, Great Basin pocket mouse, canyon mouse (*Peromyscus crinitus*), and pinyon mouse (*Peromyscus truei*). The ringtail (*Bassariscus astutus*) could also potentially occur, in Muddy Creek Canyon.

Mahogany and Mountain Brush

Mahogany and mountain brush represent the most abundant (33.30 percent) habitat type in the analysis area. Species associated with this habitat on the Wasatch Plateau include the spotted skunk (*Spilogale gracilis*), cliff chipmunk, brush mouse (*Peromyscus boylii*), canyon mouse, and mountain cottontail. The cliff chipmunk and mountain cottontail were observed in the analysis area.

Grasslands and Forblands

Grassland/forbland habitats are relatively common (10.93 percent) in the analysis area, occurring primarily in patches adjacent to pinyon-juniper, and sagebrush habitat types. Small mammals found in these habitats on the Wasatch Plateau include the badger (*Taxidea taxus*), yellow-bellied marmot (*Marmota flaviventris*), Uintah ground squirrel (*Spermophilus armatus*), least chipmunk (*Tamias minimus*), northern pocket gopher (*Thomomys talpoides*), plains pocket mouse (*Perognathus flavescens*), Great Basin pocket mouse (*Perognathus parvus*), long-tailed vole, montane vole (*Microtus montanus*), meadow vole, western jumping mouse (*Zapus princeps*), black-tailed jackrabbit, and white-tailed jackrabbit. The badger, yellow-bellied marmot, Uintah ground squirrel, northern grasshopper mouse, both species of jackrabbits, and an unidentified pocket gopher species were observed in the analysis area.

Aspen and Aspen-Mixed Conifer

The aspen and aspen-mixed conifer habitat type is common (24.96 percent) in the analysis area. Small mammal species using those habitats include beaver (*Castor canadensis*), porcupine (*Erethizon dorsatum*), and snowshoe hare (*Lepus americanus*), all of which were observed in the analysis area.

Mixed Conifer

Mixed conifers (mostly Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), subalpine fir (*Abies lasiocarpa*), Englemann spruce (*Picea engelmannii*)) represent small (0.72 percent) component of the analysis area and are associated primarily with the perennial drainages. Typical small mammal species inhabiting coniferous forests on the Wasatch Plateau include the northern flying squirrel (*Glaucomys sabrinus*), the red squirrel (*Tamiasciurus hudsonicus*), the porcupine, and the snowshoe hare. The Uintah chipmunk is found in openings in coniferous forests or at forest edges. Most of these species were observed in the analysis area, with the exception of the northern flying squirrel.

Ponderosa Pine

Ponderosa pine represents a minor component (0.06 percent) in the analysis area as is limber pine (0.22 percent), occurring only in small, localized areas. Small mammal species using these two habitats on the Wasatch Plateau primarily include generalist species that can be found in a variety of other habitats as

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well including the cliff chipmunk (observed in the analysis area), least chipmunk, northern pocket gopher, deer mouse (*Peromyscus sp.*), and long-tailed vole.

Rock Outcrops and Barren Areas

Rock outcrops and barren areas are rare (2.48 percent) in the analysis area. Several small mammals use these habitat features on the Wasatch Plateau. Species observed in the analysis area include the yellow-bellied marmot, golden-mantled ground squirrel (*Spermophilus lateralis*), cliff chipmunk, Uintah chipmunk (*Tamias umbrinus*), bushy-tailed woodrat (*Neotoma cinerea*), and mountain cottontail. The spotted bat uses cliffs with rock crevices for roosting and was heard vocalizing at night. The ringtail, spotted skunk, rock squirrel (*Spermophilus variegatus*), Hopi chipmunk, desert woodrat (*Neotoma lepida*), canyon mouse (*Peromyscus crinitus*), and pika (*Ochotona princeps*) could also occur in this habitat type.

Riparian Areas and Wetlands

Riparian areas and wetlands are scarce (0.22 percent) in the analysis area but are used by the highest number of wildlife species. These habitats are present in Muddy Creek Canyon and associated tributaries, and along the North Fork of Quitchupah Creek and several other sections of the project area. Typical riparian or wetland species found on the Wasatch Plateau include the masked shrew (*Sorex cinereus*), northern water shrew (*Sorex palustris*), vagrant shrew (*Sorex vagrans*), ringtail, raccoon (*Procyon lotor*), ermine (*Mustela erminea*), mink (*Neovison vison*), beaver, western harvest mouse (*Reithrodontomys megalotis*), western jumping mouse, long-tailed vole, meadow vole, water vole (*Microtus richardsoni*), and muskrat (*Ondatra zibethicus*). Of these species, only the beaver was actually seen in the analysis area, but the other species are also expected to occur there. Most bat species also forage near water.

2.4.4.4 Non-game birds

A list of bird species observed was compiled from incidental observations made during field visits to the study area in spring, summer, and fall 2001 to 2003. This list is presented in the Muddy Creek Wildlife Technical Report; Appendix C (Cirrus 2004). Cirrus personnel identified 90 species of birds in the previous Muddy analysis area, including 84 non-game birds and 6 game birds. Unidentified flycatchers (*Tyrannidae sp.*) and vireos (*Vireo sp.*) were also observed. Forest Service personnel completed additional migratory bird surveys in June and July of 2008. Some 7,800 acres in the Wildcat Knolls area was surveyed for this effort (Forest Service 2008c).

A probability-of-occurrence analysis was conducted to determine what additional non-game bird species (that were not observed during field surveys), could potentially occur in the analysis area. Factors used to determine probable occurrence included habitat requirements reported in the literature, habitat presence in the project area, and documented occurrence, through surveys, historic records, and incidental observations of individuals in or near the analysis area. Results of this analysis are discussed generally below by habitat types described in section 2.4.4.3, and are depicted in Appendix E of the Muddy Creek Wildlife Technical Report (Cirrus 2004).

According to the information presented in Dalton et al. (1990), 201 species of non-game birds frequent the Wasatch Plateau area, excluding accidental species that are not normally found in the area. This includes 69 yearlong residents, 92 summer residents, 8 winter residents and 32 transients. Yearlong and summer residents are species that breed in the area (161 species total), winter residents breed in northern regions and only spend the winter in the area, and transients pass through the area during spring and/or fall migrations and do not remain in the area for any extended period of time. Nine of these species are unlikely to occur in the project area due to lack of suitable habitat or because the project area is outside of their range. On the other hand, six additional species were observed by Cirrus personnel in the analysis area or its vicinity, and five more could potentially be present there, based on the predicted habitat maps from the UDWR web site (UDWR 2013). This brings the total number of non-game birds potentially

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present in the analysis area to 203, of which 84 were actually observed during the 2001 to 2003 survey effort.

A comprehensive list of non-game bird species and their habitat requirements, seasonal status, and relative abundance in the Wasatch Plateau area is presented in Appendix E of the Muddy Creek Wildlife Technical Report (Cirrus 2004). Upland game birds, waterfowl, and pigeons/doves were considered to be game birds and are not included in the table. Five species of upland game birds, 20 waterfowl species (10 of them transient) and 3 pigeon/dove species are also present in the Wasatch Plateau area.

Non-game bird species observed in sagebrush habitat in the analysis area included the turkey vulture (*Cathartes aura*), golden eagle (*Aquila chrysaetos*), common poorwill (*Phalaenoptilus nuttallii*), broad-tailed hummingbird (*Selasphorus platycercus*), gray flycatcher (*Empidonax wrightii*), sage thrasher (*Oreoscoptes montanus*), and vesper sparrow (*Pooecetes gramineus*). The Brewer's sparrow (*Spizella breweri*) was also observed, even though this species was listed by Dalton et al. (1990) as not known to inhabit the Wasatch Plateau area. The rough-legged hawk (*Buteo lagopus*) is expected to occur in this habitat during winter but most of the analysis area is usually inaccessible in that season due to deep snow or mud making the roads un-drivable, therefore, the presence or absence of this species could not be determined.

Species observed in pinyon-juniper habitat included the gray flycatcher, ash-throated flycatcher (*Myiarchus cinerascens*), western scrub jay (*Aphelocoma californica*), pinyon jay (*Gymnorhinus cyanocephalus*), green-tailed towhee (*Pipilo chlorurus*), and gray vireo (*Vireo vicinior,* which was not listed by Dalton et al. (1990) as present in the Wasatch Plateau area). The bushtit (*Psaltriparus minimus*), juniper titmouse (*Baeolophus ridgwayi*), blue-gray gnatcatcher (*Polioptila caerulea*), Bewick's wren (*Thryomanes bewickii*), black-throated gray warbler (*Dendroica nigrescens*), and Virginia's warbler (*Vermivora virginiae*) could also occur in this habitat in the analysis area.

Species commonly occurring in mahogany and mountain brush on the Wasatch Plateau include the broad-tailed hummingbird, the dusky flycatcher (*Empidonax oberholseri*), the western scrub jay, the black-billed magpie (*Pica hudsonia*), the bushtit, the Virginia's warbler, the dark-eyed junco (*Junco hyemalis*), and the spotted towhee (*Pipilo maculatus*). Of these, the broad-tailed hummingbird, western scrub jay, black-billed magpie, dark-eyed junco, and spotted towhee were observed in the analysis area, as well as unidentified flycatchers.

Species observed in grassland and forbland habitats in the analysis area included the turkey vulture, prairie falcon (*Falco mexicanus*), short-eared owl (*Asio flammeus*), common poorwill, vesper sparrow, and western meadowlark (*Sturnella neglecta*), even though this last species was not listed as present on the Wasatch Plateau by Dalton et al. (1990). Other species potentially using these habitats in the analysis area include the northern harrier (*Circus cyaneus*), rough-legged hawk (in winter), and horned lark (*Eremophila alpestris*). In 2004 Cirrus surveyed some of the grasslands in the analysis area for burrowing owls (*Athene cunicularia*) but did not find any. Grasslands in the analysis area may not be open enough for this species, as most of them are small and interspersed with shrubs.

Aspen and aspen-mixed conifer habitats in the analysis area are used by the Cooper's hawk (*Accipiter cooperii*), northern goshawk, flammulated owl, broad-tailed hummingbird (near openings), northern flicker (*Colaptes auratus*), downy woodpecker (*Picoides pubescens*), hairy woodpecker (*Picoides villosus*), Williamson's sapsucker (*Sphyrapicus thyroideus*), red-naped sapsucker (*Sphyrapicus nuchalis*), olive-sided flycatcher (*Contopus cooperi*), western wood-pewee (*Contopus sordidulus*), violet-green swallow (*Tachycineta thalassina*), black-capped chickadee (*Poecile atricapillus*), red-breasted nuthatch (*Sitta canadensis*), brown creeper (*Certhia americana*), warbling vireo (*Vireo swainsonii*), yellow-rumped warbler (*Dendroica coronata*), orange-crowned warbler (*Vermivora celata*), western tanager (*Piranga ludoviciana*), and dark-eyed junco. The white-breasted nuthatch (*Sitta carolinensis*) and solitary

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vireo (*Vireo solitarius*) were not observed but are also expected to occur in that habitat in the study area (Cirrus 2004).

Mixed conifers provide habitat for the Cooper's hawk, northern goshawk, great horned owl (*Bubo virginianus*), flammulated owl, northern saw-whet owl (*Aegolius acadicus*), broad-tailed hummingbird (near openings), three-toed woodpecker (*Picoides tridactylus*), hairy woodpecker, Williamson's sapsucker, red-naped sapsucker, olive-sided flycatcher, western wood-pewee, tree swallow (*Tachycineta bicolor*), violet-green swallow (*Tachycineta thalassina*), Steller's jay (*Cyanocitta stelleri*), Clark's nutcracker (*Nucifraga columbiana*), gray jay (*Perisoreus canadensis*), mountain chickadee (*Poecile gambeli*), red-breasted nuthatch (*Sitta canadensis*), brown creeper, ruby-crowned kinglet (*Regulus calendula*), hermit thrush (*Catharus guttatus*), Townsend's solitaire (*Myadestes townsendi*), yellow-rumped warbler, western tanager, dark-eyed junco, chipping sparrow (*Spizella passerina*), pine siskin (*Carduelis pinus*), and pine grosbeak (*Pinicola enucleator*). Additional species that were not observed but are expected to occur in this habitat include the cordilleran flycatcher (*Empidonax occidentalis*), white-breasted nuthatch, golden-crowned kinglet (*Regulus satrapa*), Swainson's thrush (*Catharus ustulatus*), Cassin's finch (*Carpodacus cassinii*), and red crossbill (*Loxia curvirostra*). The Townsend's warbler (*Dendroica townsendi*) could occur here during migrations.

Species observed in ponderosa pine included the flammulated owl, northern flicker, hairy woodpecker, brown creeper, and pine grosbeak. The pygmy nuthatch, solitary vireo, and Cassin's finch are also likely to be present in this habitat in the study area and the Williamson's sapsucker could occur in this habitat also (it was observed in the analysis area in a different habitat).

Species associated with rocky outcrops or barren areas included the golden eagle, peregrine falcon, prairie falcon, white-throated swift, canyon wren, and rock wren. Many of these species are known to occur in close proximity to the Greens Hollow area in the canyon areas just southeast of the project area and directly south of the Wildcat Knolls lekking areas.

Of all habitats, riparian areas, wetlands, and reservoirs are used by the highest number of bird species. Some species use almost exclusively these habitats while others spend part of their time in other habitats. Most transient species use these habitats during migrations, including loons, grebes, shorebirds, waterfowl, gulls, and warblers. Two reservoirs are present in the Muddy Creek buffer surveyed for the 2003 EIS (Julius Flat Reservoir and Brush Reservoir), as well as various ponds and several perennial streams. Typical species using riparian areas, wetlands, or reservoirs in the analysis area include the sora rail, spotted sandpiper, cliff swallow, tree swallow, American dipper, MacGillivray's warbler, yellow warbler, and song sparrow. Five bald eagles were also observed along Cowboy Creek on the Muddy Tract in November 2003, as mentioned earlier in this report. The common loon, western grebe, pied-billed grebe, American white pelican, American coot, common snipe, great blue heron, California gull, belted kingfisher, barn swallow, bank swallow, northern rough-winged swallow, willow flycatcher, Wilson's warbler, and lazuli bunting were not observed but could also occur in the study area, as well as a variety of transient shorebirds.

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3.0 RESULTS AND DISCUSSION

This section provides background information necessary to assess potential impacts to terrestrial and aquatic wildlife that could occur as a result of implementing the action alternatives. The potential and/or known occurrence and habitat requirements for four categories of wildlife are discussed. The categories of wildlife addressed include the following: (1) federally listed endangered, threatened, and candidate species and Forest Service sensitive species (TES), (2) management indicator species (MIS), (3) species

of high federal interest, and (4) other wildlife species not addressed in the previous categories, including fishes, amphibians, reptiles, small mammals, and non-game birds.

3.1 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1.1 AQUATIC AND TERRESTRIAL HABITAT

The analysis area is comprised of the mining analysis area boundary as described in Chapter 2. The proposed area of subsidence mining varies in size depending on the alternative being proposed. Those acreages will be disclosed with the discussions of alternatives.

Ten wildlife habitat types are used in this analysis, of which one is aquatic and the rest terrestrial. The digital coverage of vegetation types for the MLNF (Forest Service 2002) was used as a guide to define these types, and similar vegetation cover types in this coverage were consolidated. A brief description of habitat types used in this analysis follows. Further discussion of habitat types can be found in the Vegetation Resources Technical Report (Cirrus 2013a).

3.1.1.1 Aquatic Habitat

The primary perennial streams in and around the analysis area include Muddy Creek, North and South Forks of Muddy Creek, and the North Fork of Quitchupah Creek. In addition, perennial flow is present intermittently in portions of Cowboy Creek, Greens Hollow, Greens Canyon, and North Fork of Quitchupah Creek. Of these streams, only portions of Muddy Creek and its north and south forks, Cowboy Creek, Greens Hollow, and the North Fork of Quitchupah Creek occur within the mining analysis area boundary. Most streams in the analysis area are intermittent and do not provide good quality fish habitat. Intermittent streams are unlikely to contain cutthroat trout or other fish species. A complete list of perennial streams in the analysis area is included in the Surface and Ground Water Technical Report (Cirrus 2013b).

The analysis area includes a riparian habitat component which comprises less than one percent of the entire analysis area; however, it is of critical importance to wildlife species. Included in this habitat component are wetlands; dry and wet meadows; willow and tree dominated riparian areas; lakes, ponds, and reservoirs; and springs and seeps. These habitats are important for a variety of wildlife species, as many wildlife use riparian areas for at least some part of their life cycle. The extent of wetlands in the analysis area is detailed in the Vegetation Resources Technical Report (Cirrus 2013a).

3.1.1.2 Terrestrial Habitat

The analysis area contains a variety of terrestrial habitats, including sagebrush, pinyon-juniper, mahogany and mountain brush, grassland and forbland, aspen and aspen-mixed conifers, mixed conifers, ponderosa pine, limber pine, and rock outcrops and barren areas (Figure 7).

Mahogany and mountain brush (9,092.8 acres or 27.4 percent) constitute the most abundant habitat type, occurring throughout the analysis area. Sagebrush (7,740.6 acres or 23.3 percent) is the second most widespread and abundant habitat type in the analysis area. The aspen and aspen-mixed conifer (5,724.4 acres or 17.2 percent) habitat type is common throughout the analysis area as well. Grassland/forbland (3,891.6 acres or 11.7 percent) habitats are relatively common in the analysis area, occurring primarily in patches adjacent to pinyon-juniper and sagebrush habitat types. Mixed conifers (371.3 acres or 1.1 percent, mostly Douglas-fir, subalpine fir, and Englemann spruce) represent a small component of the analysis area and are associated primarily with the perennial drainages. Ponderosa pine represents a minor component (1,754.1 acres or 5.3 percent) in the analysis area, occurring throughout the tract. However, this is one of the only locations where ponderosa pine occurs on the North Zone of the MLNF. The pinyon-juniper (977.6 acres or 2.9 percent) and limber and/or bristlecone pine (344.6 acres or 1.0

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percent) habitat types are rare in the analysis area, occurring mostly outside the tract. Rock outcrops and barren areas (706.7 acres or 2.1 percent) are also rare in the analysis area, being limited primarily to the canyon walls of the Muddy drainage.

3.1.2 TES

The U.S. Fish and Wildlife Service's (USFWS) annual list of federally listed and proposed endangered, threatened, and candidate species and habitat in Utah by County (USFWS 2013) indicates that three terrestrial threatened or endangered species (endangered: California condor, and threatened: Utah prairie dog, and yellow-billed cuckoo), and one candidate species for listing (greater sage-grouse) could potentially occur in Sanpete and/or Sevier counties. Four aquatic Colorado River endangered fishes (bonytail, Colorado pikeminnow, humpback chub, and razorback sucker), have recently been listed for Sanpete and Sevier Counties since water from drainages in these counties ultimately reaches the Colorado River (USFWS 2013). There is also one aquatic candidate species (least chub) (USFWS 2013). The Forest Service document titled *Intermountain Region Threatened, Endangered, Proposed, and Sensitive Species: Known/Suspected Distribution by Forest* (Forest Service 2013b) indicates Forest Service Sensitive species that could occur on the MLNF and FLNF. The species that could occur on one or both forests and their status are listed in Table 6.

Of the species listed in Table 6, the yellow-billed cuckoo, Utah prairie dog, Columbia spotted frog, least chub, southern leatherside chub, bighorn sheep, and Canada lynx are not predicted to occur in the analysis area and are not analyzed in this document. The remaining species could potentially occur in the analysis area and are addressed in this document.

The yellow-billed cuckoo is not addressed because the analysis area is above the elevational range (2,500 to 6,000 feet in Utah) of this species (Parrish et al 2002).

Although approximately 10 percent of the project area is low-to-mid-elevation perennial grasslands and forblands, Utah prairie dogs do not occur within the project area. Suitable habitat is present near the town of Emery, however, the last record of this species in this area was in 1929 (Utah Gap Analysis 1997). The Utah prairie dog is not addressed as there is no evidence of historical occupation or current and likely recurring presence of prairie dog towns or complexes in the project area (NatureServe 2013).

The Columbia spotted frog is not addressed because the analysis area is outside of the habitat range for this species. Although this species does occur in Sanpete County, it has only been found in the Sanpete Valley along the San Pitch River. This population is geographically isolated from all other populations and is known only from 11 spring complexes on private agricultural land. (USFWS 2002b).

The least chub and southern leatherside chub are not addressed since they are lower elevation species that are not known to occur on the MLNF or FLNF (Forest Service 2013b).

Bighorn sheep are known to occur on the MLNF and FLNF; however they do not occur in the analysis area (Forest Service 2013b).

The Canada lynx is not addressed because there are not suitably large tracts of denning or winter foraging habitat for the species in the project area. However, a single, transient lynx from the Colorado Division of Wildlife (CDOW) reintroduction program was trapped south of the town of Emery (more than 30 straight-line miles away) in early November 2004. The sub-adult male lynx had taken up residence in a desert wash adjacent to agricultural fields in historical bobcat habitat. Fearing the lynx would be injured during bobcat trapping season UDWR and CDOW personnel trapped the lynx and returned it to more traditional, high-alpine lynx habitat in Colorado. (UDWR 2004).

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Table 6. Federally listed threatened and endangered and candidate species and Forest Service sensitive species potentially occurring on the MLNF and FLNF in Sanpete and/or Sevier counties.	
Species	**Status**
Fishes	
Bonytail (*Gila elegans*)	Endangered
Colorado pikeminnow (*Ptychocheilus lucius*)	Endangered
Humpback chub (*Gila cypha*)	Endangered
Razorback sucker (*Xyrauchen texanus*)	Endangered
Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*)	Sensitive (FLNF and MLNF)
Bonneville cutthroat trout (*Oncorhynchus clarki utah*)	Sensitive (FLNF and MLNF)
Southern leatherside chub (*Leidomeda aliciae*)	Sensitive (FLNF and MLNF)
Birds	
California condor (*Gymnogyps californianus*)	Endangered
Bald eagle (*Haliaeetus leucocephalus*)	Sensitive (MLNF and FLNF)
Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*)	Threatened (Sanpete and Sevier counties)
Northern goshawk (*Accipiter gentilis*)	Sensitive (MLNF and FLNF)
Flammulated owl (*Otus flammeolus*)	Sensitive (MLNF and FLNF)
Peregrine falcon (*Falco peregrinus*)	Sensitive (MLNF and FLNF)
Three-toed woodpecker (*Picoides ridactytus*)	Sensitive (MLNF and FLNF)
Greater sage-grouse (*Centrocercus urophasianus*)	Candidate (Sanpete and Sevier counties) and Sensitive (MLNF and FLNF)
Mammals	
Utah prairie dog (*Cynomys parvidens*)	Threatened
Bighorn sheep (*Ovis canadensis*)	Sensitive (FLNF and MLNF)
Pygmy rabbit (*Brachylagus idahoensis*)	Sensitive (FLNF)
Spotted bat (*Euderma maculatum*)	Sensitive (MLNF and FLNF)
Townsend's big-eared bat (*Corynorhinus townsendii pallescens*)	Sensitive (MLNF and FLNF)
Amphibians	
Columbia spotted frog (*Rana luteiventris*)	Sensitive (MLNF)
Western boreal toad (*Bufo boreas boreas*)	Sensitive (FLNF and MLNF)

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3.1.2.1 TES Fish

Habitat requirements and life history characteristics of the fish species present within the analysis area or in the vicinity of it are described below. Special emphasis is given to Threatened, Endangered, and Sensitive species. However, although the bonytail, Colorado pikeminnow, humpback chub, and razorback sucker do not occur within the analysis area, it is reasonably foreseeable that water from the Colorado River drainage could be used for conceptual implementation of surface resources. Within the

analysis area, Colorado River and Bonneville cutthroat trout are the only fish species listed as sensitive by R4 of the Forest Service. No other TES fish are present within the analysis area

The results of fish surveys conducted in 2001 and 2002 on perennial streams by the Utah Division of Wildlife Resources (UDWR) indicated that native cutthroat trout are present in Muddy Creek and the South Fork of Muddy Creek (Berg 2002a, Berg 2002b, Berg 2002c, and Hart and Berg 2003). Surveys in 2010 confirmed the persistence of cutthroat trout in tributaries of the South Fork of Muddy Creek although surveys downstream, near the MLNF border detected no fish in Muddy Creek (Jewkes 2013c). Cutthroat trout were also observed incidentally on the North Fork of Muddy Creek, but formal surveys have not yet occurred there. This cutthroat trout is thought to be of the Colorado River subspecies based on their known distribution in Utah. No cutthroat trout were observed at the North Fork of Quitchupah Creek (Berg 2002a, Berg 2002b, Berg 2002c, and Hart and Berg 2003).

3.1.2.1.1 Colorado River Cutthroat Trout

The distribution and abundance of Colorado River Cutthroat Trout (CRCT) have declined and it is now believed that this species occupies less than 14 percent of its historical range. CRCT historically occupied about 21,386 miles of habitat in the western U.S. CRCT currently occupy about 3,022 miles of habitat, of which 1,111 miles are within the state of Utah. Of the 3,022 miles of habitat currently occupied by CRCT, 2,248 miles are administered by Federal agencies. Two-thirds of all occupied habitats occur on National Forests (Hirsch et al. 2005). Within the Lower Colorado Geographic Unit, there are 14 CRCT conservation populations in 50 miles of stream and 5 conservation populations in 21 acres of lakes throughout the state (CRCT Coordination Team 2006). As noted previously, CRCT are thought to occur in the analysis area in the South Fork of Muddy Creek.

3.1.2.1.2 Bonneville Cutthroat Trout

A total of 153 separate Bonneville Cutthroat Trout (BVCT) populations occupy 2,061 miles of habitat which were designated as "conservation populations" (87 percent of currently occupied habitat). These conservation populations were spread throughout the historical range, occurring in 19 of the 23 hydrologic units historically occupied by BVCT (May and Albeke 2005). Currently, there are only four streams on the MLNF with populations of BVCT. There are no BVCT populations within the analysis area (Jewkes 2008b).

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3.1.2.1.3 Bonytail

The bony tail evolved 3 to 5 million years ago and is a member of the minnow family. Historically, they were probably the most abundant fish species in the main river channels of the Colorado and Green rivers. They thrived in open areas of large river channels of uniform depth and current velocity. This species is considered to be adapted to pools and eddies of mainstream rivers that have moderately swift currents and shifting sand bottoms. They were once common in portions of the upper and lower Colorado River basins. It has been extirpated from most of its historic range, and nearly extinct upstream of Lake Powell. Currently, a small number of adults exist in Lake Mohave and Lake Havasu in the Lower Colorado River Basin, and there are small numbers of individuals in the Green and Yampa Rivers and in sub-basins of the Upper Colorado River Basin (USFWS 2002a). This species was given full protection under the Endangered Species Act (ESA) when it was listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1980, and it was given protection under Utah law in 1974. There are no known reproducing populations in the wild; however bonytail are being hatchery raised, and reintroduced into the wild through stocking in the Colorado, Green, and Yampa rivers. They have been known to live nearly 50 years, are capable of spawning at 5 to 7 years of age, and are thought to spawn during late June and early July in warm water reaches.

3.1.2.1.4 Colorado Pikeminnow

The Colorado pikeminnow is the largest minnow in North America, and is endemic to the Colorado River Basin. It historically extended from the Green River in Wyoming, to the Gulf of California; it was widespread and abundant in warm-water rivers and tributaries. Currently in Utah, they exist in the Green

River from Lodore Canyon to the confluence of the Colorado River, and in the lower Duchesne River. It is a long-distance migrator (hundreds of miles to and from spawning areas). Adults require deep pool and eddie habitats in streams that have high spring flows (USFWS 2002c). This species was listed as endangered by the Service in 1967 and given full protection under ESA in 1973, and it was given protection under Utah law in 1973. They live 50 or more years, begin spawning by 6 years of age, and spawn between Late July and early September.

3.1.2.1.5 Humpback Chub

The humpback chub is thought to have evolved 3 to 5 million years ago. It is restricted to deep, swift mainstems and large tributaries in relatively inaccessible canyons of the Colorado River Basin. Adults require eddies and sheltered shorelines in streams that maintain high spring flows that flush sediments from spawning areas and form clean gravel deposits. Young require low-velocity shoreline habitats (USFWS 2002d). Historically, this species inhabited white water canyons of the Colorado River and four of its tributaries: the Green, Yampa, White and Little Colorado rivers. Currently there are two stable populations in canyons in the upper Colorado River and one in the Grand Canyon. There are smaller populations in the Yampa and Green rivers. This species was listed as endangered by the Service in 1964 and given full protection under the ESA in 1973, and given protection under Utah law in 1973. They may live more than 30 years in the wild, can reproduce by 2 to 3 years of age, and spawn between March and July.

3.1.2.1.6 Razorback Sucker

Historically the razorback sucker was widely distributed in warm-water reaches of the Colorado River and its tributaries from Wyoming to Mexico. Adults require deep pools, eddies and backwaters in the spring; shallow water associated with sandbars in summer; and low velocity pools and eddies in winter. Young require quiet, warm, shallow water found at tributary mouths and in coves or shorelines in reservoirs. Currently, within the Upper Colorado River Basin this species is only found in small numbers in the middle Green River between the confluence of the Duchesne and Yampa rivers, and in the lower reaches of those two tributaries (USFWS 2002e). This species was listed as endangered by the Service in 1991, and it was given protection under Utah law in 1973. They have been known to live 40 years or more. They can begin reproducing as early as age 3 or 4, and typically spawn between mid-April and Mid June, but have known to spawn as early as November.

3.1.2.1.7 Southern Leatherside Chub

Southern leatherside chub inhabit desert streams of the Bonneville Basin. Southern leatherside require flowing water and do not persist in lakes or reservoirs. Stream systems occupied by this species have a broad range of widely varying physical conditions including high variability of stream flow, annual precipitation, gradient, elevation, conductivity, and pH. The elevational range of observations for southern leatherside is from 3,700 to 8,600 feet (UDWR 2010). Southern leatherside chub have been documented in three 4th level HUCs (Hydrologic Unit Code) in the Utah Lake drainage and six 4th level HUCs in the Sevier River Drainage (UDWR 2010). There are no populations of southern leatherside chub present within the analysis area. The southern leatherside chub is not addressed in detail in Chapter 4 because the analysis area is outside of the range for this species.

3.1.2.2 TES Birds

3.1.2.2.1 Bald Eagle

In Utah, the bald eagle is primarily a winter resident, with only eleven known pairs of nesting eagles in the state, none of which occur on the MLNF or FLNF (UDWR 2005a, 2009). An eagle nest does occur on private land about 18 miles east of the northeastern boundary of the analysis area, near the town of Castledale. It is unlikely that individuals from this eagle pair would utilize portions of the analysis area for foraging, since suitable habitat is available closer to the nest site.

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Only one observation of bald eagles was recorded in the analysis area during the 2001 to 2003 analysis period (Cirrus 2004). Five bald eagle individuals (3 adults and 2 juveniles) were sighted in November 2003 along Cowboy Creek, presumably during fall migration (Cirrus 2004). Winter roosting habitat is limited in the analysis area due to the high elevation and lack of roost trees. In general, use of the permit area would be incidental and likely in connection with fall or spring migration.

3.1.2.2.2 Northern goshawk

Suitable habitat is present in the analysis area, but is limited primarily to the aspen and aspen-mixed conifer cover types on the western portion of the tract buffer. Two years of surveys were conducted for goshawks in suitable habitat in the analysis area from 2001 to 2003 (see section 2.4.1.3). During the survey period for the Muddy Creek analysis, goshawks were heard and/or seen at three calling stations within the analysis area (Cirrus 2004).

The Forest Service has been monitoring two goshawk nests near the analysis area. One occurs north of Julius Flat Reservoir. This territory was unoccupied during the 2000, 2004, 2005, 2007, and 2010 breeding seasons, but found to be occupied in 2006 and 2008 (Jewkes 2008a). The other nest occurs near Meadow Gulch, about four miles northeast of the Greens Hollow tract. This territory has been unoccupied since 1996 (Jewkes 2008a). In 2009, a goshawk was observed on two different occasions during breeding bird surveys (Forest Service 2009e). None of the goshawk responses during the survey effort occurred within the home ranges of the known goshawk pairs, indicating that these goshawks were from a different pair or pairs.

The northern goshawk was added to the list of MIS for the MLNF in June 2003 as an amendment to the 1986 Forest Plan. This species replaced the blue grouse as a MIS. One of the standards and guidelines associated with goshawk management is monitoring of territory occupancy on a Forest-wide basis. Less than 20 percent decline in territory occupancy over a 3-year period is considered acceptable for this species. As of 2012, territory occupancy of total nests checked is approximately 42 percent forest-wide (Forest Service 2013b). This is slightly lower than the 2001 high of approximately 45 percent, but the trend over the past five years (since 2008), shows a dramatic increase in territory occupancy (see Figure 5 above).

3.1.2.2.3 Flammulated Owl

Flammulated owls occur in mixed pine forests, from pine mixed with oak and pinyon at lower elevations to pine mixed with spruce and fir at higher elevations. They have also been found in aspen, second-growth ponderosa pine, and mixed coniferous forest. Preferred habitat is mature ponderosa pine/Douglas-fir forests with dense saplings and oak or other brushy understory (McCallum 1994). Large diameter (>20 inch dbh) dead trees with cavities at least as large as northern flicker cavities are important site characteristics. Flammulated owls are strictly nocturnal and feed almost exclusively on insects. Foraging occurs in large, open forest stands with space between the tree crowns to provide room for flight and hovering (Reynolds and Linkhart 1987). Territory size varies and is determined by age and patchiness of tree canopy. Flammulated owls are migratory in the northern part of their range. They arrive on their breeding territories in May and depart by mid-October, when they migrate south to central Mexico and Central America (McCallum 1994).

Preferred habitat is present in and around the southeastern portion of the analysis area. In addition, aspen stands to the west provide suitable habitat for this species. Two years of surveys were conducted for flammulated owls in suitable habitat in the Muddy Creek analysis area between 2001 and 2003 as well as surveys in 2008 (section 2.4.1.2). Flammulated owls were heard and/or seen at 26 calling stations (section 2.4.1.2). Surveys conducted in 2008 received no responses to broadcast calls (Cirrus 2008). Surveys were also conducted on the Pines Tract in 2008, 2009, and 2010 by MLNF personnel (Forest Service 2010a). This area is directly north and east of the Wildcat Knolls sage-grouse leks. Surveys were conducted in the Wildcat Knolls area in 2009, 2010, and 2011 (Forest Service 2013d). Detections were

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recorded during these survey efforts at the Pines Tract but not at Wildcat Knolls (Jewkes 2008a, Forest Service 2010b, Forest Service 2013d).

3.1.2.2.4 Peregrine Falcon

Peregrine falcons are found in a wide variety of habitats in the Intermountain West. They prefer to nest on cliffs (generally at least 200 feet in height), usually in mountainous areas or in river canyons and gorges; although aeries are also known in metropolitan areas on structures such as towers and high-rise buildings (White et al 2002). Peregrines prey almost exclusively on other species of birds, especially doves, pigeons, shorebirds, waterfowl, and passerines. They may forage up to 18 miles away from their aeries, although most hunting occurs within a 10-mile radius of the nest, and often over 80 percent of the foraging occurs within 1 mile of the aerie (Ehrlich et al. 1988). Peregrines overwinter in a wide range of habitats, but in the Intermountain West they appear to concentrate along large rivers and in wildlife refuges. Some birds may remain on their breeding territories throughout the year if there is an adequate food supply. Aeries have been reported at elevations above 10,500 feet, although nesting above 8,000 feet is extremely rare (White et al 2002).

Suitable nesting habitat is present in the analysis area on the rock escarpments bordering parts of Muddy Creek and its tributaries. A pair of peregrine falcons was observed in 2002 near the rim of Muddy Creek Canyon outside of the expected subsidence zone to the east of the analysis area. The pair was exhibiting territorial behavior and it was presumed that a nest was nearby within the cliff faces. A peregrine falcon was observed circling above an inactive golden eagle nest during UDWR aerial surveys in 2003, less than one-half mile from the 2002 observation. No falcons were observed in 2001 (Cirrus 2004). Additional peregrine falcon surveys have not been completed in the project vicinity since 2003.

3.1.2.2.5 Three-Toed Woodpecker

Three-toed woodpeckers typically inhabit spruce/fir forests up to 9,000 feet, but where insect populations are high they may also occur in ponderosa or lodgepole pine forests. They are most apparent in years and locations where trees have high insect populations, and are attracted to areas with numerous dead trees from wildfires, insect epidemics, blow-down, or other die-off (Andrews and Righter 1992). The woodpeckers forage on wood-boring insects in dead trees, primarily spruce beetles (Peterson 1990). Foraging habitat appears to be more strongly affected by the proportion of dead and damaged trees as opposed to particular tree species. Soft snags are preferred for excavating nest cavities, although they occasionally excavate live trees. This species may make small movements off its breeding territory in the winter to find food but is generally a year-round resident (Wiggins 2004).

Surveys for this woodpecker in the analysis area from June 21 to July 19 in 2001 and May 24 to June 23 in 2002 resulted in 16 individual responses at 13 separate locations (see section 2.4.1.7). Additionally, a female was observed incidentally in the area during a goshawk survey in 2002. All woodpecker observations were in or within two miles of the western portion of the analysis area boundary and associated with the aspen and aspen mixed conifer habitat type (Cirrus 2004). During 2010 surveys, no three-toed woodpeckers were observed in the Wildcat Knolls area (Forest Service 2010c); however two were observed in The Pines area (Forest Service 2010d).

3.1.2.2.6 Greater Sage-grouse

The greater sage-grouse is an upland game bird that is entirely dependent upon sagebrush communities for all stages of its life cycle, with extensive areas of this habitat type required year-round. Sage-grouse have a high fidelity to their seasonal habitats (breeding, late brood-rearing, and wintering habitats), and females commonly return to the same areas to nest each year (Peck et al 2012). Depending on geographic location, breeding activities occur from March through early summer. Most sage-grouse nests are located under sagebrush plants that provide overhead cover, with 15 to 30 percent canopy cover preferred. Late brood-rearing habitats, used from summer into fall, usually have less dense sagebrush canopy than nesting habitats and generally have a higher proportion of grasses and forbs in the understory. Riparian meadows, springs, and streams are also used during this time, especially in dry years, as these areas

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produce the forbs and insects necessary for juvenile birds. Because the diet of chicks consists of forbs and insects, diverse plant communities with abundant insect populations are especially important. During winter, sage-grouse feed almost exclusively on sagebrush leaves and buds, so exposure above the snow, rather than canopy cover, is critical (Connelly et al 2004).

One known lek complex adjacent to the analysis area (the Wildcat Knolls strutting ground) is currently used by the species (Forest Service 2013a). While no formal surveys of this population were conducted prior to 1991, biologists in the area observed a decline in the sage-grouse population to the point where it was suspected that there were only a few remaining individuals in the area. In order to reverse this decline, 48 sage-grouse were transplanted to the southern portion of the analysis area by UDWR between 1987 and 1990 (Cirrus 2004). UDWR and the Forest Service have been annually monitoring the Wildcat Knolls lek complex since 1991. The site has received use by 3 to 36 cocks on a given year, with the lowest numbers observed in 2003. In recent years (2011 to 2013), higher grouse numbers have been observed (Forest Service 2013a). Sage-grouse counts in 2013 show numbers at 33 birds (Forest Service 2013a).

Grouse sign was observed in additional portions of the analysis area that potentially provide suitable habitat for lek sites. These sites were surveyed during the breeding season between 2001 and 2003, and although a few cocks and hens were observed between the Head of Box Canyon and East Fork Box Canyon, the birds were not engaged in any lekking displays. Abundant grouse sign was observed in that area and several adults were observed near the headwaters of Box Canyon later in the survey years. It is assumed the canyon edges are used for roosting. Brood-rearing habitat is also present. In addition, several grouse were observed drinking from cattle troughs in this area. Grouse were also observed using Box Pond as a watering site. (Cirrus 2004).

Winter surveys for strutting greater sage-grouse on the Wildcat Knolls lek complex have been ongoing since 1991 (Forest Service 2013a). In Section 2.4.1.3 the results of these surveys are discussed and presented in Table 2.

Sage-grouse habitat is fairly limited on the Greens Hollow tract (Figure 8). According to the UDWR "sage-grouse habitat" map there are 3,840 acres (including the lek) of "priority" sage-grouse habitat on the Greens Hollow tract. There is no "general" habitat in the area. However, the UDWR layer was created with a very coarse resolution and includes many areas that are not sage-grouse habitat (e.g., ponderosa pine stands, cliff areas, aspen stands); therefore, another layer was created for use on this project that more accurately reflects sage-grouse habitat in the area. The revised sage grouse habitat map shows a total of 1,617 acres of "priority" sage-grouse habitat on the Greens Hollow tract (Figure 8).

The revised sage-grouse habitat layer in Figure 8 is a more accurate representation of sage-grouse habitat in the project area, and excludes non-habitat areas included in the UDWR habitat layer. This layer was created by Forest Service Biologists, Kevin Albrecht and Jeff Jewkes, after site visits on July 8, 2013, and October 25, 2013. Photos provided (Figures 9-16) correspond to photo points on Figure 8 and show representative areas of unsuitable habitat that were removed from the UDWR sage-grouse habitat layer.

Research on the Wildcat Knolls sage-grouse population has been recently concluded by Utah State University graduate students. This research not only supports lek counts collected by Forest Service personnel, but has mapped nesting and brood-rearing locations in the area as well. Their findings indicate that the Wildcat Knolls area not only serves as good lekking habitat but sage-grouse use the area year round and are nonmigratory (Perkins 2010). The USU research suggests that given the nonmigratory, isolated nature of this population, great care should be taken to protect this habitat (Perkins 2010).

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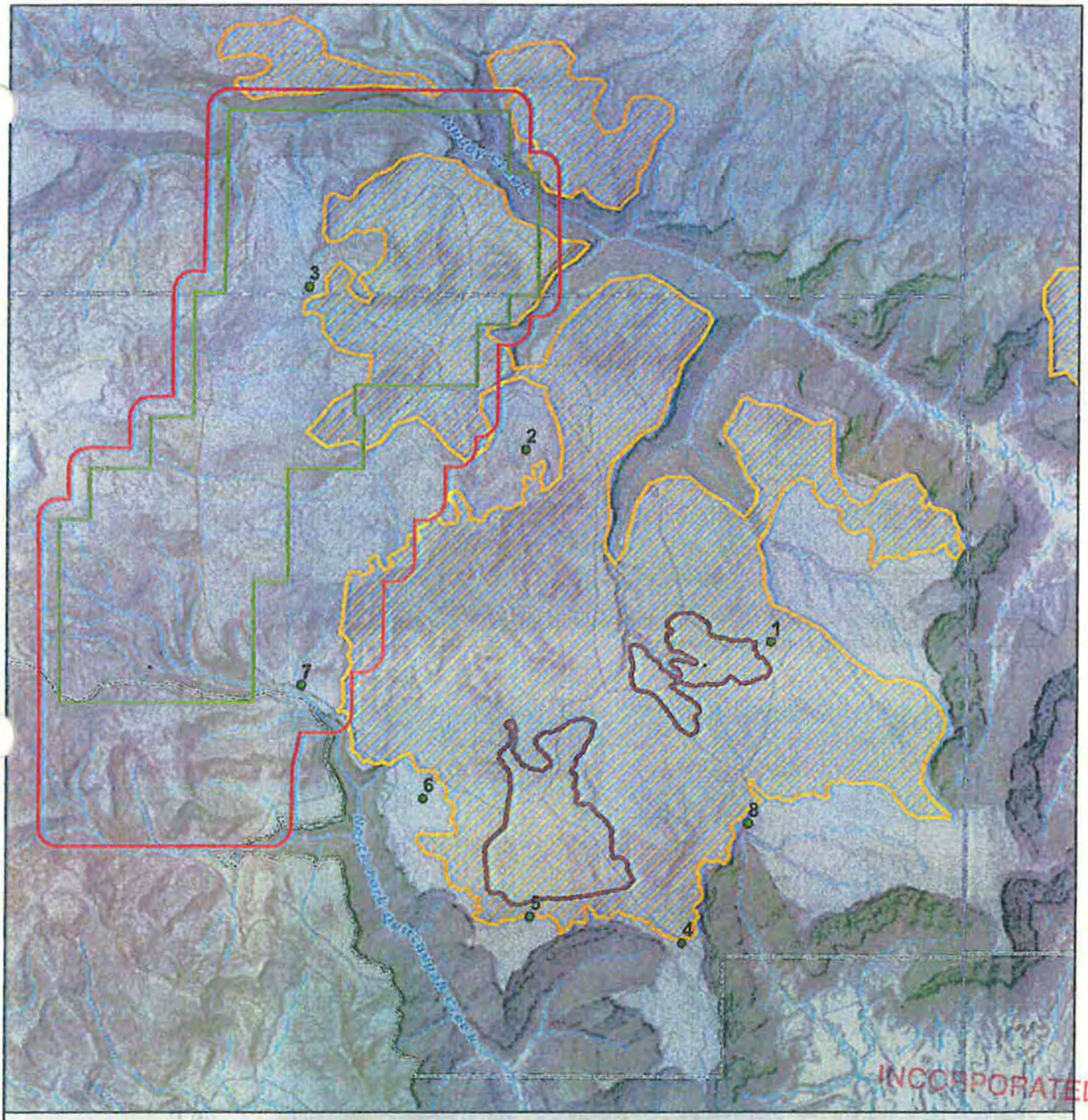

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Figure 8. Revised sage-grouse habitat.

N
W E
S

1 0.5 0 1 Miles

1:74,500

Legend

- Photo Points
- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- Manti-La Sal/Fishlake Forest Boundary
- Sage-Grouse Lek
- Revised Sage-Grouse Habitat
- UDWR Sage-Grouse Habitat

Figure 9. Photopoint 1, facing northeast.

Figure 10. Photopoint 2, facing southwest.

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Figure 11. Photopoint 3, facing south.

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Figure 12. Photopoint 4, facing south.

Figure 13. Photopoint 5, facing south.

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Figure 14. Photopoint 6, facing southwest.

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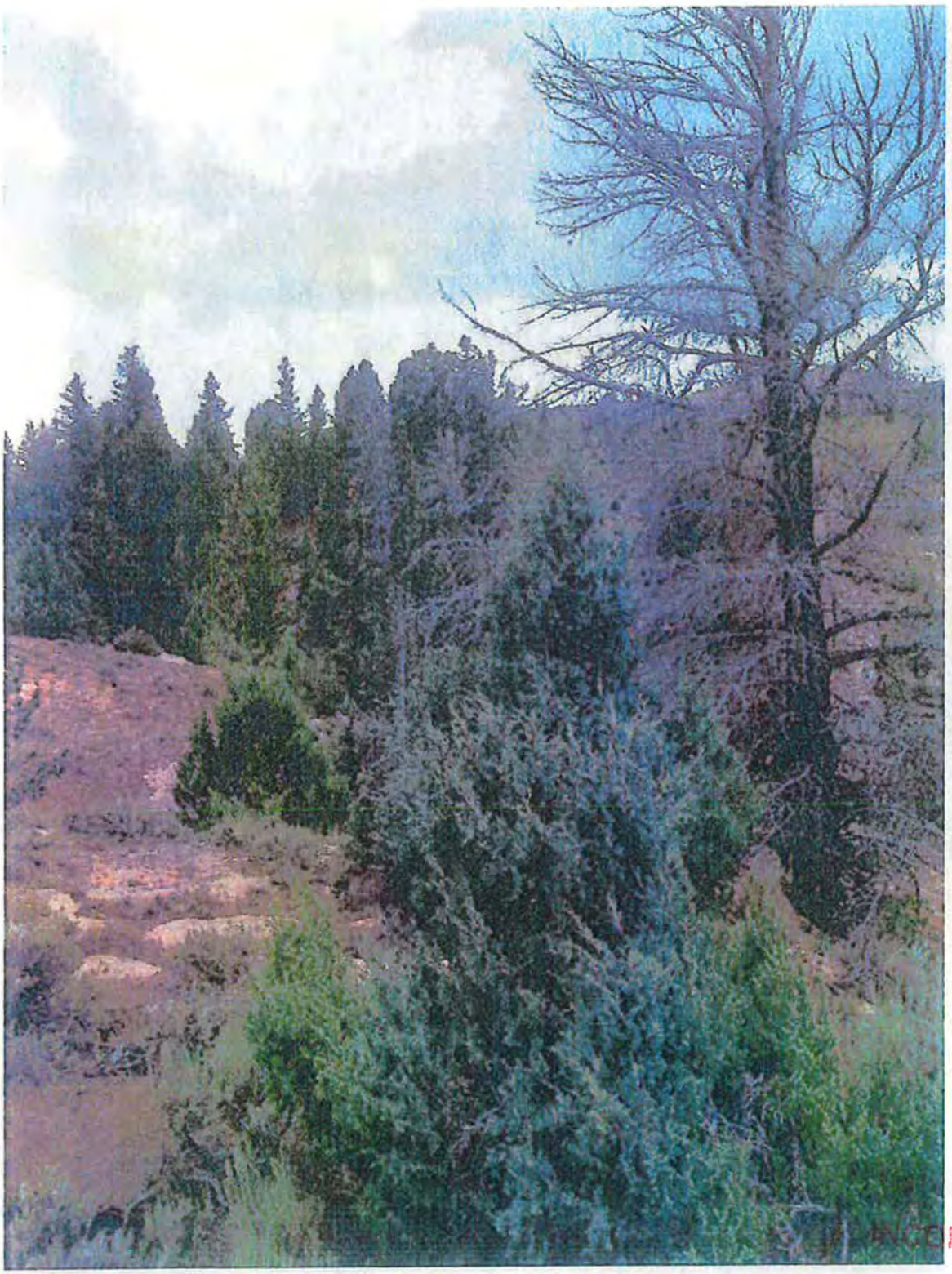

Figure 15. Photopoint 7, facing north.

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Figure 16. Photopoint 8, facing east.

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3.1.2.2.7 California Condor

California condors were recently added to the Sanpete and Sevier County lists (USFWS 2013) of federally endangered species in Utah. Not a habitat specialist, the species demonstrates very broad habitat and climatic tolerances. Historically, condors covered a large portion of western North America from British Columbia to Baja Mexico and as far east as western Colorado and Wyoming. Currently, the species inhabits a much smaller range, but still, diverse habitats within that range are occupied (Snyder and Schmitt 2002).

Nesting habitats have ranged from scrubby chaparral to forested montane regions subject to winter snowfalls. Most foraging activity has been documented in relatively open grassland regions. In recent times, primary foraging regions have been separate from the primary nesting regions, necessitating substantial commutes between nests and food supplies. The most critical habitat requirements may be adequate food supplies, open-enough habitat that food can be readily found and accessed, and reliable air movements allowing extended soaring flight (Snyder and Schmitt 2002).

3.1.2.3 TES Mammals

3.1.2.3.1 Spotted bat

Spotted bats are found in relatively remote, undisturbed areas in a variety of habitats, including open ponderosa pine, desert shrub, pinyon-juniper, and open pasture and hay fields, and have been recorded at elevations as high as 9,500 feet. They roost alone in rock crevices on steep cliff faces and have been found hibernating in caves. Spotted bats are territorial and use echolocation to avoid each other while foraging. Their diet consists primarily of moths caught in flight after dark in open pine stands and over marshes (Wai-Ping and Fenton 1989). Information on seasonal movements is scarce, though spotted bats are thought to migrate south to hibernate (Toone 1993).

Suitable roosting habitat for spotted bats is abundant in vertical cracks of the sandstone cliff faces of steep canyons in the analysis area. Riparian habitat and forest edges in this area also provide potential foraging opportunities. Several spotted bats were identified in the analysis area by audible vocalizations.

Auditory bat observations were associated with the rocky cliff habitat and ponderosa pine along the East Fork and main stem of Box Canyon and along Greens and Cowboy Canyons. Bats were also observed foraging in the limber pine habitat near Julius Flats Reservoir and above the North Fork of Muddy Creek, and in the limber pine/Douglas-fir habitat along the jeep trail running west and south of Cowboy Creek (Toone 1993). Spotted bats have also been identified in Muddy Creek Canyon and the lower end of Box Canyon with ANABAT detectors (Perkins and Peterson 1997).

3.1.2.3.2 Townsend's Big-eared Bat

Townsend's big-eared bats use juniper/pine forests, shrub/steppe grasslands, deciduous forests, and mixed coniferous forests from sea level to 10,000 feet. During winter they roost singly or in small clusters in caves, mine shafts, rocky outcrops, or occasionally in old buildings (Oliver 2000). They remain at these sites, called hibernacula, from October to February. They do not migrate, but will move to different roost locations within hibernacula during winter. In summer, females roost with their young in nursery roosts. Males and non-breeding females roost alone. Townsend's big-eared bats are sensitive to human disturbance and will abandon roost sites if disturbed. Townsend's big-eared bats are nocturnal insectivores and prey primarily on moths along forest edges (Oliver 2000).

No substantial caves have been observed in the analysis area and no other structures are considered potentially suitable for Townsend's big-eared bat hibernacula (Cirrus 2004). However, there are some rock alcoves in or near the area that may serve as suitable habitat. The diet of this species specializes in moths, beetles, wasps, and other insects along the edges of vegetation. The analysis area could provide suitable foraging habitat for the species.

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3.1.2.4 TES Amphibians

3.1.2.4.1 Western Boreal Toad

Western boreal toads are found in western North America from Alaska to Baja California, with their range extending as far east as Colorado. They are found at a wide range of elevations from sea level to more than 11,000 feet. Western boreal toads can occur around any slow moving or still water in their range. They use shallow slow moving portions of these habitats for egg-laying which occurs in late spring or early summer following snow melt in high elevation habitats. Eggs hatch in 3—12 days and metamorphose in 1—3 months, with shorter durations in warmer habitats and longer durations in colder habitats. While western boreal toads are dependent on water they can travel several kilometers away from water to find new habitats. (NatureServe 2013.)

Surveys of potentially suitable amphibian habitat completed as part of the inventory work for the Muddy Tract analysis observed boreal toad larvae in July of 2001, approximately 150 yards SSW of the White Mountain Cabin (Cirrus 2004). This pond site is located within the old 2004 Muddy Creek analysis area, but is 1.3 miles west of the current Greens Hollow tract boundary. This is the only site where boreal toads were observed.

3.1.3 MANAGEMENT INDICATOR SPECIES

Rocky Mountain elk, mule deer, golden eagles, aquatic macroinvertebrates, sage nesters, cavity nesters, and riparian nesters are Manti-La Sal and/or Fishlake National Forest MIS discussed in the following section. The northern goshawk is also a MIS; however, it is addressed above as a Forest Service sensitive species in section 3.1.2.2.2.

3.1.3.1 Rocky Mountain Elk

Rocky Mountain elk inhabit coniferous and mixed-coniferous forests as well as woodlands, chaparral, and grasslands in the Rocky Mountains. Mid to late seral range vegetation is used for forage. They rely on grasses for most of the year but also consume forbs in the summer and may browse on woody plants where grasses are unavailable, especially during winter months. Water is an important habitat component, particularly on summer range. During the summer elk spend the majority of their time in alpine and subalpine mountain meadows or in stream habitats. Thermal and security cover is required year-round by elk and generally consists of mature forest with large amounts of edge along grasslands or meadows. During the winter, elk movements are restricted by forage availability and snow conditions, and heat and energy are conserved in order to survive. Elk migrate from higher to lower elevations where snow depth is shallow and typically inhabit coniferous forests interspersed with riparian areas, south-facing slopes with sagebrush and shrubs, as well as aspen forests. Calving habitat for elk contains forage areas, hiding cover, and thermal cover within forest stands. Components of this habitat include shrubs or downed logs, gentle slopes, succulent forage, and a source of nearby water (less than 1,000 feet). (Rodriguez et al 2006).

The analysis area contains critical winter and critical summer range for elk (UDWR 2013). The winter aerial census for elk conducted in 2004 shows that the elk populations in the South Manti Sub-Unit of the Manti Management Unit to be below UDWR objectives and lower than they were when analyzed for the 2001 to 2003 study (Cirrus 2004). However, elk numbers were purposely decreased, through increasing the number of cow tags issued, to compensate for the effects of the drought (UDWR 2007b). The MLNF Forest Plan has a minimum viable population for elk of 2,125 (Forest Service 1986). The current population estimate of elk on herd on the Manti Division is 12,500 (Forest Service 2013b, Bernales et al. 2012).

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3.1.3.2 Mule Deer

Mule deer are found in coniferous forests, shrub steppe, chaparral and grasslands with shrubs, from dry, open country to dense forests. They are often associated with early successional vegetation. They are known to utilize rocky brushy areas, open meadows, open pine forests, and burns. Mid to late seral range vegetation is used for forage. They browse on various grasses and forbs during the spring, summer, and fall, and on woody plants during the winter. Thermal and hiding cover is required year-round by mule deer. Thermal cover for deer generally consists of small conifers and shrubs on winter range, and deciduous or evergreen saplings or shrubs with high canopy closure on summer and spring-fall ranges. Water is also an important habitat component, especially on summer range. Fawning habitat for deer consists of low shrubs or small trees (2 to 6 feet tall) under a partially closed forest canopy. The fawning areas tend to be relatively small, close to water (less than 600 feet), and on mild slopes where succulent vegetation is abundant. (Thomas et al. 1979, Rodriguez et al 2006).

The analysis area contains crucial winter and crucial summer range for mule deer (UDWR 2013) as well as General and Key Winter Range as designated by the Manti-La Sal Forest Plan. Annual winter counts of deer are not conducted by the UDWR. However, population data is modeled using harvest data for the entire Manti Deer Management Unit, which contains the analysis area. The mule deer population counts in 2011 for the state of Utah estimated population levels at 286,100 animals which were below the objective of 411,900 (Bernales et al 2012). The mule deer population on the Manti Division is estimated at 20,900 animals, which is below the objective of 38,000 (UDWR 2007a, 2007b, Bernales et al. 2012). The deer population is far below the UDWR objectives for this unit and has been so for several years. The decline in deer populations is attributed to the drought and other natural environmental factors (UDWR 2007a, 2007b, 2008).

3.1.3.3 Golden Eagle

Golden eagles are typically found in open country, including shrublands, grasslands, canyons, and desert plains, as well as open coniferous forests in mountainous regions. Elevated nest sites, typically on cliff faces near hunting grounds, are the preferred breeding habitat. In the absence of suitable cliffs and rock outcrops, they have been known to nest in trees. Golden eagles feed mainly on small mammals, especially rabbits, marmots, and ground squirrels, but also eat insects, snakes, birds, juvenile ungulates, and carrion. Golden eagles typically mate for life. The breeding season generally begins in mid-January and continues through mid-September, though it can vary according to geographic region. (Rodriguez et al 2006).

Suitable nesting habitat is present in the northern and northeastern portions of the analysis area on rock escarpments along Muddy Creek Canyon and some of its tributaries. Aerial surveys for eagles have been conducted by UDWR since 1998 (Cirrus 2004). Over the past 10 years of surveys (1998 to 2007), approximately 10.7 percent of golden eagle nests on the MLNF have been active. In 2002 to 2004, nesting activity was extremely low, but appeared to rebound beginning in 2004 and was above the ten-year average in 2005 and 2006 (UDWR 2007b). In 2007 and 2008, however, the population trend again declined. In 2012 (the next year surveys were conducted on the MLNF), activity rates for nests were up to 11.7 percent (Forest Service 2013b). Annual nesting variation is likely a result of precipitation rates (drought) and declines in prey availability (rabbits, prairie dogs, etc.).

3.1.3.4 Aquatic Macroinvertebrates

Macroinvertebrates are benthic organisms including aquatic insects (mayflies, caddis flies, daphnia, cyclops, stoneflies and others), mollusks and worms. The 1986 Forest Plan's monitoring and evaluation program includes aquatic macroinvertebrates as a management indicator species and calls for monitoring at baseline stations or as needed for select project activities (page IV-6). Aquatic habitat is to be monitored and evaluated under the Forest Plan. Macroinvertebrates serve as natural indicators of management activities undertaken within each watershed. The Forest Plan (page E-9) in defining macroinvertebrates states, "the composition of the [macroinvertebrate] community is an indication of the

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quality of the aquatic habitat and reflects the condition of the entire drainage". Representative baseline locations were selected for sampling.

Most monitoring locations are near the Forest boundary and are designed to reflect the overall water quality and aquatic habitat quality of the stream system and watershed above the monitoring point. The sampling locations are not designed to monitor the effects of a single land use or activity. These locations are not suitable for project-level monitoring or evaluation.

Freshwater macroinvertebrate communities are highly variable. In a stream system, many physical, chemical, and biotic factors interact to affect macroinvertebrate communities in ways that are not fully understood. The effects of landslides, wildfires, floods and droughts may take several years to affect these communities. The effects may persist for several years and may outweigh the effects of human activities in the watershed. "Cause and effect are often separated in time and space, concealing linkages in a complex series of physical and biological interactions. Consequently, it is often difficult to: 1) clearly link land use or management effects to environmental impacts and 2) separate man caused impacts from those that result from natural phenomena" (Larsen and Herlihy 1998).

The monitoring techniques of the 1986 Forest Plan were the Biotic Condition Index (BCI), a macroinvertebrate community index, and the Habitat Condition Index (HCI); the measurement frequency was 5 years. The BCI data indicated highly variable communities across the Forest; probably in response to droughts, floods, and landslides in addition to land management activities. There were no statistically significant trends in the data. There revealed no apparent upward trend in the number of streams that did not meet the Forest Plan standard, nor was there an apparent downward trend in the number of streams that surpassed the standard. Over the entire period of record, only 5% of the samples have not met the Forest Plan BCI standard (Forest Service 2006).

The Forest Plan was amended in 2006 to update the protocols used to collect macroinvertebrate data and to change the method used to analyze the data. The 2006 amendment did not alter the language regarding macroinvertebrate monitoring as an optional technique for selected projects. The Manti-La Sal National Forest will continue monitoring aquatic habitat using macroinvertebrate sampling, but change the type of appraisal method used. The methodology is similar to that being used by the Utah Division of Water Quality for macroinvertebrate monitoring. The State program has selected relatively unimpaired representative streams as reference sites for different stream types. Monitoring will continue at baseline stations to characterize Forest-wide conditions; data analysis will be in cooperation with the Utah Division of Water Quality.

The closest Forest-wide monitoring site is located at the Forest Boundary where Muddy Creek leaves the National Forest. In 2009, samples were collected and the results were analyzed by the UDWQ and the O/E percentages determined. O is the number of species predicted and E is number of taxa present. Those results were compared to the 2004 results. Currently, Muddy Creek is meeting Forest Plan standards.

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No site-specific surveys of aquatic macroinvertebrates have been conducted and no site-specific monitoring is proposed for this project.

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3.1.3.5 Sage Nesters (Fishlake National Forest MIS)

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Sage nesting species are species that require sagebrush during at least part of the year for survival. Sage nesters are represented by Brewer's sparrow (*Spizella breweri*), vesper sparrow (*Pooectes gramineus*), and sage thrasher (*Oreoscoptes montanus*). The analysis area as a whole (including both FLNF and MLNF lands), contains approximately 7,741 acres (or 23.3 percent) sagebrush habitat potentially suitable for the various sage nesting MIS. Each of these species has been detected recently on the MLNF in close proximity to the analysis area (Forest Service 2013d).

Although specific habitat requirements differ between species, general issues affecting sage nesters tend to be similar across species and include the loss, fragmentation, and degradation of sagebrush habitats. Habitat requirements of some species vary with life stage and season. Therefore, it is important to analyze the impacts for a diversity of habitat conditions within sagebrush ecosystems, so that the requirements of all sagebrush obligate species are met throughout their life cycles. In addition to local habitat conditions, landscape characteristics such as fragmentation and patch size are also important to many sagebrush obligate species.

3.1.3.5.1 Brewer's sparrow (Spizella breweri)

The Brewer's sparrow commonly breeds in arid sagebrush steppes of western North America (Rodriguez et al 2006). The distribution of Brewer's sparrows generally coincides with the distribution of sagebrush in the West, from British Columbia, southeast to Saskatchewan, south to California, and east to New Mexico (Rodriguez et al 2006). They breed in the northern Rocky Mountains of the Yukon and British Columbia and in the Great Basin south to southern California and New Mexico. The species winters in the southwestern United States, though they are absent from the Pacific Coast (Rodriguez et al 2006).

A Brewer's sparrow is approximately 5 inches (13 cm) long. It has light brown upper-parts with black streaks, and pale unmarked undersides. It has a brown crown that is finely streaked with black. The ear patch is darker and well defined, and bordered by a fine black eye line. The Brewer's sparrow song usually consists of alternating trills that can be musical or buzzy.

This species builds cup-shaped nests in sagebrush, with nests between 20 and 50 cm from the ground. Brewer's sparrows prefer shrubs tall enough (about 69 cm) and dense enough to provide sufficient cover (Rodriguez et al 2006). They often build their nests in the outer branches. The nest is a cup of dry grass stems, forbs, and rootlets lined with find grasses, rootlets, and hairs (Rodriguez et al 2006). Brewer's sparrows breed primarily from late May through June (Rodriguez et al 2006). There are usually 3 or 4 eggs per clutch, though occasionally 5 are laid (Rodriguez et al 2006). Incubation is between 11 and 13 days, and the altricial young fledge in 8-9 days (Ehrlich et al. 1988, Rodriguez et al 2006).

The diet of this sparrow primarily consists of insects and spiders in the summer and seeds and grasses of forbs in the winter. This species will commonly drink and bathe, but may not require free water (Rodriguez et al 2006). They are able to meet water needs by eating insects and can subsist on dry seeds for up to 3 weeks (Rodriguez et al 2006).

3.1.3.5.2 Vesper sparrow (Pooectes gramineus)

The vesper sparrow is found in fields, pastures, and roadsides in farming country. This species breeds from British Columbia, Ontario, and Nova Scotia south to California, Texas, Tennessee, and western North Carolina. It winters in California, Oklahoma, New Jersey, and Long Island (Rodriguez et al 2006).

This species is approximately 5-6 1/2" (13-17 cm) in length. It is grayish and streaked, though there is a patch of chestnut color on the bend of the wing. It has a white eye ring and white outer tail feathers. Its song begins with 4 whistles followed by a descending trill (Rodriguez et al 2006).

Vesper sparrow's annual diet is about half insects and spiders, and half grass and forb seeds (Rodriguez et al 2006). Vesper sparrows have been observed drinking, but also recorded individuals 10-15 miles away from known surface water (Rodriguez et al2006). Captives drank 19.7 percent of body weight per day, but could survive on dry seeds without water.

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3.1.3.5.3 Sage thrasher (Oreoscoptes montanus)

The sage thrasher breeds from southern British Columbia, central Idaho, and southern Montana, south to southern California, southern Nevada, New Mexico, and western Oklahoma. It winters mainly in the southwestern United States and southern Texas (Rodriguez et al 2006). The sage thrasher breeds

primarily in semiarid sagebrush plains, but may extend into shrubby or open woodland growth on foothills (Rodriguez et al 2006).

Sage thrashers eat insects and other small, terrestrial arthropods. They also eat berries when the fruit is in season. The sage thrasher gleans prey, including great numbers of grasshoppers and Mormon crickets from the ground beneath and between shrubs (Rodriguez et al 2006). The sage thrasher apparently reduces nest parasitism by removing cowbird eggs from its nest (Rodriguez et al 2006).

The sage thrasher breeds in late April and early May. A clutch usually consists of 1-5 eggs. Incubation ranges from 13-17 days, averaging 15 days. Both parents tend their altricial young. Nests are built either on the ground below sagebrush or in the branches near the main axis of the plant. Nests may be lined with rootlets and grass, and often with fur or feathers. Sage thrashers require some foliage for cover above the nest. (Rodriguez et al 2006).

3.1.3.6 Cavity Nesters (Fishlake National Forest MIS)

Cavity nesting species are represented by hairy woodpeckers (*Picoides villosus*), western bluebirds (*Sialia mexicana*), and mountain bluebirds (*Sialia currucoides*). Generally speaking, cavity nesting species favor open woodlands with a well-developed understory of shrubs and/or herbaceous vegetation. During the breeding season, they are mainly found in open ponderosa pine forests, riparian woodlands dominated by cottonwoods, and burned stands. Snags are required for nesting. Oak woodlands and commercial orchards are typical habitats during winter. Cavity nesting avian species feed on insects during the breeding season and on nuts and fruits during winter. Fire suppression, overgrazing of riparian areas, salvage logging, and loss of habitat to agriculture and urban development are detrimental to this species. Overgrazing suppresses ground cover and prevents regeneration of cottonwoods and other trees in riparian areas. (Rodriguez et al 2006).

Although specific habitat requirements differ between species, general issues affecting cavity nesters tend to be similar across species and include the loss, fragmentation, and degradation of habitat. Habitat requirements of some species vary with life stage and season. Therefore, it is important to analyze the impacts for a diversity of habitat conditions within general cavity nesting ecosystems, so that the requirements of all species are met throughout their life cycles. In addition to local habitat conditions, landscape characteristics such as fragmentation and patch size are also important to many species. The project area includes approximately 8,193 acres (or 24.7 percent), of potential cavity-nesting MIS habitat as well as many more square miles of similar habitat outside the project area boundaries.

3.1.3.6.1 Hairy woodpecker (Picoides villosus)

The hairy woodpecker is a fairly common, permanent resident of mixed-conifer and riparian deciduous habitats at elevations up to 9,500 feet. The whole of temperate North America is occupied by one or another of its various subspecies. It uses stands of large mature trees and snags. The hairy woodpecker uses relatively open or patchy stands of conifers with abundant snags. (Rodriguez et al 2006).

This woodpecker excavates a nest cavity from 3 to 55 feet above ground in the soft interior of a snag or dead branch of aspen, sycamore, pine, or other tree species. It begins breeding from late March to late May. The male drums on dry, resonant limbs to attract the female. Average clutch is 4 eggs, though the range is 3-5. They have one brood per year. Both the male and female dig a cavity, incubate the eggs about two weeks, and care for altricial young. (Rodriguez et al 2006).

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Most of the hairy woodpecker's food comes from trees. The food consists of larvae, beetles, spiders, flies, ants, and in the winter, seed, grains, nuts, and acorns. It often congregates to feed in insect-infested or burned areas and frequents riparian habitats year-round. (Rodriguez et al 2006).

Competition for food between hairy woodpeckers and other birds, including those of their own species, is apparently reduced by feeding on different species of tree, or in different locations in same tree. Most foraging takes place on the trunk of the tree. Hairy woodpeckers may be important in reducing populations of adult and larval bark beetles. (Rodriguez et al 2006).

3.1.3.6.2 Western bluebird (Sialia mexicana)

The western bluebird prefers open woodlands and pastures where old trees provide nest sites. The western bluebird is most abundant in open ponderosa pine forests of the Transition Zone, but may also be found in oak woodlands, pinyon-juniper, mixed-conifer, and subalpine forests. They breed from southern British Columbia south to Baja and east, throughout the mountains of the West to New Mexico and Texas. It winters over most of the breeding range, though populations in the north may move southward. (Rodriguez et al 2006).

The western bluebird requires nest cavities, low perches to hunt from, and insect prey at lower understory and ground levels. It can be found in open country. Availability of snags frequently limits population density (Rodriguez et al 2006).

The western bluebird usually nests in old woodpecker holes or natural cavities, in oak, sycamore, and pine trees. It has been known to also use other cavities or nest boxes. It occasionally uses nests of cliff swallows or other species. Nests are usually 5-40 feet above ground. The western bluebird breeds from early April into May. Clutch size was 4-5 in a northern Arizona study from 1998-2000. Incubation lasts 12 days. Both parents tend altricial young. This species is frequently double-brooded. The male may tend fledglings while the female re-nests (Rodriguez et al 2006).

3.1.3.6.3 Mountain bluebird (Sialia currucoides)

The mountain bluebird is differentiated from the western bluebird by the lack of red on the breast. Males are pure sky blue above and lighter below. The females are similar, though duller and grayer. The bluebird nests in nearly all timber types of the Rocky Mountain region, and is usually found between 7,000-11,000 feet in open forests or edges (Rodriguez et al 2006).

This species prefers open terrain with an occasional tree, rock, fence post, power line, or similar perches. It requires suitable cavities for roosting and nesting, usually in a snag or dead portion of tree. In winter, this species occurs in virtually any open or sparsely wooded habitat (Rodriguez et al 2006).

The mountain bluebird builds a nest in a natural cavity or woodpecker hole in a snag or dead portion of a tree. Less frequently it nests in a crevice or cavity in a rock, building, or other human structure; it also uses nest boxes or the nest of a cliff swallow or other species. The mountain bluebird is monogamous; it lays eggs mid-May to mid-June in Washington. It may double brood, with each brood clutch containing 5-6 eggs. Incubation is 13-14 days and both sexes care for altricial young. Fledging age is 22-23 days (Rodriguez et al 2006).

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3.1.3.7 Riparian Nesters (Fishlake National Forest MIS)

Riparian nesting species are represented by Lincoln's sparrow (*Melospiza lincolnii*), song sparrows (*Melospiza melodia*), yellow warblers (*Dendroica petechia*), and MacGillivray's warblers (*Oporornis tolmiei*). The analysis area as a whole (including both FLNF and MLNF lands), contains approximately 48 acres (or 0.1 percent), of willow-dominated riparian habitat potentially suitable for the various avian, riparian MIS as listed by the FLNF Forest Plan. Migratory bird surveys were conducted in proximity to the analysis area in 2009. Song sparrows were observed near (on the adjacent Pines Tract), but not inside the analysis area during these survey efforts (Forest Service 2013d). The close proximity of this tract suggests that the species may use nearby habitat in the analysis area as well.

3.1.3.7.1 Lincoln's sparrow (Melospiza lincolnii)

The Lincoln's Sparrow breeds from Alaska, northern Quebec, Labrador, and Newfoundland south to California, New Mexico, and northern New England. It can be found in brushy bogs and willow and alder thickets. It winters across the southern tier of the United States in woodland thickets and brushy pastures. The diet consists mainly of insects, but spiders and millipedes will also be eaten. Grass and forb seed are also consumed (Rodriguez et al 2006).

The Lincoln's sparrow breeds very locally in wet montane meadows of corn lily, sedges, and low willows. The nest is often on the edge of wet areas, or in wet places on drier raised mounds. The nest is a grass tussock or sunk in shallow depression on sphagnum or moss. It is a cup made of grass or sedge and lined with fine grass and hair (Rodriguez et al 2006).

Breeding season begins late in May in the south areas and mid-June in the north. Typically 4 to 5 eggs are laid, though 3 to 6 has been observed. Incubation is carried out by the female and lasts between 12 and 14 days. The altricial young are cared for by both parents, and fledge in 9-12 days (Rodriguez et al 2006).

3.1.3.7.2 Song sparrow (Melospiza melodia)

The song sparrow is one of the most widespread, diverse, and geographically variable of North American birds. There are 34 recognized subspecies, covering a breeding range from the Aleutians and mainland Alaska east to Newfoundland and south to California, North Dakota, and the Carolinas. They winter from southern Canada throughout the United States to the Gulf Coast and Mexico (Rodriguez et al 2006).

The song sparrow builds its nest on the ground; however, it also nests in shrub, thicket, emergent vegetation, and small trees, usually within 4 feet of the ground. The ground nest is hidden under low, dense vegetation, usually near water, in emergent vegetation, or in other moist sites. The breeding season occurs from March to June, with a peak at the end of March. Clutch size is 3 or 5, rarely 2 or 6. They will often double-brood, or sometimes brood three times a year to replace lost clutches. Incubation lasts 12-14 days. The altricial young are tended by both parents, leave the nest after about ten days, and become independent about 25 days later (Rodriguez et al 2006).

Seeds are the most important foods in the annual diet of song sparrows, but insects, beetles, and other small invertebrates make up part of their diet. Numerous insects may be available for forage, especially in the summer. The song sparrow usually forages on the ground or in low vegetation, under cover of dense thickets or wetland vegetation. It gleans from the ground or low plants and often scratches in litter. Water is also required in a song sparrow territory. The song sparrow is commonly host to nest parasitism by brown-headed cowbirds (Rodriguez et al 2006).

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3.1.3.7.3 Yellow warbler (Dendroica petechia)

The yellow warbler breeds throughout most of Alaska across Canada and south to southern California, northern Oklahoma, and northern Georgia. It winters in the tropics. This warbler is found nesting in moist thickets, especially along streams and swampy areas. The male yellow warbler has golden yellow plumage with rusty streaks on the breast. The male's back may have a slight greenish tint. The females have plain yellow plumage and breast streaks are absent. (Rodriguez et al 2006).

Yellow warblers select nest sites based upon characteristics surrounding the nest bush rather than the nest bush itself. Dense growth may be preferred in order to reduce nest predation and brood parasitism. It is subject to predation by jays, predatory birds, small mammals, and snakes, and is apparently quite rarely parasitized by cowbirds (Rodriguez et al 2006).

Yellow warblers nest in shrubs, willows, or low trees near water. They breed in shrubby growth by swamps and watercourses, in wet scrub, tree foliage, mangroves, gardens, shrubberies and berry patches. The males are sometimes polygamous. The female builds a neat, compact cup nest in an upright twig

fork 2 to 12 feet up, sometimes up to 40 or even 60 feet. Incubation of the 3 to 6 (usually 4 or 5) whitish spotted eggs is for 11 days. Both parents tend the nestlings until fledging occurs at 9 to 12 days. Yellow warblers are insectivorous, with larger bugs being ingested as the birds grow (Rodriguez et al 2006).

3.1.3.7.4 MacGillivray's warbler (Oporornis tolmiei)

The MacGillivray's warbler is found in coniferous forest edges, burns, brushy cuts, or streamside growth. It breeds from Alaska and Yukon south to California and central New Mexico. Winters are spent in the tropics (Rodriguez et al 2006).

The MacGillivray's warbler eats mostly insects, though young may take sap from sapsucker drillings in willows. Willow, alder, and other dense shrubs in riparian areas or in moist woodlands provide cover at all seasons. Drier shrub habitats near water are used to a lesser extent (Rodriguez et al 2006).

The MacGillivray's warbler nests between May and early August. It lays 3 to 6 eggs, usually 4. Incubation is 11 to 13 days, by the female only. Both parents tend altricial nestlings until the fledging stage in eight or nine days. This species prefers dense, moist, brushy habitat, or areas with tall weeds or ferns for nesting. The nest is usually placed 0.5 to 2 feet above ground in a shrub, up to 6 feet in saplings or juniper trees, or is attached to stalks of several plants (Rodriguez et al 2006).

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3.1.4 Species of High Federal Interest

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Species of high federal interest, as defined by the USFWS, include several migratory birds. No other categories of wildlife were identified by the USFWS.

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3.1.4.1 Migratory Birds

Thirty high priority migratory bird species and bird species of concern that could occur on the Manti Division of the Manti-La Sal National Forest were reviewed for this analysis. The list of species was gathered from the Avian Conservation Strategy (PIF, Parrish et al. 2002), Birds of Conservation Concern (BOCC, USFWS 2008), and the Utah Comprehensive Wildlife Conservation Strategy (CWCS, UDWR 2005a). Of the thirty possible species on the Manti Division, ten were determined not to have suitable habitat that could be impacted by the Proposed Action. These ten species were removed from further analysis: bald eagle (also listed as sensitive in Section 3.1.2.2.1), black rosy finch, black swift, juniper titmouse, long-billed curlew, osprey, short-eared owl, southwestern willow flycatcher, veery, and yellow-billed cuckoo. The remaining species that could potentially be impacted by the Proposed Action are listed in Table 7.

Many other species of non-game migratory birds use the analysis area and surrounding habitat. In addition to the species listed in Table 7, surveys in the Wildcat Knolls areas have recorded the following species: vesper sparrow, lark sparrow, chipping sparrow, American robin, northern flicker, western meadowlark, mountain bluebird, yellow-rumped warbler, violet-green swallow, tree swallow, horned lark, unknown hummingbird, hermit thrush, Clark's nutcracker, and green-tailed towhee (Forest Service 2013d). Additionally, migratory bird surveys in The Pines area (Forest Service 2013d), have recorded American robin, chipping sparrow, song sparrow, mountain chickadee, unidentified woodpecker, northern flicker, red-naped sapsucker, vesper sparrow, lark sparrow, Clark's nutcracker, dark-eyed junco, unknown hummingbird, mourning dove, warbling vireo, Townsend's solitaire, Wilson's warbler, red-breasted nuthatch, dusky flycatcher, red-tailed hawk, olive-sided flycatcher, house wren, western bluebird, plumbeous warbler, black-capped chickadee, mountain bluebird, ruby-crowned kinglet, green-tailed towhee, white-breasted nuthatch, western tanager, yellow warbler, yellow-rumped warbler, violet-green swallow, northern mockingbird, pine grosbeak, pine siskin, unknown jay, hermit thrush, western meadowlark, and western wood-pewee.

Table 7. Migratory bird species that could occur on the Manti Division of the MLNF.			
Species	**Lists[1]**	**Primary and Secondary Habitat Types[2]**	**Observations Near/In the Analysis Area[3]**
Black-throated gray warbler *Dendroica nigrescens*	PIF, BOCC, CWCS	Pinyon-juniper Mountain Shrub	E
Brewer's Sparrow[4] *Spizella breweri*	PIF, CWCS	Shrub steppe High-desert scrub	A, B, C, E, I, M, N, O
Broad-tailed hummingbird *Selasphorus platycercus*	PIF, CWCS	Lowland riparian Mountain riparian	B, C, E, O
Cassin's finch *Carpodacus cassinii*	BOCC	Aspen Sub-alpine conifer	B, C, I, N, O
Ferruginous hawk *Buteo regalis*	PIF, BOCC, CWCS	Pinyon-juniper Shrub-steppe	K
Flammulated owl[5] *Otus flammeolus*	BOCC	Ponderosa pine Sub-alpine conifer	E, G, H, I, J, N
Golden eagle *Aquila chrysaetos*	BOCC	Cliff High desert scrub	E
Grace's warbler *Dendroica graciae*	CWCS	Ponderosa pine Mixed conifer	C, I, N, O
Gray vireo *Vireo vicinior*	PIF, BOCC, CWCS	Pinyon-juniper Oak	B, C, E, I, N, O
Greater sage-grouse[5] *Centrocercus urophasianus*	CWCS	Sagebrush Shrub-steppe	A, B, E, F, O
Lewis's woodpecker *Melanerpes lewis*	PIF, BOCC, CWCS	Ponderosa pine Lowland riparian	L
Northern goshawk[5] *Accipiter gentilis*	CWCS	Mixed conifer Aspen	C, D, E, O
Peregrine falcon[5] *Falco peregrinus*	CWCS	Cliff Lowland riparian	E
Pinyon jay *Gymnorhinus cyanocephalus*	CWCS	Pinyon-juniper Ponderosa pine	B, E, I, M, N
Sage sparrow *Amphispiza belli*	PIF, BOCC, CWCS	Shrub-steppe High desert scrub	B, C, E, I, M, N, O
Sage thrasher[4] *Oreoscoptes montanus*	CWCS	Shrub-steppe High desert scrub	A, B, C, E, I, M, O
Three-toed woodpecker[5] *Picoides tridactylus*	CWCS	Sub-alpine conifer	E, I
Virginia's warbler *Vermivora virginiae*	PIF, BOCC, CWCS	Oak Pinyon-juniper	C, E, O
Williamson's sapsucker *Sphyrapicus thyroideus*	BOCC, CWCS	Sub-alpine conifer Aspen	E
Willow flycatcher *Empidonax traillii*	BOCC	Lowland riparian Mountain riparian	K

[1]PIF = Partners In Flight (Parrish et al. 2002), BOCC = Birds of Conservation Concern (USFWS 2008), CWCS = Utah Comprehensive Wildlife Conservation Strategy (UDWR 2005a).

[2]Where both primary and secondary habitat types are applicable.

[3]A = Ferron/Price Ranger District Migratory Bird Survey Summary 2008-Wildcat Knolls (Forest Service 2008d), B = Ferron/Price/Sanpete Ranger Districts Migratory Bird Survey Summary 2009-Wildcat Knolls (Forest Service 2009b), C = Ferron/Price/Sanpete Ranger Districts Migratory Bird Survey Summary 2009-The Pines (Forest Service 2009c), D = Greens Hollow Goshawk Trend Data (Forest Service 2009d), E = Muddy Creek Technical Report-Wildlife (Cirrus 2004), F = Sage-Grouse Strutting Ground Counts (Forest Service 2009a), G = Flammulated Owl Survey Data Form-The Pines 2008 (Forest Service 2008d), H= Flammulated Owl Survey Data Form-The Pines 2009 (Forest Service 2009e), I = 2010 Breeding Bird Survey (Forest Service 2010c, 2010d), J = 2010 Flammulated Owl Survey (Forest Service 2010a), K = Not observed, but presence is suspected (Cirrus 2004), L = Not observed, and presence is not suspected (Cirrus 2004). M = Ferron/Price Ranger District Migratory Bird Survey Summary 2010-Wildcat Knolls (Forest Service 2013d), N = Ferron/Price Ranger District Migratory Bird Survey Summary 2010-The Pines (Forest Service 2013d), O = 2008 and 2009 Breeding Bird Survey (Forest Service 2013d).

[4]Also discussed as a sage nesting MIS for the FLNF in Section 3.1.3.5.3

[5]Also discussed as a TES avian species for the project in Section 3.1.2.2.5

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3.1.5 Other Species

Other species of wildlife that are not classified as TEPS, MIS, or species of high federal interest are discussed below.

3.1.5.1 Fishes

Rainbow and brook trout were also observed during fish surveys conducted by UDWR on perennial streams in the analysis area (Berg 2002a, 2002b, and 2002c, Hart and Berg 2003). Rainbow trout were observed in Muddy Creek and South Fork of Muddy Creek, while Brook trout were only observed in Muddy Creek. Surveys conducted by the Forest Service in 2010 on Mill Fork Creek and Black Fork (both tributaries of South Fork of Muddy Creek) showed cutthroat trout and brook trout present but no rainbow trout. The further downstream 2010 survey location near where Muddy Creek crosses the MLNF border showed a complete absence of fish (Jewkes 2013c). The streams where cutthroat trout were also observed during surveys and incidentally (i.e., Muddy Creek and its South and North forks) present moderate to high quality trout habitat. As described above, no fish were observed in the North Fork of Quitchupah Creek. Erosion, siltation, and low water flows have led to the poor trout habitat in this stream. Speckled dace (*Rhinichthys oscolus*) have been observed on mainstem sections of Quitchupah Creek located outside of the analysis area (Cirrus 2004).

3.1.5.1.1 Brook trout

Brook trout (*Salvelinus fontinalis*) is a sport fish native to the eastern United States and eastern Canada. This species has become established in many of Utah's cold higher-elevation lakes and streams. The diet of brook trout is based primarily on invertebrates, including insects and zooplankton; large individuals occasionally feed on small fishes. Spawning occurs in the fall over gravel substrate in lakes and streams. Hatching and emergence occurs approximately after two months. The successful reproduction of brook trout has led to overcrowding, and consequently, to a large number of stunted (small) individuals in streams in Utah. The overcrowding problem can be exacerbated by low fishing pressure in the brook trout's high elevation habitat. This species poses a threat to native cutthroat trout populations (Sigler and Sigler 1996).

3.1.5.1.2 Rainbow trout

Rainbow trout (*Oncorhynchus mykiss*) is a popular sport fish in Utah. This species is native to western North America but is not native to Utah. The popularity of this species in addition to their unsuccessful reproduction in the wild has led to the introduction of millions of rainbow trout to cold and cool waters throughout the state by the UDWR. Their diet is based primarily on invertebrates, including insects, worms, zooplankton, and insect larvae. Rainbow trout that reach larger sized can switch to a piscivorous diet. The species spawns in streams over gravel substrate during the spring, and the eggs hatch in about one month. Fry emergence occurs approximately two to three weeks after hatching. The presence of rainbow trout in streams that provide habitat to cutthroat poses a major threat to the native species. Similarities in the habitat and timing of spawning often lead to the production of rainbow - cutthroat hybrids, and thus, to the loss of genetic purity through hybridization (Sigler and Sigler 1996).

3.1.5.2 Amphibians

Amphibian habitat is limited in the analysis area, consisting of wetlands, ponds (natural and stock), edges of lakes and reservoirs, springs and seeps, and pooled habitat adjacent to streams. Potentially suitable amphibian habitat surveyed during the analysis period resulted in observations of boreal toads, chorus frogs, tiger salamanders, and possibly Great Basin spadefoot toads. Chorus frogs were the most abundant species observed (see section 2.4.4.1). All life stages of chorus frogs and tiger salamanders (eggs, tadpoles, and adults) were observed in ponds. Chorus frogs were also heard at Julius Flat Reservoir. All boreal toad observations were of larvae in ponds. Great Basin spadefoot toads were potentially heard at a pond and at the bottom of a canyon (Cirrus 2004).

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Other amphibian species that could potentially occur in the analysis area include the Great Plains toad, Woodhouse's toad, and northern leopard frog. The R4 sensitive species Columbian spotted frog is not expected to occur as far south as the analysis area (USFWS 2002b).

3.1.5.3 Reptiles

Suitable habitat for several reptile species is present in the analysis area. Lizard, whiptail, and skink species primarily occur in desert and semi-desert areas with sandy or rocky soil and sparse vegetation, such as pinyon-juniper and sagebrush, but also occur in grasslands and the lower edge of the spruce-fir zone. Habitat for snake species is also variable, ranging from lowlands to high mountains, with some species having an affinity for riparian habitats, and others for more arid environments. (Dalton et al 1990).

Five reptile species were incidentally observed in the analysis area: the eastern fence lizard, tree lizard, sagebrush lizard, short-horned lizard, and western terrestrial garter snake (see section 2.4.4.2). Reptile species not observed but likely present include the common side-blotched lizard, gopher snake, night snake, striped whipsnake, and western rattlesnake. Other species possibly present include the Great Basin collared lizard, long-nosed leopard lizard, desert spiny lizard, western whiptail, western skink, eastern racer, milk snake, southwestern blackheaded snake, and ground snake.

3.1.5.4 Small Mammals

Seventy species of small mammals could potentially occur in the study area, including 5 shrews, 15 bats, 8 small carnivores, 36 rodents, and 6 lagomorphs (see section 2.4.4.3). Of these, 16 were observed by Cirrus personnel (1 bat, 1 carnivore, 10 rodents, and 4 lagomorphs). All habitats in the analysis area are potentially used by at least some small mammals, with riparian habitats being used by the largest number of species. (Cirrus 2004).

3.1.5.5 Non-Game Birds

A total of 203 species of non-game birds could potentially occur in the study area (see section 2.4.4.4). Of these, 84 were observed by Cirrus personnel (2004). All habitats in the analysis area are potentially used by at least some non-game birds, with riparian habitats being used by the largest number of species. Non-game species that potentially use cliffs in the analysis area for nesting include, but are not limited to, the golden eagle, prairie falcon, peregrine falcon, red-tailed hawk, raven, white-throated and black swifts, cliff swallows, and canyon wren.

Surveys in the area are ongoing. The 2008 Wildcat Knolls survey near the analysis area recorded vesper, lark, and chipping sparrows; American robins; and Northern flickers. Also, three bird species of interest were observed: Brewer's sparrow, greater sage-grouse, and sage thrasher (Forest Service 2013d).

The survey efforts in 2009 and 2010 recorded a greater variety of migratory bird species including: Vesper sparrow, western meadowlark, mountain bluebird, an unknown species of hummingbird, hermit thrush, Clark's nutcracker, chipping sparrow, and green-tailed towhee. A larger variety of species of interest were also observed in 2009 and 2010. These species included: greater sage-grouse, broad-tailed hummingbird, gray vireo, pinyon jay, sage thrasher, sage sparrow, Brewer's sparrow, and Cassin's finch (Forest Service 2013d).

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APPENDIX A.

BLM and State Sensitive Species

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BLM and State sensitive species present in Sanpete and Sevier counties and their status in the Greens Hollow Federal Coal Lease Tract project area.				
Species	**Analyzed in SEIS?**	**Habitat Present in the Project Area?**	**Known to Occur in the Project Area?**	**Analyzed Species with Shared Habitat**
Wildlife Species				
American white pelican *Pelecanus erythrorhynchos*	No	No - Breeds on islands in freshwater lakes. Winters at coastal sites.[1]	No	None
Bald eagle *Haliaeetus leucocephalus*	Yes	-	-	-
Big free-tailed bat *Nyctinomops macrotis*	No	Yes - Rocky woodland habitat, roosts in caves, mines, old buildings, and rock crevices.	No	Spotted bat
Black swift *Cypseloides niger*	No	No - Nests on rock ledges near or behind waterfalls in montane areas.[1]	No	None
Burrowing owl *Athene cunicularia*	No	No - Nests in open grasslands occupied by burrowing mammals such as prairie dogs.[1]	No	Utah prairie dog
Carinate Glenwood pyrg *Pyrgulopsis inopinata*	No	No - Three springs in Sevier County: two near Glenwood and one south of Sigurd.[2]	No	None
Ferruginous hawk *Buteo regalis*	No	No - Low elevation, flat, rolling grassland and shrubsteppe habitats. Avoids forests and narrow canyons.	No	None
Fringed myotis *Myotis thysanodes*	No	Yes - Inhabits caves, mines and buildings in desert and woodland areas.[2]	No	None
Grasshopper sparrow *Ammodramus savannarum*	No	No - Nests in grasslands with sparse shrub cover.[1]	No	None
Kit fox *Vulpes macrotis*	No	No - Inhabits open desert plains.[2]	No	None
Lewis's woodpecker *Melanerpes lewis*	No	Yes - Inhabits ponderosa pine forests, lowland riparian areas with cottonwoods, oak woodlands, and pinyon-juniper woodlands.[1]	No	None
Long-billed curlew *Numenius americanus*	No	No - Nests in low vegetative density grasslands. Avoids areas with thick bunchgrasses or shrubs.[1]	No	None
Ninemile pyrg *Pyrgulopsis nonaria*	No	No - Two springs near Ninemile Reservoir in Sanpete County.[2]	No	None
Otter Creek pyrg *Pyrgulopsis fusca*	No	No - Known from three sites in tributaries of Otter Creek in Piute and Sevier Counties.	No	None
Pygmy rabbit *Brachylagus idahoensis*	Yes	-	-	-

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BLM and State sensitive species present in Sanpete and Sevier counties and their status in the Greens Hollow Federal Coal Lease Tract project area.				
Species	**Analyzed in SEIS?**	**Habitat Present in the Project Area?**	**Known to Occur in the Project Area?**	**Analyzed Species with Shared Habitat**
Short-eared owl *Asio flammeus*	No	No - This species does not breed further south than the northernmost parts of Utah. Nonbreeding habitat consists of large expanses of open grasslands or shrubsteppe with abundant small mammals, often in and around marshes.[2]	No	None
Smooth Glenwood pyrg *Pyrgulopsis chamberlini*	No	No - Two springs near Glenwood in Sevier County.[2]	No	None
Southern Bonneville springsnail *Pyrgulopsis transversa*	No	No - Six springs in north-central Utah: four in Tooele County, one in Utah County, and one in Sanpete County.[3]	No	None
Southern leatherside chub *Lepidomeda aliciae*	Yes	-	-	-
Three-toed woodpecker *Picoides tridactylus*	Yes	-	-	-
Townsend's big-eared bat *Corynorhinus townsendii*	Yes	-	-	-
Boreal (Western) toad *Bufo boreas*	Yes	-	-	-
Vegetation Species				
Alicielia tenuis Emery, Sevier	No	No - Limestone or sandstone, in open grass, shrub, and woodland communities, between 5,200 and 7,100 feet elevation.[4] Restricted to sandstone outcrops and sandy detrital slopes in association with a curious mixture of mountain brush, pinyon-juniper, and cushion plants. Largest concentrations are on sandstone (including mudstone and siltstone) with interbedded gypsum, on ledges, in cracks, and on talus slopes. Most populations are on steep terrain.[5]	No	None
Astragalus loanus Sevier	No	No - Known only from the middle Sevier Valley[6]; sagebrush and PJ communities on igneous substrates, 6,300 to 6,800 ft.[7]	No	None
Eriogonum brevicaule mitrophyllum Sevier	No	No - Edemic to Sevier County; Arapien shale on clay flats and slopes, 5,250 to 5,575 feet. [7]	No	None
Ericameria lignumviridis Sevier	No	No - 6150-6250ft elevation; crevices in igneous rock outcrops and cliffs[7,8]	No	None

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BLM and State sensitive species present in Sanpete and Sevier counties and their status in the Greens Hollow Federal Coal Lease Tract project area.				
Species	**Analyzed in SEIS?**	**Habitat Present in the Project Area?**	**Known to Occur in the Project Area?**	**Analyzed Species with Shared Habitat**
Mentzelia argillosa Sanpete, Sevier	No	No - Steeply sloping and constantly moving talus or scree slopes of the Arapien shale in Utah [9]	No	None
Penstemon wardii Piute, Sanpete, Sevier	No	No - Ephedra, rabbitbrush, shadescale, mountain mountain mahogany, sagebrush, and pinyon-juniper communities on semibarren, white to gray, fine-textured (often calcareous or gysiferous) substrates (mostly Arapien shale), 5,500 to 6,800 ft. [7]	No	None
Phacelia utahensis Carbon, Sevier, Sanpete	No	No - Salt desert shrub on clay hills and banks in the Arapien shale formation, 5,500 to 6,200 ft. Salt desert shrub on clay hills and banks in the Arapien shale formation, 5,500 to 6,200 ft. [7]	No	None
Townsendia jonesii lutea Juab, Piute, Sevier	No	No - Salt desert and mixed desert shubs and juniper-sagebrush communities on Arapien shale and clays in volcanic rubble, 5,500 to 6,300 ft.[7]	No	None

1. Birds of North America. http://bna.birds.cornell.edu/bna
2. Utah Conservation Data Center. http://dwrcdc.nr.utah.gov/ucdc/default.asp
3. Oliver and Bosworth 1999. http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1530&context=govdocs
4. http://www.fs.fed.us/wildflowers/rareplants/profiles/critically_imperiled/aliciella_tenuis/index.shtml
5. http://eol.org/pages/487521/details
6. http://loco.biosci.arizona.edu/astragalus/images/Astragalus_images/Aloanus.htm
7. Utah Rare Plants guide online.
8. http://eol.org/pages/482827/details
9. http://eol.org/pages/487671/details

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Biological Evaluation for the Proposed Greens Hollow Coal Lease Tract Program

Price/Ferron Ranger District
Manti-La Sal National Forest

and

Richfield Ranger District,
Fishlake National Forest

Sensitive Wildlife and Plant Species

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I. INTRODUCTION

This Biological Evaluation (BE) analyzes and evaluates the potential effects the Ark Land Company Greens Hollow Coal Lease Tract on Forest Service Region 4 (R4) sensitive wildlife and plant species (Table 1) potentially occurring in areas proposed for coal extraction and where disturbances may occur on the Price/Ferron Ranger District of the Manti-La Sal National Forest (MLNF), and the Richfield Ranger District of the Fishlake National Forest (FLNF). It is a summary of the analysis disclosed in the Wildlife Technical Report (Cirrus 2010a) and Vegetation Technical Report (Cirrus 2010b) prepared for this project. Additional information regarding life histories and habitat requirements for these species can be found in those two documents. This BE also recommends mitigation measures that, if implemented, would help preserve, maintain, or protect specific habitat or species in question.

The Forest Service's list entitled *Intermountain Region Proposed, Endangered, Threatened, and Sensitive Species Known/Suspected Distribution by Forest* (Forest Service 2010a) was reviewed to determine which sensitive species potentially present on the Forest should be addressed in this document. Table 1 lists the sensitive species reviewed for this project. It includes a brief habitat description and an analysis of habitat suitability for each species to determine if the species should be fully analyzed in this document. Only those species potentially occurring in the project area are carried forward for analysis.

Table 1. Suitability of habitat in the project area for Forest Service R4 Sensitive wildlife and plant species found on the Manti-La Sal and Fishlake National Forests (Forest Service 2010a).

Species	Habitat Description	Analysis of Habitat Suitability/Rationale
Mammals		
Spotted Bat *Euderma maculatum*	Ponderosa pine, pinyon-juniper woodlands, and shrub desert. Elevations up to 10,600 feet. Roosts in crevices of rocky cliffs.	**Considered.** Pinyon-juniper and crevice habitat is present.
Townsend's Big-eared Bat *Corynorhinus townsendii pallescens*	Semidesert shrublands, pinyon-juniper woodlands, and open montane forests. Elevations up to 9,500 feet. Roosts in caves and abandoned mines.	**Considered.** Suitable foraging habitat present; roosts limited.
Pygmy Rabbit *Brachylagus idahoensis*	Areas with tall, dense sagebrush. Requires deep soils to excavate burrows.	**Not Considered.** Suitable habitat not available. Nearest historical record south of the Town of Emery in early 1900s.
Birds		
Bald Eagle (*Haliaeetus leucocephalus*)	Winter habitat includes open water where fish and waterfowl can be caught throughout the fall and early winter. After the open water freezes, eagles generally move to the foothills and valleys to feed on small mammals and carrion.	**Considered.** Bald eagles have been recorded in the area. Closest known nest approximately 18 miles from project area.
Northern Goshawk *Accipiter gentilis*	Habitat includes a wide variety of forest ages, structural conditions, and successional stages for foraging. Generally nests in coniferous, mixed coniferous, and riparian (aspen stringers) forests.	**Considered.** There are recorded goshawk responses in the project area and several territories in the general area. Extensive suitable habitat is present.

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Table 1 (cont'd). Suitability of habitat in the project area for Forest Service R4 Sensitive wildlife and plant species found on the Manti-La Sal and Fishlake National Forests (Forest Service 2010a).

Species	Habitat Description	Analysis of Habitat Suitability/Rationale
Peregrine Falcon *Falco peregrinus anatum*	Preferred nesting sites are cliffs in mountainous areas or in river canyons and gorges. Forage in riparian areas or in open meadows.	**Considered.** Suitable cliff habitat for nesting is available. Records in the general area exist and two known nests in the area are present.
Flammulated Owl *Otus flammeolus*	Mature pine, mixed conifer and aspen forests. Snags with cavities required for nesting.	**Considered.** Suitable habitat present. Numerous responses in the area recorded.
Three-Toed Woodpecker *Picoides tridactylus*	Coniferous and mixed forest types at elevations up to 9,000 feet. Requires snags for nesting and foraging.	**Considered.** Species is known to be present in the area from previous surveys. Extensive suitable habitat present.
Greater Sage-grouse *Centrocercus urophasianus*	Sagebrush communities used during all life cycle stages. Riparian meadows, springs, and streams are also used during late brood-rearing.	**Considered.** Active leks present. Numerous grouse recorded each year in the area.
Fish		
Bonneville Cutthroat Trout *Oncorhynchus clarki utah*	Small headwater streams with cool, clear water, pools, and well-vegetated streambanks. Clean, gravel substrate in cool water required for spawning. May also inhabit lakes.	**Not Considered.** Species on found in or near the project area.
Colorado River Cutthroat Trout *Oncorhynchus clarki pleuriticus*	Headwater streams and lakes with cold, clean water of the Colorado river drainage system; only occurs on the Loa Ranger District of the Fishlake National Forest.	**Considered.** Species known from the project area.
Southern leatherside chub *Leidomeda aliciae*	Desert streams of the Bonneville Basin. Require flowing water and do not persist in lakes or reservoirs.	**Not Considered.** Species not found in or near the project area.
Amphibians		
Columbia spotted frog *Rana luteiventris*	In or near permenant bodies of water including lakes, ponds, slow streams, and marshes. Non-woody wetland plant communities.	**Not Considered.** Outside of the habitat range. Near the project area, it only occurs in the San Pete Valley along the San Pitch River.
Western boreal toad *Bufo boreas boreas*	Found in a variety of habitats, including slow moving streams, wetlands, desert springs, ponds, lakes, meadows, and woodlands.	**Not Considered.** Species not found in the area where impacts would occur.

Plants (Welsh et al. 2003, UNPS 2010)			
Species	**National Forest**	**Habitat Description**	**Analysis of Habitat Suitability/Rationale**
Allium geyeri chatterleyi Chatterley onion	Manti-La Sal	San Juan County. Pinyon-juniper, ponderosa pine-manzanita, and mountain mahogany communities.	**Not Considered.** Outside of known range.
Androsace chamaejasme ssp. carinata Sweet-flowered rock jasmine	Manti-La Sal	Grand and San Juan counties. Alpine tundra at 10,000 - 12,680 feet in the La Sal mountains.	**Not Considered.** Outside of known range and above elevation of project area.

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Table 1 (cont'd). Suitability of habitat in the project area for Forest Service R4 Sensitive wildlife and plant species found on the Manti-La Sal and Fishlake National Forests (Forest Service 2010a).

Aquilegia flavescens var. rubincunda Link Trail columbine	Manti-La Sal	Emery and Sevier counties. East margins of the Wasatch Plateau in ponderosa pine, aspen, and spruce-fir communities, generally associated with seeps at the base of Mesa Verde group sandstones adjacent to coal measures, 6,900 to 8,500 fee[b]	**Considered.** Species is present in Box Canyon and Greens Canyon outside of the project area. It is also present in nearby Link Canyon as well.
Aster kingii var. barebyana Barneby woody aster	Fishlake	Mountain mahogany and oak communities on rock outcrops in Juab and Millard counties, Utah.	**Not Considered.** Outside of known range.
Astragalus consobrinus Bicknell milkvetch	Manti-La Sal Fishlake	Sagebrush-grassland and pinyon-juniper communities on the Mancos Shale Formation; Volcanic gravel to barren stony hillsides on the upper forks of the Sevier River and the east slope of the Utah Plateaus from southeast Emery and Sevier to southwest Garfield counties between 6,000 to 8,500 feet	**Considered.** Sagebrush and pinyon-juniper habitat is present in project area. However, there are no records of this species in the project area.
Castilleja parvula var. parvula Tushar Mountain paintbrush	Fishlake	Endemic to the Tushar Mountain, Beaver and Piute counties, Utah.	**Not Considered.** Outside of known range.
Cryptantha creutsfeldtii Creutzfeldtii cryptanth	Manti-La Sal Fishlake	Western Carbon and Emery counties. Shadescale and mat atriplex communities on shadscale formations between 5,200 and 6,500 feet	**Not Considered.** Project area is outside of the habitat constraints for this species.
Cymopterus beckii Pinnate spring parsley	Fishlake	Cliff faces in sandstone canyon bottoms of Navajo Sandstone. Endemic to San Juan and Wayne counties.	**Not Considered.** Outside of known range.
Draba sobolifera Creeping draba	Fishlake	Endemic to the Tushar Mountains, Beaver, and Piute counties, Utah.	**Not Considered.** Outside of known range.
Epilobium nevadense Nevada willowherb	Fishlake	Pinyon-juniper and mountain brush communities on limestone outcrops in Millard and Washington counties.	**Not Considered.** Outside of known range.
Erigeron abajoensis Abajo daisy	Manti-La Sal	Garfield, Piute, San Juan, and Wayne counties. Pinyon-juniper ponderosa pine, and spruce-fir communities at 7,000 – 11,320 feet.	**Not Considered.** Outside of known range.
Erigeron carringtonae Carrington daisy	Manti-La Sal Fishlake	Emery and Sanpete counties. Meadow and escarpments margins on Flagstaff limestone between 10,000 and 11,000 feet.	**Not Considered.** Project area is outside the habitat constraints for this species. Flagstaff limestone outcrops at the appropriate elevation are not present.
Erigeron kachinensis Kachina daisy	Manti-La Sal	San Juan County. Montane sites with mountain brush, pinyon-juniper, and ponderosa pine, Douglas fir, and Manzanita communities at 5,250 - 8,000 feet.	**Not Considered.** Outside of known range.

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Table 1 (cont'd). Suitability of habitat in the project area for Forest Service R4 Sensitive wildlife and plant species found on the Manti-La Sal and Fishlake National Forests (Forest Service 2010a).

Species	National Forest	Habitat Description	Analysis of Habitat Suitability/Rationale
Erigeron mancus LaSal daisy	Manti-La Sal	Grand and San Juan counties. Subalpine fir, and alpine forb and grass-sedge communities, frequently in rockstripes at 10,000 – 12,240 feet.	**Not Considered.** Outside of known range and above elevation of project area.
Eriogonum batemanii var. ostlundii Elsinore buckwheat	Fishlake	Igneous outcrops and gravels in shadscale, sagebrush, ponderosa pine, mixed desert shrub, and pinyon-juniper communities at 5,500 to 6,500 feet elevation. Endemic to Piute and Sevier Counties in central Utah.	**Not Considered.** Outside of known range.
Gilia caespitosa Wonderland Alice flower	Fishlake	Wayne County. Pinyon-juniper-cercocarpus communities at 5,690 – 8,515 feet on Navajo Sandstone and Carmel Limestone.	**Not Considered.** Outside of known range.
Hedysarum occidentale var. *canoe* Canyon sweetvetch	Manti-La Sal	Carbon, Duchesne, and Emery counties. Pinyon-juniper, sagebrush, serviceberry, maple, mountain mahogany, and wash communities between 6,400 and 8,315 feet	**Considered.** Potential habitat is present in the project area.
Lomatium latilobum Canyonlands lomatium	Manti-La Sal	Grand and San Juan counties. Pinyon-juniper, dwarf mountain mahogany, and desert shrub communities, mainly in Entrada Sandstone at 4,350 – 7,120 feet.	**Not Considered.** Outside of known range.
Najas caespitosa Fishlake niad	Fishlake	Shallow water off of Pelican Point, Fish Lake, Utah.	**Not Considered.** Outside of known range.
Penstemon parvus Little penstemon	Fishlake	Sagebrush-grass and pinyon-juniper communities on tertiary volcanic gravels. Endemic to Utah in Piute, Garfield, and Wayne counties.	**Not Considered.** Outside of known range.
Penstemon wardii Ward's penstemon	Fishlake	Desert shrub, pinyon-juniper, sagebrush, shadscale, and greasewood communities on the Bald Knoll and Arapien Shale formations at the 5,200 to 6,810 feet elevations.	**Not Considered.** Outside of known range.
Salix arizonica Arizona willow	Manti-La Sal Fishlake	Riparian corridors above 8,300 feet in unshaded or partially shaded wet meadows, streamsides, and cienegas, typically in or adjacent to perennial water.	**Considered.** Potential habitat is present in the project area.
Senecio castoreus Beaver Mountain groundsel	Fishlake	Endemic to the Tushar Mountains between 11,000 and 12,700 feet on windswept ridges downward to spruce-fir communities in Piute County.	**Not Considered.** Outside of known range.
Senecio musiniensis Musinea groundsel	Manti-La Sal	Sanpete county. Ridgetops on Flagstaff limestone barrens and talus slopes at Musinea Peak and on margins of the Wasatch Platuea between 9,700 and 10,900 feet.	**Not Considered.** Project area is outside the habitat constraints for this species. Flagstaff limestone outcrops at the appropriate elevation are not present.

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Table 1 (cont'd). Suitability of habitat in the project area for Forest Service R4 Sensitive wildlife and plant species found on the Manti-La Sal and Fishlake National Forests (Forest Service 2010a).

Species	National Forest	Habitat Description	Analysis of Habitat Suitability/Rationale
Silene petersonii Maguire campion	Manti-La Sal Fishlake	Ponderosa pine, aspen, and spruce-fir communities between 7,000 and 11,300 feet on Flagstaff limestone and Claron Formation, mainly at plateau margins. Known from the Manti-La Sal National Forest.	**Not Considered.** Potential habitat does not occur in the project area.
Thelesperma subnuda var. aplina Bicknell thelesperma	Fishlake	Navajo Sandstone and Carmel Limestone between 6,888 and 9,000 feet. Endemic to Wayne County.	**Not Considered.** Outside of range.
Townsendia jonesii var. lutea Sevier townsendia	Fishlake	Salt desert shrub and juniper communities 5,500 to 6,400 feet in the Arapien shale and Arapien clays in volcanic rubble.	**Not Considered.** Outside of known range.

The project area contains potentially suitable habitat for the spotted bat, Townsend's big-eared bat, bald eagle, northern goshawk, peregrine falcon, flamulated owl, three-toed woodpecker, sage-grouse, Colorado River cutthroat trout, Link Trail columbine, Bicknell milkvetch, canyon sweetvetch. These species are carried forward into analysis in this document. Habitat in the project area is unsuitable for the pygmy rabbit, Bonneville cutthroat trout, Southern leatherside chub, Columbia spotted frog, Western boreal toad, and the other sensitive plant species considered in Table 1. Therefore, the proposed project would not impact these species, and they are not considered further in this document.

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VIII. DETERMINATIONS AND RATIONALE

This Biological Evaluation prepared for this project, tiers off the analysis presented in the Greens Hollow Wildlife Technical Report (Cirrus 2010a). The determinations outlined below are that the Proposed Action would affect Region 4 sensitive species in one of four ways: (1) no impact, (2) beneficial impact, (3) may adversely impact individuals, but not likely to result in a loss of viability in the planning area nor cause a trend toward Federal listing, or (4) likely to result in a loss of viability in the planning area or in a trend toward Federal listing. The determinations are based on specific habitat requirements of the different species in relation to anticipated effects of the Proposed Action.

A no-impact determination was made for eight of the species analyzed. For nine species, the Proposed Action may adversely impact individuals, but is not likely to result in a loss of viability in the Planning Area, nor cause a trend toward Federal listing, and for one species, it is determined that the Proposed Action may adversely impact individuals of the following species and is likely to result in a loss of viability in the planning area, and/or cause a trend toward Federal listing. Rationale specific to each determination is disclosed below. Further, it can be assumed that the Proposed Action would have "No Impact" on those species disclosed in Table 1 that were not carried through the analysis.

"No Impact" Determination

Based on the analysis provided in this document, it is determined that the Proposed Action would have **no impact** on the following Region 4 species:

- Bald eagle
- Bonneville cutthroat trout
- Columbia spotted frog
- Pygmy rabbit
- Southern leatherside chub
- Western boreal toad
- Bicknell's milkvetch
- Canyon sweetvetch

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These "no impact" determinations are based on one of the following rationales (Table 5):

1. Species are not likely to occur in the project area due to habitat and/or elevational requirements not found on the ski area.

2. Species have never been known in the project area.

3. Species or suitable habitat may occur within the project area, but no elements of the Proposed Action would affect them.

4. The immediate and greater surrounding area is currently subject to similar activities as those in the Proposed Action. There is documented history and on-the-ground evidence to support this determination.
5. Species occur outside of the project area, and elements of the proposed project would not affect the species.

Table 5. Rationale for "No Impact" determination on USDA Forest Service R4 sensitive species.

Species	Rationale
Bald eagle	3, 4
Bonneville cutthroat trout	1, 2, 4
Columbia spotted frog	1, 2, 4
Pygmy rabbit	1, 2, 4
Southern leatherside chub	1, 2
Western boreal toad	5
Bicknell's milkvetch	2, 3
Canyon sweetvetch	2, 3

"MAY IMPACT" DETERMINATION

Based on the analysis provided in this document, it is determined that the Proposed Action **may adversely impact individuals of the following species but not likely to result in a loss of viability in the planning area, nor cause a trend toward Federal listing.**

- Colorado River cutthroat trout
- Flammulated owl
- Northern goshawk
- Peregrine falcon
- Three-toed woodpecker
- Spotted bat
- Townsend's big-eared bat
- Link Trail Columbine
- Arizona willow

Further, based on the analysis provided in this document, it is determined that the Proposed Action **may adversely impact individuals of the following species and is likely to result in a loss of viability in the planning area, and/or cause a trend toward Federal listing.**

- Greater sage-grouse

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This "may impact" determination is based on the following rationale and summarized in Table 6.

1. As described above throughout Section 4.4, an extremely small amount of habitat compared to the project area as a whole as well as the larger, connected landscape would be destroyed/altered/impacted by the Proposed Action. This small amount of lost or altered habitat is expected to impact a small number of individuals and not impact species on the population scale.

2. Any effects experienced as a result of implementing the Proposed Action would be temporary to species' populations, although some individuals could be killed.

3. Best Management Practices (BMPs), Forest Plan S&Gs, and other design criteria, and mitigation measures designed to protect sensitive species and their habitat would be implemented to prevent population-wide disturbances which could impact breeding viability in the project area.

4. The nature of the direct, indirect, and cumulative impacts of the Proposed Action would constitute an incremental increase in the factors that have affected habitat values and sensitive species use in some cases (livestock grazing) for more than 150 years. This incremental increase is expected to be small in scope and not impact wildlife at the larger, population scale, although some individuals are expected to be impacted.

5. The immediate and greater surrounding area is currently subject to similar activities as those in the Proposed Action. Some serious issues such as loss of water needed by sensitive species has occurred in these surrounding areas under similar activities. However, special stipulations and mitigation measures have been put in place to protect these resources and ensure this determination remains true, that populations would remain viable, should the project area experience negative impacts to wildlife. There is documented history and on-the-ground evidence to support this determination.

6. Greater sage-grouse in the area currently experience roadways that travel through the lek sites. No new roads will be developed in these areas. Although traffic to the proposed northern vent shaft will increase along existing roads throughout the construction period of that shaft, lekking sage-grouse have been habituating to vehicular traffic through these areas for years. Further, mitigation has been put in place to minimize any of the additional impacts to the area that grouse may experience.

7. Forest Service Intermountain Region direction on greater sage-grouse states that if there is any impact to sage-grouse due to a proposed action, then the determination of "**may adversely impact individuals of the species and is likely to result in a loss of viability in the planning area, and/or cause a trend toward Federal listing**" is required.

Table 6. Rationale for "May Impact" determination on USDA Forest Service R4 sensitive species.

Species	Rationale
Colorado River cutthroat trout	1, 2, 3, 4, 5
Flammulated owl	1, 3, 4, 5
Greater sage-grouse	1, 2, 3, 4, 5, 6, 7
Northern goshawk	2, 3, 4, 5
Peregrine falcon	2, 3, 4, 5

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Table 6 (cont'd). Rationale for "May Impact" determination on USDA Forest Service R4 sensitive species.

Species	Rationale
Three-toed woodpecker	1, 3, 4, 5
Spotted bat	1, 2, 3, 4, 5
Townsend's big-eared bat	1, 2, 3, 4, 5
Link Trail Columbine	1
Arizona willow	1

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Utah's State Listed Species by County

Disclaimer: This list was compiled using known species occurrences and species observations from the Utah Natural Heritage Program's Biodiversity Tracking and Conservation System (BIOTICS); other species of special concern likely occur in Utah Counties. This list includes both current and historic records. (Last updated on October 1, 2015).

Beaver County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
Dark Kangaroo Mouse	Microdipodops megacephalus	SPC
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Hamlin Valley Pyrg	Pyrgulopsis hamlinensis	SPC
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Long-billed Curlew	Numenius americanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Spotted Bat	Euderma maculatum	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Western Toad	Bufo boreas	SPC

Box Elder County

Common Name	Scientific Name	State Status
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Deseret Mountainsnail	Oreohelix peripherica	SPC
Ferruginous Hawk	Buteo regalis	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Gray Wolf	Canis lupus	S-ESA
Great Plains Toad	Bufo cognatus	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC

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Box Elder County - continued

Common Name	Scientific Name	State Status
Kit Fox	Vulpes macrotis	SPC
Lahontan Cutthroat Trout	Oncorhynchus clarkii henshawi	S-ESA
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Lyrate Mountainsnail	Oreohelix haydeni	SPC
Mountain Plover	Charadrius montanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Northern Leatherside Chub	Lepidomeda copei	SPC
Northwest Bonneville Pyrg	Pyrgulopsis variegata	SPC
Preble's Shrew	Sorex preblei	SPC
Pygmy Rabbit	Brachylagus idahoensis	SPC
Sharp-tailed Grouse	Tympanuchus phasianellus	SPC
Short-eared Owl	Asio flammeus	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Physa	Physella utahensis	SPC
Western Pearlshell	Margaritifera falcata	SPC
Western Toad	Bufo boreas	SPC
Yellowstone Cutthroat Trout	Oncorhynchus clarkii bouvieri	SPC

Cache County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Black Swift	Cypseloides niger	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Canada Lynx	Lynx canadensis	S-ESA
Deseret Mountainsnail	Oreohelix peripherica	SPC
Fringed Myotis	Myotis thysanodes	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Great Plains Toad	Bufo cognatus	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Lyrate Mountainsnail	Oreohelix haydeni	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Sharp-tailed Grouse	Tympanuchus phasianellus	SPC

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Cache County - continued

Common Name	Scientific Name	State Status
Short-eared Owl	Asio flammeus	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Red Bat	Lasiurus blossevillii	SPC
Western Toad	Bufo boreas	SPC

Carbon County

Common Name	Scientific Name	State Status
Bald Eagle	Haliaeetus leucocephalus	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bluehead Sucker	Catostomus discobolus	CS
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Bonytail	Gila elegans	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Greater Sage-grouse	Centrocercus urophasianus	SPC
Humpback Chub	Gila cypha	S-ESA
Kit Fox	Vulpes macrotis	SPC
Northern Goshawk	Accipiter gentilis	CS
Razorback Sucker	Xyrauchen texanus	S-ESA
Roundtail Chub	Gila robusta	CS
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Red Bat	Lasiurus blossevillii	SPC
Western Toad	Bufo boreas	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC

Daggett County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bear Lake Sculpin	Cottus extensus	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bluehead Sucker	Catostomus discobolus	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Canada Lynx	Lynx canadensis	S-ESA
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Humpback Chub	Gila cypha	S-ESA
Lewis's Woodpecker	Melanerpes lewis	SPC
Northern Goshawk	Accipiter gentilis	CS

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Daggett County - continued

Common Name	Scientific Name	State Status
Razorback Sucker	Xyrauchen texanus	S-ESA
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Toad	Bufo boreas	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC

Davis County

Common Name	Scientific Name	State Status
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
Columbia Spotted Frog	Rana luteiventris	CS
Ferruginous Hawk	Buteo regalis	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Short-eared Owl	Asio flammeus	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Pearlshell	Margaritifera falcata	SPC
Western Toad	Bufo boreas	SPC

Duchesne County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Black Swift	Cypseloides niger	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bluehead Sucker	Catostomus discobolus	CS
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Eureka Mountainsnail	Oreohelix eurekensis	SPC
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Gray Wolf	Canis lupus	S-ESA
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC

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Duchesne County - continued

Common Name	Scientific Name	State Status
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Mountain Plover	Charadrius montanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Spotted Bat	Euderma maculatum	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Toad	Bufo boreas	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC

Emery County

Common Name	Scientific Name	State Status
Bald Eagle	Haliaeetus leucocephalus	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bluehead Sucker	Catostomus discobolus	CS
Bonytail	Gila elegans	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Canada Lynx	Lynx canadensis	S-ESA
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Great Plains Toad	Bufo cognatus	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Humpback Chub	Gila cypha	S-ESA
Kit Fox	Vulpes macrotis	SPC
Northern Goshawk	Accipiter gentilis	CS
Razorback Sucker	Xyrauchen texanus	S-ESA
Roundtail Chub	Gila robusta	CS
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Toad	Bufo boreas	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC

Garfield County

Common Name	Scientific Name	State Status
Allen's Big-eared Bat	Idionycteris phyllotis	SPC
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Arizona Toad	Bufo microscaphus	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Black Canyon Pyrg	Pyrgulopsis plicata	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS

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Garfield County - continued

Common Name	Scientific Name	State Status
Bonytail	Gila elegans	S-ESA
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Common Chuckwalla	Sauromalus ater	SPC
Desert Night Lizard	Xantusia vigilis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Humpback Chub	Gila cypha	S-ESA
Kit Fox	Vulpes macrotis	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Spotted Bat	Euderma maculatum	SPC
Spotted Owl	Strix occidentalis	S-ESA
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Physa	Physella utahensis	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Western Toad	Bufo boreas	SPC

Grand County

Common Name	Scientific Name	State Status
Allen's Big-eared Bat	Idionycteris phyllotis	SPC
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bluehead Sucker	Catostomus discobolus	CS
Bonytail	Gila elegans	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Cornsnake	Elaphe emoryi	SPC
Eureka Mountainsnail	Oreohelix eurekensis	SPC
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Great Plains Toad	Bufo cognatus	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Gunnison Sage-grouse	Centrocercus minimus	S-ESA, CS

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Grand County - continued

Common Name	Scientific Name	State Status
Gunnison's Prairie-dog	Cynomys gunnisoni	SPC
Humpback Chub	Gila cypha	S-ESA
Kit Fox	Vulpes macrotis	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Northern Goshawk	Accipiter gentilis	CS
Razorback Sucker	Xyrauchen texanus	S-ESA
Roundtail Chub	Gila robusta	CS
Smooth Greensnake	Opheodrys vernalis	SPC
Spotted Bat	Euderma maculatum	SPC
Spotted Owl	Strix occidentalis	S-ESA
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC
Yellow-billed Cuckoo	Coccyzus americanus	S-ESA

Iron County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
Arizona Toad	Bufo microscaphus	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Black Swift	Cypseloides niger	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brian Head Mountainsnail	Oreohelix parawanensis	SPC
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Dark Kangaroo Mouse	Microdipodops megacephalus	SPC
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Long-billed Curlew	Numenius americanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Spotted Bat	Euderma maculatum	SPC
Spotted Owl	Strix occidentalis	S-ESA
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA

Juab County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC

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Juab County - continued

Common Name	Scientific Name	State Status
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Columbia Spotted Frog	Rana luteiventris	CS
Dark Kangaroo Mouse	Microdipodops megacephalus	SPC
Eureka Mountainsnail	Oreohelix eurekensis	SPC
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Physa	Physella utahensis	SPC
Western Toad	Bufo boreas	SPC

Kane County

Common Name	Scientific Name	State Status
Allen's Big-eared Bat	Idionycteris phyllotis	SPC
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Arizona Toad	Bufo microscaphus	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Bonytail	Gila elegans	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Common Chuckwalla	Sauromalus ater	SPC
Desert Night Lizard	Xantusia vigilis	SPC
Desert Sucker	Catostomus clarkii	SPC
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Great Plains Toad	Bufo cognatus	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Humpback Chub	Gila cypha	S-ESA
Kanab Ambersnail	Oxyloma kanabense	S-ESA

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Kane County - continued

Common Name	Scientific Name	State Status
Kit Fox	Vulpes macrotis	SPC
Northern Goshawk	Accipiter gentilis	CS
Roundtail Chub	Gila robusta	CS
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Southwestern Willow Flycatcher	Empidonax traillii extimus	S-ESA
Spotted Bat	Euderma maculatum	SPC
Spotted Owl	Strix occidentalis	S-ESA
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Virgin Spinedace	Lepidomeda mollispinis	CS
Western Toad	Bufo boreas	SPC

Millard County

Common Name	Scientific Name	State Status
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bifid Duct Pyrg	Pyrgulopsis peculiaris	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Cloaked Physa	Physa megalochlamys	SPC
Columbia Spotted Frog	Rana luteiventris	CS
Dark Kangaroo Mouse	Microdipodops megacephalus	SPC
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Longitudinal Gland Pyrg	Pyrgulopsis anguina	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Sub-globose Snake Pyrg	Pyrgulopsis saxatilis	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Western Toad	Bufo boreas	SPC

Morgan County

Common Name	Scientific Name	State Status
Bald Eagle	Haliaeetus leucocephalus	SPC
Bluehead Sucker	Catostomus discobolus	CS

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Morgan County - continued

Common Name	Scientific Name	State Status
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Deseret Mountainsnail	Oreohelix peripherica	SPC
Ferruginous Hawk	Buteo regalis	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Lyrate Mountainsnail	Oreohelix haydeni	SPC
Northern Goshawk	Accipiter gentilis	CS
Sharp-tailed Grouse	Tympanuchus phasianellus	SPC
Western Pearlshell	Margaritifera falcata	SPC
Western Toad	Bufo boreas	SPC

Piute County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
California Floater	Anodonta californiensis	SPC
Ferruginous Hawk	Buteo regalis	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Long-billed Curlew	Numenius americanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Otter Creek Pyrg	Pyrgulopsis fusca	SPC
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Physa	Physella utahensis	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Western Toad	Bufo boreas	SPC

Rich County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bear Lake Sculpin	Cottus extensus	SPC
Bear Lake Springsnail	Pyrgulopsis pilsbryana	SPC
Bear Lake Whitefish	Prosopium abyssicola	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cisco	Prosopium gemmifer	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS

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Rich County - continued

Common Name	Scientific Name	State Status
Bonneville Whitefish	Prosopium spilonotus	SPC
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Ferruginous Hawk	Buteo regalis	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Lyrate Mountainsnail	Oreohelix haydeni	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Western Pearlshell	Margaritifera falcata	SPC
Western Toad	Bufo boreas	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC

Salt Lake County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Black Swift	Cypseloides niger	SPC
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Columbia Spotted Frog	Rana luteiventris	CS
Ferruginous Hawk	Buteo regalis	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Lyrate Mountainsnail	Oreohelix haydeni	SPC
Northern Goshawk	Accipiter gentilis	CS
Short-eared Owl	Asio flammeus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Spotted Bat	Euderma maculatum	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Pearlshell	Margaritifera falcata	SPC
Western Toad	Bufo boreas	SPC
Yellow-billed Cuckoo	Coccyzus americanus	S-ESA

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San Juan County

Common Name	Scientific Name	State Status
Allen's Big-eared Bat	Idionycteris phyllotis	SPC
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Arizona Toad	Bufo microscaphus	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonytail	Gila elegans	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Common Chuckwalla	Sauromalus ater	SPC
Desert Night Lizard	Xantusia vigilis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Gray Wolf	Canis lupus	S-ESA
Great Plains Toad	Bufo cognatus	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Gunnison Sage-grouse	Centrocercus minimus	S-ESA, CS
Gunnison's Prairie-dog	Cynomys gunnisoni	SPC
Humpback Chub	Gila cypha	S-ESA
Kit Fox	Vulpes macrotis	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Mogollon Vole	Microtus mogollonensis	SPC
Northern Goshawk	Accipiter gentilis	CS
Razorback Sucker	Xyrauchen texanus	S-ESA
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Silky Pocket Mouse	Perognathus flavus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Southwestern Willow Flycatcher	Empidonax traillii extimus	S-ESA
Spotted Bat	Euderma maculatum	SPC
Spotted Owl	Strix occidentalis	S-ESA
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC
Yavapai Mountainsnail	Oreohelix yavapai	

Sanpete County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA

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Sanpete County - continued

Common Name	Scientific Name	State Status
Burrowing Owl	Athene cunicularia	SPC
Canada Lynx	Lynx canadensis	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Columbia Spotted Frog	Rana luteiventris	CS
Ferruginous Hawk	Buteo regalis	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Ninemile Pyrg	Pyrgulopsis nonaria	SPC
Northern Goshawk	Accipiter gentilis	CS
Southern Bonneville Springsnail	Pyrgulopsis transversa	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Western Toad	Bufo boreas	SPC

Sevier County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Black Swift	Cypseloides niger	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Canada Lynx	Lynx canadensis	S-ESA
Carinate Glenwood Pyrg	Pyrgulopsis inopinata	SPC
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Long-billed Curlew	Numenius americanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Otter Creek Pyrg	Pyrgulopsis fusca	SPC
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Smooth Glenwood Pyrg	Pyrgulopsis chamberlini	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Western Toad	Bufo boreas	SPC

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Summit County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Canada Lynx	Lynx canadensis	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Columbia Spotted Frog	Rana luteiventris	CS
Deseret Mountainsnail	Oreohelix peripherica	SPC
Ferruginous Hawk	Buteo regalis	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Northern Goshawk	Accipiter gentilis	CS
Northern Leatherside Chub	Lepidomeda copei	SPC
Short-eared Owl	Asio flammeus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Western Pearlshell	Margaritifera falcata	SPC
Western Toad	Bufo boreas	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC

Tooele County

Common Name	Scientific Name	State Status
Allen's Big-eared Bat	Idionycteris phyllotis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Columbia Spotted Frog	Rana luteiventris	CS
Dark Kangaroo Mouse	Microdipodops megacephalus	SPC
Eureka Mountainsnail	Oreohelix eurekensis	SPC
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Lyrate Mountainsnail	Oreohelix haydeni	SPC
Northern Goshawk	Accipiter gentilis	CS
Northwest Bonneville Pyrg	Pyrgulopsis variegata	SPC
Preble's Shrew	Sorex preblei	SPC

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Tooele County - continued

Common Name	Scientific Name	State Status
Pygmy Rabbit	Brachylagus idahoensis	SPC
Short-eared Owl	Asio flammeus	SPC
Southern Bonneville Springsnail	Pyrgulopsis transversa	SPC
Southern Tightcoil	Ogaridiscus subrupicola	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Physa	Physella utahensis	SPC

Uintah County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Black-footed Ferret	Mustela nigripes	S-ESA
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonytail	Gila elegans	S-ESA
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Canada Lynx	Lynx canadensis	S-ESA
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Cornsnake	Elaphe emoryi	SPC
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinhis	CS
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Humpback Chub	Gila cypha	S-ESA
Kit Fox	Vulpes macrotis	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Mountain Plover	Charadrius montanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Razorback Sucker	Xyrauchen texanus	S-ESA
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Spotted Bat	Euderma maculatum	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC
Yellow-billed Cuckoo	Coccyzus americanus	S-ESA

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Utah County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Black Swift	Cypseloides niger	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
California Floater	Anodonta californiensis	SPC
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Columbia Spotted Frog	Rana luteiventris	CS
Eureka Mountainsnail	Oreohelix eurekensis	SPC
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
June Sucker	Chasmistes liorus	S-ESA
Kit Fox	Vulpes macrotis	SPC
Least Chub	Iotichthys phlegethontis	CS
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Northern Goshawk	Accipiter gentilis	CS
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Southern Bonneville Springsnail	Pyrgulopsis transversa	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Spotted Bat	Euderma maculatum	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Physa	Physella utahensis	SPC
Western Red Bat	Lasiurus blossevillii	SPC
Western Toad	Bufo boreas	SPC
White-tailed Prairie-dog	Cynomys leucurus	SPC
Yellow-billed Cuckoo	Coccyzus americanus	S-ESA

Wasatch County

Common Name	Scientific Name	State Status
American Three-toed Woodpecker	Picoides dorsalis	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Black Swift	Cypseloides niger	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Canada Lynx	Lynx canadensis	S-ESA

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Wasatch County - continued

Common Name	Scientific Name	State Status
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Columbia Spotted Frog	Rana luteiventris	CS
Ferruginous Hawk	Buteo regalis	SPC
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Northern Goshawk	Accipiter gentilis	CS
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Western Toad	Bufo boreas	SPC
Yellow-billed Cuckoo	Coccyzus americanus	S-ESA

Washington County

Common Name	Scientific Name	State Status
Allen's Big-eared Bat	Idionycteris phyllotis	SPC
American Three-toed Woodpecker	Picoides dorsalis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Arizona Toad	Bufo microscaphus	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Black Swift	Cypseloides niger	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Brown (Grizzly) Bear	Ursus arctos	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Common Chuckwalla	Sauromalus ater	SPC
Desert Iguana	Dipsosaurus dorsalis	SPC
Desert Night Lizard	Xantusia vigilis	SPC
Desert Springsnail	Pyrgulopsis deserta	SPC
Desert Sucker	Catostomus clarkii	SPC
Desert Tortoise	Gopherus agassizii	S-ESA
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Gila Monster	Heloderma suspectum	SPC
Gray Wolf	Canis lupus	S-ESA
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Mojave Rattlesnake	Crotalus scutulatus	SPC
Mountain Plover	Charadrius montanus	SPC

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Washington County - continued

Common Name	Scientific Name	State Status
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Relict Leopard Frog	Rana onca	S-ESA
Short-eared Owl	Asio flammeus	SPC
Sidewinder	Crotalus cerastes	SPC
Southwestern Willow Flycatcher	Empidonax traillii extimus	S-ESA
Speckled Rattlesnake	Crotalus mitchellii	SPC
Spotted Bat	Euderma maculatum	SPC
Spotted Owl	Strix occidentalis	S-ESA
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Virgin Chub	Gila seminuda	S-ESA
Virgin Spinedace	Lepidomeda mollispinis	CS
Western Banded Gecko	Coleonyx variegatus	SPC
Western Red Bat	Lasiurus blossevillii	SPC
Western Threadsnake	Leptotyphlops humilis	SPC
Western Toad	Bufo boreas	SPC
Wet-rock Physa	Physella zionis	SPC
Woundfin	Plagopterus argentissimus	S-ESA
Yellow-billed Cuckoo	Coccyzus americanus	S-ESA
Zebra-tailed Lizard	Callisaurus draconoides	SPC

Wayne County

Common Name	Scientific Name	State Status
Allen's Big-eared Bat	Idionycteris phyllotis	SPC
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Big Free-tailed Bat	Nyctinomops macrotis	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bonytail	Gila elegans	S-ESA
Burrowing Owl	Athene cunicularia	SPC
Colorado Pikeminnow	Ptychocheilus lucius	S-ESA
Colorado River Cutthroat Trout	Oncorhynchus clarkii pleuriticus	CS
Ferruginous Hawk	Buteo regalis	SPC
Flannelmouth Sucker	Catostomus latipinnis	CS
Fringed Myotis	Myotis thysanodes	SPC
Greater Sage-grouse	Centrocercus urophasianus	SPC
Humpback Chub	Gila cypha	S-ESA
Kit Fox	Vulpes macrotis	SPC
Northern Goshawk	Accipiter gentilis	CS
Pygmy Rabbit	Brachylagus idahoensis	SPC
Razorback Sucker	Xyrauchen texanus	S-ESA
Roundtail Chub	Gila robusta	CS
Short-eared Owl	Asio flammeus	SPC
Southern Leatherside Chub	Lepidomeda aliciae	SPC
Spotted Bat	Euderma maculatum	SPC

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Wayne County - continued

Common Name	Scientific Name	State Status
Spotted Owl	Strix occidentalis	S-ESA
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Utah Prairie-dog	Cynomys parvidens	S-ESA
Western Toad	Bufo boreas	SPC

Weber County

Common Name	Scientific Name	State Status
American White Pelican	Pelecanus erythrorhynchos	SPC
Bald Eagle	Haliaeetus leucocephalus	SPC
Bluehead Sucker	Catostomus discobolus	CS
Bobolink	Dolichonyx oryzivorus	SPC
Bonneville Cutthroat Trout	Oncorhynchus clarkii utah	CS
Burrowing Owl	Athene cunicularia	SPC
Columbia Spotted Frog	Rana luteiventris	CS
Deseret Mountainsnail	Oreohelix peripherica	SPC
Grasshopper Sparrow	Ammodramus savannarum	SPC
Gray Wolf	Canis lupus	S-ESA
Greater Sage-grouse	Centrocercus urophasianus	SPC
Kit Fox	Vulpes macrotis	SPC
Lewis's Woodpecker	Melanerpes lewis	SPC
Long-billed Curlew	Numenius americanus	SPC
Lyrate Mountainsnail	Oreohelix haydeni	SPC
Northern Goshawk	Accipiter gentilis	CS
Sharp-tailed Grouse	Tympanuchus phasianellus	SPC
Short-eared Owl.	Asio flammeus	SPC
Smooth Greensnake	Opheodrys vernalis	SPC
Townsend's Big-eared Bat	Corynorhinus townsendii	SPC
Yellow-billed Cuckoo	Coccyzus americanus	S-ESA

Key to State Status Field

Symbol	Definition
S-ESA	Federally-listed or candidate species under the Endangered Species Act.
SPC	Wildlife species of concern.
CS	Species receiving special management under a Conservation Agreement in order to preclude the need for Federal listing.

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INTERMOUNTAIN REGION (R4) THREATENED, ENDANGERED, PROPOSED, AND, SENSITIVE SPECIES

June 2016

KNOWN / SUSPECTED DISTRIBUTION BY FOREST

STATUS	FOREST															
ENDANGERED	**ASH**	**BOI**	**B-T**	**CAR**	**CHA**	**DIX**	**FIS**	**HUM**	**M-L**	**PAY**	**SAL**	**SAW**	**TAR**	**TOI**	**UIN**	**W-C**
MAMMALS																
Black-footed ferret 3/11/67 *Mustela nigripes*			o													o
Sierra Nevada bighorn sheep *Ovis canadensis* sierra January 3, 2000														X		
BIRDS																
Southwestern willow flycatcher 2/27/95 *Empidonax traillii extimus* ED 3/29/95									X					?		
Whooping crane 3/11/67 *Grus americana*			X										?			
REPTILES AND AMPHIBIANS																
Sierra Nevada Yellow-legged Frog 06/30/2014 *Rana sierrae*														X		
INSECTS																
Mt. Charleston Blue Butterfly 10/21/2013 *Icaricia shasta charlestonensis*														X		
FISH																
June sucker 3/31/86 *Chasmistes liorus*															o	o
Bonytail chub 4/23/80 *Gila elegans*	o		o			o	o		o						o	o
Humpback chub 3/11/67 *Gila cypha*	o		o			o	o		o						o	o
Colorado pike minnow 3/11/67 *Ptychocheilus lucius*	o		o			o	o		o						o	o
Kendall Warm Springs dace 10/13/70 *Rhinichthys osculus*			X													

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ENDANGERED	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Sockeye salmon, (Snake River0 11/20/91 *Oncorhynchus nerka* (CH 12/28/98)					+					+	+	X				
Razorback sucker 10/23/91 *Xyrauchen texanus* (ED 11/22/91)	o		o			o	o		o						o	o
Sturgeon, pallid *Scaphirhynchus albus*			o													
PLANTS																
San Rafael cactus *Pediocactus despainii*							X									
Clay phacelia 09/28/78 *Phacelia argillacea*									?						X	
THREATENED	**ASH**	**BOI**	**B-T**	**CAR**	**CHA**	**DIX**	**FIS**	**HUM**	**M-L**	**PAY**	**SAL**	**SAW**	**TAR**	**TOI**	**UIN**	**W-C**
MAMMALS																
Canada lynx 4/15/00 *Lynx canadensis*	X	X	X							X		X	X		?	?
Grizzly bear 9/21/2009 *Ursus arctos horribilis*			X										X			
Gray wolf (Wyoming Rocky Mountain DPS 10J Experimental Population) *Canis lupus*			X	X									X			X
Utah prairie dog 6/04/73 *Cynomys parvidens*						X	X									
Northern Idaho ground squirrel 3/24/00 *Spermophilus brunneus*		X								X						
BIRDS																
Mexican spotted owl 3/16/93 *Strix occidentalis lucida (ED 4/15/93)*						X	X		X							
Yellow-billed cuckoo 11/03/2014 *Coccyzus americanus*	X	X	X		?	?	?	X	X	X	?	X	X	X	X	X
REPTILES AND AMPHIBIANS																
Desert tortoise 8/04/89 *Gopherus agassizii*														X		
Yosemite toad 6/30/2014 *Anaxyrus canorus*														X		
FISH																
Steelhead trout (Snake River summer) *Oncorhynchus mykiss*		X			X					X	X	X				

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x=known species/habitat; ?=suspected/potential habitat; *=wild/naturally reproducing; +=migration; o=offsite; r= reintroduced populations; ED=Effective dates

THREATENED	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Chinook salmon, Snake River sprg/smr *Oncorhynchus tshawytscha 4/22/92* (ED 5/22/92)		X			X					X	X	X				
Chinook salmon, Snake River fall *Oncorhynchus tshawytscha 4/22/92* (ED 5/22/92)										X						
Greenback cutthroat trout *Oncorhynchus clarki stomiua*									X							
Railroad Valley springfish 3/31/86 *Crenichthys nevadae*														X		
Lahontan cutthroat trout 10/13/70 *Oncorhynchus clarki henshawi*								X						X		
Columbia River bull trout 6/10/98 *Salvelinus confluentus*		X			X			X		X	X	X				
Paiute cutthroat trout 3/11/67 *Oncorhynchus clarki seleniris*														X		
PLANTS																
Deseret milkvetch 10/20/99 *Astragalus desereticus*									?						?	
Heliotrope milkvetch 11/6/87 *Astragalus limnocharis var.montii (A. montii)*									X							
Slick-spot peppergrass 10/08/09 *Lepidium papilliferum*		?														
Winkler cactus *Pediocactus winkleri*									?							
Maguire's primrose 8/21/85 *Primula cusickiana var. maguirei (P. maguirei)*																X
Last chance townsendia 8/21/85 *Townsendia aprica*						X	X									
Ute ladies' tresses orchid 1/17/92 *Spiranthes diluvialis* (2/18/92)		?		?	?		?				?	?	X		X	?
Webber ivesia 7/3/2014 *Ivesia webberi*														X		
PROPOSED	**ASH**	**BOI**	**B-T**	**CAR**	**CHA**	**DIX**	**FIS**	**HUM**	**M-L**	**PAY**	**SAL**	**SAW**	**TAR**	**TOI**	**UIN**	**W-C**
North American wolverine Gulo gulo (luscus)	X	X	X	X	X					X	X	X	X	X		X

x=known species/habitat; ?=suspected/potential habitatt; *=wild/naturally reproducing; +=migration; o=offsite; r= reintroduced populations; ED=Effective dates

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CANDIDATE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Sierra Nevada red fox *Vulpes vulpes necator*														X		
Whitebark Pine *Pinus albicaulis*		X	X		X			X		X	X	X	X	X		

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
MAMMALS																
Bighorn Sheep *Ovis canadensis* - Includes Rocky Mountain bighorn sheep (*O. c. canadensis*), California bighorn sheep (*O. c. californiana*), and desert bighorn sheep (*O. c. nelsoni*) (7/29/2009)	X	X	X		X		X	X	X	X	X	X	X	X	X	X
Gray wolf (Rocky Mountain DPS) *Canis lupus*		X		X	X					X	X	X	X			X
Pygmy rabbit *Brachylagus idahoensis*				X	X	X	X	X			X	X	X	X		
Spotted bat *Euderma maculatum*	X	X	X	X	X	X	X	X	X	X	X	X	?	X	X	X
Fisher *Martes pennanti*		X	X		X					X	X	X	?		X	
Southern Idaho Ground Squirrel *Spermophilus brunneus endemicus*		X								X						
Townsend's Western Big-Eared Bat *Corynorhinus townsendii townsendii*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BIRDS																
Bald eagle *Haliaeetus leucocephalus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Boreal owl *Aegolius funereus*	X	X	X	X	X					X	X	X	X			X
Greater sage-grouse *Centrocercus urophasianus*	X	X	X	X	X	X	X	X	X	?	X	X	X	X	X	X
Greater sage-grouse Bi-State DPS *Centrocercus urophasianus*														X		
Trumpeter swan *Cygnus buccinator*			X	X									X			
Peregrine falcon 3/20/84 *Falco peregrinus anatum*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Common loon *Gavia immer*		X	X		+					?	+	X	X			
Harlequin duck *Histrionicus histrionicus*			X	X	?+					X	?+		X			
Mountain quail *Oreortyx pictus*		X						X		X		X		X		
Flammulated owl *Otus flammeolus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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x=known species/habitat; ?=suspected/potential habitatt; *=wild/naturally reproducing; +=migration; o=offsite; r= reintroduced populations; ED=Effective dates

SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
White-headed woodpecker *Picoides albolarvatus*		X								X		X		X		
Three-toed woodpecker *Picoides tridactylus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Great gray owl *Strix nebulosa*	X	X	X	X	X					X	X	X	X	X		X
California spotted owl *Strix occidentalis occidentalis*														X		
Columbian sharp-tailed grouse *Tympanuchus phasianellus columbianus*		X		X				X		X		X	X			X
Northern goshawk *Accipiter gentilis*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
REPTILES AND AMPHIBIANS																
Columbia spotted frog *Rana luteiventris*	?	X	X	X	X			X	X	X	X	X	X	X	X	X
Boreal Toad *Bufo boreas*	X		X	X		X	X		X				X		X	X
FISH																
Wood River sculpin *Cottus leiopomus*												X				
Westslope cutthroat trout *Oncorhynchus clarki lewisi*		X	X		X					X	X	X				
Colorado River cutthroat trout *Oncorhynchus clarki pleuriticus*	X		X			X	X		X						X	X
Bonneville cutthroat trout *Oncorhynchus clarki utah*			X	X		X	X	X	X						X	X
Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri*			X	X								X	X			
Northern Leatherside Chub *Lepidomeda copei*			X	X								X	X			X
Southern Leatherside Chub *Lepidomeda aliciae*						X	X		X						X	
Big Lost River Whitefish *Prosopium williamsoni*					X											
INSECTS																
Spring Mountain Checkerspot *Chlosyne acastus robusta*														X		
Dark Blue														X		

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x=known species/habitat; ?=suspected/potential habitatt; *=wild/naturally reproducing; +=migration; o=offsite; r= reintroduced populations; ED=Effective dates

SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Euphilotes ancilla purpura																
Morand's Checkerspot *Euphydryas anicia morandi*														X		
PLANTS																
Pink agoseris *Agoseris lackschewitzii*			X								X		X			
Wonderland Alice flower Aliciella (=*Gilia) caespitosa*						X	X									
Chatterley Onion *Allium geyeri var. chatterleyi*									X							
Swamp onion *Allium madidum*										X						
Tolmie's onion *Allium tolmiei* var. *persimile*		X								X						
Candystick *Allotropa virgata*										X						
Sweet-flowered rock jasmine *Androsace chamaejasme ssp. carinata*			X						X				X			
Charleston angelica *Angelica scabrida*														X		
Wheeler's angelica *Angelica wheeleri*															X	X
Meadow pussytoes *Antennaria arcuata*								X								
Charleston pussytoes *Antennaria soliceps*														X		
Link Trail columbine *Aquilegia flavescens var. rubicunda*									X							
Graham columbine *Aquilegia grahamii*	X															
Rosy King's sandwort *Arenaria kingii* ssp. *rosea*														X		
Petiolate wormwood *Artemisia campestris ssp. borealis var. petiolata*	X															
Eastwood milkweed *Asclepias eastwoodiana*								X						X		
Clokey milkvetch *Astragalus aequalis*														X		

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Lost River milkvetch *Astragalus amnis-amissi*					X											
Goose Creek milkvetch *Astragalus anserinus*												?				
Lemhi milkvetch *Astragalus aquilonius*					X							?				
Bicknell milkvetch *Astragalus consobrinus*							X		?							
Meadow milkvetch *Astragalus diversifolius var. diversifolius*			X		X								X			
Dana milkvetch *Astragalus henrimontanensis*						X										
Isely's milkvetch *Astragalus iselyi*									X							
Starvling milkvetch *Astragalus jejunus var. jejunus*			X	X												
Long Valley milkvetch *Astragalus johannis-howellii*														X		
Broad-pod freckled milkvetch *Astragalus lentiginosus var. latus*								X								
Navajo Lake milkvetch *Astragalus limnocharis* var. *limnocharis*						X										
Table Cliff milkvetch *Astragalus limnocharis* var. *tabulaeus*						X										
Lee Canyon milkvetch *Astragalus oophorus* var. *clokeyanus*														X		
Lavin's egg milkvetch *Astragalus oophorus* var. *lavinii*														X		
Payson's milkvetch *Astragalus paysonii*			X							X			?			
Spring Mountain milkvetch *Astragalus remotus*														X		
Lamoille Canyon milkvetch *Astragalus robbinsii* var. *occidentalis*								X								
Toquima milkvetch *Astragalus toquimanus*														X		
Currant milkvetch *Astragalus uncialis*								X								

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x=known species/habitat; ?=suspected/potential habitatt; *=wild/naturally reproducing; +=migration; o=cffsite; r= reintroduced populations; ED=Effective dates

SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
White Cloud milkvetch *Astragalus vexilliflexus* var. *nubilus*					X					X		X				
Guard milkvetch *Astragalus zionis var. vigulus*						X										
Bodie Hills rockcress Boechera (=*Arabis*) *bodiensis*														X		
Grouse Creek rockcress Boechera (=*Arabis*) *falcatoria*								X								
Spring Mountains rockcress Boechera (=*Arabis*) *nevadensis*														X		
Washoe tall rockcress Boechera (=*Arabis*) *rectissima* var. *simulans*														X		
Galena Creek rockcress Boechera (=*Arabis*) *rigidissima* var. *demota*														X		
Ophir rockcress Boechera (=*Arabis*) *ophira*														X		
Tiehm rockcress Boechera (=*Arabis*) *tiehmii*														X		
Upswept moonwort *Botrychium ascendens*														X		
Dainty moonwort *Botrychium crenulatum*	X												X	X	X	
Slender moonwort *Botrychium lineare*	X							?		?		X		X	?	X
Paradox moonwort *Botrychium paradoxum*						X										
Little grape fern *Botrychium simplex*												X				
Moosewort *Botrychium tunux*														X		
Beautiful Bryum *Bryum calobryoides*		X										X				
Cascade reedgrass *Calamagrostis tweedyi*										X						
Cusick camas *Camassia cusickii*										X						
Seaside sedge *Carex incurviformis*			X		X											

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Black and purple sedge *Carex luzulina var. atropurpurea*			X													
Tioga Pass sedge *Carex tiogana*														X		
Aquarius paintbrush *Castilleja aquariensis*						X										
Christ's Indian paintbrush *Castilleja christii*												X				
Tushar paintbrush *Castilleja parvula* var. *parvula*						X	X									
Reveal paintbrush *Castilleja parvula* var. *revealii*						X										
Centennial rabbitbrush *Chrysothamnus parryi* ssp. *montanus*													X			
Flexible alpine collomia *Collomia debilis var. camporum*											X					
Wasatch fitweed *Corydalis caseana spp. brachycarpa*															X	X
Creutzfeldt-flower cryptanth *Cryptantha creutzfeldtii*									X							
Yellow-white catseye *Cryptantha ochroleuca*						X										
Bodie Hills draba *Cusickiella quadricostata*														X		
Pinnate spring-parsley *Cymopterus beckii*						X			X							
Davis' wavewing *Cymopterus davisii*												X				
Douglas' biscuitroot *Cymopterus douglassii*					X						X	X				
Goodrich biscuitroot *Cymopterus goodrichii*														X		
Cedar Breaks biscuitroot *Cymopterus minimus*						X										
Brownie ladyslipper *Cypripedium fasciculatum*	X															X
Lesser yellow Lady's slipper *Cypripedium parviflorum (Cypripedium calceolus*																X

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
var. parviflorum)																
Wyoming tansymustard *Descurainia torulosa*			X													
Wasatch shooting star *Dodecatheon utahense*																X
Idaho douglasia *Douglasia idahoensis*		X								?		?				
Abajo peak draba *Draba abajoensis*									X							
Arid draba *Draba arida*														X		
Star draba *Draba asterophora* var. *asterophora*														X		
Wasatch Draba *Draba brachystylis*														X	?	X
Burke's draba *Draba burkei*																X
Rockcress draba *Draba globosa (=D. densifolia var. apiculata)*	X		X		X							X			X	X
Jaeger draba *Draba jaegeri*														X		
Maguire draba *Draba maguirei*																X
Serpentine draba *Draba oreibata* var. *serpentina*								?						X		
Charleston draba *Draba paucifructa*														X		
Pennell draba *Draba pennellii*								X								
Mt. Belknap draba *Draba ramulosa*							X									
Santaquin draba *Draba santaquinensis*															X	
Creeping draba *Draba sobolifera*						X	X									
Stanley's whitlow-grass *Draba trichocarpa*					X							X				
Nevada willowherb							X							X		

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Epilobium nevadense																
Spring Mountain goldenweed *Ericameria compacta (=Haplopappus compactus)*														X		
Pine Valley goldenweed *Ericameria crispa (=Haplopappus crispus)*						X										
Narrow-leaf goldenweed *Ericameria discoidea var. linearis (=Haplopappus macronema var.linearis)*			X													
Abajo daisy *Erigeron abajoensis*									X							
Carrington daisy *Erigeron carringtonae*									X							
Snake Mountain erigeron *Erigeron cavernensis*								X								
Cronquist daisy *Erigeron cronquistii*																X
Garrett's fleabane *Erigeron garrettii*															X	X
Kachina daisy *Erigeron kachinensis*									X							
Woolly daisy *Erigeron lanatus*			X													
Maguire daisy *Erigeron maguirei*							X									
LaSal daisy *Erigeron mancus*									X							
Untermann daisy *Erigeron untermannii*	X															
Widtsoe buckwheat *Eriogonum aretioides*						X										
Elsinore buckwheat *Eriogonum batemanii* var. *ostlundii*							X									
Desert buckwheat *Eriogonum brevicaule var. desertorum*												X				
Welsh buckwheat *Eriogonum capistratum var. welshii*					X											
Sunflower Flat buckwheat								X								

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Eriogonum douglasii var. elkoense																
Toiyabe buckwheat *Eriogonum esmeraldense var. toiyabense*														X		
Clokey buckwheat *Eriogonum heermannii var. clokeyi*														X		
Lewis's buckwheat *Eriogonum lewisii*								X								
Logan buckwheat *Eriogonum loganum (=E. brevicaule* var. *loganum)*																X
Guardian buckwheat *Eriogonum meledonum*					X							X				
Altered andesite buckwheat *Eriogonum robustum*														X		
Clokey greasebush *Glossopetalon clokeyi*														X		
Smooth dwarf greasebrush *Glossopetalon pungens var. glabra (=G.pungens)*														X		
Puzzling halimolobos *Halimolobos perplexa* var. *perplexa*										X						
Canyon sweetvetch *Hedysarum occidentale* var. *canone*									X							
Jones goldenaster *Heterotheca jonesii*						X										
Sierra Valley ivesia *Ivesia aperta* var. *aperta*														X		
Dog Valley ivesia *Ivesia aperta* var. *canina*														X		
Charleston ivesia *Ivesia cryptocaulis*														X		
Jaeger ivesia *Ivesia jaegeri*														X		
Plumas ivesia *Ivesia sericoleuca*														?		
Utah ivesia *Ivesia utahensis*															X	X
Wasatch jamesia															X	X

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Jamesia americana var. macrocalyx																
Zion jamesia *Jamesia americana var. zionis*						X										
Basin jamesia *Jamesia tetrapetala*								X								
Grimes lathyrus *Lathyrus grimesii*								X								
Wasatch pepperwort *Lepidium montanum* var. *alpinum*															?	X
Neeses' peppergrass *Lepedium montanum* var. *neeseae*						X										
Hazel's prickly phlox *Leptodactylon pungens* ssp. *hazeliae*										X						
Garrett bladderpod *Lesquerella garrettii*															X	X
Hitchcock bladderpod *Lesquerella hitchcockii var. hitchcockii*														X		
Payson bladderpod *Lesquerella paysonii*			X	X									X			
Maguire lewisia *Lewisia maguirei*								X								
Sacajawea's bitterroot *Lewisia sacajaweana*		X			X					X	X	?				
Canyonlands lomatium *Lomatium latilobum*									X							
Three-ranked hump-moss *Meesia triquetra*														X		
Goodrich stickleaf *Mentzelia goodrichii*	X															
Bank monkeyflower *Mimulus clivicola*										X						
Fish Lake naiad *Najas caespitosa*							X									
Idaho pennycress *Noccaea idahoensis var. aileeniae (=Thlaspi aileeniae)*					X							X				
Shevock rockmoss *Orthotrichum shevockii*														X		

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Spjut's brittle-moss *Orthotrichum spjutii*														X		
Challis crazyweed *Oxytropis besseyi* var. *salmonensis*					X											
Beaver Mountain groundsel *Packera (=Senecio) castoreus*							X									
Podunk groundsel *Packera (=Senecio) malmstenii*						X										
Arctic poppy *Papaver radicatum* var. *pygmaeum*	X															X
Naked-stemmed parrya *Parrya nudicaulis*			X		.											
Paria breadroot *Pediomelum pariense*						X										
Stemless beardtongue *Penstemon acaulis* var. *acaulis*	X															
Dune penstemon *Penstemon arenarius*														?		
Red Canyon beardtongue *Penstemon bracteatus*						X										
Cache beardtongue *Penstemon compactus*				X												X
Elegant penstemon *Penstemon concinnus*								?								
Idaho penstemon *Penstemon idahoensis*												X				
Charleston beardtongue *Penstemon leiophyllus* var. *keckii*														X		
Lemhi penstemon *Penstemon lemhiensis*											X					
Mt. Moriah penstemon *Penstemon moriahensis*								X								
Little penstemon *Penstemon parvus*						X	X									
Pinyon penstemon *Penstemon pinorum*					.	X										
Bashful penstemon *Penstemon pudicus*								X								

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Rhizome beardtongue *Penstemon rhizomatosus*								X								
Wassuk beardtongue *Penstemon rubicundus*														X		
Jaeger beardtongue *Penstemon thompsoniae ssp. jaegeri*														X		
Ward beardtongue *Penstemon wardii*							X									
Inconspicuous phacelia *Phacelia inconspicua*								?								
Small-flower phacelia *Phacelia minutissima*		X						X				?				
Mono phacelia *Phacelia monoensis*														X		
Salmon twin bladderpod *Physaria didymocarpa* var. *lyrata*											X		X			
Creeping twinpod *Physaria integrifolia v. monticola*			X													
Whitebark Pine *Pinus albicaulis*		X	X		X			X		X	X	X	X	X		
Altered andesite popcorn flower *Plagiobothrys glomeratus*														X		
Marsh's bluegrass *Poa abbreviata ssp. marshii*					X			X			X	X		X		
White Mountain skypilot *Polemonium chartaceum*														X		
Williams combleaf *Polyctenium williamsii*														X		
Angell cinquefoil *Potentilla angelliae*						X										
Cottam cinquefoil *Potentilla cottamii*												X				X
Sagebrush cinquefoil *Potentilla johnstonii*								X								
Alkali primrose *Primula alcalina*													X			
Ruby Mountain primrose *Primula capillaris*								X								

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Nevada primrose *Primula cusickiana var. nevadensis (=P. nevadensis)*								X								
Greenland primrose *Primula egaliksensis*			X													
Bugleg goldenweed Pyrrocoma *(=Haplopappus) insecticruris*		X										X				
Radiate goldenweed *Pyrrocoma radiata (=Haplopappus radiatus)*										X						
Bartons' blackberry *Rubus bartonianus*										X						
Arizona willow *Salix arizonica*						X	X		X							
Weber's saussurea *Saussurea weberi*			X													
Tobias' saxifrage *Saxifraga bryophora* var. *tobiasiae*										X						
Tolmie's saxifrage *Saxifraga tolmiei* var. *ledifolia*										X						
Musinea groundsel *Senecio musiniensis*									X							
Mono ragwort *Senecio pattersonensis*														X		
Clokey silene *Silene clokeyi*														X		
Nachlinger silene *Silene nachlingerae*								X								
Maguire campion *Silene petersonii*						X	?		X							
Railroad Valley globemallow *Sphaeralcea caespitosa var. williamsiae*								X								
Rock-tansy *Sphaeromeria capitata*						X										
Low sphaeromeria *Sphaeromeria compacta*														X		
Masonic Mountain jewelflower *Streptanthus oliganthus*														X		
Soft aster			X													

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Symphyotrichum molle (=Aster mollis)																
Charleston kittentails *Synthyris ranunculina*														X		
Caespitose greenthread *Thelesperma caespitosum*	X															
Uinta green thread *Thelesperma pubescens*																X
Bicknell thelesperma *Thelesperma subnudum* var. *alpinum*						X	X									
Wavy-leaf thelypody *Thelypodium repandum*					X											
Alpine goldenweed *Tonestus (=Haplopappus) alpinus*														X		
Barneby woody aster *Tonestus (=Aster) kingii* var. *barnebyana*							X								X	
Sevier townsendia *Townsendia jonesii* var. *lutea*							X									
Charleston ground daisy *Townsendia jonesii* var. *tumulosa*														X		
Short-slyle tofieldia *Triantha occidentalis ssp. brevistyla*										X						
Currant Summit clover Trifolium *andinum var. podocephalum*								X								
Leiberg's clover *Trifolium leibergii*								X								
Rollins clover *Trifolium macilentum var. rollinsii*														X		
Charleston violet *Viola charlestonensis*														X		
Smith violet *Viola franksmithii*																X
Lithion violet *Viola lithion*								X								
Idaho range lichen *Xanthoparmelia idahoensis*											X					

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ASH - Ashley	CHA - Challis	M-L - Manti-LaSal	TAR - Targhee
BOI - Boise	DIX - Dixie	PAY - Payette	TOI - Toiyabe
B-T - Bridger-Teton	FIS - Fishlake	SAL - Salmon	UIN - Uinta
CAR - Caribou	HUM - Humboldt	SAW - Sawtooth	W-C - Wasatch-Cache

KEY:	***This list was compiled from the following sources:***
X = known distribution species and/or habitat ? = suspected or potential habitat * = wild and naturally reproducing stocks + = migration corridors only o = offsite impacts (e.g. downstream) r = reintroduced Central Idaho & Yellowstone populations, covered under ESA Section 10(j), and declared experimental non-essential populations, and thus are treated like "proposed" species ## = no longer meet "sensitive"criteria (personal communication with Forest botanists and Dr. Duane Atwood), but no official list revision yet Dates are dates the Final Rule was published in the *Federal Register;* ED = Effective dates are about 30 days later if not listed.	*R-4 Vertebrate Sensitive Species List* (August 13, 1990) *R-4 Sensitive Plant List* (April 29, 1994) *Endangered and Threatened Wildlife and Plants*, USDA-U.S. Fish & Wildlife Service (August 20, 1994) *Northern Goshawk - Listed as a Sensitive Species in R4* (October 31, 1991) *Miscellaneous Federal Registers*

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INTERMOUNTAIN REGION (R4) THREATENED, ENDANGERED, PROPOSED, AND, SENSITIVE SPECIES

June 2016

KNOWN / SUSPECTED DISTRIBUTION BY FOREST

STATUS	FOREST															
ENDANGERED	**ASH**	**BOI**	**B-T**	**CAR**	**CHA**	**DIX**	**FIS**	**HUM**	**M-L**	**PAY**	**SAL**	**SAW**	**TAR**	**TOI**	**UIN**	**W-C**
MAMMALS																
Black-footed ferret 3/11/67 *Mustela nigripes*			o													o
Sierra Nevada bighorn sheep *Ovis canadensis* sierra January 3, 2000														X		
BIRDS																
Southwestern willow flycatcher 2/27/95 *Empidonax traillii extimus* ED 3/29/95									X					?		
Whooping crane 3/11/67 *Grus americana*			X										?			
REPTILES AND AMPHIBIANS																
Sierra Nevada Yellow-legged Frog 06/30/2014 *Rana sierrae*														X		
INSECTS																
Mt. Charleston Blue Butterfly 10/21/2013 *Icaricia shasta charlestonensis*														X		
FISH																
June sucker 3/31/86 *Chasmistes liorus*															o	o
Bonytail chub 4/23/80 *Gila elegans*	o		o			o	o		o						o	o
Humpback chub 3/11/67 *Gila cypha*	o		o			o	o		o						o	o
Colorado pike minnow 3/11/67 *Ptychocheilus lucius*	o		o			o	o		o						o	o
Kendall Warm Springs dace 10/13/70 *Rhinichthys osculus*			X													

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ENDANGERED	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Sockeye salmon, (Snake River0 11/20/91 *Oncorhynchus nerka* (CH 12/28/98)					+					+	+	X				
Razorback sucker 10/23/91 *Xyrauchen texanus* (ED 11/22/91)	o		o			o	o		o						o	o
Sturgeon, pallid *Scaphirhynchus albus*			o													
PLANTS																
San Rafael cactus *Pediocactus despainii*							X									
Clay phacelia 09/28/78 *Phacelia argillacea*									?						X	
THREATENED	**ASH**	**BOI**	**B-T**	**CAR**	**CHA**	**DIX**	**FIS**	**HUM**	**M-L**	**PAY**	**SAL**	**SAW**	**TAR**	**TOI**	**UIN**	**W-C**
MAMMALS																
Canada lynx 4/15/00 *Lynx canadensis*	X	X	X							X		X	X		?	?
Grizzly bear 9/21/2009 *Ursus arctos horribilis*			X										X			
Gray wolf (Wyoming Rocky Mountain DPS 10J Experimental Population) *Canis lupus*			X	X									X			X
Utah prairie dog 6/04/73 *Cynomys parvidens*						X	X									
Northern Idaho ground squirrel 3/24/00 *Spermophilus brunneus*		X								X						
BIRDS																
Mexican spotted owl 3/16/93 *Strix occidentalis lucida (ED 4/15/93)*						X	X		X							
Yellow-billed cuckoo 11/03/2014 *Coccyzus americanus*	X	X	X		?	?	?	X	X	X	?	X	X	X	X	X
REPTILES AND AMPHIBIANS																
Desert tortoise 8/04/89 *Gopherus agassizii*														X		
Yosemite toad 6/30/2014 *Anaxyrus canorus*														X		
FISH																
Steelhead trout (Snake River summer) *Oncorhynchus mykiss*		X			X					X	X	X				

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THREATENED	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Chinook salmon, Snake River sprg/smr *Oncorhynchus tshawytscha* 4/22/92 (ED 5/22/92)		X			X					X	X	X				
Chinook salmon, Snake River fall *Oncorhynchus tshawytscha* 4/22/92 (ED 5/22/92)										X						
Greenback cutthroat trout *Oncorhynchus clarki stomiua*									X							
Railroad Valley springfish 3/31/86 *Crenichthys nevadae*														X		
Lahontan cutthroat trout 10/13/70 *Oncorhynchus clarki henshawi*								X						X		
Columbia River bull trout 6/10/98 *Salvelinus confluentus*		X			X			X		X	X	X				
Paiute cutthroat trout 3/11/67 *Oncorhynchus clarki seleniris*														X		
PLANTS																
Deseret milkvetch 10/20/99 *Astragalus desereticus*									?						?	
Heliotrope milkvetch 11/6/87 *Astragalus limnocharis var.montii (A. montii)*									X							
Slick-spot peppergrass 10/08/09 *Lepidium papilliferum*		?														
Winkler cactus *Pediocactus winkleri*									?							
Maguire's primrose 8/21/85 *Primula cusickiana var. maguirei (P. maguirei)*																X
Last chance townsendia 8/21/85 *Townsendia aprica*						X	X									
Ute ladies' tresses orchid 1/17/92 *Spiranthes diluvialis* (2/18/92)		?		?	?		?				?	?	X		X	?
Webber ivesia 7/3/2014 *Ivesia webberi*														X		
PROPOSED	**ASH**	**BOI**	**B-T**	**CAR**	**CHA**	**DIX**	**FIS**	**HUM**	**M-L**	**PAY**	**SAL**	**SAW**	**TAR**	**TOI**	**UIN**	**W-C**
North American wolverine Gulo gulo (luscus)	X	X	X	X	X					X	X	X	X	X		X

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CANDIDATE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Sierra Nevada red fox *Vulpes vulpes necator*														X		
Whitebark Pine *Pinus albicaulis*		X	X		X			X		X	X	X	X	X		

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
MAMMALS																
Bighorn Sheep *Ovis canadensis* - Includes Rocky Mountain bighorn sheep (*O. c. canadensis*), California bighorn sheep (*O. c. californiana*), and desert bighorn sheep (*O. c. nelsoni*) (7/29/2009)	X	X	X		X		X	X	X	X	X	X	X	X	X	X
Gray wolf (Rocky Mountain DPS) *Canis lupus*		X		X	X					X	X	X	X			X
Pygmy rabbit *Brachylagus idahoensis*				X	X	X	X	X			X	X	X	X		
Spotted bat *Euderma maculatum*	X	X	X	X	X	X	X	X	X	X	X	X	?	X	X	X
Fisher *Martes pennanti*		X	X		X					X	X	X	?		X	
Southern Idaho Ground Squirrel *Spermophilus brunneus endemicus*		X			-					X						
Townsend's Western Big-Eared Bat *Corynorhinus townsendii townsendii*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BIRDS																
Bald eagle *Haliaeetus leucocephalus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Boreal owl *Aegolius funereus*	X	X	X	X	X					X	X	X	X			X
Greater sage-grouse *Centrocercus urophasianus*	X	X	X	X	X	X	X	X	X	?	X	X	X	X	X	X
Greater sage-grouse Bi-State DPS *Centrocercus urophasianus*														X		
Trumpeter swan *Cygnus buccinator*			X	X									X			
Peregrine falcon 3/20/84 *Falco peregrinus anatum*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Common loon *Gavia immer*		X	X		+					?	+	X	X			
Harlequin duck *Histrionicus histrionicus*			X	X	?+					X	?+		X			
Mountain quail *Oreortyx pictus*		X						X		X		X		X		
Flammulated owl *Otus flammeolus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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White-headed woodpecker *Picoides albolarvatus*		X								X		X		X		
Three-toed woodpecker *Picoides tridactylus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Great gray owl *Strix nebulosa*	X	X	X	X	X					X	X	X	X	X		X
California spotted owl *Strix occidentalis occidentalis*					·									X		
Columbian sharp-tailed grouse *Tympanuchus phasianellus columbianus*		X		X				X		X		X	X			X
Northern goshawk *Accipiter gentilis*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
REPTILES AND AMPHIBIANS																
Columbia spotted frog *Rana luteiventris*	?	X	X	X	X			X	X	X	X	X	X	X	X	X
Boreal Toad *Bufo boreas*	X		X	X		X	X		X				X		X	X
FISH																
Wood River sculpin *Cottus leiopomus*												X				
Westslope cutthroat trout *Oncorhynchus clarki lewisi*		X	X		X					X	X	X				
Colorado River cutthroat trout *Oncorhynchus clarki pleuriticus*	X		X			X	X		X						X	X
Bonneville cutthroat trout *Oncorhynchus clarki utah*			X	X		X	X	X	X						X	X
Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri*			X	X								X	X			
Northern Leatherside Chub *Lepidomeda copei*			X	X								X	X			X
Southern Leatherside Chub *Lepidomeda aliciae*					·	X	X		X						X	
Big Lost River Whitefish *Prosopium williamsoni*					X											
INSECTS																
Spring Mountain Checkerspot *Chlosyne acastus robusta*														X		
Dark Blue														X		

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Euphilotes ancilla purpura																
Morand's Checkerspot *Euphydryas anicia morandi*														X		
PLANTS																
Pink agoseris *Agoseris lackschewitzii*			X								X		X			
Wonderland Alice flower Aliciella (=*Gilia) caespitosa*						X	X									
Chatterley Onion *Allium geyeri var. chatterleyi*									X							
Swamp onion *Allium madidum*										X						
Tolmie's onion *Allium tolmiei* var. *persimile*		X								X						
Candystick *Allotropa virgata*										X						
Sweet-flowered rock jasmine *Androsace chamaejasme ssp. carinata*			X						X				X			
Charleston angelica *Angelica scabrida*														X		
Wheeler's angelica *Angelica wheeleri*															X	X
Meadow pussytoes *Antennaria arcuata*								X								
Charleston pussytoes *Antennaria soliceps*														X		
Link Trail columbine *Aquilegia flavescens var. rubicunda*									X							
Graham columbine *Aquilegia grahamii*	X															
Rosy King's sandwort *Arenaria kingii* ssp. *rosea*														X		
Petiolate wormwood *Artemisia campestris ssp. borealis var. petiolata*	X															
Eastwood milkweed *Asclepias eastwoodiana*								X						X		
Clokey milkvetch *Astragalus aequalis*														X		

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Lost River milkvetch *Astragalus amnis-amissi*					X											
Goose Creek milkvetch *Astragalus anserinus*					.							?				
Lemhi milkvetch *Astragalus aquilonius*					X							?				
Bicknell milkvetch *Astragalus consobrinus*							X		?							
Meadow milkvetch *Astragalus diversifolius var. diversifolius*			X		X								X			
Dana milkvetch *Astragalus henrimontanensis*						X										
Isely's milkvetch *Astragalus iselyi*									X							
Starvling milkvetch *Astragalus jejunus var. jejunus*			X	X												
Long Valley milkvetch *Astragalus johannis-howellii*														X		
Broad-pod freckled milkvetch *Astragalus lentiginosus var. latus*								X								
Navajo Lake milkvetch *Astragalus limnocharis* var. *limnocharis*						X										
Table Cliff milkvetch *Astragalus limnocharis* var. *tabulaeus*						X										
Lee Canyon milkvetch *Astragalus oophorus* var. *clokeyanus*														X		
Lavin's egg milkvetch *Astragalus oophorus* var. *lavinii*					.									X		
Payson's milkvetch *Astragalus paysonii*			X							X			?			
Spring Mountain milkvetch *Astragalus remotus*														X		
Lamoille Canyon milkvetch *Astragalus robbinsii* var. *occidentalis*								X								
Toquima milkvetch *Astragalus toquimanus*														X		
Currant milkvetch *Astragalus uncialis*								X								

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White Cloud milkvetch *Astragalus vexilliflexus* var. *nubilus*					X					X		X				
Guard milkvetch *Astragalus zionis var. vigulus*						X										
Bodie Hills rockcress Boechera (=*Arabis*) *bodiensis*														X		
Grouse Creek rockcress Boechera (=*Arabis*) *falcatoria*								X								
Spring Mountains rockcress Boechera (=*Arabis*) *nevadensis*														X		
Washoe tall rockcress Boechera (=*Arabis*) *rectissima* var. *simulans*														X		
Galena Creek rockcress Boechera (=*Arabis*) *rigidissima* var. *demota*														X		
Ophir rockcress Boechera (=*Arabis*) *ophira*														X		
Tiehm rockcress Boechera (=*Arabis*) *tiehmii*														X		
Upswept moonwort *Botrychium ascendens*														X		
Dainty moonwort *Botrychium crenulatum*	X												X	X	X	
Slender moonwort *Botrychium lineare*	X							?		?		X		X	?	X
Paradox moonwort *Botrychium paradoxum*						X										
Little grape fern *Botrychium simplex*												X				
Moosewort *Botrychium tunux*														X		
Beautiful Bryum *Bryum calobryoides*		X										X				
Cascade reedgrass *Calamagrostis tweedyi*										X						
Cusick camas *Camassia cusickii*										X						
Seaside sedge *Carex incurviformis*			X		X											

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Black and purple sedge *Carex luzulina var. atropurpurea*			X													
Tioga Pass sedge *Carex tiogana*														X		
Aquarius paintbrush *Castilleja aquariensis*						X										
Christ's Indian paintbrush *Castilleja christii*												X				
Tushar paintbrush *Castilleja parvula* var. *parvula*						X	X									
Reveal paintbrush *Castilleja parvula* var. *revealii*						X										
Centennial rabbitbrush *Chrysothamnus parryi* ssp. *montanus*													X			
Flexible alpine collomia *Collomia debilis var. camporum*											X					
Wasatch fitweed *Corydalis caseana spp. brachycarpa*															X	X
Creutzfeldt-flower cryptanth *Cryptantha creutzfeldtii*									X							
Yellow-white catseye *Cryptantha ochroleuca*						X										
Bodie Hills draba *Cusickiella quadricostata*														X		
Pinnate spring-parsley *Cymopterus beckii*						X			X							
Davis' wavewing *Cymopterus davisii*												X				
Douglas' biscuitroot *Cymopterus douglassii*					X						X	X				
Goodrich biscuitroot *Cymopterus goodrichii*														X		
Cedar Breaks biscuitroot *Cymopterus minimus*						X										
Brownie ladyslipper *Cypripedium fasciculatum*	X															X
Lesser yellow Lady's slipper *Cypripedium parviflorum (Cypripedium calceolus*																X

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var. parviflorum)																
Wyoming tansymustard *Descurainia torulosa*			X													
Wasatch shooting star *Dodecatheon utahense*																X
Idaho douglasia *Douglasia idahoensis*		X								?		?				
Abajo peak draba *Draba abajoensis*									X							
Arid draba *Draba arida*														X		
Star draba *Draba asterophora* var. *asterophora*														X		
Wasatch Draba *Draba brachystylis*														X	?	X
Burke's draba *Draba burkei*																X
Rockcress draba *Draba globosa (=D. densifolia var. apiculata)*	X		X		X							X			X	X
Jaeger draba *Draba jaegeri*														X		
Maguire draba *Draba maguirei*																X
Serpentine draba *Draba oreibata* var. *serpentina*								?						X		
Charleston draba *Draba paucifructa*														X		
Pennell draba *Draba pennellii*								X								
Mt. Belknap draba *Draba ramulosa*							X									
Santaquin draba *Draba santaquinensis*															X	
Creeping draba *Draba sobolifera*						X	X									
Stanley's whitlow-grass *Draba trichocarpa*					X							X				
Nevada willowherb							X							X		

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Epilobium nevadense																
Spring Mountain goldenweed *Ericameria compacta (=Haplopappus compactus)*														X		
Pine Valley goldenweed *Ericameria crispa (=Haplopappus crispus)*						X										
Narrow-leaf goldenweed *Ericameria discoidea var. linearis (=Haplopappus macronema var.linearis)*			X													
Abajo daisy *Erigeron abajoensis*									X							
Carrington daisy *Erigeron carringtonae*									X							
Snake Mountain erigeron *Erigeron cavernensis*								X								
Cronquist daisy *Erigeron cronquistii*																X
Garrett's fleabane *Erigeron garrettii*															X	X
Kachina daisy *Erigeron kachinensis*									X							
Woolly daisy *Erigeron lanatus*			X													
Maguire daisy *Erigeron maguirei*							X									
LaSal daisy *Erigeron mancus*									X							
Untermann daisy *Erigeron untermannii*	X															
Widtsoe buckwheat *Eriogonum aretioides*						X										
Elsinore buckwheat *Eriogonum batemanii* var. *ostlundii*							X									
Desert buckwheat *Eriogonum brevicaule var. desertorum*												X				
Welsh buckwheat *Eriogonum capistratum var. welshii*					X											
Sunflower Flat buckwheat								X								

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Eriogonum douglasii var. elkoense																
Toiyabe buckwheat *Eriogonum esmeraldense var. toiyabense*														X		
Clokey buckwheat *Eriogonum heermannii var. clokeyi*														X		
Lewis's buckwheat *Eriogonum lewisii*								X								
Logan buckwheat *Eriogonum loganum (=E. brevicaule* var. *loganum)*																X
Guardian buckwheat *Eriogonum meledonum*					X							X				
Altered andesite buckwheat *Eriogonum robustum*														X		
Clokey greasebush *Glossopetalon clokeyi*														X		
Smooth dwarf greasebrush *Glossopetalon pungens var. glabra (=G.pungens)*														X		
Puzzling halimolobos *Halimolobos perplexa* var. *perplexa*										X						
Canyon sweetvetch *Hedysarum occidentale* var. *canone*									X							
Jones goldenaster *Heterotheca jonesii*						X										
Sierra Valley ivesia *Ivesia aperta* var. *aperta*														X		
Dog Valley ivesia *Ivesia aperta* var. *canina*														X		
Charleston ivesia *Ivesia cryptocaulis*														X		
Jaeger ivesia *Ivesia jaegeri*														X		
Plumas ivesia *Ivesia sericoleuca*														?		
Utah ivesia *Ivesia utahensis*															X	X
Wasatch jamesia															X	X

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SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Jamesia americana var. macrocalyx																
Zion jamesia *Jamesia americana var. zionis*						X										
Basin jamesia *Jamesia tetrapetala*								X								
Grimes lathyrus *Lathyrus grimesii*								X								
Wasatch pepperwort *Lepidium montanum* var. *alpinum*															?	X
Neeses' peppergrass *Lepedium montanum* var. *neeseae*						X										
Hazel's prickly phlox *Leptodactylon pungens* ssp. *hazeliae*										X						
Garrett bladderpod *Lesquerella garrettii*															X	X
Hitchcock bladderpod *Lesquerella hitchcockii var. hitchcockii*														X		
Payson bladderpod *Lesquerella paysonii*			X	X									X			
Maguire lewisia *Lewisia maguirei*								X								
Sacajawea's bitterroot *Lewisia sacajaweana*		X			X					X	X	?				
Canyonlands lomatium *Lomatium latilobum*									X							
Three-ranked hump-moss *Meesia triquetra*														X		
Goodrich stickleaf *Mentzelia goodrichii*	X															
Bank monkeyflower *Mimulus clivicola*										X						
Fish Lake naiad *Najas caespitosa*							X									
Idaho pennycress *Noccaea idahoensis var. aileeniae (=Thlaspi aileeniae)*					X							X				
Shevock rockmoss *Orthotrichum shevockii*														X		

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Spjut's brittle-moss *Orthotrichum spjutii*														X		
Challis crazyweed *Oxytropis besseyi* var. *salmonensis*					X											
Beaver Mountain groundsel *Packera (=Senecio) castoreus*							X									
Podunk groundsel *Packera (=Senecio) malmstenii*						X										
Arctic poppy *Papaver radicatum* var. *pygmaeum*	X															X
Naked-stemmed parrya *Parrya nudicaulis*			X													
Paria breadroot *Pediomelum pariense*						X										
Stemless beardtongue *Penstemon acaulis* var. *acaulis*	X															
Dune penstemon *Penstemon arenarius*														?		
Red Canyon beardtongue *Penstemon bracteatus*						X										
Cache beardtongue *Penstemon compactus*				X												X
Elegant penstemon *Penstemon concinnus*								?								
Idaho penstemon *Penstemon idahoensis*												X				
Charleston beardtongue *Penstemon leiophyllus* var. *keckii*														X		
Lemhi penstemon *Penstemon lemhiensis*											X					
Mt. Moriah penstemon *Penstemon moriahensis*								X								
Little penstemon *Penstemon parvus*						X	X									
Pinyon penstemon *Penstemon pinorum*						X										
Bashful penstemon *Penstemon pudicus*								X								

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Rhizome beardtongue *Penstemon rhizomatosus*								X								
Wassuk beardtongue *Penstemon rubicundus*														X		
Jaeger beardtongue *Penstemon thompsoniae ssp. jaegeri*														X		
Ward beardtongue *Penstemon wardii*							X									
Inconspicuous phacelia *Phacelia inconspicua*								?								
Small-flower phacelia *Phacelia minutissima*		X						X				?				
Mono phacelia *Phacelia monoensis*														X		
Salmon twin bladderpod *Physaria didymocarpa* var. *lyrata*											X		X			
Creeping twinpod *Physaria integrifolia v. monticola*			X													
Whitebark Pine *Pinus albicaulis*		X	X		X			X		X	X	X	X	X		
Altered andesite popcorn flower *Plagiobothrys glomeratus*														X		
Marsh's bluegrass *Poa abbreviata ssp. marshii*					X			X			X	X		X		
White Mountain skypilot *Polemonium chartaceum*														X		
Williams combleaf *Polyctenium williamsii*														X		
Angell cinquefoil *Potentilla angelliae*						X										
Cottam cinquefoil *Potentilla cottamii*												X				X
Sagebrush cinquefoil *Potentilla johnstonii*								X								
Alkali primrose *Primula alcalina*													X			
Ruby Mountain primrose *Primula capillaris*								X								

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Nevada primrose *Primula cusickiana var. nevadensis (=P. nevadensis)*								X								
Greenland primrose *Primula egaliksensis*			X													
Bugleg goldenweed Pyrrocoma (=*Haplopappus) insecticruris*		X										X				
Radiate goldenweed *Pyrrocoma radiata (=Haplopappus radiatus)*										X						
Bartons' blackberry *Rubus bartonianus*										X						
Arizona willow *Salix arizonica*						X	X		X							
Weber's saussurea *Saussurea weberi*			X													
Tobias' saxifrage *Saxifraga bryophora* var. *tobiasiae*										X						
Tolmie's saxifrage *Saxifraga tolmiei* var. *ledifolia*										X						
Musinea groundsel *Senecio musiniensis*									X							
Mono ragwort *Senecio pattersonensis*														X		
Clokey silene *Silene clokeyi*														X		
Nachlinger silene *Silene nachlingerae*								X								
Maguire campion *Silene petersonii*						X	?		X							
Railroad Valley globemallow *Sphaeralcea caespitosa var. williamsiae*								X								
Rock-tansy *Sphaeromeria capitata*						X										
Low sphaeromeria *Sphaeromeria compacta*														X		
Masonic Mountain jewelflower *Streptanthus oliganthus*														X		
Soft aster			X													

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x=known species/habitat; ?=suspected/potential habitatt; *=wild/naturally reproducing; +=migration; o=offsite; r= reintroduced populations; ED=Effective dates

SENSITIVE	ASH	BOI	B-T	CAR	CHA	DIX	FIS	HUM	M-L	PAY	SAL	SAW	TAR	TOI	UIN	W-C
Symphyotrichum molle (=Aster mollis)																
Charleston kittentails *Synthyris ranunculina*														X		
Caespitose greenthread *Thelesperma caespitosum*	X															
Uinta green thread *Thelesperma pubescens*																X
Bicknell thelesperma *Thelesperma subnudum* var. *alpinum*						X	X									
Wavy-leaf thelypody *Thelypodium repandum*					X											
Alpine goldenweed *Tonestus (=Haplopappus) alpinus*														X		
Barneby woody aster *Tonestus (=Aster) kingii* var. *barnebyana*							X								X	
Sevier townsendia *Townsendia jonesii* var. *lutea*							X									
Charleston ground daisy *Townsendia jonesii* var. *tumulosa*														X		
Short-slyle tofieldia *Triantha occidentalis ssp. brevistyla*										X						
Currant Summit clover Trifolium *andinum var. podocephalum*								X								
Leiberg's clover *Trifolium leibergii*								X								
Rollins clover *Trifolium macilentum var. rollinsii*														X		
Charleston violet *Viola charlestonensis*														X		
Smith violet *Viola franksmithii*																X
Lithion violet *Viola lithion*								X								
Idaho range lichen *Xanthoparmelia idahoensis*											X					

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x=known species/habitat; ?=suspected/potential habitatt; *=wild/naturally reproducing; +=migration; o=offsite; r= reintroduced populations; ED=Effective dates

ASH - Ashley	CHA - Challis	M-L - Manti-LaSal	TAR - Targhee
BOI - Boise	DIX - Dixie	PAY - Payette	TOI - Toiyabe
B-T - Bridger-Teton	FIS - Fishlake	SAL - Salmon	UIN - Uinta
CAR - Caribou	HUM - Humboldt	SAW - Sawtooth	W-C - Wasatch-Cache

KEY:	***This list was compiled from the following sources:***
X = known distribution species and/or habitat ? = suspected or potential habitat * = wild and naturally reproducing stocks + = migration corridors only o = offsite impacts (e.g. downstream) r = reintroduced Central Idaho & Yellowstone populations, covered under ESA Section 10(j), and declared experimental non-essential populations, and thus are treated like "proposed" species ## = no longer meet "sensitive"criteria (personal communication with Forest botanists and Dr. Duane Atwood), but no official list revision yet Dates are dates the Final Rule was published in the *Federal Register;* ED = Effective dates are about 30 days later if not listed.	*R-4 Vertebrate Sensitive Species List* (August 13, 1990) *R-4 Sensitive Plant List* (April 29, 1994) *Endangered and Threatened Wildlife and Plants*, USDA-U.S. Fish & Wildlife Service (August 20, 1994) *Northern Goshawk - Listed as a Sensitive Species in R4* (October 31, 1991) *Miscellaneous Federal Registers*

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ECOS

ECOS / Species Reports / Species occurrence by state / Listed species believed to or known to occur in Utah

Listed species believed to or known to occur in Utah

Notes:

- **As of 02/13/2015 the data in this report has been updated to use a different set of information. Results are based on where the species is believed to or known to occur. The FWS feels utilizing this data set is a better representation of species occurrence. Note: there may be other federally listed species that are not currently known or expected to occur in this state but are covered by the ESA wherever they are found; Thus if new surveys detected them in this state they are still covered by the ESA. The FWS is using the best information available on this date to generate this list.**
- This report shows listed species or populations believed to or known to occur in Utah
- This list does not include experimental populations and similarity of appearance listings.
- This list includes species or populations under the sole jurisdiction of the National Marine Fisheries Service.
- Click on the highlighted scientific names below to view a Species Profile for each listing.

Listed species -- 42 listings

Animals -- 17 listings

Status	Species/Listing Name
E	Ambersnail, Kanab Entire (*Oxyloma haydeni kanabensis*)
E	Chub, bonytail Entire (*Gila elegans*)
E	Chub, humpback Entire (*Gila cypha*)
E	Chub, Virgin River Entire (*Gila seminuda (=robusta)*)
T	Cuckoo, yellow-billed Western U.S. DPS (*Coccyzus americanus*)
E	Flycatcher, southwestern willow Entire (*Empidonax traillii extimus*)
T	Lynx, Canada Contiguous U.S. DPS (*Lynx canadensis*)

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Status	Species/Listing Name
T	Owl, Mexican spotted Entire (*Strix occidentalis lucida*)
E	Pikeminnow (=squawfish), Colorado Entire, except EXPN (*Ptychocheilus lucius*)
T	Prairie dog, Utah Entire (*Cynomys parvidens*)
T	sage-grouse, Gunnison entire (*Centrocercus minimus*)
E	Sucker, June Entire (*Chasmistes liorus*)
E	Sucker, razorback Entire (*Xyrauchen texanus*)
T	Tortoise, desert Entire, except in Sonoran Desert (*Gopherus agassizii*)
T	trout, Greenback Cutthroat Entire (*Oncorhynchus clarki stomias*)
T	Trout, Lahontan cutthroat Entire (*Oncorhynchus clarkii henshawi*)
E	Woundfin Entire, except EXPN (*Plagopterus argentissimus*)

Plants -- 25 listings

Status	Species/Listing Name
E	Bear-poppy, Dwarf (*Arctomecon humilis*)
E	Bladderpod, kodachrome (*Lesquerella tumulosa*)
E	Buttercup, autumn (*Ranunculus aestivalis (=acriformis)*)
T	cactus, Pariette (*Sclerocactus brevispinus*)
E	Cactus, San Rafael (*Pediocactus despainii*)
T	Cactus, Siler pincushion (*Pediocactus (=Echinocactus, =Utahia) sileri*)
T	cactus, Uinta Basin hookless (*Sclerocactus wetlandicus*)
T	Cactus, Winkler (*Pediocactus winkleri*)
E	Cactus, Wright fishhook (*Sclerocactus wrightiae*)
T	Cycladenia, Jones (*Cycladenia humilis var. jonesii*)

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Status	Species/Listing Name
T	Ladies'-tresses, Ute (*Spiranthes diluvialis*)
E	mallow, Gierisch (*Sphaeralcea gierischii*)
T	Milk-vetch, Deseret (*Astragalus desereticus*)
T	Milk-vetch, heliotrope (*Astragalus montii*)
E	Milk-vetch, Holmgren (*Astragalus holmgreniorum*)
E	Milk-vetch, Shivwits (*Astragalus ampullarioides*)
T	Milkweed, Welsh's (*Asclepias welshii*)
E	Phacelia, clay (*Phacelia argillacea*)
T	Primrose, Maguire (*Primula maguirei*)
E	Reed-mustard, Barneby (*Schoenocrambe barnebyi*)
T	Reed-mustard, clay (*Schoenocrambe argillacea*)
E	Reed-mustard, shrubby (*Schoenocrambe suffrutescens*)
E	Ridge-cress, Barneby (*Lepidium barnebyanum*)
T	Sedge, Navajo (*Carex specuicola*)
T	Townsendia, Last Chance (*Townsendia aprica*)

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Greens Hollow Sound Study

Prepared for:

Canyon Fuel Company,
Sufco Mine

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Prepared by:

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September 04, 2008

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1.0 INTRODUCTION

This report presents the methods and results of sound monitoring conducted by Tetra Tech, Inc. (Tetra Tech) on July 29–30, 2008, as requested by Canyon Fuel Company's Sufco Mine. Monitoring was conducted on and adjacent to the Sufco Mine in association with development and operation of the Greens Hollow Coal Lease in Sevier County, Utah (**Figure 1**). The study area is located in and around Quitchupah Canyon within the Manti-La Sal and Fishlake National Forests.

Sound level monitoring was implemented to obtain data on sound levels around an existing ventilation fan for the Sufco Mine and at select sensitive resource locations (i.e. Forest System roads and greater sage-grouse leks). Data collected at each site will establish baseline information on sound generated by the operational ventilation shaft fan. Vegetative cover, geomorphology, topography, and other environmental variables will be considered, as each of these could affect sound levels. Additionally, sound attenuation will be evaluated by measuring sound levels at regular distances from the operational ventilation shaft fan in the direction of sensitive resources.

The existing fan and study areas are located within immediate proximity (3500 meters south) to a proposed ventilation fan location. It is the intention of this study to determine the possible sound impacts, of the proposed fan, based upon sound level data generated by the operational ventilation fan presently in use at the Sufco mine. The collected sound level data will be used to determine measures which could reduce sound related impacts associated with the operation of the proposed ventilation fan.

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2.0 METHODS

2.1 Sound Monitoring Locations

All sound monitoring sites were located on and adjacent to the Sufco coal mine area as determined through consultation Canyon Fuel Company. Sound level measurements were collected at the operational ventilation fan, herein referred to as the source, and at 10 meters (m) from the source in all four cardinal directions (north, south, east, and west), where feasible. Sound level measurements were also collected at 100 m intervals from the source in the direction of the nearest sensitive resource locations, up to 500 m. Sound level measurements were also collected at specific sound sensitive sites. Sound level monitoring locations, existing fan location, proposed fan location, and sensitive resource locations are all detailed in **Figure 1**.

Through consultation with Canyon Fuel Company, five sensitive resource locations were identified:

- Wildcat Knolls sage-grouse lek,
- Wildcat Knolls satellite sage-grouse lek,
- Forest Service Road 007,
- Forest Service Road 044, and
- Forest Service Road 025.

2.2 Sound Monitoring Methods

All sound monitoring was conducted using a Quest Technologies Model 2200 sound level meter. Sound levels were recorded as A-weighted decibels (dBA). Sound level measurements were collected during a two minute period with the maximum (MAX), minimum (MIN), and the equivalent continuous noise level (AVG) sound levels recorded. Environmental conditions, vegetative cover, date, time, observer, and weather conditions were also recorded.

Sound level measurements were taken during daylight hours (7:00am – 8:00pm) and within manufacturer's temperature specifications. Measurements were taken during dry (no precipitation) and calm (wind less than five meters per second (m/s)) periods. Wind was measured prior to each sound level measurement with a hand-held anemometer. The sound level meter was fitted with a windscreen to reduce wind-generated sound and directed at the source approximately one meter off the ground. The sound level meter was calibrated at a sound pressure of 114 dBA, before each day of survey. Terminal calibrations, using the 14 dBA standard, were conducted at the end of each day to ascertain the instruments continued accuracy through the survey period.

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3.0 RESULTS

Background outdoor sound levels for the project area were between 27.6 dBA and 57.9 dBA. Average sound levels for the study area were determined to be ±34.7 dBA. These sound measurements were calculated using data from sampling locations where the operational fan was not audible. These values were collected in the vicinity of the mine, within the study site, and should be recognized as a baseline for ambient sound levels in the project area.

3.1 Existing Ventilation Fan

The ventilation fan presently in operation at the Sufco mine is situated in Quitchupah Canyon approximately 300 m below the rim of the canyon. Quitchupah Canyon is sparsely vegetated by conifer trees and scrub brush that account for approximately 40 percent ground cover. The canyon walls are steep sandstone talus slopes comprised of large sandstone boulders and loose sand. Vertical sandstone cliffs line the top 20 m of the canyon rim.

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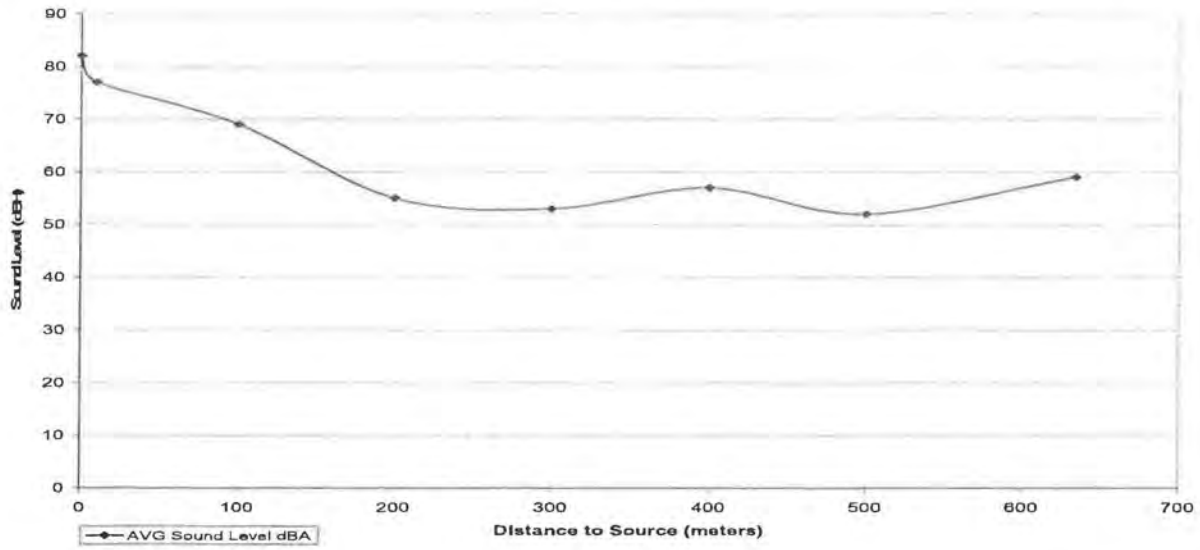
Photograph (view NE) of existing ventilation fan within Quitchupah Canyon.

Sound level transects at the existing ventilation fan had higher sound level measurements when compared to the sensitive resource areas. The sound levels from the existing fan decreased with distance, however no definitive distance was found to be indicative of reaching ambient sound levels. Maximum sound levels between 75.4 dBA to 95.7 dBA were recorded at the source, and decreased as distance between the source and monitoring point locations increased. Sound generated by the source was continuous and produced ranges up to ±15 dBA between MAX and MIN recordings. Greater decibel ranges were noted as distance increased between the source and monitoring point locations. These larger ranges can be attributed to affects of wind, line of sight, echoing, vegetative cover, and topography on the sound level measurements.

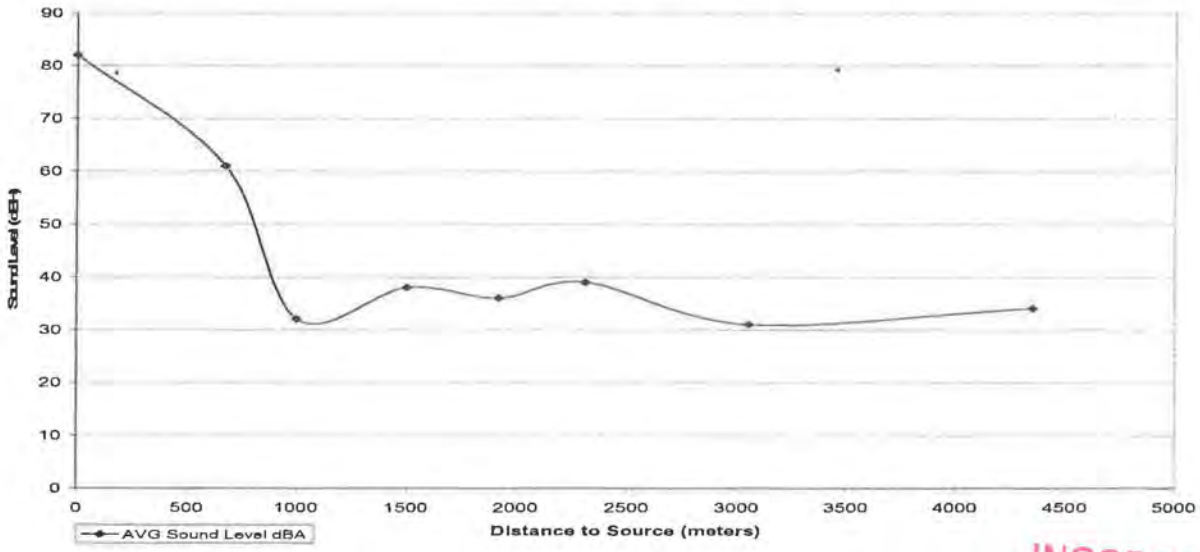
Sound level measurements along the transects were used to generate distance versus sound level curves from the source to select sensitive resource locations (up to 4350 m). All data

collected along the sound level transects were graphed for the AVG (equivalent continuous sound) sound level in the following graphs.

Graph 1: Eastern Sound Level Transect (Toward Forest Service Roads and Sage Grouse Leks to 650 m)



Graph 2: Northeastern Sound Level Transect (Toward Forest Service Roads and Sage Grouse Leks to 4500 m)



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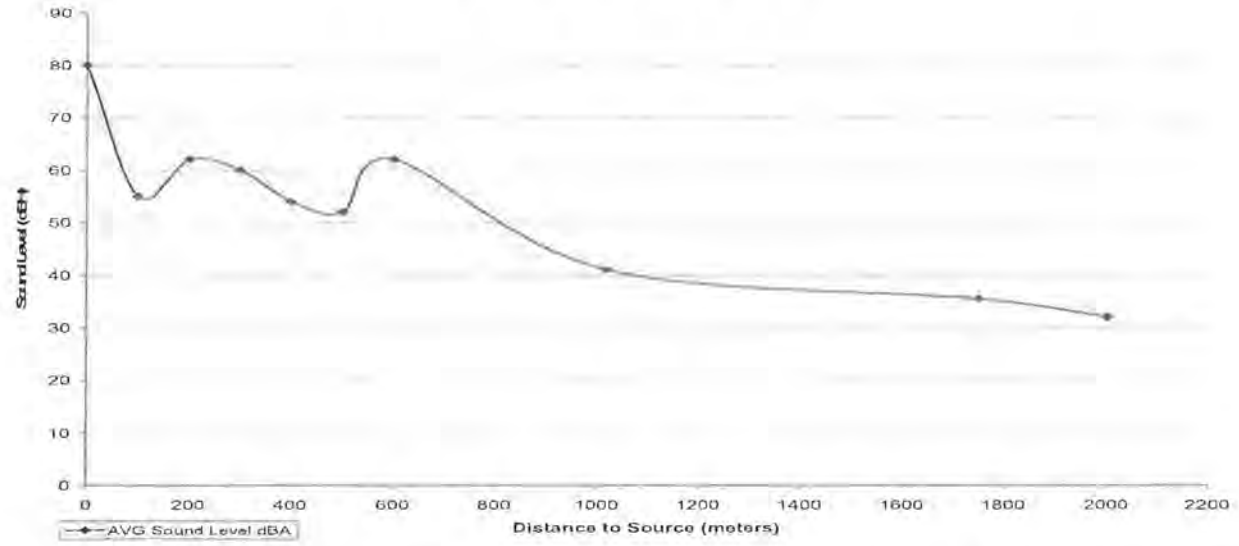
Graph 3: Southeastern Sound Level Transect (Toward Forest Service Roads and Sage Grouse Leks to 2100 m)



The greatest distance from which the fan was audible was determined to be ±2310 m away from the source to the northeast within Wildcat Knolls Lek. Sound levels recorded at this location ranged between 28.4 dBA to 54.5 dBA. Though the fan was audible, these sound levels were near background noise levels (27.6 dBA and 57.9 dBA) during the time of the survey.

Line of sight sound monitoring was conducted when the field staff identified the source with no visual interruption between the sound level meter and the source. Line of sight surveys give implied decibel reduction over distance, and provide useful information in determining sound travel in the survey area. The greatest distance in which a line of sight measurement was conducted was 830 m. Sound level measurements at this distance were between 51.4 dBA and 62.7 dBA. These line of sight readings are 24 dBA to 33 dBA lower than source level readings (74.5 dBA to 95.7 dBA). A sound level reduction rate of ±2.9 dBA every 100 m was calculated from 830 m away from the source. The dissipation rate of ±2.9 dBA is the lowest calculated dissipation rate within the study area. Four other line of sight studies were conducted yielding results of greater decibel reductions. This reduction rate (±2.9 dBA) should be considered the most conservative scenario for sound reduction within the project area, as no vegetative cover, geomorphology, or topography was impeding the sound travel.

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Amplification of source sounds within Quitchupah Canyon resulted in higher sound level readings near the canyon. Echoing effects, generated from the close sandstone walls within the canyon, are the sources of sound level amplification and resulted in higher sound level readings. Data collected within and above the canyon suggests these effects are most apparent at the canyon rim. An increase of 4 dBA to 16 dBA, in MAX decibel readings, occurred at or near the sandstone cliffs between the 500 m sound monitoring locations and the sound monitoring locations above the rim. These patterns are shown in sound versus distance graphs 1 and 3.

Source sound level reduction was observed during this sound study, and was observed on several sound monitoring locations within the study area. These reductions are results of vegetative buffers and topographic features within the study area. Vegetative buffers,

consisting of both trees and shrubs, occur on both sides of Quitchupah Canyon and aid in the reduction of sound levels above the rim of the canyon to the east and west of the existing fan.

Topographic features such as hills, mountains, or bends in a canyon will also create reductions in source sounds. The existing fan is located in Quitchupah Canyon ±300 m below the sensitive resource locations. Sound from the source is reduced by the elevational differences and relief between the source and sensitive resource locations.

3.2 Sensitive Resource Locations

Sound level measurements taken within the sensitive resource locations ranged between 27.6 dBA and 70.3 dBA. Minimum, maximum, and average sound level measurements within sage-grouse leks and along Forest System roads are included in **Table 1**. Sounds from the source were discernible in the sensitive resource locations, and most were at or near background (27.6 dBA to 57.9 dBA) sound levels.

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Table 1: Sensitive Resource Monitoring Locations

Location (Distance from Fan)	Fan Audible	Sound Level (dBA)		
		AVG	MIN	MAX
Existing Fan (highest measured sound)	Y	87.3	80.1	95.7
Existing Fan (100 m SE)	Y	72.1	69.7	74.3
Existing Fan (500 m NE)	Y	61.9	52.2	68.6
Background Sound Level	N	34.0	27.6	57.9
Greater Sage Grouse Leks				
Wildcat Knolls Lek (1750 m E)	Y	36.4	29.3	47.7
Wildcat Knolls Lek (2000 m E)	Y	31.7	27.8	50.7
Wildcat Knolls Lek (2310 m NE)	Y	39.2	28.4	54.5
Wildcat Knolls Lek (3050 m NE)	N	31.0	27.6	51.9
Wildcat Knolls Satellite Lek (4350 m NE)	N	33.5	27.6	55.6
Forest Service Roads				
FSR 007 NW (3500 m NW)[a]	N	32.8	29.1	54.5
FSR 007 NW (2430 m E)	N	56.6[b]	28.6	70.3[b]
FSR 007 (2310 m NE)	Y	39.2	28.4	54.5
FSR 007 (4350 m NE)	N	33.5	27.6	55.6
FSR 044 (4350 m NE)	N	33.5	27.6	55.6
FSR 025 (4500 m N)	N	35.1	29.4	54.1
FSR 52284 (1000 m NE)	Y	32.3	28.3	52.7
FSR 52284 (1020 m E)	Y	41.3	31.2	61.2
FSR 52284 (1750 m E)	Y	36.4	29.3	47.7
Near Un-authorized Route (1000 m W)	Y	36.4	29.9	46.6
FSR 2490 (2430 m E)	N	56.6[b]	28.6	70.3[b]
FSR 2058 (4350 m NE)	N	33.5	27.6	55.6

[a] near proposed fan site
[b] recreational vehicle on Forest Service Road 007

3.2.1 Greater Sage-Grouse Leks

Wildcat Knolls Lek is located 1700 m east of the source on sagebrush foothills south of Big Ridge. Sound level measurements taken within the lek ranged between 27.6 dBA and 54.5 dBA (**Table 1**). Forest Service Road 007 and Forest Service Road 52284 run directly through the center of Wildcat Knolls Lek. Although the operational fan was discernable within the Wildcat Knolls Lek, sound levels in the lek fell at or near background sound levels.

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Wildcat Knolls Satellite Lek is located 4350 m northeast of the source with sound measurements ranging between 27.6 dBA and 55.6 dBA (**Table 1**). Forest Service Road 007 and Forest Service Road 044 run adjacent to this lek on the western boundary. No sound associated with the operational fan was noted within Wildcat Knolls Satellite Lek. Sound levels within the lek fell within the range of background sound levels for the project area.

3.2.2 Forest Service System Roads

Forest Service System Roads run along the rim of Quitchupah Canyon, on Big Ridge, and through sage-grouse leks in the study area. Vehicle travel associated with Forest System Road use was observed throughout the study area.

Sound level measurements taken on Forest Service Road 007 ranged between 32.8 dBA and 70.3 dBA. This road, at it closest point, is 1600 m west of Quitchupah Canyon and runs along the rim canyon and through portions of Wildcat Knolls Lek. The existing ventilation fan is audible from portions of Forest Service Road 007 along the eastern side of Quitchupah Canyon. Although the ventilation fan was audible, sound level measurements recorded within this road were at background sound levels. Recreational vehicle traffic was present during the time of the survey and was recorded at one sound survey location. The recreational vehicle drove on the road within 10 m of the sound survey location with a recorded MAX decibel reading of 70.3 dBA.

Forest Service Road 044 runs north and south through the study area approximately 4350 m to the east of the source. Sound level measurements taken on the road ranged between 27.6 dBA and 55.6 dBA. No sound impacts, associated with the operation of the existing fan, were identified for Forest Service Road 044.

Forest Service Road 025 runs east and west on Big Ridge approximately 4560 m to the north of the source. Sound level measurements near the road ranged between 29.4 dBA and 54.1 dBA. No sound impacts, associated with the operation of the existing fan, were identified for Forest Service Road 025.

Forest Service Road 52284 runs along the eastern rim of Quitchupah Canyon and experiences sound related impacts from the existing fan. The existing fan is audible from portions of this road, however most sound level measurements fell near background sound levels. Sound level measurements taken from this road ranged between 32.3dBA and 61.2dBA. Higher sound level measurements taken at this location could be a result of wind gusts. Wind measurements taken during the sound level recording on July 30th were reported between 5 and 8 miles per hour. It is likely that wind gusts through the trees could have influenced sound levels at this monitoring location.

Two sound level measurements were conducted near an unauthorized route west of Quitchupah Canyon. This sampling location was chosen for the western sound level measurement above the canyon. The sound measuring location is 1000 m west of the existing fan and experiences sound level impacts near background sound level recordings.

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3.3 Proposed Ventilation Fan

This proposed ventilation fan is situated near the northeastern reach of Quitchupah Canyon above the eastern rim on sagebrush foothills of Big Ridge. This proposed site is located in a natural valley and is surrounded by foothills hills to the east, Big Ridge to the north and west, and Quitchupah Canyon to the south. Forest Service Road 007 runs adjacent to the proposed fan site approximately 100 m southwest of the proposed location. Forest Service Road 025 is

located 1340 m north of the proposed fan site running along the top Big Ridge. Forest Service Road 044 is located 4500 m northeast of the proposed ventilation fan adjacent to Wildcat Knolls Satellite Lek. Wildcat Knolls lek is approximately 2680 m east of the proposed fan location. Decibel readings at the proposed fan location were within background sound levels for the study area.

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4.0 SUMMARY

Below is the summary of potential sound impacts on select sensitive resource locations within the study area. These potential sound impacts were determined based upon sound level data collected at the existing fan and at identified sensitive resource locations. Tetra Tech based this summary on the assumption that the proposed ventilation fan will be identical in size, shape, power, and orientation to the existing fan. Should changes in fan size, shape, power or orientation be necessary, it is expected that the actual decibel levels may vary greatly from those proposed in this study.

This study addresses sound level measurements over a two day period in mid summer 2008, and does not address temporal differences that may exist in the study area. These differences may need to be addressed should further sound studies be conducted. Factors such as time of day, wind patterns, and seasonal events such as snow fall may need to be included future sound surveys within the area.

4.1 Proposed Ventilation Fan

Sounds from the proposed ventilation fan will likely be discernable within 2300 m of its proposed location, as this was the greatest distance from which the existing fan is audible. The sound levels from the proposed fan will decrease with distance, however no definitive distance could be determined at which this proposed fan's sound levels would reach ambient sound levels.

The existing fan is presently directed upward and is producing sound levels ranging between 75.4 dBA and 95.7 dBA at 10m distance. It is anticipated that the proposed fan will have similar sound levels at the 10 m location. The proposed fan location is presently situated in a valley and is expected to experience sound levels similar to line of sight data collected at the existing fan. Given the location of the proposed fan, direct line of sight will exist in many areas within 500 m of the proposed location. Sound levels 500 m away from the proposed fan location are expected to fall between 45.7 dBA and 73.4 dBA.

It was determined that the line of sight sound level reduction rate was ±2.9 dBA every 100m away from the source. Given that this reduction rate is the most conservative decibel reduction rate recorded with the study area, it is possible that sound produced from the proposed fan (±95.7 dBA) will be at or near average background sound levels (34.7 dBA) ±2100 meters from the source in any direction. It is anticipated that the proposed fan will still be audible at this distance.

Amplification of source sounds from the proposed fan may likely occur southwest of the proposed location within Quitchupah Canyon. The sandstone formations, of Quitchupah Canyon, may produce echoing effects from the proposed fan. This echoing is expected to amplify sounds within the canyon near the proposed fan. The existing fan is presently amplified up to 16 dBA by echoing effects within the canyon. Given that the sandstone cliffs are smaller and that vegetation is present it is expected that amplification of source sound will be less than that experienced near the existing fan. No other areas near the proposed fan location are likely to amplify sounds from the proposed fan.

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Source sound level reduction was observed during this study and is expected to occur in areas around the proposed fan. Vegetation around the proposed fan may aid in the reduction of sound impacts in the vicinity. Vegetated areas north of the proposed fan location, near Big Ridge, are expected to experience the greatest amount of sound reduction. Vegetative buffers

occur on both sides of Quitchupah Canyon and are expected to aid in the reduction of sound levels and reduce the effects of echoing within the canyon.

Topographic features around the proposed ventilation fan are also expected to create reductions in sounds. The proposed fan is located in a vegetated valley below Big Ridge and above Quitchupah Canyon. Foothills to the north, east, and west of the project site are expected to contribute the greatest amount of sound level reduction around the fan. These foothills are approximately 60 m in height and may aid in sound level reductions between the proposed fan and sage-grouse leks. These sounds may also be reduced by the elevational differences (50 – 60 m) and relief between the proposed fan and sensitive resource locations.

4.2 Sensitive Resource Locations

4.2.1 Greater Sage-Grouse Leks

The proposed fan is approximately 2680 m west of Wildcat Knolls Lek, and is separated by less topographic relief than the existing fan. This lek is situated 60 m above the proposed vent fan location, and is topographically separated from the proposed fan by several vegetated foothills. Presently, the existing fan is audible from this lek at a distance of 2300 m. Though this distance and topographic features will significantly reduce sound from the proposed fan, it is anticipated that the proposed fan will be audible from the Wildcat Knolls Lek and will likely remain at or near background sound levels.

Wildcat Knolls Satellite Lek is located 4500 m northeast of the proposed fan site and is separated by less topographic relief than the existing fan. Vegetated foothills are present between the lek and the proposed fan site, and are expected to reduce sounds created by the operation of the proposed fan. Presently no sounds associated with the source are discernable at Wildcat Knolls Satellite Lek. It is likely that the proposed fan will not be discernable from the lek. Should the proposed fan be audible from this lek, it is anticipated that the sounds will be at or below background sound levels.

4.2.2 Forest Service Roads

Sound impacts, associated with the operation of the proposed fan, are expected on Forest Service System Roads in the study area. It is likely that sound, from the proposed fan, will be discernable on Forest Service System roads occurring within ±2310 m of the proposed fan location. The Forest Service System roads are expected to experience sound level impacts up to 74 dBA, the highest decibel recording within 100 m of the operational fan.

Forest Service Road 007 is anticipated to experience the greatest level of impacts near the proposed fan location. This road is located 100 m southwest of the proposed fan location and will experience sound levels greater than background sound levels (27.6 dBA to 57.9 dBA). Sound levels generated 100 m from the operational fan ranged between 52 dBA and 74 dBA, and are the expected sound level for portions of Forest Service Road 007 near the proposed ventilation fan. Sound reducing mitigation such as an earthen berm surrounding the fan or vegetative buffer may greatly reduce sound impacts to Forest Service Road 007.

Forest Service Road 044 is located 4300 m northeast of the proposed fan site and is separated by less topographic relief than the existing fan. Vegetated foothills are present between the road and the proposed fan site. These foothills are expected to reduce sounds created by the operation of the proposed fan. Presently, no sounds associated with the source are discernable at Forest Service Road 044. It is likely that the proposed fan will not be discernable from the

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road. Should the proposed fan be audible from this location, it is anticipated that the sounds will be at or near background sound levels (27.6 dBA to 57.9 dBA).

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APPENDIX A
LOCATIONS AND SOUND LEVEL DATA

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TETRA TECH

CLIENT: SUFCO mine DATE: 2008

JOB TITLE: Greens Hollow Sound Monitoring JOB NUMBER: 115-8520020032

SUBJECT: GPS Locations and Sound Level Measurements SHEET: 1

Easting	Northing	MAX Sound	MIN Sound	AVG Sound	Time	Wind Speed (mph)
466918	4312025	83	76	80	1350	4
467011	4312007	58	58	55	1350	4
467111	4311989	65	59	62	na	0
467221	4311993	66	55	60	1215	2
467312	4311964	60	48	54	1209	0
467410	4311955	57	46	52	1150	2
467011	4312012	74	70	72	1231	1
467495	4311881	73	52	62	1213	7
467939	4312041	61	31	41	1225	5
468579	4312613	48	29	36	1237	8
468694	4312966	51	28	32	1245	0
467555	4312259	73	49	61	1156	9
467442	4312899	53	28	32	1404	5
467599	4313382	55	29	38	1353	9
467439	4313881	55	29	36	1338	5
468664	4313555	55	28	39	na	0
470026	4315181	56	28	34	1319	5
466946	4312071	86	79	82	1015	5
467306	4312545	65	50	59	1136	9
467314	4312352	69	52	62	1118	3
468714	4314501	52	28	31	1303	5
467013	4312079	74	61	69	1020	0
467062	4312183	66	51	55	1028	2
467095	4312286	58	49	53	1038	2
467135	4312385	63	51	57	1050	3
467187	4312463	61	47	52	1103	4
466903	4312070	83	75	77	1010	3
467410	4312097	54	42	45	1138	1
466904	4312032	96	80	87	957	5
466888	4312030	53	57	55	1330	1
466022	4311597	47	30	36	820	2
466175	4311672	63	51	56	850	0
462366	4308399	47	29	34	821	3
465102	4315189	54	29	35	951	5
464987	4315165	54	30	36	948	5
464900	4315199	54	34	36	945	5
465632	4314221	46	38	33	936	5
465147	4313707	70	29	57	926	8
463821	4313098	58	28	34	915	2
465416	4315224	55	29	33	955	0
465519	4315202	57	29	35	1008	1
465597	4315151	53	28	33	1012	5
465689	4315113	54	28	33	1020	5
465779	4315068	52	28	32	1024	0
465870	4315013	55	28	31	1029	0
466389	4314904	54	35	44	na	0
466720	4314496	55	29	39	1433	5
467060	4314088	50	33	37	na	0

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FIGURE 1
GREENS HOLLOW SOUND STUDY MAP

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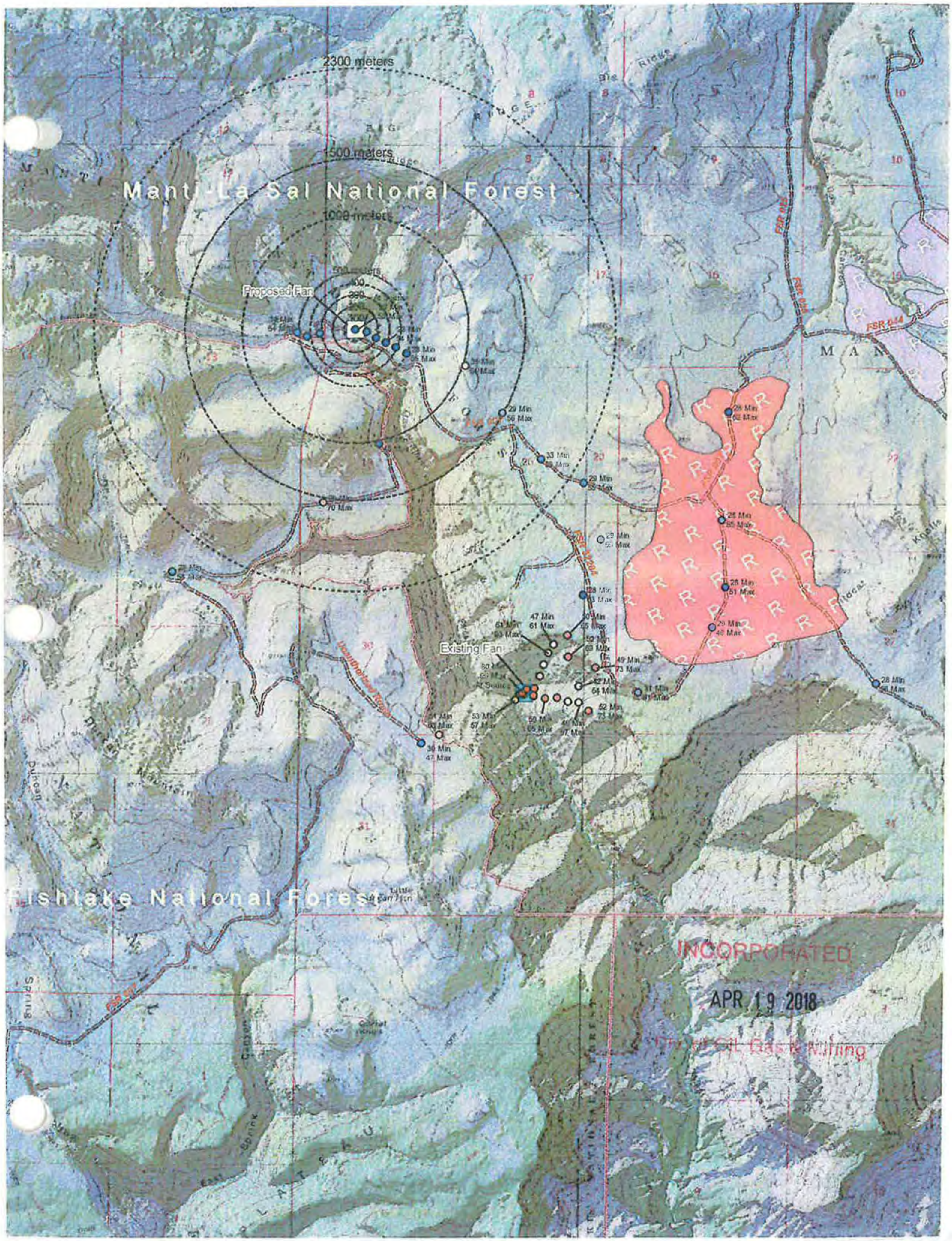

2300 meters
1500 meters
1000 meters
500 meters
Manti-La Sal National Forest
Proposed Fan
Existing Fan
Fishlake National Forest
Big Ridge
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CHAPTER 4

LAND USE AND AIR QUALITY

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CHAPTER 4
LAND USE AND AIR QUALITY

4.10 Land Use

This section of the permit application includes descriptions of the premining and proposed postmining land use(s).

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS). The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text. The Sitla Muddy Tract/Lease should not be confused with the BLM Muddy Creek Tract/Lease of which the Greens Hollow Lease was once a part.

4.1.1 Environmental Description

A statement of the conditions and capabilities of the land to be affected by coal mining and reclamation operations follows in this section.

4.1.1.1 Premining Land Use

The surface lands within the lease and permit areas (except for 640 acres privately owned) are owned by the U.S. Government and are either parts of the Fishlake National Forest, the Manti-La Sal National Forest or lands administered by the Bureau of Land Management. These lands have been inventoried by the respective regulatory agencies who are responsible for the administration and use of these government lands. Federal comprehensive land use plans have been prepared by the U.S. Forest Service Offices.

Land Use Map. Plates 4-1 and 4-1C presents these Federal comprehensive land use plans information in the lease and permit areas.

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Land Capability. The SUFCO Mine area's recreational use (excluding hunting) is approximately 427 days annually. Most of this use is dispersed among horseback riding, snowmobiling, hiking, camping, four wheeling and fuel wood gathering (Billy Dye, Ferron Ranger District; Bob Tuttle, Fishlake National Forest).

The major plant communities in the SUFCO Mine area are identified in Section 3.2.1.1.

The pinyon/juniper woodland occurs on steep unstable slopes and is considered unsuitable for grazing although it is grazed within the allotment. The vegetation condition within the pinyon/juniper woodland type was considered good. Forage production (mainly Indian rice-grass and bluebunch wheatgrass) is low. Arnold et. al. (1964), Jameson and Dodd (1964), and Jameson (1971) found that as tree canopy increased, understory vegetation decreased. Phillips (1965) found that mature stands with a 74 per unit crown canopy produced 96 pounds of forage per acre while stands with 1-2 percent cover produced from 418-577 pounds per acre. Lewis et. al. (1965-1967) found production values between 40 and 460 pounds per acre in stands sampled. Areas where trees had been removed produced as much as 900 pounds per acre. Canopy cover of pinyon and juniper in the SUFCO Mine Quitchupah lease area fairly dense and forage production in the type would generally be less than 100 lbs./acre in an average year. Assuming 50 percent utilization and 25 lbs./animal/day, it would take 15 acres to carry an animal for a month (WESTECH, 1978).

A large part of the flatter upland area is dominated by sagebrush/ grassland. The U.S. Forest Service (unpublished, 1971) has mapped this area as suitable rangeland with vegetation condition. The sagebrush/grassland type within the SUFCO Mine Quitchupah lease area is the most desirable type for grazing, producing the most available forage per acre for livestock. It generally has lower vegetation condition than other types indicating it receives heavier grazing pressure. Three transects established in 1971 by the U.S. Forest Service on the SUFCO Mine Quitchupah lease area averaged 1100 lbs/acre (dry weight). Of this, about 940 lbs/acre was perennial grasses and sedges. The transects established, however, are in areas where shrub coverage is low and forage production would probably be lower for most of the sagebrush/grassland type where shrub coverage is higher. For this type, it would take 2-3 acres to carry an animal for a month. The U.S.

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Forest Service estimates a carrying capacity of 0.5 animal units per month (AUM) per acre (B. Bass personal correspondence, 1979).

The aspen type is an important producer of forage for big game and domestic stock. A high percentage of the production is forbs which makes this type more desirable to big game and sheep. Mature aspen with a herbaceous understory in good to excellent condition will produce from 1,000 to 1,800 lbs/acre air dry forage (Lewis, 1971). The U.S. Forest Service estimates that in this area, aspen type produces 1,000 to 1,500 lbs/acre with 0.6 to 0.65 AUM/acre (M. Stubbs personal correspondence, 1979). Most of the aspen stands in the SUFCO Mine Quitchupah lease area serial with vegetation condition (U.S. Forest Service, unpublished, 1971).

The ponderosa pine, mountain shrub and coniferous forest types are generally lower forage producers although the extent of these types on the study area makes them an important component of the grazing system. Portions of these types, especially along the steep canyon walls, have been rated unsuitable for grazing and receive little grazing pressure due to limited accessibility to livestock. Areas of these types on more gentle slopes receive heavier grazing as indicated by lower vegetation condition. These areas provide some forage for livestock and are valuable forage producers for big game. Julander (1955) estimated forage production for mountain brush and oak types. He found that the mountain brush type produced 723 lbs/acre (green weight) of which 11 lbs/acre were grasses. He found that grasses are preferred forage for cattle and are selected as their key forage species. Where grasses were unavailable, however, cattle used forb and shrub species resulting in competition with big game species.

Valley bottoms receive little grazing pressure except in the vicinity of water sources where pressure is locally heavy. Valley bottoms are generally narrow and represent limited available forage. Steep slopes receive limited grazing pressure from livestock because of the steep inclines and lack of water. Flatter mesa tops and rolling terrain receive heavier pressure because of easier movement by livestock and more available forage. Grazing pressure is heaviest around water sources in these more accessible areas.

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Very little of the SUFCO Mine area is in vegetation communities capable of producing timber products. The pinyon/juniper woodland community generally occurs on steep, unstable slopes making it undesirable for accessibility.

The coniferous forest type also occurs on steep slopes and generally in small stands. Economics of harvesting these stands would result in a high cost/benefit ratio. Other than very limited consumption for posts and poles, this type receives no use in the area as a timber producer. Christmas tree cutting, however, is higher in this community type than others in the area.

The ponderosa pine type is the only vegetation community receiving substantial use for timber production. This type generally occurs on flatter sandy sites and is readily accessible. Large, mature (250 + years) trees have been harvested on a selective basis. Pine regeneration in cut over stands is sparse and mountain mahogany and manzanita appear to be increasing in the understory. Within the SUFCO Mine Quitchupah lease area approximately 528 thousand board feet (MBF) have been harvested between 1977 and 1978 with average volumes of 1.3 average net volume/acre (M. Stubbs personal correspondence, 1979). Quaking aspen stands receive limited local pressure for posts and poles.

The vegetation communities supported in the Pines Tract area and SITLA Muddy Tract area are discussed in Chapter 3 of this M&RP.

Land Use Description. The leased areas lie within the Manti-La Sal and Fishlake National Forests and are subject to the Land and Resource Management plans prepared by the agency. These plans identify the principle use of the lease areas as rangeland with small areas set aside for timber harvesting and as general big game range. Recreation in the lease areas includes camping, firewood gathering, hunting, some snowmobiling, and sight seeing from late spring to late fall. Yearly recreation use is light, but during deer and elk hunts, use is extremely heavy.

There are no developed or inventoried recreation campgrounds on the lease areas. The mining operation will not impact any of these uses and will preserve the uses into the postmining period.

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The timber on the lease areas are open grown Ponderosa pine. All commercial stands occur on the benches. Trees are of low quality because of the poor tree growing site. Cutting is limited to older over-matured trees and occurs infrequently. No adverse timber impacts are anticipated.

The aesthetic value of the area has been categorized by the U.S. Forest Service as follows: "The mesa rim and deep canyons can be seen as background from Emery (Dog Valley). They are classified as distinctive with variety. Activity from the proposal will not be visually evident from the valley. The lease area is seen as middle ground from a few remote spots on the Duncan Mountain Road. This scene area is presently classified in Sensitivity Level 2 (Average Sensitivity). The visual objective as recommended by the Land Use Plan is 2 (Modification). This permits activities to visually dominate the characteristic landscape. Very few people visit the area and those that do, come for something other than scenic attractions."

With the inclusion of the Pines Tract into the SUFCO lease and permit areas "changes in the existing landscape could include escarpment failures. This is not expected to change the visual character of the region."

A portion of the surface area is grazed by cattle under the Quitchupah Grazing Association allotment (Fishlake National Forest). The allotment covers approximately 43,156 acres, it presently supports 813 head of cattle from June 11 through September 30, for a total of 2,981 cow months (Bob Tuttle, Fishlake National Forest).

The Emery allotment (Manti-La Sal Forest) supports 1,300 head of cattle. This allotment is under an intensive rest-rotation management system, placing the cattle in the mine area for approximately one month a year. Several ranches in Emery County are dependent on the allotment. Structural range improvements include one watering trough (spring fed) and two cattle guards on the access route into the lease.

The number of hunters in the Salina Planning Unit increased 122 percent from 1969 to 1972 (U.S. Forest Service, 1976). In Deer Unit #43/45 (Salina) 9,383 hunters were recorded afield during the 1990 hunting season. The Fishlake Elk Herd Unit #14 hosted 4,027 hunters during the 1990

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season. Additional hunter use information reported by the Utah Division of Wildlife Resources can be found in the Utah Big Game Annual Report for 1991 (Appendix 4-1).

Pines Tract Area

The existing land uses in the Pines Tract area include: timber production, livestock grazing, wildlife habitat, recreation, transportation corridors and underground coal mining (SUFCO Mine). The existing land uses not previously discussed are the transportation corridors and underground coal mining (SUFCO Mine, Quitchupah Lease). The roads/transportation corridors are generally single-lane native surface forest development roads which are passable during the drier months of the year. The forest development roads connect with local roads that access major highways.

In the late 1970s two Roadless Area Review and Evaluation (RARE) II areas were inventoried. Neither area was designated as wilderness, nor were they classified as roadless or semi-primitive recreation management areas under the Forest Plan in 1986 (Pines Tract Project EIS, 1999).

The Pines grazing unit is part of the Emery C&H grazing allotment. The Pines unit supports 1,387 head of cattle during the early grazing season. Eight ponds for livestock and wildlife use have been developed in the Pines Tract area (see Chapter 3, Appendix 3-9, Figure 2 - Springs, Seeps and Riparian Areas). The Link Canyon troughs and the Joe Mill ponds are the most reliable sources of developed water within the tract area.

The limited amount of perennial water within the analysis area reduces the potential for many species of fish to be present. However, Muddy Creek and the lower portion of Box Canyon Creek support fish populations.

The Sevier County Zoning Resolution designates the area as GRF-1. The primary uses designated for GRF-1 areas include gravel pits, clay pits, rock quarries, oil and gas wells, mines, mineral reduction, processing structures and facilities. There are no oil or gas leases associated with the Pines Tract area.

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Muddy Tract Area

The existing land uses in the SITLA Muddy Tract area include: timber production, livestock grazing, wildlife habitat, recreation, transportation corridors and underground coal mining (SUFCO Mine). The roads/transportation corridors are generally single-lane native surface forest development and maintenance roads which are passable during the drier months of the year. The roads are classified by the Forest as Level 2 roads and generally no restrictions are placed on these roads for public use. The Forest does recommend the use of high clearance vehicles for most of the roads in the SITLA Muddy Tract area and to avoid use when the road surfaces are wet. However, if the permittee is using the roads for other than periodic monitoring, special use permits must be obtained from the Forest. Many of the forest development roads connect with local roads that access major highways.

In the late 1970s two Roadless Area Review and Evaluation (RARE) II areas within the SITLA Muddy Tract region were inventoried. Neither area was designated as wilderness, nor were they classified as roadless or semi-primitive recreation management areas under the 1986 Forest Plan Revision (Pines Tract Project EIS, 1999). Recent re-inventories (July 2004) of Roadless Areas by the Manti LaSal National Forest as part of their Forest Plan Revision to be completed by the end of 2006 have included nearly all of the SITLA Muddy Tract as potentially "roadless". This designation excludes the existing Forest Development Roads 044, 2033, and 010 that lie within the eastern and northern portions of the SITLA Muddy Tract. Only a small segment of land west and north of the Main Fork of Box Canyon and western SITLA Muddy Tract boundary, east of Forest Road 044, and south of the southern boundary of sections 2, 3, and 4 of T 21 S., R 5 E., SLM is identified as not being included in the proposed roadless area. Currently, the Forest typically administers most of the areas identified as having "roadless" characteristics as though the areas were officially accepted as roadless. This action is being taken to preserve, where possible, unroaded characteristics of portions of the Forest.

The SITLA Muddy Tract area is part of the Emery C&H grazing allotment. The SITLA Muddy Tract unit supports 1,387 head of cattle during the early grazing season. Three ponds for livestock and wildlife use have been developed in the SITLA Muddy Tract area. The limited amount of perennial

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water within the analysis area reduces the potential for many species of fish to be present. However, Muddy Creek and the lower portion of Box Canyon Creek support fish populations.

There are no oil or gas leases associated with the SITLA Muddy Tract area.

3 Right 4 East Panel(s)

In the area of the Quitchupah lease two major cultural resource surveys were competed, one in 1977 (AERC) and one in 1983 by Centuries Research, Incorporated. The nature of the cultural resources found indicates that the area was used very lightly in prehistoric times, and mostly for flaking and hunting.

In 1992 a cultural survey (UT-92-AF-381f) was performed by AERC on the north canyon rim above North Fork Quitchupah Creek. Three sites were identified, one in each of two adjoining sections and one straddling the section line of the two. According to SHPO and National Register of Historic Place, these sites have not been listed with the National Register (Beth Karpinski, Archeologist, Tetra Tech, December 15, 2016). The sites are north of the 3R4E panel(s), but lie over existing mains.

Cultural and paleontological resources above the 3 Right 4 East panel and within the potential subsidence angle-of-draw will be surveyed and the reported findings will be submitted to the Manti-La Sal Forest Archeologist for processing for clearance. A copy in the reports are located in confidential Appendix 4-2. Due to heavier snows in 2016/2017 the survey will be delayed until the area can be accessed. Longwall mining of this panel will not be started until the archeological clearances have been obtained.

During the 2017 Class III cultural survey two of the previously recorded sites were re-inventoried, one was determined to be eligible (42SV2310), the other was not eligible (42SV2309). Improved GPS equipment has placed the eligible site over the mine entries with the potential for 8" of subsidence. " The site does not have any architectural or unique features...The site is stable with no significant impact or threats currently facing it.....The observed surface scatter is the result of ...eroding...anchored lee side dune." The recommendation as eligible is due to the "potential for

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intact buried cultural deposits" (Tetra Tech, June 23, 2017, Appendix 4-2). Two additional sites were found and two IOs were located, none of these sites were determined to be eligible during this survey.

Based on reports from local mines the general rarity of significant vertebrate fossil particularly in the Castlegate Sandstone supports the lack of potential to expose or damage paleontological resources due to escarpment subsidence impacts. (Paleontology Resource Appraisal 2017, Appendix 4-2).

Land uses include mining, firewood collection, livestock grazing, wildlife habitat, watershed, exploration and recreation. These uses existed in the early 1900's and would be expected to continue without disruption by continued mining in the lease tract.

Greens Hollow Tract

The area is not proximate to local communities and the access to the area is time consuming. Overall recreational use is light compared to other areas of the Forest, there are no small reservoirs or collector roads. Seasonal use begins in May and end following hunting season in October. Approximately 24 miles of forest road are used by OHV's 4WD's and conventional vehicles.

Noise levels vary in the tract area from, recreational vehicles, wood cutting and the mines exhaust fan. A noise study was conducted, sound levels ranged from 32. 8 dBA to 70.3 dBA. Higher sound level measurement taken at various monitoring locations could be a result of wind gusts. Appendix 3-15 contains a copy of Sound Study Report prepared by Tetra Tech.

The majority of the tract falls with the Emery Cattle and Horse Grazing Allotment (9,107 acres) on the Manti-La Sal National Forest. A small parcel on the north is on the Ferron Cattle and Horse Grazing Allotment (203 acres) also on the Manti-La Sal Forest. On the southern end of are tract on the Fishlake National Forest lies the Quitchupah Cattle and Horse Grazing Allotment (1,714 acres). The limiting factor for the allotments is stock water, spring-fed troughs provide the most reliable sources of stock water , with develped stock ponds and natural pond providing a less reliable source. Refer to Appendix 4-6 for figure showing range allotments.

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Documented land uses for the Greens Hollow Tract include:
Livestock grazing, spring development and other water improvements (guzzler, etc), habitat improvement, prescribed burns, sage grouse brood rearing habitat, forest service road development, mining, recreation timber operations and private land access, dispersed camping and hunting, exploration drilling, and geophysical surveys. Underground room and pilling mining at the Ricci Mine was done in the area on the north slope of Muddy Creek.

The tract contains two Inventoried Roadless Areas (IRAs), the Muddy Creek-Nelson Mountain IRA is on the Manti and the White Mountain IRA on both the Fishlake and Manti. Five percent of the Muddy Creek IRA is in the tract and 10% of the White Mountain IRA is within the tract. The Wildcat Knoll IRA (0.6%)is with the the extended analysis area. Activities on the IRAs are subject to restrictions specified in the USFS 2001 Roadless Rule.

The Paiute Indian Tribe, Navajo Nation and Ute Indian Tribe were consulted; no sacred sites were identified in the course of the tribal consultation (FESEIS).

Cultural and Historic Resources Information. Cultural resource information and maps identifying cultural and historical study areas are located in Appendix 4-2. An intensive cultural resource evaluation of five coal exploration well locations has been conducted on the Quitchupah Lease by Dr. Richard Hauck of AERC (see Appendix 4-2). As part of this evaluation he also made a record search at the State Historic Preservation office and the National Register of Historic Places. No sites were found that would be effected by the drilling activity. A ten percent cultural resource potential survey was completed by Les Sikle, Forest Archeologist, Manti-La Sal National Forest. A copy of his report is included in Appendix 4-2 along with the Utah State Historical Society's concurrence letter.

An intensive cultural resource evaluation of a proposed breakout, substation and power line in the Link Canyon Locality conducted by Dr. Richard Hauck of AERC is included in Appendix 4-2. No cultural or paleoentological resources were observed within the proposed Link Canyon development area during the archaeological survey.

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A cultural resource evaluation of the Link Canyon Mine portals area in Link Canyon was conducted by John Senulis of Senco-Phoenix. A copy of his report is included in Appendix 4-2. The conclusion of his evaluation of the portal site was that no cultural or paleoentological resources are present. Many of his conclusions were based on work previously performed in the immediate portal area and surrounding areas by Dames and Moore, AERC, JBR, and the BLM.

There are no cemeteries, public parks, historic places, or areas within the boundaries of any units of the National System of Trails or the Wild and Scenic Rivers System located in areas to be affected by the SUFCO Mine (See Appendix 4-6 for a description). The Applicant agrees, however, to notify the regulatory authority and the Utah State Historical Society of previously unidentified cultural resources discovered in the course of mining operations. The Applicant also agrees to have any such cultural resources evaluated in terms of National Register of Historic Places eligibility criteria. Protection of eligible cultural resources will be in accordance with regulatory authority and Utah SHPO requirements. The Applicant will also instruct its employees that it is a violation of federal and state laws to collect individual artifacts or to otherwise disturb cultural resources.

150 Acre Incidental Boundary Change

Cultural and Historic Information. Cultural resource information and maps identifying cultural and historical study areas are located in Appendix 4-2. Dr. Richard Hauck of AERC conducted an intensive evaluation of the 150 acre IBC. Four new sites were discovered and recorded during the evaluation. All the sites are located on or near the east rim of Box Canyon. The sites include two significant rock shelters (42SV 2492 and 42SV 2495), a significant ceramic scatter (42SV 2493), and a non-significant kill-butchering locus (42SV 2494).

Site 42 SV 2492 - The site consists of a rock shelter. This site is considered to be a significant resource and excellent potential for National Register classification. The site is 15 meter wide with a sandstone arched roof and is susceptible to surface subsidence.

Site 42 SV 2493 - The site consists of ceramic scatter occupying an area of 20 to 30 meters on the bedrock top at the canyon rim. This site is considered to be a significant resource

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and has the potential for National Register classification. This site is not considered to be at-risk or susceptible to surface subsidence.

Site 42 SV 2494 - The site consists of a dispersed scatter of debris and lithic tool fragments and is situated on the bedrock on the east rim overlooking Box Canyon. This site is not considered to be a significant resources and lacks potential for National Register classification.

Site 42 SV 2495 - The site consists of a scatter of debris primarily on the north facing slope below the base of a shallow shelter under a sandstone ledge. The site is considered to be a significant resource and has limited potential for National Register classification. This site is not considered to be at-risk or susceptible to surface subsidence.

The Applicant agrees, however, to notify the regulatory authority and the Utah State Historical Society of previously unidentified cultural resources discovered in the course of mining operations. The Applicant also agrees to have any such cultural resources evaluated in terms of National Register of Historic Places eligibility criteria. Protection of eligible cultural resources will be in accordance with regulatory authority and Utah SHPO requirements. The Applicant will also instruct its employees that it is a violation of federal and state laws to collect individual artifacts or to otherwise disturb cultural resources.

Pines Tract Area

Cultural and Historic Information. Cultural resource information and maps identifying cultural and historical study areas are located in Appendix 4-2. Dr. Richard Hauck of AERC made a record search at the State Historic Preservation office, National Register of Historic Places and conducted field investigations under state project numbers UT-96-AF-0443f and UT-97-AF-0598f. AERC coordinated the research and field investigations with SHPO.

Information concerning the potential of specific sites as to being either in the subsidence zone or out of the zone or being evaluated or unevaluated is contained in the Memorandum of Agreement between Federal and State agencies.

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The monitoring, treatment plans and mitigation of the cultural resource sites will be in accordance with the Memorandum of Agreement (MOA) 00-MU-11041000-017, and any amendment to it, between the USFS - Manti-La Sal, USHPO, the Advisory Council on Historic Places, UDOGM, and the SUFCO Mine located in Appendix 4-5.

Sufco intends to undermine portions of the East Fork of Box Canyon beginning in the Fall of 2003 as they extract coal from the 3LPE and 4LPE longwall panels. This change in the mining plan will change the required monitoring schedule in accordance with the Memorandum of Agreement for site 42SV2430/ML-3446 - Elusive Peacock which will be undermined under the 3LPE longwall panel. In accordance with pages 11-12 of the MOA the required monitoring schedule of this site will change from Monitor Schedule A (Sites in areas that will be mined using full-support methods) to Monitor Schedule B (Sites in areas which will be mined under and subsided) requiring the implementation of additional monitoring of the site. Monitoring results will be provided in DOGM Annual Reports. (2003, 2004, 2005, 2006, and indefinitely until movement ceases)

Historic properties documented in the Pines Tract area include 42SV2424, a sawmill, and site 42SV2391 a complex of trash scatters. Both sites are considered ineligible for the NRHP.

The Applicant agrees, however, to notify the regulatory authority and the Utah State Historical Preservation Office (SHPO) of previously unidentified cultural resources discovered in the course of mining operations. The Applicant also agrees to have any such cultural resources evaluated in terms of National Register of Historic Places eligibility criteria.

Muddy Creek Coal Tract Area

Cultural and Historic Information. Cultural resource information and maps identifying cultural and historical study areas are located in Appendix 4-2. Cirrus Ecological Solutions, LC conducted an intensive evaluation of the Muddy Tract Area. Thirty-four sites were documented during the evaluation. Refer to Confidential Appendix 4-2, "Muddy Creek Technical Report, Heritage Resources".

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The three sites located in the SITLA Muddy Tract lease area are located on or near the east rim of Box Canyon. The sites include two significant lithic scatters (42SV2554 and 42SV2597), and a non-significant lithic scatter (42SV2594). None of these three sites will be undermined under the present mine plan.

The Applicant agrees, however, to notify the regulatory authority and the Utah State Historical Preservation Office (SHPO) of previously unidentified cultural resources discovered in the course of mining operations. The Applicant also agrees to have any such cultural resources evaluated in terms of National Register of Historic Places eligibility criteria.

Results from USDA Manti-La Sal National Forest, Price Ranger District, Project #ML-02-1033, Utah State Project #U-02-MM-0311f, s, b, p

Site #	Site Type	Evaluation (Cirrus Ecological Solutions, LC)	Undermined/potential for impact by mining	Date Surveyed
42SV2584*	LS, RS,C	Significant	No/Not expected	1966(PI 1976)
42SV2596	LS, RS	Non-significant	No/Not expected	1966(PI 1976)
42SV2597	LS	Non-significant	No/Not expected	1966
42SV2554	LS	Significant	No/Not expected	1966
42SV2492	LS	Non-significant	No/Not expected	1966

LS - Lithic Scatter RS- Rock Shelter C-Ceramics

* Re-recorded on IMACS form, lumped ML#s 2281 and 2282 with this.

Site 42SV2584 and 42SV2596 lie within the boundary of the SITLA lease expansion (Section 32, T 20 S, R 5 E). According to a report prepared for the Manti-La Sal Forest by Cirrus Ecological Solutions, LC, site 42SV2584 is considered significant, while 42SV2596 is considered non-significant. In the current Sufco five year mine plan no mining is planned beneath either location and they do not lie within the angle-of-draw (Plate 5-10A), therefore no impact is anticipated to

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either site. Should the mine plan change where the eligible site could be impacted, the permittee will coordinate with DOGM and the USFS prior to mining.

Sites 42SV2584 and 42SV2596 were reevaluated by USFS archeologist in 2015. On 11/20/15, SHPO concurred with the USFS recommendation that site 42SV2584 be determined eligible and 42SV2596 be determined not eligible. A copy of the SHPO concurrence letter is located in Appendix 4-2 (Confidential) of the M&RP.

West Coal Lease Modification Areas

Cultural and Historic Information. Cultural resource information and maps identifying cultural and historical study areas are located in Appendix 4-2 in the Confidential folder of the M&RP. EarthTouch, Inc. conducted an intensive evaluation of the West Coal Lease Modification Areas.

The results of the cultural resource inventory for the project resulted in the identification of 15 cultural resource sites, which included three previously recorded sites (42SV1301, 42SV1386 and 42SV2688), and 12 new sites (42SV3207-3215 and 42SV3246-3248). Overall, the identified cultural resource sites consist of small- to moderate-sized lithic scatters and small rock shelters/overhangs, some with associated pictographs. Of the 15 sites identified within the West Coal Lease Modification Areas, six sites are recommended eligible for the National Register of Historic Places. These sites include 42SV3209, 42SV3211, 42SV3212, 42SV3213, 42SV3247 and 42SV3248 which consist of small rock shelters and rock shelters with pictographs. Site 42SV3209 will be the only site undermined under the present mine plan. This shelter is more of a terrace overhang that extends 6 meters long, with a 1.5 meter overhang or width.

2RWL Sinkhole - In 2016 an additional cultural resource review/inventory was performed by Tetra Tech a consulting firm, for the area of the sinkhole. The inventory included information from the EarthTouch report previously mentioned and from other previously prepared reports. A copy of the inventory results have been included in Appendix 4-2. Within the inventory area, no cultural resources had been recorded. Thus, no impacted were anticipated during the repair of the sinkhole. Clearance for the repair of the sinkhole was give by SHPO from documentation prepared by Tetra Tech and Jessica Montcalm of the Division of Oil, Gas and Mining. The area of the sink

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hole is part of the West Lease Modification Area previously permitted in 2011. An EA prepared for the West Lease Modification is located in Appendix 3-13.

3 Right 4 East - Quitchupah Tract

In 1989 more than 960 acres of the tract had been surveyed for cultural resources. The survey indicated that the area was used lightly in prehistoric times (Environmental Assessment, Coal Lease U63214, October 1988). The U.S. Forest Service and State Historic Preservation Officer determined that mining induced subsidence will have minimal impact on cultural resources (UDOGM Environmental Assessmen, October 27, 1989).

4 Right 4 East - Quitchupah Tract

In the area of the Quitchupah lease two major cultural resource surveys were completed, one in 1977 (AERC) and one in 1983 by Centuries Research, Incorporated. The nature of the cultural resources found indicates that the area was used very lightly in prehistoric times, and mostly for flaking and hunting (Environmental Assessment, Coal Lease U-63214, October 1988). The U.S. Forest Service and State Historic Preservation Officer determined that mining induced subsidence will have minimal impact on cultural resources (UDOGM Environmental Assessment, October 27, 1989).

During the 2017 Paleontology Resource Appraisal of the 4 Right area the Castlegate and Price River formations were determined to have little potential for the preservation of vertebrate fossils. Based on reports from local mines the general rarity of significant vertebrate fossil particularly in the Castlegate Sandstone supports the lack of potential to expose or damage paleontological resources due to escarpment subsidence impacts. (Paleontology Resource Appraisal 2017, Appendix 4-2).

Because the Mine has no plans to cause surface disturbance within the project area, a Class III cultural resource inventory was only required by the USFS in areas with a high potential for subsidence where cultural resources existed and could be adversely impacted. Historically, the areas include canyon walls and their associated rims. The inventory was conducted in portions of Sections 27 and 34. Two new sites were recorded adjacent to the 4 Right panel in Section 27

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(42SV3786 and 42SV3787) neither was considered to be eligible to be listed by SHPO as recommended by the USFS. The cultural resource inventory and SHPO concurrence letter agreeing with USFS in not listing the new sites are located in Appendix 4-2 (Confidential). Two isolated objects were also located in Section 34 during the inventory. There are no known cultural and paleontological resources above the 4 Right 4 East panel and within the potential subsidence angle-of-draw.

South Fork of Quitchupah Area of 2R2S Block "A" and 3R2S Block "B"

Cultural and Historic Information. Cultural resource information and maps identifying cultural and historical study areas are located in Appendix 4-2 in the Confidential folder of the M&RP. Canyon Environmental conducted an evaluation of the South Fork of Quitchupah in and adjacent to the 2R2S Block "A" panel Area.

The results of the cultural resource inventory for the project resulted in the identification of 4 cultural resource sites, which included one previously recorded site (42SV2690), and 3 new sites (42SV3462, 42SV3463 and 42S3464). Overall, the identified cultural resource sites consist of lithic scatters and a small rock shelter/overhang. Of the 4 sites identified within the South Fork of Quitchupah Area, two sites are recommended eligible for the National Register of Historic Places.

These sites include 42SV2690 which consists of a lithic scatter and 42SV3464 which consists of a lithic scatter associated with a small rock shelter. Both sites will be undermined under the present mine plan. This shelter is more of a terrace overhang that measures approximately 1.5 meters high and 4 meters wide at the opening and extends 1.5 meters beneath the rock to a tapered edge. The shelter shows signs of modern disturbance and it appears that some of the fill material has been disturbed by minor looting activities.

A cultural resource investigation plan for the 42SV3464 rock shelter was requested and approved between the U.S. Forest Service, Utah State Historic Preservation Office (SHPO), EnviroWest, LLC and Canyon Fuel Company, LLC since the shelter appeared to have been disturbed. Testing of the rock shelter for significance was conducted by EnviroWest and Fishlake National Forest Archaeologist in the fall of 2012. While the site was initially evaluated as being eligible for listing

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in the National Register of Historic Places, subsequent testing has found it to be ineligible for listing due to disturbance. A copy of the cultural resource investigation testing report and the Determination of Significance and Effect form are located in Appendix 4-2 in the Confidential folder of the M&RP. No further testing of the 42SV2690 lithic scatter was required.

South Fork of Quitchupah Canyon - 2013 Inventory (October 2014)

During July and August 2013 a file search of archeological/cultural resource records and a pedestrian inventory of the study area was performed by EnviroWest LLC. The report is located in Appendix 4-2, Confidential Folder (2013). During the pedestrian inventory five new cultural resource sites were documented, three consisted of lithic scatters located on the bench area and two rock shelters in the canyon. The lithic scatters were recommended by EnviroWest LLC as ineligible for listing in the National Register of Historic Places (NRHP), whereas the two rock shelters were recommended to be eligible for listing in the NRHP. Upon consideration of the EnviroWest LLC report recommendations and a mine plan prepared by Sufco showing several panels to be mined to the north of 3R2S panel a "Determination of Significance and Effect" was prepared by Forest Service Archeologist Charmaine Thompson and signed by SHPO representative in 2013 showing a finding of "adverse effect", Appendix 4-2, Confidential (2013)

Due to a change in Sufco's mine plan and further evaluations by an engineer and geologist it was determined the potential for impact to either shelter by subsidence associated with mining was unlikely. A drawing included in Appendix 4-2, Tension Cracks(2 South) illustrates the location of the shelters in proximity to the 3R2S panel and showed surveyed surface cracks as a result of mining in the 2R2S panel. Evaluation of the cracks from past mining(2R2S, Pines) illustrates that surface cracking associated with subsidence primarily occurs within the mined panel area and well within the anticipated angle of draw of subsidence. Therefore, it is believed that the information and maps provided in Appendix 4-2 demonstrate that the two shelters 42SV3550 and 42SV3551 should not be affected by the mining.

The additional information was provided to Manti-La Sal Forest Service Archeologist Charmaine Thompson. During a second review of the information pertaining to mining activities in relation to the two shelters (Forest Service Project - ML-13-1452, Appendix 4-2) and a visit to the study area,

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Ms. Thompson revised her earlier determination to be "no adverse effect" to the shelters listed in the report. Ms. Thompson's evaluation letter and determination were forwarded to the Utah State Historical Society, with a request for concurrence with the decision of "no adverse effect", concurrence was given by Chris Merritt, Senior Preservation Specialist. The documentation of the decision and concurrence is located in Confidential Appendix 4-2.

Greens Hollow Tract

The first archaeological survey of the tract area occurred in 2008, and additional survey was conducted in 2009. Twenty-nine heritage resource inventories (including the two previously mentioned) were completed within one mile of the Greens Hollow tract analysis area between 1977 and 2009. Twenty-seven were in association with mining. Over 1,820 acres have been surveyed within the maximum area of potential subsidence. The surveys are highly variable with significanly less surveys being performed in the steeper or more rugged terrain.

To protect the archeological sites, the canyons within the study area were excluded from mining, which reduced the archaeological sites to five with only one of the five being recommended as eligible for inclusion in the NRHP. Refer to Appendix 4-2 and Confidential Plate 5-10C for information associated with the sites. .

Paleontological resources are expected to exist in the formations within the Green Hollow tract, however no surveys have been conducted. The resources are likely to be of the unprotected variety according to the "Heritage Resource" report in Appendix 4-2.

The Greens Hollow Tract Lease area was originally part of the Muddy Creek Tract(not the same as the SITLA Muddy Tract), reports and documents referring to the Muddy Creek Tract in this chapter text and appendices are applicable to the Greens Hollow Tract. The connection of the two tracts is presented in the Final Supplemental environmental Impact Statement for the Greens Hollow Federal Coal Lease Tract Section 1.2.6.

Site specific archeological/paleontological resources studies will be performed on the Greens Hollow Lease area as required for surface disturbance associated with mining. The location of

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inventoried cultural sites are shown on drawings within their respective reports contained in Appendix 4-2 and Plate 5-10C. Memorandum of Agreement (MOA)between Manti-La Sal Forest and Utah State Historic Preservation Officer, Attachment D, Page 7 states "The is one identified National Register eligible site within the area of subsidence mining that might be adversely affected by subsidence mining. 42SV3224 is on the very edge of this area which make it unlikely that mining would occur under it. However, it is in an area with little overburden, which make it more likely that if subsidence mining does occur, surface cracking of the kind that could affect the site is more likely to occur. ..... In general, surface cracks that do not bisect features or buried deposits will be considered to have no adverse effect on that site. The results of subsidence that will be considered to produce an adverse effect to a given site are cracks through features or buried deposits or cracks near features that cause potential new channels for water that would, in turn, bisect or otherwise damage features or buried deposits." Since there are several different reports for the Greens Hollow area a table has been prepared listing the cultural resource sites existing within the lease area and within the estimated subsidence angle of draw. Surface construction of a power line and shafts were evaluated in the MOA, EIS and other reports, the reports designated mitigation requirements, however the permittee does not currently plan construction, road modification or surface disturbance, therefore mitigation obligations are not required currently.

ELIGIBLE - No surface distrubance or road improvement planned (12/2017)

Site /SHPO #	Brief Description	Mitigation/Monitoring /Protection
42sp504	Scatter	Outside, NA
42sv1484 West Area	Scatter and trash	Outside, NA
42sv2589	Scatter w shelter	Non Subsidence Zone, Outside
42sv2586	Scatter w camp	Non Subsidence Zone, Outside, NA
42sv2584	Scatter w shelter; ceramics	Non Subsidence Zone, Outside
42sv2949	Scatter and tools	Non Subsidence Zone, Outside, NA
42sv3224 **	Scatter, hearth and tools	Non Subsidence Zone, Outside, NA
42sv3226	Scatter	Non Subsidence Zone, Outside, NA
42sv1578/2341	Multicomponent	Outside, NA

Notes:
NA - Not Applicable/required
Outside - outside area of influence by subsidence, no surface disturbance/construction
Non Subsidence Zone - If any mining, first mining only, no long wall mining
** - Recommended for inclusion in the National Register of Historic Places, however to date not included

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An extended version of this table containing non-eligible NRHP sites is provided in Appendix 4-2 along with the Cultural Resource Sites Greens Hollow EIS drawing showing the location of both eligible and non-eligible sites and the long-wall mine plan.

Memorandum of Agreement (MOA)between Manti-La Sal Forest and Utah State Historic Preservation Officer, Attachment D, Page 7 states "The is one identified National Register eligible site within the area of subsidence mining that might be adversely affected by subsidence mining. 42SV3224 is on the very edge of this area which make it unlikely that mining would occur under it. However, it is in an area with little overburden, which make it more likely that if subsidence mining does occur, surface cracking of the kind that could affect the site is more likely to occur. ..... In general, surface cracks that do not bisect features or buried deposits will be considered to have no adverse effect on that site. The results of subsidence that will be considered to produce an adverse effect to a given site are cracks through features or buried deposits or cracks near features that cause potential new channels for water that would, in turn, bisect or otherwise damage features or buried deposits." Site 42SV3224 is not within the Greens Hollow Lease (UTU-84102), it is located within Lease U-63214.

The following steps/requirements apply only to sites 42SV3224, 42SV2584 and 42SV2589 listed in Appendix D, Step 1 of the MOA as quoted below and to no other archeological sites: "The following steps will be done to establish the presence or absence of potential effects to sites from subsidence mining. These are based on the nature of the known sites and on the types of subsidence effects that have been noted in nearby areas of existing subsidence mining (particularly in The Pines Tract). These will be done within the context of the same research design used to guide treatment of sites within the road right of way that has been reviewed by the Utah SHPO and interested Tribes.

1) Create detailed, base-line maps and photographic records of 42SV3224, 42SV2584 and 42SV2589 before subsidence mining begins. The goal of this documentation is to establish the presence of natural rills and other natural surface features that might be mistaken for surface cracks resulting from subsidence. These maps would include any features (such as hearths) that might be adversely affected by any cracking near or through those features and provide a more detailed record of the location and nature of surface artifacts than is on

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the existing site forms.

2) Monitor each site once a year while mining is occurring under the area of those sites.

3) If surface cracking or buckling is found, each crack will be examined in relationship to the existing detailed site map. If surface artifacts are found to be missing or displaced, this will be noted in the monitoring notes. Loss or displacement of documented artifacts will be considered to be of no adverse effect to the site.

4) Each crack will be examined for the presence or absence of subsurface deposits, including the use of trowels or shovels to establish clean profiles. These exposed sediments will be documented for the presence or absence of buried artifacts, soil stains or features. If no such artifacts, deposits, or features are found, than the crack will be considered to be of no adverse effect to the site. Damage to such materials by surface cracking will be considered an adverse effect and the following steps will be implemented.

   a) All buried artifacts, soil stains, or features found within subsidence cracks will be documented using sub-meter GPS units and standard archaeological documentation procedures.

   b) Any decision to expand excavation of these features will be guided by the research design and may include 1 x 1 meter units that expose more or all of features such as hearths.

   c) Once the goals of the research design are reached, excavations of material exposed in that particular subsidence crack will cease and the adverse effect of that crack will be considered to be mitigated. The results of the excavations will then be analyzed and reported to SHPO in a report that meets professional standards.

5) If cracking or buckling that resulted from subsidence mining is found at any of the rock shelters at sites 42SV2584 and 42SV2589, then this will be considered an adverse effect that requires additional consultation with the Utah SHPO and interested Tribes and amendment of this agreement as described in Stipulation VIII of the Memorandum of Agreement."

Greens Hollow Federal Coal Lease Tract (UTU-84102) MOA Stipulation VIII: "8) A monitoring plan will be developed that monitors potential project effects at sites within the project area and immediately adjacent to roads that area improved as a result of the project. This plan will meet four goals. The first is to have archaeologists on scene during initial layout of the south vent shaft construction footprint in order to ensure full avoidance of sites 42SV2949 and 42SV3224. The

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second is to monitor the site within the area of subsidence mining that might be affected by surface cracking (42SV3224). The third goal is to monitor area sites for indications of illegal artifact collecting and looting. The fourth is to monitoring the two sites containing rock shelter sites with the area of no subsidence mining (42SV2584 and 42SV2589) in order to ensure that no effects from subsidence occur."

The MOA for the Greens Hollow Lease lists three sites of concern 42SV3224, 42SV2484 and 42SV2589. Per the first step:

"1) Create detailed, base-line maps and photographic records of 42SV3224, 42SV2584 and 42SV2589 before subsidence mining begins. "

Site forms prepared for the sites and on files with the Manti-La Sal Forest constitute baseline maps and photos for these sites, the first step is considered complete as identified per a e-mail communications with Charmaine Thompson, Heritage Program Leader Manti La Sal Forest on March 1, 2018.

When the area below or immediately adjacent to the sites has been mined, the second step will be undertaken. Mining will occur beneath 42SV3224 but not under sites 42SV2584 and 42SV2589 since both are "within the area of no subsidence mining" in accordance with Lease UTU-84102. Step 2 if required will be postponed in the winter, until the snow is off the ground. Per the aforementioned e-mail communication with Charmaine Thompson, mine personnel will notify DOGM and USFS approximately six months from when mining immediately adjacent or beneath the three sites is completed.

The mining adjacent to sites 42SV2584 and 42SV2589 will occur sometime after the year 2025. The mining beneath 42SV3224 was completed in February 2018, a site visit will be arranged in 2018 in accordance with Step 2. Representatives from Sufco mine, DOGM and the Forest Service heritage staff will survey the three sites for the effects of subsidence. Once it is established whether or not the sites have been affected by subsidence, either the monitoring will cease due to no effect or a contract archeologist will be enlisted by the mine to complete a research design, complete limited documentation/possible small scale excavation procedures and prepare a report of the results of those findings(Steps 3 - 4). Should there be effects of subsidence at sites 42SV2484 and 42SV2589, the mine with the assistance from the Forest Service archeologist will do additional consultation with SHPO, the Tribes and other affected parties as defined at the time

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of consultation to resolve the effects (Step 5). Once it has been determined that subsidence has ceased in the area immediately adjacent to sites 42SV2584 and 42SV2589 and at site 42SV3224 monitoring indicates "no effect" further monitoring will cease. The inventory forms for these sites are located in Appendix 4-2.

In accordance with previous commitments the mine has made in previous sections of this M&RP, protection of eligible cultural resources will be in accordance with regulatory authority and Utah SHPO requirements. The Applicant will also instruct its employees that it is a violation of federal and state laws to collect individual artifacts or to otherwise disturb cultural resources.

The Applicant agrees to notify the regulatory authority and the Utah State Historical Preservation Office (SHPO) of previously unidentified cultural resources discovered in the course of mining operations. The Applicant also agrees to have any such cultural resources evaluated in terms of National Register of Historic Places eligibility criteria.

4.1.1.2 Previous Mining Activity

Portions of the mine plan area were mined prior to the filing of this permit application. SUFCO Mine began a small operation mining the Upper Hiawatha Coal seam in 1941. There was no previous mining activity prior to the 1941 SUFCO operation.

From 1941 through 1974, the coal was removed by conventional mining techniques. From 1974 through 1978, both conventional and continuous mining methods were used. From 1978 until October 1985, all mining used continuous mining methods. Since October 1985 both continuous mining and longwall mining methods have been used. The portion of the seam mined by conventional methods was only partially extracted leaving all pillars for support. The majority of the mining done has been full extraction. All longwall mining is full extraction.

The quantity of coal mined prior to this permit application was approximately 37,058,100 tons. The earlier workings are shown on Plate 5-1 as an integral part of the mining operation.

Use of the land preceding mining was primarily grazing. The area also supported limited timbering in the Ponderosa stands and hunting.

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4.1.2 Reclamation Plan

4.1.2.1 Postmining Land Use Plan

All uses of the land immediately prior to mining and the capability of the land to support prior alternate uses will remain equally available throughout the life of the mine without impact from underground mining except on insignificant levels. The infinitesimal effect of underground mining on surface use is accounted for as follows:

1. Isolated facilities in use for duration of the mine, including portal and associated buildings, comprise only 48.432 of the 27,605.17 acres under consideration, which is too small to adversely affect general land use.

2. Gradual and even subsidence over most of the lease and permit areas is too imperceptible to affect general land use. The ultimate subsidence affect over the lease will be "uniform." As a qualification, there probably will be an uneven arching effect on the surface over the full-extraction mining areas during actual mining operations which will stabilize in uniform subsidence once the entire area has been mined. The total subsidence effect should be minor so as to not affect general land use.

The Applicant intends that the postmining land uses will be consistent with the land use plans prepared by the Forest Service. Final reclamation activities such as grading and seeding as detailed within this M&RP will be completed in a manner to provide uses of the lands consistent with those uses required by the U.S. Forest Service land use plans. Retention of pre-SMCRA highwalls is discussed in Section 5.5.3.6.

The SUFCO Mine lease areas are predominantly U.S. Forest Service land managed under the multiple use and sustained yield concepts. Present management emphasizes livestock grazing, wildlife, timber and watershed development.

The land use plans for the lease areas developed by the U.S. Forest Service includes eight different management prescriptions (U.S. Forest Service 1986):

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a. Management prescription MMA. Emphasis is on leaseable minerals development. Land surface is to be made available for existing and potential major mineral developments. In units where mineral development is pending, renewable resource activities strive to be compatible with the management goals of adjacent management units. Long-term investments, such as timber planting, generally are not made. However, short-term investments, such as range and wildlife revegetation projects, may be made on these units. As the developments are removed and restoration is completed, these areas may be changed to other appropriate management units.

b. Management prescription TBR. Emphasis is on wood-fiber production and harvest. The harvest methods by Forest cover type are single tree and group selection and shelterwood in Englemann spruce-subalpine fir, Douglas-fir, ponderosa pine, mixed conifers, and clear cutting in aspen. Wildlife habitat diversity may be enhanced by vegetative manipulation. Livestock grazing may be permitted. Water yield could be altered through vegetation management, as well as decrease evapotranspiration and maximize snow retention in small openings on low energy slopes. Dispersed recreation opportunities vary between semi-primitive non-motorized and roaded natural appearing.

c. Management prescription RNG. Emphasis is on production of forage and cover for domestic livestock and wildlife. Intensive grazing management systems are generally favored. Nonstructural restoration practices include a full spectrum of treatments such as plowing, seeding, cutting, chaining, burning, spraying with herbicides, crushing, pitting, furrowing, and fertilization. Dispersed recreation opportunities vary between semi-primitive non-motorized and roaded natural appearing. Management activities are evident, but harmonize with the natural setting.

d. Management prescription GWR. Management emphasis is on providing general big-game winter range. These are areas wildlife traditionally use. Treatments of various types are applied to increase forage production and plant species composition. This may include chaining, cutting, prescribed burning, seeding,

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spraying, planting, and other treatments. Selected browse species are regenerated to maintain a variety of age classes. Permanent roads and special uses may be permitted. Short-term or temporary roads are obliterated and rehabilitated within one year after intended use. Motorized use is managed as appropriate to prevent unacceptable stress on big-game animals during the primary use season.

e. Management prescription 4B. Management emphasis is on habitat for management indicator species. The goal is to optimize habitat capability, and thus numbers of the species. Investments in other compatible resource uses may occur but will be secondary to habitat requirements. Recreation and other human activities are regulated to favor the needs of the designated species. Roaded-natural recreation opportunities are provided along forest arterial and collector roads. Local roads and trails are either open or closed to public motorized travel. Management activities may dominate in foreground and middleground , but harmonize and blend with the natural setting.

f. Management prescription 6B. Management emphasis is on livestock grazing intensive range resource management is applied. Condition is improved through use of vegetation and soil restoration practices, improved livestock management, and regulation of other resource activities. Dispersed recreational opportunities vary between semi-primitive non-motorized and roaded natural. Management activities are evident but harmonize and blend with the natural setting.

g. Management prescription 9F. Management emphasis is on improving watershed condition. This will be achieved by protection, seeding, cultural treatment or any combination of other methods that will accomplish the objectives. Management activities in the foreground, middleground, and background may dominate, but should be designed to harmonize and blend with the natural setting to the extent possible. Motorized travel is prohibited except for over-snow machines and for designated routes.

h. Management prescription KWR. Management emphasis is on providing key big-game winter range. These areas are essential to wildlife. Motorized use is

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managed as appropriate to prevent unacceptable stress on big-game animals during the primary use season.

4.1.2.2 Land Owner or Surface Manager Comments

Surface owner approval of the Applicant's proposed postmining land use will be confirmed by the approval of this Mining and Reclamation Plan by the respective Forest Service units for those federal lands that they administer. The private landowner comments concerning the postmining land use are contained in the UNELCO letter in Appendix 1-1.

4.1.2.3 Suitability and Capability

Final fills will not contain excess spoils.

4.1.3 Performance Standards

The performance standards for the areas to be reclaimed for postmining land use are contained in this section.

4.1.3.1 Postmining Land Use

The proposed postmining land uses will be identical to the premining land uses and the land will be capable of supporting such land uses.

4.1.3.2 Determining Premining Uses of Land

The Applicant plans for the same postmining land uses as existed before the operation began.

4.1.3.3 Criteria for Alternative Postmining Land Uses

No alternative postmining land uses have been planned.

4.1.4 Alternative Land Use

No alternative postmining land uses have been planned.

4.20 Air Quality

This section includes descriptions of plans to comply with the Clean Air Act and applicable Utah or federal statutes and regulations pertaining to air quality standards.

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4.2.1 Air Quality Standards

SUFCO Mine's mining activities are being conducted in compliance with the requirements of the Clean Air Act and the Utah Air Quality Regulations.

4.2.2 Compliance Efforts

The state of air quality control of the SUFCO Mine is generally excellent except the control of fugitive dust in the product loadout area. Watering of this area is done in accordance with stipulations in the Air Quality Permit.

a. Access road - The access road is paved and free of mud and potholes. Access to the road is limited by the surrounding terrain which leaves it free of carried-on mud or dirt by vehicles. Emissions from the access road are minimal.

b. Service area - Fugitive Emissions. The service area is compact and efficient in size and layout. The area in front of the portal and office building as well as the area in front of the shop is paved. Traffic to and from the mine is limited by the small parking area available (approximately 25 car capacity). Personnel are transported to and from the work site by company bus and van pools. Dust emissions caused by personnel and mining support operations are minimal in spite of the partially unpaved parking area. The SUFCO Mine currently employs approximately 234 people. Based-on an average round trip of 62 miles per day, 3.0 million miles of personal car transportation is saved annually by the use of company transportation. This represents an extremely significant limitation of vehicular emissions.

   Fugitive dust emissions from the load out area are moderate. Coal load out operations are the source of most of the fugitive dust emissions. Trucks are routed near the emergency coal storage area. Because some stored material must be loaded with a front end loader, physical separation of the driveway and the storage area is not feasible. Trucks encroach upon the coal storage piles resulting in a thin layer of pulverized coal dust. This emission source is controlled through regular water applications. The area is within the sediment pond collection system.

c. Coal crushing and conveying - All crushing is conducted in closed areas. The main

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conveyor belts are covered, as are most lifts and drop points. Fugitive emissions observed are extremely low. The low emissions were evidenced even during winds of approximately 15 miles per hour. The extremely good dust control in this area is attributed to the excellent condition of covers and seals and to the relatively high water content of the product.

d. Truck loading - Loading is primarily accomplished by dropping the product from a bin-hopper into the haul trucks. Drop points are well protected from the prevailing wind directions. Loading is accomplished almost immediately after the product is removed from the mine and the water content of the product is assumed responsible for severely limiting dust emissions. Loading of temporarily stored material by front end loader results in significantly increased fugitive emissions. The limited use of this method of loading allows discounting its overall contribution.

The operator controls fugitive dust by application of water to areas where needed. An assessment of the particulate emissions at the mine site are included as Appendix 4-3.

Due to the general excellent air quality and the Pines Tract area's high air mixing, cumulative impacts on the quality of the ambient air are minimal (Pines Tract Project EIS, 1999).

Greens Hollow. The are no anticipated impacts to air quality associated with the addition of the Greens Hollow Lease or current plans to modify the existing Air Quality Approval Order. Sufco will continue to be considered a "Minor Source" by the Utah Department of Environmental Quality and the mining of the Greens Hollow Lease is not a significant acid rain source (FSEIS, 2015). The demand for coal from the Sufco mine is established, the addition of the coal in the Greens Hollow Lease extends the supply of coal for years. Coal production and therefore trucking is intended to remain within the limits of the existing Air Quality Approval Order (Review production quantities in Section 5.2.3). Should mining changes require a revision, the Air Quality Approval Order will be updated at that time.

4.2.3 Monitoring Program

The UDOGM does not require an air monitoring program for the SUFCO underground mine at this time. The mine currently operates under Division of Air Quality Approval Order DAQE-

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AN0106650013-11 SUFCO Mine site dated March 30, 2011 and Small Source Registration DAQE-EN0106590004-11 Waste Rock Disposal Site dated March 31, 2011 found in Appendix 4-4.

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APPENDIX 4-5

Cultural Resource Memorandum of Agreement
Manti-La Sal National Forest

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MEMORANDUM OF AGREEMENT

BETWEEN THE MANTI-LA SAL NATIONAL FOREST

AND THE

UTAH STATE HISTORIC PRESERVATION OFFICER

REGARDING THE GREENS HOLLOW COAL LEASE TRACT

WHEREAS the Manti-La Sal National Forest (MLS NF) plans to consent to proposed coal leasing by the Bureau of Land Management in the Greens Hollow Coal Lease Tract pursuant to the authority of the Mineral Leasing Act of 1920, as amended by the Federal Coal Leasing Amendments Act of 1976; and

WHEREAS the undertaking would consent to coal leasing in the tract under stipulations described in Attachment A that protect non-mineral resources within the lease area; and

WHEREAS, the MLS NF has defined the undertaking's area of potential effect (APE) as 6,157 acres of Federal coal estate in the Muddy Creek and North Fork Quitchupah Creek drainages in central Utah under lands managed by the MLS NF and Fishlake NF and as described in Attachment B that are subject to surface subsidence as well as the APE of potential ground disturbing actions that include vent shaft and power line construction and road upgrades that may also lead to increased illegal artifact collecting in the area; and

WHEREAS the MLS NF has determined that the undertaking may have an adverse effect on archaeological sites 42SV1484, 42SV1578/2341, 42SV2554, 42SV2584, 42SV2586, 42SV2589, 42SV2597, 42SV2949, 42SV3224 and 42SV3226, which are eligible for listing in the National Register of Historic Places, and has consulted with the Utah Historic Preservation Officer (SHPO) pursuant to 36 C.F.R. part 800, of the regulations implementing Section 106 of the National Historic Preservation Act (16 U.S.C. § 470f); and

WHEREAS, the MLS has consulted with the Ute Indian Tribe and Paiute Tribe of Utah regarding the effects of the undertaking on historic properties and they have chosen not to sign this MOA as concurring parties; and

WHEREAS, in accordance with 36 C.F.R. § 800.6(a)(1), the MLS has notified the Advisory Council on Historic Preservation (ACHP) of its adverse effect determination with specified documentation and the ACHP has chosen not to participate in the consultation pursuant to 36 CFR § 800.6(a)(1)(iii); and

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NOW, THEREFORE, the MLS NF and the Utah SHPO agree that the undertaking shall be implemented in accordance with the following stipulations in order to take into account the effect of the undertaking on historic properties.

STIPULATIONS

The MLS NF shall ensure that the following measures are carried out:

1) The MLS will consent to the Greens Hollow Coal Lease only under application of Special Stipulations 1 and 9, which affect cultural resources. These are shown in Attachment A.
2) Underground mining shall only occur under the areas marked "Area of Subsidence Mining" as shown in Attachment B in accordance with Special Stipulation 9. It will not occur near the edges of Muddy Creek, Greens Hollow, Cowboy Creek or the North Fork of Quitchupah Creek in the area shown as the "Area of No Subsidence Mining" in Attachment B. This will help avoid adverse effects from subsidence at sites 42SV2584, 42SV2586, 42SV2589, 42SV2949 and 42SV3226. Both 42SV2584 and 42SV2589 contain two rock shelters each. This will help ensure that no known rock shelters within the project area will be affected by subsidence.
3) The layout of the south vent shaft construction location shall be designed in such a way as to avoid an adverse effect to sites 42SV2949 and 42SV3224. These sites both contain intact hearths and/or roasting pits and these features will be preserved.
4) The power line location shall be moved in order to avoid an adverse effect to site 42SV1578/2341 from power line construction. This site contains a large rock shelter and extensive surface lithic scatter.
5) All of the identified sites that are adjacent to or bisected by proposed upgrades to Forest Roads 007 and 044 will be upgraded in a way that creates the least direct impacts to those sites. These sites are 42SV1484, 42SV1578/2341, 42SV2554, 42SV2597, 42SV2949 and 42SV3226. All of these sites are open lithic scatters. Attachment C describes a process for reducing impacts at these sites and a staged approach to mitigating any adverse effects.
6) Signs that describe the importance of site protection (and the legal consequences of illegal artifact collecting and looting) will be posted in appropriate places within or near the Greens Hollow project area. These are intended for both area visitors and construction employees. At a minimum, they will be posted near the south vent shaft construction area.
7) Project construction employees will be given written and verbal information on the importance of site protection and the legal consequences of illegal artifact collecting and site looting.
8) A monitoring plan will be developed that monitors potential project effects at sites within the project area and immediately adjacent to roads that are improved as a result of the project. This plan will meet four goals. The first is to have archaeologists on scene during initial layout of the south vent shaft construction footprint in order to ensure full avoidance of sites 42SV2949 and 42SV3224. The second is to monitor the site within the area of subsidence

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mining that might be affected by surface cracking (42SV3224). The third goal is to monitor area sites for indications of illegal artifact collecting and looting. The fourth is to monitor the two sites containing rock shelter sites within the area of no subsidence mining (42SV2584 and 42SV2589) in order to ensure that no effects from subsidence occur.

9) If any effects to surface features or rock shelters from subsidence are identified at sites 42SV2949, 42SV3224, 42SV2584 or 42SV2589, than the procedures identified in Appendix D will be followed.
10) All of the above mitigation measures shall be identified in the Permit Application Package, which will be completed as part of the mining permitting process within 2- 4 years. This document will describe in detail how the coal sold under this lease will be mined.
11) In accordance with Special Stipulation 1 (Attachment A), the Permit Application Package shall be reviewed for any potential effects to cultural resources. If any of these actions create an adverse effect to cultural resources not described in these stipulations, then the MLS shall amend this agreement as per Stipulation VIII below.
12) The MLS shall consult with interested Indian Tribes on the potential for mining activities in the Permit Application Package to affect cultural resources. In particular, the Ute Indian Tribe and Paiute Tribe of Utah both played key roles in resolving the potential adverse effects identified under Measures 2 through 5 above.
13) The MLS shall continue to invite interested Indian Tribes to participate in the implementation of stipulations in this agreement. This includes development of signs and written site protection information described in Measure 6 and 7 above and minimizing adverse effects to sites as described in Measure 5.

IV. DURATION

This MOA will be null and void if its terms are not carried out within 7 (seven) years from the date of its execution. The Prior to such time, the MLS NF may consult with the other signatories to reconsider the terms of the MOA and amend it in accordance with Stipulation VIII below.

V. POST-REVIEW DISCOVERIES

If potential historic properties are discovered or unanticipated effects on historic properties found, the MLS shall implement the discovery plan included as Attachment E of this MOA.

VI. MONITORING AND REPORTING

Each year following the execution of this MOA until it expires or is terminated, the MLS shall provide all parties to this MOA and the ACHP if desired a summary report detailing work undertaken pursuant to its terms. Such report shall include any scheduling changes proposed, any problems encountered, and any disputes and objections received in the MLS's efforts to carry out the terms of this MOA.

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VII. DISPUTE RESOLUTION

Should any signatory or concurring party to this MOA object at any time to any actions proposed or the manner in which the terms of this MOA are implemented , the MLS shall consult with such party to resolve the objection. Ifthe MLS determines that such objection cannot be resolved, the MLS will:

A. Forward all documentation relevant to the dispute, including the MLS's proposed resolution, to the ACHP. The ACHP shall provide the MLS with its advice on the resolution of the objection within thirty (30) days ofreceiving adequate documentation . Prior to reaching a final decision on the dispute, the MLS shall prepare a written response that takes into account any timely advice or comments regarding the dispute from the ACHP, signatories and concurring parties, and provide them with a copy of this written response. The MLS will then proceed according to its final decision.

B. Ifthe ACHP does not provide its advice regarding the dispute within the thirty (30) day time period, the MLS may make a final decision on the dispute and proceed accordingly. Prior to reaching such a final decision, the MLS shall prepare a written response that takes into account any timely comments regarding the dispute from the signatories and concurring parties to the MOA, and provide them and the ACHP with a copy of such written response.

C. The MLS's responsibility to carry out all other actions subject to the terms of this MOA that are not the subject of the dispute remain unchanged.

VIII. AMENDMENTS

This MOA may be amended when such an amendment is agreed to in writing by all signatories. The amendment will be effective on the date a copy signed by all of the signatories is filed with the ACHP.

IX. TERMINATION

Ifany signatory to this MOA determines that its terms will not or cannot be carried out, that party shall immediately consult with the other parties to attempt to develop an amendment per Stipulation VIII, above. Ifwithin thirty (30) days (or another time period agreed to by all signatories) an amendment cannot be reached, any signatory may terminate the MOA upon written notification to the other signatories.

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Once the MOA is terminated, and prior to work continuing on the undertaking, the MLS must either (a) execute an MOA pursuant to 36 CFR § 800.6 or (b) request, take into account, and respond to the comments of the ACHP under 36 CFR § 800.7. The MLS shall notify the signatories as to the course of action it will pursue.

Execution of this MOA by the MLS and the Utah SHPO and implementation of its terms evidence that the MLS has taken into account the effects of this undertaking on historic properties and afforded the ACHP an opportunity to comment.

SIGNATORIES:

Manti-La Sal National Forest

Liz Close Date Nov 28, 2011

Liz Close, Acting Manti-La Sal National Forest Supervisor

Utah State Historic Preservation Office

Date Nov 30, 2011

Wilson G. Martin, Utah State Historic Preservation Officer

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MEMORANDUM OF AGREEMENT

BETWEEN THE MANTI-LA SAL NATIONAL FOREST

AND THE

UTAH STATE HISTORIC PRESERVATION OFFICER

REGARDING THE GREENS HOLLOW COAL LEASE TRACT

ATTACHMENT A

Special Stipulations

The following are two of twenty Special Stipulations that will be observed during implementation of the Greens Hollow Coal Lease. These are the only stipulations that apply to cultural resources. The stipulations apply during the MLS consent to the lease of coal, which is the current project. They also apply to any actions included in the Permit Application Package, which specifies how each of the surface and subsurface components of the mining plan will be done. This package will be finalized in the next 3-5 years and will identify specific design plans used to mine the coal that is leased.

Federal Regulations 43 CFR 3400 pertaining to Coal Management make provisions for the Surface Management Agency (the Federal agency other than the Department of Interior who has jurisdiction on surface lands) to consent to leasing and to prescribe conditions to insure the use and protection of those lands. All or parts of this lease contain lands the surfaces of which are managed by the United States Department of Agriculture, Forest Service, Manti-La Sal National Forest and Fishlake National Forest.

Special Stipulation #1

Before undertaking activities that may disturb the surface of previously undisturbed leased lands, the Lessee may be required to conduct a cultural resource inventory and a paleontological appraisal of the areas to be disturbed. These studies shall be conducted by qualified professional cultural resource specialists or qualified paleontologists, as appropriate, and a report prepared itemizing the findings. A plan will then be submitted making recommendations for the protection of, or measures to be taken to mitigate impacts for identified cultural or paleontological resources.

If cultural resources or paleontological remains (fossils) of significant scientific interest are discovered during operations under this lease, the Lessee, prior to disturbance, shall immediately bring them to the attention of the appropriate authority. Paleontological remains of significant scientific interest do not include leaves, ferns or dinosaur tracks commonly encountered during underground mining operations.

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The cost of conducting the inventory, preparing reports, and carrying out mitigati ng measures shall be borne by the Lessee.

Special Stipulation #9

Except at locations specifically approved by the Authorized Officer. with the concurrence of the Forest Service, underground mining operations shall be conducted in such a manner so as to prevent surface subsidence that would: (1) cause the creation of hazardous conditions such as potentia l escarpment failure and landslides, (2) cause damage to existing surface structures, and (3) damage or alter the flow of perennial streams. Where the Forest Service specifically approves exceptions to the above restrictions on subsidence. the Lessee shall provide specific measures for the protection of escarpments, and detennine corrective measures to assure that hazardous conditions are not created.

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ATTACHMENT B

Final Decision Map for the
Greens Hollow Environmental Impact Statement

Showing Areas of Subsidence Mining and
No Subsidence Mining

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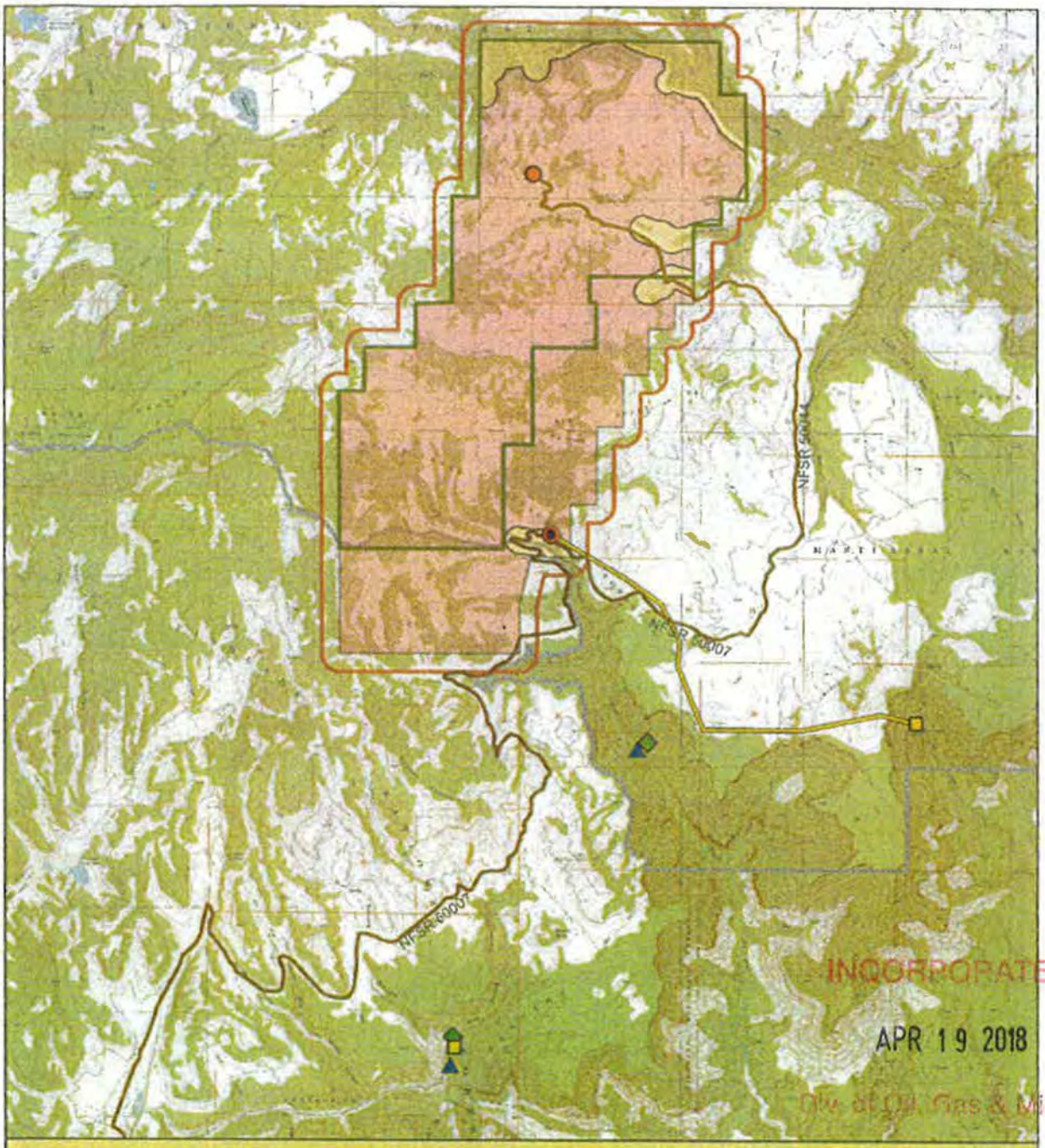

Figure 2. Decision Map (Alternative 3).

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ATTACHMENT C

Mitigating Potential Adverse Effects to Sites along Roads

The following steps shall be taken to avoid or minimize adverse effects to 42SV1484, 42SV1578/2341, 42SV2554, 42SV2597, 42SV2949 and 42SV3226 from upgrading native surface Forest Roads 007 and 044 to year-round roads for use by construction equipment. All of these sites are open lithic scatters that are either bisected by or adjacent to these roads.

1) Each site shall be considered individually, and strategies to avoid or minimize adverse effects will be identified in the field by MLS Forest Engineers and MLS Heritage Staff and if appropriate, the contractors hired by Ark Land Company to complete the road improvements.
2) At each site, the following will be considered. Can the road be used safely and in an environmentally sound way by avoiding the following actions within the boundaries of the site? These actions include.

    (1) Widening the road beyond the existing shoulders;
    (2) Constructing drainage features or culverts;
    (3) Constructing safety pull-outs;
    (4) Digging into the existing road surface in order to reshape the road or to improve the road substrata; and/or
    (5) Widening on the side of the road that includes the most extensive cultural deposits.

3) If any of these actions are necessary, than the following phased steps will be taken to mitigate the adverse effects that might result from them. These will be done within the context of a research design reviewed and approved by the Utah SHPO and interested Tribes.
    a) Detailed maps of the site surface will be prepared and all artifacts and features will be described and documented in more detail than is included on the existing site forms. This includes detailed examination of the site deposits exposed in the existing road cuts.
    b) Systematic and limited sampling of subsurface deposits within the area of effect from road upgrading will follow.
    c) The results of the limited subsurface sampling and the detailed site mapping will then be reviewed using the research design. If this data is sufficient to mitigate adverse effects to the site, then archaeological data recovery will end.

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d) Ifthe results of the limited subsurface sampling and detailed site mapping suggest that additional excavations are necessary under the research design. then the limited testing units will be expanded into 1 x 1 meter or larger excavation units.
e) Ifthe expanded excavation units indicate that additional features or deposits should be investigated (according to the research design), then the final phase of data recovery would include removal of all topsoil and documentation of all features within the area of effect.

4) Ifany of the actions proposed in Section II above must occur at unevaluated site 42SV1031. than the steps described in Section III above will be applied at that site.
5) The placement of gravel over the top of the existing native surface road without any other manipulation of the road surface or shoulders will not be considered an adverse effect on the site.
6) All actions identified to avoid or minimize effects at each site shall be identified in the Permit Application Package operating plan.

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ATTACHMENT D

Identifying and Mitigating Potential Unanticipated Effects from Subsidence

The purpose of this attachment is to address potential effects to sites within or near the project area from subsidence mining. The project has been designed to minimize the potential for it to adversely affect sites through subsidence. Nonetheless, this document provides a way of effectively dealing with those unanticipated effects should they arise.

There is one identified National Register eligible site within the area of subsidence mining (as shown in Appendix B) that might be adversely affected by subsidence mining. 42SV3224 is on the very edge of this area, which makes it unlikely that it mining would occur under it. However, it is in an area with little overburden, which makes it more likely that if subsidence mining does occur, surface cracking of the kind that could affect the site is more likely to occur.

In addition, there are seven sites within the area of no subsidence mining that is immediately adjacent to the area of subsidence mining. All of these sites (42SV1566, 42SV2584, 42SV2586, 42SV2589, 42SV2949, 42SV3224, and 42SV3226) are near the edges of escarpments. Two of these sites (42SV2584 and 42SV2589) also include two rock shelters at each site. Although the area of no subsidence mining was created in part to avoid impacts to these sites, this attachment identifies ways to verify the lack of such impacts or to address the consequences of subsidence impacts if those are identified.

All of the sites described above are located on or near bedrock with generally shallow surface soils. Only 42SV3224 contains a feature that can be identified on the existing site surface (a small hearth or roasting pit). The rock shelters at 42SV2584 and 42SV2589 are relatively small and shallow but contain buried cultural deposits. Although there are additional sites within the area of no subsidence mining that might possibly be affected by subsidence, these two sites are close to the edges of the escarpments and stand as good proxies for all of the sites which might be affected.

In general, surface cracks that do not bisect features or buried deposits will be considered to have no adverse effect on that site. The results of subsidence that will be considered to produce an adverse effect to a given site are cracks through features or buried deposits or cracks near features that cause potential new channels for water that would, in turn, bisect or otherwise damage features or buried deposits.

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The following steps will be done to establish the presence or absence of potential effects to sites from subsidence mining. These are based on the nature of the known sites and on the types of subsidence effects that have been noted in nearby areas of existing subsidence mining (particularly in The Pines Tract). These will be done within the context of the same research design used to guide treatment of sites within the road right of way that has been reviewed by the Utah SHPO and interested Tribes.

1) Create detailed, base-line maps and photographic records of 42SV3224, 42SV2584 and 42SV2589 before subsidence mining begins. The goal of this documentation is to establish the presence of natural rills and other natural surface features that might be mistaken for surface cracks resulting from subsidence. These maps would include any features (such as hearths) that might be adversely affected by any cracking near or through those features and provide a more detailed record of the location and nature of surface artifacts than is on the existing site forms.
2) Monitor each site once a year while mining is occurring under the area of those sites.
3) If surface cracking or buckling is found, each crack will be examined in relationship to the existing detailed site map. If surface artifacts are found to be missing or displaced, this will be noted in the monitoring notes. Loss or displacement of documented artifacts will be considered to be of no adverse effect to the site.
4) Each crack will be examined for the presence or absence of subsurface deposits, including the use of trowels or shovels to establish clean profiles. These exposed sediments will be documented for the presence or absence of buried artifacts, soil stains or features. If no such artifacts, deposits, or features are found, than the crack will be considered to be of no adverse effect to the site. Damage to such materials by surface cracking will be considered an adverse effect and the following steps will be implemented.
   a) All buried artifacts, soil stains, or features found within subsidence cracks will be documented using sub-meter GPS units and standard archaeological documentation procedures.
   b) Any decision to expand excavation of these features will be guided by the research design and may include 1 x 1 meter units that expose more or all of features such as hearths.
   c) Once the goals of the research design are reached, excavations of material exposed in that particular subsidence crack will cease and the adverse effect of that crack will be considered to be mitigated. The results of the excavations will then be analyzed and reported to SHPO in a report that meets professional standards.
5) If cracking or buckling that resulted from subsidence mining is found at any of the rock shelters at sites 42SV2584 and 42SV2589, then this will be considered an adverse effect that requires additional consultation with the Utah SHPO and interested Tribes and amendment of this agreement as described in Stipulation VIII of the Memorandum of Agreement.

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ATTACHMENT E

Unanticipated Discovery Plan

In accordance with 36 CFR § 800.13(a) and 43 CFR Part 10.4, the Forest Service, through consultation with the SHPO, has developed the following general plan for dealing with historic properties likely to be discovered during activities associated with the Greens Hollow Coal Lease. While every effort has been made to locate all historic properties within the area of potential effects (APE) for surface facilities, it is recognized that local geomorphology and past use may be of such a nature that obscured buried deposits may be present and that they may be exposed during vent shaft construction or road upgrades.

Archaeological survey and documentation research on the southern end of the Wasatch Plateau on the Manti-La Sal National Forest indicate that the following type of properties may be encountered during coal lease activities:

1. Buried Native American artifacts or features that are outside of identified site boundaries.

Upon discovery of buried cultural materials during any kind of construction activity, the following steps should be followed:

1. Work will cease in the immediate area of the discovery and cultural materials will be protected from further disturbance until the appropriate mitigation actions are detennined.

2. Within 24 hours. the Project Administrator will notify the District Ranger, who will, in tum, notify the Forest Archaeologist.

3. The Forest Archaeologist will assess the significance of the discovery within 48 hours. Ifthe discovery consists of Native American cultural remains. the Forest will follow the procedures outlined in steps 4-7, below.

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4. The Forest Archaeologist will notify the SHPO and interested Tribes of the discovery and afford the both of them an opportunity to comment on the discovery, provided that comment can be provided within 48 hours of notification.

5. The Forest Archaeologist will then implement the following steps to document the artifact or feature:
    a. The location of the artifact or feature will be mapped using sub-meter accuracy GPS equipment.
    b. Measured stratigraphic profiles or plan drawings will be prepared to illustrate archaeological features and depositional environments and/or to document the location of the artifact and/or feature;
    c. All photo documentation will be done using digital methods that meet archival quality standards;
    d. All chronologically, technologicall y and functionally diagnostic artifacts will be collected and prepared for curation in a federal curation facility; and
    e. Upon completion of the monitoring action an analysis and report meeting professional standards will be prepared and forwarded to the Utah SHPO.

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APPENDIX 4-6

Cultural Resource Documentation

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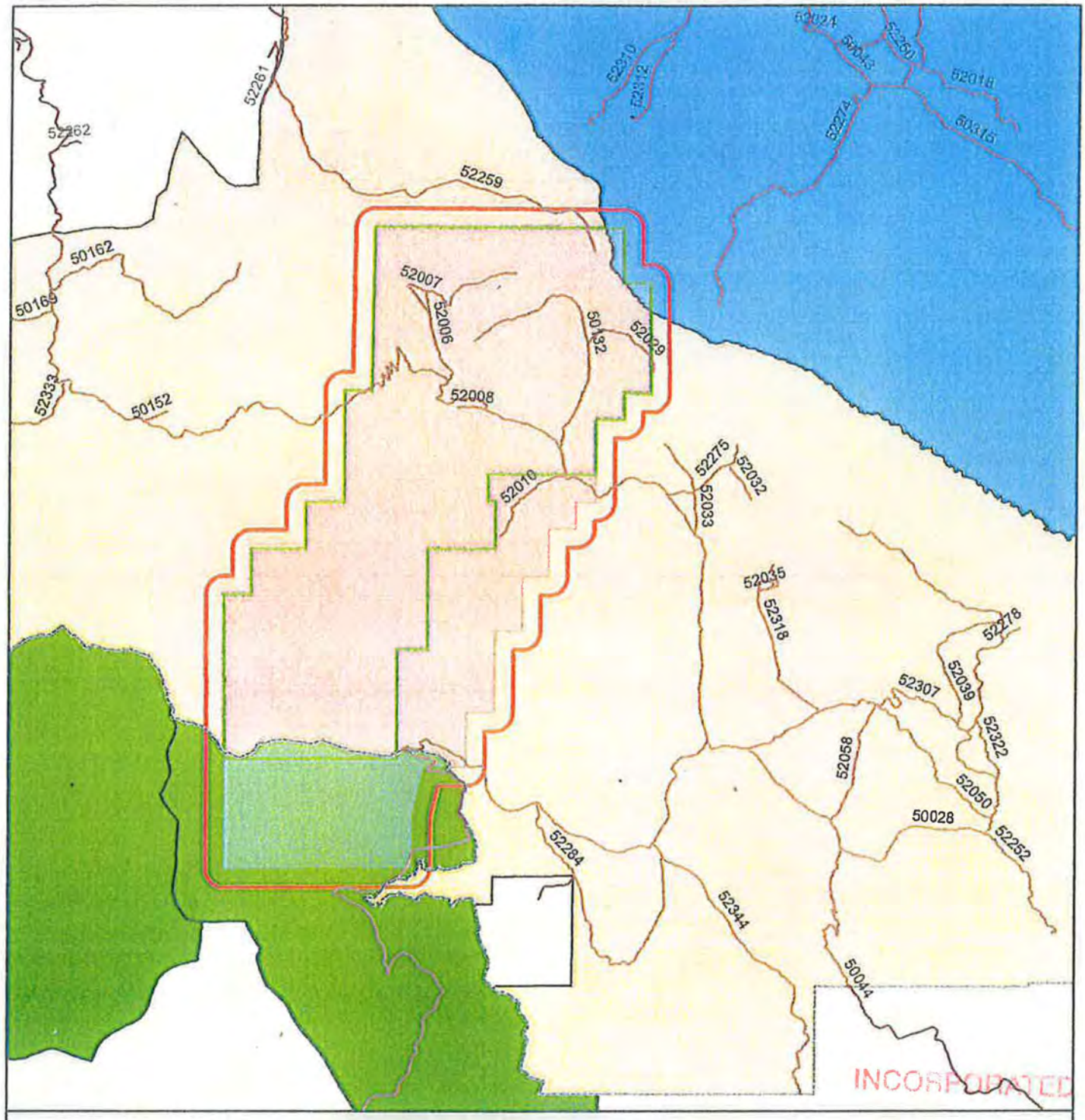

Greens Hollow range allotments.

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Legend

- National Forest System Roads
- Greens Hollow Coal Least Tract
- Area of Subsidence Mining
- Mining Analysis Area Boundary
- Manti-La Sal/Fishlake Forest Boundary
- Ferron Allotment
- Emery Allotment
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CHAPTER 5

ENGINEERING

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CHAPTER 5

ENGINEERING

5.10 Introduction

This chapter provides a discussion of general engineering aspects, an operation plan, a reclamation plan, design criteria, and performance standards related to the SUFCO Mine. The existing and proposed coal mining and reclamation activities associated with the mine have been or will be designed, located, constructed, maintained, and reclaimed in accordance with the operation and reclamation plans.

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS) . The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text. The Greens Hollow Tract Lease area was originally part of the Muddy Creek Tract, reports and documents referring to the Muddy Creek Tract in this chapter text and appendices are applicable to the Greens Hollow Tract. The Muddy Creek Tract should not be confused with the SITLA Muddy Tract.

5.1.1 General Requirements

This permit application includes descriptions of the proposed coal mining and reclamation operations together with the appropriate maps, plans, and cross sections. Methods and calculations utilized to achieve compliance with the design criteria are also presented.

5.1.2 Certification

Where required by the regulations, cross sections and maps in this permit application have been prepared by or under the direction of, and certified by, qualified registered professional engineers or land surveyors. As appropriate, these persons were assisted by experts in the fields of hydrology, geology, biology, etc.

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5.1.2.1 Cross Sections and Maps

Previously Mined Areas. A certified map showing the location of previously mined areas is provided as Plate 5-1.

Surface Facilities. Certified maps and cross sections concerning the disposal of underground development waste are provided in this M&RP, Volume 3. A certified map showing the location of non-coal (non-waste rock) waste storage, coal storage and loading areas, explosive storage and handling facilities, and topsoil stockpiles is provided as Plate 5-2A. An additional topsoil stockpile associated with the waste-rock disposal area is located as provided in Volume 3 of this M&RP.

Locations of sedimentation ponds are noted on Plate 5-2A, 5-2B and in Volume 3 of this M&RP. No water treatment facilities exist at the site other than the sewage leach field, sediment basin, and sedimentation ponds.

The following facilities or activities do not exist or occur within the permit area:

- Coal preparation plant,
- Coal cleaning,
- Coal processing waste banks, dams, or embankments,
- Disposal of non-coal (non-waste rock) waste other than durable rock-type construction materials such as cinder block, and
- Air pollution control facilities.

Hence, certified maps or cross sections of these facilities are not provided in this plan. The durable rock-type construction materials are disposed of in the waste-rock disposal area together with the mine development waste.

Surface Configurations. Certified maps and cross sections showing the final (post-reclamation) surface configuration of the East Spring Canyon disturbed area are provided on Plates 5-3A&B and 5-4. Cut and fill volumes for final reclamation are contained in Appendix 2-5. Information regarding the final surface configuration of the waste-rock disposal areas is provided in Volume 3 of this M&RP.

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Hydrology. Certified maps and cross sections associated with the hydrology of the SUFCO Mine area are provided in Chapter 7.

Geology. Certified maps and cross sections associated with the geology of the SUFCO Mine area are provided in Chapter 6.

5.1.2.2 Plans and Engineering Designs

All plans and engineering designs presented in this M&RP were prepared by or under the direction of and certified by a qualified registered professional engineer.

Excess Spoil. No excess spoil will be generated from the permit area.

Durable Rock Fills. No durable rock fills will exist in the permit area.

Coal Mine Waste. The design of the waste-rock facility has been certified by a qualified registered professional engineer.

Impoundments. The only impoundments constructed for the mining and reclamation operation consist of sedimentation ponds. Each of these ponds was designed by a professional engineer using current, prudent, engineering practices. These designs were certified by a qualified registered professional engineer.

The existing impoundments within the permit area consist of the four structures constructed for sediment control purposes. These structures are:

- The concrete sediment trap located near the southern end of the mine yard.
- The primary sedimentation pond located immediately below the fill on which the existing mine facilities are constructed.
- The overflow pond located 800 feet downstream from the primary sedimentation pond.
- The sedimentation pond located at the waste rock disposal site.

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All pertinent information regarding these sedimentation ponds is presented in Sections 7.3.2.2 and 7.4.2.2.

Primary Roads. The design and construction of the primary road associated with the mine has been certified by a professional engineer as meeting the requirements of R645-301-534.200 and R645-301-742.420. This certification is presented in Appendix 5-1.

Variance From Approximate Original Contour. The design for the proposed variance from the approximate original contour requirements of R645-301-270 has been certified by a professional engineer in conformance with professional standards established to assure the stability, drainage, and configuration necessary for the intended postmining use of the site. This certification is presented in Appendix 5-2.

5.1.3 Compliance with MSHA Regulations and MSHA Approvals

5.1.3.1 Coal Processing Waste Dams and Embankments

No coal processing waste dams or embankments exist within the permit area.

5.1.3.2 Impoundments and Sedimentation Ponds

No impoundments or sedimentation ponds in the permit area meet the size criteria of 30 CFR 77.216(a).

5.1.3.3 Underground Development Waste, Coal Processing Waste, and Excess Spoil

No underground development waste, coal processing waste, or excess spoil is disposed of in underground mine workings in the permit area.

5.1.3.4 Refuse Piles

The waste-rock disposal area has been designed and constructed to meet the requirements of 30 CFR 77.214 and 30 CFR 77.215. Details of this design are presented in the M&RP, Vol. 3.

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5.1.3.5 Underground Openings to the Surface

Upon abandonment, each opening to the surface from the underground will be capped, sealed, backfilled, or otherwise properly managed in accordance with 30 CFR 75.1771. Details regarding final abandonment of mine openings are provided in Section 5.4.2.7.

5.1.3.6 Discharges to Underground Mines

No discharges occur from the surface to underground mine workings in the permit area.

5.1.3.7 Surface Coal Mining and Reclamation Activities

No surface coal mining and reclamation activities occur in the permit area.

5.1.3.8 Coal Mine Waste Fires

If any coal mine waste fires occur within the permit area, these will be reported immediately to MSHA and the UDOGM. Immediate remedial action will be taken as deemed necessary by SUFCO Mine to protect public health and safety as well as the environment. Following initial remedial efforts, a long-term plan will be formulated in discussion with MSHA and the UDOGM to extinguish any existing fires and prevent future fires.

5.1.4 Inspections

5.1.4.1 Excess Spoil

Excess spoil is not generated at the SUFCO Mine.

5.1.4.2 Refuse Piles

Regular inspections of the waste-rock area will be made during placement and compaction of the coal mine refuse materials. These inspections will be made by or under the direction of a registered professional engineer experienced in the construction of similar earth and water structures. These inspections will occur at least quarterly throughout placement of the waste materials and during the following critical periods of the phased construction of the site:

- Foundation preparation (including removal of organic material and topsoil),
- Installation of final surface drainage systems, and

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- The final graded and revegetated facility.

The frequency of the inspections will be increased if a danger or harm exists to public health and safety or to the environment. Inspections will continue until the waste-rock area has been finally graded and revegetated.

A certified report will be submitted by a registered professional engineer to the UDOGM within two weeks after each inspection. This report will indicate whether or not the waste-rock pile has been constructed and maintained as designed and in accordance with the approved plan and the R645 rules. The report will also include a discussion of any appearances of instability, structural weakness, and other hazardous conditions noted during the inspection. A copy of the inspection report will be maintained at the mine office.

5.1.4.3 Impoundments

Inspections of all sedimentation ponds associated with the SUFCO Mine will be made at least quarterly. A report of inspection will be prepared by a qualified individual and submitted to the UDOGM within two weeks after each inspection. No other mine-related impoundments exist in the permit area.

New impoundments that may be constructed in the future within the permit area will be inspected regularly during construction and upon completion of construction. These inspections will be made by or under the direction of a registered professional engineer experienced in the construction of similar earth and water structures. Inspections will continue until removal of the structure or release of the performance bond.

All sediment ponds associated with the SUFCO Mine will be inspected annually by a registered professional engineer. A certified report will be prepared by a registered professional engineer and submitted to the UDOGM within two weeks after each inspection. This report will indicate whether or not the impoundment has been constructed and maintained as designed and in accordance with the approved plan and the R645 rules. The report will also include a discussion of any appearances of instability, structural weakness or other hazardous conditions, depth and elevation

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of any impounded waters, existing storage capacity, and existing or required monitoring procedures and instrumentation, and any other aspects of the structure affecting stability, as noted during the inspection. A copy of the inspection report will be maintained at the mine office.

No impoundments currently exist within the permit area that are subject to 30 CFR 77.216. If impoundments subject to 30 CFR 77.216 are constructed in the future, these impoundments will be inspected on a weekly basis. These inspections will be performed in accordance with 30 CFR 77.216-3.

5.1.5 Reporting and Emergency Procedures

5.1.5.1 Slides

If a slide occurs within the permit area that may have a potential adverse effect on the public, property, health, safety, or the environment, SUFCO Mine will notify the UDOGM by the fastest available means following discovery of the slide and will comply with any remedial measures required by the UDOGM.

5.1.5.2 Impoundment Hazards

If any examination or inspection of an impoundment discloses that a potential hazard is associated with that impoundment that may have an adverse effect on the public, property, health, safety, or the environment, the person who examined the impoundment will promptly inform the UDOGM of the finding and of the emergency procedures formulated for public protection and remedial action. If adequate procedures cannot be formulated or implemented, the UDOGM will be notified immediately.

5.1.5.3 Temporary Cessation of Operations

Prior to a temporary cessation of operations within the permit area that will last for a period of 30 days or more or as soon as it is known that a temporary cessation will extend beyond 30 days, SUFCO Mine will submit to the UDOGM a notice of intention to cease or abandon operations. This notice will include the following:

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- A statement of the exact number of surface acres and the horizontal and vertical extent of subsurface strata which have been affected by mining operations in the permit area prior to cessation of operations,
- A discussion of the extent and kind of reclamation activities which will have been accomplished prior to cessation of operations, and
- An identification of the backfilling, regrading, revegetation, environmental monitoring, underground opening closures, and water treatment activities that will continue during the temporary cessation.

During the temporary cessation, SUFCO Mine will support and maintain all surface access openings to underground operations. SUFCO Mine will also secure surface facilities in areas in which there are no current operations but where future operations are to be resumed under an approved permit.

5.20 Operation Plan

5.2.1 General

5.2.1.1 Cross Sections and Maps

Previously Mined Areas. Plate 5-1 shows the location and extent of known workings of active, inactive, or abandoned underground workings, including openings to the surface, within the permit and adjacent areas. No previously surface-mined areas exist within the permit area.

Existing Surface and Subsurface Facilities and Features. Plates 5-2A,2B,2C,2D,2E,2F and 5-5 depicts the following information:

- All buildings in and within 1000 feet of the permit area, including an identification of the current use of the buildings,
- The location of surface and subsurface features within, passing through, or passing over the permit area, including major electric transmission lines and pipelines (no agricultural drainage tile fields exist within the permit area),
- Each public road located in or within 100 feet of the permit area,
- The location of the waste-rock disposal area, and

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- The location of each sedimentation pond within the permit area (there are no permanent water impoundments within the permit area).
- The location and features of the repaired sinkhole are shown in Appendix 5-13.

Tipple Building was modified in 2008 to widen the tipple building sump to accommodate the use of a larger loader to collect coal fines when the Tipple Building is being cleaned. This allows a loader to collect the coal fines from the Tipple Building cleanup and put them on the coal storage pile preventing them from being washed through the mine yard. Design and cross sections of the Tipple Building Modification are provided on Figures 5-0C and 5-0D (Appendix 5-11).

To facilitate the separation of rock from coal, a rock chute will be attached to the Tipple Building, with a steel girder in a concrete pier (2' X 2' Approx.) atop a spread footing (3' X 3' X 1' Approx.) providing additional stability. The rock exiting the chute will drop into a rock bin constructed of pre-cast 3'X3'x6' concrete blocks. The diagrams of the rock chute structure and rock bin are located in Appendix 5-11. The location of the rock chute footings and rock bin is used for coal storage, preparation and coal loading, making the salvage of topsoil or subsoil unlikely. Excavated material not of a quality to be placed in the coal pile will be hauled and placed with the waste rock.

Landowner, Right-of-Entry, and Public Interest. Plate 5-6 shows the boundaries of lands and the names of present owners of record of those lands, both surface and subsurface, included in or contiguous to the permit area. SUFCO Mine has a legal right to enter and begin coal mining operations on all of the lands within the permit area.

Coal mining and reclamation operations are conducted within 100 feet of the right-of-way line of a public road (except where mine access roads join that right-of-way) at the waste-rock disposal area. The measures to be used to ensure that the interests of the public and the affected landowners are protected by operations at the waste-rock disposal facility are outlined in the M&RP, Volume 3.

Coal mining and reclamation operations are conducted within 100 feet of the right-of-way line of the Link Canyon Road, a public-access dirt road. SUFCO Mine uses a portion of this road to

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access the mining operation's electrical system from the Link Canyon Portal. Mining activities are conducted within 100 feet of this road during maintenance and operation of the electrical substation. The interests of the public and the affected landowners will be protected with respect to this road by the following measures:

- Surface activities will be conducted in a manner that will not block the road,
- The portal area access road will be gated and the mine portal intake will be protected from unauthorized entry by the installation of steel sets and a locked chain-link gate. The key for the gate will be kept approximately 25 feet from the gate inside the mine. This permits emergency exit from the mine but prevents entrance from the outside,
- During initial construction of the facilities the public will be protected by posting warning signs on the road, talking to contractors, and by a temporary chain-link fence with warning sign during portal entrance construction when the contractor is not on site to prevent entrance to the portal, and
- Regular inspections of that portion of the road are conducted by mine personnel to ensure that erosion does not become a problem. In the event that material damage due to erosion as a result of mining activities is discovered on or along the side of this road, SUFCO Mine will repair this damage and implement additional runoff-control measures as needed.

The mine portals enter the ground beneath the East Side USFS Public Stock Trail, a public-access dirt road that is constructed on the east side of East Spring Canyon from the bottom of SUFCO Mine to the upper plateau. This road has historically been used to herd livestock between grazing allotments during seasonal changes. SUFCO Mine also uses portions of this road to access the mining operation's electrical and water supply systems. Mining activities are conducted within 100 feet of this road during maintenance and operation of the electrical substation and water supply system (adjacent to the road) and where the portals enter the ground (beneath the road). The interests of the public and the affected landowners will be protected with respect to this road by the following measures:

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- No subsidence or caving operations will be conducted to affect any portion of the right-of-way of this road within 100 feet of the underground entry system,
- Surface activities will be conducted in a manner that will not block the road, and
- Water bars have been constructed on that portion of the road bordering the disturbed area adjacent to the mine surface facilities. Regular inspections of that portion of the road are conducted by mine personnel to ensure that erosion does not become a problem. In the event that material damage due to erosion as a result of mining activities is discovered on or along the side of this road, SUFCO Mine will repair this damage and implement additional runoff-control measures as needed.

Subsidence from underground mining operations may affect public-access dirt roads throughout the lease and permit areas . As part of the subsidence monitoring program, these roads will be regularly inspected. If material damage occurs to these roads as a result of mine subsidence, the roads will be repaired by SUFCO Mine.

Mining Sequence and Planned Subsidence. The mine plan for the SUFCO Mine is presented in Plate 5-7 (Upper Hiawatha seam) and Plate 5-8 (Lower Hiawatha seam). These maps show the boundaries of all areas proposed to be affected over the estimated total life of the coal mining and reclamation operations, including the size, sequence, and timing of mining of subareas to be affected beyond the present permit term. No surface disturbances are currently anticipated within the permit area beyond that presented in this M&RP.

Plates 5-7 and 5-8 also shows the location and extent of underground workings in which planned-subsidence mining methods will be used as well as areas where measures will be taken to prevent, control, or minimize subsidence and subsidence-related damage. The location of the waste-rock disposal area in relation to the underground mine workings, is discussed in Volume 3 of this M&RP.

Land Surface Configuration. Slope measurements for undisturbed areas adjacent to disturbed areas associated with the mine are shown on Plate 5-2A&B. Surface facilities at the site have been in existence since 1941. Pre-mining topographic maps do not exist. Therefore, the slope

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measurements shown on Plate 5-2A&B are considered generally indicative of original land slopes in the vicinity of the mine.

2RWL Sinkhole - A mitigation plan for the repair of a sinkhole located on Lease U-47080 is located in Appendix 5-13. An Environmental Assessment UT-070-08-083 was prepared in January 2009 for the West Coal Lease Modification for the BLM and Fishlake National Forest where the sinkhole is located. A copy of the assessment if located in Appendix 3-13. The sinkhole is with the West Lease Modification Areas permitted in 2011.

The area of the sinkhole was undermined within Lease U-47080 in December 2015. The sinkhole feature has previously occurred naturally in the area, but this is the first hole to occur during longwall mining. It is suspected that mining-related subsidence triggered this collapse into an existing cavity within the fault zone close to the surface. Previously, exploration drilling has encountered voids that were interpreted as limited zones of open fractures.

The depth of overburden in the area is 890 feet, at that depth, at mid-panel, subsidence has the potential of 5 - 6 feet. The sinkhole was approximately 41' wide, 64' long and 40' deep. It was assumed in this case that there was a large open cavity near the surface, that opened when mining occurred in 2015. Refer to Section 5.20 for reclamation information.

Surface Facilities. Plates 5-2A,B,C,D,E,&F and Figure 5-0E shows the locations of the following surface facilities:

- Buildings, utility corridors, and facilities to be used,
- The area of disturbance at the mine mouth,
- Coal storage and loading facilities,
- Non-coal (non-waste rock) storage areas, and
- Explosive storage and handling facilities.
- Portal sites.

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The remaining area of land to be affected by mining and reclamation operations is at the waste-rock site. The area of land to be affected at the waste-rock site is shown on maps provided in Volume 3 of this M&RP. The disturbed areas shown on Plates 5-2A,B,C,D,&E and the waste-rock area surface facility maps are the same as the land areas for which a performance bond or other guarantee has been posted.

Locations of topsoil stockpiles are shown on Plates 5-2A, 5-2B and in Volume 3 (Map 2). No coal processing waste banks, dams, or embankments exist in the permit area. Similarly, no spoil or coal preparation waste sites exist in the permit area. Sediment that is periodically removed from the sedimentation ponds will be disposed of at the waste-rock disposal site.

General refuse that is generated on site is stored at the location indicated on Plate 5-2A. This waste consists predominantly of old brattice cloth, ventilation tubing, broken timbers, wire, broken machinery parts, paper, cardboard, and miscellaneous garbage. This non-hazardous, non-toxic, non-coal, non-waste rock refuse is disposed of periodically at the Sevier County Landfill. The agreement with the Sevier County Landfill for disposal of this refuse is provided in Appendix 5-3.

Transportation Facilities. Roads that have been constructed, used, or maintained by SUFCO Mine in the permit area for the mining and reclamation operations are shown on Plate 5-2A&B. No rail systems or overland conveyor systems (other than the material-handling conveyors in the mine yard) are associated with the permit area. Drainage structures associated with the roads are presented in Section 7.5.2.2. Cross sections of the roads are provided on Plate 5-9.

5.2.1.2 Signs and Markers

Mine and Permit Identification Signs. Mine and permit identification signs have been placed at the locations shown on Plates 5-2A,B,D,E,&F. Each identification sign contains the following information:

- Mine name,
- Company name,
- Permanent program permit number as obtained from the UDOGM,

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- MSHA identification number,
- EPA permit number, and
- Federal Coal Lease numbers pertinent to the operation.

These signs will be retained and maintained until after the release of all bonds for the permit area.

Perimeter Markers. Perimeter markers (disturbed area boundary) have been installed at the locations shown on Plates 5-2A,B,C,D,E,&F. These markers, consisting of red and yellow steel T-posts, delineate the areas affected by surface operations at the mine. Each perimeter marker can be seen from the ground connectively from another marker.

Buffer Zone Markers. Stream buffer zone markers have been placed at the three locations within the permit area where surface effects of mining activities approach perennial or intermittent stream channels. These locations are as follows:

- Quitchupah ventilation entries located adjacent to the North Fork of Quitchupah Creek in S 1/2 Sec. 29, T. 21 S., R. 5 E.
- The vicinity of the pump station and leach field near the confluence of East Spring Canyon and Quitchupah Creek in S 1/2 Sec. 12, T. 22 S., R. 4 E.
- The vicinity of the Link Canyon Portal in SW 1/4 NW 1/4 Sec. 26, T. 21 S., R. 5 E.

Each buffer zone marker has dimensions of 12 inches by 18 inches and is labeled "Stream Buffer Zone - No Disturbing Beyond This Point".

Topsoil Markers. Markers have been placed on all topsoil stockpiles. These markers are labeled "Topsoil Storage Area".

5.2.2 Coal Recovery

Current mining operations at the SUFCO Mine occur in the Upper Hiawatha Seam. Future mining operations are also planned to occur in the Lower Hiawatha Seam. The overall objective of mining operations in the lease and permit areas is to maximum coal recovery coupled with safety. Coal recovery at the mine has been and will continue to be maximized through the following efforts:

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(Figure 5-0E)

Proposed 300,000 Gallon Fire Water Tank Pad Detail

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- Pre-mining analysis of drill-hole data allows estimates to be made of the nature, depth, and thickness of the coal seam and associated partings. Using these data, the mine plan and mining methods are evaluated and amended as necessary to maximize coal recovery.
- Experience gained during mining is used to amend future mine plans if coal recovery can be increased.
- The mine converted from an exclusive room-and-pillar extraction method to a combination of room-and-pillar and longwall extraction methods in October 1985. As a result of this conversion, coal recovery at the mine increased from approximately 75 percent under exclusive room-and-pillar methods to 88 percent under the combined room-and-pillar and longwall methods.

The mine layout has been planned relative to panels, barriers, and pillars to optimize both coal recovery and safety using a combination of longwall and room-and-pillar mining techniques.

An evaluation of geologic data collected in the southern portion of lease U-28297 indicates that the Upper Hiawatha seam in this area contains a paleochannel system and associated parting. The parting attains a thickness in excess of 20 feet and occurs in a northeast-southwest trending band varying in width from 2,000 feet to 7,500 feet. Because of this parting, most of the southern portion of lease U-28297 is deemed unminable from both technological and economic viewpoints.

Mining is not planned on the extreme east and southeast portions of the Pines Tract Lease UTU-76195 as a result of poor quality and seam height. A parting located in the middle of the seam, will not allow mining to occur at the minimum height without putting quality at unacceptable levels. Much of the seam height in these areas is between 4-6 feet. Reserves are also lost to burn in these areas as a result of several promontories in the area which allow greater exposure of the outcrop to the atmosphere.

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Mining is not planned on the northern portion of the SITLA Muddy Tract Lease ML 49443-OBA in the Upper Hiawatha Seam as a result of a sand channel and seam height that will not allow mining to occur.

The Lower Hiawatha seam will be mined in the northwest portion of the lease area where the interburden thickness between the Upper and Lower Hiawatha seams exceeds 30 feet. The mine plans are columnized or stacked where both seams are to be extracted. The Duncan seam does not contain sufficient minable reserves to warrant mining within the lease area.

The Duncan seam occurs about 100 to 130 feet above the Upper Hiawatha seam in a small portion of lease U-28297. The unsplit area of the Duncan seam is of small extent, probably less than 50 acres. Federal Lease U-28297 grants Canyon Fuel Company, LLC SUFCO Mine only the right to mine the Upper Hiawatha seam.

The Quitchupah Tract Resource Recovery and Protection Plan (R2P2) for Canyon Fuel Company, LLC SUFCO Mine is on file with the Bureau of Land Management. The R2P2 contains detailed mine plan and reserve calculations for all of the Quitchupah Tract leases operated by Canyon Fuel Company, LLC SUFCO Mine.

The Pines Tract Resource Recovery and Protection Plan (R2P2) for Canyon Fuel Company, LLC SUFCO Mine is on file with the Bureau of Land Management. The R2P2 contains detailed mine plan and reserve calculations for the Pines Tract lease operated by Canyon Fuel Company, LLC SUFCO Mine.

The SITLA Muddy Tract Plan of Operations Resource Recovery and Protection Plan (R2P2) for Canyon Fuel Company, LLC SUFCO Mine is on file with the State of Utah, School and Institutional Trust Lands Administration. The Plan of Operations Resource Recovery and Protection Plan (R2P2) contains detailed mine plan and reserve calculations for the SITLA Muddy Tract lease operated by Canyon Fuel Company, LLC SUFCO Mine.

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The Greens Hollow "Plan of Operations" associate with the R2P2 has not been finalized, but once completed it will be filed with the BLM . The plan will contain detailed mine plans and reserve calculations for the Greens Hollow lease operated by Canyon Fuel Company, LLC SUFCO Mine. Reference Stipulation 22, page 5 (Appendix 1-1) in the Greens Hollow Lease for a discussion of requirements associated with mining and the R2P2.

5.2.3 Mining Methods

A combination of room-and-pillar and longwall mining methods are used in the SUFCO Mine. The use of these two mining methods has been selected to maximize coal recovery and enhance production rates within the specific geologic constraints of the lease area.

Room-and-Pillar Mining. Room-and-pillar mining is conducted at the SUFCO Mine using continuous miners for the following purposes:

- To develop the mains, submains, and panel entries,
- To extract panels where the cover is 1,500 feet or less,
- To partially extract coal in areas where surface features require protection, and
- To extract coal in areas where geological conditions or physical boundaries are not suitable for longwall mining.

Panel development under room-and-pillar mining methods is achieved by driving three panel entries from the main entries along side the designated panels. Each mining panel is then developed from these entries on the retreat. Pillars within panels that are not required to remain in place to protect long-term mine access or surface resources are also extracted upon retreat from an area to increase coal recovery.

Coal is transported from the continuous miner to the belt feeder by electric or diesel haulage units. Coal is conveyed out of the panel and on out of the mine by belt conveyors. Diesel-powered, rubber-tired tractors and service cars are used to transport personnel and materials from the portals to the working faces.

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Pillars in developed entries will be left to protect adjacent panels.

Longwall Mining. Longwall mining is used for extraction of large, uniform blocks of coal where the panels are more than 2,500 feet in length and where a suitable longwall panel can be laid out. Coal thicknesses of up to 14 feet are mined in the SUFCO Mine using longwall methods. In areas where coal is thicker than the height capacity of the mining equipment, the unmined coal will be left on the bottom of the bed unless economic or safety conditions warrant otherwise.

The longwall mining system at the SUFCO Mine consists of three basic integrated sub-systems: self advancing roof support, shearer, and conveyance. Shield-type roof supports are used. Shield supports are generally considered more suitable for mining conditions such as those encountered at the SUFCO Mine and are designed for expansion, contraction, advancement, and movement in varying thicknesses of coal.

The longwall shearer at the SUFCO Mine utilizes a double-ended shearer system for efficiency and flexibility of operation. Such a system consists of two rotary cutting drums mounted on ranging arms which are pivoted to a common body containing the power and drive assemblies. An optimum-tip drive speed is associated with each drum-pick configuration and diameter to assure minimization of fines in the sheared coal. The conveyance system used in the mine has been designed to convey extracted coal along the 540 to 1000 foot faces.

Anticipated Production. Anticipated annual production of coal from the SUFCO Mine during the permit term is a follows:

2017 - 2021 coal production will range from 5.5 thru 6.3 million tons

Major Equipment. Major equipment in use at the SUFCO Mine is listed in Table 5-1. The same type of equipment or equivalent is expected to be used in the future.

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5.2.4 Blasting and Explosives

Mining and reclamation activities at the SUFCO Mine generally does not require the use of blasting or explosives on the surface. Historically the infrequent surface blasting conducted at the SUFCO Mine has been for construction projects and for removal of dislodged boulders that roll into the surface facility area. These blasts have been under the 5 pound exemption in most cases, and have been conducted under the direction of a certified blaster. Any future blasting associated with mining and reclamation activities that may be needed will be conducted in accordance with R645-301-524. All underground blasting activities at the mine are conducted under the direction of a MSHA certified blaster.

TABLE 5-1
List of Major Equipment

Type of Machinery	Manufacturer	Model Number
Cutting Machine	Joy	15RU
Continuous Miner	Joy	12CM-12
Coal Drills	Long-Airdox	RDF-24
Roof Bolters	Lee Norse, Fletcher	T1-43, HDDR-13
Roof Bolters	Secoma	PEC-22M-1BR-D4
Shuttle Cars	Wagner / Joy	MTT-F20-S18, MTT-F17-I45 / 10SC32
Front-End Loaders	Eimco	913, 915D, 915E
Front-End Loaders	Wagner	ST2D
Feeder Breakers	Stamler / McLanahan	14B / HV56
Feeder Breakers	Long-Airdox	R11
Compressors	Gardner-Denver	185 CFM
Rock Dusters	MSA	400
Mantrips	Getman / Dodge	R62 X PC / RAM 3500
Longwall Shearer	Joy	7LS
Longwall Shields	Joy	960 Ton
Stage Loader	MTA	---

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Face Conveyor	MTA	
Crusher	MTA	
Mobile Tailpiece	Joy	---

5.2.5 Subsidence

SUFCO began operations which caused surface subsidence in June 1976. At that time, continuous miners were used to extract coal from pillars which were developed as part of a retreating panel. The panels were approximately 650 feet wide and varied in length up to 2,500 feet. The average mining height in this initial area of pillar extraction approached 11 feet and the extraction ratio averaged about 80 percent.

The resulting subsidence from the initial retreat mining averaged about 4 feet in plateau areas where the overburden was approximately 900 feet thick. In areas where panel boundaries were outside the escarpment created by (i.e., not overlain by) the Castlegate Sandstone, subsidence increased with the decreasing overburden thickness and the decreasing strength of the overlying rock. The maximum subsidence in this first area of pillar extraction was 8.5 feet in an area not overlain by the Castlegate Sandstone where the overburden thickness was only about 600 feet.

Longwall mining was introduced at the SUFCO Mine in October 1985, when a longwall system was added. Longwall panels have ranged in width from 540 feet to 1000 feet and up to 17,000 feet in length. Mining heights have varied from 8.5 feet to 13.5 feet with the longwall system.

Subsidence above the longwall panels has historically averaged about 4 feet. Overburden thickness above the longwall panels has typically been greater than above the room-and-pillar panels. The maximum subsidence caused by longwall mining to date has been 7 feet.

Several draw angle surveys have been performed at the mine over the past fourteen years. These surveys have been oriented both parallel and perpendicular to the long axis of the panel. Data collected over continuous-miner areas to date indicate that the average draw angle is 15 degrees. Individual measurements over continuous-miner areas have ranged from 10 to 21 degrees. New longwall draw angle data obtained in 1995 indicates an angle of 15 degrees for the longwall areas. Draw angle study completed in 1999 over 13L4E LW panel indicates 15 degrees is valid. Summary results of the LW panel studies are shown in Figures 5-0A and 5-0B.

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(Figure 5-0A)

14L4E Draw Angle Study

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(Figure 5-0B)

6 East Draw Angle Study

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Tension cracks have occurred over most of the subsidence areas. These cracks tend to be most pronounced in areas where pillars have been extracted (as compared to areas overlying longwall panels). The lengths of the cracks vary from a few feet to nearly 200 feet. Most are oriented either parallel to the natural jointing pattern or parallel to the boundaries of the underground excavation. Cracks with the longest continuous length appear to be natural joints which have been intensified by subsidence action. Vertical displacement along the cracks is uncommon and horizontal displacement varies from hairline to several inches in width. Follow-up observations of individual tension cracks indicate that the cracks tend to close (either partially or fully) following initial development (see Appendix 5-4).

Monitoring data collected to date indicate that subsidence above the SUFCO Mine occurs rapidly after initial movement. Approximately 80 percent of maximum subsidence occurs within about four months. The remainder of subsidence occurs slowly over a period of a few years. These monitoring data have been presented and summarized annually in reports submitted to the UDOGM by SUFCO Mine. Refer to Appendix 5-13 for description of 2RWL repaired sinkhole, Section 5.2.1.1 and Section 5.4.1.1 provide additional information.

3 Right 4 East Panel(s)

Mining of this panel(s) will straddle Leases U-63214 and U-62453 which are referred to as the Quitchupah Tract throughout the M&RP in text, appendices and on drawings. Both leases were issued to the permittee in 1989, the tract was originally delineated in 1982. The mine plan is shown on Plate 5-7, mining will occur only in the Upper Hiawatha coal seam. Overburden is approximately 900 feet or more. An environmental assessment was prepared for Lease U-63214 in 1988 and an EIS for the Quitchupah Tract in 1983, a variety of information from these assessments are included in the existing M&RP.

4 Right 4 East Panel(s)

Mining of this panel will occur in Lease U-63214 which is referred to as the Quitchupah Tract throughout the M&RP in text, appendices and on drawings. This lease was issued to the permittee in 1989, the tract was originally delineated in 1982. See Appendix 5-14, Plate 5-6 and Plate 5-7 for the 4R4E mine plan, lease locations and mine timing respectively. Mining will occur only in the

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Upper Hiawatha coal seam. Overburden ranges approximately from 300-900 feet. The projected subsidence across the 4R4E panel ranges from 1 -5 feet and the projected average subsidence is approximately 2 feet. See the 4R4E Projected Subsidence Map in Appendix 6-4. No surface disturbance, new surface facilities or infrastructure will be associated with the mining of the 4R4E panel therefore no bonding will be needed.

5.2.5.1 Subsidence Control Plan

Potential Areas of Subsidence. Structures that are present above the existing or planned mine workings that may be affected by mining are shown on Plate 5-5. Renewable resource lands within the lease and permit areas are shown on Plates 4-1 A, B, C, 5-10C, 7-2 and 7-3. Two subsidence monitoring locations were added in 2017, one west of the Greens Hollow lease(#2251), the second is within the Greens Hollow lease (#2250), additional subsidence monitoring locations will be added as mining progresses to the north.

Green Hollow. Various information for the Greens Hollow Lease is located in Appendix 7-27 and the renewable resource lands plates listed above. The Greens Hollow area contains troughs, stock and natural ponds which may be affected by subsidence. They are shown on drawing in this appendix under divider "Natural and Stock Ponds" The area of the Greens Hollow lease is not known to contain non-commercial buildings; public buildings and facilities; churches; schools; hospitals; occupied residential dwellings or related structures. The Rough Brothers cabin the only one known of in the area was demolished in 2016 according the USFS personnel owners of the cabin. See "Subsidence Control Measures" for repair and protection commitments and "Subsidence Monitoring" commitments below in this section.

State appropriated water supply locations within the Greens Hollow Lease and adjacent area are shown on the Water Rights Plate 7-2. The water rights information is provided in Appendix 7-1. The water rights assigned within the Greens Hollow Lease and immediately adjacent belong to the USFS. According to water right records no manmade ponds or troughs are assigned state appropriated water supplies. Because of stipulations within the lease document, the M&RP and the conclusion of the PHC and CHIA is not anticipated that water resources will receive impacted and if they are they will be mitigated as discussed in Sections 5.2.5 and 7.3.1.8.

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The underground workings mine plan is shown on Plates 5-7 and 5-8.

Mining Methods. As noted in Section 5.2.3, both room-and-pillar and longwall mining methods are used in the SUFCO Mine. The size, sequence, and timing for the development of the underground workings are shown on Plates 5-7 and 5-8.

Physical Conditions Affecting Subsidence. A detailed description of the physical conditions in the lease and permit areas that influence subsidence (i.e., overburden lithology and thickness, coal seam thickness, etc.) is provided in Chapter 6.

Subsidence Control Measures. Most of the land within the lease area will eventually be affected by subsidence. Anticipated areas of subsidence and those areas planned for protection from subsidence are shown on Plates 5-10& 5-10C. The primary areas where subsidence is not anticipated are the areas overlying the pre-1977 workings in Lease SL-062583 shown on Plate 5-1 (referred to herein as the "Old Mine") and certain lease areas underlying Quitchupah Canyon, Box Canyon, and Muddy Creek.

The "Old Mine" area was mined in such a manner that coal pillars were left for support throughout the entire workings. Since these pillars are large enough to support the overburden and further mining is not anticipated in these workings, the surface area above the workings should not experience any subsidence.

Where perennial streams are not undermined they will be protected from subsidence by establishing stream buffer corridors within the mine from which only limited coal recovery will occur. Support pillars will be left in these locations to preclude subsidence. Underground stream buffers will only be crossed to the extent necessary to allow access to reserves. This access will consist of entries and cross cuts with support pillars. Entries that cross through the underground stream buffer corridors with less than 300 feet of cover will be sealed and/or backfilled upon abandonment using the best available technology to prevent disturbance of the overlying streams.

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Protected cultural resource sites will be designed to include a buffer zone to protect the area from the effects of subsidence caused by underground full extraction mining. The width of the corridor will be calculated as follows: the depth of overburden to the coal seam will first be established. This depth will be multiplied by tan 15° to obtain the distance underground mining needs to be away from the area to not cause subsidence effects. An additional 25 foot buffer will be added to this calculated distance to account for minor irregularities in the course of the stream or cultural resource site.

Surface structures overlying the area to be subsided consist of trails, unimproved dirt roads, fences, runoff catchment ponds, and streams. The applicant will repair any subsidence caused damage to these or other structures to the extent economically and technically feasible, and will comply with R645-301-525.160 and R645-301-525.230. Additional mediation and remedial measures are described in Section 5.2.5.2 Subsidence Control.

Monitoring within the lease area has shown that subsidence rarely exceeds 50 percent of the mining height where the overburden thickness is greater than 800 feet. This overburden thickness is generally achieved above the rim of the Castlegate Sandstone (see Plates 5-10& 5-10C). Topography above the Castlegate Sandstone is gently sloping while that within and below the sandstone outcrop contains cliffs and steep slopes. With the exception of the experimental mining practice described below, future subsidence is typically planned only for those areas above the rim of the Castlegate Sandstone where the overburden thickness exceeds 800 feet.

Experimental Mining and Subsidence. To protect the environmental resources associated with escarpments, SUFCO Mine currently has a general policy of precluding subsidence below the rim of the Castlegate Sandstone. This requires that significant quantities of coal remain unrecovered.

Pillars were extracted from room-and-pillar workings beneath two areas of escarpment. The location of these areas is shown on Plate 5-1. These areas involved a 5,000-foot section of escarpment on Federal lease (SL-062583) in East Spring Canyon (1977-78) and 2,000 feet of escarpment on Fee property (1983-88) on the east side of Quitchupah Canyon. The East Spring

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Canyon escarpment is much less distinct than the Quitchupah Canyon escarpment due to the greater depth of Quitchupah Canyon.

Following pillar removal from the East Spring Canyon area, tension cracks were found around the perimeter of the canyon. Most of these cracks followed natural joints which were temporarily amplified by subsidence. There were no slope or cliff failures along the entire 5,000 feet of affected escarpment.

A similar pattern of tension cracks occurred above three room-and-pillar panels in Quitchupah Canyon. There were no slope failures, but one incidence of cliff spalling occurred.

Longwall mining was first implemented by SUFCO Mine in 1985 in areas that would not affect the escarpments. Observations during the next two years indicated that, unlike room-and-pillar extracted areas, subsidence in areas overlying longwall panels did not cause significant tension cracking that might result in massive slope failure if the cracking was to occur along the escarpments. With this in mind, and with the goal of both SUFCO Mine and the land management agencies being to maximize coal recovery while minimizing environmental impacts, an experimental project was requested by SUFCO Mine and approved by the UDOGM in 1987 (see Appendix 5-5). Under this program, a section of Quitchupah Canyon below the Castlegate Sandstone escarpment was included in the planned longwall subsidence zone. The purpose of this project was to determine whether or not an escarpment could be undermined by longwall mining with minimal or no surface effects.

Prior to mining in the experimental areas, a raptor survey was conducted of the cliff areas on both the west side of Quitchupah Canyon where the mining was to occur and the east side of the canyon opposite the mining section. A visual and photographic survey was also performed of the experimental area to document pre-mining conditions. Pre-mining subsidence monitoring stations were established above the experimental panels to provide future survey control. These stations were installed in high and low tension areas around the escarpment and near naturally-eroded blocks of sandstone that were standing independent of the cliff face.

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Three longwall panels were completed in 1987 as part of the project. The area of proposed escarpment subsidence (the "Experimental Mining Practice" area) is shown on Plate 5-1. The north ends of two of the longwall panels extended beyond the escarpment toward the canyon. The third longwall panel was located entirely beyond the cliff beneath the canyon wall.

To date, monitoring efforts associated with the experimental mining practice have established that subsidence has occurred in a predictable manner varying from one foot to seven feet with minimal surface disturbance. One of the independent sandstone blocks fell from the escarpment during subsidence and a few tension cracks were created along the cliff face. No other visible signs of mining were found even though the surface elevations have dropped several feet in some areas of the experiment. Monitoring stations have moved horizontally from a few tenths of a foot to nearly three feet. Post-mining monitoring of the surface above the longwall panels is continuing. A report which describes the experimental project and its results in greater detail has been prepared for submittal to the UDOGM.

Subsidence Monitoring. In 1976 (i.e., prior to the onset of subsidence), SUFCO Mine began collecting baseline topographic data from the lease area using conventional survey methods. The use of conventional survey methods for subsidence monitoring continued until 1985 (i.e., at the beginning of longwall mining), when the lease area was flown to establish a set of baseline photography and a grid of surface elevations. Where possible, elevations were photogrammetrically determined from this baseline photography on an approximate 200-foot grid. These original horizontal and vertical data, together with the original conventional-survey data, serve as the comparative database for determining ground movement in subsequent years. A baseline was also established to monitor changes in vegetative cover with the use of color infrared aerial photography (CIR). The first baseline was done in 1987 for the existing leases. The baseline for the Quitchupah lease was flown in 1988 with CIR. The applicant will follow up with CIR coverage of the leases at least every five years. The CIR photographs are stored at the SUFCO Mine. CIR photography was taken in 1990, 1995, 1999, 2003 (East Fork Box Canyon only), and 2004. The next projected CIR flight dates will be in 2008, 2013, and 2018.

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Additional aerial photography of the lease area is currently obtained on an annual basis. New elevations are then determined at each of the previously-selected horizontal coordinates and the differences between the original and the new elevation measurements are used to generate a subsidence contour map. This map and supporting narrative are submitted annually to the UDOGM in the form of a subsidence report. This subsidence report outlines the history of subsidence at SUFCO Mine as well as the status of subsidence during the previous year.

Numerous control points have been established within the lease area to assist in the subsidence surveys (see Plates 5-10& 5-10C). Current (2005) coordinates and elevations of these control points are provided in Table 5-2. Additional control points will be added as necessary when existing points become influenced by subsidence. Future points will typically consist of 3-foot lengths of No. 4 rebar embedded in concrete with a stamped brass cap for identification. Since geologic and mining uncertainties often force a change in planned mining sequences, future control points will be installed only after the mine panels are in their development phase.

All subsidence areas will be monitored and reported in the Annual Subsidence Report for a minimum of three years after no additional subsidence is detected within the area. The applicant will map and report areas 3 and 4 in the 1993 Subsidence Report as required by Division Order #93A issued May 11, 1993.

A annual monitoring program was developed to analyze the subsidence cracks related to undermining of the West Fork of Box Canyon. Mining in the area in 1999 did produce visible fracturing at the surface on both the northwest and southeast walls of the canyon in this area. The monitoring program includes measuring the offset and/or width of portions of selected subsidence cracks. Similar data will also be collected from specified segments of subsidence cracks that have occurred away from the walls of the canyon and do not appear to be influenced by the lack of bedrock support created by the canyon. Information gathered from this monitoring program, along with previous studies that SUFCO has performed, will be used to predict the effects of subsidence within other areas of the Pines Tract and other areas of the

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CHAPTER 6

GEOLOGY

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CHAPTER 6
GEOLOGY

6.10 Introduction

This chapter presents a description of the geologic resources in the area of the SUFCO Mine.

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS). The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text.

6.1.1 General Requirements

The geologic resources in the SUFCO Mine area are discussed in Sections 6.2.1 through 6.2.7 of this chapter. The plans for casing and sealing of exploration holes and for subsidence monitoring are addressed in Sections 6.3.1 through 6.3.2.

6.1.2 Certification

All maps, plans, and cross-sections presented in this chapter, required by the regulations, have been certified by a professional engineer.

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6.20 Environmental Description

This section presents a description of the geologic resources in the area of the SUFCO Mine.

6.2.1 General Requirements

This section presents the regional and site-specific geologic information for the SUFCO Mine area. The site-specific geologic information for the nearby waste rock disposal site is contained in Volume 3, Part 2.2.

6.2.2 Cross Sections, Maps and Plans

Plate 6-1 presents the surficial geology of the site area, the coal outcrop lines and the strike and dip of the coal seam mined. Plate 6-1 also presents the locations of the drillholes in the mine area. Elevations are given for the drillholes which were logged and sampled. These logs are presented in Appendix 6-1.

The geologic cross-sections, presented on Plate 6-2, 6-3, 6-4 and 6-5, displays the thickness of the coal seams together with their surrounding lithology and the lateral correlation of coal seams using the following drillholes, measured underground mine sections, and measured outcrop sections. (Figure 6-1 presents the generalized stratigraphic section for the mine area.)

- MC-80-16-7
- MC-80-17-8C
- TP-1
- 76-29-Y
- 2L4E (Underground)
- US-77-5
- 76-32-J
- 76-32-I
- US-79-14
- 2R5E (Underground)
- US-79-17
- US-79-10
- US-79-8
- 01-8-1
- MC-80-9-2C
- MC-80-2-1C
- CH-83-6
- MC-80-15-6
- TP-4
- MC-80-13-5C
- WM-82
- DS-97-2
- MC-80-2-1C
- MC-80-12-4
- MC-80-23-10
- TP-3
- UL-77-2
- MC-80-26-13C
- 01-7-1
- 01-9-1
- MC-80-10-3

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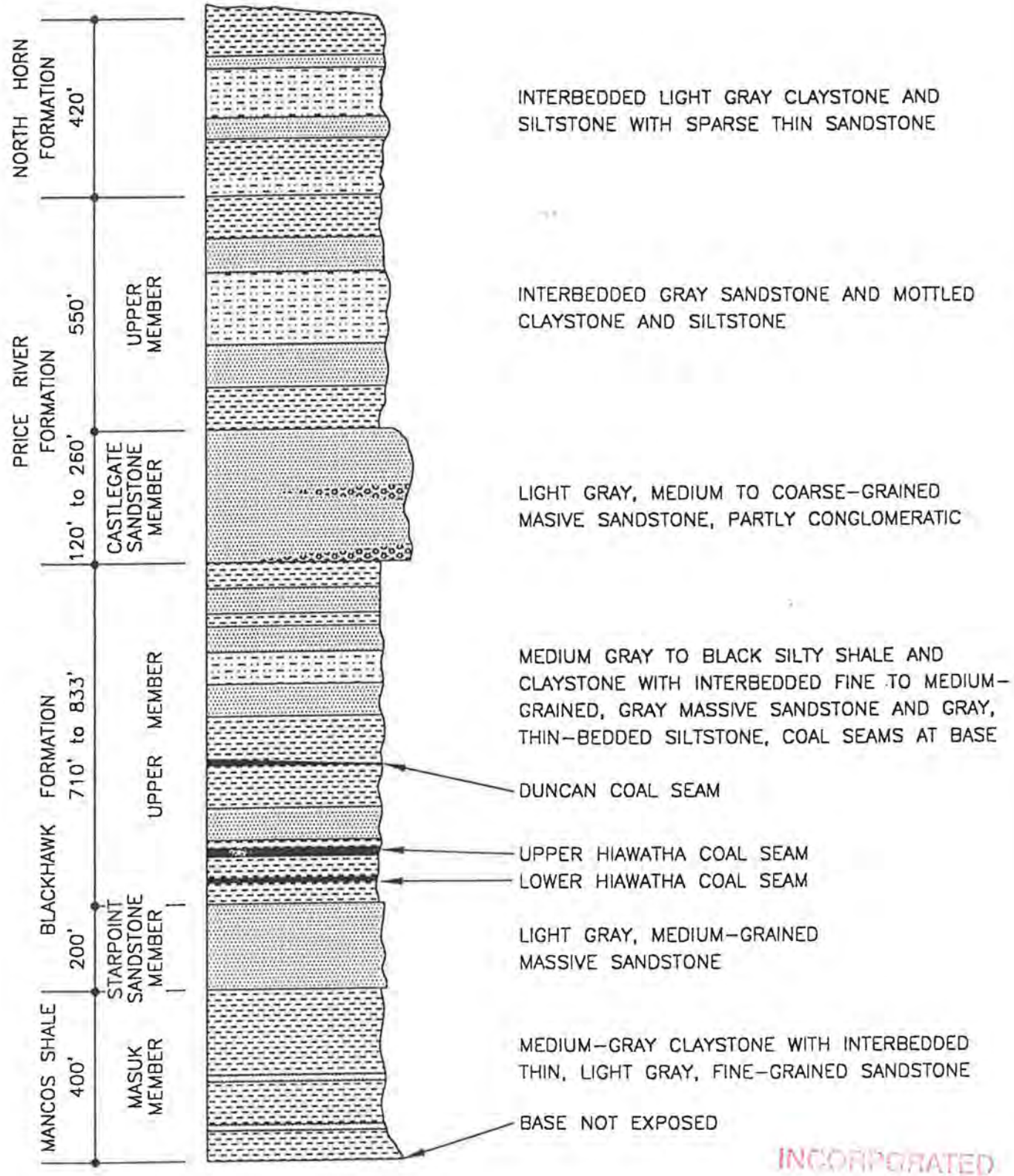

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FIGURE 6-1. GENERALIZED STRATIGRAPHIC SECTION.

3 Right 4 East Panel(s)

Refer to Section 5.2.1.1 for reference to various maps, including those containing topography of the 3 Right 4 East panel. Additional geology maps requested by the Manti-La Sal forest geologist are located in Appendix 6-4 (Confidential). The maps are of subsidence, geology and overburden superimposed over the panel(s) mine plan and cross-sections of longwall panel within the coal seam. The information on the geology maps within Appendix 6-4 with the label "Panel 3R4E" are specific and more comprehensive than generalized information presented within this chapter.

4 Right 4 East Panel(s)

The 4R4E panel is located within Lease U-63214 which is referred to as the Quitchupah Tract. This tract is located within the southern region of the Wasatch Plateau which lies with the Basin and Range-Colorado Plateau Province. The topography of the tract consists of a flat plateau that is deeply dissected by narrow canyons., The coal seams crop out in the southeastern portion of the tract along the steep escarpments of Quitchupah Canyon, Dry Fork Canyon, East Fork Canyon and Link Canyon, The 4R4E panel is located in Dry Fork Canyon. See Appendix 5-14, Plate 5-6 and Plate 5-7 for the 4R4E mine plan, lease locations and mine timing respectively. Mining will occur only in th Upper Hiawatha coal seam. Overburden ranges approximately from 300-900 feet. The projected subsidence across the 4R4E panel ranges from 1-5 feet and the projected average subsidence is approximately 2 feet. See the 4R4E Projected Subsidence Map in Appendix 6-4.

The Applicant has a Resource Recovery and Protection Plan (R2P2) on file with the Bureau of Land Management. This R2P2 contains a detailed description of the two mineable coal seams on the SUFCO Mine leasehold. The overlying Duncan Seam is not considered mineable (see Section 5.2.2).

There is a plugged and abandoned gas well located in Section 23, T21S, R5E in the Pines Tract. No other oil or gas wells are known to exist within a quarter mile of the mine area. No other water wells have been drilled in the lease area except those drilled by the applicant for the purpose of monitoring the groundwater.

6.2.3 Geologic Determinations

The information required by UDOGM to make a determination of the acid or toxic forming characteristics of the site strata is presented in Section 6.2.4.3 of this M&RP.

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The information required by UDOGM to make a determination as to whether the reclamation plan, described in Section 5.40, can be accomplished is presented in Section 6.2.4.

The information required to prepare the subsidence control program is addressed in Section 6.2.4.

6.2.4 Geologic Information

6.2.4.1 Regional Setting

The SUFCO Mine is located beneath the Old Woman Plateau, 20 miles east of Salina, Utah. The Old Woman Plateau lies in the Wasatch Plateau Subprovince of the Colorado Plateau Physiographic Province.

Stratigraphy. All rock units within the SUFCO Mine property boundaries are sedimentary (Plate 6-1 and Figure 6-1). No igneous or metamorphic units are found in the area. Most exposed, consolidated sedimentary rocks in the area were deposited during the Cretaceous Age of the Mesozoic Era. The uppermost North Horn Formation is Upper Cretaceous to lower Tertiary (Paleocene) in age. The oldest unit is the Upper Cretaceous Masuk Member of the Mancos Shale, which is overlain in order of increasingly younger rocks, by the Star Point Sandstone Member of the Blackhawk Formation; the Upper Blackhawk Formation, the Castlegate Sandstone, the Price River Formation and the overlying North Horn Formation (Figure 6-1).

Mancos Shale-Masuk Member

The Masuk Member of the Mancos Shale has been mapped throughout eastern Utah and western Colorado. The Masuk Member crops out along the entire eastern edge of the Wasatch Plateau and varies in thickness from 300 to 1,300 feet (Davis, and Doelling, 1976). It thins from north to south and from east to west. The Masuk is probably 500 to 600 feet thick in the North Fork of Quitchupah Canyon on the east side of the mine property.

The Masuk Member of the Mancos Shale is the lowest rock unit exposed and consists of blue-gray fissile claystone or silty claystone which weathers light blue-gray to light tan. The unit contains thin calcareous sandy or silty interbeds which increase in frequency toward the top of the unit. The interbeds are usually light tan to yellow, and in places their weathering gives the Masuk a light tan cast. The Member forms the lower slopes of the Convulsion and North Fork Quitchupah Canyons on the south and east sides of the mine property. It forms steep, barren, easily eroded slopes with occasional ledges of more resistant fine-grained sandstone, siltstone, or sandy claystone

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Star Point Sandstone

Exposures of the Star Point Sandstone form a broad, arcuate band crossing eastern Utah and extending into eastern Wyoming, where it is roughly correlative to the Shannon Sandstone of the Cody Shale, and into southwestern Colorado and northeastern New Mexico, where its equivalent is the Point Lookout Sandstone (McGookey, 1973). The Star Point in Utah is almost continuously exposed for about 100 miles along the eastern edge of the Wasatch Plateau (Spieker, 1931).

The unit ranges in thickness to more than 1,000 feet in the Pleasant Valley area in the northern part of the Wasatch Plateau. Eastward, it intertongues and grades with the Mancos Shale until it is absent as a unit near Sunnyside in the Bookcliffs. The unit thins southward along the Wasatch Plateau, and the lowermost units of the Star Point grade into the underlying Masuk Shale (Spieker, 1931). Near the SUFCO Mine property, Bucurel (1977) estimates the Star Point to be about 200 feet thick. The top of the Star Point is nearly planar in the mine area, with the exception of some intertonguing with the overlying Blackhawk Formation (Marley, 1980) in Convulsion Canyon, and again in the Link Canyon-Muddy Creek area northeast of the SUFCO Mine property.

The Star Point Sandstone is a tan to gray, fine- to medium-grained, friable, usually well sorted sandstone, with minor thin interbeds of siltstone or claystone. In places, the upper few feet are bleached white. Marley and Flores (1977) note that the Star Point contains trace fossils, and that siltstones and shales in the unit are intensely bioturbated. Marley et. al. (1979) state that the Star Point Sandstone is a coastal complex of distributary channel, delta front, and beach barrier sediments. The Star Point Sandstone in the mine area is a massive cliff-forming unit which created a nearly unbroken ledge along Convulsion Canyon and North Fork Quitchupah Canyons.

Blackhawk Formation

The Blackhawk Formation outcrops from Thousand Lakes Mountain in south central Utah along the Wasatch Plateau northward to the Bookcliffs, and eastward along the Bookcliffs to a few miles east of Thompson, Utah, in Grand County, where it pinches out. The unit is well exposed along the front of the Wasatch Plateau and in the canyons cutting the Plateau. In the mine area, it is well exposed in Convulsion and Quitchupah Canyons. The Blackhawk Formation varies in thickness from 400 feet, south of John's Peak (Davis, and Doelling, 1976), to 1,750 feet in the Pleasant Valley area (Hintze, 1973) with a general thickening from east to west. On the SUFCO Mine property the Blackhawk varies in thickness from 700 to 830 feet, generally thickening northeastward.

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The Blackhawk Formation consists of interbedded alluvial plain and marginal marine deposits of sandstone, siltstone, claystone and coal. Sandstone comprises up to 65 percent of the total thickness of the Blackhawk Formation. The fine- to medium-grained sandstones occur as thin to massively bedded paleochannel deposits. The paleochannels increase in frequency, thickness, and lateral extent upward in the formation. There is also a vertical repetition of erosional scours within the upper sandstones (Marley et. al., 1979). The sandstones grade laterally into siltstones and shale. Most of the coal seams in the Blackhawk occur in the lower 200 feet, with the thicker coal seams occurring in the lower 150 feet.

Three coal seams with thickness greater than five feet (the Upper Hiawatha Seam and two others of lesser importance; the Lower Hiawatha Seam and the Duncan Seam) are found in the Blackhawk Formation within the mine property (Figure 6-1). The Upper Hiawatha Seam is the only one of the three which is minable within most of the mine property boundary. This seam has a thickness of between 9 and 18 feet over most of the property but thins sufficiently due to a mid-seam parting in the southeastern portion of the property that it becomes unminable. The Lower Hiawatha Seam occurs in the interval between the Upper Hiawatha Seam and the Star Point Sandstone. It is 2 to 29 feet above the Star Point Sandstone. The interval between the two coal seams varies between 5.6 and 70 feet. The Lower Hiawatha Seam is thin and discontinuous, varying in thickness from 0 to 17.2 feet. The seam is rendered unminable over much of the property due to partings. The Lower Hiawatha seam is only considered to be mineable where the interburden between the Upper Hiawatha seam is greater than 30 feet. This condition and a sufficient mining height occurs only in the northwest corner of the SUFCO Mine property.

The third coal seam occurs 100 to 130 feet above the Upper Hiawatha and has been informally named the Duncan Seam by the SUFCO Mine. The Duncan seam occurs in a small portion of lease U-28297. Because it is of such limited lateral extent, it cannot be correlated with any coal seams in areas surrounding the SUFCO Mine property. It has a maximum thickness of ten feet and is not mineable because of its limited lateral extent. The unsplit area of the Duncan seam is of small extent, probably less than 50 acres. The Duncan zone may correlate with the Muddy coal seam which occurs north of the SITLA lease.

The Upper Member of the Blackhawk Formation generally forms a steep, irregular slope between the cliffs of the underlying Star Point Sandstone and the overlying Castlegate Sandstone. Ledges of sandstone up to 50 feet thick break the slope. In some exposures, the unit is nearly vertical where the Star Point below has sheared off and erosion has not brought the slope to equilibrium.

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In Convulsion and Quitchupah Canyons, there are large areas of coal burn where the coal has burned naturally and baked the enveloping clays and sandstones to form a resistant reddish clinker layer. These areas are generally steeper than the surrounding slopes. Vegetative cover is generally sparse such that the Blackhawk strata can be easily seen except on some north-facing slopes where vegetation masks the unit.

Castlegate Sandstone

The Castlegate Sandstone extends across the eastern part of Utah, along part of the Bookcliffs and the entire length of the Wasatch Plateau (Spieker, 1931) but loses its character as a cliff-former south of Interstate Highway 70. It is correlative to the Cliffhouse Sandstone of southwestern Colorado and northern New Mexico (McGookey, 1973). In the Wasatch Plateau, its thickness varies from 50 to 500 feet (Spieker, 1931). It is thickest in Price River Canyon at the north end of the Wasatch Plateau. The Castlegate Sandstone is exposed along the rims of Convulsion and North Fork of Quitchupah Canyons. Its thickness varies across the SUFCO Mine property from about 120 to 260 feet with a general northwestward thickening.

The Castlegate Sandstone is a fluvial deposit composed mostly of sandstone, conglomeratic sandstone, pebble conglomerate, and gritstone lenses. There are some thin interbeds of siltstone and claystone, especially toward the base of the unit. The member forms much of the surface of Old Woman Plateau in the southern part of the mine property, and creates a nearly unbroken cliff along the canyons which flank the SUFCO Mine on the south and east.

Price River Formation

The Price River Formation is the uppermost member of the Mesa Verde Group and in the vicinity of the mine it caps the mesa which forms the Old Woman Plateau. The formation is reported to be approximately 550 feet thick in the mine area.

The Price River Formation consists of gray to white gritty sandstone, interbedded with subordinate shale and conglomerate. The formation is resistant to weathering and is a ledge and slope former due to interbedding of resistant sandstones with less resistant shales and claystones.

North Horn Formation

The North Horn Formation straddles the Cretaceous-Tertiary boundary. The maximum thickness of the North Horn within the lease area occurs on Big Ridge where it is estimated to be approximately 430 feet thick. A few seasonal springs are found in the North Horn. The Castlegate

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Sandstone, other beds of the Price River Formation and the North Horn Formation constitute the cap rock in this area of the Wasatch Plateau.

According to Spieker (1931), the North Horn "consists in the central part of the Plateau predominantly of vari-colored shale, in which the combinations of various shades of red, purple, chocolate-brown, green, and gray are characteristic of the coloring of (correlative) rocks in the general region, but it contains many irregular beds of gray, brown, and cream-colored sandstone of various texture, and thin beds of fresh-water limestone, chiefly steel-gray and cream colored but in places also white, tan, and dark blue-gray. In the southwestern, central-eastern, and northern parts of the Plateau the member contains more sandstone. Beds of conglomerate occur in the member irregularly both as to horizon and locality."

Structure. The mine area lies midway between the Joe's Valley-Paradise Fault Zone to the east and the Musinia Fault Zone to the west. Rock units in the mine area strike roughly N40°E and dip 1 to 2 degrees (about 250 feet per mile) to the northwest (Plate 6-1). Local dips may range up to 10 degrees in areas where paleochannels underlying the coal seam cause significant differential compaction. Such local structural variations cannot generally be predicted based on drilling due to the narrow width and sinuous character of these paleochannels found in the lower Blackhawk Formation.

Small displacement faults (apparent vertical displacement of about three feet or less) and some of greater displacement have been encountered and will be encountered as development of the SUFCO Mine progresses. These faults most commonly strike approximately N10° to 15°W and are near vertical. Joints occur parallel and normal to the fault trend.

Geomorphology. The Old Woman Plateau is a gently rolling plateau which is dissected by canyons incised by Quitchupah Creek and its tributaries (Plate 6-1). These canyons are steep-walled and adjacent plateau areas are capped by the Castlegate Sandstone. In the southern part of the mine area, there are areas on the plateau where the nearly flat-lying bedrock forms the surface of the plateau. This structural plain feature is common in the Colorado Plateau. There are also erosional remnants above the plateau surface such as Duncan Mountain and Little Duncan Mountain that are comprised of the Price River Formation and the North Horn Formation. Range terraces were developed on one of the slopes of Little Duncan Mountain during the 1930's.

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Tension cracks were developed during the 1970's near East Spring Canyon due to subsidence. These cracks are now mostly healed at the surface by the soil filling them in. Additional subsidence-related tensions cracks have formed within the Pines Lease. Those occurring in soil have healed over time, however, those occurring in the Castlegate Sandstone outcrop are still visible.

Quitchupah and Box Canyon Creeks are perennial and are supplied by springs and ephemeral streams.

Surface and Groundwater Impact. Surface and groundwater impact are discussed in Chapter 7 of this M&RP.

Coal Geology. The coal which is extracted from the SUFCO Mine occurs in the lower portion of the Blackhawk Formation of the Mesa Verde Group of rocks of Upper Cretaceous age. Doelling (1972) identifies the seam as being the Upper Ivie bed while the SUFCO Mine calls it the Upper Hiawatha. The Blackhawk is overlain by the Price River Formation, including the Castlegate Sandstone, and is underlain by the Star Point Sandstone, all being members of the Mesa Verde Group.

The Upper Hiawatha coal seam has quite uniform thickness from southwest to northeast as shown in the Cross-Sections (Plates 6-2, 6-3 and 6-4). North and west of section 7, T22S, R5E, the thickness is also uniform and averages approximately 15 feet. Drillhole information (Appendix 6-1) and Spieker (1931) indicate that the coal thins from Section 7 toward Convulsion Canyon to the southeast. Drillhole data show 6.3 feet of coal in Section 7.

The as-mined quality of the Upper Hiawatha coal seam averages 11,400 BTU, 9.4% ash, 9.5% moisture, 38% volatile matter and 44% fixed carbon.

The Duncan Coal Seam will not be mined as a part of the SUFCO Mine operations because it is discontinuous and has insufficient minable reserves. The Lower Hiawatha Coal Seam will only be mined in the western portion of the Quitchupah lease because this is the only area where the coal is thick enough to mine and there is sufficient interburden between the Upper and Lower Hiawatha seams to allow mining. The Lower Hiawatha seam may also occur in minable thickness at the northern edge of the SITLA lease but it is not currently under lease (only the Upper Hiawatha seam is under lease).

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Greens Hollow - Both the Upper and Lower Hiawatha occur in the lease, the Lower Hiawatha seam has mineable coal thickness throughout the majority of the lease tract and the Upper has mineable thickness in a portion of the lease. The interburden between the Lower Hiawatha and the overlying Upper Hiawatha is considered too thin to mine both seams. Overburden in the area ranges from 1,000 to 2,500 feet. The anticipated mining height ranges from approximately 9 to 15 feet.

The rocks in the Greens Hollow area are sedimentary, with the exposed units being the Blackhawk, Castlegate Sandstone, Price River, North Horn and Flagstaff Limestone in ascending order. Refer to General Stratigraphy, Figure 1 and Geologic Fence Diagram, Map 2, in the Geology Technical Report found in Appendix 6-54. Subsurface units include Mancos Shale and Star Pont Sandstone. Much of the topography exhibits mass movement including landslides, slumps, rock falls, thin alluvium in canyon bottoms and incised moderate to deeply eroded stream channels.

Cross-Sections, Maps and Plans. The cross-sections and maps are discussed in Section 6.2.4 and are located at the end of this chapter. The applicant request's that this information remain confidential.

Drill Logs and Chemical Analyses. See Section 6.2.4.3 and Appendices 6-1 and 6-2. The applicant requests that this information remain confidential and that public access to these sections be limited to only persons with an interest which is or may be adversely affected as provided under Section 40-10-10(4) of the Act.

6.2.4.2 Test Boring and Drillhole Data (overburden removed)

SUFCO Mine does not plan to remove any overburden above the coal seam to be mined. Regulations related to overburden removal do not apply to this M&RP.

6.2.4.3 Test Boring and Drillhole Data (overburden not removed)

The drill logs and chemical analyses required by regulations R645-301-624.310 through R645-301-624.330 are presented in Appendices 6-1 and 6-2.

Lithologic Logs. Lithologic logs of drillholes are presented in Appendix 6-1. The applicant requests that this information be kept confidential and that public access to these sections be limited to only persons with an interest which is or may be adversely affected as provided under Section 40-10-10(4) of the Act.

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Acid, Toxic, and Alkaline Chemical Analyses (above and below the coal seam). Chemical analyses for acid- and toxic-forming and alkalinity-producing materials from the waste rock disposal site and roof and floor rock material from drill cores is presented in Appendix 6-2. Using Table 2 in the Guidelines for Management of Topsoil and Overburden for Underground and Surface Coal Mining (Appendix 6-3), only two unacceptable values have been reported. Samples of material placed in the waste rock disposal site are taken regularly and analyzed quarterly and are considered to be representative of the coal, roof, floor, and partings. The boron concentration of the waste rock disposal site sample taken in the second quarter of 1991 exceeds the acceptable level of 5.0 ppm by only 0.44 ppm; therefore, this boron value is not of significant concern. Secondly, the SAR value of 19.30 for the Upper Hiawatha coal seam in drillhole 89-20-2 is unacceptable. However, as there have been no other unacceptable SAR values since this sample was taken, it is probably due to contamination, lab error or sampling error. Analytical results of all other samples are acceptable.

Acid, Toxic, and Alkaline Chemical Analyses (coal seam). The chemical analyses discussed above are also representative of the coal seam mined. Additionally, analyses of pyrite and sulfur forms have been performed on roof, parting, and floor samples taken from various core holes. The results of these analyses are reported in Appendix 6-2.

Properties of Rocks in Room and Pillar Areas. Room and pillar mining is now only used in the stream buffer zones and beneath escarpments to prevent subsidence. Pillars are not removed in these areas.

The clay content of floor and roof rock samples from two drill holes was determined analytically (see Appendix 6-2) but otherwise clay content is based on description of cores. The lithology of the stratum immediately below the minable coal varies from drillhole to drillhole. Therefore, the clay content will range from almost 100% (pure claystone) to less than 5% (submature or mature sandstone). Drillholes 74-36-5, 76-28-K, 76-29-Y, US-79-14, US-79-15 and US-81-4 penetrate the stratum immediately below the coal seam to be mined. Lithologic logs for these drillholes (which include lithotypes of the stratum immediately below the coal seam to be mined) are presented in Appendix 6-1. No engineering properties for the underlying claystone have been determined, because its friable nature makes it next to impossible to prepare samples.

6.2.5 Additional Geologic Information

It is not anticipated that any additional geologic data will need to be collected for this site.

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6.2.6 Sampling Waivers

SUFCO Mine does not request a sampling waiver for this site.

6.2.7 Description of the Overburden Thickness and Lithology

Overburden thickness above the coal seam varies due to the plateau and canyon-type topography from approximately 600 to 1800 feet and averages about 900 feet. Stratigraphically, the overburden consists of the Upper Blackhawk Formation which contains the coal seams, the Castlegate Sandstone, the Price River Formation, and the North Horn Formation, as described in Section 6.2.4.1 of this M&RP.

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APPENDIX 6-5

Greens Hollow Tract

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GEOLOGY
TECHNICAL REPORT
GREENS HOLLOW COAL LEASE TRACT

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GEOLOGY TECHNICAL REPORT
GREENS HOLLOW COAL LEASE TRACT

1.0 INTRODUCTION

1.1 STATEMENT OF PROJECT OBJECTIVES

Passage of the Utah Schools and Lands Exchange Act of 1998 included the exchange of lands to resolve issues associated with creation of the Escalante-Grand Staircase National Monument. To balance land values exchanged under that act, the coal estates on several tracts of federal coal underlying the Manti-La Sal National Forest (MLNF) were conveyed to the State of Utah School and Institutional Trust Lands Administration (SITLA). This conveyance is temporal and the ownership of the coal will revert back to the federal government once a specific tonnage is produced or a specified royalty value is collected.

On the conveyed coal estates, SITLA has sole authority to lease the coal. Under the Surface Mine Control and Reclamation Act of 1977 and Utah Coal Rules, Forest Service must consent to the mine plan prior to mine development and can impose requirements for the protection of non-coal resources. The Forest Service decisions, as federal actions, are subject to the requirements of the National Environmental Policy Act of 1969 (NEPA), requiring environmental analysis and appropriate NEPA documents.

The U.S. Department of Interior, Bureau of Land Management (BLM) is the leasing authority on the remaining federal coal estates within the Muddy Creek Tract on National Forest System (NFS) land. Under the Mineral Leasing Act of 1920, as amended by the Federal Coal Leasing Amendments Act of 1975, leases can only be issued by the BLM with consent from the Forest Service with conditions for protection of non-mineral resources. As federal actions subject to NEPA, both the BLM leasing decisions and the Forest Service consent decisions must be based on an environmental analysis and appropriate NEPA document.

This geology technical report is based on information obtained from the Division of Oil, Gas, and Mining, US Geological Survey, Utah Geological Survey, and the employees at the Southern Utah Fuel Company (SUFCO) mine; and field studies and reconnaissance completed for this project. This technical report will form the basis for an analysis of impacts to geology in the project area in the subsequent Environmental Impact Statement (EIS) planned for the Greens Hollow Tract on MLNF.

1.2 STATEMENT OF THE ISSUES WITH EVALUATION CRITERIA

1.2.1 GEOLOGY, MINING, SUBSIDENCE AND SEISMICITY

- *Mining of the underground coal reserves can cause subsidence, non-uniform subsidence features, seismicity, and cracking of the ground surface. (Note: The geologic setting is important in addressing these issues. Geology is a key data element involved in applying the evaluation criteria below. The Mining, Subsidence, Seismicity, and Structures and Facilities Technical Report has used the geologic data to address most of the evaluation criteria for this issue. Only the criteria directly addressed by the geologic task are listed below.)*

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Evaluation Criteria: Location and Amount of Subsidence Expected (measured in feet), Maximum Credible Mining-Induced Seismic Event By Range of Magnitude and Probability (Richter, % probability), Location and Severity of Cracks (primarily based on monitoring at Sufco Mine), Connection Between Surface and Underground Cracks Relative to Depth of Cover, Angle-of Draw, Tension and Compression Zones.

1.3 DESCRIPTION OF THE ALTERNATIVES EVALUATED

1.3.1 ALTERNATIVE 1 - NO ACTION

Under the No Action alternative, the lease tract would not be offered for lease and there would be no coal mining within the tract. The No Action alternative provides a baseline for estimating the effects of the action alternatives.

1.3.2 ALTERNATIVE 2 - PROPOSED ACTION

The Proposed Action is for the BLM to lease and the Forest Service to consent to leasing within the Greens Hollow Federal Coal Lease Tract (Greens Hollow tract) based on a mine plan submitted by Ark Land Company. The leasing would be consistent with the standard lease terms, conditions, and special stipulations. The Greens Hollow tract would be made available for competitive leasing and underground coal mining within the entire tract. The project elements within the analysis area are shown in Map 1. Map 1 also identifies the area that would be designated for subsidence mining and the subsidence analysis area boundary. Subsidence mining would be allowed anywhere within the area of subsidence mining.

While mining could occur anywhere within the area of potential subsidence mining under this alternative, an example of a conceptual mining plan for full extraction mining that will be evaluated for potential impacts was developed. The boundary of that mining plan is shown in Map 1. The conceptual plan consists of longwall mining using current technology. The conceptual mining plan has been developed to avoid some subsidence impacts on surface resources. The conceptual mining plan assumes that mining would be done through the existing SUFCO mine workings. Proposed underground workings in the SUFCO Mine would be extended through the western portion of existing Federal and State leases (these lie within the permit area but are not included as part of the currently approved mine plan) to the Greens Hollow tract. This would involve driving main entries to the west and nearly parallel under the South Fork of Quitchupah Creek and driving a system of mains to the north crossing under the North Fork of Quitchupah Creek and then driving another set of submains to the west to set up longwall panels that would extend into the Greens Hollow Tract. Long-wall or full-extraction mining could be allowed throughout the conceptual mine plan area, which could result in subsidence of the entire area. The conceptual mine plan would produce an estimated 73.4 million tons of in-place coal (approximately 56.6 million tons of recoverable coal) and extend the life of the mine by approximately 8.8 years.

No expansion of the existing surface portal facilities for the SUFCO Mine in Quitchupah Canyon would be required. Access to the coal reserves would be from existing underground workings in the adjacent leases. Water discharge would be from existing permitted discharge points in Quitchupah Creek in Quitchupah Canyon.

Support elements of this alternative could consist of reasonably foreseeable surface facilities and improvements. Reasonably foreseeable surface facilities and improvements could include two areas

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containing ventilation shafts (one with a reserve diesel generator for power), power transmission line for the ventilation fan and the mine itself, and road access.

1.3.3 ALTERNATIVE 3

Alternative 3 was developed to address issues of concern raised during public and agency scoping. This alternative analyzes the entire lease tract, as that shown in Alternative 2, while focusing on reduction of subsidence impacts to surface resources within the lease tract boundary. Similar to the Proposed Action, Alternative 3 leasing would be consistent with the standard lease terms, conditions, and special stipulations. However, Alternative 3 specifies geographical areas that would be protected (full-support mining). Issues driving this alternative include potential impacts to water, geology, vegetation, wildlife habitat, socioeconomics, and cultural resources. This alternative evaluates the use of full support mining in specific locations to protect surface resources from subsidence (Map 2). Areas of substantial surface impact were based on perennial streams where surface flow could be lost to subsidence induced cracking of Castlegate sandstone or where escarpments could fail.

Under Alternative 3, underground workings would extend from the SUFCO Mine through the western portion of existing Federal and State leases (these lie within the permit area but are not included as part of the currently approved mine plan) to the Greens Hollow tract. Longwall mining would occur within the tract in an unspecified manner while avoiding the subsidence of areas of substantial surface impact. Long-wall or full-extraction mining could be allowed throughout the remainder of the tract, which could result in subsidence of the unprotected area. Alternative 3 would extend the life of the mine by 8.7 years and produce an estimated 55.7 million tons of mineable coal.

As with Alternative 2, no expansion of the existing surface portal facilities for the SUFCO Mine in Quitchupah Canyon would be required. Access to the coal reserves would be from existing underground workings in the adjacent leases. Water discharge would be from existing permitted discharge points in Quitchupah Creek in Quitchupah Canyon.

Support elements of this alternative could consist of reasonably foreseeable surface facilities and improvements. Reasonably foreseeable surface facilities and improvements would include two areas containing ventilation shafts (one with a ventilation fan system and two reserve diesel generators for power), power transmission line for the ventilation fan system and the mine itself, and road access.

2.0 METHODS

2.1 CONTACTS MADE

The BLM holds a portion of the coal data under a confidentiality agreement with those who did the exploration. An agreement was signed with the BLM giving AK&M Consulting, LLC the right to evaluate coal drilling data for the tract which was available prior to 2004. In addition, contacts were made with the Utah state office of the BLM during the mine planning, as a liaison for the mining engineering team. Contacts at the BLM offices included: Jim Kohler, Utah BLM; Stan Perks, Utah BLM; Jeff McKenzie, Utah BLM; and Mike Stevens, Price BLM. Mr. Dave Tabet, coal geologist, Utah Geological Survey was contacted relative to general coal data and current geologic mapping/projects in the area. Mr. Grant Willis, Utah Geological Survey was also contacted regarding the surface mapping available in the area. Chris Kravits, AK&M Consulting, LLC was consulted numerous times through the project. Mr. Kravits served as the coal geologist for the SUFCO mine during most of the 1990s. Mr.

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Mark Bunnell, of Canyon Fuels was contacted regarding faulting on the adjacent SUFCO mine leases, present exploration activities, and future exploration and obtaining current drilling data. Mr. Carter Reed and Dale Harber were consulted for guidance on BLM/Forest Service cooperation for the project. Mr. Hamid Maleki of MTI Technologies, Inc. and a subcontractor to Cirrus Ecological Solutions, LLC, was consulted throughout the project duration in regards to coal resource information, general geology, mine planning, and subsidence projections.

2.2 SOURCES AND DESCRIPTIONS OF EXISTING INFORMATION

Numerous references are cited in the body of this report and listed in Section 4.0, titled "Literature Cited and Contacts." Most of the information on the geology of the tract came from the available geologic maps of the area (see Literature Cited and an index on the geologic map). The most detailed scale available was used. This data was compiled to a scale of 1 inch equals 2,000 feet for the final map. BLM data files were made available and contain all coal drill hole data drilled prior to 2000, both public domain data and confidential data. A new United States Geological Survey (USGS) publication on the coals of the southern Wasatch Plateau (Professional Paper 1625-B) was very helpful. The Utah Geological Survey publications provided information on fractures and coal cleats from the Wasatch Plateau area, an excellent summary of public domain drill hole information, coal outcrop and thicknesses, as well as mining history and coal quality.

Division of Oil, Gas, and Mining data base on oil and gas drill holes was also used. The adjacent Pines Tract EIS was a helpful reference. Digital Elevation Model (DEM) data (30 meter) was obtained from the USGS and used in calculation of the overburden depth. This collection of sources plus cooperation from the staff of the SUFCO mine provided an excellent basis of information for the analysis.

2.3 DATA COLLECTION AND ANALYSIS METHODOLOGY

2.3.1 SURFACE GEOLOGY AND STRUCTURE

No field mapping of geologic contacts was performed under the contract. All mapping shown is compiled at the scale of 1:24,000 from previous work in the public domain. Not all of the sources for the map were completed at the same scale. Some 1:100,000 geologic mapping was used and compiled to the new scale. These areas are suspect. Refer to the sources and scales of the original mapping shown on Plate 1, Explanation.

A few joints were measured in the field and appear on the geologic map (Plate 1) as well as those areas which appear to be unstable cliff escarpments. These were mapped using large scale Forest Service color aerial photography.

Coal data, available prior to 2004, came from the BLM data base at the state office courtesy of Mr. James Kohler. Much of these data are available through published sources (Smith 1981, and Dubiel et al. 2000). Confidential drill hole data were examined and the results of that analysis is part of the interpretation while protecting the original data's confidential status. No drilling data post-dating 2000 were examined. In the process of evaluating the drill hole data, it was noted that different sources had different (up to several hundred feet) location coordinates for the same drill holes. Resolution of these data discrepancies was not attempted. The author used BLM and some SUFCO location data.

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Where geophysical logs were available, the coal picks in the BLM data base were verified. Some new log picks, from recently drilled holes not previously in the BLM data base, were added and are used here. A table is provided in Appendix A to help correlate BLM drill hole ID numbers with previously published names for drill holes.

2.3.2 Coal Reserves

Coal reserves were estimated for the in-place, mineable and recoverable categories but current to the end of 2003. Reserve calculations for the Greens Hollow tract have been performed by the BLM and are part to the tract delineation report.

2.3.3 Future Exploration

Permits and approvals of future exploration drilling will be documented in a separate process. The likely location of future exploration activities and their effects on the Greens Hollow tract over the mining life of the tract were estimated in 2003. More recent estimates of future exploration activities have been developed by SUFCO personnel. Most exploration activities would occur within the area of subsidence mining. A limited amount of new roads built outside the tract to support exploration would likely be required. The analysis of new and existing dirt road information will be disclosed in the separate analysis. At this point in time, future exploration drilling, will be based on primarily road-supported drilling systems (22). Helicopter-supported drilling will be used only in the most rugged topographic locations (3).

2.4 Description of Inventories and Data Collected by the Consultant

The largest data base gathered for the geologic analysis is the coal data base provided by the BLM. This data base was checked for accuracy by examining the available geophysical logs for the holes. Correlations were checked and tops were picked for the Castlegate Sandstone if they were not in the data base. Four holes were added to the existing data base based on interpretation of geophysical logs provided by the BLM. SUFCO provided access to holes drilled since 2000 for use in the evaluation of the Castlegate Sandstone and interval immediately above the sandstone. A portion of the data base is confidential and not included in this report. The confidential data was, however, used in the analysis of the coal resource during the work performed prior to 2004.

Fracture data were gathered from examination of aerial photographs provided by the Manti-LaSal National Forest and included in Appendix A. Field checking of the photographic work verified its accuracy and added a few additional field measurements of fractures and their density. This small data base was used by the mining engineer in mine planning. Additionally, areas where rock formations appeared to be vulnerable to toppling over were noted during the examination of the photos and presented here on the geologic map. Some of these areas were examined in the field as well.

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3.0 RESULTS AND DISCUSSION

3.1 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1.1 TOPOGRAPHY

The Greens Hollow tract and the mining analysis area boundary (hereafter referred to as the "study area") lies in the Wasatch Plateau physiographic sub province of Utah (Stokes 1988), which is part of the Basin and Range-Colorado Plateau Transition physiographic province.

The topography in the study area varies greatly in character and elevation. The eastern portion of the study area lies at the eastern edge of the Wasatch Plateau. Muddy Creek cuts a deep canyon in the plateau (Plate 1). The eastern edge of the Wasatch Plateau is formed by a serrated resistant to semi-resistant line of cliffs. The coals of the Wasatch Plateau occur about midway in the escarpment in a series of ledges (up to 25 feet high) and steep slopes. A cliff-forming sandstone caps overlies much of the eastern escarpment, with very gentle to flat terrain on top of the plateau near the cliff's eastern edge and along drainages. Further back from the escarpments edge and to the west are moderately steep slopes, some with occasional sandstone ledges forming step-like topography. Much of this topography is dominated by mass movement, including landslides and incised by moderate to deeply eroded stream channels. Hummocky topography is associated with the landslides and to a lesser degree with the areas of mass movement. West of the study area, the plateau is capped by flat-topped white limestone cliffs, up to 250 feet high. Where these are erosional remnants, they form buttes and mesa-like features all along the top of the Wasatch Plateau.

Muddy Creek and Quitchupah Creek are the two major drainages eroding into the tract. Muddy Creek lies along the northern boundary of the tract (Plate 1). In the northeast portion of the study area, Greens Canyon is a major tributary to Muddy Creek which bifricates into Greens Hollow and Cowboy Canyon. These drainages are steep-sided and have no valley floor in their upper reaches. The North Fork of Quitchupah Creek lies within the tract boundary on the southeast. Unnamed tributaries of the North Fork of Quitchupah drain the very southern portion of the tract. A large ridge called "Big Ridge" is present about a third of the north-south distance north from the southern boundary of the tract. This ridge forms the drainage divide between Muddy Creek and Quitchupah Creek (to the south).

Surface elevations range from approximately 7,400 feet in the eastern portion of the study area in Muddy Canyon to 9,760 feet at the western edge of the study area east of White Mountain. Overall net topographic relief is approximately 2,360 feet with the greatest local relief at the escarpment of the Wasatch Plateau on the east side of the study area.

3.1.2 STRATIGRAPHY

All rocks exposed in the study area are sedimentary and include conglomerate, sandstone, siltstone, shale, coal and limestone. The rocks range in age from Late Cretaceous to Paleocene (Early Tertiary) (Hintze 1988). The rock units exposed on the surface include, in ascending order –the Blackhawk Formation, the Castlegate Sandstone, the Price River Formation, the North Horn Formation, and the Flagstaff Limestone. On the cross section on Plate 1, some additional subsurface units are shown and include the Masuk Shale Member of the Mancos Shale (sometimes referred to as the Upper Blue Gate Shale Member and simply as "Mancos Shale" when no other members are within the mapped area) and the Star Point Sandstone. Figure 1 is a generalized stratigraphic section for the Greens Hollow tract area and Plate 2 is a fence

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diagram of the stratigraphic section constructed using drill hole data in the area. Quaternary and Recent deposits include slumps, rock falls, landslides and mass movement deposits, and thin alluvium in canyon bottoms. These are described in more detail in the following sections.

Masuk Shale Member of the Mancos Shale (or Upper Blue Gate Shale Member) – This unit crops out east of the study area (Plate 1) in Muddy Canyon and consists of shale and silty shale with minor siltstone and very thin beds of fine-grained sandstone. This unit forms the base of the cliffs along the Wasatch Plateau, eastern escarpment. The unit has an overall yellow to blue gray color and in the Link Canyon 23215 oil and gas test well (T21S, R5E, section 23) was 952 feet thick. The USGS reports a thickness closer to 600 feet (Dubiel et al. 2000). This unit is present in the subsurface but not on the surface within the mapped area on Plate 1.

Star Point Sandstone – This formation makes the first cliff above the badlands topography of the Masuk Shale along the eastern escarpment of the Wasatch Plateau. The Star Point is reported to be between 170 and 500 feet thick in the study area and consists of tan weathering marine sandstone, often occurring in several tongues separated by Masuk Shale (Doelling 1972). The Star Point Sandstone was deposited as a beach or wave-dominated delta-front sandstone which prograded to the east to northeast (Dubiel et al. 2000). The top 4 to 10 feet of the Star Point Sandstone is typically bleached white on outcrop. This unit is present in the subsurface but not on the surface within the mapped area on Plate 1.

Blackhawk Formation – The Blackhawk Formation averages 825 feet thick (with a minimum of 714 feet and maximum of 1,033 feet in the study area), consists of tan to brown weathering, fine- to medium-grained sandstone interbedded with subordinate gray and black carbonaceous shale, and three coal seams with significant areas over 6 feet thick. Coal is mostly found in the lower quarter of the formation. The upper portion of the Blackhawk is transitional to the Castlegate Sandstone in that it consists of thick-bedded sandstone that is petrographically similar to the Castlegate Sandstone.

In the southwest corner of section 19, T20S, R5E, where cross section line A-A' runs, is an area in which the surface mapping and the subsurface data do not match. In drill hole 1510, the Castlegate Sandstone's position is inconsistent with mapping in the South Fork of Muddy Creek of the same unit. This conclusion is based on the assumption that the structural mapping is correct (see following section on Structure). Explanations for this could be: a fault between drill hole 1510 and the canyon; poor surface mapping; or poor picks of formation tops in drill hole 1510. The last is unlikely. Further investigation is required to resolve this issue.

Castlegate Sandstone – The Castlegate Sandstone is the most prominent unit in the study area because it forms high cliffs and its resistant nature controls local base level of streams. This unit is between 114 and 304 feet thick, with an average thickness of 156 feet and consists of thick-bedded light gray to gray, coarse-grained and gritty sandstone that weathers to cream to tan color. Minor thin lenses of gray to carbonaceous shale, as well as coal pods are present. The contacts on logs of this formation are often unclear. Occasionally a thick channel sandstone will be present in the Blackhawk or Price River Formation, immediately above or below the true Castlegate. The sand-on-sand contact makes it improbable to correctly pick the formation boundary on logs. From an evaluation of the stratigraphic interval of 0 to 50 feet directly above the top of the unit, the average siltstone plus mudstone composition is 74 percent.

Price River Formation – The Price River Formation consists of interbedded sandstone, shale and siltstone, with minor conglomerate and is a slope-former. The sandstone composition of the Price River Formation is lithologically similar to the Castlegate (Kravits 2002). Most drilling within the study area does not

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penetrate the full formation thickness of the Price River. Dubiel and others (2000) show a thickness of about 500 feet on their cross section. Doelling (1972) has a generalized section for the entire Wasatch Plateau and indicates the thickness is between 600 to 1,000 feet. From drilling in section 20, Township 20 South, Range 4 East a thickness of 824 feet of Price River Formation was penetrated based on a sample log from the well (Division of Oil, Gas, and Mining web site, 2008). The sandstones are gray to white and gritty and the shales are gray to brown and locally carbonaceous (Doelling 1972).

North Horn Formation – This unit consists of variegated beds of mainly red shade with minor sandstone, conglomerate, and freshwater limestone (Doelling 1972). It is estimated to be 1,490 feet thick near the study area based on the geologic map (Sanchez and Hayes 1979). No drilling in the area has penetrated both the upper and lower contacts of the formation; in addition, the lower contact is transitional with the Price River Formation, making that contact a difficult pick. The shaley nature of the formation and its occurrence in high precipitation areas make mass movement, slope failures, and landslides common occurrences along the outcrop belt.

Flagstaff Limestone – The Flagstaff Limestone is a fairly evenly-bedded, dark yellow-gray or cream-colored lacustrine limestone with interbeds of sandstone, shale, and volcanic ash (Doelling 1972). It is resistant to weathering and forms tall cliffs such as Flagstaff Peak, Ferron Mountain, and White Mountain. It has an estimated thickness of 250 feet in this portion of the Wasatch Plateau.

Quaternary and Recent deposits - Slumps, rock falls, land slides, colluvium, alluvium, and coal burn of Quaternary and Recent age are found in the study area. Only major landslides and massive slumps, and alluvium, were separately mapped by previous workers (Sanchez and Hayes 1979; Doelling 1972; Doelling 2004).

3.1.3 STRUCTURE

The study area is located between the San Rafael Swell to the east and the Basin and Range Province to the west. The rocks in the study area have inherited structural characteristics of both areas. The rocks generally strike N 38° E and dip gently approximately 2° to the northwest. A slight anticlinal feature is present in the center of the tract and its axis is approximately parallel to the structural dip. An oil and gas dry hole lying just east of the study area in section 23, T21S, R5E, tested this structural high (Plate 1).

Faulting within the study area is minimal. No faults have been mapped within the area on published geologic maps (see references for mapping, Plate 1). Coal mining is impacted by minor faulting, and underground mapping by company geologists for SUFCO mine have detected minor faults in the Pines tract to the east of the study area (Bunnell 2003). These faults trend N 26° W and have vertical displacements less than 7 feet. These faults occur in the southeastern portion of the study area and are likely to continue some unknown distance into the tract in that general area.

Fractures were measured in the tract and buffer zone using aerial photos and supplemented with limited, field measurements. Plate 1 shows the areas where fracture measurements were made. The average orientation of these field measurements is N 17° W (n=138). Aerial photo analysis of fractures in both the tract and buffer resulted in an average orientation of N 24° W (n=278) with a median and mode of N 20° W, and a standard deviation of 35 degrees. Hucka (1991) gathered cleat (coal fracture) data and limited surface fracture measurements from in and near the SUFCO mine portal, about 6 miles south of the tract, and reports an average face cleat direction of N 15° E, and butt cleat, N 55° W (n=50, Upper Hiawatha coal seam); surface fractures N 15° W with minor trend N 65°E (n=32).

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3.1.4 Coal Geology

The potentially mineable coal seams in the tract are the Lower Hiawatha, Upper Hiawatha, and the Muddy #1. The Lower Hiawatha seam occurs directly above the Star Point Sandstone and below the Upper Hiawatha seam (Figure 1). The Lower Hiawatha seam varies in thickness from 5 to 18 feet (BLM 2007). Generally the mineable thicknesses of the Lower Hiawatha are obtained on the tract. This seam is presently not mined at the adjacent SUFCO mine. Interburden between the Lower Hiawatha and overlying Upper Hiawatha coal seam varies from 10 to 55 feet (based on drilling in 2003), with the interburden thickness increasing to the northwest. Current planning for the Greens Hollow tract is for mining only in the Lower Hiawatha seam due to relatively thin interburden between the Upper Hiawatha and the Lower Hiawatha seams and partings in the Upper Hiawatha. The Upper Hiawatha seam is presently mined in areas both south and east of the tract by the SUFCO mine. On the Greens Hollow tract, the Upper Hiawatha coal seam attains mineable (6 to 14 feet) thickness, with an average thickness of 6.2 feet (from available drill hole data as of 2003). The Upper Hiawatha attains mineable thickness in the southern and eastern portions of the tract. The interburden between the Upper Hiawatha and Muddy #1 coal seam ranges from 19 to 54 feet with an average of 34.3 feet (from available drill hole data as of 2003). The Muddy #1 coal seam is only thicker than the minimum mineable cutoff (6 feet) in the very northern part of the tract (less than 640 acres) and is not included in any mineable reserves for the tract. Overburden varies from less than 600 feet to over 2,500 feet in areas where the coal seams are mineable.

Partings in the coal seams do occur and may increase or decrease the amount of mineable coal. Local flexures around channel sandstone bodies and above marine sandstones are probably present and will likely produce thickness irregularities that may impact mining and coal recovery. A channel sandstone has rendered the Upper Hiawatha seam unmineable in a limited area near the boundary of the tract in section 2, T21S, R5E, (Bunnell 2003). It is likely this channel will be found in the Greens Hollow tract. Faulting is not expected to significantly hinder mining in the tract.

Coal burn occurs along much of the coal seam outcrop. BLM guidance and experience dictated a requirement to designate a zone of coal burn 500 feet horizontally in from the outcrop. This will vary from place to place and broken roof rock and decreased coal quality may extend beyond the 500 foot zone. The only area possibly affected by outcrop burn is in the very north portion of the mine plan area, near Muddy Canyon.

3.1.5 Mass Wasting

Recent and ongoing mass wasting is found in the study area. The most common occurrences are mass slumping, landslides, and rock falls. Slumping and landslides have and are currently occurring in clay-rich units especially the Price River and North Horn Formations and, to a limited extent, in the Blackhawk Formation. The slumps and landslides vary in size from a few to hundreds of acres and appear to have no preference as to the direction the slope faces.

Rockfalls have and are currently occurring mainly from the major cliff-forming units (Star Point Sandstone, Castlegate Sandstone, and Flagstaff Limestone). The rockfalls occur as either nearly equidimensional blocks roll down slope or as slabs cave from the cliff face and slip to the base of the cliff. Rock falls are strongly influenced by jointing and often occur along these zones of weakness.

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3.1.6 MINING HISTORY

One historic mine is located east of the study area – the so-called Ricci or Muddy Creek Mine (Section 35, T20S, R5E). Doelling (1972) states the following about the mine:

The Ricci mine in Muddy Canyon just south of the Sanpete-Sevier County line near the mouth of Last Water Canyon has two mineable seams, the Muddy No. 1 and No. 2. The lower is at least 12 feet thick and the upper 4 feet thick with 12 to 18 feet between them. The thicker seam has a parting up to 6 inches thick about one-third from the top of the bed. At least 35,000 tons have been mined. Doelling (1972) also notes that the mine was active from 1941 to 1953.

There is current mining in the study area, both to the east, in the SITLA Tract (accessed through the SUFCO mine) and to the south, in the SUFCO mine proper, an active mine.

3.1.7 EXPLORATION

Future coal exploration will be required to clearly delineate the mineable reserves and will take place chiefly in the first five years after leasing has occurred. Future coal exploration will be analyzed through a separate process.

3.2 DETAILED TECHNICAL ASSESSMENT/DESCRIPTION OF THE POTENTIAL EFFECTS

3.2.1. NO ACTION ALTERNATIVE DIRECT AND INDIRECT EFFECTS

Under Alternative 1, the tract would not be leased so natural weathering and erosion of the Wasatch Plateau would continue. Spalling of the Castlegate Sandstone cliffs (and other smaller cliff faces) would occur across the entire tract at a rate similar to the last 10,000 years. Flash floods would occur with normal frequency of intensity, changing the stream bottom characteristics such as pool riffle ratio and local stream profile. The coal resource found on the tract would remain in place and continue to have future value. Should no action be taken for an extended period of time (approximately > ten years), one potential scenario could have the SUFCO mine close because of lack of mineable reserves. With the closing and abandonment of the existing mine, future access to the coal would likely require a new portal in Muddy Canyon or another location, potentially dramatically increasing the surface impacts in order to extract the coal resource at a later date. Other uses such as foraging by wildlife, livestock grazing, timber harvesting, oil and gas extraction, and recreation activities would result in similar impacts on geologic resources as those presently occurring throughout the project area.

3.2.2 ALTERNATIVE 2 – PROPOSED ACTION DIRECT AND INDIRECT EFFECTS

Issue 1: *Mining of the underground coal reserves can cause subsidence, non-uniform subsidence features, seismicity, and cracking of the ground surface.*

The most important impact related to geology is the extraction of coal and related subsidence of the land with a potential impact of additional rock falls and accelerated spalling of the Castlegate Sandstone cliffs (and other smaller cliff faces). In addition, the disruption of the integrity of the stratal layers above the coal seams due to mining could impact the local flow of ground water. Changes in the topography of the

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surface may also impact surface water patterns and stream profiles. These impacts are covered in other resource sections in this EIS.

3.2.2.1 Coal Resources

The Muddy #1, Muddy #2, Upper Hiawatha, and several thin uncorrelated coal seams as well as areas where the Hiawatha is less than 6 feet thick would be impacted by the Proposed Action. Future mineability or recoverability of these coal seams by a potential future method would be reduced or eliminated in areas that would be subsided. At present, these coal seams are either too thin, have too little interburden, or are of such limited extent that they are not considered mineable in today's market. Should future mining methods or markets make such thin coals recoverable, this resource would likely be greatly reduced or lost because of the caving, fractures, stresses, and impounded water left by mining the presently economic portions of the Hiawatha coal seam within the tract. Additionally, coal left behind as unrecoverable as roof, floor, and pillar coal would likely be unrecoverable for the foreseeable future.

3.2.2.2 Oil and Gas Resources

Exploration for oil and gas and coalbed methane would be impacted by mining the coal. Coalbed methane (CBM) is likely present in the Ferron Sandstone Member of the Mancos Shale beneath the coal tract. Current data (Gloyn et al. 2003 and Smith 1985) indicate that the gas content of the Blackhawk coals is too low to be considered a resource. The underlying Ferron Sandstone coalbed gas contents are higher than the Blackhawk coals but at present, uneconomic. In addition to the depressed gas contents of the Ferron coals in the southern Castle Valley/Wasatch Plateau area, the Ferron coals lie at a depth of about 4,700 feet below the surface of the tract. Few commercial coalbed gas wells produce at those depths today. The nearest commercial gas production is from Ferron coals about 25 miles to the northeast in the Drunkards Wash and Buzzards Bench fields at depths between about 1,000 to 3,500 feet. Drilling for Ferron CBM below the Wasatch Plateau escarpment near the tract has yet to produce any commercial wells, but it should be noted that natural gas prices have risen substantially, which could drive CBM activity further south and perhaps west along Castle Valley/Wasatch Plateau trend.

Conventional oil and gas resources lying stratigraphically below the coal in both the Emery Sandstone and Ferron Sandstone members of the Mancos Shale have potential. The nearest oil and gas test well was drilled in T21S, R5E, section 23 in 1981 (API number 4304130024) about 2 miles southeast of the tract. No tests were run in the well. The total depth drilled was 5,730 feet with the bottom of the hole in the Tununk Shale Member of the Mancos Shale (Tripp 1989). The well tested the Ferron and Emery sandstone reservoir potential but deeper potential horizons remain and are locally untested.

The probability of future drilling for oil and gas on the mined portion of the tract is moderate to low (Gautier et al. 1996). Undermining would increase the difficulty of drilling. Directional drilling could be utilized to explore from off-site locations.

3.2.2.3 Subsidence

Surface subsidence occurs because of downward rock mass movement caused by the closure and collapse of mined-out coal seams. The subsidence process is discussed in detail in the Mining, Subsidence, Seismicity, and Structures and Facilities Technical Report (Malcki 2008). Two major mechanisms of surface subsidence associated with mining are the formation of sinkholes and the formation of troughs. Subsidence on the Greens Hollow tract is predicted to be the trough type, which is characterized by the formation of a relatively smooth basin and is much less damaging than sinkhole subsidence. The subsidence process occurs on the surface as the upper strata bend and settle. Surface subsidence processes result in both vertical and horizontal displacement of rocks. In general, impacts from vertical

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displacement are less damaging to surface features than is differential horizontal displacement. The subsidence process is expected to be complete within a few years after mining.

Impacts of concern due to subsidence on the Greens Hollow tract would include damage to structures and facilities, stock ponds, roads and trails, and natural ponds, springs, and streams. Potential damage to stock ponds is discussed in more detail in the Range Resources Summary Report. Impacts to roads and trails are discussed in the Recreation Summary Report. Damage to facilities and structures is discussed in Section 3.2.2.5 of this section. Potential impacts to natural ponds, springs, and streams are discussed in the Surface and Ground Water Technical Report.

Predicted surface subsidence would be up to approximately 8 feet in the northern half of the tract and up to 4.3 feet on the southern half of the tract. Subsidence would increase with increasing extraction height and decreasing overburden cover. Predicted tensile strains would reach levels that could cause surface fractures, particularly above longwall gateroads and near shallow block boundaries to the northeast part of the tract. Fractures are more likely to occur over panel boundaries and gateroads. Many fractures within the panels, if they break the surface, should close due to compression and settling of the surface, but the fractures along the panel margins are more likely to remain open. These fractures would intercept surface run-off water and could create a public hazard in some areas.

Expected surface movement extending horizontally beyond (outside of) the underground mining boundaries would be approximately 270 feet for shallow workings and 800 feet for deep workings. Change in surface slopes would be a direct impact of subsidence. These changes would be moderate (generally less than 2 to 3 percent) and thus vertical subsidence would not be visually discernable because of gradual changes in surface slopes. However, the consequences of subsidence may be noticeable (such as rock falls from escarpments, ponding, visible surface cracks, etc.).

The potential for damage from "permanent" tensile strains would be greatest at longwall block boundaries, particularly at the shallow depths in the northeast part of the tract near the Muddy Canyon. The North Fork of Quitchupah Creek and its tributaries would be undermined and potentially impacted under Alternative 2. The minimum amount of overburden distance between the coal seam and the North Fork of Quitchupah Creek and its perennial tributaries is approximately 1,300 feet. Based on a very conservative estimate for the depth of the fractured zone (60 times a possible extraction thickness or 900 feet), minimal impacts on North Fork of Quitchupah Creek and its tributaries would be expected (the overburden thickness numbers, such as "900 feet" are dependent on the actual full extraction mining height and local rock characteristics). However, the overburden distance between the coal seam and portions of Muddy Creek is less than 900-feet under Alternative 2, so that stream flow loss to mine workings could occur as a result of longwall mining under Muddy Creek in these locations. The risk of this occurring could be greatly minimized by reducing the mining heights through the immediate areas. Furthermore, because of differential settling along the stream, the pre-mining gradient of both the North Fork of Quitchupah Creek and Muddy Creek would both increase (approaching panel boundary) and decrease (leaving panel boundary) as a result of longwall mining under these streams. The maximum expected change in streambed gradient would be approximately 1 percent over the Greens Hollow tract.

Perennial segments of Cowboy Creek, Greens Hollow, and Muddy Creek would also be undermined. The minimum amount of overburden cover above the coal to be mined along Cowboy Creek and Greens Hollow is proposed to be approximately 1,200 feet. Using the estimate provided by Maleki (2008) for the maximum extension and expansion of existing fracture systems and upward propagation of new fractures of 60 times extraction coal thickness, permanent loss of water from Cowboy Creek and Greens Hollow to the underground workings due to mine subsidence would be very unlikely. Nevertheless, surface tensile

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fractures could develop near the edges of the longwall panels, resulting in some localized displacement of water from the streams where they cross shallow fractures. Surface tensile fractures would tend to develop in areas where bedrock tension is permanent, such as along the edges of mine subsidence panels. Fractures would pose a risk of permanent displacement of water in stream channels where the Castlegate Sandstone is exposed or has insufficient depth of overburden containing clays and shale to heal the cracks.

The overburden cover is less than 900 feet where Muddy Creek crosses the eastern boundary of the Greens Hollow tract, which is the maximum predicted height of the rock fracture zone. However, 900 feet is based on mining 15 feet of the coal seam which can be reduced locally as necessary. Along this segment of Muddy Creek, there is potential for mining-induced subsidence to result in water loss from the creek into underground mine workings. This risk is further compounded where the Castlegate Sandstone is exposed or has insufficient overburden depth with clays or shales to heal cracks. In this case, water displacement due to surface tensile cracks could actually be lost to the mine workings rather than displaced within the stream channel.

Mining to within 350 feet of escarpments could result in destabilizing ground movements. Small, marginally stable rock overhangs, for instance, could fail in some canyons, depending on geometry of the block. The blocks at the leading edges of overhangs are most likely to spall because of reduced rock confinement in these areas.

3.2.2.4 Seismicity

Removal of the coal seam by the longwall mining technique usually results in caving of overburden rocks and load transfer to panel boundaries. Load transfer would result in the accumulation of stress at the longwall face and would contribute to rock noise (low level seismicity). Seismic impacts of concern for Greens Hollow tract include the following: perception of seismic events by National Forest System users, potential damage to stock ponds, and potential damage to structures and facilities. Structures and facilities would be protected under the lease contract, Special Stipulation #13 states: "Existing Forest Service owned or permitted surface improvements will need to be protected, restored, or replaced to provide for the continuance of current land uses".

Based on the results of modeling presented in the Mining, Subsidence, Seismicity, and Structures and Facilities Technical Report (Maleki 2008), the maximum probable seismic event is expected to be 3.4 on the Richter scale where mining occurs under thicker cover. At shallower cover, seismicity would be even more moderate, similar to that experienced in the permitted areas at the Pines Tract. These levels of seismicity are considered normal and acceptable for Wasatch Plateau coal fields, particularly where major surface structures, such as dams, are not present nearby. Thus, level of perception of seismic events by National Forest System users, including recreational users, is expected to be low. Potential for damage to stock ponds due to seismicity is expected to be low, and is discussed further in the Range Resources Summary Report. Potential for damage to other facilities is discussed in Section 3.2.2.5. Structures and facilities would be protected under Special Stipulation #13.

Issue 2: *Mining-induced subsidence could damage the Rough Brothers' Cabin.*

3.2.2.5 Structures and Facilities

The permanent strains may cause slight damage to Rough Brothers of the Hills cabin, a wooden structure. The potential damage may not be noticeable on the exterior because of its construction of flexible material (wood instead of steel). However, the concrete slab may show signs of strain (cracks). Slight

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damage may result in the long-term due to permanent tensile strains including cracks and deformation of doors (sticking) and windows. The Forest Service is not renewing the special use permit for the Rough Brothers of the Hills cabin and its associated facilities, and they are scheduled to be removed by December 31, 2016.

3.2.3 ALTERNATIVE 3 DIRECT AND INDIRECT EFFECTS

Issue 1: *Mining of the underground coal reserves can cause subsidence, non-uniform subsidence features, seismicity, and cracking of the ground surface.*

As with Alternative 2, the most important impact related to geology is the extraction of coal and related subsidence of the land with a minor potential impact of additional rock falls and accelerated spalling of the Castlegate Sandstone cliffs (and other smaller cliff faces). Alternative 3 would reduce the area of full subsidence in the Muddy Canyon, Greens Hollow, and North Fork of Quitchupah areas. Only the Muddy Canyon area alterations would likely decrease the potential for rock falls, due to the proximity of mining to the canyon edge.

3.2.3.1 Coal Resources

Under Alternative 3, coal resource-related impacts would change relative to Alternative 2. The total recoverable coal would decrease and the potential lost in-place resource would increase in the perimeter areas surrounding Alternative 2 (net small reduction). The result would be an economic loss since the in-place resource has not been assigned a value.

3.2.3.2 Oil and Gas Resources

Impacts to oil and gas resources would be similar to those described under Alternative 2. In this alternative, drilling would be less difficult due to the areas which would not be undermined, providing slightly more potentially drillable area which would not encounter subsurface mine workings.

3.2.3.3 Subsidence

Under Alternative 3, subsidence mining would be excluded from areas identified for protection, including stream segments with shallow overburden over the Castlegate Sandstone and along cliff escarpments, as shown in Map 2. Subsidence mining would be restricted in the North Fork of Quitchupah Creek, Muddy Creek, Cowboy Creek, and Greens Hollow drainages where the overburden is insufficient in thickness or rock types to facilitate healing of surface tensile cracks. Excluding subsidence mining from these areas would minimize the risk of water displacement, or loss in the case of Muddy Creek. Excluding subsidence mining from within 350 feet of cliff escarpments would minimize/eliminate the risk of spalling and rock fall that would be present under Alternative 2 if these features are undermined.

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3.2.3.4 Seismicity

Seismicity would essentially be the same as described under Alternative 2.

Issue 2: *Mining-induced subsidence could damage the Rough Brothers' Cabin.*

3.2.3.5 Structures and Facilities

Potential impact to structures and facilities would essentially be the same as described under Alternative 2.

3.2.4 Special Stipulations and Design Criteria

Monitoring and requirements to protect non-mineral resources are specified in the Special Coal Lease Stipulations which will be part of the lease. The Utah Coal Mining Rules at R645-525 require a pre-subsidence survey of all structures prior to mining. After mining, the coal operator would promptly repair or compensate the owners for any subsidence caused damage. Other design criteria to address impacts due to subsidence are listed in the specific resource section where the impacts are analyzed.

3.2.5 Cumulative Effects

This section considers the cumulative effects of the Greens Hollow tract project in the context of other past, on going, and reasonably foreseeable projects that have, or are likely to affect the geologic resources in the cumulative effects analysis area. The cumulative effects analysis area as defined for the geology analysis includes portions of the Muddy Creek and Quitchupah Creek watersheds that encompass the landscape setting for the Greens Hollow tract project. Specific past, present, and future activities affecting the cumulative effects analysis area are considered in the analysis below.

The effects of this project would be cumulative with other impacts occurring in the area. Subsidence effects would be limited to the full extraction areas (panels) and a perimeter area related to the angle of draw and depth of overburden. Impacts from adjacent tracts could cross tract boundaries on both the east and southern boundaries of the Greens Hollow tract. This would occur if the full extraction areas of the existing neighboring leases were near enough to common lease boundaries with the Greens Hollow tract. Cumulative subsidence impacts from adjacent tracts and the Greens Hollow tract would be less than or equal to those from full extraction areas on either side of the boundary.

On the east, only in the north-central part of Section 3 would the workings of the Greens Hollow tract come close enough to the Pines Tract lease to see subsidence east of the tract boundary. This would only be applicable for Alternative 2. In Alternative 3, mining on the Greens Hollow tract would be far enough from the tract boundary to cause no subsidence at the east boundary with the Pines Tract. There are no adjacent mines to the north or west of the tract.

Also related to coal mining is exploratory drilling. This drilling has been conducted in the cumulative effects analysis area to describe the geology and coal reserves. Additional exploratory drilling is anticipated to occur, including during the development of the Greens Hollow tract. This information would add to the geologic understanding of the cumulative effects area.

Cumulative impacts associated with livestock grazing, both historic and ongoing, and wildlife habit improvements, including water developments, controlled burns, and sagebrush treatments would not affect geologic resources to any notable degree.

Recreation use has resulted in primarily localized impacts, usually associated with campsites and ATV/off-road vehicle use. In some cases geologic resources have been exposed to erosive forces as surface materials are removed by these activities.

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MAPS, PLATES, AND FIGURES

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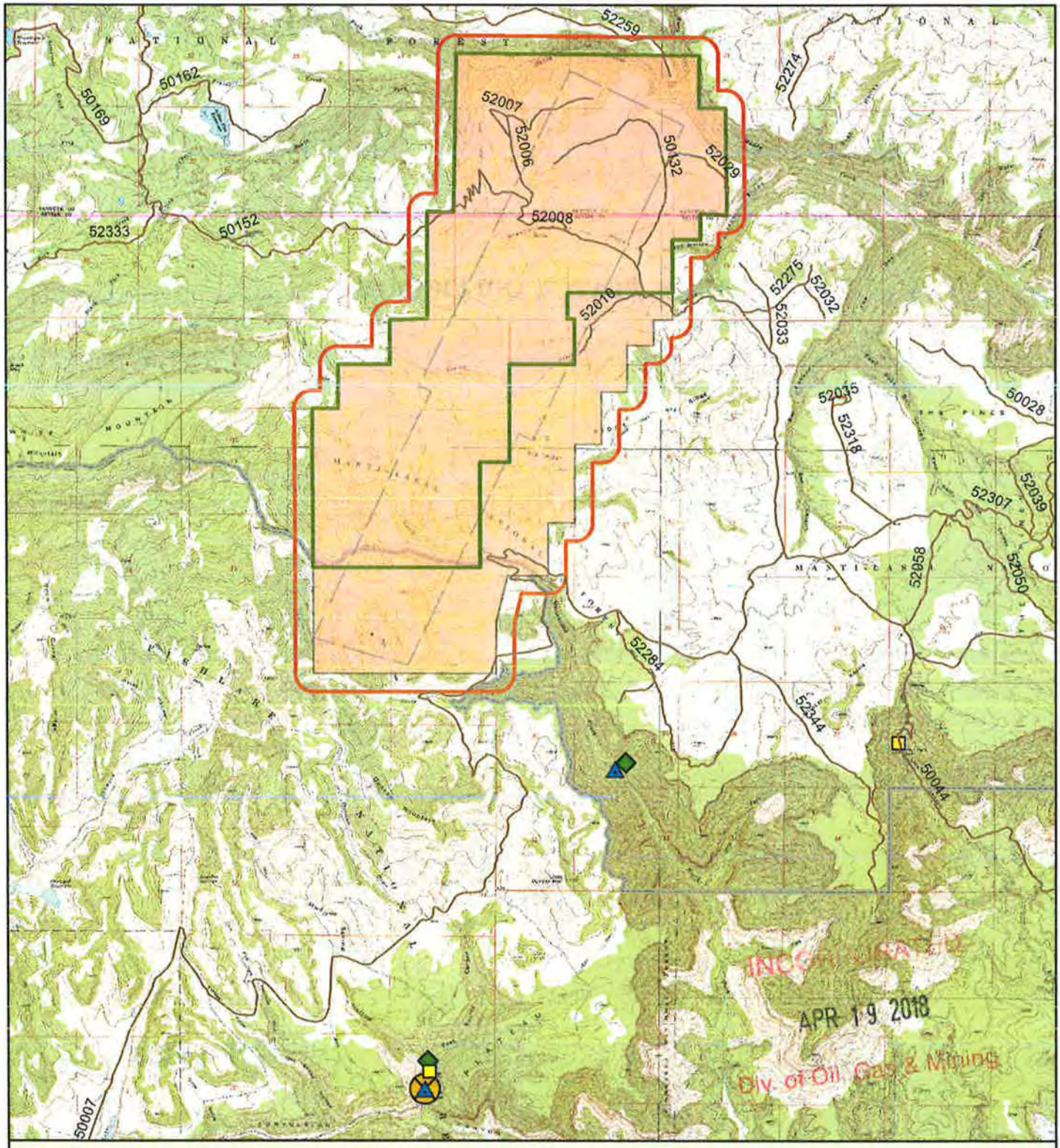

Map 1. Alternative 2 - Proposed Action.

Legend

- National Forest System Roads
- Substation Locations
- SUFCO Water Discharge
- Existing Fan Locations
- SUFCO Mine Portal
- Greens Hollow Coal Lease Tract
- Conceptual Mining Area
- Area of Subsidence Mining
- Mining Analysis Area Boundary
- Manti-La Sal/Fishlake Forest Boundary

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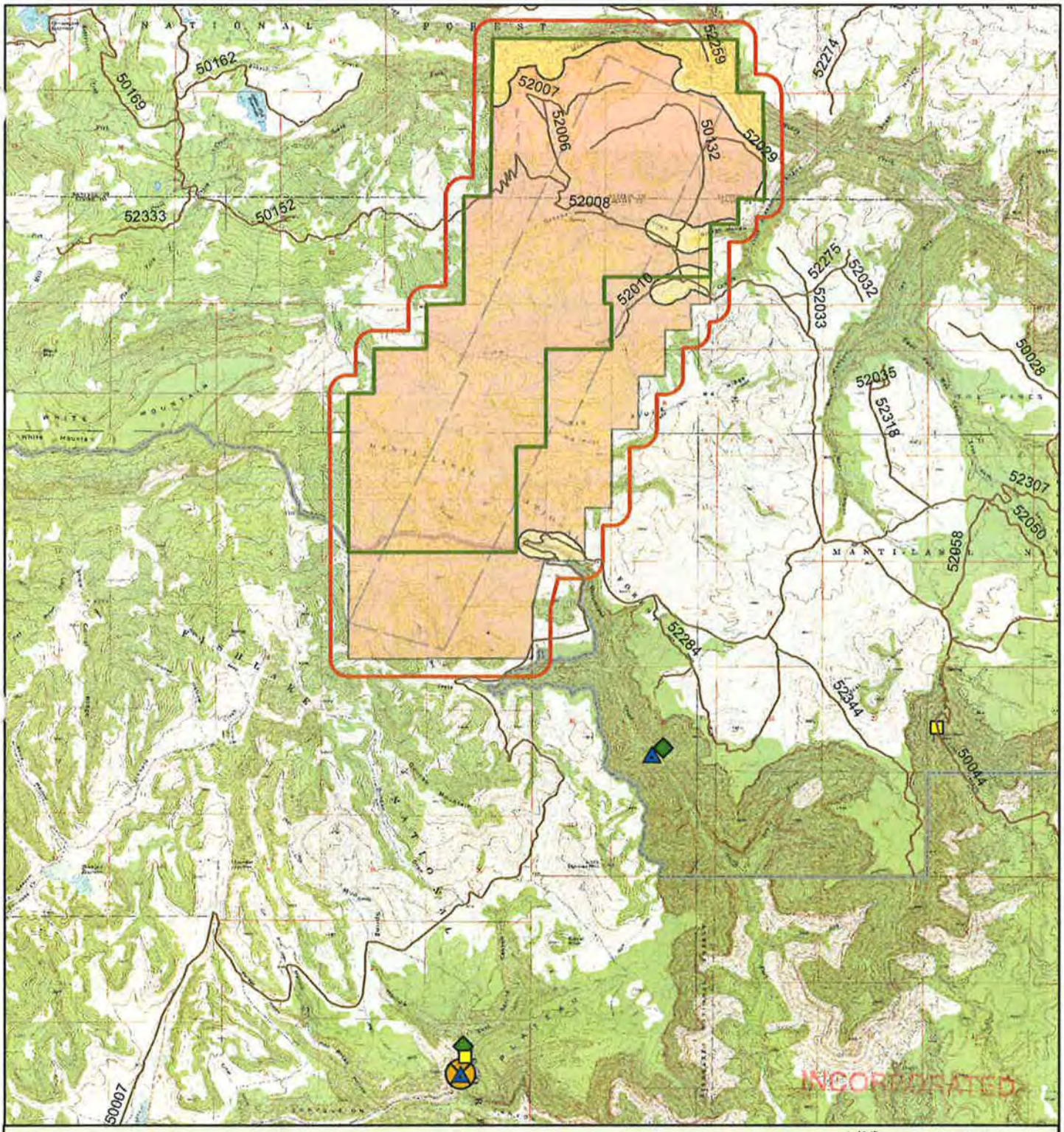

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Map 2. Alternative 3.

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Legend

- National Forest System Roads
- Substation Locations
- SUFCO Water Discharge
- Existing Fan Locations
- SUFCO Mine Portal
- Greens Hollow Coal Lease Tract
- Conceptual Mining Area
- Area of Subsidence Mining
- Area of No Subsidence Mining
- Mining Analysis Area Boundary
- Manti-La Sal/Fishlake Forest Boundary

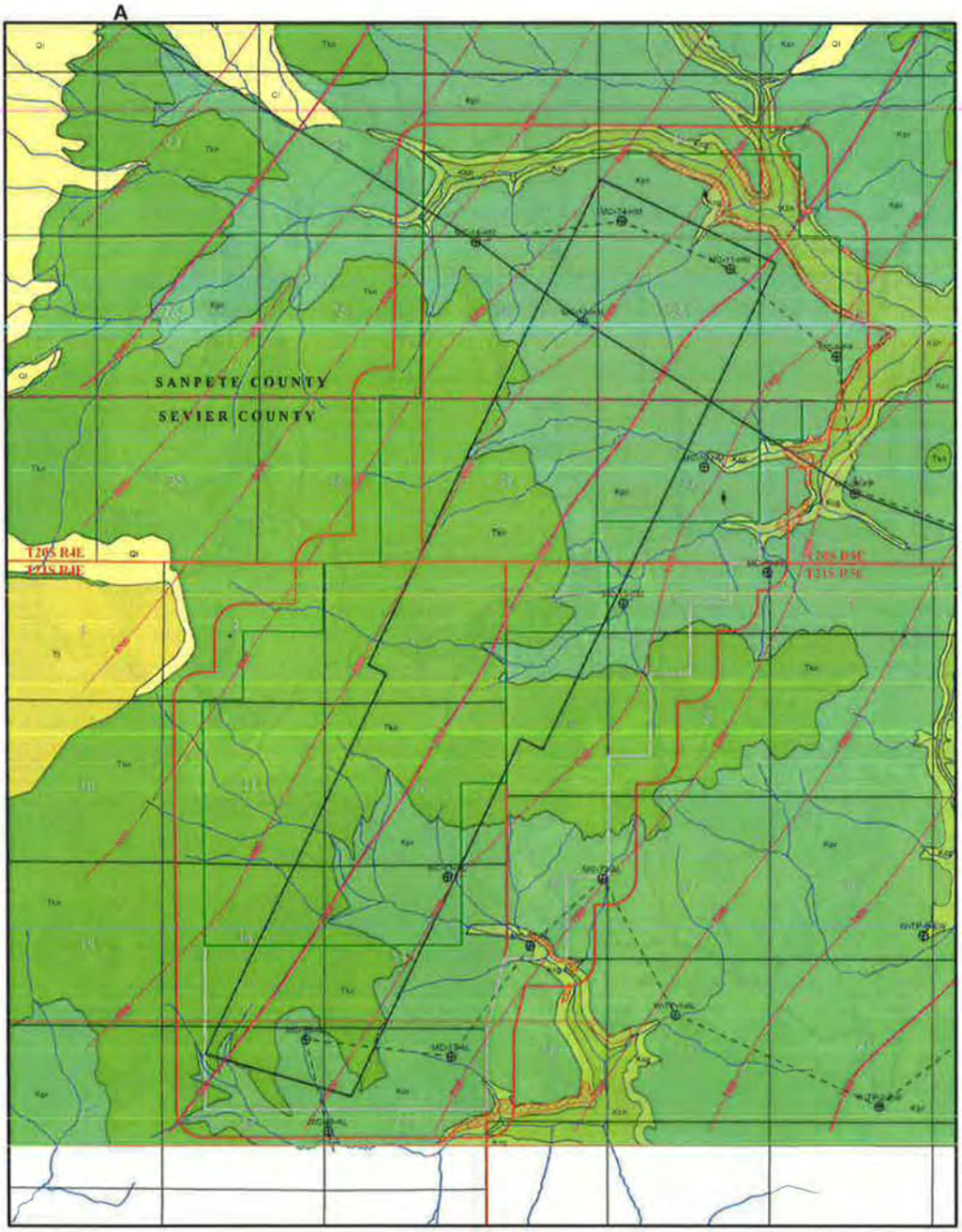

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Plate 1. Geologic Map

Cirrus Ecological Solutions, LC
Greens Hollow Tract

EXPLANATION

Land Boundaries

- Greens Hollow Coal Lease Tract
- Ark Land Proposed Mine Area
- Area of Subsidence Mining (Alt. 2)
- Mining Analysis Area Boundary

Paul B. Anderson | 10/15/08

Explanation

- Landslide/mass movement
- Flagstaff Limestone
- North Horn Formation
- Price River Formation
- Castlegate Sandstone
- Blackhawk Formation
- Star Point Sandstone (cross section only)
- Mancos Shale (cross section only)
- Rock fall potential areas
- Jointing
- Formational contact
- Structure contour (top Upper Hiawatha coal) (Contour interval 100 feet - dashed)
- Coal exploration drill hole
- Tract boundary
- Coal cross section (USGS, PP 1625-B)
- Cross section A - A'

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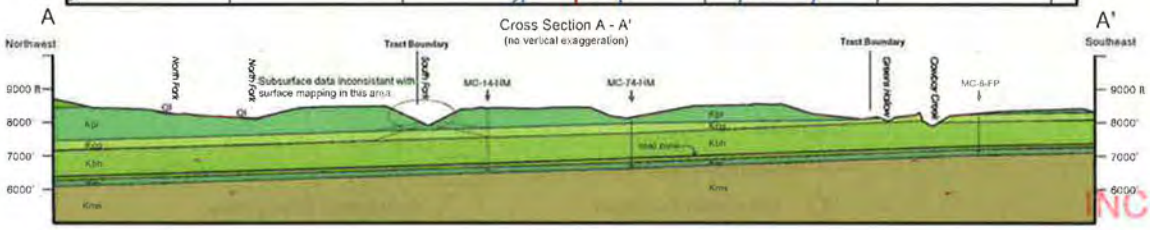

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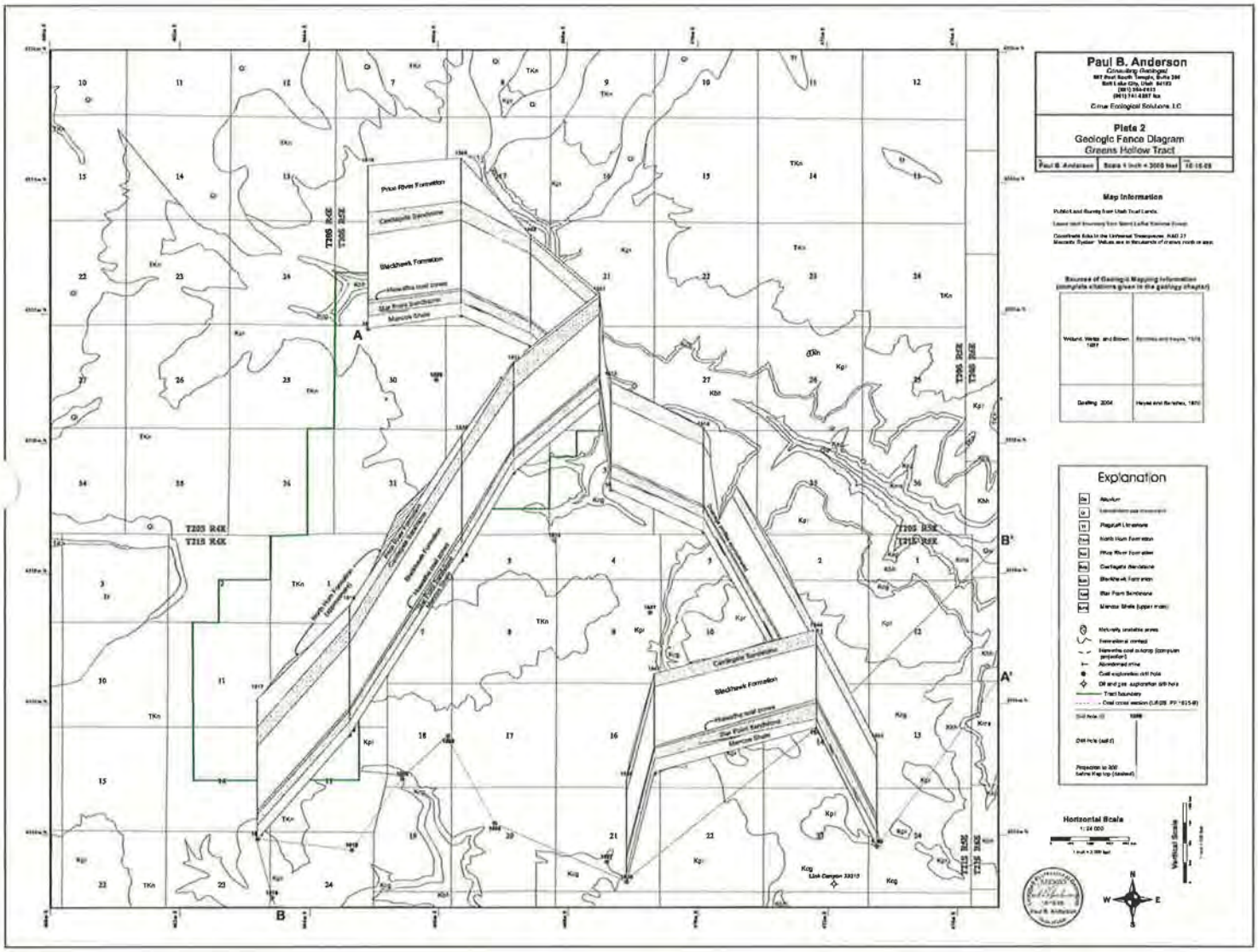

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Figure 1.

General Stratigraphy of the Greens Hollow Coal Lease Tract

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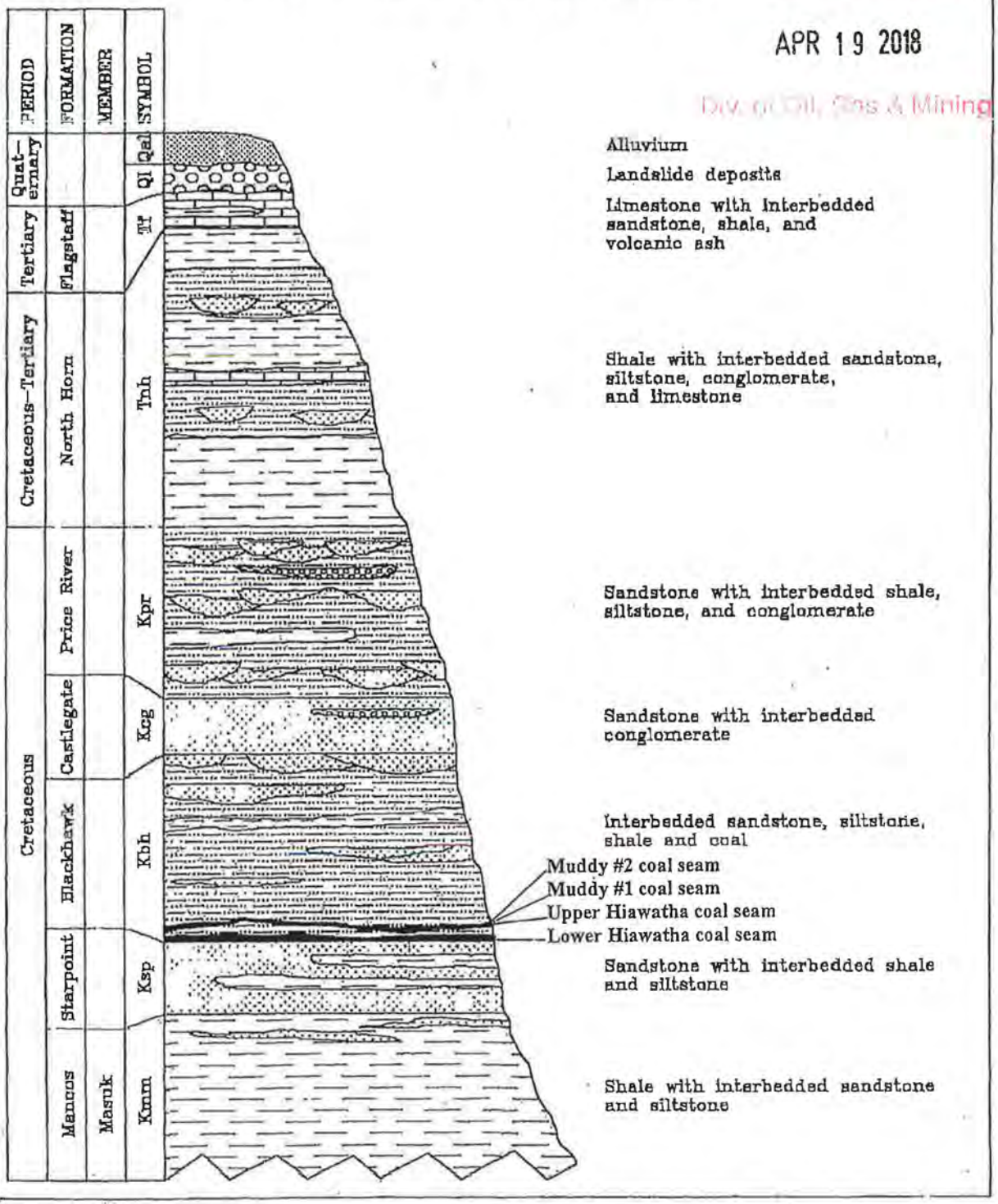

APPENDIX A: SUPPORTING DATA

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Greens Hollow Tract Air Photo Fracture Pattern Analysis												360		
Tract + Buffer, North-Trending Quadrant Fracture Data Values														
Air Photo ID	Area Designation (Public Land Survey System, Salt Lake Base and Meridian)				Stratigraphic Unit		Fracture Analysis Air Photo scale is 1:17500 (9 measures) * Use Engineer's 30 scale (1" = 1500', with smallest division = 50')						Assume	
Line - Photo ID	1/4 1/4	Section	Township	Range	all uppermost Castlegate		ID #	Quadrant (N=315-45 E=45-135)	Orientation (0 - 359)	Orientation (-45 to +45)	Length* (ft)	Spacing* (ft)		
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		9	N	0	-360	100			
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		10	N	0	-360	75	50		
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		11	N	0	-360	75			
200-184	sw 1/4	12	21S	5E	uppermost Castlegate		34	N	329	-31	175			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		13	N	329	-31	200	30		
200-185	e 1/2	11	21S	5E	uppermost Castlegate		14	N	329	-31	200			
600-137	nw 1/4	23	21S	5E	uppermost Castlegate		24	N	330	-30	175			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		6	N	331	-29	200			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		7	N	331	-29	175			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		8	N	331	-29	275			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		15	N	331	-29	200			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		25	N	331	-29	75	30		
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		26	N	331	-29	150	50		
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		27	N	331	-29	100			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		28	N	331	-29	200			
200-184	sw 1/4	12	21S	5E	uppermost Castlegate		33	N	331	-29	175			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		22	N	331	-29	175			
100-42	sw se	21	21S	5E	uppermost Castlegate		36	N	332	-28	525			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		9	N	332	-28	150			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		11	N	332	-28	175			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		24	N	332	-28	375			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		18	N	332	-28	175			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		1	N	333	-27	250			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		2	N	333	-27	100			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		3	N	333	-27	200			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		4	N	333	-27	125			
600-137	nw 1/4	23	21S	5E	uppermost Castlegate		25	N	333	-27	300			
600-137	nw 1/4	23	21S	5E	uppermost Castlegate		26	N	333	-27	175			
100-42	se nw	20	21S	5E	uppermost Castlegate		9	N	334	-26	275	30		
100-42	se nw	20	21S	5E	uppermost Castlegate		10	N	334	-26	575			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		4	N	334	-26	225	40		
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		5	N	334	-26	150			
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		10	N	334	-26	150			
200-185	e 1/2	11	21S	5E	uppermost Castlegate		5	N	334	-26	175	40		
200-185	e 1/2	11	21S	5E	uppermost Castlegate		6	N	334	-26	100			
600-137	se 1/4	15	21S	5E	uppermost Castlegate		8	N	334	-26	175			
100-42	se nw	20	21S	5E	uppermost Castlegate		21	N	335	-25	250			
100-42	se nw	20	21S	5E	uppermost Castlegate		31	N	335	-25	225			
100-42	se nw	20	21S	5E	uppermost Castlegate		32	N	335	-25	150			
600-137	ne sw	22	21S	5E	uppermost Castlegate		29	N	335	-25	200			
600-137	ne sw	22	21S	5E	uppermost Castlegate		30	N	335	-25	200			
100-38	e 1/2	33	20S	5E	uppermost Castlegate		22	N	335	-25	200			
100-38	e 1/2	33	20S	5E	uppermost Castlegate		23	N	335	-25	175			
100-38	e 1/2	33	20S	5E	uppermost Castlegate		24	N	335	-25	150			

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Greens Hollow Tract Air Photo Fracture Pattern Analysis												
									360			
Tract + Buffer, North-Trending Quadrant Fracture Data Values												
Air Photo ID	**Area Designation (Public Land Survey System, Salt Lake Base and Meridian)**				**Stratigraphic Unit**		**Fracture Analysis** Air Photo scale is 1:17500 (9 measures) * Use Engineer's 30 scale (1" = 1500', with smallest division = 50')					Assume
Line - Photo ID	1/4 1/4	Section	Township	Range	all uppermost Castlegate		ID #	Quadrant (N=315-45 E=45-135)	Orientation (0 - 359)	Orientation (-45 to +45)	Length* (ft)	Spacing* (ft)
100-42	se nw	20	21S	5E	uppermost Castlegate		26	N	336	-24	200	
100-42	se nw	20	21S	5E	uppermost Castlegate		27	N	336	-24	225	
100-42	sw se	21	21S	5E	uppermost Castlegate		35	N	336	-24	150	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		31	N	336	-24	200	30
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		32	N	336	-24	125	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		23	N	336	-24	300	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		24	N	336	-24	225	
600-137	ne sw	22	21S	5E	uppermost Castlegate		34	N	336	-24	100	50
600-137	ne sw	22	21S	5E	uppermost Castlegate		35	N	336	-24	100	
600-137	ne sw	22	21S	5E	uppermost Castlegate		39	N	336	-24	100	
600-137	ne sw	22	21S	5E	uppermost Castlegate		40	N	336	-24	75	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		2	N	336	-24	175	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		11	N	336	-24	300	
100-36	ne sw	21	20S	5E	uppermost Castlegate		8	N	337	-23	300	
100-42	w1/2 sw	20	21S	5E	uppermost Castlegate		2	N	337	-23	225	
100-42	n1/2 nw	20	21S	5E	uppermost Castlegate		3	N	337	-23	300	
100-42	se nw	20	21S	5E	uppermost Castlegate		15	N	337	-23	425	
100-42	se nw	20	21S	5E	uppermost Castlegate		16	N	337	-23	300	
100-42	se nw	20	21S	5E	uppermost Castlegate		28	N	337	-23	250	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		1	N	337	-23	400	40
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		2	N	337	-23	275	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		3	N	337	-23	175	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		8	N	337	-23	150	50
200-185	e 1/2	11	21S	5E	uppermost Castlegate		9	N	337	-23	175	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		10	N	337	-23	175	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		17	N	337	-23	200	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		18	N	337	-23	100	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		19	N	337	-23	450	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		21	N	337	-23	250	
600-137	nw 1/4	23	21S	5E	uppermost Castlegate		22	N	337	-23	575	
600-137	ne sw	22	21S	5E	uppermost Castlegate		31	N	337	-23	225	
600-137	ne sw	22	21S	5E	uppermost Castlegate		32	N	337	-23	200	
600-137	ne sw	22	21S	5E	uppermost Castlegate		33	N	337	-23	75	
100-36	e 1/2	33	20S	5E	uppermost Castlegate		25	N	337	-23	225	
100-36	se nw	21	20S	5E	uppermost Castlegate		7	N	338	-22	150	
100-42	n1/2 nw	20	21S	5E	uppermost Castlegate		5	N	338	-22	350	
100-42	se nw	20	21S	5E	uppermost Castlegate		22	N	338	-22	200	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		7	N	338	-22	250	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		19	N	338	-22	250	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		20	N	338	-22	150	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		21	N	338	-22	250	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		6	N	338	-22	200	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		7	N	338	-22	175	

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Greens Hollow Tract Air Photo Fracture Pattern Analysis												
							360					
Tract + Buffer, North-Trending Quadrant Fracture Data Values												
Air Photo ID	Area Designation (Public Land Survey System, Salt Lake Base and Meridian)				Stratigraphic Unit		Fracture Analysis Air Photo scale is 1:1 7500 (9 measures) * Use Engineer's 30 scale (1" = 1500', with smallest division = 50')					Assume
Line - Photo ID	1/4 1/4	Section	Township	Range	all uppermost Castlegate		ID #	Quadrant (N=315-45 E=45-135)	Orientation (0 - 359)	Orientation (-45 to +45)	Length* (ft)	Spacing* (ft)
600-137	nw 1/4	23	21S	5E	uppermost Castlegate		23	N	338	-22	150	
600-137	ne sw	22	21S	5E	uppermost Castlegate		27	N	338	-22	200	
600-137	ne sw	22	21S	5E	uppermost Castlegate		28	N	338	-22	250	
600-137	ne sw	22	21S	5E	uppermost Castlegate		41	N	338	-22	225	
100-36	se nw	21	20S	5E	uppermost Castlegate		1	N	339	-21	150	40
100-36	se nw	21	20S	5E	uppermost Castlegate		2	N	339	-21	425	40
100-36	se nw	21	20S	5E	uppermost Castlegate		3	N	339	-21	200	50
100-36	se nw	21	20S	5E	uppermost Castlegate		4	N	339	-21	200	50
100-36	se nw	21	20S	5E	uppermost Castlegate		5	N	339	-21	175	
100-36	se nw	21	20S	5E	uppermost Castlegate		6	N	339	-21	100	
100-42	se nw	20	21S	5E	uppermost Castlegate		29	N	339	-21	575	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		19	N	339	-21	150	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		22	N	339	-21	125	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		23	N	339	-21	200	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		29	N	339	-21	175	30
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		30	N	339	-21	200	
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		16	N	339	-21	250	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		12	N	339	-21	200	60
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		13	N	339	-21	150	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		14	N	339	-21	325	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		13	N	339	-21	150	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		28	N	339	-21	325	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		29	N	339	-21	250	50
600-138	w 1/2	15	21S	5E	uppermost Castlegate		30	N	339	-21	200	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		31	N	339	-21	275	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		10	N	339	-21	100	
100-38	nw se	33	20S	5E	uppermost Castlegate		11	N	339	-21	200	40
100-38	nw se	33	20S	5E	uppermost Castlegate		12	N	339	-21	150	
100-42	n1/2 nw	20	21S	5E	uppermost Castlegate		4	N	340	-20	225	
100-42	se nw	20	21S	5E	uppermost Castlegate		6	N	340	-20	375	
100-42	se nw	20	21S	5E	uppermost Castlegate		14	N	340	-20	225	
100-42	se nw	20	21S	5E	uppermost Castlegate		30	N	340	-20	275	
100-42	sw se	21	21S	5E	uppermost Castlegate		34	N	340	-20	500	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		12	N	340	-20	250	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		16	N	340	-20	200	60
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		17	N	340	-20	150	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		18	N	340	-20	400	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		20	N	340	-20	500	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		21	N	340	-20	250	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		16	N	340	-20	150	30
200-185	e 1/2	11	21S	5E	uppermost Castlegate		17	N	340	-20	175	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		25	N	340	-20	75	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		26	N	340	-20	325	

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Div. of Oil, Gas & Mining

Greens Hollow Tract Air Photo Fracture Pattern Analysis										360		
Tract + Buffer, North-Trending Quadrant Fracture Data Values												
Air Photo ID	Area Designation (Public Land Survey System, Salt Lake Base and Meridian)				Stratigraphic Unit		Fracture Analysis Air Photo scale is 1:17500 (9 measures) * Use Engineer's 30 scale (1" = 1500', with smallest division = 50')					Assume
Line - Photo ID	1/4 1/4	Section	Township	Range	all uppermost Castlegate		ID #	Quadrant (N=315-45 E=45-135)	Orientation (0 - 359)	Orientation (-45 to +45)	Length* (ft)	Spacing* (ft)
600-137	se 1/4	15	21S	5E	uppermost Castlegate		1	N	340	-20	175	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		2	N	340	-20	150	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		3	N	340	-20	200	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		4	N	340	-20	125	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		15	N	340	-20	325	40
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		16	N	340	-20	375	
600-137	ne sw	22	21S	5E	uppermost Castlegate		36	N	340	-20	225	
600-137	ne sw	22	21S	5E	uppermost Castlegate		37	N	340	-20	150	
600-137	ne sw	22	21S	5E	uppermost Castlegate		38	N	340	-20	200	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		32	N	340	-20	200	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		50	N	340	-20	200	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		51	N	340	-20	175	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		52	N	340	-20	125	30
600-138	se 1/4	15	21S	5E	uppermost Castlegate		53	N	340	-20	175	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		57	N	340	-20	150	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		58	N	340	-20	200	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		59	N	340	-20	225	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		22	N	340	-20	150	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		23	N	340	-20	175	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		24	N	340	-20	100	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		25	N	340	-20	150	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		26	N	340	-20	100	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		27	N	340	-20	125	
100-38	nw se	33	20S	5E	uppermost Castlegate		9	N	340	-20	225	40
100-38	nw se	33	20S	5E	uppermost Castlegate		10	N	340	-20	250	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		26	N	340	-20	150	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		27	N	340	-20	150	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		28	N	340	-20	200	
100-42	w1/2 sw	20	21S	5E	uppermost Castlegate		1	N	341	-19	300	
100-42	se nw	20	21S	5E	uppermost Castlegate		11	N	341	-19	200	
100-42	se nw	20	21S	5E	uppermost Castlegate		19	N	341	-19	150	
100-42	se nw	20	21S	5E	uppermost Castlegate		23	N	341	-19	150	
100-42	sw se	21	21S	5E	uppermost Castlegate		37	N	341	-19	500	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		12	N	341	-19	200	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		6	N	341	-19	100	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		16	N	341	-19	125	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		17	N	341	-19	125	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		18	N	341	-19	175	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		41	N	341	-19	125	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		47	N	341	-19	200	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		48	N	341	-19	175	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		49	N	341	-19	100	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		54	N	341	-19	175	

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Greens Hollow Tract Air Photo Fracture Pattern Analysis												
Tract + Buffer, North-Trending Quadrant Fracture Data Values												
Air Photo ID	Area Designation (Public Land Survey System, Salt Lake Base and Meridian)				Stratigraphic Unit		Fracture Analysis Air Photo scale is 1:17500 (9 measures) * Use Engineer's 30 scale (1" = 1500', with smallest division = 50')					Assume
Line - Photo ID	1/4 1/4	Section	Township	Range	all uppermost Castlegate		ID #	Quadrant (N=315-45 E=45-135)	Orientation (0 - 359)	Orientation (-45 to +45)	Length* (ft)	Spacing* (ft)
600-138	se 1/4	15	21S	5E	uppermost Castlegate		55	N	341	-19	150	
600-138	se 1/4	15	21S	5E	uppermost Castlegate		56	N	341	-19	175	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		19	N	341	-19	125	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		20	N	341	-19	225	
600-138	sw 1/4	10	21S	5E	uppermost Castlegate		21	N	341	-19	200	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		3	N	341	-19	250	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		4	N	341	-19	300	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		5	N	341	-19	250	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		8	N	341	-19	250	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		9	N	341	-19	150	
100-38	se nw	33	20S	5E	uppermost Castlegate		7	N	341	-19	325	50
100-38	se nw	33	20S	5E	uppermost Castlegate		8	N	341	-19	200	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		29	N	341	-19	200	
100-42	se nw	20	21S	5E	uppermost Castlegate		17	N	342	-18	125	50
100-42	se nw	20	21S	5E	uppermost Castlegate		18	N	342	-18	100	
100-42	se nw	20	21S	5E	uppermost Castlegate		20	N	342	-18	125	
100-42	se nw	20	21S	5E	uppermost Castlegate		24	N	342	-18	100	40
100-42	se nw	20	21S	5E	uppermost Castlegate		25	N	342	-18	100	
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		13	N	342	-18	225	50
200-184	ne 1/4	11	21S	5E	uppermost Castlegate		14	N	342	-18	275	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		11	N	342	-18	300	
200-185	e 1/2	11	21S	5E	uppermost Castlegate		15	N	342	-18	325	
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		13	N	342	-18	300	
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		14	N	342	-18	175	60
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		15	N	342	-18	200	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		11	N	342	-18	350	
600-137	ne 1/4	22	21S	5E	uppermost Castlegate		20	N	342	-18	200	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		2	N	342	-18	175	30
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		3	N	342	-18	125	40
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		4	N	342	-18	200	30
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		5	N	342	-18	175	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		14	N	342	-18	100	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		15	N	342	-18	225	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		37	N	342	-18	150	50
600-138	w 1/2	15	21S	5E	uppermost Castlegate		38	N	342	-18	200	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		39	N	342	-18	150	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		40	N	342	-18	150	
100-38	nw nw	33	20S	5E	uppermost Castlegate		1	N	342	-18	150	
100-38	nw nw	33	20S	5E	uppermost Castlegate		2	N	342	-18	225	
100-38	nw nw	33	20S	5E	uppermost Castlegate		3	N	342	-18	375	
100-38	nw nw	33	20S	5E	uppermost Castlegate		4	N	342	-18	150	
100-38	nw nw	33	20S	5E	uppermost Castlegate		5	N	342	-18	175	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		19	N	343	-17	75	30

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Greens Hollow Tract Air Photo Fracture Pattern Analysis										360		
Tract + Buffer, North-Trending Quadrant Fracture Data Values												
Air Photo ID	**Area Designation** (Public Land Survey System, Salt Lake Base and Meridian)				**Stratigraphic Unit**		**Fracture Analysis** Air Photo scale is 1:17500 (9 measures) * Use Engineer's 30 scale (1" = 1500', with smallest division = 50')					Assume
Line - Photo ID	1/4 1/4	Section	Township	Range	all uppermost Castlegate		ID #	Quadrant (N=315-45 E=45-135)	Orientation (0 - 359)	Orientation (-45 to +45)	Length* (ft)	Spacing* (ft)
200-45	s 1/2	19	21S	5E	uppermost Castlegate		20	N	343	-17	75	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		21	N	343	-17	225	40
200-45	s 1/2	19	21S	5E	uppermost Castlegate		22	N	343	-17	100	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		23	N	343	-17	100	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		5	N	343	-17	200	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		9	N	343	-17	200	
600-137	se 1/4	15	21S	5E	uppermost Castlegate		10	N	343	-17	350	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		10	N	343	-17	100	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		11	N	343	-17	275	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		12	N	343	-17	650	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		42	N	343	-17	225	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		43	N	343	-17	150	30
600-138	w 1/2	15	21S	5E	uppermost Castlegate		44	N	343	-17	125	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		45	N	343	-17	150	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		46	N	343	-17	200	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		18	N	343	-17	275	40
100-38	e 1/2	33	20S	5E	uppermost Castlegate		19	N	343	-17	300	
100-36	se sw	21	20S	5E	uppermost Castlegate		9	N	344	-16	100	
100-42	se nw	20	21S	5E	uppermost Castlegate		7	N	344	-16	725	
100-42	se nw	20	21S	5E	uppermost Castlegate		8	N	344	-16	350	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		17	N	344	-16	175	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		18	N	344	-16	300	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		7	N	344	-16	125	30
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		8	N	344	-16	125	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate		9	N	344	-16	100	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		33	N	344	-16	275	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		34	N	344	-16	500	60
600-138	w 1/2	15	21S	5E	uppermost Castlegate		35	N	344	-16	200	
600-138	w 1/2	15	21S	5E	uppermost Castlegate		36	N	344	-16	150	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		17	N	344	-16	175	
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate		12	N	345	-15	300	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		24	N	345	-15	100	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		26	N	345	-15	125	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		27	N	345	-15	75	
200-45	s 1/2	19	21S	5E	uppermost Castlegate		28	N	345	-15	125	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		1	N	345	-15	200	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		6	N	345	-15	300	
600-139	w 1/2	3	21S	5E	uppermost Castlegate		7	N	345	-15	100	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		13	N	345	-15	225	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		14	N	345	-15	100	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		15	N	345	-15	150	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		16	N	345	-15	200	
100-38	e 1/2	33	20S	5E	uppermost Castlegate		21	N	345	-15	250	

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Greens Hollow Tract Air Photo Fracture Pattern Analysis										360			
Tract + Buffer, North-Trending Quadrant Fracture Data Values													
Air Photo ID	**Area Designation (Public Land Survey System, Salt Lake Base and Meridian)**					**Stratigraphic Unit**		**Fracture Analysis** Air Photo scale is 1:17500 (9 measures) * Use Engineer's 30 scale (1" = 1500', with smallest division = 50')					Assume
Line - Photo ID	1/4 1/4	Section	Township	Range	all uppermost Castlegate			ID #	Quadrant (N=315-45 E=45-135)	Orientation (0 - 359)	Orientation (-45 to +45)	Length* (ft)	Spacing* (ft)
200-45	s 1/2	19	21S	5E	uppermost Castlegate			25	N	346	-14	150	
600-138	w1/2 ne	10	21S	5E	uppermost Castlegate			1	N	346	-14	150	
100-36	se sw	21	20S	5E	uppermost Castlegate			11	N	347	-13	175	40
100-36	se sw	21	20S	5E	uppermost Castlegate			12	N	347	-13	250	
100-36	se sw	21	20S	5E	uppermost Castlegate			13	N	347	-13	225	
100-36	se sw	21	20S	5E	uppermost Castlegate			14	N	347	-13	225	40
100-36	se sw	21	20S	5E	uppermost Castlegate			15	N	347	-13	150	30
100-36	se sw	21	20S	5E	uppermost Castlegate			16	N	347	-13	125	
200-45	se 1/4	18	21S	5E	uppermost Castlegate			3	N	347	-13	75	
100-42	sw se	21	21S	5E	uppermost Castlegate			33	N	348	-12	400	
200-45	se 1/4	18	21S	5E	uppermost Castlegate			2	N	348	-12	400	
200-45	se 1/4	18	21S	5E	uppermost Castlegate			4	N	348	-12	75	50
200-45	se 1/4	18	21S	5E	uppermost Castlegate			5	N	348	-12	200	
200-45	se 1/4	18	21S	5E	uppermost Castlegate			6	N	348	-12	250	
200-45	se 1/4	18	21S	5E	uppermost Castlegate			7	N	348	-12	125	
100-38	e 1/2	33	20S	5E	uppermost Castlegate			32	N	349	-11	100	40
100-38	e 1/2	33	20S	5E	uppermost Castlegate			33	N	349	-11	75	
200-45	e1/2 ne	19	21S	5E	uppermost Castlegate			8	N	350	-10	150	
200-45	se 1/4	18	21S	5E	uppermost Castlegate			1	N	355	-5	125	
Statistics:													
Count										**278**	**278**	**278**	**44**
Maximum		**maximum value in the distribution**								**355**	**-5**	**725**	**60**
Minimum		**minimum value in the distribution**								**0**	**-360**	**75**	**30**
Average		**mean of the distribution**								**---**	**-24**	**207**	**42**
St. Dev.		**standard deviation of the distribution**								**---**	**35**	**103**	**10**
Median		**the value in the middle of the distribution**								**---**	**-20**	**200**	**40**
Mode		**the most frequent occurring or repetitive value of the distribution**								**---**	**-20**	**200**	**40**

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CHAPTER 7

HYDROLOGY

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CHAPTER 7
HYDROLOGY

7.10 Introduction

7.1.1 General Requirements

This chapter presents a description of:

- existing hydrologic resources within the permit and adjacent areas;
- proposed operations and the potential impacts to the hydrologic balance;
- methods of compliance with design criteria;
- applicable hydrologic performance standards; and
- hydrologic reclamation plans for the SUFCO Mine.

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS) . The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text. The Greens Hollow Tract Lease area was originally part of the Muddy Creek Tract, reports and documents referring to the Muddy Creek Tract in this chapter text and appendices are applicable to the Greens Hollow Tract. The Muddy Creek Tract should not be confused with the SITLA Muddy Tract.

7.1.2 Certification

All maps, plans, and cross sections presented in this chapter have been certified by a qualified, registered professional engineer.

7.1.3 Inspection

Impoundments associated with the mining and reclamation operations will be inspected as described in Section 5.1.4.3 of this M&RP.

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7.20 Environmental Description

7.2.1 General Requirements

This section presents a description of the premining hydrologic resources within the permit area and adjacent areas that may be affected or impacted by the proposed coal mining and reclamation operation.

7.2.2 Cross Sections and Maps

7.2.2.1 Location and Extent of Subsurface Water

Groundwater occurs in perched zones of limited areal extent within the leased area. The PHC studies conducted by Mayo and Associates (Appendix 7-17 and Appendix 7-18) have determined that none of the formations down through the Blackhawk support a continuous aquifer. According to Mayo's research all of the aquifers within the permit area and adjacent areas are perched and discontinuous so it is not possible to represent a potentiometric surface for the area.

Seasonal variations in well water levels are discussed in Section 7.2.4.1.

The PHC for the Greens Hollow Lease area is located in Appendix 7-28 and discusses subsurface water.

7.2.2.2 Location of Surface Water Bodies

A map showing the location of surface water bodies (such as streams, ponds, and springs) for which water rights exist or for which there are pending water rights applications is provided as Plate 7-2. A listing of water rights data (names, locations and ownership) is presented in Appendix 7-1. Other than for the indicated springs, no water rights exist for groundwater in the permit and adjacent areas.

7.2.2.3 Locations of Monitoring Stations

Surface water and groundwater monitoring stations associated with the SUFCO operation are located as shown on Plate 7-3. Approximate surface elevations of the monitoring stations are also indicated on Plate 7-3.

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7.2.2.4 Location and Depth of Water Wells

No water-supply wells exist in the permit or adjacent areas. Groundwater monitoring wells in the area are located as shown on Plate 7-3. Depths of these wells and other completion details are summarized in Table 7-1.

Greens Hollow. Well MW-15-5-2 is located near Cowboy Creek (Plate 7-3). The well depth is approximately 295' deep. The well was drilled in 2015 has consistently been dry during monitoring,

An in-mine monitoring well will be drilled into the Starpoint Sandstone to below the coal seam during 2019. The well will be drilled as close to the Greens Hollow Lease boundary as possible with the location being determined by safety, access and etc. The well location will be added to Plate 7-3 and 7-10 once the well has been completed. The well's drill log with depth and other relevant information will be added to Appendix 6-1 (confidential) and a description of the well's groundwater quality will be included in Appendix 7-27 once the information is available. Observation wells that are monitored as part of the SUFCO hydrologic monitoring program are monitored three times per year.

7.2.2.5 Surface Topography

Surface topographic features in the permit and adjacent areas are shown on the base maps used for Plate 7-3.

7.2.3 Sampling and Analysis

All water samples collected for use in this M&RP have been analyzed according to methods in either the "Standard Methods for the Examination of Water and Wastewater" or 40 CFR parts 136 and 434. Where feasible, these same references have been used as the basis for sample collection.

7.2.4 Baseline Information

Surface water, groundwater, and climatic resource information is presented in this section to assist in determining the baseline hydrologic conditions which exist in the area of the mine. This information provides a basis to determine if mining operations have had, or can be expected to have, a significant impact on the hydrologic balance of the area.

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TABLE 7-1

OBSERVATION WELL COMPLETION SUMMARY[a]

Well Number	Total Drilled Depth (ft)	Elev. Top of Casing (ft)	Total Depth Cased (ft)	Casing ID (in)	Length of Perf. (ft)	Formation Monitored[b]
US-77-7	1220	8495.7	Unknown	1.25	Unknown	Unknown
US-77-8	1140	8424.6	160	1.25	110	Kc
US-77-9	1140	8360.2	100	1.25	75	Lower Kc/Upper Kbh
US-79-9	970	8541.8	860	2.0	20	Upper Hiawatha Coal
US-79-10	990	8553.8	880	2.0	20	Upper Hiawatha Coal
US-79-12	990	8523.1	860	2.0	20	Upper Hiawatha Coal
US-79-13	1014	8527.6	710	2.0	20	Kbh
US-80-2	207	8380.0	200	4.0	40	Kc
US-80-4	245	8394.0	240	4.0	40	Kc
US-81-1	1300	8492.3	1300	2.0	20	Upper Hiawatha Coal
US-81-2	1450	8688.0	1460	2.0	20	Upper Hiawatha Coal
US-81-3	1980	9029.4	1940	6.0/2.0	20	Upper Hiawatha Coal
US-81-4	1300	8383.9	1300	4.5	20	Upper Hiawatha Coal
89-16-1	1065	8374.2	1003	2.875	60	Upper and Lower Hiawatha
89-16-1W	160	8374.8	154	2.875	60	Kc
89-18-1	1300	8405.8	1282	2.875	60	Upper and Lower Hiawatha
89-20-1	1025	8272.1	983	2.875	60	Upper Hiawatha Coal
89-20-2	1022	8359.5	975	2.875	60	Upper and Lower Hiawatha
89-20-2W	170	8358.8	167	2.875	60	Kc
89-21-1	1014	8389.8	973	2.875	60	Upper and Lower Hiawatha
01-8-1	1910	8994.1	1865	2.375	20	Upper Hiawatha Coal

(a) See Plate 7-3 for well locations

(b) Kc = Castlegate Sandstone member of the Price River Formation. Kbh = Blackhawk Formation

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7.2.4.1 Groundwater Information

This section presents a discussion of baseline groundwater conditions in the mine area. A discussion of the groundwater conditions in the SUFCO leased area is presented in this section and appended by Appendix 7-17. A discussion of groundwater conditions in the Pines Tract is presented in Appendix 7-18 of this Chapter. A discussion of groundwater conditions in the West Coal Lease Modifications is presented in Appendix 7-24 of this Chapter. A discussion of groundwater conditions at the waste rock disposal site is provided in Waste Rock Volume of this M&RP.

The locations of wells and springs in the mine area are presented on Plate 7-3. The wells in the mine area are all water monitoring wells, not water supply wells. Water rights for the mine and adjacent areas are addressed in Section 7.2.2.2 of this M&RP. With the exception of the potable use of source 94-87 by SUFCO, all other groundwater use (seeps and springs) is confined to stock watering. The hydrology in the area of the 2RWL sinkhole are discussed in the PHC located in Appendix 7-24.

Greens Hollow. Appendix 7-27 contains selected water monitoring data for the Green Hollow Tract. The appropriated water rights within the Greens Hollow Lease belong to the USFS. The PHC for the Greens Hollow Lease is located in Appendix 7-28.

AQUIFERS

Geologic conditions in the permit and adjacent areas are described in detail in Chapter 6 of this M&RP. Groundwater occurrences within the permit and adjacent areas occurs predominantly in the Blackhawk Formation and Star Point Sandstone. However, perched aquifers of limited areal extent are present in the geologic formations. Hydrogeologic conditions within the permit and adjacent areas are summarized below. Refer to the PHC's in Appendices 7-17 thru 7-20, 7-24, 7-26, 7-28 for more specific information.

North Horn Formation. The North Horn Formation crops out in the northwest portion of the lease area. This formation consists of interbedded shale, sandstone, and limestone. Data presented in Appendix 7-2 indicate that only one seep and one spring issue from the North Horn Formation within the lease area. Recharge occurs to outcrops of the North Horn Formation west of the lease

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area (Thiros and Cordy, 1991). Thus, it may serve as an aquifer in some portions of the western adjacent area.

Upper Price River Formation. The upper Price River Formation consists of about 450 feet of interbedded sandstone and claystone. Within the area, the upper Price River Formation has not been identified as a significant aquifer. Thiros and Cordy (1991) estimated that combined recharge to the upper Price River Formation and the Castlegate Sandstone is limited to 1.2 percent of the total annual precipitation. As indicated in Appendix 7-2, a few isolated springs have been identified discharging from the sandstone lenses within the formation. No groundwater has been identified within this formation during the exploration drilling which has been conducted from the top of the plateau. As a result no monitoring or water supply wells have been completed in this formation within the mining area.

Five monitoring wells have been completed in a massive sandstone unit in the Price River Formation at the waste rock disposal site. Hydrographs of three representative wells (B-3, B-6, and B-8) are depicted in Figure 7-1. Seasonal fluctuations are typically less than one foot in wells B-3 and B-6, and less than three feet in B-8. All three wells display a general downward trend in water levels from spring to late summer (see also Appendix 7-4 and Waste Rock Volume).

Castlegate Sandstone. The Castlegate Sandstone consists of an estimated 120 to 260 feet of medium to coarse-grained sandstone with a few thin interbedded mudstones or shales near the base. The sandstone is conglomeratic, forms prominent cliffs along the outcrop, and is well cemented with calcarious cement.

A limited number of springs issue from the Castlegate Sandstone in the Quitchupah lease area, with flow generally less than 1 gpm. In the Pines Tract area, several springs issue from and near the base of the Castlegate Sandstone. The waters from these springs feed the Main Fork and East Fork of Box Canyon Creek. Base flow from these springs is generally less than 1 to 2 gpm with a few flowing at rates of 5 to 6 gpm.

Based on information from the exploration drill holes and observation wells in the area, the Castlegate Sandstone contains small quantities of groundwater. No significant quantities of

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groundwater (more than 2 gpm) were encountered in any of the exploration holes nor was groundwater identified in all drill holes.

Of the observation wells completed in the Castlegate Sandstone, two (US-77-9 and 89-16-1W) have been dry during their entire period of record. Two additional wells (US-77-8 and 89-20-2W) have only a brief period of record (due to lack of water or time since installation, respectively). Hydrographs of the remaining two Castlegate Sandstone observation wells (US-80-2 and US-80-4) are presented in Figure 7-2. Water-level data for all wells are provided in Appendix 7-3. Seasonal fluctuations of groundwater levels in these wells have typically been less than one foot.

Coal exploration holes drilled in and near the Pines Tract by the USGS, have geophysical logs indicating similar conditions for the Castlegate Sandstone. Exploration Hole W-TP-4-EW found fluids present at a depth of 82 feet below ground surface, within the Castlegate Sandstone. Exploration holes W-TP-3-EW and W-TP-2-EW did not encounter fluids within the Castlegate Sandstone.

This formation is not considered to be a significant regional aquifer. It is assumed that the groundwater occurrence within the Castlegate Sandstone is limited to isolated perched zones contained in the more permeable sandstone lenses or within weathered bedrock and fractures/joints at and near the escarpments within Box Canyon. Because groundwater occurrence within the Castlegate Sandstone is not continuous over the permit and adjacent areas, no potentiometric surface could be developed for the unit.

The data presented in Figure 7-2 indicate a downward trend in static water levels for the Castlegate Sandstone. This trend is most probably due to decreased precipitation during the last several years. A discussion of climatic conditions in the permit and adjacent areas is provided in Section 7.2.4.4 of this M&RP.

Groundwater recharge to the Castlegate Sandstone is from precipitation and snowmelt. Over much of the area, the Castlegate Sandstone and the remainder of the Price River Formation form the surface of the plateau. However, as evidenced by the fact that the Castlegate is not continuously saturated, total recharge is probably low. This is due to the lack of a significant

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developed soil to encourage infiltration and the presence of low permeability shales in the upper Price River Formation (see Waddell et al., 1979).

Discharge from the Castlegate Sandstone occurs mainly as springs along the outcrop and as through-flow to the underlying Blackhawk Formation. As indicated above, spring flow from the unit is limited in flow and in occurrence. These springs are used only for livestock and wildlife watering. Besides the monitoring wells completed in the Castlegate Sandstone, no known wells are completed in the formation.

Blackhawk Formation. The Blackhawk Formation underlies the Castlegate Sandstone and consists of about 710 to 830 feet of interbedded sandstone, siltstone, shale, and coal. The Upper Hiawatha coal seam, mined by SUFCO, is located near the base of the Blackhawk Formation. During the drilling of the exploration and observation holes, groundwater was encountered in each of the drill holes; however, no significant quantities of water were identified in any of the holes.

Recharge to the Blackhawk Formation occurs mainly from vertical movement of water from the overlying Castlegate Sandstone. Recharge from direct infiltration where the Blackhawk Formation is exposed is considered to be negligible due to the limited area of exposure. The quantity of groundwater recharge in the region area has been estimated to be 3 to 8 percent of the average annual precipitation (Danielson and Sylla, 1983).

Discharge from the Blackhawk Formation occurs from springs, seeps, and the SUFCO Mine. Based on both the drilling and underground observations, groundwater flow in the Blackhawk Formation appears to occur primarily along fractures. Few springs or seeps are present in the Blackhawk sandstone lens outcrop areas. This suggests that general flow through the pores in the sandstone is not significant.

Generally, flow rates from the springs and seeps issuing from the Blackhawk Formation are moderate to low in the spring and decline through the summer and into the fall (Appendix 7-1). These flow rates are typically less than 1 gpm with a few flowing at a slightly higher rate in the Pines Tract area.

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At the SUFCO mine, groundwater is encountered in the underground workings. Since 1982, the mine has discharged at an average flow rate of 580 gpm (1.29 cfs). The underground water is primarily encountered at the working faces and is associated with faults, fractures, and roof bolt holes. As with many of the mines in the Wasatch Plateau, these zones yield water readily when new areas are opened, but inflow rates normally decrease rapidly as mining progresses. The inflow rates are commonly less than 5 gpm at any given point and cease after a few months, suggesting the presence of perched aquifers of limited areal extent. Monitoring point SUFCO-062, which has been the only underground monitoring point for inflow, averages 0.0011 cfs (0.49 gpm).

Hydrographs of water levels in selected Blackhawk Formation observation wells are presented in Figure 7-3. As indicated in these hydrographs and the remaining data provided in Appendices 7-3, seasonal water-level fluctuations are typically less than two feet. However, the long-term trend is for water-level elevations to be decreasing.

The downward trend in water-level elevations is probably caused by two factors. First, decreased precipitation during the past few years (see Section 7.2.4.4 of this M&RP) has contributed to lower groundwater recharge in the area. Second, interception of groundwater by mining operations has increased groundwater discharge from the area.

Star Point Sandstone. The Star Point Sandstone is fine to medium grained in texture with the coarser grained material occurring in the upper portions of the formation. The Star Point forms a well defined cliff between the slopes of the Mancos Shale and the overlying Blackhawk Formation. Except where eroded or exposed in deep canyons, the Star Point Sandstone underlies the entire lease area.

In 1989, four monitoring wells were completed in the basal Blackhawk/upper Star Point Sandstone Formation. The wells ranged from 1012 to 1300 feet deep and were completed in the intervals indicated on Table 7-1. These holes did not encounter significant quantities of groundwater.

Recharge to the Star Point Sandstone probably occurs primarily from vertical movement of the water through the overlying Blackhawk Formation. Discharge from the Star Point is considered to be primarily to adjacent canyons at the contact with the underlying Mancos Shale. These discharge points are generally covered with alluvial fill of the stream systems. Therefore, little surface expression of the discharge has been identified. This was noted in Convulsion Canyon, however there was no evidence of this occurring in Muddy Creek Canyon.

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Mancos Shale. Underlying the mine area and exposed in the deep canyons is the Mancos Shale. This dark, slope-forming, marine shale is relatively impermeable and is not considered to be a regional or local aquifer (Danielson and Sylla, 1983).

Quaternary Alluvium. Unconsolidated Quaternary deposits are present along streams and generally consist of silts, sands, and occasional gravels. The deposits, which have low to moderate permeability, receive water from the adjacent bedrock in some of the deeply incised canyons. Discharge from these materials is to the surface water system. SUFCO collects water in the alluvium at the base of East Spring Canyon and pumps it to the mine for use as culinary water. The average flow from this source is approximately 25 gpm. Water is probably supplied to the alluvium by seepage from the Blackhawk Formation and Star Point Sandstone.

RECHARGE

Recharge within the area occurs primarily on the exposed upland outcrops of the Price River Formation and the Castlegate Sandstone. The annual recharge to these units is estimated to be 1.2 percent of the total annual precipitation. "Much recharge occurs" on outcrops of the Flagstaff Limestone and the North Horn Formation west of the lease area (Thiros and Cordy, 1991). Recharge to the Blackhawk Formation and the Star Point Sandstone probably occurs primarily from vertical movement of water through the overlying formations. The Mancos Formation underlies the entire area and is exposed in the deep canyons. It is relatively impermeable. Groundwater descending from the Star Point Sandstone flows along the Mancos-Star Point contact and discharges to the surface.

Locally, recharge is probably greater where surface fractures intersect topographic highs (plateaus). These areas occur where the North Horn Formation or the Castlegate Sandstone crops out (Thiros and Cordy, 1991). The North Horn Formation crops out in the northwest corner and along the western border of the lease area. The Castlegate Sandstone generally crops out along the top edges of the steep-walled canyons (Plate 6-1). However, in the east and north central parts of the permit area, the Castlegate Sandstone caps the plateaus in relatively large areas. According to Thiros and Cordy (1991), recharge is increased where fractures extend down through the Price River Formation to the Castlegate Sandstone. This may occur in the southwestern corner of the permit area where subsidence cracks have been seen to penetrate the Castlegate Sandstone and Price River Formation (Thiros and Cordy, 1991). Additionally, faults along the western and northern margins of the permit area may increase secondary permeability, thus locally increasing recharge.

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Recharge occurs in the northwest corner (T.21 S., R.4 E., sections 11 and 23) and the northeastern part of the permit area (T.21 S., R.5 E., section 16). The first area is a topographic high and fractured where the North Horn Formation crops out. The second area is a topographic high, capped by the Price River Formation. Linear features that imply fracturing are located in this area (Plate 6-1 and SUFCO, 1992).

Recharge to shallowly circulating groundwater systems within the Castlegate Sandstone and Blackhawk Formation also occurs in the Pines Tract area. These shallow groundwater systems appear to occur within approximately 1000 feet of the Box Canyon escarpments.

The recharge age for water flowing into the SUFCO mine was estimated at 70 years or older (Thiros and Cordy, 1991). Mayo and Associates (1997a and 1997b) identified mean groundwater residence times for in-mine discharges of 7,000 to 20,000 years. This indicates that recharge to the Blackhawk aquifer is not being affected by the increased hydraulic conductivities created by subsidence.

Assuming mass-balance and stable hydrologic conditions in the permit area, over the long term, recharge must be equal to discharge. Recharge occurs mostly on the plateaus and over time moves vertically downward primarily along fractures. Where perched aquifers are encountered, the groundwater may flow through the aquifer until it meets an impermeable layer. Vertical flow typically does not extend below the top of the Mancos Formation.

Greens Hollow Tract

In 2015 and 2016 samples were collected at underground locations as close as possible to the Greens Hollow Tract to be analyzed for age and one sample was analyzed for water chemistry. Three locations were sampled with the recharge age for the waters sampled being similar to conclusions previously in this section. Refer to information/drawing provided and discussed in the PHC in Appendix 7-28, including a sampling location drawing.

Pre-mine head in the coal has been measured in four observation wells completed in the Upper Hiawatha coal seam in the vicinity of Duncan Mountain. The three wells near the edge of the Wasatch Plateau were found to be dry. The head in the mine following cessation of mining and pumping would be expected to recover to approximately 80 percent of the premining level. Based on this assumption the heads in the mined-out area of the Greens Hollow tract would be expected to remain below the elevation at the outcrop of the Hiawatha coal seam near the edge of the Wasatch Plateau. Pressure redistribution with the coal supports rapid recovery of about 80 percent

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of the potentiometric levels to pre-mining levels. The final 20 percent of recovery occurs more slowly. Most of the water entering the coal during final recovery is stored within units of the Blackhawk Formation. Any effects on the ground water discharges from the underlying Star Point Sandstone or the hydrogeologic units located stratigraphically above the coal would be low and unmeasurable. (Cirrus, (2013c).

According to the FSEIS "water conveying faults are not expected to be encountered during underground mining in the Greens Hollow Tract". Anderson (2004a) found faulting in the study area to be minimal. Should water underground be encountered that is flowing directly from formation greater than 1 CFS, which continually flows for 30 days, a sample will be collected for lab analysis. The sample will be analyzed for the parameters listed on Table 7-2, subcategory D9. The analysis for tritium age dating will be completed once during the 30 day sampling period (carbon 14, carbon 13 and tritium). Flow measurements will be taken weekly until access is no longer available and /or flow stabilizes/stops. A map will be created showing the approximate panel location of the flow (as described above), the monitoring information and map will be incorporated into Appendix 7-27.

Mine Water Management System. Water is both pumped to and from mining districts underground. Process water is pumped into mining districts for uses on the longwall and in continuous miner sections. During the mining process water is primarily used on the longwall shearer, continuous miner, roof bolter and along conveyor belts for dust suppression. Water is also used in a mining district to clean equipment and assist with maintenance work. Water is collected from the mining districts in sumps, where particulate matter can settle prior to being either re-circulated for use, pumped to a sealed mine workings for storage/further treatment or discharged to the surface. The mine discharges water as UPDES Outfall 003 the location is shown on Plate 7-3.

WATER QUALITY

Observation wells and springs that are monitored as part of the SUFCO hydrologic monitoring program are monitored three times per year. Due to the general inaccessibility of the sample points during the winter, no winter sampling occurs. A historical summary of water-quality analyses for groundwater samples (wells, springs and mine inflow) collected from the permit and adjacent areas is presented in Appendix 7-4.

Groundwater-quality samples have been collected in the permit and adjacent areas from:

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* Springs that issue from the North Horn Formation, the upper Price River Formation, the Castlegate Sandstone, the Blackhawk Formation, and the Star Point Sandstone,
* In-mine monitoring well finished in the Starpoint Sandstone formation in the vicinity of the Greens Hollow Lease boundary,
* Monitoring wells at the waste-rock disposal site that are completed in the upper Price River Formation, and
* Mine inflow that issues from the Blackhawk Formation.

Results of analyses of these samples have been submitted to UDOGM. Historical results are summarized in Appendix 7-4.

Historical data have been collected from one spring issuing from the North Horn Formation (SUFCO-057A). Over its period of record, the water issuing from this spring has been a calcium bicarbonate type with an average total dissolved solids (TDS) concentration of 371 mg/l and an average pH of 7.5. Total and dissolved iron concentrations have averaged 0.24 and 0.02 mg/l, respectively. Total manganese concentrations have averaged 0.09 mg/l. Except for one apparent outlier, dissolved manganese concentrations at the spring have averaged 0.04 mg/l. Insufficient data are available to determine seasonal trends in water quality from this spring.

One spring and three monitoring wells completed in the upper Price River Formation have been sampled in the permit and adjacent areas. Historical data collected from the spring (GW-13) indicates that this water is a sodium bicarbonate type with an average TDS concentration of 745 mg/l and an average pH of 7.3. Dissolved iron and dissolved manganese concentrations have averaged 0.08 and 0.05, respectively, during the period of record. Data concerning total iron and total manganese are not available. The limited data suggest that pH and TDS concentrations are inversely proportional to flow while iron and manganese concentrations are directly proportional to flow. However, the data base is currently insufficient (seven sampling events) to draw detailed conclusions.

Historical data collected from the monitoring wells (located at the waste-rock disposal site) indicate that the water in this area is of mixed chemical type with no consistently dominant ions. TDS concentrations in groundwater immediately underlying the waste-rock disposal site are high relative to other portions of the permit area (average TDS concentration of 2100 to 6170 mg/l), with average pH values that are approximately neutral (varying between the wells from 6.8 to 7.2). Dissolved iron and dissolved manganese concentrations have averaged 0.1 mg/l or less at the three wells (with the exception of one apparent outlier manganese value). Data concerning total

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iron and total manganese are not available. Although there are no historic seasonal trends in the available data, the water quality data show that in 1991, sulfate and bicarbonate concentrations increased and chloride concentrations and pH values decreased from spring to fall (Appendix 7-4 and Waste Rock Volume).

TDS concentrations generally increase in the downgradient direction beneath the waste-rock disposal site. This increase is natural as evidenced by data collected prior to the onset of waste-disposal operations. The relatively high TDS concentrations at the site (compared, for example, with spring GW-13) and the downgradient increases in these concentrations are considered to be the result of natural dissolution of minerals in the general vicinity of the site.

Three springs issuing from the Castlegate Sandstone (SUFCO-001, SUFCO-089, and GW-21) were sampled as part of the SUFCO hydrologic monitoring program. All water issuing from these springs is a calcium bicarbonate type, with historic mean TDS concentrations varying from 82 to 302 mg/l. The average TDS concentration between all three springs was 238 mg/l.

Spring waters issuing from the Castlegate Sandstone and Blackhawk Formation in the Pines Tract area are also calcium bicarbonate type. Historic TDS concentrations vary from 90 to 450 mg/l. Additional information regarding the physical and chemical characteristics of the springs in the Pines Tract is contained in Appendix 7-18 in the Probable Hydrologic Consequences of Mining in the Pines Tract Area, SUFCO Mine.

The pH of water issuing from the Castlegate Sandstone springs is approximately neutral. Dissolved iron and dissolved manganese historically averaged 0.03 and 0.01 mg/l, respectively, at SUFCO-001 and GW-21. At SUFCO-089, dissolved iron and dissolved manganese averaged 0.47 and 0.17 mg/l, respectively. At SUFCO-001, total iron and total manganese concentrations historically averaged 0.11 and 0.01 mg/l, respectively. None of the chemical data have exhibited consistent seasonal trends.

Historical data collected from stations SUFCO-047 and SUFCO-062 are considered representative of the Blackhawk-Star Point aquifer. Although station SUFCO-047 consists of seepage collected from alluvium and used for the mine domestic water supply, it is regarded as being fed by outflow from the adjacent Blackhawk-Star Point aquifer. Station SUFCO-062 represents inflow to the mine from the surrounding Blackhawk Formation.

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Groundwater from these two sources is a calcium bicarbonate type, with historical TDS concentrations averaging 373 to 492 mg/l and pH values averaging 7.2 to 7.5. Between the two sources, average total iron concentrations range from 0.08 to 0.15 mg/l while average dissolved iron concentrations are both equal to 0.02 mg/l. Total manganese concentrations average 0.05 to 0.06 mg/l between the two sources, while dissolved manganese concentrations average 0.02 to 0.05 mg/l. The data have not exhibited consistent seasonal trends.

As a general point of comparison, the ground water quality analyses were compared to the primary drinking water standards (40 CFR 141) and the secondary drinking water standards (40 CFR 143). These comparisons indicate that there were no exceedances of the primary drinking water standards for any of the groundwater samples. Exceedances of the secondary drinking water standards were found in groundwater samples only for sulfate and TDS concentrations (with recommended standards of 250 mg/l and 500 mg/l, respectively). All of the sulfate exceedances and most of the TDS exceedances occurred in groundwater collected from monitoring wells at the waste-rock disposal site. These exceedances are probably due to the natural dissolution of marine salts known to exist in the local strata (Waddell et al., 1981).

4 Right 4 East Panel - Water Quality

The area of the panel was initially surveyed for surface and ground water resources in the late 1980's and early 1990's to provide information for the USFS and BLM Environmental Assessment of the Quitchupah Lease (U-63214) and the US Geological Survey Water Resources Investigation Report 90-4084. At approximately 11:30 AM on April 24, 2017 a walking survey of the surface above and immediately adjacent to the panel was conducted by a qualified CFC employee to locate surface and groundwater resources. The day was cloudy with a temperature of approximately 50 degrees F and wind ranging from approximately 5-10 mph. There were no surface or groundwater sources identified during the survey. Two exploration wells were drilled in August of 2017 near the 4R4E panel. The head geologist over the drilling project reported that no water was encountered in either well while drilling. See Table 7-11 below for drill hole locations, completion dates and other information. See Plate 7-10C for the 4R4E drillhole logs and 7-11 for the drillhole location map. The closest know surface water is an established natural pond approximately 3/4 mile northwest of the panel in T21S, R5E, Section 28.

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Table 7-11

SUFCO 2017 DRILLHOLE INFORMATION- 4RIGHT 4 EAST PANEL AREA								
Drill Hole ID	Date Completed	UTM Z12 WGS 84 Utah State Plane SLB Nad 27				Collar	TD (ft)	Water Encountered
		EAST	NORTH	EAST	NORTH	Elev (ft)		
17-34-1	8/14/17	469641.30	4311077.10	2042787.07	223975.43	8620.15	1018	No water encountered drill with no circulation
17-34-2	8/9/17	470248.20	4311437.40	2044772.46	225168.69	8659.34	1037	No water encountered drill with no circulation

Greens Hollow Tract

The description is based on and extensive three year study of the Muddy Creek area and a 2-mile buffer surrounding the tract performed by Cirrus in 2004 and the continuation of sampling by the Permittee. Springs were identified as occurring in the Castlegate, Price River and North Horn formations. "The overall risk for permanent water loss at any spring located within the tract should be relatively low" (FSEIS, 2015).

Cirrus- A total of 33 springs were measured for flow and various parameters during the spring and fall seasons for 2001 to 2004. A summary of the collected data in included in the Tables 2A & B located in the PHC Tables. Water quality samples were collected for laboratory analysis from eight springs during 2001 - 2004. The field parameter monitoring results for the springs indicate that the relevant criteria for the State of Utah with the exception of dissolved oxygen, which is typically low in springs. Laboratory analysis met the relevant criteria except for some slight exceedances in arsenic, cadmium, lead, TDS, selenium and zinc. Based on the knowledge of local geology and soil the water chemistry reflects natural conditions.

The permittee continued monitoring selected springs and surface water locations shown on Plates 7-3, 7-10 and the data is summarized in the PHC in Appendix 7-28. Summaries include data spring data for M-SP 4 - 12, 14,15, 19, 20, 40, 41, 44, 45, 53, 60 and etc.

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7.2.4.2 Surface Water Information

WATER QUANTITY

Major surface drainages in the permit and adjacent areas are depicted in Figure 7-4. As indicated, the lease area exists entirely within the Muddy Creek watershed. Most of the lease area drains southward into Quitchupah Creek via the North Fork of Quitchupah Creek and various ephemeral tributaries. Quitchupah Creek flows southeastward into Ivie Creek which in turn flows eastward into Muddy Creek. The northeast portion of the lease area, including the majority of the Pines Tract, drains into Muddy Creek via Box Canyon.

Based on flow data obtained during the collection of water-quality samples, the following streams are considered perennial:

- North Fork of Quitchupah Creek (as measured at stations SUFCO-007 and SUFCO-042
- South Fork of the North Fork of Quitchupah Creek (as measured at station SUFCO-006)
- Quitchupah Creek (as measured at stations SUFCO-041 and SUFCO-046)
- Box Canyon, including East Fork Box Canyon (as measured at stations SUFCO-090, Pines 403, Pines 407 and Pines 408)
- Muddy Creek (as measured at stations Pines 405 and Pines 406)
- Cowboy Creek (as measured at station M-STR4)

According to Thiros and Cordy (1991), Link Canyon contains an ephemeral stream. Two small areas of riparian vegetation are supported in the canyon by discharge from springs near the head of the canyon (Link Canyon Spring GW-21, Plate 7-3) and the abandoned Link Canyon Mine workings (Link Portal West and Link Portal East, Plate 7-3). Water from Spring GW-21 near the head of Link Canyon typically flows only about 300 to 750 feet below the source, depending upon the season. Water discharged from the Link Canyon portals typically flows on the surface for 500 feet or less during early spring. In 2002, the surface flow only reached about 250 feet downstream of the portals.

Link Canyon, in the area of the portals, is typified by four types of stream gradient segments or reaches. The initial drainage segment, Segment 1, flows across a low gradient surface with a slope of approximately 3 percent (Plate 7-9). The drainage sits on top of the Castlegate Sandstone

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and the channel floors consist of bed rock with a thin covering of loose, fine to coarse grain sands and silts. Channels can be shallow and broad or narrow and deeply incised in the minimal soil cover. Surface water is observed flowing in this reach only after significant storm events or on a few warm days during the spring runoff. No significant riparian vegetation is associated with this reach of the drainage.

From the point where the drainage enters the canyon near spring GW-21 (which discharges from the Castlegate Sandstone) to a point approximately 1200 feet downstream, the gradient increases to approximately 12 percent. In this reach, Segment 2, the drainage is cutting through the Castlegate Sandstone and the channel floors are typified by very shallow soils consisting of sand. Bedrock is exposed at or near the surface in the channel walls in this reach. The channel itself is in the very bottom of the canyon and in locations where soil is present, it is deeply incised in the soils with steep, eroding banks. This area of the drainage is typically heavily grazed by livestock. Water flows from the springs for about 300 to 750 feet in the channel bottom before disappearing into the sands of the channel floor, into the bedrock, or evaporates. Riparian vegetation is supported in this reach beginning at spring Pines 100 and continuing downstream about 1200 feet. The riparian vegetation consists of alders, willows, wild rose, horsetails, etc. The riparian vegetation is limited generally to the floor of the channel and the spring areas (Plate 7-9). The riparian vegetation does extend further downstream than typical surface flows suggesting water does continue to flow in the subsurface downstream of where surface water disappears. The vegetation typical of this area has been described in Chapter 3 of this M&RP.

The third segment of the stream, Segment 3, is approximately 1500 feet long and extends from a point approximately 1200 feet below Pines 100 to a point approximately 250 feet below the Link Canyon Mine Portals. The slope of the gradient in this reach is approximately 50 percent. The drainage cuts through the Blackhawk Formation and the upper Star Point Sandstone. This reach is typified by alternating sandstone ledges and shaley slopes with little to no soil cover. The channel contains large boulders, cobbles and gravel and at times is poorly defined. Surface water above the mine portals has only been observed in this reach during and shortly after significant storm events. Surface water flows downstream of the portals for a distance typically less than 500 feet. Riparian vegetation is located slightly upstream and for approximately 800 feet below the Link Canyon portals. This vegetation is typified by willow, alder, stinging nettle, rose, horsetail, carex, Kentucky Bluegrass, rush, and clematis. As in segment 2, the riparian vegetation is typically

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limited to the bottom of the channel or a short distance up the channel walls. This suggests that the water source for these plants is the water discharged from the mine into the channel and not an areal extensive aquifer discharging to the channel at numerous locations and elevations.

The final reach of the drainage, Segment 4, described herein runs from a point beginning approximately 250 feet below the portals to the USFS boundary and the south section line of Section 26, or approximately 2600 feet. The slope of the gradient in this reach is approximately 10 percent. The drainage channel cuts through the Mancos shale in this reach and typically has a floor of sandstone cobbles and boulders resting in fine to coarse sand and silt. The channel itself can be incised in the minimal soil cover or be broad and flat where bedrock is exposed and little soil cover is found. Surface water would flow in this reach only after significant precipitation events. However, in five years of monitoring the two sites, Link 001 (located near the base of the third stream segment) and 002 (located near the base of the fourth stream segment), surface water has not been observed in the channel.

Station locations are indicated on Plate 7-3. All other streams within the permit and adjacent areas are ephemeral, unless specified otherwise.

Based on channel-geometry measurements and a technique described by Fields (1975), Waddell et al. (1981) estimated that the historic average annual flow of Quitchupah Creek is approximately 3800 acre-feet immediately above the confluence with Link Canyon. With a drainage area of 85.4 square miles (Waddell et al., 1981), this results in a unit-area average annual streamflow of 44.5 acre-feet per square mile per year (AF/mi^2/yr) for Quitchupah Creek above Link Canyon.
The U.S. Geological Survey collected streamflow data from Ivie Creek from 1951 through 1961 at a station located approximately 11 miles south of the mine surface facilities. During the period of record, data published by the U.S. Geological Survey indicate that the average annual streamflow at this station was 2830 AF/yr. Based on a published drainage area of 50 mi^2, the unit-area average annual streamflow of upper Ivie Creek was 56.6 AF/mi^2/yr. This compares favorably with the unit-area yield of Quitchupah Creek and with the mean annual water yields presented by the Utah Division of Water Resources (1977).

Seasonal variations in historic streamflow in the vicinity of the lease area are portrayed graphically in Figure 7-5. The Muddy Creek station is located approximately 6 miles downstream from the

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confluence of Box Canyon and Muddy Creek while the Ivie Creek station was located about 11 miles south of the mine surface facilities. These trends (which are considered representative of perennial streams in the permit and adjacent areas) indicate that peak monthly stream flows in the area generally occur in May or June, probably as a result of snowmelt runoff. The Ivie Creek data also indicate that an additional rise in the monthly hydrograph occurs in July or August, probably as a result of summer thunderstorm activity.

Even though selected stations have been monitored for over eight years, no streamflow data are available for ephemeral drainages in the permit and adjacent area. When it does occur, ephemeral runoff in the area is expected to occur predominantly in the months of July, August, and September as a result of thunderstorm activity. These storms are expected to result in runoff with a short duration and high intensity.

Greens Hollow Tract

Surface runoff from the tract flows into tributaries of Muddy Creek and the North Fork of Quitchupah Creek. Watersheds for the tract include most of the Greens Canyon, Greens Hollow, Cowboy Creek, North Fork Quitchupah Creek and South Fork Quitchupah Creek watersheds. The main stem of Muddy Creek is perennial as it passes along the northern edge of the Greens Hollow tract. North Fork of Quitchupah Creek does not flow into Muddy Creek but does have perennial flow. According to USGS records the annual average flow for Muddy Creek near Emery is 37.5 cfs (USGS 2013). In 2001 the average flow was 33.2 cfs.

A loss/gain study for Greens Canyon and its tributaries, Greens Hollow and Cowboy Creek was done in 2001. The study showed losses for the streams in the Blackhawk Formation and Castlegate Sandstone. Cirrus was not confident that this study was representative of normal conditions. Quarterly field visits by Cirrus to stock ponds in the Muddy Creek Tract boundary from summer 2002 through fall 2003 showed most ponds being empty by early summer.

Cirrus did monitoring of surface water and as did the permittee, locations are shown on Plate 7-3 and the data is summarized in Tables 2A & B in PHC. Summaries include data for the South Fork of Quitchupah (Upper), U-Mud and MSTR-6.

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Small catchment ponds have been constructed in the permit and adjacent areas to capture water for wildlife and stock watering. Those catchment ponds are located as shown on Plate 7-2 and on a plate in Appendix 7-27 (Ponds, Troughs and Water Monitoring Locations). Appendix 7-27 contains a table providing historic (2008 -2017) information about the ponds inside the Greens Hollow Lease boundary and within an approximate one mile radius of the lease boundary. The catchment ponds capture water either from an adjacent spring and/or precipitation (rain, snow, etc). SUFCO commits to visiting the ponds (M-P 02 - 05, 07 -10 and GH-P01 thru 09) within the Greens Hollow Lease and immediately adjacent area when accessible in the spring of each year (typically late April to June), photographing each pond, observe the pond for evidence of cracking, estimate the depth and surface area of water contained in the pond, inspect the immediate drainage area for evidence of surface cracking, note general soil moisture conditions within the pond, and note the general condition of the pond. The same data will be collect during an additional monitoring visit made in the Fall annually (typically late September to early November). The pond monitoring information will be compiled and submitted in an annual report or provided to the Division's hydrologist upon written request (e-mail, etc.). Refer to Appendix 7-27 for additional information pertaining to ponds adjacent to and within the Greens Hollow Lease.

The Sufco mine has three UPDES discharge monitoring points. The locations of these points are shown on Plate 7-3.

UPDES monitoring point 001 represents an emergency mine discharge point that is used only in the event of a failure of the mine dewatering system. To discharge from this point, the emergency in-mine pump must be started and the valve on the discharge pipe must be manually opened. When the point is used, water is discharged into the East Spring Canyon 72-inch bypass culvert shown on Plate 7-6.

UPDES monitoring point 002 represents discharge from the East Spring Canyon sedimentation pond. Discharge from this point occurs only infrequently as a result of pond dewatering.

UPDES monitoring point 003 (equivalent to hydrologic monitoring station SUFCO-021) represents normal discharge from the underground workings into the North Fork of Quitchupah Creek. As indicated in the 1990 annual report, discharge at this point averaged approximately 550 gpm during the period of 1983 through 1990. From 1988 through 1990, this discharge rate generally increased

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from a pre-1988 rate of about 450 gpm to about 1,000 gpm (see Figure 7-6). Discharge rates tend to relate to coal production rates and are not seasonally affected.

Note that the waste-rock disposal area sedimentation pond does not have a UPDES permit since this is a total-containment, non-discharge facility (see the Waste Rock Volume of this M&RP).

WATER QUALITY

Surface-water quality samples have been collected in the permit and adjacent areas from stations located on Quitchupah Creek, the North and South Forks of Quitchupah Creek, mine discharges into the North Fork of Quitchupah Creek, drainages to Muddy Creek and Box Canyon. Historical data from these sources are summarized in Appendices 7-4, 7-17 and 7-18.

Historical data collected from stations SUFCO-006 (upper South Fork of Quitchupah Creek) and SUFCO-007 (upper North Fork of Quitchupah Creek) indicate that water in the upper reaches of this drainage is predominantly a calcium-bicarbonate chemical type with an average TDS concentration that varies from about 330 to 470 mg/l. The pH of this water is slightly alkaline, averaging 7.9 to 8.0. Total iron concentrations at these stations typically ranges from 1.7 to 3.0 mg/l, with dissolved iron concentrations averaging 0.03 to 0.04 mg/l. Total manganese concentrations at these stations average 0.11 to 0.12 mg/l, with dissolved manganese concentrations averaging 0.02 to 0.05 mg/l.

Alkalinity typically exceeds acidity at these upper stations by a factor of approximately 25. TDS concentrations tend to be inversely proportional to flow, while total iron and manganese concentrations are typically directly proportional to flow. Consistent seasonal variations in pH, dissolved iron, and dissolved manganese concentrations are not apparent.

The historical mine discharge at SUFCO-021 (UPDES monitoring station 003) is a calcium-bicarbonate-sulfate water with an average TDS concentration of 603 mg/l and an average pH of 7.4. Sulfate concentrations in the mine-water discharge average 236 mg/l. This compares with an average sulfate concentration of 81 mg/l between stations SUFCO-006 and -007 and an average of 66 mg/l in the mine inflow (station SUFCO-062). This increase in sulfate (and TDS) in the mine-water discharge as compared with adjacent surface and underground water may be the result of dissolution of the calcium-sulfate based rock dust used in the mine.

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Total and dissolved iron concentrations in the mine-water discharge average 0.08 and 0.03 mg/l, respectively. Total and dissolved manganese concentrations in this water average 0.02 and 0.01 mg/l, respectively. On the average, the alkalinity exceeds the acidity by a factor of approximately 20. The chemical data have not exhibited consistent seasonal variations.

At the mouth of the North Fork of Quitchupah Creek (SUFCO-042), the predominant ions are calcium, bicarbonate, and sulfate. The average historical TDS concentration at this location is 518 mg/l, with an average pH of 7.9. Total and dissolved iron concentrations at this station average 3.4 and 0.03 mg/l, respectively, with total and dissolved manganese concentrations averaging 0.08 and 0.01 mg/l, respectively. Alkalinity exceeds acidity by a factor of more than 20.

TDS concentrations at SUFCO-042 are generally inversely proportional to flow, while total iron and manganese concentrations are directly proportional to flow. Seasonal variations in pH, dissolved iron, and dissolved manganese are not apparent.

Stations SUFCO-046 and SUFCO-041 monitor Quitchupah Creek above East Spring Canyon and above the North Fork of Quitchupah Creek, respectively. Average historical TDS concentrations at these stations vary from 697 to 685 mg/l, with pH averaging 7.6 to 8.0. Water in Quitchupah Creek is of mixed chemical type. Average total iron concentrations range from 0.28 mg/l at the 7-23D
upstream station to 3.76 mg/l at the downstream station. Average dissolved iron concentrations range from 0.03 to 0.04 mg/l at the two stations. Total manganese averages 0.08 at both stations, with dissolved manganese ranging from 0.06 mg/l at the upstream station to 0.02 mg/l at the downstream station.

Alkalinity typically exceeds acidity in Quitchupah Creek by a factor of at least 25. Flow-TDS and flow-total metal relationships are as indicated above. Seasonal variations in pH, dissolved iron, and dissolved manganese are not apparent.

The historical chemical quality of surface water in East Spring Canyon at station SUFCO-047A is similar to that of Quitchupah Creek at SUFCO-046. The water is of mixed chemical type, with an average TDS concentration of 724 mg/l and an average pH of 7.4. Total and dissolved iron concentrations average 0.43 and 0.04, respectively, with total and dissolved manganese

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concentrations averaging 0.04 and 0.02, respectively. Alkalinity typically exceeds acidity in East Spring Canyon by a factor of approximately 20. Flow-TDS and flow-total metal relationships are as indicated above. Seasonal variations in pH, dissolved iron, and dissolved manganese are not apparent.

The historical chemical quality of streamflow in Box Canyon (as monitored at station SUFCO-090) contains an average TDS concentration of 93 mg/l and an average pH of 7.1. No total iron or manganese data are available. However, dissolved iron and manganese concentrations have averaged 0.27 and 0.04 at the station, respectively. The data base is insufficient to assess seasonal variations. However, trends between flow, TDS, and total metals are anticipated to be as described for the North and South Forks of Quitchupah Creek. Data collected from monitoring sites Pines 407 and Pines 408 are included in Appendices 7-17 and 7-18.

As a general point of comparison the surface-water analytical data were compared to primary and secondary drinking water standards. With the exception of two slight exceedances of the barium standard of 1.0 mg/l (one at SUFCO-007 and one at SUFCO-041), no exceedances of the primary drinking water standards occurred at the monitored stations. Exceedances of the secondary drinking water standards occurred for both sulfate and TDS. With the exception of the mine discharge, these exceedances are likely due to dissolution of marine salts in the sediments and outcropping rocks (Waddell, 1979 and Doelling, 1972).

7.2.4.3 Geologic Information

Geologic information related to the permit and adjacent areas is presented in Chapter 6 of this M&RP.

7.2.4.4 Climatological Information

Climatological data have been collected from a station location at the mine surface facilities since July 1986. Historical monthly summaries of these data are presented in Appendix 7-5. These and other regional data are summarized in this section. Updated climatological data have been submitted to the Division in annual reports.

Precipitation. Based on regional data, normal annual precipitation at the mine is about 18 inches per year (Utah Division of Water Resources, 1977). Approximately 42 percent of this precipitation

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falls in the period of May through September, with the remainder falling in the October through April period, primarily as snow (Utah Division of Water Resources, 1977).

During the historical period of record at the mine site, precipitation has been below the regional normal cited above, averaging 12.51 inches per year (see Appendix 7-5). Average monthly precipitation at the mine has ranged from 0.59 inch in June to 1.65 inches in August, with the August peak being the result of summer thunderstorm activity. Snow cover is typically on the ground from September through May.

Wind. The station closest to the mine that reports wind data is located at Gunnison, Utah (approximately 28 miles northwest of the mine). Due to the mountainous conditions in the area, the wind data collected at this station are not considered representative of the mine site. Periodic observations by mine personnel suggest that the prevailing wind at the mind is up the local canyons (i.e. south to north at the mine surface facilities).

Temperature. The normal annual temperature at the Salina, Utah station (located 24 miles west of the mine) is 49.5° F (National Weather Service, 1989). Seasonally, this temperature varies from a normal monthly low of 27.6° F in January to a normal monthly high of 73.7° F in July. During the period of record, temperatures at the mine have ranged from a low of -19° F in February 1989 to a high of 92° F in July 1989.

7.2.4.5 Supplemental Information

No supplemental information is required at this time.

7.2.4.6 Survey of Renewable Resource Lands

The existence and recharge of aquifers in the permit and adjacent areas is discussed in Section 7.2.4.1 of this M&RP. A discussion of the potential for material damage or diminution of these aquifers and their recharge areas due to subsidence is provided in Section 7.2.8 of this M&RP.

7.2.4.7 Alluvial Valley Floor Requirements

Information regarding the presence or absence of alluvial valley floors in the permit and adjacent areas is presented in Chapter 9 of this M&RP.

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7.2.5 Baseline Cumulative Impact Area Information

The hydrologic and geologic information required for UDOGM to develop a Cumulative Hydrologic Impact Assessment is presented in this M&RP under Chapters 6 and 7. Required information not available in these chapters is available from the Utah Division of Water Rights and Water Resources and from the U.S. Geological Survey, the U.S. Bureau of Land Management, and the U.S. Forest Service. The Greens Hollow PHC is located in Appendix 7-28.

7.2.6 Modeling

No numerical groundwater or surface water modeling was conducted in support of this M&RP.

7.2.7 Alternative Water Source Information

No surface mining has been or will be conducted in the permit and adjacent areas. Therefore, this section does not apply to the SUFCO Mine.

7.2.8 Probable Hydrologic Consequences

This section addresses the probable hydrologic consequences of coal mining and reclamation operations in the mine permit and adjacent areas. Mitigating measures are discussed generally in this section and in detail in Section 7.3 of the M&RP. The Greens Hollow PHC is located in Appendix 7-28.

7.2.8.1 Potential Impacts to Surface and Groundwater

Potential impacts of coal mining on the quality and quantity of surface and groundwater flow may include:

- Contamination from acid- or toxic-forming materials;
- Increased sediment yield from disturbed areas;
- Increased total dissolved solids concentrations;
- Flooding or stream flow alteration;
- Impacts to groundwater or surface water availability;
- Hydrocarbon contamination from above ground storage tanks or from the use of hydrocarbons in the permit area;
- Contamination of surface and groundwater from road salting; and
- Contamination of surface water from coal spillage due to hauling operations.

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These potential impacts are addressed in the following sections of this M&RP.

Greens Hollow Seep & Spring Inventory - In the time that has elapsed subsequent to the 2000-2004 spring and seep survey and baseline monitoring activities performed by Cirrus Ecological Solutions in the Greens Hollow Tract (U.S. Forest Service, 2005), Petersen Hydrologic personnel have traversed all of the major surface water drainages and observed hydrologic conditions (including spring discharge locations and conditions) within the tract and adjacent area. The areas traversed include the Muddy Creek drainage in the vicinity of the northern portions of the tract, the Greens Hollow area, the upper and lower Cowboy Canyon areas, the North Fork stream drainage, the South Fork stream drainage, Big Ridge, and the broad upland plateau areas that are situated between the major drainages that are developed on erosional surfaces in the Price River Formation within and adjacent to the Greens Hollow Tract. Additionally, Petersen Hydrologic personnel have in the past several years routinely traversed the Box Canyon and Skutumpah Canyon areas adjacent to the Greens Hollow Tract. In addition, many of these areas have also been traversed by Canyon Fuel environmental specialists in recent years (personal communication, Vicky Miller, 2017).

The field visits to these areas have occurred in conjunction with quarterly hydrologic monitoring in the area (2000-2017), supplemental quarterly baseline monitoring activities specifically for the Greens Hollow Tract (2014-2017), and in conjunction with miscellaneous hydrologic field investigations that have been performed in the area (2000-2017). Most of the areas have been traversed by foot, while others have been observed from vehicles or ATV's, or during aerial surveys from helicopters. In the course of these field visits and observations, a single previously unidentified spring, USP-2 (a Price River Formation spring with measured flows less than 0.5 gpm), was identified by Petersen Hydrologic personnel. USP-2 was incorporated into the water monitoring plan. No additional significant springs (i.e. with measurable discharges) were identified within the Greens Hollow Tract during these site visits.

During the course of the supplemental baseline hydrologic monitoring that has been performed at the Greens Hollow Tract by Petersen Hydrologic (2015-2017), *all of the springs* within the Greens Hollow Tract previously identified in the 2000-2004 spring and seep and baseline monitoring activities conducted by Cirrus Ecological Solutions have been visited, monitored and observed by Mr. Petersen during 2nd, 3rd and 4th quarters each year (2015 - 2017). During these field visits, it

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was noted that the metallic field spring-identification tags that were placed at individual spring locations during the 2000-2004 Cirrus Ecological Solutions surveys were found for almost all of the previously identified springs. Additionally, the geographic UTM coordinates that were determined by Cirrus (2000-2004) using hand-held GPS devices were field verified by Petersen Hydrologic using a Garmin hand-held GPS device for all of the identified spring locations during the recent traverses. The Cirrus locations and the recent Petersen Hydrologic locations were found to be in agreement. There is no indication that there has been any substantial movement of spring discharge locations during the time that has elapsed since the initial 2000-2004 spring identification activities. There was likewise no indication that any new substantial springs had emerged subsequent to the 2000-2004 surveys.

Hydrologic monitoring of springs and streams was performed by Petersen Hydrologic as follows:

Discharge measurements at springs were performed using a stopwatch and a calibrated container. Typically, the spring discharge measurements were performed by damming and diverting the spring discharge through a pipe, and then performing time-to-fill measurements using an appropriately sized container of known volume. Time-to-fill measurements were repeated at a site until the discharge through the pipe had stabilized. Generally, after the discharge from the pipe had stabilized, at least three additional time-to-fill measurements were performed. The time-to-fill values measured after the discharge had stabilized were averaged and used to calculate the reported discharge rate.

Discharge measurements at stream monitoring sites where stream discharge rates were low were typically performed using the time-to-fill technique described above. Where stream flows were greater, discharge measurements were usually performed using current-velocity techniques described by the United States Geological Survey. Stream velocity measurements were performed using a Marsh-McBirney brand electromagnetic current-velocity meter and top-set wading rod. In some locations, discharge measurements were performed using a portable 90-degree v-notch weir or a portable 3-inch Parshall flume constructed in accordance with United States Department of the Interior, Bureau of Reclamation specifications. Discharge measurements at the historic monitoring site on the South Fork of Quitchupah Creek (Sufco 006) were commonly measured using the permanently installed 12-inch Parshall flume at the monitoring station when flows were substantial.

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Temperature measurements were performed using a Taylor brand electronic digital thermometer or a conventional glass-bulb thermometer. Discharge temperature measurements at springs were performed as close to the spring discharge locations as possible. Stream temperature measurements were performed, where possible, in a shaded, actively flowing portion of the stream.

Specific conductance measurements were performed using an Extech brand model EC400 conductivity meter with automatic temperature compensation or a Hanna brand Tester Dist 5 model with automatic temperature compensation. The instruments were calibrated using NIST traceable conductivity standard solutions in accordance with the manufacturer's recommendations.

Water pH Measurements were performed using an Oakton model pH Testr 30 with automatic temperature compensation, or a Hanna Model pHep 5 with automatic temperature compensation. The instruments were calibrated using NIST traceable pH standard solutions in accordance with the manufacturer's recommendations.

Dissolved oxygen measurements were performed using a YSI brand model 55 dissolved oxygen meter. The meter was calibrated using atmospheric oxygen calibration methods in accordance with the manufacturer's recommendations.

Water quality laboratory analyses were performed by SGS Laboratories of Huntington, Utah or Chemtech-Ford Laboratories of Murray, Utah. Both of these laboratories are NELAC certified water analysis laboratories. Information regarding laboratory standard analytical methods and procedures used and laboratory detection limits are recorded on laboratory reporting sheets.

Field data from monitoring events were recorded in bound, water-resistant field notebooks and archived for future reference.

Groundwater and surface-water quantity and quality information from the Greens Hollow Tract area was compiled into an electronic format. The compiled hydrologic information was utilized in the performance of investigations of groundwater and surface-water systems and the determination of the probable hydrologic consequences of coal mining in the Greens Hollow Tract. The compiled groundwater and surface-water monitoring data for springs, seeps, and streams in the Greens Hollow Tract area are presented in Appendix 7-28, Tables 2-A, 2-B, 4 and 5. Once the mining

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plan for the Greens Hollow Lease area is approved the Division's Coal Water Quality On-line Electronic Database will be updated to include the added monitoring sites and their associated water data.

The drainages, canyons and ridges in the following sections were traversed by foot with the assistance of motorized transportation between areas during annual monitoring (April - December, 2015 - 2017): T21S R 4E Sections 1, 2,10,11,12, 13, 22, 23, 24; T21S R5E Sections 5, 6, 7: T20S R 5E Sections 19, 20, 21, 28, 30, 31,32,33: and T20S R 4E Sections 35, 36. The areas were visited by Mr. Petersen as well as personnel from Sufco familiar with hydrology monitoring during these years, however some areas have been visited since the early 2000's.

The following Sections were traversed by air or motorized vehicle T20S R 5E Section 29

The monitoring was completed when weather conditions and safety issues did not interfere

It is Mr. Petersen's professional opinion that, based on the observations and monitoring activities performed to date as described herein, the current identification of springs and seeps in the Greens Hollow Tract (as of 2017) has been reasonably and adequately performed in a manner consistent with good hydrogeologic practice.

7.2.8.2 Baseline Hydrologic and Geologic Information

Baseline geologic information is presented in Chapter 6 of this M&RP. Confidential drill logs and other information related to geology is located in Appendix 6-1. Appendix 6-4 contains geologic information related to the Greens Hollow Lease. Baseline hydrologic information is presented in Sections 7.2.4.1 and 7.2.4.2 of this M&RP. The baseline monitoring sources are believed to be representative of existing ground water and surface water. An additional inventory is not planned unless circumstances dictate a need for change.

7.2.8.3 PHC Determination

Potential Impacts to the Hydrologic Balance. Potential impacts to the hydrologic balance are addressed in the following subsections of this M&RP and in Appendices 7-17, 7-18, 7-19, 7- 20 and 7-24. Appendices 7-18, 7-20 and 7-24 contain PHC determinations for mining activities in the

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Pines Tract, SITLA Muddy Tracts and West Coal Lease Modifications, respectively. The PHC for the area of Greens Hollow Lease is located in Appendix 7-28.

Acid- or Toxic- Forming Materials. Information on acid-and toxic-forming materials is presented in Chapter 6. These data reveal boron, sodium absorption ratio, and specific conductance exceedances of the Table 2 guidelines for management of topsoil and overburden (Leatherwood and Duce, 1988) in waste rock from the SUFCO mine. As noted in Section 7.2.4.2 of this M&RP, the alkalinity of the mine discharge water typically exceeds the acidity of this water by a factor of 20. Additionally, mine discharge water typically meets the standards for water quality for the state of Utah (Utah Water Quality Board, 1987). Thus, analytical data obtained from mine-water discharges indicate that although potential exists in localized portions of the mine for acid- or toxic-forming materials to be present, there has been no known impact to the surface or groundwater in the permit and adjacent areas.

Sediment Yield. The potential impact of mining and reclamation on sediment yield is an increase in sediment in the surface waters downstream from disturbed areas. Sediment-control measures (such as sedimentation ponds, diversions, etc.) have been installed to minimize this impact. These facilities are regularly inspected (see Section 5.1.4) and maintained.

Data on file with the Utah Department of Environmental Quality (formerly the Utah Division of Environmental Health) indicate that waters discharging from the mine have typically not exceeded the total suspended solids standards (40 CFR 434) of 70.0 mg/l maximum, 35.0 mg/l 7-day average, and the 25.0 mg/l average daily. Samples of sedimentation pond discharge have rarely exceeded the maximum standard with the exceedances ranging from 26.0 to 261 mg/l. Except under unusual circumstances, the average total suspended solids concentration of the sedimentation pond discharge is less than the average daily standards. Thus, although a limited number of exceedances of the standards have occurred, the sediment-control measures at the mine are considered effective at minimizing the impacts of increased sediment yield on adjacent streams.

Sediment yields may increase locally due to subsidence. Subsidence cracks which intersect ephemeral drainages with steep gradients could, for a short period of time, increase the sediment yield of the stream. However, this sediment increase would cause the crack to be quickly filled,

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recreating pre-subsidence stream channel conditions. Thus, the potential impact to sediment yield would be minor and of short duration.

An assessment of the Alternative Sediment Control Measures to be implemented during reclamation was performed as indicated in Appendix 7-15. These calculations indicate that the implementation of each sediment control measure substantially reduces the amount of sediment erosion from the reclaimed areas, to the point that the mulch theoretically inhibits soil loss more effectively than a baseline level of undisturbed ground cover. In fact, the combination of surface soil preparation, an application of wood fiber hydromulch at 2000 pounds per acre, and the use of silt fences results in a 37% to 85% reduction of soil erosion below that which would be expected from naturally vegetated grass/sage slopes. Thus, sediment control measures to be implemented during reclamation will preclude adverse impacts to the environment.

In the area of the Link Canyon Portal and Link Canyon Substation No. 1 and No. 2 pads and access roads, sediment yield from the disturbed areas will be controlled with berms and/or silt fences. The calculations supporting the use of berms and /or silt fences for these areas are presented in Appendix 7-15. Undisturbed runoff from above the Link Canyon Portal pad area that naturally flowed down the Link Canyon drainage will be diverted under the pad area by the use of a diversion culvert and will be channeled back into the existing Link Canyon drainage. Undisturbed runoff from above the substation pad areas that naturally flowed directly into the existing Link Canyon Road inside ditch will be diverted around the substation pad areas by the use of a diversion ditch and will be channeled back into the existing Link Canyon Road inside ditch. Sediment yield from the undisturbed drainage ditch will be controlled with a silt fence. From the point that the Substation No. 2 undisturbed drainage reenters the existing Link Canyon Road ditch the existing road ditch drainage flows for about 30' along the inside of the road before the flow is diverted across the road by an existing water bar were the flow is directed toward the channel at the bottom of Link Canyon. This drainage is by Division definition an intermittent stream. However, water only flows in this canyon in the substation areas as the result of snow melt runoff or the occasional summer thunderstorm.

Acidity, Total Suspended Solids, and Total Dissolved Solids. Probable impacts of mining and reclamation operations to the acidity and total suspended solids concentrations of surface and

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groundwater in the permit and adjacent areas were addressed previously in this section. Impacts to water quality parameters within the Pines Tract area are addressed in Appendix 7-18.

Data presented in Appendix 7-4 and summarized in Section 7.2.4.1 of this M&RP indicate that the average TDS concentration of water entering the mine (as measured at SUFCO-062) is 397 mg/l. This a calcium-bicarbonate water with an average sulfate concentration of 63 mg/l. As noted in Section 7.2.4.2, the average TDS concentration of water discharging from the mine (as measured at SUFCO-021) is 667 mg/l (with a historical range of 350 to 970 mg/l). This is a calcium-bicarbonate-sulfate water with an average sulfate concentration of 277 mg/l (with a historical range of 40 to 469 mg/l).

These data indicate that the TDS concentration of water flowing through the mine increases by a factor of approximately 1.6. The sulfate concentration of this water increases by a factor of about 3.5. As noted in Section 7.2.4.2, this increase in TDS and sulfate concentrations may be the result of dissolution of calcium-sulfate rock dust used in the mine.

Subsidence may cause some surface water to be diverted into the groundwater. As the water flows slowly through the ground, the water dissolves the salts available in the formations and TDS concentrations increase. When the diverted water is later discharged to the surface, TDS concentrations may be higher than if it had flowed over the surface. Due to the nature of ephemeral streamflow, these subsidence-caused diversions would be small in volume. When a fracture becomes sealed with bentonitic materials available in the area (Thiros and Cordy, 1991), the diversion either ceases or flows into a higher stratigraphic unit. Thus, potential impacts would be minor and not of significant concern.

The impact of the TDS and sulfate concentration increases on surface-water resources in the permit and adjacent areas is considered minimal for three reasons. First, surface water in the permit and adjacent areas has been classified in the Utah Department of Environmental Quality Wastewater Disposal Regulations as Class 3a and 4 water (protected for cold water aquatic life and agricultural uses, respectively). No sulfate discharge standard exists for either of these two classifications. The only TDS standard is for Class 4 water, with a discharge limitation of 1200 mg/l. Thus, the mine water does not exceed the applicable discharge standard and small amounts of surface water diverted through the groundwater system would not cause exceedances of the applicable standards.

Second, according to data presented in Section 7.2.4.2, although the discharge of mine water into the North Fork of Quitchupah Creek increases the TDS and sulfate concentrations of the receiving

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water (compare data from SUFCO-006, SUFCO-007 and SUFCO-042), the TDS concentration of the discharge water is less than that of Quitchupah Creek above the influence of the mining operation (compare data from SUFCO-046). As a result of these factors, the impacts of increased TDS and sulfate concentrations in the mine-water discharge relative to the adjacent natural water are not considered significant.

Finally, as indicated on Plate 6-1, surface water in the North Fork of Quitchupah Creek flows across Mancos Shale immediately downstream from the mine discharge point. Similarly, Quitchupah Creek crosses Mancos Shale immediately downstream from the confluence with East Spring Canyon. Since the Mancos Shale is a gypsiferous formation, sulfate and TDS concentrations are naturally high in areas underlain by this unit. Thus, the additional input of these constituents from the mine waters to local streams is considered minimal.

As indicated previously, tension cracks created by subsidence may locally increase the rate of downward percolation of groundwater. However, as indicated by Mayo in Appendix 7-17, the potential for increased vertical percolation of groundwater due to subsidence is not considered to be significant and should have no impact on mine discharge water quality.

No subsidence is anticipated to occur in the Link Canyon Substation pad area. Therefore, disturbance in this area is not anticipated to adversely effect groundwater. Surface water will not be adversely effected in this area since runoff will be treated prior to discharge, thus limiting the amount of total suspended solids. Additionally, the soils in the area are not toxic or acid forming and the total increase of dissolved solids added to the runoff from the limited area of the pad will not be significant. The receiving waters pass over large areas of exposed Mancos Shale before it is put to beneficial use. Therefore, the contribution of TSS and TDS from the pad area when compared to the contribution of the in-place soils and shale bedrock will be insignificant.

Flooding or Streamflow Alteration. Runoff from all disturbed areas is treated through sedimentation ponds or other sediment-control devices prior to discharge to adjacent undisturbed drainages. Three factors indicate that these sediment-control devices minimize or preclude flooding impacts to downstream areas as a result of mining operations:

1. The sediment-control facilities have been designed and constructed to be geotechnically stable. Thus the potential is minimized for breaches of the sediment-control devices to occur that could cause downstream flooding.

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2. The flow routing that occurs through these sediment-control devices reduces peak flows from the disturbed areas. This precludes flooding impacts to downstream areas.
3. By retaining sediment on site in the sediment-control devices, the bottom elevations of stream channels downstream from the disturbed areas are not artificially raised. Thus, the hydraulic capacity of the streams channels is not altered.

Following reclamation, stream channels will be returned to a stable state (see Section 5.4.2.2). The reclamation channels have been designed to safely pass the peak flow resulting from the 100-year, 24-hour storm. Thus, flooding in the reclaimed areas will be precluded. Interim sediment-control measures and maintenance of the reclaimed areas during the post-mining period will preclude deposition of significant amounts of sediment in downstream channels following reclamation, thus maintaining the hydraulic capacity of the channels and precluding adverse flooding impacts.

The mine has been designed to minimize subsidence impacts to perennial streams (see Section 5.2.5.1). Any material damage to the stream channel will be mitigated. Streamflow volume in the North Fork of Quitchupah Creek will, however, increase due to mine water discharge.

Mine water discharge to the North Fork of Quitchupah Creek has increased streamflow by over 1000 gpm (2.25 cfs). Waters encountered in the Pines Tract will be pumped to the Quitchupah discharge point. The worst case flow increase is estimated to be approximately 3.75 cfs. Once mining has ceased, the mine will be sealed and no discharges will occur. The streamflow volume will return to pre-mining discharge levels. Increased flow to the North Fork of Quitchupah during seasonal flow conditions are addressed by Mayo in Appendix 7-17.

Subsidence tension cracks that propagate to the surface, will increase the secondary porosity of the formations overlying the SUFCO mine. Thiros and Cordy (1991) state that bentonitic shale and plastic flow in mudstone within the perching layers could possibly slow or stop the downward movement of groundwater. If these cracks do not become blocked with bentonite, recharge to aquifers that feed spring flow may increase. Thus, subsidence may contribute to increases in streamflow.

Subsidence may decrease spring flow if the perched aquifer which supplies the spring is intersected by tension cracks, allowing groundwater to drain to underlying strata (Thiros and Cordy, 1991). Subsidence has occurred beneath East Spring (monitoring station 001), but no major

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changes in flow rate or water quality have been detected from 1985 to 1986 (Thiros and Cordy, 1991). Groundwater monitoring data (Appendices 7-4 and 7-17) indicate that flow rates of this spring have declined from 1987 to 1995. This decline in flow, however, is likely due to the drought conditions of the last several years (Appendix 7-5). Flow rates from other springs currently monitored by SUFCO, but located in unsubsided areas (057A and FS-109), have also declined during the last several years (Appendices 7-4 and 7-17).

Subsidence will occur in areas occupied by ephemeral and perennial stream channels. According to Thiros and Cordy (1991), surface water flow to natural drainages has the potential of being intercepted by subsidence fractures that extend to the land surface. In addition, the broad depressions created by subsidence may locally retain runoff that would normally discharge from an area. Although surface cracks that result from subsidence in the area tend to heal with time (see Appendix 5-4), stream flows may be partially intercepted prior to completion of the healing process. However, the following factors indicate that the impact of subsidence on streamflow will be minimal:

1. Bentonitic shale and plastic flow in mudstone within perching layers could possibly slow or stop the downward movement of previously perched groundwater (Thiros and Cordy, 1991).
2. Field observations indicate that there are no sustained above normal inflows in the mine. Thus, flow along fractures is either from a relatively small source, or the conduits become sealed quickly.
3. Ephemeral streamflow in the area is sporadic, allowing significant periods of time which may allow for surface cracks to heal between flow events.
4. Ephemeral streamflow typically carries a high sediment load. During precipitation runoff events, perennial streams will also carry a high sediment load. This sediment will fill remaining cracks. As the cracks heal, the potential for interception of streamflow is minimized.
5. The depressions created by subsidence are sufficiently broad that changes in slope are not typically of an ample magnitude to cause ponding in anything other than local areas. If ponding does occur, the shallow depressions will fill with sediment quickly due to the periodic high sediment load of streams and the drainage will return to the previous pattern.

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Groundwater and Surface Water Availability. The potential impacts of mining on reductions in surface-water availability are discussed above. As indicated, these impacts are not considered to be significant.

As noted in Section 7.2.4.2, groundwater is encountered in the SUFCO mine and pumped to the surface, generally into the North Fork of Quitchupah Creek at UPDES station 003.

According to Mayo (Appendix 7-17), the rate of discharge from the mine has increased since 1987 from approximately 1.0 cfs (450 gpm) to about 3.56 cfs (1,600 gpm).

The increase in flow into and out of the mine is considered to be the result of increased coal production. The primary method of mining converted from room-and-pillar to longwall in October 1985. As a result of this change, production in the mine increased (see Figure 7-6). With the increase in production, new areas were mined at an increasingly higher rate. According to Mayo (Appendix 7-17), the mine discharge hydrograph shows that the rate of mine water discharge does not increase as the total area of the mine increases, but rather, the rate of discharge is related to the amount of recently mined areas.

As indicated in Section 5.2.3 of this M&RP, long-term production from the SUFCO mine is expected to average about 6 million tons. Projecting this production rate and the mine discharge rate on Figure 7-6, it is estimated that long-term discharge of groundwater from the mine will average approximately 2.6 cfs (1,200 gpm).

It should be noted that the discharge of mine water to a stream probably results only in a local increase in flow and not a basin-wide increase. As noted on Plate 6-1, the Mancos Shale outcrops in the North Fork of Quitchupah Creek just upstream from the mine-water discharge point and in Quitchupah Creek above the confluence with East Spring Canyon. The shales of this formation have a low permeability (Waddell et al., 1981), thus forcing groundwater to the surface as streamflow. Thus, although the discharge of water from the mine may result in a local loss of groundwater and gain in surface water, this discharge does not disrupt the hydrologic balance of the basin.

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The long-term mean mine discharge to North Fork Quitchupah Creek is 980 gpm and discharge varies between 460 and 1760 gpm. The mean upstream flow during high-flow conditions (June) is 2,650 gpm and during low-flow conditions (October) the flow is 290 gpm. Thus, mine discharge represents a mean increase in creek discharge of 37% and 337% for June and October, respectively. The mean low flow discharge measured at site 042, 5 miles downstream from the mine discharge point, is 950 gpm. This suggests that the lower reaches of North Fork Quitchupah Creek could go dry in late summer and early fall without the contribution of mine water to the stream.

Subsidence has occurred in the leased mined area (Plate 5-10). More subsidence is expected to occur in the future as longwall mining progresses. Fractures that remain open or fill with permeable material would locally increase the hydraulic conductivity of the strata. However, when tension fractures intercept mudstones or shale units that contain bentonitic or montmorillonite clays, these fractures become sealed, stopping vertical flow (Thiros and Cordy, 1991). When tension fractures intercept strata that are more brittle or less amenable to sealing by clays, such as the Castlegate Sandstone, these fractures will heal naturally by filling in with silt and organic material such as sticks, pine needles, pine cones, and pine cone fragments. This natural healing could take longer to seal the cracks with the potential to impact water resources for a period of time. A discussion of the potential impacts to water resources due to subsidence is provided in Section 7.2.8.3 of this M&RP and in Appendix 7-17. DeGraff (Appendix 5-4) indicates that tension cracks in the leased area typically heal quickly. There are no sustained above normal inflows in the mine due to mining or subsidence. Thus, most fractures in the leased area appear to become sealed in a relatively short period of time. Intersection of locally perched aquifers by subsidence cracks could divert groundwater from a spring. Water will not be lost from a specific basin, but may become diverted within the basin.

The discharge from the abandoned Link Canyon Mine was to be maintained during and after utilization of the western portal for Sufco Mine access. The water naturally discharging from the abandoned mine is not considered to be a UPDES mine discharge point by the Utah Division of Water Quality so long as the water is not contaminated or comes in contact with Sufco mining related activities. The initial plan by Sufco was to maintain the flow of water from the flooded old works to the abandoned eastern portal and out the rehabilitated western portal. However, when the old works were accessed, both from inside the Sufco Mine and the surface, very little water was

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encountered and the old works did not appear to be flooded. The majority of water encountered during rehabilitation efforts was located just inside the western portal. A small pond of water had formed behind a roof fall in the old mine. It was apparent that shallow ground water or surface water entered the mine just in by the portals and upgradient of the roof fall, forming the small pond. Once the roof fall was removed and the water drained, water ceased discharging from the western portal. The volume of water discharging from the eastern portal area also appeared to decrease. It further appears that most of the water that currently seeps into the old workings near the portal evaporates before it can accumulate and discharge out the western portal. Small volumes of runoff and ground water still accumulates in the eastern portal area and can be seen in the spring and fall discharging over the rock ledges below the portal.

The riparian vegetation in the area of the Link Canyon portals is feed not only by the discharge from this portal but also by subsurface flow discharged by springs above the mine in the Castlegate Sandstone. Thus, the riparian vegetation above and below the west portal was sustained during site construction by subsurface flows from the upgradient springs and flows from the east portal.

Water, if any, that enters the portion of the Link Canyon Mine utilized by Sufco will be discharged at UPDES discharge point 003. The Link Canyon Portal elevation is 7663 feet and the elevation where the old works will connect to the existing Sufco Mine is 7658 feet with the mine average dip being 2% N45°W. As of August 2005, water had not accumulated in the abandoned Link Canyon Mine and draining and discharging the water through the existing Sufco Mine has not been necessary.

The activity related to reopening the western Link Canyon portal should not have a significant negative impact on surface water flows in Link Canyon Creek. While the creek has been designated as an intermittent stream under the R645 rules as a result of its drainage area size, the stream functions primarily as an ephemeral stream (Thiros and Cordy, 1991). As described in Section 7.2.4.2 of this chapter, the majority of the stream's reaches typically only flow as a result of runoff from significant precipitation events and during brief periods of snow melt runoff. The two surface water sites, Link 001 and Link 002 which are located above and below the portals (Plate 7-3), did not have measurable or monitorable flows during quarterly monitoring episodes from 1999 through 2002 (Erik Petersen, personnel communication, November 2002). Observable surface flows in the stream are generally limited to just below the developed springs *(Pines 100 and GW-*

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21) near the head of the canyon and just below and adjacent to the Link Canyon Portals. In both locations water flow or moist soils have been observable for only a few hundred feet below the source. Table 7-1A details the dates, flows, and monitoring personnel for sites Link 001, Link 002, Link Portal West and Link Portal East.

TABLE 7-1A
FLOW OBSERVATIONS IN LINK CANYON WATER MONITORING SITES
Link 001, Link 002, Link Portal West, and Link Portal East

LOCATION	DATE OF OBSERVATION	FLOW (gpm)	SAMPLER
Link 001 and Link 002	06-03-97	No Flow	E. Petersen
	10-29-97	No Flow	E. Petersen
	11-03-97	No Flow	E. Petersen
	06-29-98	No Flow	E. Petersen
	09-16-98	No Flow	E. Petersen
	11-04-98	No Flow	E. Petersen
	06-22-99	No Flow	E. Petersen
	08-25-99	No Flow	E. Petersen
	10-28-99	No Flow	E. Petersen
	06-01-00	No Flow	E. Petersen
	08-22-00	No Flow	E. Petersen
	11-14-00	No Flow	E. Petersen
	06-13-01	No Flow	E. Petersen
	08-22-01	No Flow	E. Petersen
	10-01-01	No Flow	E. Petersen
	05-18-02	No Flow	E. Petersen
	09-26-02	No Flow	E. Petersen
	10-08-02	No Flow	E. Petersen

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TABLE 7-1A (Continued)
FLOW OBSERVATIONS IN LINK CANYON
WATER MONITORING SITES
Link 001, Link 002, Link Portal West, and Link Portal East

LOCATION	DATE OF OBSERVATION	FLOW (gpm)	SAMPLER
Link Portal - West	09-17-77	5 (estimated)	Hydrometrics
	08-04-86	1.5	Thiros & Cordy*
	08-20-86	2.2	Thiros & Cordy*
	09-15-86	1.6	Thiros & Cordy*
	11-04-86	1.3	Thiros & Cordy*
	05-11-87	2.0	Thiros & Cordy*
	06-16-87	1.5	Thiros & Cordy*
	07-20-87	1.7	Thiros & Cordy*
	09-08-87	1.6	Thiros & Cordy*
	09-16-98	1.0 (estimated)	Erik Petersen
	12-07-01	0.5 (estimated)	Chris Hansen
	10-26-02	No Flow - Standing Water	Erik Petersen
	10-30-02	No Flow - Standing Water	Erik Petersen
	11-06-02	No Flow - Standing Water	Erik Petersen
	11-15-02	No Flow - Standing Water	Erik Petersen
Link Portal - East	12-07-01	0.5 (estimated)	Chris Hansen
	10-26-02	No Flow - Standing Water	Erik Petersen
	10-30-02	No Flow - Standing Water	Erik Petersen
	11-06-02	No Flow - Standing Water	Erik Petersen
	11-15-02	No Flow - Standing Water	Erik Petersen

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Vegetation in the Link Canyon channel below the mine will be photographically monitored on a quarterly basis, except in the winter months, to determine what, if any, impacts the reduction of discharge from the western portal has on the vegetative community. The vegetation monitoring was started in the summer of 2005 and will continue through the reclamation of the portals. The general health of the willows, Woods Rose, clematis, and wire grasses present in the vegetative community will be observed and the observations reported in the mine's annual report. If significant changes occur in the vegetation monitored, these changes will be reported to the Division and the Forest Service. A plan may be developed and instigated at that time to mitigate any damages to the vegetation as a result of mining activities. Refer to Section 3.2.2.2 for additional vegetation information.

Flows from the Link Canyon portals have been measured periodically since 1977 with discharges ranging from 5 gpm (estimated by Hydrometrics, 1977) to no discharge (Petersen 2002). Samples of the water discharged from the west portal have been obtained and analyzed by Thiros and Cordy (1991), Mayo and Associates during the Pines Tract EIS process (1998), and recently by Petersen (2002, Appendix 7-4).

Prior to disturbing the portals, additional samples have been obtained from both the east and west portals in October and November 2002. One sample from each portal was obtained for four consecutive weeks. No surface flow was present in the summer of 2002 at either of the portals. However, a small pool of standing water was present at the mouth of the west portal through most of the year. The samples were obtained by first excavating a depression near the mouth of the east portal and allowing water to gradually fill the depression and by sampling the standing water at the mouth of the western portal. These samples were obtained as baseline samples in compliance with a request from the Forest. The samples have been analyzed according to the Division's guidelines for baseline water monitoring samples. Copies of the sample analyses results for samples obtained on October 26, October 30, November 6, and November 15, 2002 are included in Appendix 7-4. Included in Appendix 7-4 is a brief report by Erik Petersen of Petersen Hydrologic, Inc. that discusses the various sampling events, the results of the sample analyses, and an interpretation of the data as it relates to the origin of the water in the Link Canyon Mine.

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Mr. Petersen discusses in his report that water issuing from the Link Canyon portals is likely not sourced from the springs at the head of the canyon but probably from surface water that enters the mine through the weathered bedrock near the surface. It appears that during periods of normal or greater than normal precipitation, the water discharged from the mine has a TDS level of near 500 mg/l. However, in drought years, as has occurred in the area beginning in 1999 and continuing through 2002, the TDS levels in the water naturally rises due to a lack of fresh water flushing of the abandoned mine workings water. Hence, the samples obtained in the fall of 2002 had TDS concentrations greater than 1400 mg/l.

A hydrograph of the discharges from the Link Canyon Mine is provided in the USGS report by Thiros and Cordy (1991). This hydrograph, along with the additional data collected by Mayo and Associates and Erik Petersen suggest the discharge from the mine is influenced by seasonal changes in precipitation. Significantly, the flow from the mine has nearly ceased as a result of the area drought which began in 1999 and has continued through at least 2002.

Water discharged from the mine will continue to be monitored at sites Link Portal West and Link Portal East, as part of the quarterly water monitoring program. Significant changes in water chemistry and the apparent causes will be reported to the Division.

The only actual loss of groundwater from the hydrologic balance is that water which is the difference between the average as-shipped moisture minus the inherent moisture or in-situ moisture of the coal and leaves the basin upon mining. Based on an average coal moisture loss of groundwater content of 1.8 percent and a long-term coal production rate of 6 million tons per year, approximately 80 AF/yr of groundwater is removed from the basin. This represents about 2 percent of the average annual flow of Quitchupah Creek above Link Canyon.

Several springs and stream locations in the leased area are monitored for quantity and quality as prescribed by the M&RP water monitoring program. Analysis of the monitored flows indicated that very little impact has occurred to springs and streams. Erik Petersen of Petersen Hydrologic, Inc evaluated the flow data collected from several springs and surface flows in the Box Canyon drainage. His evaluation was forwarded to Sufco in the form of a letter report dated August 14, 2003 and is included in Appendix 7-19. Mr. Petersen determined that since mining began in the Pines Tract, a few the area springs have exhibited an increase in flow during a period of prolonged

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drought. He also concluded that perhaps one spring, Pines 303, in the lower portion of the Box Canyon, may have experienced reduced flows as a result of mining activities. However, because of the prolonged drought in the area that began in 1998, it is not possible to determine with certainty whether mining activities, drought conditions, or both have resulted in the loss of spring flow. A loss in flow from this spring was a predicted possibility described in the Pines Tract EIS. The loss of flow from this spring(less than 4 gpm) has apparently not adversely affected area vegetation or wildlife. Because of the increased discharge of springs farther up canyon, the loss of the less than the 4 gpm contribution of ground water from Pines 303 to Box Canyon Creek is insignificant to the total flow of the creek. No water rights were found to have been filed on this spring discharge.

Mr. Petersen has noted an increase in the flow of springs Pines 209 and 212 and in the flow of the Main Fork of Box Canyon Creek that appears to coincide with mining in the western portion of the Pines Tract. He reasons that the increase in spring flow is related to subsidence enhanced recharge or hydraulic conductivity of the aquifers sourcing the springs. The increase in spring flow has resulted in the increase in flow in the Main Fork of Box Canyon Creek. This has been noted as a positive impact to the creek during a time of drought. Analysis of the flow data presented by Petersen suggests the increase in flow from these springs may be short lived. He has also indicated that flow from these springs will not cease but should return to near pre-mining rates. In fact, the data presented in his August 14, 2003 letter report suggests the flow rates may already be beginning to return to pre-mining rates.

Greens Hollow Tract

Although subsidence has occurred beneath springs and streams in areas adjacent to the Greens Hollow Tract, few springs or streams have been permanently effected. The sedimentary geology is the dominant factor influencing the hydrologic system of the area, determining how subsidence affects the surface and subsurface water resources. The geologic units of importance in this commentary are the Blackhawk Formation, the Castlegate Sandstone, Price River Formation and North Horn Formation. Widespread subsidence impacts across the Greens Hollow tract would not be expected. Refer to Appendix 7-4, FSEIS pages 147 - 150, highlighted portions.

"The overall risk for permanent water loss at any spring located with the tract would be relatively low. If the flow at a particular spring is diminished as a result of subsidence-induced surface tensile

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fracture, the ground water would not be drained to the mine or lost from the hydrogelogic system" (FSEIS, 2015).

"Petersen (2009) provides an assessment of subsidence impacts observed in the adjacent Pines Lease Tract and local confirmation of Wilkowske et. al. (2007) indicate that there is minimal risk of water loss from perennial streams where overburden cover is greater than 600 feet and on the order of 60 times mining height." FSEIS, 2015).

Potential Hydrocarbon Contamination. Diesel fuel, oils, greases, and other hydrocarbon products are stored and used at the site for a variety of purposes. Diesel and oil stored in above-ground tanks at the mine surface facilities may spill onto the ground during filling of the storage

tank, leakage of the storage tank, or filling of the vehicle tank. Similarly, greases and other oils may be spilled during use in surface and underground operations.

The probable future extent of the contamination caused by diesel and oil spillage is expected to be small for three reasons. First, because the tanks are located above ground, leakage from the tanks can be readily detected and repaired. Second, spillage during filling of the storage or vehicle tanks is minimized to avoid loss of an economically valuable product. Finally, the Spill Prevention Control and Countermeasure Plan presented in Appendix 7-6 provides inspection, training, and operation measures to minimize the extent of contamination resulting from the use of hydrocarbons at the site.

The potential for hydrocarbon contamination of the environment at the Link Canyon Substation or the reopened Link Canyon Mine Portal is minimal since no fuels or lubricants will be stored at this site. If a catastrophic failure of the transformers at the substation occurred, the minimal volume of oil would be contained behind the berm to be built around the equipment.

Periodically due to difficult recovery conditions or roof collapse, mining equipment is abandoned underground. Abandoned mining equipment locations are shown on Figure 7-7. Prior to leaving equipment underground, lubricating and hydraulic fluids are removed to the extent possible. Since the equipment is steel and not too different compositionally from the roof support throughout the mine, contamination to ground water from abandoned equipment will cause minimal, if any,

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disturbance to the hydrologic balance within the permit and adjacent areas and is not expected to cause material damage outside the leased area. Assuming the mine were to flood and the abandoned equipment were to be covered with water, several probable results and impacts can be evaluated:

1. Flooding of the abandoned mine might be relatively rapid, but once flooded, flow of ground water into, through, and out-of the void spaces of the mine should be slow.
2. If steel or other metals in the equipment were to oxidize, it would be at a very slow rate and the amount of iron and other metals added to the ground water at any one time would be very small.
3. Oxides of most metals are insoluble or slightly soluble in water. At temperatures expected in the mine, metal oxides would tend to precipitate as solids within the mine rather than flow in solution in the ground water. If any metal were to go into solution, concentrations would be highest near the abandoned equipment, but the volume of water in the flooded mine would dilute concentrations outside the immediate vicinity of the equipment.
4. Because of dilution and dispersion, natural seasonal fluctuations, changes in water quality would not be expected to be large enough to be detected at the surface at springs, ground-water baseflows to streams, or in discharges from the mine.

Road Salting. No salting of the mine road occurs within the permit area. This impact is not a significant concern.

Coal Haulage. Coal is hauled over the paved county road from the mine portal area to Interstate Highway 70. Past experience has indicated that approximately one truck load of coal (43 tons) is spilled annually. Residual coal following cleanup of the spill may wash into local streams during a runoff event. Possible impacts to the surface water are increased total suspended solids and turbidity from the fine coal particulates. The probability of a spill occurring in an area sufficiently close to a stream channel to introduce coal to the stream bed is considered small.

In order to minimize fugitive coal dust haulage trucks are either covered or modified to reduce the amount of coal dust blown off the trucks. The impact from fugitive coal dust is therefore considered to be insignificant due to the small amounts lost during haulage in the permit and adjacent areas.

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3 Right 4 East Panel(s)

In 1986/1987 an experimental practice of subsiding escarpments on the west side of Quitchupah Canyon containing the North Fork of Quitchupah Creek in Section 32, Township 21 South, Range 5 East and Section 5, Township 22 South, Range 5 East was approved by the Division. The planned 3 Right 4 East panel straddles Sections 28, 29, 32 and 33, Township 21 South, Range 5 East on the east side of Quitchupah Canyon. The planned panel (northern) and the experimental area (southern) are both in Section 32, across the canyon from one another. The objective of the practice was to ascertain whether or not the escarpment could be undermined by a longwall while causing minimal surface damage.

In 1991 a report was written discussing the observations, the information collected was submitted to the Division in annual reports. The escarpment test area was monitored visually, by photography and by reliable survey measurements for horizontal and vertical movement. The conclusion of the report state the "One independent block of rock fell during subsidence and a few tension cracks were created along the cliff face. No other visible signs of mining were found even though the surface elevations were reduced several feet."

Because spalling is considered a natural feature of the Castlegate Formation it is anticipated that cliff spalling may occur, since the entire area of the Quitchupah Canyon escarpment is heavily fractured by natural jointing and in some areas is highly sculpted where the combined effects of jointing and erosion are the most severe. The slopes are littered with block of stone which have eroded way from the Castlegate and other small sandstone members to the Blackhawk Formation. The channel grade in the North Fork of Quitchupah Creek which lies to the west of the panel to be mined should be sufficient to allow the flow to continue should rocks from spalling enter the creek channel. It is not anticipated that enough rock from spalling will enter the North Fork to block flow, but the surface flow at water monitoring site 042 downstream of the panel will be checked during the mining of the 3 Right 4 East panel to determine if an action is required. There are no known groundwater sites in the area of the 3 Right 4 East panel.

7.2.9 Cumulative Hydrologic Impact Assessment (CHIA)

A Cumulative Hydrologic Impact Assessment to include the permit and adjacent areas is to be prepared by the UDOGM.

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7.30 Operation Plan

7.3.1 General Requirements

This permit application includes an operation plan which addresses the following:

- Groundwater and Surface Water Protection and Monitoring Plan;
- Sediment Pond Sludge Sampling and De-watering Plan;
- Design Criteria and Plans;
- Performance Standards; and
- Reclamation Plan.

7.3.1.1 Hydrologic-Balance Protection

Groundwater Protection. To protect the hydrologic balance, coal mining and reclamation operations will be conducted to handle earth materials and runoff in a manner that minimizes acidic, toxic, or other harmful infiltration to the groundwater system. Additionally, SUFCO will manage excavations and disturbances to prevent or control discharges of pollutants to the groundwater. SUFCO commits to replace loss of any surface water identified for protection in this M&RP that are impacted by mining at the SUFCO mine.

Surface Water Protection. To protect the hydrologic balance, coal mining and reclamation operations will be conducted to handle earth materials and runoff in a manner that minimizes acidic or toxic drainage, prevents, to the extent possible, additional contributions of suspended solids to streamflow outside the permit area, and otherwise prevents water pollution. Additionally, SUFCO will maintain adequate runoff- and sediment-control facilities to protect local surface waters. SUFCO commits to mitigating any material damage resulting from subsiding perennial streams in the leased area as indicated in Chapter 5 of this M&RP. The plan for protection of the perennial streams meets the BLM requirements for protection of their water rights (BLM, 1992).

Sedimentation Pond Sludge Plan. Sludge contained in the sediment ponds will be cleaned from the ponds and temporarily stockpiled upstream of the pond to allow water to drain from the sludge back into the pond. The sludge will be sampled for acid and toxic forming substances prior to be transported to the waste rock disposal site. Sedimentation pond sludge will be incorporated into the fill as described in Section 536 of Waste Rock Volume.

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7.3.1.2 Water Monitoring

Groundwater Monitoring. Groundwater monitoring is proposed to be conducted in the SUFCO permit and adjacent areas according to the water monitoring plans presented in Tables 7-2 through 7-5A and for the rock waste disposal site in Section 731 in Waste Rock Volume of this M&RP. These tables are based on the studies done by Mayo and Associates (Appendices 7-17 and 7-18) and supersede previous plans.

The location of the monitoring points are presented on Plate 7-3 and 7-10. The location of the monitoring wells for the rock waste disposal site are presented on Map 5A, Waste Rock Volume of this M&RP. The monitoring plans were developed based on information presented in the PHC determinations, the baseline hydrologic data, and the geology chapter of this M&RP.

The monitoring programs provide data that are reviewed and compared to the baseline data. Any significant changes are evaluated to determine their impact on the hydrologic balance. These comparisons have taken the form of reports prepared by Hydrometrics early in the permit term (1978-1987). Results of these evaluations are submitted periodically to the UDOGM. The annual Water Quality Report submitted to the Division contains the monitoring data.

Baseline data collected for the Pines Tract area included performing field surveys to identify existing springs. Additionally, springs identified in the USGS publication "Hydrology and Effects of Mining in the Quitchupah and Pines -Coal Lease Tracts, Central Utah " (Thiros and Cordy, 1991) were searched for and, when found, included in the baseline survey. Those springs identified and found within the Pines Tract in the above referenced publication are labeled on Plate 7-3 with the prefix "GW - ". During the baseline surveys, several springs identified in the publication could not be found as illustrated on the document maps or by using the printed location descriptions. It is assumed the springs that could not be found have a) stopped flowing; b) were miss mapped; or c) were in close proximity to springs found during the baseline surveys but could not be positively identified as USGS located springs and were therefore given new number designations.

Baseline data collected for the Muddy Tract area is located in the "Coal Tract Evaluations on the Manti-La Sal National Forest" report prepared for the Manti-La Sal National Forest by Cirrus Ecological Solutions, LC. Those springs identified and found within the Muddy Tract in the above referenced publication are labeled on Plate 7-3 with the prefix "M- ".

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Sampling for the SUFCO Mine and adjacent areas is accomplished in accordance with the schedule outlined on Tables 7-2 through 7-5A. Sampling for the waste rock disposal site is accomplished in accordance with the schedule and the parameter list as outlined in Chapter 7 of the Waste Rock Volume of this M&RP.

Groundwater monitoring data are submitted to UDOGM by the end of the quarter following samplingMonitoring data are submitted in an annual summary by March 31 of the subsequent year.

Groundwater monitoring will continue through the mining and post-mining periods until bond release. The monitoring requirements, including the analytical parameters and the sampling frequency may be modified in the future in consultation with the UDOGM if the data demonstrates that such a modification is justified.

Groundwater monitoring wells US-77-7, US-77-8, US-77-9, US-79-9, US-79-10, US-79-12, US-81-1, US-81-2, US-81-3, 89-16-1, 89-16-1W, 89-18-1, 89-20-1, 89-20-2, and 89-21-1 have been removed from the operational monitoring plan and are listed as historic monitoring wells because these are old baseline wells, wells that have been discontinued or wells the water level measurements are not possible due to the collapse or blockage of the casing. These historic monitoring wells will be permanently sealed along with all the operational groundwater monitoring wells during the final reclamation of the mine in accordance with Sections 6.3.1 and 7.4.8.

In addition to gathering ground water samples from seeps and springs at the surface, SUFCO will obtain a ground water sample, if ground water is encountered, in-mine within the proposed 150 acre lease expansion located in T21S, R5E, Section 10. This sample will be taken shortly after the start-up of the longwall and will be age-dated using isotopic analysis methods. After the longwall advances through approximately 50% of the panel length within the 150 acre lease expansion, a second ground water sample will be obtained from the face and analyzed for the same parameters. The results of the analysis and a sample location map will be submitted to the Division.

Total hardness, total alkalinity, dissolved iron, and dissolved manganese were not included in the groundwater operational monitoring plan proposed by Mayo and Associates (Appendicies 7-17 and 7-18). The reasons for excluding these parameters are discussed below:

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- Mayo does not believe that total hardness is a necessary parameter in the operational monitoring plan. Total hardness describes the soap-consuming capacity of water, but has very limited value in geochemical studies. This parameter is generally calculated from the milliequivalent concentrations of Ca^{2+} and Mg^{2+}. Because Ca^{2+} and Mg^{2+} are included in the operational monitoring plan, the parameter could be calculated if it were ever necessary to evaluate total hardness.

- Mayo does not believe that total alkalinity should be included in the operational monitoring plan. In the waters of Wasatch Plateau, total alkalinity is almost exclusively the product of bicarbonate and carbonate alkalinity. Both bicarbonate and carbonate alkalinity are included in the operational monitoring plans. Contributions to alkalinity from hydroxide, silicate, borate, and organic ligands are trivial.

- Mayo did not include dissolved iron and dissolved manganese in the operational monitoring plan because iron and manganese do not readily exist in dissolved form in basic (pH>7) waters but exist instead as hydroxide complexes. All waters in the leased area are basic. Measurements of total iron and manganese quantify both the dissolved and complex forms of these elements.

Equipment, structures and other devices used in conjunction with monitoring the quality and quantity of groundwater in the permit and adjacent areas have been installed, maintained, and operated in accordance with accepted procedures. This equipment will be removed or properly abandoned by SUFCO when no longer needed.

TABLE 7-2
Water Monitoring Program

Monitoring Wells	Protocol	Comments
US-80-2	A	Screened in Castlegate Sandstone
US-80-4	B	Screened in Castlegate Sandstone
89-20-2W	A	Screened in Castlegate Sandstone
US-79-13	B	Screened in Blackhawk Formation
US-81-3	A	Screened in Blackhawk Formation

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TABLE 7-2 (Continued) Water Monitoring Program

	Protocol	Comments
US-81-4	A	Screened in Blackhawk Formation
01-8-1	A	Screened in Blackhawk Formation
MW-15-5-2	A	Screened in Castlegate Sandstone
In-mine Well (Proposed)	A	Screened in Starpoint Sandstone
Streams		
SUFCO 006	C,2	Upper South Fork Quitchupah Creek
SUFCO 006D	F,1	Upper South Fork Quitchupah Creek
SUFCO 007 (North Fork Lower)	C,2	Upper North Fork Quitchupah Creek
SUFCO 041	C,2	Lower Quitchupah Creek
SUFCO 042	C,2	Lower North Fork Quitchupah Creek
SUFCO 046	C,2	Upper Quitchupah Creek
SUFCO 047A	C,2	Lower East Spring Canyon Creek
SUFCO 090	C,1	Upper Box Canyon Creek
Pines 106	C,2	Upper East Fork Box Canyon
Pines 302	C,1	Muddy Creek-Last Water Creek Confluence
Pines 403	C,2	Lower Box Canyon Creek
Pines 405	C, 2	Muddy Creek - Box Creek Confluence
Pines 406	C,1	Lower Muddy Creek
Pines 406b*	C,1	Lower Muddy Creek
Pines 407	C,1	Box Canyon Creek
Pines 408	C,1	East Fork Box Canyon Creek
USFS-109	C,1	Upper Main Fork of Box Canyon Creek
Link 001	C,2	Link Canyon Drainage
Link 002	C,2	Link Canyon Drainage
FP-1	G,6	East Fork of Main Fork of Box Canyon
FP-2	G,6	East Fork of East Fork of Box Canyon
M-STR1	C,1	Cowboy Creek
M-STR4	C,1	Cowboy Creek
M-STR6	C,8	Top Greens Canyon
Muddy ABF	C,8	Lower Muddy Creek
U-Mud	C,8	Confluence North & South Fork Muddy
Cowboy Top	C,2	Top of Cowboy Creek
Cowboy Middle	C,2	Mid segment of Cowboy Creek
Cowboy Bottom	C,2	Bottom of Cowboy Creek
SP60 Creek	C,2	Creek adjacent to Monitoring point SP60

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TABLE 7-2 (Continued) Water Monitoring Program

Streams	Protocol	Comments
CPC Upper	C,2	Top of Tributary to North Fork Quitchupah
CPC Middle	C,2	Mid segment of Tributary to North Fork Quitchupah
CPC Lower	C,2	Just above North Fork confluence
North Fork Upper	C,2	Top of North Fork Quitchupah at lease edge
North Fork Middle	C,2	Mid segment of North Fork Quitchupah just above CPC confluence
ULGH	C,2	Upper Left Fork Greens Hollow Creek
URGH	C,2	Upper Right Fork Greens Hollow Creek
GH at Road	C,2	Greens Hollow Creek at road crossing
Muddy Creek below Horse	C,2	Muddy Crk below confluence with Horse Crk
Muddy Creek above Horse	C,2	Muddy Crk above confluence with Horse Crk
Horse Creek	C,2	Horse Creek at confluence with Muddy Creek
Springs		
SUFCO 001	D,3	Blackhawk Formation
SUFCO 047	D,4	Star Point Sandstone
SUFCO 057A	D,3	North Horn Formation
SUFCO 089	E,3	Castlegate Sandstone
GW-8	D,5	Price River Formation
GW-9	D,5	Price River Formation
GW-13	D,3	North Horn Formation
GW-20	D,5	Castlegate Sandstone
GW-21	D,3	Castlegate Sandstone
Pines 100	D,4	Castlegate Sandstone
Pines 105	D,3	Castlegate Sandstone
Pines 206	D,5	Blackhawk Formation
Pines 209	D,5	Blackhawk Formation
Pines 212	D,5	Blackhawk Formation
Pines 214	D,5	Blackhawk Formation
Pines 218	D,3	Castlegate Sandstone
Pines 303	D,3	Blackhawk Formation
Pines 310	D,7	Castlegate Sandstone
Pines 311	D,7	Castlegate Sandstone
Link Portal-West	D,4	Link Canyon Portal

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TABLE 7-2 (Continued) Water Monitoring Program

Springs	Protocol	Comments
Link Portal-East	D,4	Link Canyon Portal
M-SP01	D,3	Price River Formation
M-SP02	D,3	Price River Formation
M-SP04	D,9	North Horn Formation
M-SP05	D,9	North Horn Formation
M-SP06	D,9	North Horn Formation
M-SP08	D,3	North Horn Formation
M-SP09	D,9	North Horn Formation
M-SP11	D,9	North Horn Formation
M-SP12	D,9	North Horn Formation
M-SP15	D,9	North Horn Formation
M-SP18	D,3	Price River Formation
M-SP19	D,9	North Horn Formation
M-SP20	D,9	North Horn Formation
M-SP39	D,3	Price River Formation
M-SP40	D,9	North Horn Formation
M-SP41	D,9	North Horn Formation
M-SP44	D,9	North Horn Formation
M-SP45	D,9	North Horn Formation
M-SP53	D,3	North Horn Formation
M-SP60	D,9	North Horn Formation
M-SP87	D,9	Price River Formation
M-SP100	D,9	North Horn Formation
M-SP103	D,9	North Horn Formation
M-SP104	D,9	North Horn Formation
M-SP105	D,9	North Horn Formation
M-SP106	D,9	North Horn Formation
Mud Spring	D,5	Price River Formation
Broad Hollow	D,5	Blackhawk Formation
USP-2	D,9	Price River Formation

Springs	Protocol	Comments
Wedge Spring	H,3	Castlegate Sandstone
Amanda Spring	H,3	Castlegate Sandstone
94-113 Seep	H,3	Price River Formation

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Monitoring point 406B is located at an old USGS monitoring location (circa 1999) located in the NW1/4NE1/4, Sec. 21, T21S. R6E.

Should a spring listed in Table 7-2 change locations, the Division will be notified in the note section during the entry of the quarterly data into the Division's database.

TABLE 7-3
Field and Laboratory Measurement Protocol

Water level and flow measurements

A	Monitoring well:	quarterly water level measurement (3 quarters per year)
B	Monitoring well:	annual water level measurement (3rd quarter)
C	Stream:	quarterly discharge measurements
D	Spring:	quarterly discharge measurements
E	Spring Pool:	quarterly water level measurement
F	Stream:	Bi-weekly measurements while mining is occurring under the stream in 2013, thereafter quarterly for two years.
G	Stream:	Identify perennial portion of stream on or near October 1 of each year.
H	Spring:	Quarterly measurements while mining is occurring under the 2R2S panel stream in 2013, thereafter quarterly for two years.

Water quality

1	Stream: quarterly surface water quality field measurements
2	Stream: quarterly surface water quality operational laboratory measurements
3	Spring: quarterly groundwater quality field measurements
4	Spring: quarterly groundwater quality operational laboratory measurements
5	Spring: groundwater quality operational laboratory measurements quarterly for two (2) years, then reverting to quarterly water quality field measurements
6	Stream: flow measurements only, no water quality samples required.
7	Spring: initially ground water field measurements June 2006 through December 2006 as accessible then quarterly groundwater field measurements thereafter.
8	Stream: quarterly surface water quality field measurements and analysis for total dissolved solids, total suspended solids, total iron, total manganese.
9	Spring: quarterly ground water quality field measurements and analysis for total dissolved solids, total iron, total manganese.

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TABLE 7-4
Groundwater Operational Water Quality Parameters

FIELD MEASUREMENTS	REPORTED AS
Water Level or Flow	
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Temperature	°C
LABORATORY MEASUREMENTS	
Total dissolved solids	mg/l
Carbonate	mg/l
Bicarbonate	mg/l
Calcium (dissolved)	mg/l
Chloride	mg/l
Iron (total)	mg/l
Iron (dissolved)	mg/l
Magnesium (dissolved)	mg/l
Manganese (total)	mg/l
Manganese (dissolved)	mg/l
Potassium (dissolved)	mg/l
Sodium (dissolved)	mg/l
Sulfate	mg/l
Cations	meq/l
Anions	meq/l

TABLE 7-5
Surface Water Operational Water Quality Parameters

FIELD MEASUREMENTS	REPORTED AS
Flow	
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Dissolved Oxygen	mg/l

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Temperature	°C

LABORATORY MEASUREMENTS

Total Dissolved Solids	mg/l
Total Suspended Solids	mg/l
Carbonate	mg/l
Bicarbonate	mg/l
Calcium (dissolved)	mg/l
Chloride	mg/l
Iron (total)	mg/l
Iron (dissolved)	mg/l
Magnesium (dissolved)	mg/l
Manganese (total)	mg/l
Manganese (dissolved)	mg/l
Potassium (dissolved)	mg/l
Sodium (dissolved)	mg/l
Sulfate	mg/l
Oil and Grease	mg/l
Cations	meq/l
Anions	meq/l

Surface Water Monitoring. Surface water monitoring is conducted in the SUFCO Mine permit and adjacent areas based upon the monitoring plans contained in Tables 7-2 through 7-6. Surface water monitoring locations are identified in Plate 7-3. The parameters monitored meet the requirements of R645-301-731.222.1, 40 CFR 122 and 123, R645-301-751, and the applicable UPDES permits. These tables are based on studies done by Mayo (Appendices 7-17 and 7-18) and supersede previous plans. For clarification of the apparent discrepancies over the classification of stream-monitoring site 047A in the M&RP and the Mayo report (Appendix 7-17) which identified site 047A as a spring-monitoring site. SUFCO has always called the station a surface water monitoring site because samples are taken in a drainage. However, Mayo called this site a spring in their report and recommended monitoring plan. When Mayo first collected samples from the site, they were surprised to learn that water from this site had essentially no tritium. Modern surface waters contain abundant tritium. They visited this site again in June 1996 and located several springs in the drainage several hundred feet above where samples are collected

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and classified the site as a spring-monitoring site. Nevertheless, Mayo now agrees with SUFCO that this site should be considered a surface water site for monitoring purposes because, at times, this drainage has flow which is contributed by snow melt, precipitation, or sediment pond discharge.

Monitoring sites are sampled three times per year. Surface water monitoring data are submitted to UDOGM by the end of the quarter following sampling. Monitoring data are submitted in an annual summary by March 31 of the subsequent year. UPDES reporting requirements will be met for the three UPDES discharge sites at the mine (see Appendix 7-7).

To better understand the effects that mining will have, if any, on the stream flows within Box Canyon, surface water monitoring sites Pines-407 and Pines-408 will be monitored for stream flows in gallons per minute once every week during the months of June, July, August, September, and October in 1999. Starting in the year 2000, sites 407 and 408 will be monitored once a month in July, August, September, and October for a five year period. If analysis of the data shows no significant changes during this time period, monitoring at these points will be eliminated from the water monitoring program on Table 7-2. Flow measurements at these two sites will be obtained on the same day. Also, the operator will endeavor to obtain the required samples at least five days after the last precipitation event in the drainage area.

To better understand the effects that mining will have, if any, on the stream flows within the South Fork of Quitchupah, surface water monitoring sites SUFCO 006A and SUFCO 006B will be monitored quarterly starting in 2010 for stream flows in gallons per minute and once every two weeks when accessible while mining is occurring within the 15 degree angle-of-draw of the stream channel. Two additional surface water monitoring sites will be monitored quarterly, SUFCO 006C starting in 2011 and SUFCO 006D starting in 2012. Once mining has been completed within the angle-of draw, the sites will be monitored on a quarterly basis for two years after mining has progressed past the 15 degree angle-of-draw. If analysis of the data shows no significant changes during this time period, monitoring at these points will be eliminated from the water monitoring program on Table 7-2. Flow measurements at these four sites will be obtained on the same day.

Areas identified on Plate 7-3 as FP-1 and FP-2 will be monitored on or near October 1 of each year to determine the extent of perennial stream flow, if any, present in the East Fork of the Main Fork

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of Box Canyon Creek and the East Fork of the East Fork of Box Canyon Creek, respectively. Stream flows will be obtained a short distance below the point where the streams become perennial and the location will be mapped.

Monitoring points Pines 106 and USFS 109 are located at or near the points which the streams become perennial in the East Fork of Box Canyon Creek and the Main Fork of Box Canyon Creek, respectively. The drainages in the area of these two points will be monitored on or near October 1 of each year to verify and map the location where the streams become perennial. Flows will be obtained at Pines 106 and USFS 109 on or near October 1.

Data gathered from monitoring points Pines 407, Pines 408, FP-1, FP-2, Pines 106, and USFS 109 will be compared with precipitation data collected from the mine site weather station, and any other appropriate nearby station, to aid in determining if there have been any mining-related effects on the perennial flows. The flow data, perennial stream flow maps, and the results of the weather data/flow data comparison will be submitted in the fourth quarter water monitoring report each year.

Surface water monitoring will continue through the mining and post-mining periods until bond release. The monitoring requirements (except those required by UPDES) may be modified in the future in consultation with UDOGM if the data demonstrate that such a modification is justified.

Operational monitoring at surface water monitoring sites 022 and 030 has been discontinued from the monitoring plan since the data collected has demonstrated that no flow has been recorded during the monitoring of these sites from June 1983 to October 1997.

Total hardness, total alkalinity, dissolved iron, and dissolved manganese were not included in the surface water operational monitoring plan proposed by Mayo and Associates (Appendices 7-17 and 7-18). The reasons for excluding these parameters are discussed below:

- Mayo does not believe that total hardness is a necessary parameter in the operational monitoring plan. Total hardness describes the soap-consuming capacity of water, but has very limited value in geochemical studies. This parameter is generally calculated from the milliequivalent concentrations of Ca^{2+} and Mg^{2+}. Because Ca^{2+} and Mg^{2+} are included in the operational monitoring plan,

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the parameter could be calculated if it were ever necessary to evaluate total hardness.

- Mayo does not believe that total alkalinity should be included in the operational monitoring plan. In the waters of Wasatch Plateau, total alkalinity is almost exclusively the product of bicarbonate and carbonate alkalinity. Both bicarbonate and carbonate alkalinity are included in the operational monitoring plans. Contributions to alkalinity from hydroxide, silicate, borate, and organic ligands are trivial.

- Mayo did not include dissolved iron and dissolved manganese in the operational monitoring plan because iron and manganese do not readily exist in dissolved form in basic (pH>7) waters but exist instead as hydroxide complexes. All waters in the leased area are basic. Measurements of total iron and manganese quantify both the dissolved and complex forms of these elements.

Equipment, structures, and other devices used in conjunction with monitoring the quality and quantity of the surface water in the permit and adjacent areas have been installed, maintained, and operated in accordance with accepted procedures. This equipment will be removed by SUFCO when no longer needed.

Stock Water Ponds

Several stock watering ponds are located in the Pines Tract and Quitchupah Lease area. The ponds are identified as Big Ridge South Draw, Big Ridge East Draw, Box, Jensen, Johnson, Rock, Dry Point, Joes Mill, Slab and Verdus. The stock ponds are located either within the lease area or within one-half mile of the lease area. Surface cracking due to mining related subsidence within the Quitchupah Lease has apparently adversely affected a few of the ponds. Action has been taken by SUFCO in the past to mitigate the damage, including applying bentonitic seals to the pond floors and hauling water for livestock. However, ranchers and State and Federal agencies have erroneously claimed that subsidence has adversely affected several ponds outside of the mining areas. In order to more adequately monitor the effects of mining on the stock watering ponds, SUFCO has been negotiating with DOGM, USFS, and the local rancher's association to create a

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workable monitoring plan for the ponds that can be agreed upon by all participants. DOGM has taken the lead in this process, and as of May 2000, a plan had not yet been finalized. In the interim, SUFCO commits to visiting the ponds within the Pines Tract and Quitchupah Lease area as soon as they are accessible in the spring of each year (typically late April to early May), photographing the condition of each pond, observe the pond for evidence of cracking, estimate the depth and surface area of water contained in the pond, inspect the immediate drainage area for evidence of surface cracking, note general soil moisture conditions, and note the general condition of the pond. Additional monitoring visits will be made in the late summer (late July to early August) and in the fall (late September to early October) of each year. This information will be kept on file at the mine. The effects of subsidence are dormant in the Pines and Quitchupah lease area per the subsidence monitoring report for 2017 on file with the Division in the annual report. Beginning in 2018 the ponds listed above will be monitored once annually and included in the mine's annual report.

It is assumed a new monitoring plan can be agreed upon by the State, USFS, and rancher's association and will be in place prior to the end of 2000. This plan will include the afore mentioned monitoring efforts, as well as determining the functionality and water holding capacity of each potentially affected pond and the determination of the water shed area for each pond. Mitigation requirements in the event of proven mine related effects will also be agreed upon as part of the new monitoring plan.

East Fork of Box Canyon Monitoring and Mitigation Plan

Sufco anticipates undermining and subsiding a portion of the East Fork of Box Canyon beginning in November of 2003 when the mine starts longwalling panel 3LPE. Additional subsidence under the East Fork will occur when the 4LPE panel is mined in 2005. A surface and ground water monitoring and mitigation program more intensive than the general monitoring plan described previously in this Section will be initiated in this area prior to subsidence occurring within the 15-degree angle-of-draw of the stream channel. This monitoring program has included conducting a pre-mining subsidence survey of the East Fork of Box Canyon over the 3LPE and 4LPE panels that incorporated video taping the stream channel from Joe's Mill Ponds downstream to a point above the western-most gate road of the 3LPE panel. The purpose of the video will be to provide a visual record of the stream channel prior to subsidence. Fourteen sites were identified within the portion of the East Fork video taped where the monitoring of surface and/or ground water flows,

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channel width, channel substrate, vegetation, soils, and general geomorpholgy will occur. The general area in which these sites will be located are illustrated on Figure 7-8.

Stream monitoring sites will be monitored specifically for stream flow, channel width, channel substrate changes, and channel convergence. The geology of spring sources will be identified and described. The substrate of the spring tributary where water discharged from the spring converges with other flows and forms a tributary to the East Fork creek will be described. The width of the spring tributary at the location where the vegetation survey is conducted will be monitored.

Some of the site locations have been identified using a survey grade GPS. However, the locations of sites deeper in the Canyon could not be located with a GPS due to the restrictive nature of the narrow canyon when trying to locate satellites with which to triangulate a location.
The vegetation and soil monitoring program is discussed in greater detail in Section 3.2.2.2 of this M&RP. The surface and/or ground water flows and channel width at these stations will be monitored on a weekly basis while mining is occurring within the 15 degree angle-of-draw of the stream channel. Once mining has been completed within the angle-of draw, the sites will be monitored once every two weeks for a period of eight weeks after mining has progressed past the 15 degree angle-of-draw. Table 7-5A presents the monitoring site numbers, monitoring parameters, and the frequency of monitoring. The fourth quarter 2003 water monitoring will be conducted prior to mining within the area of concern in the East Fork of Box Canyon. If new springs are created as a result of subsiding the East Fork, the spring flows will be monitored two times per week until the 15 degree angle-of-draw area above the longwall face has advanced beyond the new spring. Thereafter, the spring flows will be monitored once every week for a period of eight weeks followed by monitoring the springs once every two weeks for eight weeks. A report on the impacts, if any, to the stream or ground water flows, vegetation, soils, general geomorphology, location of the longwall, etc., will be provided via e-mail to the Division on a weekly basis.

One goal of monitoring the stream sites in the East Fork of Box Canyon Creek will be to determine the portion of the stream that is perennial and where the stream is gaining or losing flow prior to, during, and after subsidence. In addition to the monitoring stations, the Thalweg of the stream channel between the lower-most monitoring station and Upper Joe's Mill pond will be surveyed. Also, two pools near monitoring sites EFB-9 and EFB-11, will be monitored before during and after

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subsidence. The criteria for monitoring the two pools will be width and depth of the pool and the height of the fall structure.

Monitoring for subsidence cracks within the stream channel of the East Fork of Box Canyon Creek will also be part of this intensive monitoring and mitigation plan. The details of the mitigation plan are discussed in greater detail in Section 5.2.5.1 of this M&RP. However, in an effort to compile as much of the monitoring requirements for the East Fork of Box Canyon in a single location within the M&RP, the parameters and frequency of monitoring for subsidence have been included in Table 7-5A. The subsidence monitoring program will consist of inspecting the stream channel floor within the active 15 degree angle-of-draw on a twice-a-week basis. Mining induced subsidence effects, such as cracks, slumps, offsets, etc., will be identified, mapped, and a brief narrative of the effects will be recorded and forwarded to the Division on a weekly basis. The portions of the stream within the active angle-of-draw will also be measured weekly for stream flow and channel convergence. The portions of the channel where the longwall shear has moved beyond the 15 degree angle-of-draw will then be monitored for subsidence effects, flow, and channel convergence on a once every two weeks basis for a period of eight weeks. Following the eight week period, monitoring will be conducted on a quarterly basis for a two year period after no subsidence, interception of water, or diversions of water are identified. This monitoring program will result in a moving zone of "high intensity" or twice a week channel monitoring occurring within an area defined by the 15 degree angle-of-draw above the active longwall face. As the longwall face advances, the "high intensity" zone advances and is followed by the "moderate intensity" once-a-week monitoring zone for eight weeks that is then followed by the "less intense" once every two week monitoring zone. A weekly report will be provided via e-mail to the Division on the results of the subsidence monitoring and mitigation activities. A summary report to the Division documenting the pre- and post-mining conditions of springs and stream channel will be submitted 90 days after subsidence monitoring is complete for the 3LPE and 4LPE panels. This report will include a description of all activities and work conducted by Sufco for stream channel evaluation and mitigation. All identified impacts and mitigation efforts will be documented. The results of mitigation, if performed, will be discussed.

Protocol

A Monitor sites for flow and channel width weekly while site is within the 15 degree angle of draw of the longwall face. Once area is outside angle of draw, monitor on a once every two

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week basis for eight weeks. Note any changes due to mine-induced subsidence to flows, soils, vegetation, geomorphology, etc. and provide a weekly report via e-mail to the Division of Oil, Gas and Mining. Spring sites will be measured for changes in the substrate conditions and width of spring tributary channel in area of vegetation study will be monitored.

B Monitor subsidence features, such as cracks, and repairs (if needed) on twice a week basis while features are within the 15 degree angle-of-draw of the active longwall face. These sites will be monitored for location, type of subsidence feature, frequency, repairs needed, type of repairs, and success of repairs. After the features are outside the angle-of-draw, monitor features on a weekly basis for eight weeks followed by monitoring of the features once every two weeks for an eight week period and then once quarterly for a two year period after observed subsidence effects are no longer active. Provide a weekly report via e-mail to the Division of Oil, Gas and Mining.

C Monitor fall structures closely associated with these stream sites. The related pool will be monitored for width and depth while the fall structure will be monitored for changes in height.

A rain and temperature monitoring station will be established in the area of the East Fork of Box Canyon as soon as permitting allows. The data collected from the station will be used in combination with data collected from local water monitoring stations to aid in determining what, if any, impacts have occurred to surface runoff, stream flows, and local springs as a result of mining activities.

Prior to implementation of any mining-induced subsidence mitigation efforts in the stream channel as described in Chapter 5, a Stream Alteration Permit will be obtained from the Utah Division of Water Rights. Sufco will have the alteration permit(s) prior to undermining the East Fork stream channel since the mitigation efforts will occur as soon as possible after a need for mitigation is determined.

Every reasonable attempt will be made by Sufco to implement and follow the monitoring program schedule. However, mining of 3LP panel under the East Fork of Box Canyon will begin in the late

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fall of 2003 and continue through early winter of 2003 and 2004. If access is limited due to snow or inclement weather, the mine's effort to access the area will be documented in the weekly report to the Division. The time of the access attempt, weather conditions, and reason(s) for failing to monitor the East Fork sites will be provided in the report.

TABLE 7-5A

East Fork of Box Canyon Monitoring and Mitigation

Monitoring Sites		Protocol	Comments
EFB -1	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -2	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -3	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -4	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -5	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -6	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -7	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -8	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -9	A, C	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -10	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -11	A, C	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -12	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -13	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB -14	A	Monitor flows, vegetation, soils, geomorphology, etc.	
EFB-***	B	Subsidence Feature - Monitor location, type, frequency, repairs, etc.	

*** Site numbers and quantity of sites will be dependant upon the number of features created due to subsidence. The weekly report to the Division will include all identified sites once mining begins in the area.

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A copy of the October 2003 "Monitoring and Mitigation Plan for Mining Under the East Fork of Box Canyon" prepared by the Division and reviewed and accepted by the Forest with some modifications has been included in Appendix 3-10. The preceding paragraphs have been prepared based on this plan. Sufco will meet all of the monitoring and mitigation responsibilities described in the plan as it pertains to the undermining of the East Fork of Box Canyon.

Springs Pines 310 and Pines 311, located in the east fork (North Water Fork) of the East Fork of Box Canyon, were added to the water monitoring list in July 2006. Initially, these springs have been monitored monthly since June 2006 and will continue to be monitored monthly through December 2006, or as accessible, for field water quality parameters and flow. After December 2006, these sites will be monitored on a quarterly basis for field water quality and flow. The flow from Pines 310 spring area is measured at a point where the majority of the spring area flow coalesce into a channel a few hundred feet north and west of the initial spring discharge area. Field water quality parameters are monitored at one of the points where ground water is discharging from the Castlegate Sandstone. Pines 311 is monitored at the western most point of where ground water is discharging from the outcrop in this spring area.

Pines 105, Joes Mill Pond, Pines 310, and Pines 311 Investigation

The Pines 105 and Joes Mill Pond springs were undermined during the winter of 2005-2006 as Sufco extracted coal from panel 5LPE. In the spring of 2006, Sufco discovered surface discharge of ground water at these locations appeared to have ceased as the area was subsided. The Division concluded that Sufco had caused material damage to the spring areas and required the mine to prepare and submit a plan to restore the spring areas. Initially, Sufco hauled sufficient water to livestock in the area to replace that which was lost when the springs stopped flowing at the surface. In July, Sufco submitted a plan to investigate the effected spring areas and a copy of the investigation plan is included in Appendix 7-22.

The purpose of the investigation proposed is three-fold:

1. Determine if ground water discharge in the area of Pines 105 and Joes Mill Pond springs continue to discharge to the alluvium;

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2. Monitor and evaluate the effects of mining on the surface and subsurface water in the Pines 310 and Pines 311 spring areas; and
3. Determine the potential for completing and operating ground water wells in the spring areas as part of the spring site mitigation activities.

The piezometers/wells completed as part of this project will be monitored on a bi-weekly basis through December 2006 or as accessible. Transducers with data loggers will be placed in several of the piezometers to record data on a more continuous basis. The monitoring frequency of the piezometers/wells after December 2006 will be dependant upon the results of the drilling investigation and the impacts to springs Pines 310, 311, 105, and the Joes Mill Pond of mining the 6LPE panel in the fall and winter of 2006.

A report detailing the results of the drilling and piezometer/ well installation and completion will be submitted to the Division by the end of October 2006. Water level data collected from the piezometers/wells will be reported to the Division electronically within two weeks at the end of each the month through December 2006. The Division will also be notified within three days via e-mail or telephone of significant changes to ground water elevations in Pines 310, 311, 105 spring areas as the 6LPE longwall panel is mined. A report compiling the water level data and interpretation of the data will be submitted to the Division by the end of January 2007.

Based on the findings of the investigation, Sufco will submit to the Division either additional plans (if water is not found in the Pines 105 and Joes Mill Pond area, additional bedrock drilling may be required to locate a suitable source of ground water) or a final plan for mitigation of the effected spring areas.

South Fork of Quitchupah 2R2S Block "A" and 3R2S Block "B" Monitoring and Mitigation Plan

A monitoring and mitigation plan that is more intensive than the general Mining and Reclamation Plan area has been proposed for monitoring water flows, subsidence cracks, and repair of the cracks in the portions of the South Fork of Quitchupah channel to be undermined. This plan is outlined below.

Prior to the initiation of undermining and subsidence, a pre-subsidence survey of the stream channel will be conducted in the portion of South Fork of Quitchupah that flows over the 2R2S

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Block "A" panel and associated gate roads. The survey will consist of a gain/loss survey of flow within the stream channel paying particular attention to surface flows and ground water discharge, soil conditions, and the general channel geomorphology. A similar study was performed in the past but all stream measurements were not conducted on the same date. The second gain/loss survey will be completed on a single day at or near base flow conditions late in the summer or early fall of 2011. The mine will attempt, as part of this second survey, to occupy the same monitoring sites in the panel area as those chosen in the initial survey.

Two weeks before and then once every two weeks after subsidence mining begins, the measuring locations occupied during the gain/loss survey will be reoccupied and flow measurements of the stream flow will be obtained. The approximate locations of these sites are illustrated on Figure 7-9. The once every other week flow measurements will be supplemented by visual observations of flow performed twice a week or once every three to four days. Flow/no flow conditions will be described on these days. If no flow or diminished flows are noted, the appropriate mine and Forest personnel will be contacted and the mitigation plan to restore flows will be implemented.

Semi-weekly flow observations and visual inspections will continue for at least 12 weeks, or as conditions allow, after the completion of mining under the stream channel. The bi-weekly (once every two weeks) stream flow monitoring will continue for at least four weeks, or as conditions and monitoring results indicate necessary, after the completion of subsidence mining under the stream channel. The monitoring plan will then change to quarterly flow and field parameter measurements for two years at four sites: one upstream of the panel, one within the panel, and two downstream of the panel. The location of these new temporary monitoring sites are listed in Table 7-2 and shown on Plate 7-3 and labeled as sites 006A, 006B, 006C and 006D. Additional flow monitoring may be needed to determine specific locations where flow is being lost, and treatments are needed.

Mining ceased beneath the South Fork of Quitchupah Creek in March 2015 (Panel 3R2S) and per the mitigation plan the weekly monitoring obligation for the ponds, springs and channel upstream of the culvert road crossing ceased on June 30, 2017. Flow data (DOGM database) has provided justification for discontinuing the monitoring. The channel, riparian vegetation and springs appear to be stable and unaffected by subsidence associated with underground mining. Ponds 94-1394, 94-982 and 94-115 have shown no effect from mining in the area of the South Fork of Quitchupah and therefore monitoring was discontinued on June 30, 2017. Weekly water monitoring (per the

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mitigation plan) will continue thru the Fall of 2017 from the culvert road crossing downstream to the confluence of the North and South Fork of Quitchupah Creek, as will the search for and repair of mining-induced subsidence damage.

The subsidence monitoring plan for the South Fork of Quitchupah will include frequent inspection of the stream channel during and after active subsidence. While mining is occurring under the stream channel, and within the 15-degree angle-of-draw above the active longwall face, that area of the channel will be inspected semi-weekly for subsidence cracks or other related features. As the longwall face advances and the 15-degree angle-of-draw area follows,
the portions of the channel that now lie outside the 15-degree angle-of-draw will be monitored for subsidence features on a quarterly basis for two years following the cessation of subsidence related effects, if any, due to mining.

Mitigation of cracks that interrupt or divert flows from the stream channel will be sealed immediately with an appropriate impermeable grout or, in some cases, native materials. Sufco will attempt to seal cracks with the least intrusive methods (typically hand placement of grout or native materials) first. The sealing material may be placed by pouring it directly into the crack or, if cracks occur in an actively flowing portion of the stream, the stream may be temporarily diverted using native materials (or a designed flume if necessary to maintain the flow) until the crack is sealed. If cracks are present in channel walls defined by soil, the soil cracks may be hand filled using a native soil/bentonite mix. The sealing of the channel floor and walls will be accomplished with hand tools such as shovel, picks, trowels, etc.

As a backup plan, in the unlikely event that cracks too large to be sealed through the efforts of one or two persons in one day do occur and it appears there is a danger of water being diverted from the channel for an extended period of time, the stream will be temporarily diverted using native materials and a pipe to carry the flow over the crack to maintain the channel flow. Arrangements will be made to get a contractor to the site as soon as possible to repair the crack after consultation with the Forest Service.

There may be sections of the stream channel that may require more intensive mitigation efforts to restore surface flows in the creek. These efforts could include the drilling of closely spaced shallow boreholes in and adjacent to the stream channel and the injection of an acceptable impermeable

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grout into the alluvium or bedrock. The work will be accomplished either using hand tools or low impact equipment to minimize surface disturbance. Existing roads and turnouts will be used as staging areas to locate larger equipment and supplies. Any hoses or lines will be transported from the staging areas to the nearby work sites either by hand, the use of pack animals, or by helicopter. This work will be done with a contractor selected after consultation with the Forest Service.

Additionally, it may be required to remove loose rock from the channel floor, either where the channel flows across thin-bedded bedrock or where large rock have fallen into the channel and is impeding flows. In the instance of the former, past experience has shown this can occur in the upper Blackhawk Formation and is easily repaired by removing enough of the broken channel surface to again expose the stream flow. In the instance of the later, removal of large rocks could be accomplished by drilling and then fracturing the rock into smaller fragments more easily moved to locations were they are not impeding flow. This work may be completed using available pneumatic or hydraulic tools that do not require road or pad building disturbances. In the unlikely event that large boulders do need to be moved, pumps and tanks necessary to complete the work will be located in pre-disturbed areas, such as roads or turnouts, and hoses will be walked into the work area.

Sufco will conduct longwall mining operations in such a manner as to minimize surface disturbance while mining within the 15-degree angle-of-draw area that includes the South Fork stream channel. This will be accomplished by advancing the longwall on a schedule where mining will not be suspended for a period to exceed 48 hours.

A copy of the "Monitoring and Mitigation Plan for Undermining the South Fork of Quitchupah 2R2S Block "A" and 3R2S Block "B"has been included in Appendix 3-14. The preceding paragraphs have been prepared based on this plan. Sufco will attempt to meet the monitoring and mitigation responsibilities described in the plan as it pertains to the undermining of the South Fork of Quitchupah 2R2S Block "A" and 3R2S Block "B". Refer to Chapter 3, Section 3.3.3.3 for additional information.

A bi-weekly (once every two weeks) report on the impacts to stream flow and required mitigation, if any, will be submitted via e-mail to the Division and the Forest detailing the results of the inspections while mining is occurring under the stream channel. The reports will include, but not

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necessarily be limited to: a map illustrating the current location of the longwall face; descriptions and dates of field activities; noted changes in stream and local geomorphology; location, width, frequency of cracks; and a description of repairs, if any, conducted. If the prescribed inspections cannot be conducted, the reason for the missed inspection and a record of the attempt to conduct the inspection will be submitted to Division and the Forest in the report. Division and the Forest will be notified immediately after mining-induced cracks, if any, are found in the South Fork stream channel and the steps taken or planned to be taken as mitigation. Thereafter, Division and the Forest will be advised of continuing mitigation efforts, if needed, in the report.

Prior to implementation of any mining-induced subsidence mitigation efforts in the stream channel as described in Chapter 5, a Stream Alteration Permit will be obtained from the Utah Division of Water Rights. Sufco will have the alteration permit(s) prior to undermining the South Fork of Quitchupah stream channel since the mitigation efforts will occur as soon as possible after a need for mitigation is determined.

Greens Hollow. Refer to Appendix 7-28 for the Greens Hollow PHC which describes the potential impacts on the hydrologic balance. The PHC also contains a drawing showing the location and a description of monitoring data for the monitoring locations within the Greens Hollow Lease. Plate 7-3 shows historic in addition to current water monitoring locations. Plate 7-10 shows current monitoring locations only.

A Greens Hollow Lease progress map (**Confidential**) will be created highlighting mined out areas segmented with monthly completion dates and labeled showing the current location of the longwall. During mining within the Lease the map will be submitted to the Division within 30 days following the end of the previous quarter with the sediment pond and waste rock quarterly inspection forms.

Locations for surface water monitoring above and below the coal panels within the Greens Hollow Lease are shown in Appendix 7-27 on Figure 1, Plate 7-3, Plate 7-10 and Table 9 of the PHC. The monitoring of the above and below sites began in the first quarter of 2017. A description of the monitoring program for the above and below sites is provided in Table 7-2.

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7.3.1.3 Acid- and Toxic-Forming Materials

Results of monitoring of mine discharge, surface, and groundwater, indicate that no impact to these waters from acid- and toxic-forming materials has been found in the permit and adjacent areas (Section 7.2.8.3). Parameters defining acid- and toxic-forming materials continue to be monitored as described in the Waste Rock Volume of this M&RP. In the event that acid- or toxic-forming materials are identified, they will be disposed of in the waste rock disposal area.
The treatment of these materials will be handled as indicated in the Waste Rock Volume of this M&RP.

7.3.1.4 Transfer of Wells

Before final release of bond, exploration or monitoring wells will be sealed in a safe and environmentally sound manner in accordance with R645-301-631, R645-301-738, and R645-301-765. Ownership of wells will be transferred only with prior approval of the UDOGM. The conditions of such a transfer will comply with State and local laws. SUFCO will remain responsible for the management of the well until bond release in accordance with R645-301-529, R645-301-551, R645-301-631, R645-301-738, and R645-301-765.

7.3.1.5 Discharges

Three UPDES discharges are associated with the SUFCO mine. These include two mine water discharges and the sedimentation pond discharge. A description of these discharges is provided in Section 7.2.4.2.

The primary mine-water discharge consists of water from the underground mine workings that is diverted into mined-out areas now used as sumps. These sumps are used to settle out fines before discharge to the surface. This diversion is done in accordance with the requirements of R645-301-731.100 through R645-301-731.522 and R645-301-731.800. The clarified water flows through a box weir and pipeline to a point on an outcrop of Star Point Sandstone about 20 feet above the North Fork of Quitchupah Creek (see Plate 7-3). From there, the water flows directly into the creek. This discharge water is monitored for compliance with the UPDES permit standards prior to release from the mine.

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An emergency mine-water discharge is also maintained. A description of this discharge point is provided in Section 7.2.4.2.

Water from the disturbed surface area in East Spring Canyon is collected and conveyed to the sedimentation pond. After the collected water is allowed time to settle-out the sediment, the water is discharged to the creek. The discharge water is monitored for compliance with the UPDES permit standards prior to release from the sedimentation pond.

No discharges of surface water are being made to underground mines and none are planned in the future.

Upon abandonment of the mining area, the connection between the Sufco Mine and old Link Canyon Mine works will be sealed and made as water tight as possible. A low area that will capture water will remain in the west portal, in the same area as the roof fall that created the underground pond prior to rehabilitating the old Link Canyon Mine portal. The low area will be allowed to fill and will discharge naturally at the west portal. Some structures used to seal the old works from the rehabilitated works may be removed as the mine is abandoned thus ensuring the discharge at the east portal during reclamation.

7.3.1.6 Stream Buffer Zones

All perennial and intermittent streams in the mine area are protected by 100 foot stream buffer zones on either side of these streams. Coal mining and reclamation operations should not cause or contribute to the violation of applicable Utah or federal water standards and should not adversely effect the water quantity and quality or other environmental resources of the stream.

Stream Channel Diversions. Temporary or permanent stream channel diversions comply with R645-301-742.300.

Buffer Zone Designation. The areas surrounding the streams that are not to be disturbed are designated as buffer zones, and SUFCO has marked these as specified in R645-301-521.260.

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7.3.1.7 Cross Sections and Maps

The locations of water rights for current users of surface water flowing into, out of, and within the permit and adjacent areas is provided on Plate 7-2. Discharges associated with the permit and adjacent areas are located as presented on Plate 7-3.

The locations of each water diversion, collection, conveyance, treatment, storage, and discharge facility to be used in the East Spring Canyon area are presented on Plate 7-6. Similar information for the waste-rock disposal site is presented in the Waste Rock Volume of this M&RP. Similar information for the Link Canyon Substation No. 1 and No. 2 facility areas is presented on Plates 5-2D and 5-2E. Similar information for the Link Canyon Portal facility area is presented on Plate 5-2F.

Locations and elevations of each station to be used for water monitoring during coal mining and reclamation operations are presented on Plate 7-3.

The construction details and cross sections for the concrete sediment trap are located in the "Alternate #1 Drainage Facilities and Sediment Control Plan" (Appendix 7-8). The existing topography and cross sections for the primary sedimentation pond are located on Plates 7-4 and 7-5. The design topography and cross sections for the overflow pond are located on Plates 7-4A and 7-5A. The design topography and cross sections for the waste rock disposal site sedimentation pond are located in the Waste Rock Volume of this M&RP.

Other Cross Sections and Maps. Other relevant cross sections or maps are presented and discussed in Chapter 5 of this M&RP.

7.3.1.8 Water Rights and Replacement

Ground and surface water rights do exist within the Sufco Mine leased area. Mitigation has been performed at stock pond locations where claims have been made that the available surface water has been impacted by subsidence. Mitigation at these locations has been performed by the placement of bentonite in the bottom of stock ponds and by hauling replacement water to the ponds for livestock use during summer months.

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The Permittee will mitigate and replace the water supply of any land owner or adversely affected State appropriated water if such a water supply proves to be contaminated, diminished or interrupted as a result of mining operations. First, a determination will be made by the Division in accordance with R645-301-731.800 as to whether or not material damage has occurred. Then, in accordance with Regulation R645-301-525.510, the operator will correct any material damage resulting from subsidence caused to surface lands (which includes water rights), to the extent technologically and economically feasible. Negotiations will be held immediately with the impacted party to determine the appropriate mitigation activities. The restoration of water flows to impacted sources will be accomplished using the Best Technology Currently Available (BTCA). These activities may include, but not necessarily be limited to: piping or trucking water to the location of the loss; sealing surface fractures to prevent further losses (i.e., stream floors on bed rock or in shallow alluvium), and; construction of a ground water well and the installation of pumps to restore flows. If the above efforts are not successful, then the operator will explore the transferring of water rights to the injured party in flow equal to the determined loss and/or monetary reimbursement for proven material damages.

The water supply in the East Fork of Box Canyon is of special concern to Sufco and the regulatory authorities. In an effort to protect the minimal surface flows in this area, an intense monitoring and mitigation plan will be implemented prior to full extraction mining taking place under the East Fork. If changes in the quantity and quality of the water in the East Fork are noted, the Division will be immediately notified. A determination of the amount of water, if any, that is lost due to mining activities will be made using surface and ground water flow and climatic data. If a loss of flow is confirmed, the loss will be addressed as described in the proceeding text of this section.

The Forest Service (USFS) continues to work with the Division of Water Rights to develop subbasin claims that would assert a claim of right for all developed and undeveloped water on the National Forest System lands. The majority of the water rights in the Greens Hollow Lease belong to the USFS for stock watering along streams and at springs. The permittee holds five water rights for multiple uses including temporary water mitigation and exploratory drilling.

7.3.2 Sediment Control Measures

The existing sediment control measures within the permit area have been designed, constructed, and maintained to prevent additional contributions of sediment to streamflow or to runoff outside

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the permit area. In addition, they have been designed to meet applicable effluent limitations, and minimize erosion to the extent possible.

The structures to be used for the runoff-control plan for the permit area include disturbed and undisturbed area diversion channels, sedimentation ponds, containment berms, silt fences, and road diversions and culverts.

7.3.2.1 Siltation Structures

The siltation structures within the permit area consist of the sedimentation ponds described in Section 7.3.2.2.

7.3.2.2 Sedimentation Ponds

There are four sedimentation ponds operating at the mine facility. Three of them are located in the immediate vicinity of the existing facilities. A fourth pond is located at the waste rock disposal site.

Concrete Sediment Trap. A sediment trap is located near the southern end of the mine yard which captures all disturbed area runoff from the mine yard area. This concrete sediment trap was designed to remove in excess of 65% of all solids from the disturbed area runoff before the water enters the main sedimentation pond below. The purpose of the concrete sediment trap is to reduce the required size of the main sedimentation pond and to decrease the amount of overall disturbance. A detailed design of the concrete sediment trap is contained in Appendix 7-8.

Operation of the sediment trap includes decanting the existing water and removing the sediment. Except during use, the telescoping decanting valve on the trap is locked to prevent unauthorized drainage of the concrete structure. On regular UPDES sampling days, the structure is inspected for sediment content. If a sediment delta is evident at the water level extending to or beyond the first of the mine discharge pipes, the structure will be decanted within one week of the observation. The decanting period shall not exceed four days. Sediment material from the structure will then be removed with a front-end loader and disposed of at the waste-rock disposal site.

Primary Sedimentation Pond. The primary sedimentation pond is located in the area immediately below the fill on which the existing mine facilities are constructed. The existing sedimentation pond topography and cross sections are presented on Plates 7-4 and 7-5 of this M&RP.

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The staff gauge in the pond has been marked to indicate the 60% clean-out elevation of 7408.1 feet as defined in Section 7.4.2. At least once each year following the spring runoff event, the pond will be drained with the decanting device to inspect the accumulated sediment level. The pond will be sampled for effluent quality immediately before the decanting operation.

If sediment has accumulated to the 60% clean-out elevation, the pond will be cleaned. The sediment will be transported and disposed of at the waste rock disposal site.

The southern-most extent of the sedimentation pond dam is located 180 feet south of the lease boundary across East Spring Canyon. The Fishlake National Forest Service issued a special use permit that approved the construction with the stipulation that the dam site be included in the disturbed mine permit area and subject to final reclamation. The area is included in the calculation of the disturbed area subject to bonding and in the calculation of final reclamation costs.

Overflow Pond. The overflow pond is located 800 feet downstream of the primary sedimentation pond. The overflow pond topography, cross sections and details are presented on Plate 7-4A and 7-5A of this M&RP.

The staff gauge in the overflow pond will be marked to indicate a clean-out elevation of 7243.62 feet as defined in Section 7.4.2. At least once each year, following the spring runoff event, the pond will be drained with the decanting device to inspect the accumulated sediment level. The pond will be sampled for effluent quality immediately before the decanting operation. When sediment has accumulated to the clean-out elevation, the pond will be cleaned. The sediment will be transported and disposed of at the waste rock disposal site.

Waste Rock Disposal Site Sedimentation Pond. The sedimentation pond located at the waste rock disposal site is presented on Map 7 in the Waste Rock Volume of this M&RP. A discussion of the operation, maintenance, and reclamation of this pond is also contained therein.

Compliance Requirements. All sedimentation ponds will be maintained until removal in accordance with the reclamation plan (see Section 5.40 of this M&RP). When a pond is removed, the land will be revegetated in accordance with the reclamation plan defined in Section 5.40.

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The Primary sedimentation pond and concrete sediment trap were designed together to contain the volume of sediment equal to 0.035 acre-foot per acre of disturbed area. The concrete sediment trap will provide for removal of 65% of this sediment volume, while the sedimentation pond will contain the remaining 35%. In addition, the sedimentation pond will fully contain the runoff from the 10-year, 24-hour storm event. The spillways for both the sedimentation pond and concrete sediment trap will adequately pass the peak flow from the 25-year, 6-hour precipitation event.

The overflow pond has been designed to retain sediment from the disturbed mine facilities and runoff from the 10-year, 24-hour storm event. The spillway for the overflow pond has been designed to safely pass the peak flow from the 25-year, 6-hour precipitation event. The affected area will be included in the calculation of the disturbed area subject to bonding and in the calculation of final reclamation costs.

The waste rock disposal site sedimentation pond was designed to contain a sediment volume equal to 0.1 acre-foot per acre of disturbed area. It will also fully contain the runoff from the 10-year, 24-hour storm event. The spillways for the pond were initially designed to pass the peak flows from the 25-year, 24-hour storm event. The revised design storm (25-year, 6-hour precipitation event) results in a smaller peak discharge and, thus, the spillways are adequately designed.

Additional design standards for all ponds are presented in Section 7.4.2.

MSHA Requirements. MSHA requirements defined in 30 CFR 77.216 are not applicable since the existing sedimentation ponds do not impound water or sediment to an elevation of 20 feet or more above the upstream toe of the structure. The ponds also store a volume less than 20 acre-feet.

7.3.2.3 Diversions

The objective of the run-off control plan is to isolate, to the maximum degree possible, run-off from disturbed areas from that of undisturbed areas. This is accomplished by:

- Allowing all upstream run-off to by-pass the disturbed area via a network of culverts.

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- Routing run-off from the undisturbed east slope above the facilities down diversion ditches in the east side road to by-pass the disturbed area.

- Routing of any run-off from undisturbed areas which enters the disturbed area into the sediment control system.

The location of each diversion ditch or culvert for the main facility area is presented on Plate 7-6. The location of each diversion ditch for the Link Canyon Portal and Substation No. 1 and No. 2 facility areas is presented on Plates 5-2D, 5-2E, and 5-2F. A brief list of each diversion structure is as follows (refer to Plates 7-6, 5-2D, 5-2E, and 5-2F for the location of each sub-watershed boundary):

Diversion Ditches:

- Interception ditch along the East Side Road which drains watershed CBE-5.
- Interception ditch along the East Side Road which drains watersheds CBE-1 through CBE-5.
- Substation pad upper undisturbed interception ditch which drains watershed CBE-4.
- Substation pad lower undisturbed interception ditch which drains watershed CBE-3. This ditch is part of the alternate sediment control measures defined in Section 7.4.2.1.
- Riprap diversion channel for CBE continuance diversion. This diversion drains watersheds CBE-1 through CBE-5.
- Interception ditch which drains undisturbed watershed ESC-6 north of ATOF.
- Interception ditch which drains undisturbed watershed ESC-7 north of ATOF.
- Interception ditch which drains undisturbed watershed MSH-2 north of ATOF.
- Sedimentation Pond access road diversion ditch which drains disturbed watershed DIS-3.
- Main access road diversion ditch which drains undisturbed watershed DWN-1.
- Link Canyon Substation No. 1 ditch which drains watersheds LINK and ASCA-1.
- Link Canyon Substation No. 1 road swell which drains watersheds LINK, ASCA-1, and ASCA-3.

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- Link Canyon Substation No. 2 ditch which drains watersheds LINK No.2, ASCA-4, and ASCA-7.
- Link Canyon Portal Access Road Channel No. 1 which diverts the access road disturbed drainage and undisturbed drainage above the access road to the Link Canyon drainage bypass culvert inlet.
- Link Canyon Portal Pad Channel No. 2 which diverts the pad area disturbed drainage and the undisturbed area above the pad to the Link Canyon drainage bypass culvert inlet.
- West Overflow Pond Undisturbed Area Diversion Channel which diverts and drains runoff from watershed DWN-3 around to Overflow Pond Access Road Channel.
- Overflow Pond Access Road Channel which diverts and drains runoff from watershed DWN-3 along the Overflow Pond Access Road.
- East Overflow Pond Undisturbed Area Diversion Channel (Shallow Section) which diverts and drains runoff from watershed DWN-5 around the Overflow Pond.
- East Overflow Pond Undisturbed Area Diversion Channel (Steep Section) which diverts and drains runoff from watershed DWN-5 down the overflow pond impoundment.

Diversion Culverts:

- CBE bypass culvert at substation which drains watersheds CBE-2 through CBE-5.
- Pipe No. 5 diversion culvert which drains undisturbed watershed DWN-1.
- Mud Spring Hollow bypass culvert which drains undisturbed watersheds MSH-1 and MSH-2. This culvert discharges into the East Spring Canyon bypass culvert.
- East Spring Canyon bypass culvert which drains undisturbed watersheds ESC-1 through ESC-7. This bypass also receives flows from the Mud Spring Hollow bypass.
- East Spring Canyon bypass culvert emergency diversion at the main mine fan. This 3.5 foot square drop drain with oil skimmer cap connects into a 48-inch culvert directed into the East Spring Canyon bypass culvert. This serves as an overflow system when the trash rack at the inlet to East Spring Canyon becomes plugged with debris.

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- 8-inch pipe diversion for undisturbed watershed ESC-7. This pipe tees to the 10-inch pipe that drains undisturbed watershed ESC-6.
- Main Mine Fan Diversion. The main mine fan is located in a depression which is nine feet below the adjacent mine yard drainage system. A sump pump with automatic float controls in front of the main fan will pump the runoff from this area into the 10-inch mine yard drain line.
- 10-inch mine yard culvert drainage system. This system discharges to the concrete sediment trap.
- Link Canyon Portal bypass culvert which drains watersheds LCP-East and LCP-West.
- The primary sediment pond diversion culvert allows runoff from the disturbed area to bypass the primary sedimentation pond, thereby allowing water to be drained from the primary sedimentation pond for sediment removal. This culvert discharges to the overflow pond.
- The 66-inch overflow pond bypass culvert allows runoff from undisturbed watersheds DWN-1, DWN-2, DWN-3, MSH-1, MSH-2, and ESC-1 through ESC-7 to bypass the overflow pond. This culvert discharges immediately downstream of the overflow pond.

All diversion ditches are maintained with adequate rip-rap or alternative erosion protection in the ditch sections where flow velocities are great enough that a ditch lining is necessary. Adequate ditch capacities are maintained in all ditch sections. Culverts are kept free of debris and each outlet is lined with adequate riprap. Detailed diversion design is presented in Section 7.4.2.

Water bars in roadside ditches have been constructed of rocks to form low dams across the ditches. The rocks are large enough to resist movement during anticipated run-off events. They are arranged to channel water down the center of the ditch rather than around the water bar ends to prevent erosion of the ditch side walls. Accumulations of sediment behind the ditch water bars are permitted to rise to the lowest height of the bar.

Diversion ditch and culvert operation and maintenance for the diversions within the waste rock disposal site are presented in the Waste Rock Volume of this M&RP.

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7.3.2.4 Road Drainage

Road drainage facilities include diversion ditches, culverts, containment berms, and/or water bars. The road drainage diversion ditches and culverts for the mine site and Link Canyon facility area are included in the list of diversions presented in Section 7.3.2.3 above. In addition, water bars have been constructed across dirt roads within the disturbed areas to channel water off the road onto downslopes or into roadside ditches. Riprap has been placed along these transitions to minimize the potential for erosion. Water bars have been constructed on the East Side road and along the access road to the sedimentation pond. Additional road drainage design information is presented in Section 7.4.2.

The operation of the road drainage diversions within the waste rock disposal site is presented in the Waste Rock Volume of this M&RP.

All road drainage diversions will be maintained and repaired to original condition following the occurrence of a large storm event. Culvert inlets and outlets will be kept clear of sediment and other debris.

7.3.3 Impoundments

7.3.3.1 General Plans

There are four sedimentation ponds operating at the mine facility as described in Section 7.3.2.2. Three ponds are located at the East Spring Canyon surface facilities. A fourth pond is located at the waste rock disposal site.

The concrete sediment trap is located near the southern end of the mine yard and captures all disturbed area runoff from the mine yard area. A detailed design of the sediment trap is contained in Appendix 7-8.

The primary sedimentation pond is located in the area immediately below the fill on which the existing mine facilities are constructed. The existing sedimentation pond topography and cross sections are presented on Plates 7-4 and 7-5 of this M&RP.

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The overflow pond is located 800 feet downstream from the primary sedimentation pond. The overflow pond is designed to allow for flood control and sediment settling while the primary sediment pond is being drawn down for sediment removal. A series of canal boxes with valves will allow the primary sediment pond to be bypassed for draw down, sediment removal, and maintenance. Detailed design information regarding the overflow pond is provided in Appendix 7-23 and Plates 7-4A and 7-5A.

The waste rock disposal site sedimentation pond is located at the waste rock disposal site and is presented on Map 7 in the Waste Rock Volume f this M&RP.

Certification. All maps and cross sections of the sedimentation ponds have been prepared by or under the direction of and certified by a qualified, registered, professional engineer.

Maps and Cross Sections. The construction details and cross sections for the concrete sediment trap are located in Appendix 7-8. The existing topography and cross sections for the main sedimentation pond are located on Plates 7-4 and 7-5 of this M&RP. The topography and cross sections for the overflow pond are located on Plates 7-4A and 7-5A of this M&RP. The design topography and cross sections for the waste rock disposal site sedimentation pond are located in the Waste Rock Volume of this M&RP.

Narrative. A description of each sedimentation pond is presented in Sections 7.3.2.2 and 7.4.2 of this M&RP.

Subsidence Survey Results. No underground coal mining occurs beneath the existing impoundments within the permit area and, therefore, there has been no effect from subsidence.

Hydrologic Impact. The preliminary hydrologic and geologic information required to assess the hydrologic impacts of the impoundments can be found in Section 7.2.4 and Chapter 6, respectively.

Design Plans and Construction Schedule. There are no additional structures proposed for the mining operation at this time. Designs of all existing structures have been described within this M&RP.

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7.3.3.2 Permanent and Temporary Impoundments

Requirements. All impoundments have been designed and constructed using current, prudent, engineering practices. Specific foundation design and construction criteria are presented in Chapter 5 of this M&RP. Specific hydrologic design criteria for each impoundment are presented in Section 7.4.3. All impoundments will be inspected regularly based on the schedule contained in Section 5.1.4.3.

Permanent Impoundments. There are no permanent impoundment structures within the mine facilities at this time.

Temporary Impoundments. The UDOGM authorized the construction of the existing temporary impoundments at the mine as part of coal mining and reclamation operations.

Hazard Notifications. The sedimentation ponds will be examined for structural weakness and erosion at least four times per year. A report of these findings will be submitted to the UDOGM on a quarterly basis.

7.3.4 Discharge Structures

The discharge structures within the East Spring Canyon facilities area include the spillways on the concrete sediment trap, primary sedimentation pond, and overflow pond. These discharge structures are defined in Section 7.4.4. The spillways constructed on the waste rock disposal site sedimentation pond are described in the Waste Rock Volume of this M&RP.

7.3.5 Disposal of Excess Spoil

There is no excess spoil generated at the mine.

7.3.6 Coal Mine Waste

Areas designated for the disposal of coal mine waste and coal mine waste structures are constructed and maintained as described in the Waste Rock Volume of this M&RP.

7.3.7 Noncoal Mine Waste

Noncoal mine waste is stored and disposed of as described in Chapter 5.

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7.3.8 Temporary Casing and Sealing of Wells

Each groundwater monitoring well identified on Plate 7-3 will be operated and maintained as described in Section 7.4.8.

7.40 Design Criteria and Plans

7.4.1 General Requirements

This M&RP includes site-specific plans that incorporate minimum design criteria for the control of drainage from disturbed and undisturbed areas.

7.4.2 Sediment Control Measures

7.4.2.1 General Requirements

Design. Existing sediment control measures have been designed, constructed and maintained to provide the following:

- Prevent additional contributions of sediment to stream flow or to runoff outside the permit area.
- Meet the effluent limitations defined in Section 7.5.1.
- Minimize erosion to the extent possible.

Appendix 5-11 contains design drawings and information pertaining to the paving of an area in the upper mine yard and the repair/re-paving of an adjacent area. The areas to be paved will have three segments of concrete gutter with drip drains/inlet boxes and a fourth drop drain/inlet box in the asphalt to collect and direct runoff to the lower mine yard.

Appendix 5-11 contains design drawings and information pertaining to the construction of a sump(also referred to as the "West Lease #1 Belt Sump") at the entrance of the existing West Lease Beltline Tunnel. New drainage line and junction boxes will direct treated water from the sump into existing mine yard drainage culverts. A portion of the mine yard will also be paved/repaved in the vicinity of the West Lease Portal, directly east of the ROM coal storage area (Appendix 5-11-2 drawing)

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Measures and Methods. The sediment control measures at the mine include practices carried out within and adjacent to the disturbed area. Sediment control methods include:

- Retention of sediment within the disturbed area;
- Diversion of runoff away from the disturbed area;
- Diversion of runoff using channels or culverts through disturbed areas to prevent additional erosion;
- Cut and fill slopes within the disturbed area will be revegetated with a quick growing vegetative cover (standard seed mix in section 3.4.1.2 minus the shrubs and trees) to provide interim reclamation and stability of the slopes during mining.
- Provide straw dikes, riprap, check dams, mulches, vegetative sediment filters, dugout ponds and other measures that reduce overland flow velocities, reduce runoff volumes or trap sediment;
- Treatment with chemicals; and
- Treatment of mine drainage in underground sumps. There are four portal sites in Quitchupah Canyon. The 4 East portal site is classified as an ASCA. South portals, 3 East portals, and Quitchupah portals have sediment control consisting of routing runoff from disturbed areas into the mine with berms and insloping. The runoff is then treated using in mine settling ponds prior to discharge through approved UPDES points. The disturbed area associated with the South portals is 0.017 acre. The disturbed area associated with the 3 East portals is 0.017 acre. The disturbed area associated with the Quitchupah portals is 0.017 acre. A calculation demonstrating the insignificance of the inflow of surface water into the mine is included in Appendix 7-16.

During construction of the new overflow pond sediment from the disturbed area will be controlled by the use of containment berms and silt fencing.

Several alternate sediment control areas are defined within the mine site and are listed below (see Plates 5-2B,C,D,E,&F):

- The original substation pad area and fire water tank above the office building. The sediment controls include a graveled pad area and silt fences. The disturbed area is 0.324 acre.

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- The topsoil stockpile near the mine site primary sedimentation pond. The sediment control consists of containment berms and silt fencing. The disturbed area is 0.105 acre.
- The topsoil stockpile near the mine site overflow pond. The sediment control consists of containment berms and silt fencing. The disturbed area of the overflow pond topsoil stockpile is 0.141 acres.
- The subsoil, topsoil and sedimentation pond topsoil stockpiles at the waste rock disposal site. The sediment controls include containment berms and silt fencing. The disturbed area of the subsoil and topsoil stockpiles is 1.24 acre. The disturbed area of the pond topsoil pile is 0.293 acre.
- The area above the mine fan in East Spring Canyon. The sediment control consists of silt fencing. The disturbed area is 0.122 acre.
- The pump house in Convulsion Canyon. The sediment control consists of containment berms and silt fencing. The disturbed area is 0.075 acre.
- The leach field in Convulsion Canyon. The sediment control consists of containment berms and silt fencing. The area is fenced to prevent grazing. The disturbed area is 0.40 acre.
- The new substation pad disturbed area is 0.287 acre. The sediment controls include gravel and silt fences.
- The 4 East portal site consists of a pad area where a mine fan has been built. The disturbed area associated with the two portal openings at this site is 0.70 acre. Alternate sediment control at this pad consists of a containment berm, gravel and silt fencing.
- The Link Canyon Substation No. 1 facility disturbed area is 0.18 acre. This substation pad area was reclaimed in 2000. The sediment control consists of containment berms, silt fencing, and vegetation.
- The Link Canyon Substation No. 2 facility disturbed area is 0.12 acre. The sediment control consists of containment berms, gravel and silt fencing.
- The Link Canyon Portal facility disturbed area is 0.18 acre. The sediment control consists of containment berms, gravel and silt fencing.

The total area for Alternate Sediment Control Areas (ASCA) is 4.167 acres. This is approximately 13.6 percent of 30.454 acres of total disturbed area at the mine site, Link Canyon Portal and

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Substation No. 1 and No. 2 facility sites, and waste rock disposal site (including ASCA's and SAE's).

The upper yard concrete gutters and inlet boxes/drop drains will direct surface runoff into existing culverts, which discharge water into the sediment pond(s) for treatment. There will be no additional runoff introduced into the designed drainage system with the paving of the upper yard area. Refer to Appendix 5-11 for details of the gutters and inlet boxes.

The West Lease #1 Belt Sump will capture and treat water from the beltline as well as from portion of the mine yard in the vicinity of the West Lease portal. Treated water from the sump will be directed through new drainage lines and junction boxes to existing mine yard drainage culverts. Refer to sheet number Appendix 5-11-2 for location of sump, drainage lines, and junction boxes. Sump design details are located in Appendix 5-11, West Lease #1 Belt Sump.

7.4.2.2 Siltation Structures

General Requirements. Additional contributions of suspended solids and sediment to stream flow or runoff outside the permit area are being prevented to the extent possible using various siltation structures.

The existing siltation structures for the main facilities area, the concrete sediment trap and primary sedimentation pond, were not constructed before beginning coal mining operations. The structures were constructed upon implementation of applicable State and Federal Regulations. The overflow pond was constructed to allow for continued compliance with State and Federal Regulations. The sedimentation pond for the waste rock disposal site was constructed before the site was used. Each structure has been certified by a qualified registered professional engineer.

All siltation structures which impound water have been designed, constructed and maintained as described in Chapter 5 and Sections 7.3.3 and 7.4.3.

Siltation structures are also provided at the mine-water discharges points. Water is presently being discharged from the mine at UPDES discharge point 003 from the Quitchupah Canyon breakouts. UPDES discharge point 001 is approved as an alternative mine water discharge point. Design of the siltation structures for these discharge points is presented in Section 7.3.1.5.

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Sedimentation Ponds. There are four sedimentation ponds operating within the permit area. These ponds are described as follows:

- Concrete sediment trap located at the south end of the main facilities area.
- Primary sedimentation pond located in the area immediately below the fill on which the existing mine facilities are constructed.
- Overflow pond located approximately 800 feet downstream from the primary sedimentation pond.
- Waste rock disposal site sedimentation pond located at the waste rock disposal site.

Sedimentation Pond Use.

Individually or in Series. The concrete sediment trap and the primary sedimentation pond or overflow pond are designed to work in series to manage the design sediment volume and pass the peak discharge rate. The overflow pond is designed to allow runoff from the concrete sediment trap to bypass the primary sediment pond to allow for draw down, sediment removal, and maintenance. The sedimentation pond at the waste rock disposal site functions individually.

Location. All sedimentation ponds are located as near as possible to the disturbed areas. The location of the concrete sediment trap, primary sedimentation pond, and overflow pond are indicated on Plate 7-6. Location of the waste rock disposal site sedimentation pond is presented in the Waste Rock Volume of this M&RP. The concrete sediment trap, primary sediment pond, and waste rock disposal site sediment pond are not located within a perennial stream channel. The overflow pond is located within a perennial stream channel.

Design, Construction and Maintenance.

Sediment Storage Volume. The concrete sediment trap, primary sedimentation pond or overflow pond were designed to, in series, control a sediment volume of 0.035 acre-feet per acre of disturbed area. The disturbed area, contributing sediment to the concrete sediment trap and primary sedimentation pond, contains 15.88 acres from contributing watersheds DIS-1 through DIS-5. The disturbed areas, contributing sediment to the overflow pond, contains 16.49 acres from

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contributing watersheds DIS-1 through DIS-6. Refer to Plate 7-6 for a location of the watersheds. Although it contributes runoff to the ponds, a sediment storage volume from the watershed CBW-1 is not included in the calculations because it is an undisturbed area.

The sediment trap was constructed to provide easy access for the removal of 65% of all solids before runoff from the disturbed area enters the primary sedimentation pond. Although the concrete basin does not have 65% of the total sediment volume it permits reduction of the primary pond size by that amount because it provides a sediment control measure for the removal of sediment equal to the reduced volume.

TABLE 7-6

Summary of Watershed Data

Watershed	Curve Number	Area (acres)	Time of Concentration (hours)
DIS-1	80	2.46	0.021
DIS-2	80	9.27	0.226
DIS-3	80	1.40	0.066
DIS-4	80	2.23	0.022
DIS-5	100	0.34	0.008
CBW-1	72	29.8	0.183
DWN-1	79	7.23	0.110
CBE-1	72	12.4	0.187
CBE-2	90	0.30	0.017
CBE-3	90	0.05	0.011
CBE-4	72	3.05	0.119
CBE-5	72	3.88	0.107
ESC-1	72	882	1.36
ESC-2	72	1010	0.875
ESC-3	72	211	0.453
ESC-4	72	468	1.18
ESC-5	72	487	0.776

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Watershed	Curve Number	Area (acres)	Time of Concentration (hours)
ESC-6	79	0.92	0.042
ESC-7	79	0.57	0.053
MSH-1	72	1956	1.89
MSH-2	79	0.55	0.046
ESC-1 through ESC-5	72	3058	1.89
DWN-2	79	6.02	0.033
DWN-3	79	2.25	0.028
DWN-4	79	36.74	0.217
DWN-5	79	12.65	0.175
DIS-6	100	0.61	0.015

The concrete sediment trap was constructed after consultation with representatives from the Office of Surface Mining, the Division of Oil, Gas and Mining and the U.S. Forest Service during the spring of 1980 and was built subsequent to approval of the various regulatory authorities. The design was selected in preference to other designs employing a full size pond due to environmental considerations. Among these considerations was that a full size pond would have required the disturbance of at least twelve additional acres of presently undisturbed area. In addition, the resulting pond would have been exceedingly difficult to maintain with respect to regular and frequent sediment recovery and disposal.

The primary sedimentation pond was designed to fully contain the remaining 35% of the design sediment volume. Based on calculations presented in Appendix 7-14, the disturbed area totals 15.88 acres. Therefore, the primary sedimentation pond will contain a maximum of 24,211 cubic feet (0.556 acre-feet) of sediment. The elevation of the maximum sediment level is 7410.4 feet. The 60% sediment clean-out volume of 14,527 cubic feet (0.333 acre-feet) has an elevation of 7408.1 feet.

The overflow pond is designed to work in series with the concrete sediment trap, and/or the primary sedimentation pond. A review of sedimentation pond discharge records for the period of 11/06/99

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to 07/09/08 indicates that normal dust suppression activities at the facility, and wash down of transport vehicles contributes a constant flow of approximately 0.046 cfs from the disturbed area to the concrete sediment trap and primary sedimentation pond. The sediment trap and the primary sedimentation pond were designed to create a quiescent sediment settling area capable of containing runoff from a 10-year, 24-hour storm with a spillway capable of safely discharging the peak flow resulting from a 25-year, 6-hour storm. Dust suppression and washdown water flows almost constantly into these two basins, the overflow pond is sized to more efficiently manage runoff from the 10-year, 24-hour storm from the disturbed and adjacent areas.

The overflow pond was designed to fully contain the design sediment volume for the disturbed area. As indicated in Appendix 7-23, the disturbed area associated with this pond totals 16.49 acres. This disturbed area includes 15.88 acres treated and detained by the concrete sediment trap and primary sediment pond and 0.61acres of the overflow pond. The 0.61 acres of disturbed area for the overflow pond includes only the pond area itself no additional sediment will be created. Based on a sediment storage volume of 0.035 acre-feet per acre of disturbed area, the overflow pond will contain 24,211 cubic feet (0.556 acre-feet) of sediment. The elevation of the maximum sediment level is 7,245.41 feet. The 60% sediment clean-out volume of 14,526 cubic feet (0.33 acre-feet) has an elevation of 7,243.62 feet.

The design sediment storage volume and 60% clean-out level for the waste rock disposal site sedimentation pond is presented in the Waste Rock Volume of this M&RP.

Detention Time. An adequate detention time will be provided in each pond to allow the effluent to meet UPDES and 40 CFR Part 434 limitations. The decant water will be sampled and discharged from the pond in accordance with the above referenced effluent limitations.

Design Event. The sedimentation ponds are designed to fully contain the 10-year, 24-hour precipitation event.

Overflow Pond, Primary Sedimentation Pond and Concrete Sediment Trap. The calculations contained in Appendix 7-14 were based on the assumption that the primary sedimentation pond will fully contain the runoff from the main facility disturbed areas. The concrete sediment trap will

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pass the water to the sedimentation pond, but will not provide significant runoff storage. The concrete sediment trap is used primarily for the removal of sediment.

Several drainage areas, identified on Plate 7-6, contribute runoff to the overflow pond. The disturbed drainage area contributing directly to the overflow pond are DIS-1 through DIS-6. The undisturbed drainage area contributing to the overflow pond is CBW-1.

The curve numbers used to determine the design runoff volume were based on information presented in Appendix 7-11 and Appendix 7-23. The curve number assumed for the disturbed watershed DIS-1 through DIS-4 is 80 and for DIS-5 and DIS-6 is 100, see Appendix 7-11 and 7-23. The curve number for undisturbed watersheds CBW-1 is 72, see Appendix 7-11. Refer to Table 7-6 for a list of all disturbed and undisturbed subwatershed areas and curve numbers within the facilities area. Based on the curve numbers presented above, the storm runoff volume from the 10-year, 24-hour storm event to the overflow pond is 57,898 cubic feet (1.33 acre-feet). The maintenance runoff rate of 0.046 cfs adds 3,975 cubic feet (0.0913 acre-feet) to this volume during a 24-hour period, resulting in a combined required runoff storage volume of 61,873 cubic feet (1.42 acre-feet) without sediment storage. The calculations, presented in Appendix 7-23, are based on hydrologic design methods described in Appendix 7-10. As presented above, the maximum sediment storage volume is 24,211 cubic feet. In order to fully contain the runoff from the 10-year, 24-hour storm event and the maximum sediment storage, the primary spillway elevation for the overflow pond is 7252.5 (2.14 acre-feet), from the stage-capacity table contained in Table 7-8A. The required minimum elevation for the primary spillway with a volume of 24,211 cubic feet is 7,252.26, for ease of construction the primary spillway elevation will be 7,252.50 feet. The actual overflow pond is 3.15 acre feet.

Several drainage areas, identified on Plate 7-6, contribute runoff to the primary sedimentation pond. The disturbed drainage areas contributing to the pond are DIS-1, DIS-2, DIS-3, DIS-4, and DIS-5. The undisturbed drainage area contributing to the pond is CBW-1. The undisturbed drainage CBW-1 is discharged to the pond because it was determined that construction of a diversion ditch along the top of the cut slope from the trash pit north to Mud Spring Hollow may cause some stability problems with the cut slope.

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TABLE 7-7

Stage-Capacity Curve for the Concrete Sediment Trap

ELEVATION (FT)	AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7436.1	360.0		0
		1469.0	
7438.7	770.0		1469.0
		756.0	
7439.6	911.0		2225.0
		377.0	
7440.0	974.0		2602.0
		613.0	
7440.6	1069.0		3215.0
		1069.0	
7441.6	1069.0		4284.0

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TABLE 7-8

Stage-Capacity Data for the Primary Sedimentation Pond

ELEVATION (FT)	AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7401.0	188.3		0
		534.9	
7402.0	881.4		534.9
		1122.6	
7403.0	1363.8		1657.5
		1567.1	
7404.0	1770.3		3224.5
		1971.6	
7405.0	2172.8		5196.1
		2390.2	
7406.0	2607.6		7586.3
		2857.8	
7407.0	3108.0		10,444.1
		3387.6	
7408.0	3667.1		13,831.6
		3941.7	
7409.0	4216.3		17,773.3
		4487.6	
7410.0	4758.8		22,260.9
		5030.7	
7411.0	5302.6		27,291.6

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TABLE 7-8 (Continued)

Stage-Capacity Data for the Primary Sedimentation Pond

ELEVATION (FT)	AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
		5587.8	
7412.0	5873.0		32,879.4
		6172.5	
7413.0	6471.9		39,051.8
		6877.2	
7414.0	7282.4		45,929.0
		7667.6	
7415.0	8052.8		53,596.6
		8405.6	
7416.0	8758.4		62,002.2
		9105.2	
7417.0	9452.0		71,107.4
		6786.2	
7418.0	9937.1		77,893.5
		4541.1	
7418.15	10,245.7		82,434.6
		1544.4	
7418.3	10,346.3		83,979.3
		7406.7	
7419.0	10,815.8		91,386.0
		11,147.2	
7420.0	11,478.6		102,533.2

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TABLE 7-8A

Stage-Capacity Data for the Overflow Pond

ELEVATION (FT)	AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7238.0	928		0
		1,170	
7239.0	1,413		1,170
		1,655	
7240.0	1,897		2,825
		2,253	
7241.0	2,609		5,078
		2,965	
7242.0	3,320		8,043
		3,728	
7243.0	4,135		11,771
		4,542	
7244.0	4,949		16,313
		5,397	
7245.0	5,844		21,710
		6,292	
7246.0	6,739		28,002
		7,217	
7247.0	7,695		35,219
		8,173	
7248.0	8,651		43,392
		9,178	

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TABLE 7-8A (Continued)

Stage-Capacity Data for the Overflow Pond

ELEVATION (FT)	AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7249.0	9,705		52,570
		10,232	
7250.0	10,759		62,802
		11,348	
7251.0	11,937		74,150
		12,526	
7252.0	13,114		86,676
		13,750	
7253.0	14,386		100,441
		15,022	
7254.0	15,658		115,463
		16,359	
7255.0	17,060		131,822

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The curve numbers used to determine the runoff volumes were based on information presented in Appendix 7-9. The average curve number for the disturbed area is 80. The curve number assumed for the undisturbed watershed CBW-1 is 72. The curve number for the pond area (watershed DIS-5) was assumed to be 100. Refer to Table 7-6 for a list of all disturbed and undisturbed subwatershed areas and curve numbers within the facilities area.

Based on the curve numbers presented above, the storm runoff volume from the 10-year, 24-hour storm event is 57,898 cubic feet (1.329 acre-feet). The calculations, presented in Appendix 7-14, are based on hydrologic design methods described in Appendix 7-10. As presented above, the maximum sediment storage volume is 24,211 cubic feet. Thus, the minimum capacity of the pond at the elevation of the primary spillway must be 82,109 cubic feet (1.885 acre-feet), assuming the spillway does not spill during the 10-year, 24-hour storm.

In order to fully contain the runoff from the 10-year, 24-hour storm event and the maximum sediment storage, the primary spillway on the sedimentation pond will need to be raised. From the stage-capacity curve for the existing pond structure contained in Appendix 7-14, the required elevation of the primary spillway is 7418.15 feet.

Waste Rock Disposal Site Sedimentation Pond. The design storm runoff volume for the waste rock disposal site sedimentation pond is presented in the Waste Rock Volume of this M&RP. The sedimentation pond adequately contains the runoff from the 10-year, 24-hour storm event with maximum sediment storage.

Dewatering Device. The concrete sediment trap contains a telescoping dewatering device which can decant water from any elevation in the basin. It will be locked to prevent unauthorized drainage of the concrete structure.

The existing dewatering device on the primary sedimentation pond will be modified so the flowline will be at the elevation of the maximum sediment level, elevation 7410.4 feet. Water will be discharged from the pond in accordance with UPDES guidelines.

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The overflow pond dewatering device is designed to decant at the 60% sediment level, 7,243.62 feet. Water will be discharged from the pond in accordance with UPDES guidelines.
The dewatering device for the waste rock site sedimentation pond is identified in the Waste Rock Volume of this M&RP.

Short Circuiting. Short circuiting is minimized in the primary sedimentation pond and the waste rock disposal site sedimentation pond because both ponds will fully contain the runoff from the 10-year, 24-hour precipitation event.

Sediment Removal. Sediment removal from the concrete sediment trap will be performed frequently such that the basin will operate efficiently. On regular UPDES sampling days, the structure will be inspected for sediment content. If a sediment delta is evident at the water level extending to or beyond the first of the mine discharge pipes. Sediment material from the structure will then be removed with a front-end loader and mixed with coal in the adjacent coal storage pile.

Sediment removal from the primary sedimentation pond will be conducted when the sediment level reaches the 60% clean-out level. From the stage-capacity curve presented in Appendix 7-14, the 60% clean-out elevation is 7408.1 feet. The sediment will be transported and disposed of at the waste rock disposal site.

Sediment removal from the overflow pond will be conducted when the sediment level reaches an elevation of 7,243.62 feet or 60% of sediment capacity. The sediment will be transported and disposed of at the waste rock disposal site.

Sediment removal procedures for the waste rock disposal site sedimentation pond are defined in the Waste Rock Volume of this M&RP.

Excessive Settlement. Existing sedimentation ponds within the permit area have been operating for a period long enough to ensure that any settlement which may have occurred is now complete. Excessive settlement has not been observed at either the primary sedimentation pond or the waste rock disposal site sedimentation pond. During construction, the embankment of the overflow pond will be compacted to an average of 95% of maximum dry density, to minimize the chance of excessive settling.

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Embankment Material. During construction of the primary sedimentation pond, overflow pond and the waste rock disposal site sedimentation pond the embankment materials were free of sod, large roots, frozen soil, and acid- or toxic forming coal-processing waste.

Compaction. During construction the primary sedimentation pond was compacted to an average of 95% of maximum dry density. The sedimentation pond at the waste rock disposal site was compacted to a maximum dry density of 90% as determined by ASTM D1557. During construction of the overflow pond, the embankment of the pond will be compacted to an average of 95% of maximum dry density.

MSHA Sedimentation Ponds. MSHA requirements defined in 30 CFR 77.216 are not applicable at this mine since the existing sedimentation ponds do not impound water or sediment to an elevation of 20 feet or more above the upstream toe of the structure. The ponds also store a volume less than 20 acre-feet.

Other Sedimentation Ponds. All sedimentation ponds within the permit area have primary and emergency spillways that will, in combination, safely discharge a 25-year, 6-hour precipitation event.

Concrete Sediment Trap, Primary Sedimentation Pond and Overflow Pond. The 25-year, 6-hour storm event was routed through the concrete sediment trap and primary sedimentation pond to determine the adequacy of the existing spillways. The concrete sediment trap and sedimentation pond are hydraulically connected since overflow from the basin is discharged to the pond. The computer software SEDIMOT II, as described in Appendix 7-10, was used for the routing. SEDIMOT II assumes that the ponds are full of water up to the spillway elevation at the beginning of the storm event. The overflow pond was designed using HydroCAD version

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TABLE 7-9
Summary of Diversion Ditches

Diversion	Minimum Bottom Width (ft.)	Minimum Top Width (ft.)	Minimum Depth (ft.)	Side Slopes (H:V)	Minimum riprap D_{50} (in.)	Min. Slope (%)	Max. Slope (%)	Peak Flow[a] (cfs)	Minimum Free-board (ft.)	Existing ditch geometry and riprap OK?
Upper East Side Road diversion draining CBE-5	1.0	2.2	0.4	1.5:1	not required	16.0	38.0	0.09	0.36	yes
Lower East Side Road diversion draining CBE-1 through CBE-5 (lower and upper sections of ditch)	Lower 1.0 Upper 1.0	Lower 2.2 Upper 2.5	Lower 0.5 Upper 0.5	Lower 1.2:1 Upper 1.5:1	Lower 2.0 Upper not required	Upper 3.0	Lower 24.0	0.79	Lower 0.36 Upper 0.29	Lower yes Upper yes
Substation pad upper interception ditch draining CBE-	1.0	1.6	0.4	0.8:1	not required	1.0	18.0	0.07	0.33	yes
Substation pad lower interception ditch draining CBE-	1.0	1.6	0.4	1:1	not required	1.0	10.0	0.03	0.35	yes
CBE continuance diversion	1.0	2.5	0.5	1.5:1	3.0	33.0	38.0	0.79	0.37	yes
Interception ditch draining ESC-6 north of ATOF	1.0	1.8	0.4	1:1	not required	1.0	1.0	0.13	0.30	yes
Interception ditch draining ESC-7 north of ATOF	1.0	2.2	0.4	1.5:1	not required	21.0	32.0	0.08	0.37	yes
Interception ditch draining MSH-2 north of ATOF	1.0	2.2	0.4	1.5:1	not required	1.0	20.0	0.08	0.32	yes
Interception ditch draining MSH-2A north of ATOF	1.0	2.2	0.4	1.5:1	not required	1.0	20.0	0.03	0.32	yes
Interception ditch draining DIS-1A	1.0	2.0	.61	1.5:1	not required	1.0	1.0	0.06	0.30	yes
Sedimentation pond access road diversion ditch draining DIS-3	1.0	2.2	0.4	1.5:1	1.0	21.0	31.0	0.35[b]	0.31	yes
Main access road diversion ditch draining DWN-1	2.0	4.0	0.5	2:1	not required	1.0	3.0	0.85	0.30	yes
Link Canyon Substation No. 1 ditch draining LINK and ASCA-1 [Reclaimed in 2000]	2.0	2.81	0.41	1:1	not required	1.0	9.82	0.87	0.30	yes
Link Canyon Substation No. 1 road swale draining LINK, ASCA-1, and ASCA-3 [Reclaimed in 2000]	Parabolic	10.0	0.398	Parabolic	not required	1.0	2.0	0.89	0.30	yes
Link Canyon Substation No. 2 ditch draining Link No.2, ASCA-4, and ASCA-7	0.0	1.52	.51	Left 2:1 Right 1:1	not required	1.0	6.7	0.20	0.30	yes
Link Canyon Portal Access Road Channel No. 1	0.0	0.97	0.48	1:1	not required	7.69	11.0	0.10[b]	0.30	yes
Link Canyon Portal Pad Channel No. 2	0.0	0.90	0.45	1:1	not required	5.21	8.3	0.06[b]	0.30	yes
West Overflow Pond Undisturbed Area Diversion	0.0	3.0	1.0	1.5:1	not required	0.97	.8	1.23[a]	0.49	yes
Access and Maintenance Road Channel	0.0	2.7	0.9	1.5:1	not required	1.0	0.9	1.23[a]	0.49	yes
East O. P. Undisturbed Area Dvrsn Channel (shallow	0.0	3.9	1.30	1.5:1	not required	1.0	0.9	3.13[a]	0.49	yes
East O.P. Undisturbed Area Dvrsn Channel (steep	0.0	2.7	0.9	1.5:1	9.0	0.24	0.25	3.13[a]	0.45	yes
Overflow Pond Inlet Swale	5.0	10.0	0.5	5:1	not required	0.025	0.025	6.26[b]	0.24	yes

[a] Peak discharge resulting from the 10-year, 6-hour precipitation event.

[b] Peak discharge resulting from the 25-year, 24-hour precipitation event.

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TABLE 7-10
Summary of Diversion Culverts

Diversion Culvert	Diameter (in.)	Material	Inlet type	Min. Slope (%)	Outlet Slope (%)	Existing riprap D_{50} (in.)	Peak Flow[a] (cfs)	Culvert inlet OK?	Existing riprap D_{50} OK?
East Spring Canyon bypass culvert at inlet	72	CMP	mitered	1.2	N/A	N/A	59.6	yes	N/A
Bypass culvert for combined East Spring Canyon and Mud Spring Hollow flows	Upper 72 Lower 48	CMP	N/A	Upper 1.2 Lower 10.0	Upper N/A Lower 10.0	Upper N/A Lower 15.0	97.7	Upper N/A Lower N/A	Upper N/A Lower yes
Mud Spring Hollow bypass - discharges to East Spring Canyon bypass	42	CMP	mitered	1.8	N/A	N/A	38.1	yes	N/A
East Spring Canyon bypass culvert emergency diversion at main mine fan	48	CMP	drop		N/A	N/A	59.6		N/A
CBE bypass at substation	18	CMP	mitered and drop	1.0	10.0	6.0	0.53	yes	yes
Pipe No. 5 diversion draining DWN-1	18	CMP	mitered	10.0	28.0	12.0	0.85	yes	yes
8-inch pipe diversion draining ESC-7, discharges to 10 inch pipe draining ESC-6	8	steel	mitered	1.0	N/A	N/A	2.4	yes	N/A
10-inch pipe diversion draining ESC-6 and ESC-7, discharges to East Spring Canyon bypass	10	steel	mitered	1.0	N/A	N/A	3.19	yes	N/A
6-inch pipe diversion draining MSH-2A, discharges to East Spring Canyon bypass	6	steel	mitered	1.0	N/A	N/A	0.24	yes	N/A
Link Canyon Portal bypass culverts	2-36	CMP	mitered	9.09	18.2	6.0	55.32[b]	yes	yes
Main mine fan diversion				Not applicable since the mine yard drainage system is not designed to handle peak flows, only daily drainage volumes.					
10-inch mine yard drainage, discharges to sediment trap	10	Steel	drop						
Sediment Trap Diversion Culvert	18	CMP	mitered	1.2	1.25	N/A	6.26[b]	yes	yes
Overflow Pond Bypass Culvert	66	CMP	mitered	2.8	3.0	12.0	622.37[c]	yes	yes

[a] Peak discharge resulting from the 10-year, 6-hour precipitation event. [b] Peak discharge resulting from the 25-year, 24-hour precipitation event. [C] Peak discharge resulting from the 100-year, 6-hour precipitation event.

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8.50 software to safely convey the 25-year, 6-hour storm event. HydroCAD assumes that the sediment trap and primary sedimentation pond are full of water up to the spillway at the beginning of the storm.

The stage-capacity data for the sediment trap, primary sedimentation pond, and overflow pond are presented in Tables 7-7, 7-8, and 7-8A. The spillway analysis for the primary sedimentation pond assumes that the primary spillway flowline is raised, per discussions above, to an elevation of 7418.15 feet. Stage-discharge data were computed for both the concrete sediment trap and the sedimentation pond and input directly into SEDIMOT II. The purpose of calculating the stage-discharge relationship in the sediment trap was that the spillway is not a typical design, and SEDIMOT II would not accommodate it directly. A stage-discharge curve was computed for the primary sedimentation pond to incorporate the discharge from both the primary and emergency spillways. The SEDIMOT II input and output for the sediment trap and primary sedimentation pond is contained in Appendix 7-14. The spillway analysis for the overflow pond utilized both HydroCAD version 8.50 and FlowMaster I. HydroCAD was used to calculate the flow rate, FlowMaster was used to calculate the flow velocity. For full calculations see Appendix 7-23.

From the final analysis of the 25-year, 6-hour storm event, the maximum inflow rate to the sediment trap from storm runoff is 2.0 cubic feet per second (cfs) and the maximum outflow rate from the basin is 2.1 cfs. The corresponding high water level in the sediment trap is 7440.0 feet, 1.6 feet below the top of the concrete structure. The maximum inflow rate to the primary sedimentation pond is 2.65 cfs and the maximum outflow rate is 2.2 cfs. The corresponding high water level is 7418.35 feet, 0.2 feet above the primary spillway flowline, and 1.65 feet below the minimum embankment elevation of 7420.0.

The maximum design inflow rate to the overflow pond is 6.31 cfs and the maximum design outflow rate is 6.31 cfs. The corresponding high water level is 7253.24, 0.74 feet above the primary spillway flowline, and 1.76 feet below the minimum embankment elevation of 7255.0.

Details for the concrete sediment trap spillway are presented in Appendix 7-8. Details for the primary and emergency spillways on the primary sedimentation pond can be found on Plate 7-5. Details for the overflow pond primary and emergency spillway can be found in Appendix 7-23 and on Plate 7-5A.

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Waste Rock Disposal Site Sedimentation Pond. The sedimentation pond at the waste rock disposal site will adequately pass the 25-year, 6-hour precipitation event through the primary and emergency spillways. Details regarding the spillway design are located in the Waste Rock Volume of this M&RP.

Other Treatment Facilities. There are no other treatment facilities within the mine permit area.

Exemptions. Exemption areas are listed below (see Plate 5-2B):

- The south side of the original substation pad area above the office building. This area is classified as an "Exempt Area". The demonstration for this area is a SEDCAD computer program and is located in Appendix 7-16. The disturbed area is 0.040 acre.
- The spring collection field in Convulsion Canyon. This area is classified as an "Exempt Area". The demonstration for this area is a SEDCAD computer program and is located in Appendix 7-16. The area is fenced to prevent grazing. The disturbed area is 0.39 acre.
- The water tank area northeast of the mine site. This area is classified as an "Exempt Area". The demonstration for this area is a SEDCAD computer program and is located in Appendix 7-16. The disturbed area is 0.193 acre.

The total disturbed area contributing to the primary sedimentation pond is 15.88 acres. The total disturbed area contributing to the overflow pond is 16.49 acres. The total disturbed area contributing to the waste rock disposal site sedimentation pond is 7.93 acres. The total area for Small Area Exemption (SAE) is 0.623 acres. This is 2.1 percent of 30.454 acres of total disturbed area at the mine site, Link Canyon Portal and Substation No. 1 and No. 2 facility sites, and waste rock disposal site (including ASCA's and SAE's).

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7.4.2.3 Diversions

General Requirements. The diversions within the permit area consist of drainage ditches and culverts. All diversions within the permit area have been designed to minimize adverse impacts to the hydrologic balance, to prevent material damage outside the permit area and to assure the safety of the public.

All diversions and diversion structures have been designed, located, constructed, maintained and used to:

- Be stable
- Provide protection against flooding and resultant damage to life and property
- Prevent, to the extent possible, additional contributions of suspended solids to stream flow outside the permit area
- Comply with all applicable local, state, and federal laws and regulations

All diversions within the permit area are temporary and will be removed when no longer needed. The diversions will be reclaimed in accordance with the reclamation plan defined in Chapter 5.

Peak discharge rates from the undisturbed and disturbed area drainages within the permit area were calculated for use in determining the adequacy of the existing diversion ditches and culverts. The storm runoff calculations for the temporary diversion structures were based on the 10-year, 6-hour precipitation event of 1.3 inches. Curve numbers were based on those defined in Appendix 7-9 and professional judgement. A description of the methods used to determine the peak discharge rates is presented in Appendix 7-10. The overflow pond bypass culvert was designed to safely convey the 100-year, 6-hour precipitation event of 2.06 inches. For more information of designs and calculations see Plates 7-5A, 7-5B, and 7-5C and Appendix 7-23. The sediment trap outfall culvert, primary sediment pond bypass, and overflow pond inlet swale were designed to safely convey the 24-year, 6-hour precipitation event of 1.55 inches. The remaining overflow pond diversion; overflow pond access road channel, west and east overflow pond undisturbed area diversion channels were designed to safely convey the 10-year, 6-hour event.

The disturbed and undisturbed drainage areas for the facilities area are presented on Plate 7-6. Those drainage areas too large to fit on Plate 7-6 can be found on Plate 7-8. A summary of watershed characteristics is presented in Table 7-6. The disturbed and undisturbed drainage areas

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for the Link Canyon facilities area are presented on Plate 5-2D,E,&F. Link Canyon diversion calculations and designs are presented in Appendix 7-12.

The size and location of each existing diversion ditch and culvert were verified in the field. All diversions are located on Plates 7-6 and 5-2D,E,&F. The minimum capacity and freeboard of each diversion ditch was determined based on the minimum ditch slope, while the maximum velocity and minimum riprap protection was calculated based on the maximum ditch slope. The capacity of each culvert was determined using the minimum culvert slope, and the outlet velocity and riprap protection was verified using the culvert outlet slope. Slopes were measured either in the field or from a contour map with the scale of 1" = 50'. A description of the methods used to determine diversion capacities, flow velocities, and riprap sizes is presented in Appendix 7-10 and 7-23. All diversion calculations are presented in Appendices 7-12, 7-13, and 7-23.

Diversion of Perennial and Intermittent Streams. Flows from the two tributary streams are diverted under the fill area by two large corrugated metal pipes. Both diversions are temporary, and can adequately pass the peak flows from the 10-year, 6-hour precipitation event.

Mud Spring Hollow flows into a 42-inch diameter CMP. The mitered inlet structure is constructed of concrete and has a headwall of approximately 4 feet. It discharges directly into the 72-inch East Spring Bypass culvert. Based on the calculations presented in Appendix 7-11, the peak flow rate from watershed MSH-1 is 38.06 cfs. The minimum culvert slope is 1.8% which results in a maximum flow depth of 1.79 feet. The existing culvert is adequate in size.

The flows in East Spring Canyon are diverted by a 72-inch diameter CMP. This pipe is large enough to handle the flows from East Spring Canyon and Mud Spring Hollow. This CMP extends under the fill area and discharges downstream below the primary sedimentation pond. The size of the bypass narrows to a 48-inch diameter CMP down the steep fill slope.

The peak flow from East Spring Canyon is 59.6 cfs. The concrete inlet structure was evaluated according to methods described in Appendix 7-10. The inlet structure is adequate to pass the design storm event.

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An emergency diversion was constructed at the main mine fan for the East Spring Canyon bypass culvert. This 3.5 foot square drop drain with oil skimmer cap connects into a 48-inch culvert directed into the East Spring Canyon bypass culvert. This serves as an overflow system when the trash rack at the inlet to East Spring Canyon becomes plugged with debris.

The combined peak flow from East Spring Canyon and Mud Spring Hollow for the 10-year, 6-hour precipitation event is 97.9 cfs. The capacity of the culvert was evaluated based on this flow rate and a minimum culvert slope of 1.2%. The resulting maximum flow depth of 2.6 feet indicates that the existing culvert is adequate. The capacity of the 48-inch culvert was also verified. The resulting maximum flow depth, corresponding to the minimum slope of 10%, is 1.75 feet. The 48-inch culvert is adequate to pass the design storm.

The discharge velocity from the 48-inch culvert was determined to verify the adequacy of the existing riprap (D_{50} = 15 inches). The calculated outlet velocity, based on a culvert outlet slope of 10%, is 18.5 feet per second. Using methods defined in Appendix 7-10, the required average riprap size at the outlet is 15 inches. The existing riprap is acceptable.

Outfall from the 48-inch East Spring Canyon and Mud Spring Hollow culvert described above flow approximately 800 feet through the natural stream at the canyon bottom into a 66-inch smooth wall CMP culvert whose inlet will be installed immediately upstream from the overflow pond. The 66-inch smooth wall CMP culvert is designed to safely convey the peak flow from a 100-yr, 6-hr storm for East Spring Canyon, Mud Spring Hollow, overflow from the primary sedimentation pond, and undisturbed areas upstream from the overflow pond (DWN-2 and DWN-4). This culvert will discharge immediately below the overflow pond within the natural stream channel. For more information see Plates 7-4 and 7-5A and Appendix 7-23.

The primary sedimentation pond diversion culvert allows discharge from the sedimentation trap to bypass the primary sedimentation pond and flow directly into the overflow pond. This culvert is also designed to allow discharge from the primary sedimentation pond to flow directly into the overflow pond. Due to this culvert acting as a bypass for the primary sedimentation pond the 18-inch CMP sedimentation trap diversion has been designed to convey the 25-year, 6-hour precipitation event. For more information see Plates 7-4 and 7-5A and Appendix 7-23.

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Diversion of Miscellaneous Flows. Diversion ditches and culverts have been utilized within the permit area to divert miscellaneous flows from disturbed and undisturbed area drainages.

Diversion Ditches. A summary table of the minimum channel geometry, channel slope, peak discharge, minimum riprap requirements, maximum flow velocity and minimum freeboard values for each diversion ditch within the facilities area is presented in Table 7-9. All calculations are contained in Appendix 7-12 and 7-23. Each ditch was verified in the field and has adequate capacity and erosion protection to pass the 10-year, 6-hour precipitation event. A description of the diversion ditches within the facilities area is presented below:

- Interception ditch along the East Side Road which drains the undisturbed watershed CBE-5. This diversion drains into the CBE bypass culvert at the substation.
- Interception ditch along the East Side Road which drains the undisturbed watersheds CBE-1 through CBE-5. This diversion drains into the CBE continuance diversion.
- Substation pad upper interception ditch which drains the undisturbed watershed CBE-4. This diversion drains into the CBE bypass culvert at the substation.
- Substation pad lower undisturbed interception ditch which drains the watershed CBE-3. This diversion drains into a drop drain for the CBE bypass culvert at the substation and is part of the alternate sediment control measures defined in Section 7.4.2.1.
- Riprap diversion channel for CBE continuance diversion. This diversion carries flows from the lower interception ditch along the East Side Road to an adjacent ephemeral drainage.
- Interception ditch for the undisturbed watershed ESC-6 north of the ATOF. This diversion discharges to the inlet of the 10-inch pipe diversion which connects into the 72-inch East Spring Canyon bypass system.
- Interception ditch for the undisturbed watershed ESC-7 north of the ATOF. This diversion drains to an 8-inch pipe that tees into the 10-inch pipe which drains ESC-6.
- Interception ditch for the undisturbed watershed MSH-2 north of the ATOF. This diversion drains to the inlet of the 42-inch Mud Spring Hollow bypass.

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- Interception ditch for the undisturbed watershed MSH-2A north of the ATOF. This diversion drains to the 6-inch pipe diversion which connects into the 72-inch East Spring Canyon bypass system
- Interception ditch draining watershed DIS-1A. This diversion drains to one of the drop drain inlets of the 10-inch mine yard drain line.
- Sedimentation pond access road diversion ditch. This diversion drains the disturbed watershed DIS-3 and discharges to the sedimentation pond.
- Main access road diversion ditch which drains undisturbed watershed DWN-1. This ditch drains to the pipe number 5 diversion.
- Link Canyon Substation No. 1 ditch which drains the watersheds LINK and ASCA-1. This diversion diverts the upper undisturbed drainage around the substation and drains to the Link Canyon Substation No. 1 road swale. This diversion ditch was reclaimed in 2000.
- Link Canyon Substation No. 1 road swale which drains watersheds LINK, ASCA-1, and ASCA-3. This diversion carries flows from the Link Canyon Substation No. 1 ditch across the substation access road to the main Link Canyon road drainage. This diversion was reclaimed in 2000.
- Link Canyon Substation No. 2 ditch which drains the watersheds LINK No.2, ASCA-4 and ASCA-7. This diversion diverts the upper undisturbed drainage around the substation and drains to the main Link Canyon road drainage.
- Link Canyon Portal access road Channel No. 1 diversion ditch. This diversion diverts the access road disturbed drainage and the undisturbed drainage above the road to the Link Canyon drainage bypass culvert inlet.
- Link Canyon Portal Pad Channel No. 2 diversion ditch. This diversion diverts the pad area disturbed drainage and the undisturbed drainage above the pad to the Link Canyon drainage bypass culvert inlet.
- The west overflow pond undisturbed area diversion channel. This channel diverts runoff from the undisturbed area immediately west of the overflow pond and conveys the runoff south to the overflow pond access road channel.
- The overflow pond access road channel. This channel diverts runoff from the undisturbed area immediately west of the overflow pond access road and runoff from the west overflow pond channel south along the west side of this road to a swale and across U.S.F.S road.

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- The east overflow pond undisturbed area diversion channel (shallow section). This channel diverts runoff from the undisturbed area immediately east of the overflow pond and conveys the runoff south to the face of the overflow pond impound.
- The east overflow pond undisturbed area diversion channel (steep section). This channel collects runoff from the east overflow pond channel shallow section and diverts it down the impoundment face into the existing natural stream channel at the bottom of east spring canyon.
- The overflow pond inlet swale. This swale conveys outfall from gate box #2 south to the overflow pond. This swale will be designed to allow track hoes and bull dozers to drive across it for maintenance purposes.

A description of the diversion ditches within the waste rock disposal site can be found in the Waste Rock Volume of this M&RP.

Diversion Culverts. A summary table of the culvert size, slope, peak discharge, existing riprap at outlet, and outlet flow velocity for each culvert within the facilities area is presented in Table 7-10. All calculations are contained in Appendix 7-13. Each culvert has adequate capacity and outlet erosion protection to pass the 10-year, 6-hour precipitation event. The primary sediment diversion culvert allows discharge from the sedimentation trap to bypass the primary sedimentation pond. Therefore this culvert must have adequate capacity to safely pass the peak flow resulting from the 25-year, 6-hour precipitation event. To ensure that the overflow pond embankment remains stable during 100-year, 6-hour storm, the overflow pond bypass culvert was designed to have adequate capacity and erosion protection to pass the 100-year, 6-hour precipitation. A description of the diversion culverts within the facilities area is presented below:

- East Spring Canyon bypass culvert. This culvert drains the undisturbed watersheds ESC-1 through ESC-5 and extends under the fill area and discharges downstream below the primary sedimentation pond.

- Mud Spring Hollow bypass culvert. This culvert drains the undisturbed watershed MSH-1 and connects into the 72-inch East Spring Canyon bypass culvert system.
- CBE bypass culvert at the substation. This culvert drains the undisturbed watersheds CBE-2 through CBE-5 and discharges to the lower East Side Road

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interception ditch. Three drop drains direct the flows to the bypass culvert. The drop drains help reduce the time the runoff water will be on the pad area to reduce the chance of water migrating through the substation pad fill and lubricating the substation slide slip zone.

- Pipe No. 5 diversion culvert which drains the undisturbed area DWN-1. This culvert discharges below the sedimentation pond access road to the natural slope. It does not drain to the pond.
- 10-inch pipe diversion for undisturbed watersheds ESC-6 and ESC-7. This pipe connects into the 72-inch East Spring Canyon bypass system.
- 8-inch pipe diversion for undisturbed watershed ESC-7. This pipe connects to the 10-inch pipe that drains undisturbed watershed ESC-6.
- 6-inch pipe diversion for undisturbed watershed MSH-2A. This pipe connects into the 72-inch East Spring Canyon bypass system.
- Main Mine Fan Diversion. The main mine fan is located in a depression which is nine feet below the adjacent mine yard drainage system. A sump pump with automatic float controls in front of the main fan will pump the runoff from this area into the 10-inch mine yard drain line.
- 10-inch mine yard drainage system. This drainage system was installed to handle normal surface flows in the mine yard and to reduce the occurrence of mud and erosion. The drainage system consists of drop inlets and a 10-inch pipeline discharging to the concrete sediment trap. It was not designed to pass the 10-year, 6-hour precipitation event. Instead, the surface area of the mine yard is graded to divert all runoff to the concrete sediment trap.
- The sediment trap diversion culvert allows the sedimentation pond to drain for sediment removal. This culvert discharges to the overflow pond.
- The 66-inch overflow pond bypass culvert allows watersheds DWN-1, DWN-2, DWN-3, MSH-1, MSH-2, and ESC-1 through ESC-7 to bypass the overflow pond. This culvert discharges immediately downstream of the overflow pond.

A description of all diversion culverts within the waste rock disposal site can be found in the Waste Rock Volume of this M&RP.

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7.4.2.4 Road Drainage

All Roads. The existing roads within the facilities area are the mine access road, the primary sedimentation pond access road, the east side road, and overflow pond access road. The existing road within the Link Canyon facilities area is the substation access road. All of the roads have been constructed to include adequate drainage control with the use of diversion ditches, culverts, and containment berms. None of the roads are located in the channel of an intermittent or perennial stream. All roads have been located to minimize downstream sedimentation and flooding. Diversion ditches and culverts for all roads are described in Section 7.4.2.3 above.

Primary Roads. The mine access road is the only primary road within the permit area. The mine access is located, where practical, to minimize erosion. The access road does not ford any stream channels.

The drainage control system for the mine access road includes a diversion ditch, culvert, and berm. The diversions will adequately pass the peak runoff from the 10-year, 6-hour precipitation event. Drainage details for the access road are presented in Section 7.4.2.3 above.

The culvert draining the undisturbed area DWN-1 adjacent to the mine access road is identified as pipe no. 5. It is constructed with an mitered inlet with a trash rack to avoid plugging. The outlet of the culvert, located below the primary sedimentation pond access road, is adequately lined with riprap to prevent erosion. Refer to Section 7.4.2.3 for additional drainage details. The diversion ditch and culvert will be maintained and operated as described in Section 7.3.2.3. No natural stream channels were relocated for the construction of the mine access road.

7.4.3 Impoundments

The existing impoundments within the permit area consist of the four structures constructed for sediment control purposes. These structures are:

- The concrete sediment trap located near the southern end of the mine yard.
- The primary sedimentation pond located immediately below the fill on which the existing mine facilities are constructed.
- The overflow pond located approximately 800 feet below the primary sedimentation pond.
- The sedimentation pond located at the waste rock disposal site.

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All pertinent information regarding these sedimentation ponds is presented in Sections 7.3.2.2 and 7.4.2.2.

7.4.4 Discharge Structures

The discharge structures within the permit area consist of the primary and emergency spillways on each sedimentation pond. The spillways on all sedimentation ponds within the permit area will adequately pass the peak discharge from the 25-year, 6-hour precipitation event. Detailed information for each sedimentation pond is presented in Sections 7.3.2.2 and 7.4.2.2.

The spillway of the concrete sediment trap consists of an overflow weir which discharges to a 24-inch CMP culvert. The culvert drains into canal box #1. From this canal box it drains either into a 24-inch culvert, then directly into the primary sediment pond, or into the 18-inch primary sediment pond bypass. Specific construction details of the spillway system for the sediment trap are presented in Plates 7-4 and 7-5A and Appendix 7-8 and 7-23.

The primary spillway on the primary sedimentation pond consists of a 12-inch steel riser with a covered oil-skimmer. The primary spillway discharges directly to the 18-inch primary sediment pond bypass culvert. The emergency spillway is a trapezoidal open channel lined with riprap. The bottom width is 14 feet with side slopes of 2:1 (horizontal:vertical). This spillway discharges to the downstream natural drainage system. The design calculations for the spillways are presented in Appendix 7-14 and 7-23. The details for each spillway are presented on Plate 7-5.

The primary spillway on the overflow pond consists of a 24-inch steel riser with an oil-skimmer. The primary spillway discharges directly to the riprap lined emergency spillway channel below the pond. The emergency spillway is a trapezoidal open channel lined with riprap. The top section of the spillway has a bottom width of 1 feet with side slopes of 12H:1V to allow vehicles to be driven across the spillway for maintenance access. The sloped section of the spillway, or bottom section, slopes down the face of the impoundment at 3H:1V with a 1 foot wide bottom. The emergency spillways discharge to the downstream natural drainage system. The primary spillway discharges through a flume to measure flow and then enters the natural drainage system. The details for each spillway are presented on Plate 7-5A.

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Details for the discharge structures on the waste rock disposal site sedimentation pond are presented in the Waste Rock Volume of this M&RP.

7.4.4.1 Erosion Protection

Each discharge structure was evaluated to determine the adequacy of the existing riprap, and capacity of the structure during the 25-year, 6-hour precipitation event. The calculations for the discharge structures within the facilities area are presented in Appendix 7-14.

The discharge structure on the overflow pond was evaluated to determine the size of the riprap, and capacity of the structure during the 25-year, 6-hour precipitation event. The calculation for the discharge structures within the overflow pond are presented in Appendix 7-23.

The 24-inch CMP from the concrete sediment trap discharges to the primary sedimentation pond. The outlet slope, measured in the field, is 53%. The peak discharge from the sediment trap is 2.1 cubic feet per second. Using methods discussed in Appendix 7-10, the flow velocity at the culvert outlet is 11.8 feet per second. The flow depth at the outlet is 0.21 feet.

The erosion protection at the culvert outlet consists of one large boulder, 6 to 8 feet in diameter, located approximately 10 feet below the outlet. In addition, riprap with the average size of 14 inches is located at the immediate vicinity of the outlet. Based on methods defined in Appendix 7-10 and an outlet velocity of 11.8 feet per second, an average riprap size of 15 inches is required at the outlet. Therefore, the combination 14-inch riprap and 6-foot boulder erosion protection at the culvert outlet is adequate.

The 12-inch primary spillway on the primary sedimentation pond discharges to 18-inch primary sediment pond bypass. The emergency spillway channel has a bottom width of 14 feet, side slopes of 2H:1V, and an average riprap size of 15 inches.

The adequacy of the existing riprap was initially evaluated assuming the peak discharge of 2.2 cfs flows exclusively down the emergency spillway. In this case, assuming a maximum channel slope of 71%, the maximum flow velocity is 3.7 feet per second. This is considered non-erosional. Finally, the riprap was evaluated assuming the peak discharge flows exclusively through the 12-inch primary spillway. In this case, assuming an outlet slope of 35%, the maximum flow velocity is 11.1 feet per second at the culvert outlet. Using methods defined in Appendix 7-10, the required

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average riprap size to provide adequate protection is 12 inches. Therefore, the existing 15-inch riprap is acceptable.

The 18-inch primary spillway on the overflow pond discharges into a flume to measure the outlet flow. From the flume discharge enters the historic natural drainage path. The top or upper emergency spillway channel has a bottom width of 1 feet, side slopes of 12H:1V and an average riprap size of 2-inches. The bottom section, which slopes down the face of the impoundment, has a 1 foot wide bottom, with 2H:1V side slopes and slopes down the impoundment at a 3H:1V.

Assuming a maximum channel slope of 33.3%, the maximum flow velocity for the emergency spillway is 5.53 feet per second. The riprap was evaluated assuming the peak discharge flows exclusively through the 18-inch primary spillway. In this case, assuming an outlet slope of 5.88%, the maximum flow velocity is 4.35 feet per second at the culvert outlet. Using methods defined in Appendix 7-10; the required average riprap size to provide adequate protection for the channel above the primary spillway outfall is 2-inches, and the required average riprap size to provide adequate protection for the channel below the primary spillway outfall is 2-inches.

The riprap design for the discharge structures on the waste rock disposal site sedimentation pond is presented in the Waste Rock Volume of this M&RP.

7.4.4.2 Design Standards

All discharge structures within the permit area were designed and constructed according to standard engineering design procedures.

7.4.5 Disposal of Excess Spoil

There is no excess spoil within the permit area.

7.4.6 Coal Mine Waste

7.4.6.1 General Requirements

All coal mine waste is contained within the waste rock disposal site. All coal mine waste will be placed in a controlled manner to minimize adverse effects of leachate and surface water runoff on surface and groundwater quality and quantity. A description of the methods of placement can be found in the Waste Rock Volume.

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7.4.6.2 Refuse Piles

A detailed description of the refuse piles at the waste rock disposal site can be found in Chapter 5 and the Waste Rock Volume of this M&RP.

Based on the size, configuration, and open graded structure of the waste rock fill and its location at the site, no underdrains or rock core chimney drains were required. There are no springs or seeps within the fill area which require special treatment.

All surface precipitation falling on the fill is channeled to the sedimentation pond located down gradient from the toe of the disposal area fill. All surface drainage from the areas above the site is diverted around the disposal area using diversion ditches. Surface drainage from the county road above the site is controlled by a shoulder ditch and diverted away from the fill area. All diversions are lined with either riprap, concrete, or vegetation to minimize surface erosion at the site.

No permanent impoundments will exist on the completed refuse pile.

7.4.6.3 Impounding Structures

There are no impounding structures within the permit area that are constructed of coal mine waste or are used to impound coal mine waste.

7.4.6.4 Return of Coal Processing Waste to Abandoned Underground Workings

Coal processing waste is not returned to abandoned underground workings at this facility.

7.4.7 Disposal of Noncoal Mine Waste

Disposal of noncoal mine waste is discussed in Chapter 5.

7.4.8 Casing and Sealing of Wells

Each water well has been cased, sealed, or otherwise managed, as approved by the UDOGM, to prevent acid or other toxic drainage from entering ground or surface water, to minimize disturbance to the hydrologic balance, and to ensure the safety of people, livestock, fish and wildlife, and machinery in the permit and adjacent area. The drill logs and completion diagrams for the water wells are contained in Appendix 6-1.

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If a water well is exposed by coal mining and reclamation operations, it will be permanently closed unless otherwise managed in a manner approved by the UDOGM.

7.50 Performance Standards

All mining and reclamation operations will be conducted to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area and support approved postmining land uses.

7.5.1 Water Quality Standards and Effluent Limitations

Discharges of water from disturbed areas will be in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining contained in 40 CFR Part 434.

7.5.2 Sediment Control Measures

All sediment control measures will be located, maintained, constructed and reclaimed according to plans and designs presented in Sections 7.3.2, 7.4.2, and 7.6.0.

7.5.2.1 Siltation Structures and Diversions

Siltation structures and diversions will be located, maintained, constructed and reclaimed according to plans and designs presented in Sections 7.3.2, 7.4.2, and 7.6.3.

7.5.2.2 Road Drainage

All roads will be located, designed, constructed, reconstructed, used, maintained and reclaimed according to plans and designs presented in Sections 7.3.2.4, 7.4.2.4, and 7.6.2. All roads have been designed to:

- Control or prevent erosion, siltation and the air pollution attendant to erosion by vegetating or otherwise stabilizing all exposed surfaces in accordance with current, prudent engineering practices;
- Control or prevent additional contributions of suspended solids to stream flow or runoff outside the permit area;
- Neither cause nor contribute to, directly or indirectly, the violation of effluent standards given under Section 7.5.1.
- Minimize the diminution to or degradation of the quality or quantity of surface- and ground-water systems;

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- Refrain from significantly altering the normal flow of water in streambeds or drainage channels.

7.5.3 Impoundments and Discharge Structures

Impoundments and discharge structures will be located, maintained, constructed and reclaimed as described in Sections 7.3.3, 7.3.4, 7.4.3, 7.4.5, and 7.6.0.

7.5.4 Disposal of Excess Spoil, Coal Mine Waste and Noncoal Mine Waste

Disposal areas for coal mine waste and noncoal mine waste will be located, maintained, constructed and reclaimed as described in Sections 7.3.6, 7.3.7, 7.4.6, 7.4.7, 7.6.0 and Chapter 5.

7.5.5 Casing and Sealing of Wells

All wells will be managed as described in Sections 7.4.8 and 7.6.5. Water monitoring wells will be managed on a temporary basis as described in Section 7.3.8.

7.60 Reclamation

7.6.1 General Requirements

A detailed reclamation plan for the mine is presented in Section 5.40. In general, SUFCO will ensure that all temporary structures are removed and reclaimed. SUFCO plans to remove all culverts within the surface facility area during final reclamation. Permanent diversions will be maintained properly and will meet the requirements of the approved reclamation plan for permanent structures and impoundments. SUFCO will renovate the diversion structures if necessary to meet the requirements of R645-301 and R645-302 and to conform to the approved reclamation plan.

7.6.2 Roads

A road not to be retained for use under an approved postmining land use will be reclaimed immediately after it is no longer needed for coal mining and reclamation operations.

7.6.2.1 Restoring the Natural Drainage Patterns

All natural drainage patterns will be restored.

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7.6.2.2 Reshaping Cut and Fill Slopes

All cut and fill slopes will be reshaped to be compatible with the postmining land use and to complement the drainage pattern of the surrounding terrain.

7.6.3 Siltation Structures

7.6.3.1 Maintenance of Siltation Structures

All siltation structures will be maintained until removed in accordance with the approved reclamation plan.

7.6.3.2 Removal of Siltation Structures

When the siltation structure is removed, the land on which the siltation structure was located will be regraded and revegetated in accordance with the reclamation plan presented in Section 5.40. Because of the narrow confines of East Spring Canyon it is not practical to remove the mine fill area and restore the area to approximate original contour without removing the sediment pond at the base of the fill. Interim sediment control measures as discussed in Section 5.40 will be implemented during the reclamation stage.

7.6.4 Structure Removal

A timetable for the removal of each structure is presented in Figure 5-2.

7.6.5 Permanent Casing and Sealing of Wells

When no longer needed for monitoring or other use approved by the UDOGM upon a finding of no adverse environmental or health and safety effects, or unless approved for transfer as a water well, each well will be capped, sealed, backfilled, or otherwise properly managed, as required by the UDOGM. Wells will be sealed and backfilled by placing a concrete plug from TD to surface. Permanent closure measures will be designed to prevent access to the mine workings by people, livestock, fish and wildlife, machinery and to keep acid or other toxic drainage from entering ground or surface waters.

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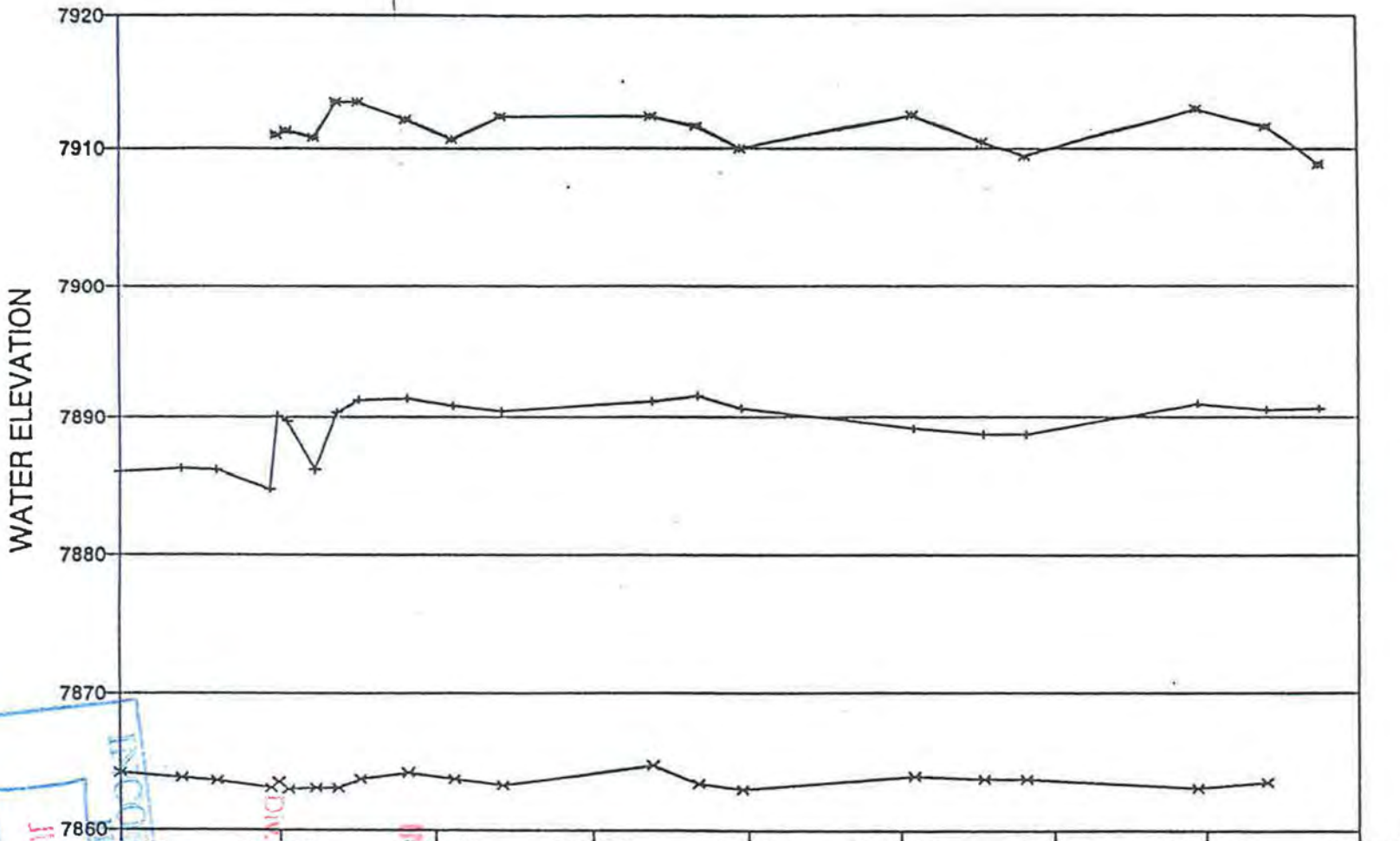

FIGURE 7-1 UPPER PRICE RIVER FORMATION HYDROGRAPHS.

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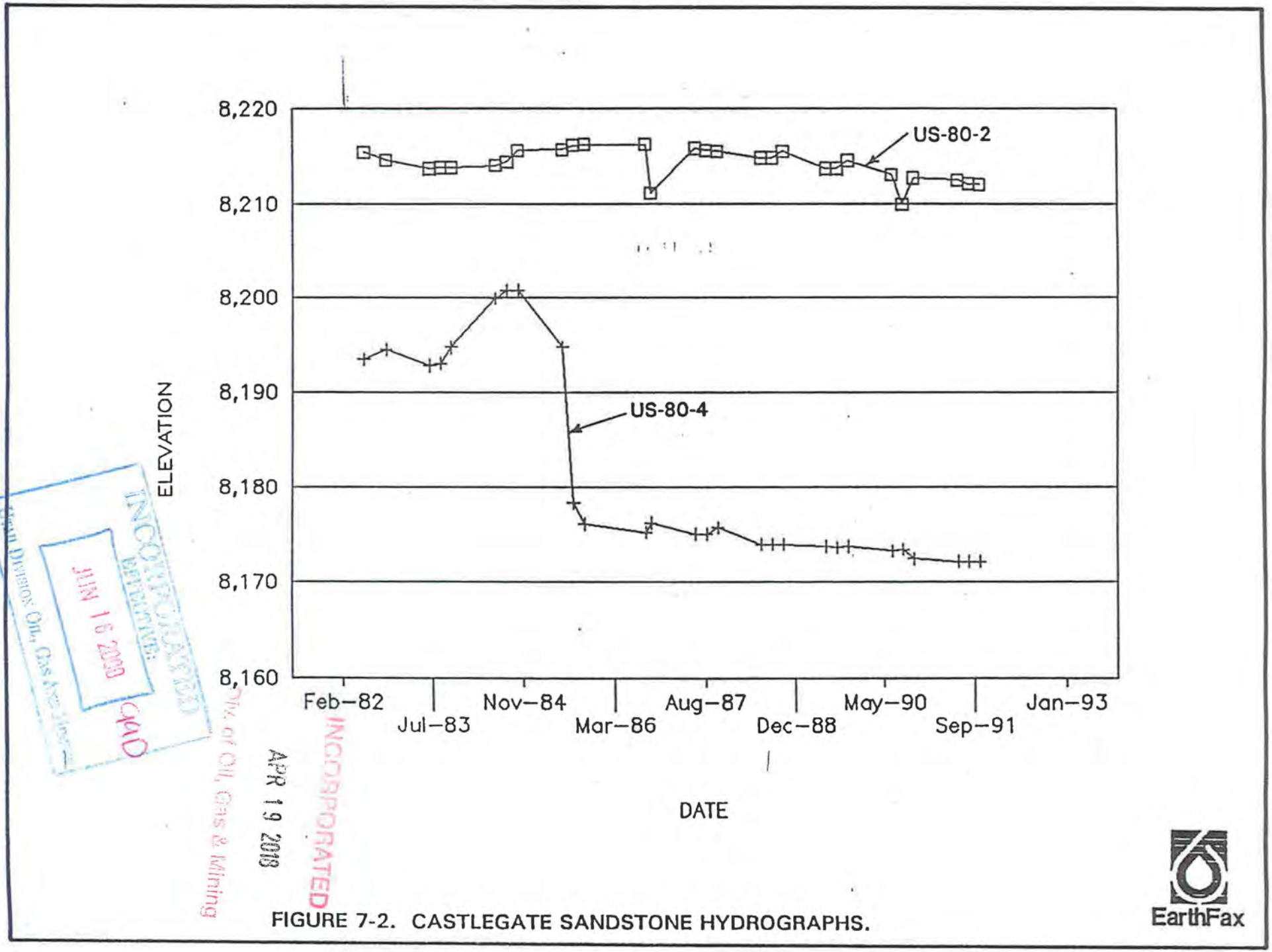

FIGURE 7-2. CASTLEGATE SANDSTONE HYDROGRAPHS.

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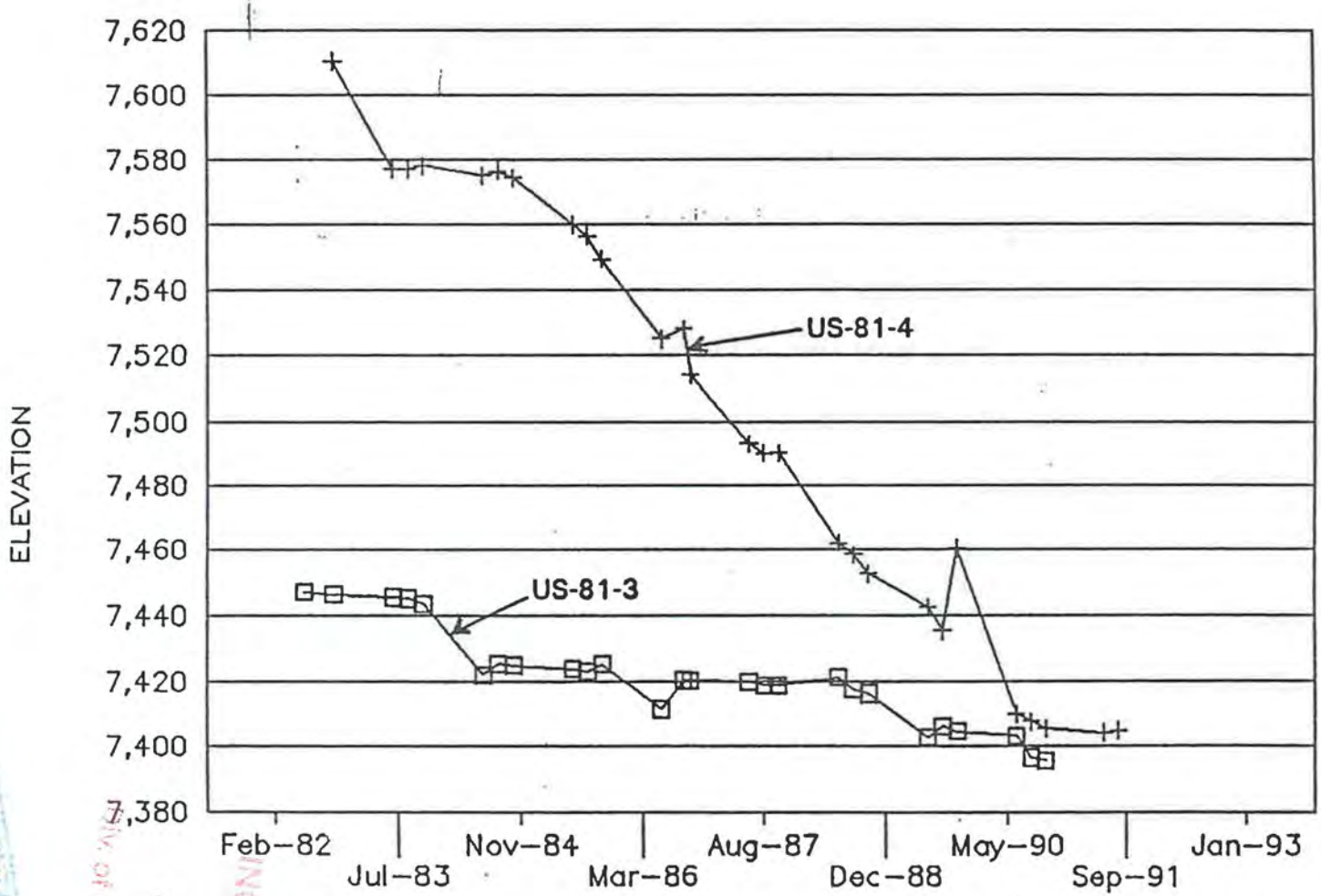

FIGURE 7-3. BLACKHAWK FORMATION HYDROGRAPHS.

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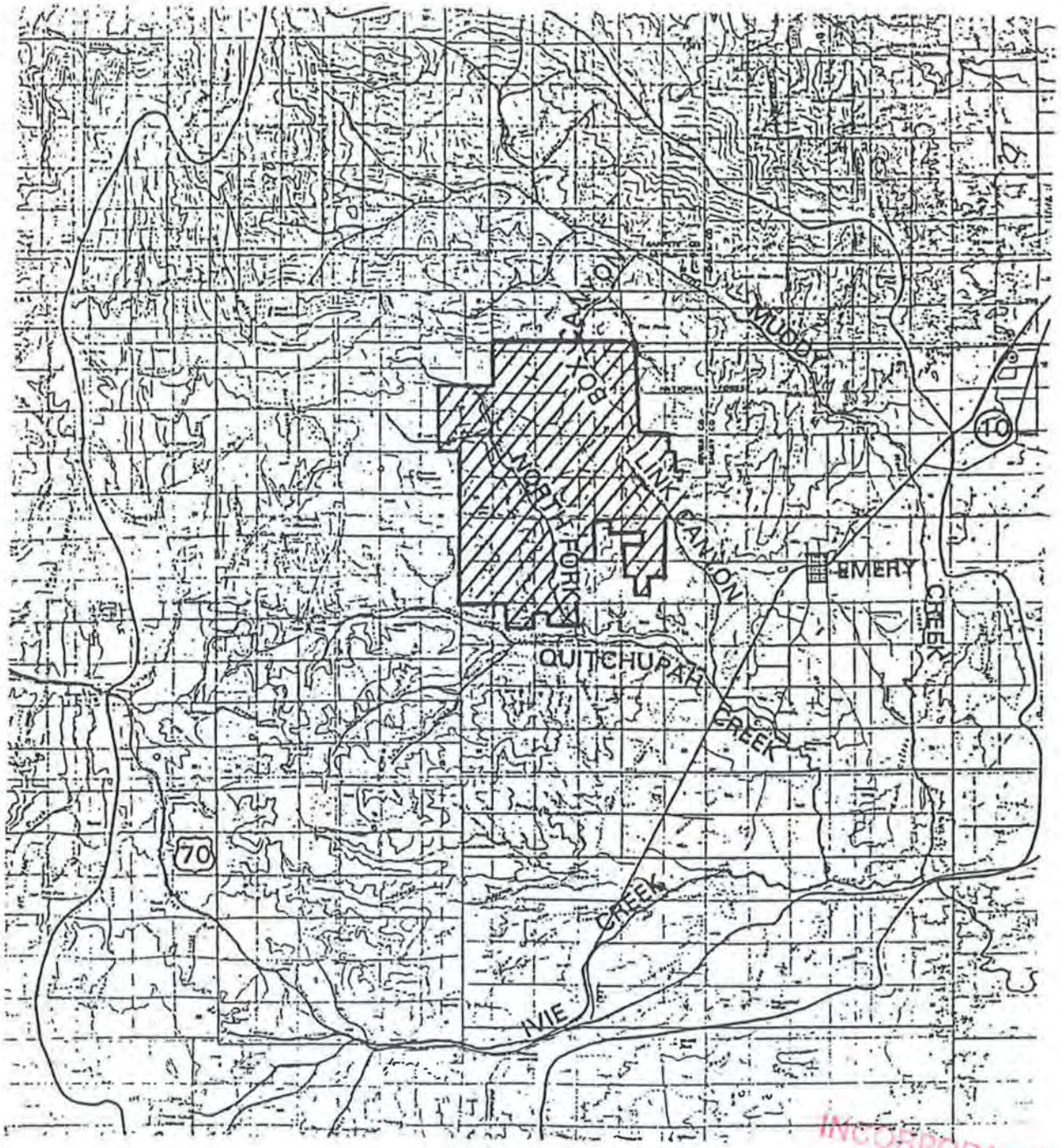

SUFCO LEASE AREA

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FIGURE 7-4. SURFACE DRAINAGE PATTERNS.

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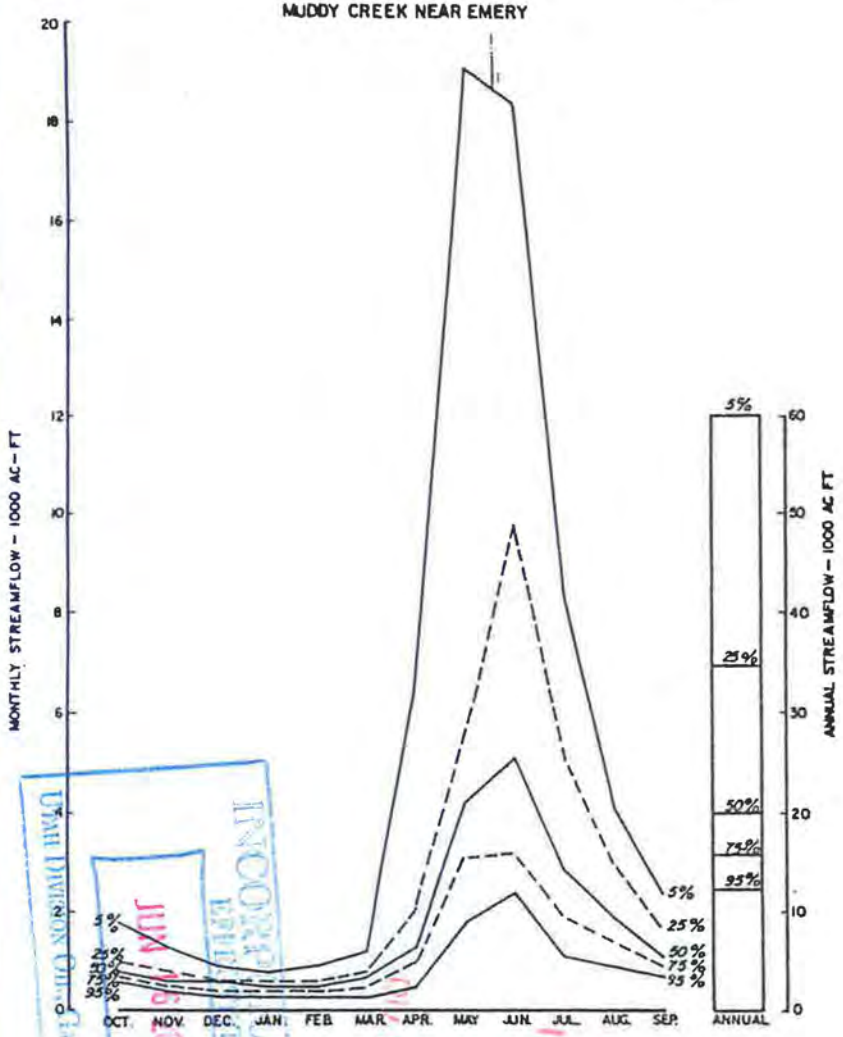

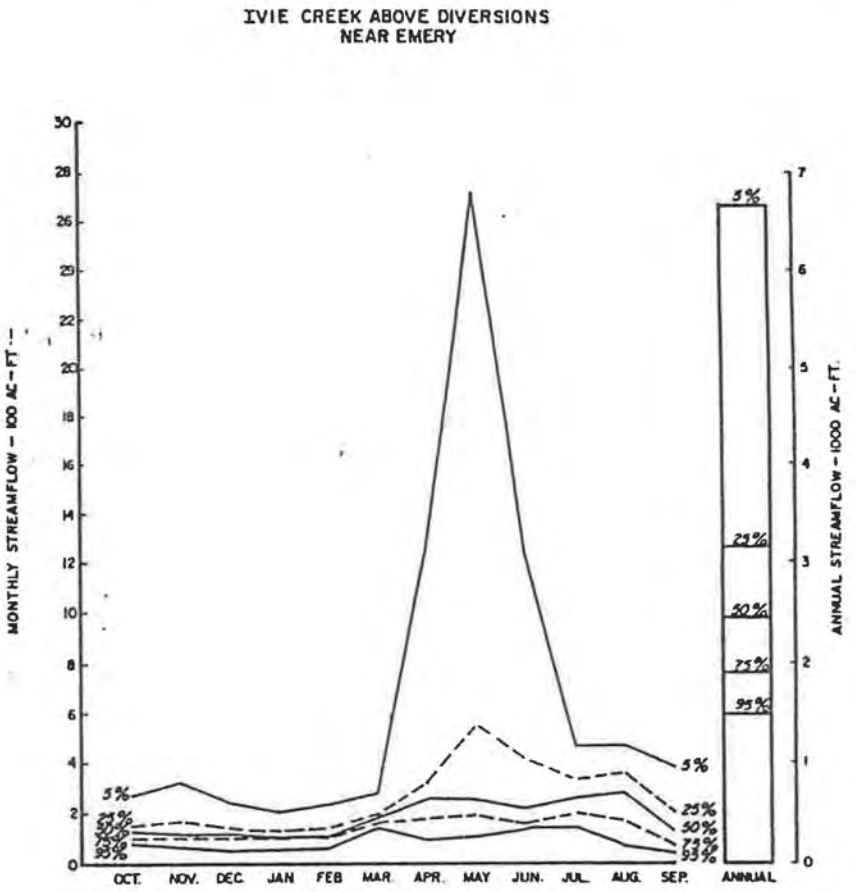

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FIGURE 7-5. STREAMFLOW PROBILITY OF SELECTED STREAMS.

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FIGURE 7-6. MINE DISCHARGE AND COAL PRODUCTION RATES.

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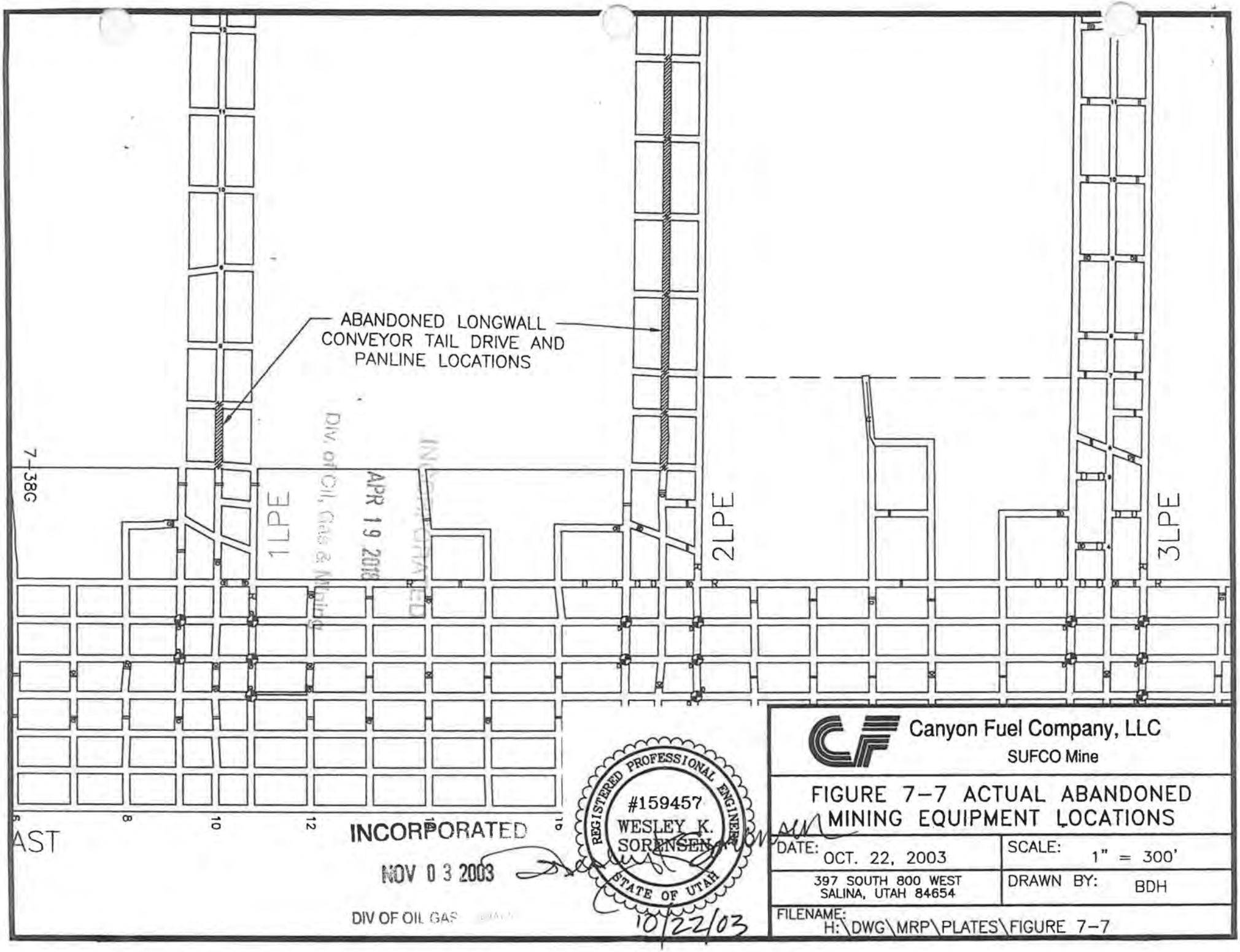
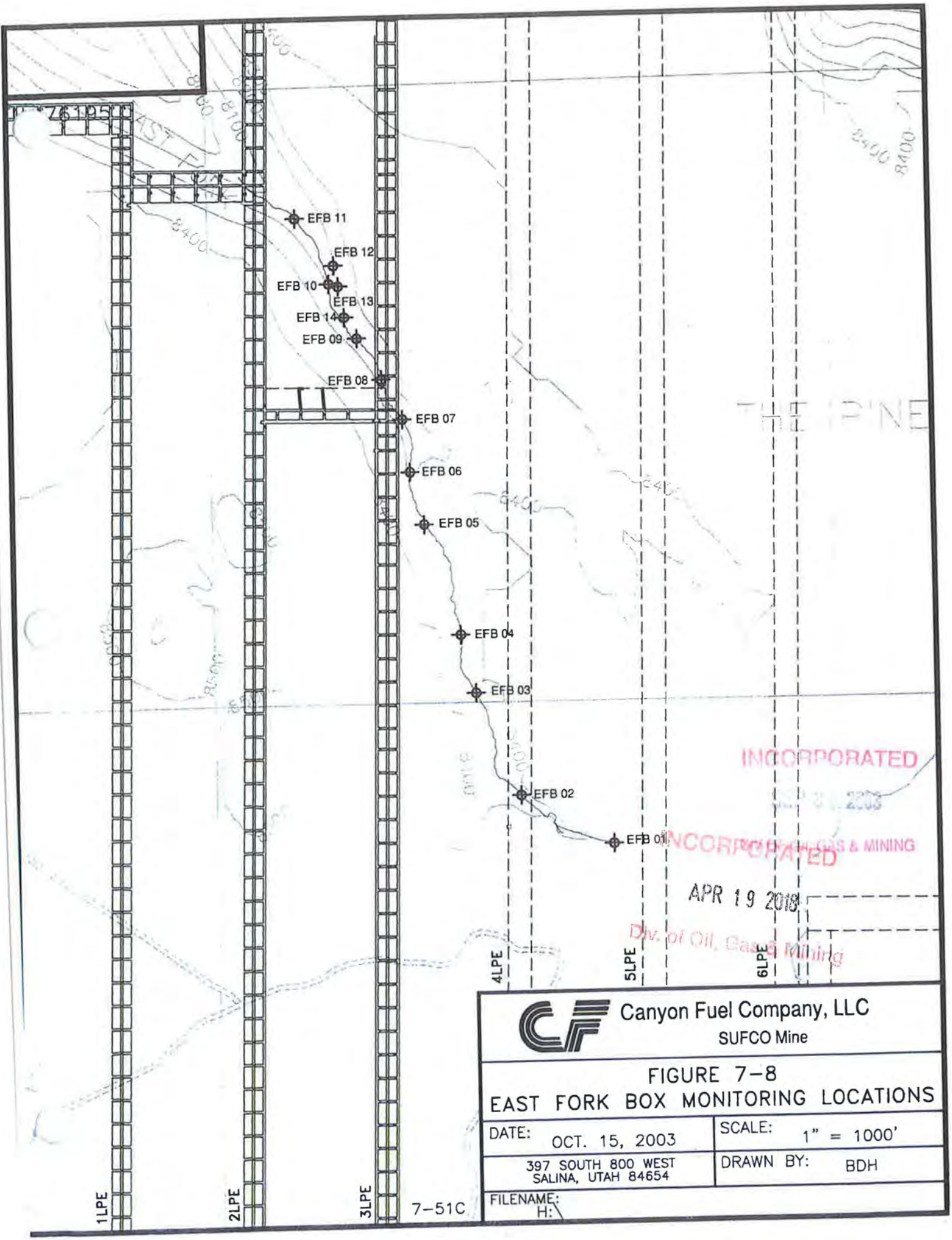


Canyon Fuel Company, LLC
SUFCO Mine

FIGURE 7-7 ACTUAL ABANDONED MINING EQUIPMENT LOCATIONS

DATE: OCT. 22, 2003	SCALE: 1" = 300'
397 SOUTH 800 WEST SALINA, UTAH 84654	DRAWN BY: BDH
FILENAME: H:\DWG\MRP\PLATES\FIGURE 7-7	



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Canyon Fuel Company, LLC
SUFCO Mine

FIGURE 7-8
EAST FORK BOX MONITORING LOCATIONS

DATE: OCT. 15, 2003	SCALE: 1" = 1000'
397 SOUTH 800 WEST SALINA, UTAH 84654	DRAWN BY: BDH
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Figure 7-9 Monitoring stations in the South Fork of Quitchupah Creek area.

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APPENDIX 7-1

Water Rights Data

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Search of TOWNSHIP = '20S' and RANGE = '4E' and BEM = 'SL'

WR Number	Diversion Type	Well Log	Location	Status	Priority	Uses	CFS	ACFT	Address	Owner Name	Latitude	Longitude
94-342	Point to Point		S660 W660 E4 19 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0519957537	-111.507670527
94-343	Point to Point		N660 E660 S4 02 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922188478	-111.437923863
94-399	Point to Point		S660 W1980 E4 01 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0963880645	-111.419104896
94-401	Point to Point		N660 E1980 W4 01 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1001631064	-111.423907198
94-407	Point to Point		S1980 E660 N4 01 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1008265918	-111.419117794
94-408	Point to Point		N660 E1980 W4 01 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1001631064	-111.423907198
94-409	Point to Point		N660 E1980 W4 02 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1003081135	-111.442535654
94-415	Point to Point		N660 W660 S4 01 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0920991774	-111.423872294
94-481	Point to Point		N1 W1600 SE 25 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0322862255	-111.417885168
94-482	Point to Point		N1 E1700 SW 25 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0323669523	-111.424821745
94-483	Point to Point		N1 E2350 SW 35 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0176327112	-111.441181235
94-484	Point to Point		N2200 E1 SW 26 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0383437371	-111.449497953
94-485	Point to Point		N1 W600 SE 34 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0175928133	-111.451567888
94-497	Point to Point		N300 W50 SE 30 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0331580379	-111.50553208
94-498	Point to Point		S2600 W4000 NE 29 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0395652378	-111.500708347
94-499	Point to Point			P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0441640386	-111.503458288

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		S900 E650 NW 29 20S 4E SL								
94-500	Point to Point	S1 W2000 NE 29 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0467335758	-111.493714113
94-501	Point to Point	N2100 E710 SW 21 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0525441675	-111.484208017
94-502	Point to Point	N2250 E1 SW 22 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0528090661	-111.467997899
94-503	Point to Point	S100 E400 NW 23 20S 4E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.061067718	-111.448070895
94-504	Point to Point	S1500 W1100 NE 27 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0425839372	-111.453350797
94-507	Point to Point	N900 E200 SW 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0638115264	-111.448792899
94-508	Point to Point	S1400 E1 NW 23 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0574918049	-111.449453952
94-509	Point to Point	S2100 E1350 NW 13 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0701010056	-111.426072708
94-510	Point to Point	S2600 W600 NE 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0687023534	-111.432935176
94-511	Point to Point	N1300 W600 SE 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0649846068	-111.433111866
94-512	Point to Point	S520 E1100 NW 13 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0744372851	-111.426979738
94-513	Point to Point	S1 E1850 NW 13 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0758724081	-111.424345474
94-514	Point to Point	N660 E660 W4 20 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0556413694	-111.503046586
94-515	Point to Point	S660 E660 NW 20 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0592085675	-111.503013941
94-516	Point to Point	N660 W660 E4 19 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0556211555	-111.507696492
94-517	Point to Point	S660 E660 N4 20 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0593234438	-111.493661394
94-518	Point to Point	N660 W660 E4 20 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0558062471	-111.488995388
94-519	Point to Point	S660 W660 E4	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.05207843	-111.470305168

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		21 20S 4E SL							
94-520	Point to Point	S660 E660 W4 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0667928071 -111.48430162
94-521	Point to Point	S660 W660 N4 22 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0594327618 -111.461066281
94-522	Point to Point	S660 W1980 E4 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0666810133 -111.475042707
94-523	Point to Point	S660 W1980 E4 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0666810133 -111.475042707
94-524	Point to Point	S660 W1980 E4 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0666810133 -111.475042707
94-525	Point to Point	N660 E660 SW 15 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0629937094 -111.46571051
94-526	Point to Point	N660 E660 SW 15 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0629937094 -111.46571051
94-527	Point to Point	S660 E660 N4 22 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0594511125 -111.456415956
94-528	Point to Point	N660 W660 S4 15 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0630581739 -111.461089867
94-529	Point to Point	N660 E660 S4 15 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.063076526 -111.456439304
94-530	Point to Point	S660 W1980 E4 15 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0668225471 -111.456482068
94-531	Point to Point	S660 E660 N4 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0741160072 -111.437871768
94-532	Point to Point	S660 W1980 E4 11 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0812691646 -111.437858488
94-534	Point to Point	S660 W1980 E4 11 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0812691646 -111.437858488
94-535	Point to Point	S660 W660 N4 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740[illegible] -111.4[illegible]3068
94-537	Point to Point	N660 W660 SE 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0777916197 -111.451890117
94-538	Point to Point	S660 W660 E4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813868956 -111.451870045

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94-539	Point to Point	N660 E660 S4 02 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922188478 -111.437923863
94-540	Point to Point	N660 E660 S4 03 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922384248 -111.456588061
94-541	Point to Point	N660 W660 S4 03 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.092220063 -111.461240542
94-542	Point to Point	S1980 E660 N4 03 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1010581009 -111.456391269
94-543	Point to Point	S660 E660 W4 02 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0966649185 -111.447165771
94-544	Point to Point	S660 E1980 W4 02 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0966827193 -111.442512988
94-545	Point to Point	S660 E660 W4 02 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0966649185 -111.447165771
94-546	Point to Point	S660 E1980 W4 02 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0966827193 -111.442512988
94-547	Point to Point	N660 E660 S4 02 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922188478 -111.437923863
94-548	Point to Point	N660 W660 SE 02 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0921687518 -111.433256464
94-549	Point to Point	N660 E1980 W4 15 20S 4E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0703625912 -111.461113911
94-550	Point to Point	N660 E660 SW 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0776943846 -111.465819409
94-551	Point to Point	N660 E660 SW 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0776943846 -111.465819409
94-552	Point to Point	N660 E660 SW 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0776943846 -111.465819409
94-553	Point to Point	S660 E660 W4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813343737 -111.465852021
94-554	Point to Point	S660 E660 W4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813343737 -111.465852021
94-555	Point to Point	S660 W660 N4 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740897812 -111.479696311
94-556	Point to Point	S660 W660 N4	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740897812 -111.479696311

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		16 20S 4E SL							
94-557	Point to Point	N660 E660 SW 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0777734321 -111.484319293
94-558	Point to Point	S660 W660 N4 17 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740110856 -111.498345253
94-559	Point to Point	N660 W660 SE 08 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0777539661 -111.488970804
94-560	Point to Point	N660 E660 S4 08 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0776563172 -111.493719265
94-561	Point to Point	S660 E660 W4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813854452 -111.484306939
94-562	Point to Point	N660 E1980 W4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0850301181 -111.479679743
94-563	Point to Point	S660 E660 W4 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0966188072 -111.484284121
94-564	Point to Point	S660 W1980 E4 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0965932184 -111.47511908
94-565	Point to Point	N660 W660 E4 04 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1002375204 -111.47049042
94-566	Point to Point	S660 W1980 E4 05 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0965796865 -111.493589618
94-567	Point to Point	S1980 E660 N4 05 20S 4E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.1008475263 -111.493712983
94-568	Point to Point	S660 E660 NW 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1046147586 -111.484248859
94-571	Point to Point	0 0 NE 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1064653143 -111.468057244
94-575	Point to Point	S660 W660 N4 17 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740110856 -111.498345253
94-582	Point to Point	N660 W660 S4 01 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922091773 -111.437923863
94-593	Point to Point	N660 E660 S4 02 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922188478 -111.437923863
94-594	Point to Point	N660 W660 S4 08 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0776364763 -111.498370762
94-598			P	1879	S	0.000 0.000			39.0466235851 -111.47007405

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	Point to Point	N1 W600 SE 21 20S 4E SL					324 - 25TH STREET	USA FOREST SERVICE	
94-600	Point to Point	N660 E660 W4 22 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0557225634 -111.465679147
94-605	Point to Point	N660 E660 S4 02 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922188478 -111.437923863
94-606	Point to Point	S660 W660 N4 17 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740110856 -111.498345253
94-609	Point to Point	S660 E660 N4 04 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1046387294 -111.47498374
94-610	Point to Point	S660 E660 N4 04 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1046387294 -111.47498374
94-482	Point to Point	N550 E1600 SW 24 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0483997181 -111.425273263
94-483	Point to Point	S1950 W2150 NE 26 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0414842887 -111.438439945
94-485	Point to Point	N1800 W1150 SE 27 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0372293741 -111.453544668
94-486	Point to Point	N1700 W1250 SE 27 20S 4E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0369533456 -111.453895098
94-496	Point to Point	N2300 E1900 SW 27 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0386360177 -111.461329858
94-497	Point to Point	S1900 E500 NW 33 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0269799829 -111.484794966
94-498	Point to Point	S1700 W2350 NE 29 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.042061992 -111.494914355
94-499	Point to Point	N2500 E400 SW 26 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0391731248 -111.448097911
94-500	Point to Point	S1950 W800 NE 29 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0413984709 -111.489450372
94-501	Point to Point	S2450 W2110 NE 28 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0398702114 -111.47534761
94-502	Point to Point	N550 E1600 SW 24 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0483997181 -111.425273263
94-503	Point to Point	S1350 E2300 NW	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0576601656 -111.4413557

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		23 20S 4E SL								
94-504	Point to Point	N1200 W300 SE 22 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0500105346	-111.450580203
94-508	Point to Point	S600 W1450 NE 23 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0597550035	-111.436074529
94-509	Point to Point	S1800 E1550 NW 24 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0564983366	-111.425485736
94-510	Point to Point	N1150 E350 SW 13 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0645850513	-111.429762268
94-511	Point to Point	N700 E350 SW 13 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0633491129	-111.429754773
94-512	Point to Point	S1500 E2400 NW 13 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0717624257	-111.422382834
94-516	Point to Point	S1980 E660 N4 20 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.05569804	-111.493636143
94-517	Point to Point	S660 E660 N4 20 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0593234438	-111.493661394
94-518	Point to Point	S660 E660 W4 21 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0522003016	-111.484320549
94-520	Point to Point	N660 W660 E4 22 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0558315586	-111.451828747
94-522	Point to Point	S660 W660 N4 22 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0594327618	-111.461066281
94-523	Point to Point	N660 W660 SE 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0629749876	-111.470361062
94-524	Point to Point	N660 W660 SE 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0629749876	-111.470361062
94-525	Point to Point	N660 W660 SE 16 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0629749876	-111.470361062
94-527	Point to Point	N660 W660 E4 22 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0558315586	-111.451828747
94-528	Point to Point	N660 W660 E4 22 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0558315586	-111.451828747
94-529	Point to Point	S660 E660 NW 23 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0595331895	-111.447145197

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94-530	Point to Point	S660 E660 W4 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0668586993 -111.447180436
94-531	Point to Point	S660 E660 W4 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0668586993 -111.447180436
94-532	Point to Point	S660 E660 N4 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0741160072 -111.437871768
94-535	Point to Point	N660 E660 W4 14 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0704841109 -111.447203317
94-537	Point to Point	S660 W660 NE 15 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.074166214 -111.45186699
94-538	Point to Point	N660 E660 S4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0777523657 -111.456529005
94-539	Point to Point	S660 W1980 E4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813687234 -111.456521815
94-540	Point to Point	N660 E660 W4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849597706 -111.465875871
94-541	Point to Point	N660 E660 W4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849597706 -111.465875871
94-542	Point to Point	N660 W660 SE 03 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922329646 -111.451896246
94-543	Point to Point	N660 E660 SW 02 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922509536 -111.447243758
94-544	Point to Point	N660 E660 SW 02 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922509536 -111.447243758
94-549	Point to Point	S660 E660 N4 15 20S 4E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0741269614 -111.45650564
94-550	Point to Point	N660 W660 S4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0777340081 -111.461180533
94-551	Point to Point	N660 E660 S4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0777523657 -111.456529005
94-552	Point to Point	S660 E1980 W4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813529181 -111.46120026
94-553	Point to Point	S660 W1980 E4 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813687234 -111.456521815
94-554	Point to Point	S660 E1980 W4	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0813529181 -111.46120026

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		10 20S 4E SL								
94-555	Point to Point	N660 W660 E4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849410392	-111.470527867
94-556	Point to Point	S660 E660 NW 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.088599755	-111.465908494
94-557	Point to Point	N660 W660 S4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0777151781	-111.479720864
94-559	Point to Point	S660 W660 N4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0885925628	-111.479766171
94-560	Point to Point	S660 E660 NW 10 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.088599755	-111.465908494
94-561	Point to Point	N660 E1980 W4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0850301181	-111.479679743
94-562	Point to Point	S660 W660 N4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0885925628	-111.479766171
94-563	Point to Point	N660 E660 S4 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922370525	-111.475138272
94-564	Point to Point	N660 W660 SE 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922064126	-111.470584827
94-566	Point to Point	N660 E1980 W4 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1002634719	-111.479655935
94-567	Point to Point	N660 E660 W4 04 20S 4E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.1002441885	-111.484308929
94-568	Point to Point	N660 E1980 W4 04 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1002634719	-111.479655935
94-570	Point to Point	S660 E660 N4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0886116632	-111.475113941
94-582	Point to Point	N660 W660 S4 01 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0920991774	-111.423872294
94-593	Point to Point	N660 W660 S4 02 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922012306	-111.[illegible]
94-594	Point to Point	S1980 E660 N4 08 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0848602607	-111.493681502
94-595	Point to Point	S660 E660 N4 09 20S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0886116632	-111.475113941

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94-598	Point to Point	N1700 E1220 SW 22 20S 4E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0513156831	-111.463693922
65-2429	Surface	S3848 E712 NW 06 20S 4E SL	P	19891220	O	0.000	320.000	1594 WEST NORTH TEMPLE, STE 2110	STATE OF UTAH DIVISION OF WILDLIFE RESOURCES	39.0955801354	-111.515509254
94-1134	Surface	S35 W100 NE 10 20S 4E SL	P	1882		DIMS 0.000	300.000	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0903317928	-111.449910334
94-2	Surface	S650 E1610 NW 04 20S 4E SL	P	19130111		DIMS 0.000	51.300	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.1046561192	-111.480900094
94-2	Rediversion	N1175 W1003 SE 04 20S 4E SL	P	19130111		DIMS 0.000	51.300	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.093615965	-111.471803187
94-32	Surface	S1650 W1050 NE 20 20S 4E SL	P	19511219		DIMS 0.000	218.000	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0566932661	-111.490314189
94-33	Surface	N1850 W245 SE 28 20S 4E SL	P	19610818		DIMS 0.000	724.940	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0373698499	-111.468876237
94-33	Surface	S2420 W1700 NE 27 20S 4E SL	P	19610818		DIMS 0.000	724.940	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0400488632	-111.455447852
94-33	Rediversion	N150 W1225 SE 22 20S 4E SL	P	19610818		DIMS 0.000	724.940	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0471139999	-111.453820064
94-40	Surface	S35 W100 NE 10 20S 4E SL	P	19501212		DIMS 0.000	8.000	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0903317928	-111.449910334
94-47	Surface	S650 E1610 NW 04 20S 4E SL	P	19581112		DIMS 0.000	238.700	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.1046561192	-111.480900094
94-47	Rediversion	N1175 W1003 SE 04 20S 4E SL	P	19581112		DIMS 0.000	238.700	P.O. BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.093615965	-111.471803187
94-487	Spring	S1400 E150 NW 35 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0284582201	-111.448910619
94-488	Spring	S2300 E1600 NW 34 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0259977455	-111.462304103
94-489	Spring	S2200 E2250 NW 34 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0262814812	-111.460017032
94-490	Spring	S1200 E2500 NW 34 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.029031503	-111.459154473
94-491	Spring	S1100 E1700 NW 34 20S 4E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0292949937	-111.461973429

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94-492	Spring	S300 W1850 NE 33 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0314418646 -111.474489336
94-493	Spring	S1200 W1900 NE 33 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0289692635 -111.474648877
94-494	Spring	S100 W800 NE 33 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0320062066 -111.470795328
94-495	Spring	N2400 E400 SW 33 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.024216783 -111.48533617
94-506	Spring	S700 E400 NW 27 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0447124553 -111.466539052
94-55	Surface	S35 W100 NE 10 20S 4E SL	P	1900	DIMS	0.000 117.000	P.O BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0903317928 -111.449910334
94-56	Surface	S1650 W1050 NE 20 20S 4E SL	P	1900	DIMS	0.000 251.000	P.O BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0566932661 -111.490314189
94-57	Surface	S35 W100 NE 10 20S 4E SL	P	1900	DIMS	0.000 225.000	P.O BOX 104	MUDDY CREEK IRRIGATION COMPANY	39.0903317928 -111.449910334
94-599	Spring	N250 E250 SW 22 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0473195373 -111.467084574
94-601	Spring	N350 W800 SE 21 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0475792712 -111.470784881
94-603	Spring	S500 E2050 NW 34 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0309478096 -111.460751615
94-604	Spring	S500 E500 NW 34 20S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.030926044 -111.466210023
94-612	Spring	N670 W800 SE 21 20S 4E SL	P	1879	S	0.011 0.000	324 - 24TH STREET	USA FOREST SERVICE	39.0484581602 -111.470790716

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Search of TOWNSHIP = '20S' and RANGE = '5E' and BEM = 'SL'

WR Number	Diversion Type	Well Log	Location	Status	Priority	Uses	CFS	ACFT	Address	Owner Name	Latitude	Longitude
93-2275	Point to Point		N660 W660 SE 01 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0920841057	-111.301820334
93-2281	Point to Point		S660 E1980 W4 12 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0812626401	-111.311035499
93-2282	Point to Point		S660 W1980 E4 12 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.081176727	-111.30644109
93-2283	Point to Point		S660 E1980 W4 12 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0812626401	-111.311035499
93-2284	Point to Point		S1980 E660 N4 12 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0848673463	-111.306401929
93-2285	Point to Point		N660 E660 W4 12 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0848755169	-111.315703489
93-2286	Point to Point		N660 E660 S4 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0921602084	-111.325006689
93-2287	Point to Point		S660 W660 E4 03 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0957861699	-111.338922638
93-2288	Point to Point		N660 W660 E4 03 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0994115884	-111.338939989
93-2289	Point to Point		N660 E660 W4 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0994250709	-111.334286966
93-2290	Point to Point		S660 W660 NE 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.1030298303	-111.320297732
93-2291	Point to Point		S660 W660 NE 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.1030298303	-111.320297732
93-2292	Point to Point		S660 W660 NE 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.1030298303	-111.320297732
93-2293	Point to Point		S660 W660 NE 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.1030298303	-111.320297732
93-2296	Point to Point		S660 W660 N4 01 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.1030443744	-111.31101713
93-2297	Point to Point		S660 W660 N4 01 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.1030443744	-111.31101713
93-2298	Point to Point		N660 W660 SE 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0921268257	-111.320351348
93-2299	Point to Point		N660 E660 S4 02 20S 5E SL	P	1877	S	0.011	0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0921602084	-111.325006689
93-2300				P	1877	S	0.011	0.000			39.0921602084	-111.325006689

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	Point to Point	N660 E660 S4 02 20S 5E SL					FEDERAL BUILDING	USA FOREST SERVICE		
93-2301	Point to Point	S660 W660 NE 01 20S 5E SL	P	1877	S	0.011 0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.1030581798	-111.301736519
93-2302	Point to Point	S1980 E660 N4 01 20S 5E SL	P	1877	S	0.011 0.000	FEDERAL BUILDING	USA FOREST SERVICE	39.0994313214	-111.306348172
93-2402	Point to Point	S660 E1980 W4 11 20S 5E SL	P	1877	S	0.000 0.000	OGDEN UT 84401	USA FOREST SERVICE	39.0813287007	-111.329602984
93-2403	Point to Point	N660 E660 S4 02 20S 5E SL	P	1877	S	0.000 0.000	OGDEN UT 84401	USA FOREST SERVICE	39.0921602084	-111.325006689
93-2406	Point to Point	N660 E660 W4 02 20S 5E SL	P	1877	S	0.000 0.000	OGDEN UT 84401	USA FOREST SERVICE	39.0994250709	-111.334286966
93-2409	Point to Point	S660 W660 E4 01 20S 5E SL	P	1877	S	0.000 0.000	OGDEN UT 84401	USA FOREST SERVICE	39.095758433	-111.301770706
93-2424	Point to Point	N660 E1980 W4 01 20S 5E SL	P	1877	S	0.000 0.000	OGDEN UT 84401	USA FOREST SERVICE	39.0994163354	-111.311026675
93-2425	Point to Point	N660 E1980 W4 01 20S 5E SL	P	1877	S	0.000 0.000	OGDEN UT 84401	USA FOREST SERVICE	39.0994163354	-111.311026675
94-340	Point to Point	N660 W660 SE 24 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0485929481	-111.301715003
94-346	Point to Point	N660 E660 W4 21 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0559053709	-111.371369499
94-350	Point to Point	N660 W660 E4 24 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0558161735	-111.301727691
94-351	Point to Point	N660 E1980 W4 25 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0413794033	-111.310951292
94-352	Point to Point	S660 E1980 W4 26 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.037745751	-111.329514941
94-353	Point to Point	N660 E660 SW 23 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0485964478	-111.334156023
94-354	Point to Point	S660 W660 N4 22 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0594877539	-111.348147135
94-355	Point to Point	N660 W660 E4 10 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849273525	-111.338923992
94-356	Point to Point	S1980 E660 N4 10 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849046859	-111.343566048
94-357	Point to Point	S1980 E660 N4 10 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849046859	-111.343566048
94-361	Point to Point	N660 W660 SE 24 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0485929481	-111.301715003
94-362	Point to Point	S1980 E660 N4 24 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0558252565	-111.306319792
94-363	Point to Point	N660 W660 S4 13 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.063063784	-111.311001753

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94-364	Point to Point	N660 W660 E4 14 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0703430846 -111.320311445
94-365	Point to Point	S660 E1980 W4 14 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0667624782 -111.329535431
94-366	Point to Point	S660 W660 E4 15 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0667357084 -111.338837181
94-367	Point to Point	N660 E660 W4 14 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0703746236 -111.334203398
94-368	Point to Point	N660 W660 S4 15 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0631131936 -111.348164937
94-369	Point to Point	S660 W660 N4 15 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740681687 -111.348130247
94-370	Point to Point	S660 W660 NE 10 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.088541201 -111.33894978
94-371	Point to Point	N660 E660 W4 10 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849214184 -111.352825737
94-372	Point to Point	N660 W660 SE 09 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0776983905 -111.35741524
94-373	Point to Point	S660 W660 N4 16 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0741123634 -111.366671067
94-374	Point to Point	S660 W660 NE 09 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0884905742 -111.357522071
94-375	Point to Point	S660 W1980 E4 09 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0812673661 -111.362111322
94-376	Point to Point	S660 E660 W4 09 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0814123509 -111.371418185
94-377	Point to Point	S1980 E660 N4 10 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849046859 -111.343566048
94-378	Point to Point	S660 E660 NW 09 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0886587072 -111.371542561
94-379	Point to Point	N660 W660 SE 05 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0922691545 -111.376214115
94-380	Point to Point	N660 E660 W4 03 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0994250334 -111.352826812
94-381	Point to Point	S1980 E660 N4 04 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0994621753 -111.36199963
94-382	Point to Point	S660 W660 E4 04 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0957853959 -111.357461524
94-383	Point to Point	N660 W660 E4 04 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.099410811 -111.357479826
94-384	Point to Point	S660 E660 W4 03 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0957996173 -111.352808749
94-405	Point to Point	N660 E1980 W4 06 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0993370786 -111.405151569

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94-406	Point to Point	N660 E1980 W4 06 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0993370786	-111.405151569
94-417	Point to Point	S1400 E1 NW 07 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0863792977	-111.412125431
94-418	Point to Point	S900 E600 NW 17 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0733659522	-111.389974015
94-419	Point to Point	S2400 E400 NW 07 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0836377514	-111.410703296
94-420	Point to Point	N1100 E1300 SW 07 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0787258433	-111.40754331
94-421	Point to Point	S1 E100 NW 18 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0756870101	-111.411754482
94-422	Point to Point	S2000 E1 NW 07 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0847313838	-111.412115842
94-423	Point to Point	N2700 W1000 SE 18 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0686777514	-111.395676149
94-424	Point to Point	N1950 E900 SW 19 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0521404009	-111.409064562
94-449	Point to Point	N2500 E1 SW 31 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0245746907	-111.41220788
93-2402	Point to Point	S660 W660 NE 12 20S 5E SL	P	1877	S	0.000 0.000	OGDEN UT 84401	USA FOREST SERVICE	39.0884586769	-111.301804891
94-360	Point to Point	N660 E660 S4 25 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0341535592	-111.306309108
94-361	Point to Point	N660 E1980 W4 25 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0413794033	-111.310951292
94-362	Point to Point	S660 E1980 W4 25 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0377539439	-111.310935409
94-363	Point to Point	N660 W660 S4 26 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0341112827	-111.329551474
94-364	Point to Point	S1980 E660 N4 27 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0413533907	-111.343444465
94-365	Point to Point	S660 E660 W4 23 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0521966249	-111.334149693
94-366	Point to Point	S660 E660 N4 21 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0596010333	-111.362083729
94-367	Point to Point	N660 E660 W4 21 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0559053709	-111.371369499
94-368	Point to Point	N660 W660 S4 15 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0631131936	-111.348164937
94-369	Point to Point	S660 W660 E4 16 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0668194817	-111.357440203
94-370	Point to Point	S660 W660 NE 20 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.059606161	-111.37598479

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94-371	Point to Point	S660 E660 NW 21 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0596211195 -111.371334404
94-372	Point to Point	S660 W1980 E4 16 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0668050768 -111 36209107
94-373	Point to Point	S660 E660 NW 21 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0596211195 -111 371334404
94-374	Point to Point	S660 E1980 W4 17 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0667630055 -111 385120484
94-375	Point to Point	S660 E1980 W4 09 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0814271285 -111.366766363
94-376	Point to Point	S660 W660 N4 17 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0740809471 -111.385181376
94-377	Point to Point	S1980 E660 N4 10 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849046859 -111.343566048
94-378	Point to Point	N660 E660 W4 08 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0848508732 -111 38985723
94-379	Point to Point	S660 W660 NE 08 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0886437387 -111.376194856
94-380	Point to Point	N660 E1980 W4 08 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0848663865 -111.385205192
94-381	Point to Point	S660 W1980 E4 04 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0957709888 -111.362114296
94-383	Point to Point	S660 W660 E4 04 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0957853959 -111.357461524
94-384	Point to Point	S660 W660 E4 04 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0957853959 -111.357461524
94-385	Point to Point	S660 E660 N4 05 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1030043325 -111.380615651
94-386	Point to Point	N660 E1980 W4 08 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0848663865 -111 385205192
94-391	Point to Point	N660 E660 W4 05 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0993019041 -111 389945472
94-392	Point to Point	S660 W660 N4 08 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0885269168 -111 38537776
94-396	Point to Point	N660 E660 W4 08 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0848508732 -111 38985723
94-397	Point to Point	N660 E1980 W4 06 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0993370786 -111 405151569
94-398	Point to Point	S660 W660 N4 06 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.1029336684 -111 404500787
94-399	Point to Point	N660 E1980 W4 06 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0993370786 -111 405151569
94-402	Point to Point	N660 E1980 W4 06 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0993370786 -111 405151569

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94-405	Point to Point	S660 E660 NW 08 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.088425073	-111.389908357
94-406	Point to Point	N660 E1980 W4 06 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0993370786	-111.405151569
94-415	Point to Point	S660 W660 N4 07 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0884068311	-111.404513775
94-416	Point to Point	S660 W660 N4 07 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0884068311	-111.404513775
94-417	Point to Point	S1900 E1500 NW 07 20S 5E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0850246473	-111.406834561
94-418	Point to Point	S2750 E1900 NW 17 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0683001459	-111.385365575
94-419	Point to Point	N1900 E2300 SW 07 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0809353688	-111.404031883
94-420	Point to Point	S100 W2600 NE 18 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0755247892	-111.401262282
94-421	Point to Point	S900 E1300 NW 18 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0732327861	-111.407511714
94-422	Point to Point	S1250 W1 NE 20 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0579931919	-111.373654583
94-423	Point to Point	N850 W1320 SE 18 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0635928165	-111.396775212
94-424	Point to Point	N1 E1250 SW 26 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.032315358	-111.332119634
94-442	Point to Point	S550 E2100 NW 35 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0308105277	-111.329119191
94-449	Point to Point	N2100 W1 SE 28 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.038043889	-111.35513165
94-461	Point to Point	N660 E1980 W4 17 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0703884332	-111.385140185
94-462	Point to Point	N400 E150 SW 33 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0188914506	-111.373182393
94-463	Point to Point	N1000 E50 SW 33 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0205382552	-111.373543162
94-467	Point to Point	S550 E3000 NW 29 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0452700828	-111.38164387
94-468	Point to Point	S1500 E1650 NW 29 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0426451426	-111.386384764
94-469	Point to Point	N1010 W1 SE 20 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0495180013	-111.373719028
94-460	Point to Point	S1 E1300 NW 35 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.032310365	-111.331943524
94-461	Point to Point	S660 W660 N4 07 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0884068311	-111.404513775

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94-467	Point to Point	S2600 E4400 NW 29 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.039655753 -111.376682746
94-468	Point to Point	N1300 E2400 SW 29 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0358928061 -111.383723554
94-469	Point to Point	N1300 W1900 SE 30 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0358417927 -111.398867429
94-576	Point to Point	S1980 E660 N4 10 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0849046859 -111.343566048
94-446	Surface	N2000 W800 SE 34 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0233256259 -111.33937014
94-447	Surface	S300 W2100 NE 34 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.031454287 -111.343913239
94-448	Surface	S450 W750 NE 33 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0310320716 -111.357734285
94-450	Surface	N2000 E1970 SW 28 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0377640998 -111.36675455
94-451	Spring	S2100 E1620 NW 33 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0264993197 -111.367928845
94-452	Surface	N1750 E1650 SW 33 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0226161633 -111.367920111
94-453	Surface	S350 E4300 NW 29 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0458343471 -111.377067794
94-454	Spring	N750 W450 SE 33 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0198398571 -111.356675048
94-457	Spring	S2350 E2750 NW 08 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0838079211 -111.382517187
94-464	Surface	S250 E2850 NW 20 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0606208652 -111.382067131
94-465	Surface	S1500 E2100 NW 20 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0571789697 -111.384690802
94-466	Surface	S2250 E3400 NW 20 20S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0551341375 -111.380099995
94-470	Spring	N850 E1400 SW 29 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0346451697 -111.387238644
94-471	Spring	N2000 E900 SW 30 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0378079056 -111.409112713
94-472	Spring	S1000 W1800 NE 31 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0295259343 -111.398479772
94-473	Spring	S450 W450 NE 31 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0310527497 -111.39373[illegible]
94-478	Spring	S750 E150 NW 32 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0302359268 -111.391616606
94-479	Spring	N200 E1880 SW 25 20S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.032876849 -111.31129742

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94-596	Spring	N2250 W2200 SE 30 20S 5E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0384473813 -111.399938685
94-597	Spring	S550 W2300 NE 30 20S 5E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.045207254 -111.400312047
94-476	Point to Point	N1000 W1 SE 32 20S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0205376774 -111.37372274
94-481	Point to Point	N500 E1 SW 19 20S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0481467264 -111.412208256
94-484	Point to Point	N1900 E900 SW 19 20S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0520030739 -111.40906377
94-507	Point to Point	N1950 E900 SW 19 20S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0521404009 -111.409064562
94-513	Point to Point	S1 W2400 NE 19 20S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0612424571 -111.400567067

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Search of TOWNSHIP = '21S' and RANGE = '4E' and BEM = 'SL'

WR Number	Diversion Type	Well Log	Location	Status	Priority	Uses	CFS	ACFT	Address	Owner Name	Latitude	Longitude
63-2710	Point to Point		N660 E660 SW 21 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9637785255	-111.476556858
63-2711	Point to Point		N660 W660 SE 21 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.963735561	-111.462651144
63-2772	Point to Point		S660 W660 NE 18 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9888191353	-111.4998918
63-2880	Point to Point		N660 E660 S4 31 21S 4E SL	P	1893	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9349115495	-111.504118229
63-2881	Point to Point		S1980 E660 N4 16 21S 4E SL	P	1893	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9852029283	-111.467312915
63-2882	Point to Point		S660 W1980 E4 16 21S 4E SL	P	1893	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9816195086	-111.467297103
63-2883	Point to Point		N660 E660 S4 10 21S 4E SL	P	1893	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9925185004	-111.448682483
63-2884	Point to Point		S660 W660 N4 27 21S 4E SL	P	1893	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9601059692	-111.453370347
63-2885	Point to Point		N660 W660 E4 27 21S 4E SL	P	1893	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.956476981	-111.444142442
63-3361	Point to Point		N660 W660 SE 17 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9781052062	-111.481263056
63-3362	Point to Point		S660 W660 N4 16 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9888096426	-111.47198245
63-3363	Point to Point		N660 E1980 W4 16 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9852846519	-111.472003228
63-3364	Point to Point		S660 W1980 E4 16 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9816195086	-111.467297103
63-3365	Point to Point		N660 W660 S4 15 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9780234145	-111.453415184
63-3366	Point to Point		S1980 E660 N4 28 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.956515599	-111.467234331
63-3367	Point to Point		N660 W660 SE 16 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9780455472	-111.462663134
63-3368	Point to Point		N660 E1980 W4 22 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9709271593	-111.453368105
63-3369	Point to Point		S660 W1980 E4 21 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9672464855	-111.467277809
63-3370				P	1873	OS	0.015	0.000			38.9743979129	-111.453392055

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	Point to Point	S660 W660 N4 22 21S 4E SL						324 25TH STREET	USA FOREST SERVICE		
63-3371	Point to Point	S660 E660 N4 22 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9744159369	-111.448747306
63-3372	Point to Point	S660 E1980 W4 15 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9816746978	-111.453361448
63-3373	Point to Point	S660 E1980 W4 15 21S 4E SL	P	1873	OS	0.000	0.200	324 25TH STREET	USA FOREST SERVICE	38.9816746978	-111.453361448
63-3374	Point to Point	N660 E1980 W4 15 21S 4E SL	P	1873	OS	0.000	0.100	324 25TH STREET	USA FOREST SERVICE	38.9853001948	-111.453384581
63-3375	Point to Point	S660 E660 NW 15 21S 4E SL	P	1873	OS	0.000	0.100	324 25TH STREET	USA FOREST SERVICE	38.98887452	-111.458018564
63-3376	Point to Point	S660 E660 NW 15 21S 4E SL	P	1873	OS	0.000	0.200	324 25TH AVENUE	USA FOREST SERVICE	38.98887452	-111.458018564
63-3377	Point to Point	N660 W660 SE 09 21S 4E SL	P	1873	OS	0.000	0.100	324 25TH STREET	USA FOREST SERVICE	38.9924816059	-111.462687873
63-3378	Point to Point	N660 W660 SE 16 21S 4E SL	P	1873	OS	0.100	0.000	324 25TH STREET	USA FOREST SERVICE	38.9780455472	-111.462663134
63-3379	Point to Point	N660 E1980 W4 16 21S 4E SL	P	1873	OS	0.000	0.100	324 25TH STREET	USA FOREST SERVICE	38.9852846519	-111.472003228
63-3380	Point to Point	S660 E660 W4 15 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9816564862	-111.45800667
63-3381	Point to Point	S660 E660 N4 16 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9888284143	-111.467336766
63-3382	Point to Point	S660 E660 NW 15 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.98887452	-111.458018564
63-3383	Point to Point	N660 E660 SW 10 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9925000096	-111.458041942
63-3385	Point to Point	N660 W660 S4 30 21S 4E SL	P	1873	OS	0.000	0.200	324 25TH STREET	USA FOREST SERVICE	38.9493458122	-111.508707844
63-3386	Point to Point	S660 E1980 W4 32 21S 4E SL	P	1873	OS	0.000	0.200	324 25TH STREET	USA FOREST SERVICE	38.9385897439	-111.490397861
63-3387	Point to Point	S660 W660 N4 17 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9887911489	-111.490596212
63-3388	Point to Point	S660 E660 NW 28 21S 4E SL	P	1873	OS	0.015	0.000	324 25TH STREET	USA FOREST SERVICE	38.9601530295	-111.476532556
63-3389	Point to Point	N660 E660 W4 29 21S 4E SL	P	1873	OS	0.000	0.200	324 25TH STREET	USA FOREST SERVICE	38.9421955803	-111.495065463
63-3390	Point to Point	N660 E660 W4 32 21S 4E SL	P	1873	OS	0.000	0.100	324 25TH STREET	USA FOREST SERVICE	38.9421955803	-111.495065463
63-3391	Point to Point	N660 W660 S4 29 21S 4E SL	P	1873	OS	0.000	0.200	324 25TH STREET	USA FOREST SERVICE	38.9493387444	-111.490421853
63-3392	Point to Point	S660 E660 NW 28 21S 4E SL	P	1873	OS	0.000	0.200	324 25TH STREET	USA FOREST SERVICE	38.9601530295	-111.476532556

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63-3393	Point to Point	S660 E1980 W4 32 21S 4E SL	P	1873	OS	0 015 0 000	324 25TH STREET	USA FOREST SERVICE	38.9385897439 -111 490397861
63-3394	Point to Point	N660 E660 S4 09 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9924538981 -111 467360622
63-3395	Point to Point	S660 E660 N4 16 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9888284143 -111 467336766
63-3396	Point to Point	S660 W660 N4 16 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9888096426 -111 47198245
63-3397	Point to Point	N660 E660 S4 09 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9924538981 -111 467360622
63-3398	Point to Point	N660 W660 SE 09 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9924816059 -111 462687873
63-3399	Point to Point	S660 W660 NE 16 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9888561192 -111 462664257
63-3400	Point to Point	N660 E1980 W4 31 21S 4E SL	P	1873	OS	0.000 0.200	324 25TH STREET	USA FOREST SERVICE	38 9421016905 -111 508475016
63-3403	Point to Point	S660 W660 NE 07 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	39 0032767833 -111 499989214
63-3404	Point to Point	N660 E1980 W4 16 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9852846519 -111 472003228
63-3405	Point to Point	S660 W660 NE 17 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9887624221 -111 481300623
63-3406	Point to Point	S660 W660 NE 20 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9744797223 -111 4812385
63-3407	Point to Point	S660 E660 W4 16 21S 4E SL	P	1873	OS	0.000 0.200	324 25TH STREET	USA FOREST SERVICE	38 981640214 -111 47662435
63-3408	Point to Point	S660 E660 W4 16 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 981640214 -111 47662435
63-3409	Point to Point	N660 E1980 W4 16 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9852846519 -111 472003228
63-3410	Point to Point	S660 E660 NW 16 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9887815647 -111 476654949
63-3507	Point to Point	N660 E660 W4 07 21S 4E SL	P	1873	OS	0.000 0.100	324 25TH STREET	USA FOREST SERVICE	38 9997788355 -111 513087333
63-3510	Point to Point	N660 W660 S4 07 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9925183155 -111 508884401
63-3511	Point to Point	S660 W660 N4 18 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9888928597 -111 508858418
63-3513	Point to Point	N660 E660 W4 18 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9853717333 -111 513124498
63-3514	Point to Point	S1980 E660 N4 18 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9852876477 -111 504187136
63-3515	Point to Point	N660 E660 SW 08 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38 9924644836 -111 495271422

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63-3516	Point to Point	N660 W660 SE 07 21S 4E SL	P	1873	OS	0.015 0.000	324 36TH STREET	USA FOREST SERVICE	38.9924445978	-111.499917325
63-3517	Point to Point	N660 E660 SW 18 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.978131505	-111.513043333
63-3519	Point to Point	N660 E1980 W4 07 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9997992607	-111.508441081
63-3520	Point to Point	N660 W660 SE 07 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9924445978	-111.499917325
63-3521	Point to Point	S660 W660 N4 17 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9887911489	-111.490596212
63-3522	Point to Point	N660 E660 S4 17 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9781584172	-111.485802628
63-3523	Point to Point	N660 E660 W4 20 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9709871533	-111.495000477
63-3524	Point to Point	S660 E660 NW 17 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.988839018	-111.495246135
63-3525	Point to Point	S660 W1980 E4 17 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9816017543	-111.485914755
63-3526	Point to Point	S660 W660 E4 18 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9816827883	-111.499749204
94-1131	Point to Point	S2450 E100 NW 34 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9406958709	-111.459931768
94-1133	Point to Point	S2450 E800 NW 34 21S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9407055805	-111.457469818
94-1392	Point to Point	S200 E1100 NW 14 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9901800165	-111.437759808
94-1396	Point to Point	N1750 E2100 SW 10 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9955136518	-111.452992743
94-25	Point to Point	S2450 E800 NW 34 21S 4E SL	P	19410124	D	0.006 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9407055805	-111.457469818
94-476	Point to Point	S550 E2100 W4 02 21S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0099688278	-111.434240768
94-486	Point to Point	N100 W800 SE 05 21S 4E SL	P	1879	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0053556172	-111.481949961
94-496	Point to Point	S1700 E450 NW 05 21S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0128992631	-111.496089814
63-3393	Point to Point	N660 W660 SE 31 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.934971024	-111.499732461
63-3394	Point to Point	S660 W1980 E4 32 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9385596433	-111.485758942
63-3395	Point to Point	N660 E660 SW 15 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9780639421	-111.458018151
63-3396	Point to Point		P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9673016492	-111.453344984

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		S660 E1980 W4 22 21S 4E SL								
63-3404	Point to Point	S660 W660 N4 21 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9744502574 -111.471939015	
63-3405	Point to Point	N660 W660 E4 28 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9564813874 -111.462655712	
63-3520	Point to Point	S660 E660 W4 18 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9817462762 -111.513098306	
63-3532	Point to Point	S660 W1980 E4 19 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9673217639 -111.504263641	
63-3536	Point to Point	N660 E660 SW 28 21S 4E SL	P	1873	OS	0.015 0.000	324 25TH STREET	USA FOREST SERVICE	38.9493154386 -111.476516946	
94-1131	Point to Point	N1 W510 SE 33 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9328664803 -111.461968713	
94-1133	Point to Point	S2450 E100 NW 34 21S 4E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9406958709 -111.459931768	
94-1392	Point to Point	S2200 W1050 NE 13 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9847836717 -111.406093357	
94-1396	Point to Point	N1150 W2280 SE 24 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9650259162 -111.412778391	
94-110	Spring	N320 E150 SW 11 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9915955993 -111.441112238	
94-111	Spring	S200 E1080 NE 14 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9902300898 -111.419297048	
94-112	Spring	N2400 E2250 SW 23 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9685444236 -111.433926902	
94-113	Spring	S2250 W130 NE 23 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9700301833 -111.423678221	
94-1130	Spring	S1750 E800 NW 34 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9426282052 -111.457482179	
94-1132	Spring	S1900 E900 NW 34 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9422175971 -111.457127816	
94-114	Spring	S465 W1277 N4 26 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9606185566 -111.437024219	
94-115	Surface	S533 E1074 N4 25 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9604483701 -111.410220577	
94-117	Spring	N48 E2268 W4 26 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9548349449 -111.433831887	
94-118	Spring	S1570 W43 N4 26 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9575997925 -111.432664447	
94-120	Surface	S157 W589 E4 35 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9396506242 -111.425359967	

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94-121	Spring	S798 E1099 N4 34 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9452470216	-111.447192255
94-122	Spring	N1060 W961 S4 35 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9357630228	-111.435944851
94-123	Surface	N782 W1124 SE 35 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9349549803	-111.427288267
94-124	Spring	N346 E1078 S4 36 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9337780947	-111.410289363
94-126	Spring	S332 W1891 E4 27 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9537357226	-111.448455752
94-1386	Surface	S3400 W400 NE 13 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9814957126	-111.4037871
94-1387	Spring	S1250 W1050 NE 26 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9584548001	-111.426949754
94-1388	Spring	S850 W1150 NE 26 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9595521524	-111.42730815
94-1389	Spring	S2400 E1600 NW 35 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9408527409	-111.43614804
94-1390	Spring	N80 W1490 SE 23 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9621020973	-111.428519666
94-1391	Spring	N1200 E1700 SW 32 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9364895357	-111.49144313
94-1393	Spring	S1900 E2400 NW 14 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9855279511	-111.433155939
94-1394	Surface	S1750 W50 NE 24 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9713802328	-111.404933961
94-1395	Spring	S1300 W1500 NE 34 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9438326109	-111.447069988
94-1397	Spring	S2150 W100 NE 14 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9848591559	-111.423448205
94-1399	Spring	S600 W2100 NE 35 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9456821371	-111.430635986
94-1400	Spring	N1850 E2100 SW 10 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9957883101	-111.452994495
94-1401	Surface	S200 W2300 NE 35 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9467781762	-111.431346111
94-1403	Surface	N2350 W2350 SE 15 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9826194105	-111.450143626
94-1404	Surface		P	1879	OS	0.000 0.000			38.9903026703	-111.451023716

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		S150 E2650 NW 15 21S 4E SL						324 - 25TH STREET	USA FOREST SERVICE	
94-1405	Surface	N200 W2300 SE 10 21S 4E SL	P	1879	OS	0.015 0.000		324 - 25TH STREET	USA FOREST SERVICE	38.9912329554 -111.449733187
94-1406	Surface	N1050 W1900 SE 10 21S 4E SL	P	1879	OS	0.000 0.000		324 - 25TH STREET	USA FOREST SERVICE	38.9935729941 -111.448340087
63-3527	Point to Point	N660 W660 E4 18 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9853082555 -111.499774715
63-3528	Point to Point	S660 W1980 E4 18 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9816627233 -111.504394302
63-3529	Point to Point	S660 W1980 E4 18 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9816627233 -111.504394302
63-3531	Point to Point	N660 E1980 W4 17 21S 4E SL	P	1873	OS	0.000 0.200		324 25TH STREET	USA FOREST SERVICE	38.9853478227 -111.490483841
63-3532	Point to Point	S660 E660 NW 17 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.988839018 -111.495246135
63-3533	Point to Point	S660 E660 W4 21 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9673259465 -111.476563153
63-3534	Point to Point	S660 E660 NW 28 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9601530295 -111.476532556
63-3535	Point to Point	N660 E660 W4 28 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9565469866 -111.476536896
63-3536	Point to Point	S660 E660 W4 21 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9673259465 -111.476563153
63-3537	Point to Point	N660 W660 E4 20 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9709323079 -111.481231966
63-3538	Point to Point	N660 E660 W4 21 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9709514379 -111.476587463
63-3539	Point to Point	S660 W660 NE 17 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9887624221 -111.481300623
63-3540	Point to Point	S660 E660 N4 17 21S 4E SL	P	1873	OS	0.015 0.000		324 25TH STREET	USA FOREST SERVICE	38.9888106616 -111.485950542
63-2771	Surface	S1150 E1790 NW 20 21S 4E SL	P	1873	OS	0.006 0.000		115 EAST 900 NORTH	USA FOREST SERVICE	38.9732373301 -111.490976444
t41643	Surface	N840 W1140 SE 15 21S 4E SL	A	20160504	O	0.000 6.000		225 NORTH 5TH STREET SUITE 900	CANYON FUEL COMPANY, L.L.C	38.9784884687 -111.443854421
t41643	Surface	N1480 W1050 SW 24 21S 4E SL	A	20160504	O	0.000 6.000		225 NORTH 5TH STREET SUITE 900	CANYON FUEL COMPANY, L.L.C	38.9659530479 -111.426994766
t41643	Surface	N1280 W950 SE 11 21S 4E SL	A	20160504	O	0.000 6.000		225 NORTH 5TH STREET SUITE 900	CANYON FUEL COMPANY, L.L.C	38.9942690478 -111.426466131

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t41643	Surface	S2170 W1320 NE 13 21S 4E SL	A	20160504	O	0.000 6.000	225 NORTH 5TH STREET SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.9848627444	-111.407044036
94-1407	Surface	N1100 E1950 SW 10 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9937263133	-111.453509313
94-1408	Surface	N550 E2250 SW 10 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9922198078	-111.452443778
94-1409	Surface	N100 E1950 SW 10 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9909797289	-111.453491777
94-1410	Spring	N1700 W1700 SE 23 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9665488777	-111.429285335
94-1411	Spring	S1600 E2300 NW 23 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9718325697	-111.433713313
94-1412	Spring	N1850 E900 SW 14 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9812898492	-111.438697871
94-1413	Spring	N2050 E350 SW 14 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9818318459	-111.440636781
94-1414	Spring	S2000 W2000 NE 15 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9851945421	-111.448639151
94-1415	Spring	S1200 W2000 NE 15 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9873918137	-111.448653026
94-218	Spring	N1013 W838 S4 10 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9934675642	-111.45396111
94-477	Spring	S1100 W1950 NE 12 21S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0020810762	-111.409338352
94-480	Spring	S150 W1900 NE 12 21S 4E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0046909311	-111.409177375
94-834	Surface	S2480 W20 NE 33 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.940611803	-111.460353284
94-835	Surface	N667 W212 SE 33 21S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9346998807	-111.460932593
94-836	Surface	S2540 E820 NW 34 21S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9404586625	-111.457397888
a36193	Spring	S2000 W2000 NE 15 21S 4E SL	A	20100114	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9851945421	-111.448639151

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Search of TOWNSHIP = '21S' and RANGE = '5E' and BEM = 'SL'

WR Number	Diversion Type	Well Log	Location	Status	Priority	Uses	CFS	ACFT	Address	Owner Name	Latitude	Longitude
94-440	Point to Point		N1 E2220 SW 11 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9970521304	-111.327429583
94-441	Point to Point		S850 W2580 NE 15 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9946658398	-111.344313899
94-442	Point to Point		S1850 E1350 NW 15 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9919682456	-111.349002645
94-443	Point to Point		S1900 E1 NW 15 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9918165408	-111.353749988
94-462	Point to Point		S1000 E880 NW 04 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0150516039	-111.369378278
94-463	Point to Point		N1 W300 SE 05 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0114844695	-111.373409832
94-474	Point to Point		S2800 E1450 NW 08 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0036865642	-111.385791178
94-475	Point to Point		S2600 W1000 NE 07 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	39.004206904	-111.394418798
94-116	Surface		S465 E1379 W4 30 21S 5E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9594230649	-111.399890659
94-119	Surface		S1233 E475 W4 31 21S 5E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9429204494	-111.403058346
94-1593	Spring		N1197 W1041 E4 31 21S 5E SL	P	1879	OS	0.015	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9495609418	-111.394568082
94-428	Spring		N500 W2050 SE 23 21S 5E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.969407036	-111.328844619
94-429	Spring		N180 E680 SW 23 21S 5E SL	P	1879	S	0.011	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9685567757	-111.332820989
94-430	Surface		S2000 W1600 NE 27 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.962545815	-111.340814521
94-431	Surface		S110 W950 NE 21 21S 5E SL	P	1879	S	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9822414698	-111.357118096

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94-432	Surface	N1000 W1800 SE 15 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9852560005 -111.341557875
94-433	Surface	N1850 W700 SE 15 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9876019689 -111.337697685
94-434	Surface	N500 W2200 SE 16 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9839032993 -111.361525585
94-435	Surface	S1200 W2050 NE 16 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9937169545 -111.360978564
94-436	Surface	N187 W1910 SE 09 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9975280552 -111.360505114
94-437	Surface	S350 W490 NE 11 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0105040514 -111.318429466
94-438	Surface	S1150 W2100 NE 11 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0082910968 -111.324087605
94-439	Surface	S4100 E2150 NW 10 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0002499739 -111.346141609
94-444	Surface	S1650 E620 NW 10 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0069628875 -111.351560624
94-445	Spring	S650 W720 NE 09 21S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0096950729 -111.356291748
94-455	Surface	S1500 E1700 NW 05 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0135522569 -111.384961684
94-456	Spring	S2100 E220 NW 08 21S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0055946941 -111.390131625
94-458	Spring	S3350 E550 NW 09 21S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0022903045 -111.370369308
94-459	Spring	N450 E2950 SW 08 21S 5E SL	P	1879	S	0.011 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9982138961 -111.380576004
94-583	Surface	N1600 E1200 SW 27 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.957998638 -111.34954813
94-584	Surface	N1650 W1900 SE 28 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9581026372 -111.360454546
94-585	Surface	S650 E250 NW 28 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9662500158 -111.371446826

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94-586	Surface	N500 E400 SW 21 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9694103291	-111.370935534
94-587	Surface	N1000 E1650 SW 20 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9707103989	-111.385141624
94-588	Surface	S700 E3000 NW 20 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9805560174	-111.380397906
94-589	Surface	N600 W2000 SE 21 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9696718112	-111.360818474
94-940	Point to Point	S660 W660 N4 35 21S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9517361541	-111.328240767
94-440	Point to Point	S900 W1880 NE 03 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0153291211	-111.341976794
94-441	Point to Point	S1150 E1000 NW 15 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9938871746	-111.350243996
94-443	Point to Point	S1100 E900 NW 15 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9940234433	-111.350596649
94-460	Point to Point	S500 W1 NE 01 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0164702066	-111.298104569
94-474	Point to Point	N800 E500 SW 05 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0135630357	-111.389189577
94-475	Point to Point	N300 W350 SE 06 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0121796876	-111.392174608
94-940	Point to Point	S660 W660 E4 35 21S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9445708596	-111.318964123
a25549	Point to Point	N660 E660 W4 15 21S 5E SL	A	20061103	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	38.991614313	-111.351463971
a25549	Surface	S3520 E135 NW 10 21S 5E SL	A	20061103	S	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	39.0018216144	-111.353242486
t41643	Surface	N2260 E1170 SW 01 21S 5E SL	A	20160504	O	0.000 6.000	225 NORTH 5TH STREET SUITE 900	CANYON FUEL COMPANY, L.L.C.	39.0176884999	-111.312616813
t41775	Surface	N785 E1804 W4 11 21S 5E SL	A	20160615	X	0.000 15.870	225 NORTH 5TH STREET SUITE 900	CANYON FUEL COMPANY, L.L.C.	39.0064147276	-111.328937564
94-590	Surface	S1650 E700 NW 21 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9780078034	-111.369843837
94-591	Spring		P	1879	S	0.011 0.000			38.9729908375	-111.31911057

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		N1800 W700 SE 23 21S 5E SL					324 - 25TH STREET	USA FOREST SERVICE	
94-592	Surface	S400 E150 NW 09 21S 5E SL	P	1879	S	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	39.0103881793 -111.371819784
n38625	Spring	S615 W2075 SE 03 21S 5E SL	A	20121214	S	0.050 2.810	324 - 25TH STREET	USA FOREST SERVICE	39.0097433671 -111.342609739

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Search of TOWNSHIP = '22S' and RANGE = '4E' and BEM = 'SL'

WR Number	Diversion Type	Well Log	Location	Status	Priority	Uses	CFS	ACFT	Address	Owner Name	Latitude	Longitude
94-1199	Point to Point		N660 E660 S4 33 22S 4E SL	P	1879	S	0.011	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8484233408	-111.466445018
94-1200	Point to Point		S660 E660 W4 33 22S 4E SL	P	1879	S	0.011	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8518018748	-111.475917422
94-1201	Point to Point		N660 W660 E4 33 22S 4E SL	P	1879	S	0.011	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8559074499	-111.46191643
94-1202	Point to Point		S660 W660 NE 33 22S 4E SL	P	1879	S	0.000	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8595084397	-111.462066524
94-1203	Point to Point		S660 W660 NE 33 22S 4E SL	P	1879	S	0.000	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8595084397	-111.462066524
94-1204	Point to Point		S660 W1980 E4 28 22S 4E SL	P	1879	S	0.000	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8666896191	-111.466837295
94-1205	Point to Point		N660 W660 E4 28 22S 4E SL	P	1879	S	0.000	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8703336836	-111.462223094
94-1206	Point to Point		S660 W660 NE 28 22S 4E SL	P	1879	S	0.011	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.87390779	-111.462332718
94-1207	Point to Point		N660 E1980 W4 21 22S 4E SL	P	1879	S	0.000	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8844837729	-111.471825159
94-1208	Point to Point		N660 E1980 W4 21 22S 4E SL	P	1879	S	0.011	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8844837729	-111.471825159
94-1209	Point to Point		N660 E660 S4 16 22S 4E SL	P	1879	S	0.011	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8916980916	-111.467200859
94-1219	Point to Point		S660 E660 N4 20 22S 4E SL	P	1879	S	0.011	0.000	466 SOUTH MAIN	WINTCH & COMPANY LIMITED	38.8879559933	-111.485746454
94-135	Point to Point		N400 E2600 SW 11 22S 4E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9060219087	-111.432811484
94-136				P	1879	OS	0.000	0.000	324 - 25TH STREET		38.9030672862	-111.444253406

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	Point to Point	S660 W660 NE 15 22S 4E SL							USA FOREST SERVICE		
94-1576	Point to Point	S660 W1980 E4 22 22S 4E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8813229792	-111.448843168
94-1578	Point to Point	S660 W660 NE 15 22S 4E SL	P	1879	OS	0.015	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9030672862	-111.444253406
94-1579	Point to Point	S660 W660 N4 27 22S 4E SL	P	1879	OS	0.015	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8740786556	-111.453255204
94-1580	Point to Point	S660 E1980 W4 13 22S 4E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8958979978	-111.416408772
94-1581	Point to Point	S660 E660 NW 34 22S 4E SL	P	1879	OS	0.015	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8595267469	-111.457429299
94-1582	Point to Point	S660 E660 N4 34 22S 4E SL	P	1879	OS	0.015	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8595389416	-111.448502451
94-1586	Point to Point	N1072 W103 SE 24 22S 4E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.878859876	-111.405228403
94-1594	Point to Point	S619 W586 E4 01 22S 4E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9244079637	-111.406880395
94-296	Point to Point	N1320 W660 S4 09 22S 4E SL	P	1900	S	0.015	0.000	C/O ACORD LAKES MTN RETREAT,255 W 800 S, SLC 84101	HANSEN LAND AND LIVESTOCK COMPANY	38.9080003755	-111.4719079
94-297	Point to Point	N660 E660 W4 16 22S 4E SL	P	1900	S	0.011	0.000	C/O: JOHN BUSHNELL, 2028 E 7000 S, SLC 84121	ACORD LAKES MOUNTAIN RETREAT	38.8989012645	-111.476462498
94-1594	Point to Point	N522 E423 S4 12 22S 4E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9063627337	-111.412635984
94-1595	Point to Point	S266 E17 NE 33 22S 4E SL	P	1879	OS	0.000	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8606000283	-111.459695157
94-101	Rediversion	S350 E300 N4 16 22S 4E SL	P	19730126	DS	0.015	0.000	ATTN: JOHN BUSHNELL	ACORD LAKES MOUNTAIN RETREAT	38.9034271584	-111.468502908
94-101	Surface	S1500 E450 N4 16 22S 4E SL	P	19730126	DS	0.015	0.000	ATTN: JOHN BUSHNELL	ACORD LAKES MOUNTAIN RETREAT	38.900270666	-111.46795488
94-125	Spring	N1550 W450 SE 01	P	1879	OS	0.015	0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9236760758	-111.406438371

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		22S 4E SL								
94-127	Surface	S908 W35 N4 02 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9303698361	-111.432655407
94-128	Surface	S1498 E859 N4 03 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9287899407	-111.448100135
94-129	Surface	S961 E1316 W4 03 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9235031164	-111.455885182
94-130	Surface	N1189 W708 S4 03 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9226491805	-111.453767763
94-134	Surface	S2530 E400 NW 10 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9124269019	-111.459086628
94-137	Surface	S1742 W175 N4 14 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.900114351	-111.433240607
94-138	Spring	S890 W563 E4 15 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.895196179	-111.443897993
94-139	Surface	N125 E852 SW 15 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8907457118	-111.457254889
94-140	Surface	N344 W826 S4 22 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8768340081	-111.453856039
94-1402	Spring	N800 W1490 SE 11 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9070910643	-111.428615436
94-141	Surface	N1735 E858 S4 22 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8806775068	-111.447962611
94-142	Spring	S698 E929 W4 26 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8667310411	-111.438611294
94-143	Spring	S380 E90 NW 34 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8612879246	-111.459136689
94-144	Spring	S484 W1000 NE 27 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8745744707	-111.453745388
94-145	Surface	N430 E317 SW 25 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8625722767	-111.422299146
94-146	Spring		P	1879	OS	0.015 0.000	324 - 25TH STREET		38.8622137191	-111.422708083

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		N300 E200 SW 25 22S 4E SL						USA FOREST SERVICE			
94-147	Surface	N1266 W1237 S4 35 22S 4E SL	P	1879	OS	0.000 0.000	324 25TH STREET	USA FOREST SERVICE	38.850337307	-111.436980076	
94-155	Spring	S1750 W2150 NE 27 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8710816893	-111.449393351	
94-1583	Spring	N962 E785 SW 27 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8639835329	-111.457018699	
94-1584	Spring	N1245 E870 SW 27 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8647620012	-111.456725046	
94-1585	Surface	S73 E113 NW 34 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8611314668	-111.459361321	
94-1587	Surface	S236 E536 N4 34 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8607018407	-111.448945393	
94-1588	Spring	S2038 W429 N4 35 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8557678904	-111.434128738	
94-1589	Spring	S671 E504 NW 26 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8740809425	-111.440086462	
94-1590	Spring	N1275 E972 SW 27 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8648458056	-111.456367211	
94-1591	Surface	S1193 W1078 E4 34 22S 4E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8508226117	-111.445644229	
94-1596	Spring	S1226 W753 N4 24 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.887083352	-111.416755317	
94-1597	Spring	N215 W2230 E4 23 22S 4E SL	P	1879	OSPX	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.883738903	-111.431219806	
94-1599	Surface	N2580 W125 SE 16 22S 4E SL	P	1900	DIS	0.015 0.000	C/O JOHN BUSHNELL	ACORD LAKES MOUNTAIN RETREAT	38.8970156172	-111.460717388	
94-1599	Surface		P	1900	DIS	0.015 0.000			38.8965228238	-111.460309981	

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		N2400 W10 SE 16 22S 4E SL					C/O JOHN BUSHNELL	ACORD LAKES MOUNTAIN RETREAT		
94-1600	Surface	N570 E250 S4 09 22S 4E SL	P	1879	S	0.015 0.000	C/O ACORD LAKES MOUNTAIN RETREAT	HANSEN LAND AND LIVESTOCK COMPANY	38.9059533403	-111.468695292
94-1881	Underground	N1557 E857 S4 08 22S 4E SL	A	20060824	DIS	0.000 2.000	976 N 2500 W	DANIEL J. & TAMMY L. DWYER	38.9085481587	-111.484952079
94-1885	Underground 431950	N129 W470 E4 16 22S 4E SL	P	20080701	D	0.000 0.250	1383 FARMERS FREEWAY	LANE R. AND LOREEN SORENSEN	38.8975282797	-111.461956449
94-1890	Surface	S200 W100 E4 16 22S 4E SL	P	20090317	D	0.015 0.250	244 NORTH 200 EAST	MELVIN J. RIDER	38.8966297961	-111.460650084
94-1893	Underground	N660 E1320 SW 08 22S 4E SL	A	20100208	DIS	0.000 1.730	PO BOX 38	LEON P. AND VIRGINIA A. CHRISTENSEN FAMILY TRUST	38.9060121831	-111.492487904
94-1903	Spring	N1140 E1491 SW 12 22S 4E SL	A	20140522	X	0.041 29.970	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY LC	38.9080630598	-111.41814144
94-1903	Spring	N1205 E1673 SW 12 22S 4E SL	A	20140522	X	0.041 29.970	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY LC	38.9082438895	-111.417502677
94-264	Spring	N1105 W1275 S4 35 22S 4E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8498945921	-111.437110844
94-298	Surface	N2100 W930 SE 16 22S 4E SL	P	1900	DS	0.067 0.000	C/O JOHN BUSHNELL, 2028 E 7000 S. SLC. 84121	ACORD LAKES MOUNTAIN RETREAT	38.8956860023	-111.46353831
94-298	Rediversion	S750 W200 NE 16 22S 4E SL	P	1900	DS	0.067 0.000	C/O JOHN BUSHNELL, 2028 E 7000 S. SLC, 84121	ACORD LAKES MOUNTAIN RETREAT	38.9023672097	-111.461061765
94-299	Rediversion	S350 E300 N4 16 22S 4E SL	P	1900	DS	0.007 0.000	C/O JOHN BUSHNELL., 2028 EAST 7000 S. SLC 84121	ACORD LAKES MOUNTAIN RETREAT	38.9034271584	-111.468502908
94-299	Surface	S1500 E450 N4 16 22S 4E SL	P	1900	DS	0.007 0.000	C/O JOHN BUSHNELL., 2028 EAST 7000 S, SLC 84121	ACORD LAKES MOUNTAIN RETREAT	38.900270666	-111.46795488
94-302	Surface	S1500 W100 NE 04 22S 4E SL	P	1899	S	0.015 0.000	C/O JOHN BUSHNELL	ACORD LAKES MOUNTAIN RETREAT	38.9292618006	-111.460849637
63-2478	Underground	N1737 E1166 S4 06 22S 4E SL	P	1900	D	0.040 7.310	365 COBBLE LANE	CAMP ESTATE	38.9234464127	-111.502165519
94-87	Surface	N1140 E1491	P	19710614	X	0.070 0.000	ATTN PROPERTY ADMINISTRATION	CANYON FUEL	38.9080630598	-111.41814144

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		SW 12 22S 4E SL					COMPANY LLC	
94-87	Surface	N1205 E1673 SW 12 22S 4E SL	P	19710614 X	0.070 0.000	ATTN: PROPERTY ADMINISTRATION	CANYON FUEL COMPANY LLC	38.9082438895 -111.417502677
94-99	Underground	S2130 W1200 NE 05 22S 4E SL	P	19730126 D	0.023 0.000	A UTAH LIMITED PARTNERSHIP	ACORD LAKES MOUNTAIN RETREAT	38.9274491017 -111.483349627
a12263	Surface	S2300 0 N4 07 22S 4E SL	A	19820429 D	0.040 0.000	BOX 213	HOWARD NIELSEN	38.9123406432 -111.50618646
a12263	Surface	N2180 E175 S4 19 22S 4E SL	A	19820429 D	0.040 0.000	BOX 213	HOWARD NIELSEN	38.881139347 -111.505909197
a12263	Surface	N1810 E380 S4 06 22S 4E SL	A	19820429 D	0.040 0.000	BOX 213	HOWARD NIELSEN	38.9236349494 -111.504930606
a12263	Surface	S800 E1200 NW 05 22S 4E SL	A	19820429 D	0.040 0.000	BOX 213	HOWARD NIELSEN	38.9309804353 -111.493036506
E2118	Underground	S1820 W240 N4 18 22S 4E SL	A	19820810 O	0.000 7.250	P.O. BOX 213	HOWARD W. NIELSEN	38.8990300866 -111.50697024
E2119	Underground	S1820 W240 N4 18 22S 4E SL	A	19820810 O	0.460 72.500	37 NORTH 100 EAST	MARLIN JR SORENSON	38.8990300866 -111.50697024

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Utah Division of Water Rights

Search of TOWNSHIP = '22S' and RANGE = '5E' and BEM = 'SL'

WR Number	Diversion Type	Well Log	Location	Status	Priority	Uses	CFS	ACFT	Address	Owner Name	Latitude	Longitude
94-1030	Point to Point		S660 E1980 W4 09 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9156183592	-111.365884731
94-1031	Point to Point		N660 E660 W4 20 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8902358103	-111.389518177
94-1032	Point to Point		N660 W660 SE 17 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8974824918	-111.375382745
94-1033	Point to Point		S660 E1980 W4 17 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9011170238	-111.384603082
94-1034	Point to Point		S1980 E660 N4 20 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8902296236	-111.38002232
94-1035	Point to Point		S1980 E660 N4 21 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8901671993	-111.361439704
94-1036	Point to Point		S660 E660 W4 21 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8866258903	-111.370916944
94-1060	Point to Point		S660 E660 W4 15 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.900976425	-111.352181718
94-1077	Point to Point		N660 E660 W4 33 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8607748779	-111.370880824
94-1078	Point to Point		S660 W660 E4 33 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8570259822	-111.356970867
94-1079	Point to Point		S1980 E660 N4 33 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8610142103	-111.361632198
94-1081	Point to Point		S660 W660 N4 33 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8646253283	-111.366288166
94-1082	Point to Point		S660 W660 N4 33 22S 5E SL	P	1879	S	0.000	0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8646253283	-111.366288166
94-1083	Point to Point		S660 E660 W4	P	1879	S	0.000	0.000	125 SOUTH	PRICE FIELD OFFICE USA	38.8716437484	-111.333880369

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		26 22S 5E SL					600 WEST	BUREAU OF LAND MANAGEMENT		
94-1084	Point to Point	S660 W1980 E4 26 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8713459578	-111.324473938
94-1085	Point to Point	N660 W660 SE 28 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8681536	-111.35703817
94-1086	Point to Point	S660 W660 NE 28 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8791981191	-111.35724327
94-1087	Point to Point	N660 E660 W4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9046020299	-111.352199615
94-1088	Point to Point	S660 W660 E4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9008601011	-111.33824764
94-1090	Point to Point	N660 E660 S4 21 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8829221149	-111.361875571
94-1102	Point to Point	N660 W660 SE 12 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9115951304	-111.30082822
94-1116	Point to Point	S660 W660 N4 23 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8934522243	-111.328964374
94-1117	Point to Point	S660 W660 N4 24 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8933680942	-111.310305543
94-1185	Point to Point	N660 E660 S4 15 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8972447409	-111.342949243
94-1186	Point to Point	N660 W660 SE 15 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8971366251	-111.338328364
94-1187	Point to Point	S660 E660 N4 23 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8934652619	-111.324324859
94-1188	Point to Point	S660 E660 N4 23 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8934652619	-111.324324859
94-1189	Point to Point	N660 E1980 W4 24 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET,	CANYON FUEL COMPANY, L.L.C.	38.8897119004	-111.310604779

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							SUITE 900		
94-1218	Point to Point	N660 W660 SE 15 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C	38.8971366251 -111.338328364
94-1289	Point to Point	S660 W660 N4 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN	38.9082961379 -111.366004855
94-1290	Point to Point	N660 E660 SW 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN	38.8974973754 -111.370742988
94-1291	Point to Point	N660 E660 SW 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN	38.8974973754 -111.370742988
94-1292	Point to Point	N660 W660 S4 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN	38.8974038956 -111.366116189
94-1595	Point to Point	N243 W72 E4 19 22S 5E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.8890818066 -111.392084574
94-1030	Point to Point	N660 W660 S4 09 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9119217311 -111.366023464
94-1031	Point to Point	S660 E660 N4 20 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8938552207 -111.380041632
94-1032	Point to Point	N660 W660 SE 17 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8974824918 -111.375382745
94-1033	Point to Point	S660 W1980 E4 17 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9010963678 -111.379926738
94-1034	Point to Point	N660 E1980 W4 20 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8902542521 -111.384878902
94-1035	Point to Point	S660 W660 N4 21 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8937782933 -111.366097586
94-1036	Point to Point	S660 E660 NW 21 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8938717756 -111.370724149
94-1060	Point to Point	N660 W660 S4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8972309618 -111.347588997
94-1081	Point to Point	S1980 E660 N4	P	1879	S	0.000 0.000	125 SOUTH	PRICE FIELD OFFICE USA	38.8898396363 -111.324308392

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		23 22S 5E SL					600 WEST	BUREAU OF LAND MANAGEMENT		
94-1082	Point to Point	S660 W660 NE 33 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8645279746	-111.357020049
94-1083	Point to Point	S660 W660 E4 35 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8567739709	-111.319678586
94-1084	Point to Point	N660 E1980 W4 25 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8750095984	-111.310575462
94-1085	Point to Point	S660 W660 NE 22 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8935110086	-111.33831118
94-1086	Point to Point	N660 E1980 W4 22 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8901022739	-111.347776982
94-1087	Point to Point	N660 W660 S4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8972309618	-111.347588997
94-1088	Point to Point	S660 W660 E4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9008601011	-111.33824764
94-1090	Point to Point	S1980 E660 N4 21 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8901671993	-111.361439704
94-1102	Point to Point	N660 W660 SE 12 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9115951304	-111.30082822
94-1116	Point to Point	S660 W660 N4 23 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8934522243	-111.328964374
94-1117	Point to Point	S660 W660 N4 24 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8933680942	-111.310305543
94-730	Point to Point	N660 W660 SE 21 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8828237350	-111.357263111
94-733	Point to Point	S660 W660 E4 28 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8718630517	-111.357131645
94-934	Point to Point	S660 W660 NE 01 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9372758861	-111.300451181
94-935	Point to Point	S660 W660 N4 01 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9373551837	-111.309711872
94-936	Point to Point	S660 W660 NE	P	1879	S	0.000 0.000	125 SOUTH	PRICE FIELD OFFICE USA	38.9372758861	-111.300451181

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		01 22S 5E SL					600 WEST	BUREAU OF LAND MANAGEMENT	
94-937	Point to Point	N660 E1980 W4 12 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9191490874 -111.310231235
94-938	Point to Point	S660 W660 NE 14 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9081086717 -111.319568126
94-939	Point to Point	S660 W660 N4 13 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9080394651 -111.310190529
94-941	Point to Point	S660 E660 NW 01 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9374464057 -111.31433018
94-942	Point to Point	S660 E660 W4 01 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9301735169 -111.314557722
94-943	Point to Point	S660 W660 N4 11 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9228753632 -111.32878244
94-944	Point to Point	N660 W660 E4 10 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.919161214 -111.338178337
94-945	Point to Point	S660 W1980 E4 10 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9155220143 -111.3428021
94-946	Point to Point	N660 E660 SW 10 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9118653397 -111.35218934
94-947	Point to Point	N660 W660 E4 09 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9191552834 -111.356739703
94-948	Point to Point	S660 E660 N4 03 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9374353014 -111.3421733
94-949	Point to Point	S660 W660 N4 04 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9374007012 -111.36537529
94-934	Point to Point	S660 W660 NE 01 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9372758861 -111.300451181
94-1185	Point to Point	N660 W660 S4 14 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L L C	38.8970778454 -111.328981084
94-1186	Point to Point	N660 W660 SE 15 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L L C	38.8971366251 -111.338328364

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94-1187	Point to Point	S660 E660 NW 24 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.893405358	-111.314978062
94-1188	Point to Point	S660 E660 N4 23 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8934652619	-111.324324859
94-1189	Point to Point	S660 W660 E4 24 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8860380609	-111.301083635
94-1218	Point to Point	N660 W660 SE 15 22S 5E SL	P	1879	S	0.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8971366251	-111.338328364
94-1289	Point to Point	N660 W660 SE 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN.	38.8973245638	-111.356849649
94-1290	Point to Point	S660 W660 E4 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN.	38.9009622773	-111.356821711
94-1291	Point to Point	N660 E660 SW 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN.	38.8974973754	-111.370742988
94-1292	Point to Point	N660 W660 S4 16 22S 5E SL	P	1879	S	0.000 0.000	675 EAST 500 SOUTH, 5TH FLOOR	UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMIN.	38.8974038956	-111.366116189
94-135	Point to Point	N2050 W1 SE 18 22S 5E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9012735634	-111.391723257
94-1178	Surface	S1050 W85 E4 24 22S 5E SL	P	1883	IS	1.750 0.000	P.O. BOX 421	SHAYNA HOUSEKEEPER	38.8849720669	-111.299058357
94-1179	Surface	S1050 W85 E4 24 22S 5E SL	P	1884	IS	5.250 0.000	P.O. BOX 421	SHAYNA HOUSEKEEPER	38.8849720669	-111.299058357
94-1183	Surface	N550 W1150 S4 15 22S 5E SL	P	1882	IS	3.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8969236657	-111.34930985
94-1184	Surface	N550 W1150 S4 15 22S 5E SL	P	1883	IS	1.000 0.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY, L.L.C.	38.8969236657	-111.34930985

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94-1190	Surface	S1050 W85 E4 24 22S 5E SL	P	1883	IS	1.750 0.000	P O BOX 533	WILLIAM B. STANSFIELD, JR., VICKIE STANSFIELD AND SHAYNA STANSFIELD	38.8849720669	-111.299058357
94-1191	Surface	S1050 W85 E4 24 22S 5E SL	P	1884	IS	5.250 0.000	P. O. BOX 533	WILLIAM B. STANSFIELD, JR., VICKIE STANSFIELD AND SHAYNA STANSFIELD	38.8849720669	-111.299058357
94-131	Surface	N2782 W1568 NW 08 22S 5E SL	P	1879	OS	0.000 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9322381927	-111.396988853
94-132	Spring	S500 E1850 NW 07 22S 5E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9232460074	-111.398325354
94-133	Spring	S1700 E1730 NW 07 22S 5E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.9199485901	-111.398728858
94-1398	Spring	N2150 W350 SE 07 22S 5E SL	P	1879	OS	0.015 0.000	324 - 25TH STREET	USA FOREST SERVICE	38.916071395	-111.392720184
94-1901	Underground	N400 W530 S4 36 22S 5E SL	A	20130220	O	0.000 4.730	C/O ARK LAND	CANYON FUEL COMPANY, LLC	38.85243468	-111.310058927
94-1904	Underground	N400 W530 S4 36 22S 5E SL	A	20140522	O	0.000 170.000	225 NORTH 5TH STREET, SUITE 900	CANYON FUEL COMPANY LLC	38.85243468	-111.310058927
94-935	Point to Point	S660 W660 NE 12 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9226142426	-111.300632401
94-936	Point to Point	S660 W660 NE 12 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9226142426	-111.300632401
94-937	Point to Point	S660 W660 E4 12 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9152918786	-111.300722679
94-938	Point to Point	N660 E660 S4 13 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.8970060225	-111.30568154
94-939	Point to Point	N660 W660 E4 13 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9042817639	-111.30991851
94-941	Point to Point	S660 W660 N4 01 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9373551837	-111.309711872
94-942	Point to Point	N660 E660 S4	P	1879	S	0.000 0.000	125 SOUTH	PRICE FIELD OFFICE USA	38.9263893845	-111.305403595

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		01 22S 5E SL					600 WEST	BUREAU OF LAND MANAGEMENT		
94-943	Point to Point	S660 W660 NE 14 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9081086717	-111.319568126
94-944	Point to Point	S660 W660 E4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9008601011	-111.33824764
94-945	Point to Point	N660 W660 E4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.904485713	-111.338264824
94-946	Point to Point	N660 E660 W4 15 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9046020299	-111.352199615
94-947	Point to Point	N660 E1980 W4 09 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9192439478	-111.365903338
94-948	Point to Point	S660 E1980 W4 04 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9301231955	-111.365612892
94-949	Point to Point	S660 E1980 W4 09 22S 5E SL	P	1879	S	0.000 0.000	125 SOUTH 600 WEST	PRICE FIELD OFFICE USA BUREAU OF LAND MANAGEMENT	38.9156183592	-111.365884731

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APPENDIX 7-17

Investigation of Surface and Groundwater Systems in the Vicinity of the SUFCO Mine, Sevier County, Utah: Probable Hydrologic Consequences of Coal Mining at the SUFCO Mine and Recommendations for Surface and Groundwater Monitoring

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Greens Hollow Lease Appendix 7-17

Active and Inactive Groundwater Flow Systems - Report

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Active and inactive groundwater flow systems: Evidence from a stratified, mountainous terrain

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ABSTRACT

We present a new conceptual model of groundwater flow that describes active and inactive groundwater flow regimes. The model is based on an analysis of interactions between surface water and shallow and deep groundwater in the 240-km-long Wasatch Range and Book Cliffs, Utah, USA. Active zone groundwater flow paths are continuous, responsive to annual recharge and climatic variability, and have groundwater resident times "ages" that become progressively older from recharge to discharge area. Active zone groundwater systems discharge at thousands of springs that issue from the 700+-m-thick, gently dipping, clastic bedrock formations. Springs waters contain appreciable ^{3}H and anthropogenic ^{14}C.

In contrast, inactive zone groundwater has extremely limited or no communication with annual recharge and has groundwater mean residence times that do not progressively lengthen along the flow path. Groundwater in the inactive zone may be partitioned, occur as discrete bodies, and may occur in hydraulically isolated regions that do not have hydraulic communication with each other. Inactive zone groundwater is encountered in-mines (coal-mines 300–700 m below ground surface) where groundwater discharge rates decline rapidly and the waters have $\delta^{2}H$ and $\delta^{18}O$ compositions that are distinguishable from near surface groundwater. In general, deep waters have no ^{3}H and have mean ^{14}C residence times of 500 to 20,000 yr (45.9 to 4.9 pmc). Chemical evolution modeling, porosity-permeability core plug analysis, and in-mine hydrographs also indicate hydraulic partitioning.

Keywords: groundwater, conceptual model, isotope chemistry, groundwater age, solute chemistry, sedimentary rocks, mountains.

INTRODUCTION

Patterns and mechanisms of groundwater circulation in stratified mountainous terrain are generally not well understood, either conceptually or at the field scale. This occurs because access to deep groundwater is generally limited, the details of subsurface stratigraphic and structural complexities are often poorly defined, and groundwater flow is often fracture-controlled (Committee on Fracture Characterizations of Fluid Flow, 1996).

Hubbert (1940) and Toth (1962, 1963) provided insight into the potential effects of topography and basin geometry on groundwater flow and described the useful concept of local, intermediate, and regional systems. Freeze and Witherspoon (1966, 1967) demonstrated theoretical effects of permeability contrast in adjacent layered strata. Jamieson and Freeze

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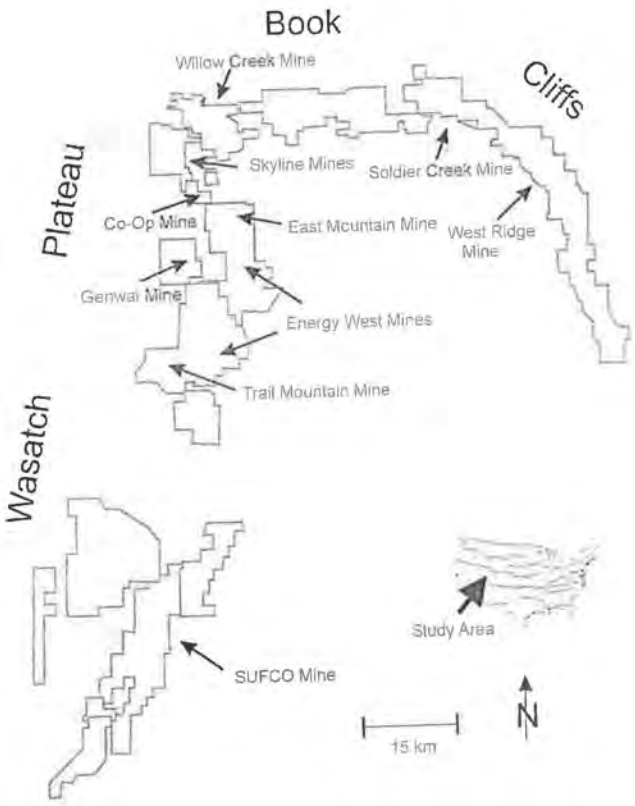

Figure 1. Location of coal mines and coal mine lease areas in Wasatch Plateau and Book Cliffs, Utah. Named mines provided data and underground access for this investigation. SUFCO—Southern Utah Fuel Company.

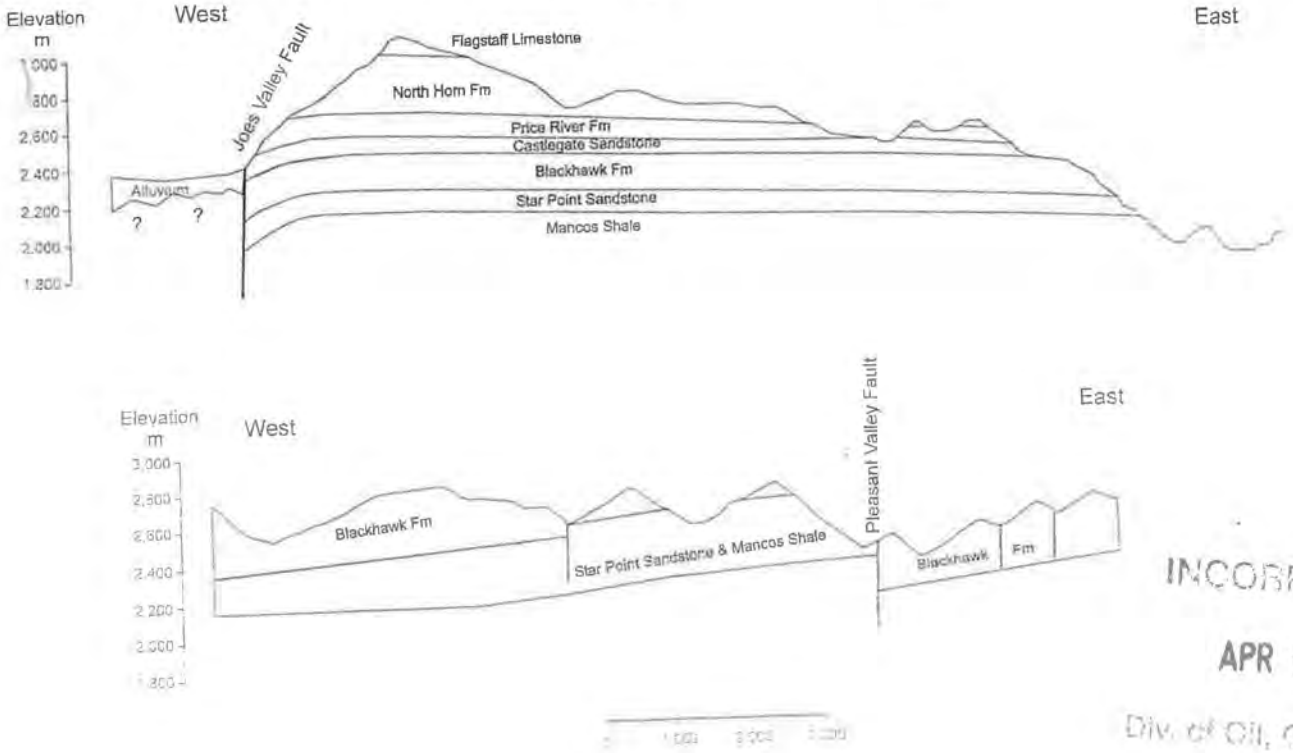

Figure 2. Generalized cross sections through the Wasatch Plateau.

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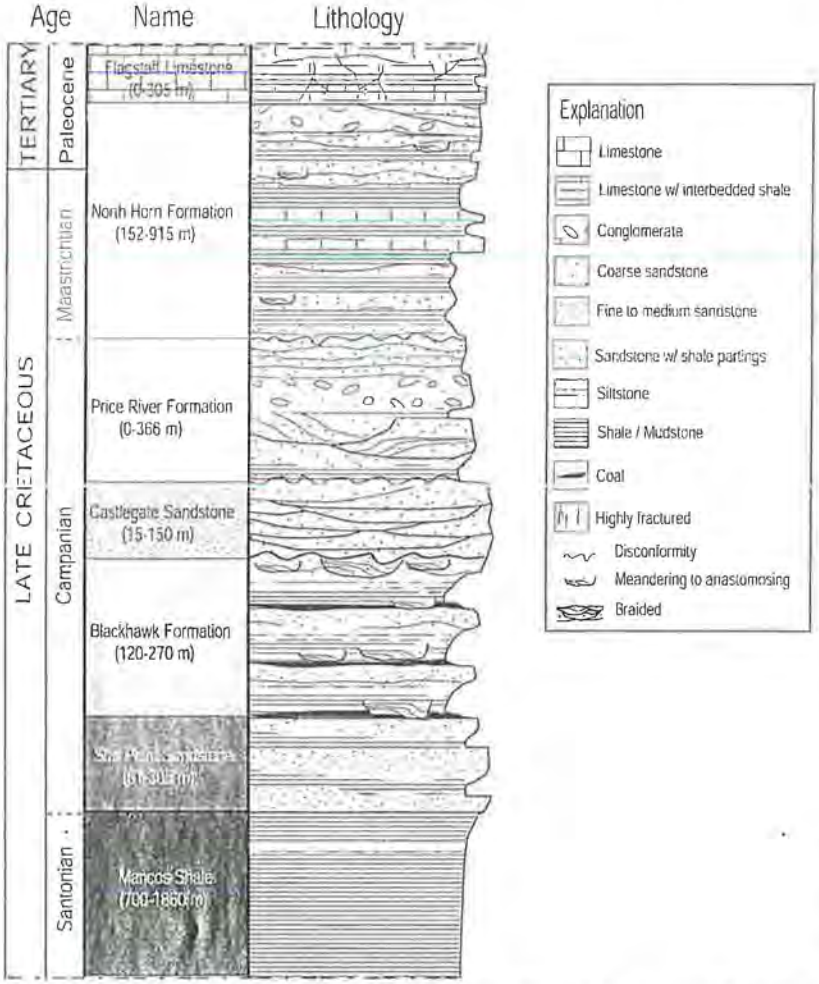

Figure 3. Stratigraphic column of bedrock formations in Wasatch Plateau and Book Cliffs.

TABLE 1. SUMMARY OF AVERAGE DISCHARGE RATES AND SOLUTE COMPOSITIONS OF SPRING AND IN-MINE GROUNDWATERS IN THE WASATCH PLATEAU AND BOOK CLIFFS, UTAH

Formation	Q n	Q (l s⁻¹)	Solute n	(°C)	Cond us/cm	pH	mg l⁻¹ TDS	meq l⁻¹						
								Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	SO_4^{2-}	Cl^{-}
Flagstaff	7	0.30	8	6.8	426	7.6	265.4	4.30	1.05	0.24	0.05	4.79	0.63	0.16
std.		0.28		2.1	59	0.4	41.2	1.15	0.36	0.27	0.09	0.59	1.08	0.17
North Horn	60	0.90	78	7.2	593	7.7	343.5	3.27	2.47	1.21	0.04	5.64	0.83	0.44
std.		3.69		3.6	186	0.5	114.9	1.18	0.93	1.46	0.05	1.08	1.13	0.59
Price River	14	0.62	22	8.6	700	7.6	399.5	4.32	2.78	1.03	0.05	6.60	1.25	0.26
std.		0.89		4.7	151	0.4	87.4	1.41	0.85	0.52	0.07	1.02	1.23	0.13
Castlegate	7	5.14	16	11.0	460	7.6	240.4	2.42	1.62	0.36	0.04	3.55	0.57	0.26
std.		11.35		10.3	462	0.6	72.6	0.97	1.02	0.22	0.02	1.63	0.36	0.19
Blackhawk	31	1.20	35	6.7	450	7.3	254.8	3.13	1.45	0.31	0.03	4.05	0.60	0.22
std.		2.84		3.2	238	0.8	99.6	1.02	1.22	0.44	0.04	1.44	0.61	0.30
In-mine			50	11.5	796	7.7	454.4	3.20	2.90	2.80	0.17	7.01	1.47	0.37
std.				2.9	333	0.5	193.8	1.78	1.41	3.50	0.15	2.58	1.61	0.34
Star Point			5	17.0	933	7.4	546.3	5.02	3.75	1.07	0.06	6.45	2.46	0.86
std.				3.4	188	0.6	150.4	1.39	1.27	0.67	0.04	0.56	1.24	0.68

Note: std—standard deviation.

(1983) and Forster and Smith (1988) evaluated theoretical relationships in well-defined mountainous aquifers that are not constrained by stratigraphic and structural barriers. Although instructive, these studies have limited applicability to groundwater flow in stratified mountainous terrain, because many are based on the limitations of computer simulations, on data collected only at or near the land surface, and on patterns of deep phreatic flow that are largely inferred.

Most stratified mountainous systems consist of numerous stratigraphic and structural features that locally and regionally affect groundwater flow patterns (Allen and Michel, 1998; Janes, 1998; Huntoon, 1981; Mayo et al., 1985; Mayer and Sharp, 1998). In this investigation, we have used geological, physical, chemical, and isotopic data to evaluate interactions between near-surface and 300–700-m-deep groundwater systems in gently dipping stratified bedrock that underlies a 6500 km^2 mountainous region in Utah, USA (Fig. 1). Because economic coal deposits are mined near the base of the 700+-m-thick section of six bedrock formations, the stratigraphy and structure of the subsurface are relatively well defined. Mine operators have identified thousands of springs and systematically collected discharge and solute data from hundreds of springs. Mine operators have also provided underground access to the geology and deep groundwater systems as much as 13 km laterally into the 240-km-long mountain front.

METHODS OF INVESTIGATION

Solute, isotopic, and hydrographic data were obtained for springs and in-mine discharges from the published literature, quarterly hydrologic reports, and permit applications prepared by various coal mines and unpublished sources.

Major ion chemistry (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, and Cl^{-}) for more than 3000 sampling events was checked for cation/anion balances. Approximately 1930 data sets from 164 springs and 50 in-mine sampling locations had acceptable error balances of ≤ 5%. These data were tabulated according to the formations from which they discharge. Differences in solute compositions of groundwater issuing from each formation and in-mine source were evaluated by normalizing the total dissolved solids data, and by discriminate and z-tests analysis. NETPATH (Plummer et al., 1991) was used to model plausible geochemical reaction pathways.

Isotopic data from surface and in-mine locations include carbon-14 (^{14}C) and tritium

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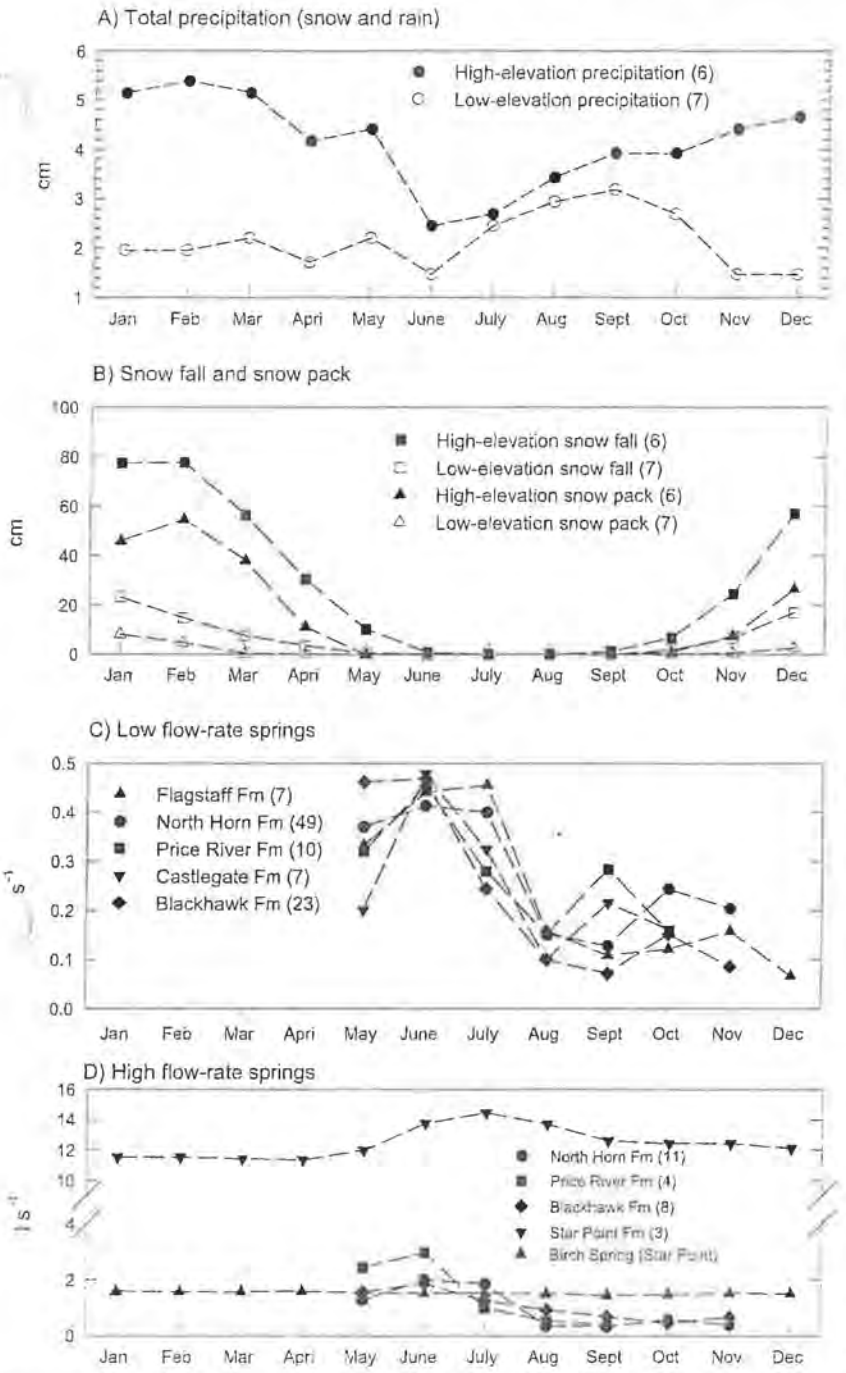

Figure 4. Mean monthly precipitation and spring discharge rates: (A) total precipitation, (B) snowfall and snowpack, (C) discharge rates of low-flow springs, and (D) discharge rates of high-flow springs. Numbers in parentheses are number of precipitation stations (A and B) or number of springs (C and D).

(^{3}H) analyses obtained from 132 sampling locations and 392 δ^2H and δ^{18}O analyses from 329 sampling locations. Mean ^{14}C residence times were calculated by isotopic mixing (Pearson et al., 1972) and isotopic mixing-exchange (Fontes and Garnier, 1979) models. These models were selected because collectively they accommodate both open and closed systems conditions with abundant carbonate mineral. Calcium carbonate is the prevailing cement in clastic rocks of the Wasatch Plateau and Book Cliffs. Only samples with HCO_3^- $\delta^{13}C > -7‰$ were modeled. Some samples had $\delta^{13}C$ values as great as $+5‰$ due to the influence of methane gas. In addition to the measured ^{14}C and $\delta^{13}C$ of the samples, other input parameters were assigned the following values: $\delta^{13}C$ soil gas -18 to $-22‰$, $\delta^{13}C$ mineral carbonate $0‰$, ^{14}C soil gas 100 percent modern carbon (pmc), and ^{14}C mineral carbonate 0 pmc. Results of the two methods, including the range of assigned $\delta^{13}C$ soil gas values, were generally within 10% or less of each other for each sample.

Precipitation data were obtained from seven low-elevation (1800–2100 m) and six high-elevation (2100–2500 m) weather stations (Western Region Climate Center, 2001). Low-elevation stations are located near the base of the Wasatch Plateau and Book Cliffs and high-elevation stations are located at elevations between one-half and two-thirds the maximum elevation of the mountains.

Stratigraphic sections were measured in the Castlegate and Star Point Sandstones to identify sedimentary facies and bounding surfaces between facies. More than 130 core plugs were collected, including multiple cores from bounding surfaces. Porosity and permeability of the cores were analyzed using a TerraTek 8400 dual porosimeter and permeameter. Photomosaics of key outcrops were compiled using Adobe Photoshop 6.0 and Adobe Illustrator 9.0. Bounding surfaces were annotated on the photomosaics in an effort to evaluate the lateral extent and number of bounding surfaces.

SETTING

Geologic Setting

The 2400–2700-m-high Wasatch Plateau and Book Cliffs form a 240-km-long, 16–40-km-wide, arc-shaped upland that rises along imposing erosional escarpments in the northern Colorado Plateau, Utah. The Wasatch Plateau is a northeast-trending mountain range that is stratigraphically and structurally contiguous with the east-west–trending Book

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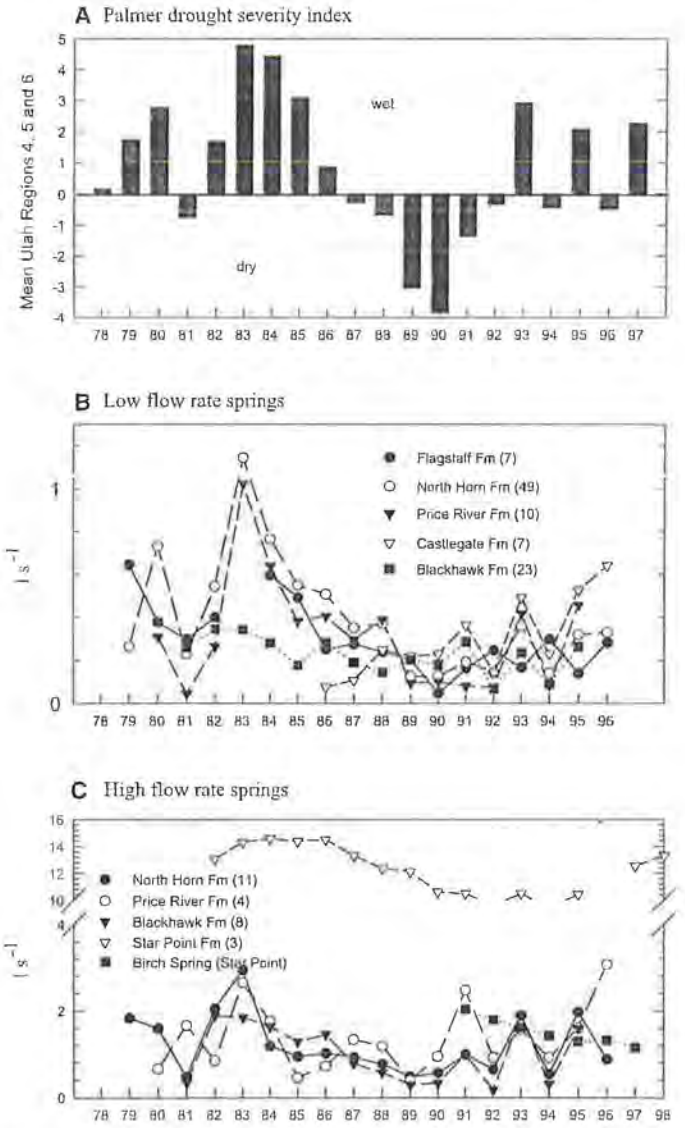

Figure 5. Climate and spring discharge rates for 1978–1987: (A) mean Palmer Hydrologic Drought Index (PHDI) for Utah Regions 4, 5, and 6; (B) low flow-rate springs; and (c) high flow-rate springs. Springs are organized by bedrock formation. Numbers in parentheses are number of springs averaged.

Cliffs. The prominent features of the eastern and southern fronts of the Wasatch Plateau and Book Cliffs, respectively, are 460–915-m-high, stair-stepped cliff faces. Ancillary canyons and reentrants, through which streams drain the interior uplands, cut the cliff faces.

The bedrock, which dips 2–5° east, is broken by high-angle normal faults that parallel the length of the plateau (Fig. 2). Some of the faulting has resulted in narrow elongate grabens internal to the plateau (Witkind and Weiss, 1991); elsewhere, normal faulting does not have a pronounced topographic expression. A large fault-block basin bounds the Wasatch Plateau to the west. The Book Cliffs mark the southern edge of the uplifted Uinta Basin. Bedrock that crops out in the cliff faces dip beneath younger Uinta Basin sediments to the north.

Six Upper Cretaceous through Lower Tertiary water-bearing formations, with an aggregate thickness as much as 2311 m, occur in the region (Fig. 3). The formations include the Flagstaff Limestone, North Horn Formation, and four formations (Price River Formation, Castlegate Sandstone, Blackhawk Formation, and Star Point Sandstone) of the Mesa Verde Group. The rocks were deposited along the edges of the western shoreline of the Cretaceous Interior Seaway on top of marine mud of the Mancos Shale (Johnson, 1978; Stanley and Colinson, 1979; Knowles, 1983; Hintze, 1988; Chan and Phaff, 1991; Franczk and Pitman, 1991; Van Wagoner et al., 1990). The highlands were the result of the Sevier Orogeny foreland thrust belt. Sediment from the highlands was shed eastward through a variety of depositional systems, including alluvial plains containing a variety of fluvial types, coastal to delta plains, and deltaic to marine shoreface deposits. Through time, the depositional systems prograded eastward, creating an overall upward-coarsening succession of Upper Cretaceous rocks.

In the latest Cretaceous (Upper Maastrichtian) and Paleocene, an intermountain basin developed in the region (Franczk and Pittman, 1991). The basin filled with low-gradient, meandering stream and over-bank flood-plain deposits of the North Horn Formation. These deposits give way upward to lacustrine carbonates of the Flagstaff Limestone (Fig. 3; Garner and Morris, 1996). Because of the stair-step erosional surface of the Wasatch Plateau and Books Cliffs, the cap rock ranges from the highly fractured Flagstaff Limestone to the Blackhawk Formation.

Economic coal seams occur in the lower portion of the Blackhawk Formation. As much as 1860 m of nonwater-bearing marine Mancos Shale interfingers with and underlies the Star Point Sandstone and Blackhawk Formation in the study area.

Climate

Mean annual precipitation varies between 25 and 90 cm, depending on elevation (Western Region Climate Center, 2001; Utah State University Climate Center, 2001). Most low-elevation precipitation falls as rain during the summer, whereas ~50% of the high-elevation precipitation falls as snow during the winter (Fig. 4, A and B). In January and February, the mean snowpack depth at high-elevation weather stations is ~0.75 m and depths as great as 1.5 m are common in the higher upland areas of the Wasatch Plateau (>2500 m) where weather stations do not exist.

The mean air temperature is below freezing between November and March. Mean nighttime minimum temperatures are below freez-

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Figure 6. Bedding discharge in North Horn Formation. Discharge is fracture-controlled and occurs in discrete locations along bedding surfaces.

ing between October and May. The snowpack begins melting at the lower elevations in March, and melting is usually complete by the end of May.

Mean Palmer Hydrologic Drought Index for Utah regions 4, 5, and 6 (National Climatic Data Center, 2001a, b) and precipitation data from nearby weather stations for the years 1978–1997 indicate that the amount of moisture available for potential groundwater recharge is cyclical (Fig. 5, A and B). The years 1979–1986 were relatively wet, 1987–1992 were relatively dry, and both wet and dry years have occurred since then.

GROUNDWATER DISCHARGE

Spring Discharges

Based on a field examination of the geology of more than 50 springs, we found five instances of shallow groundwater discharge: along bedding surfaces, along fracture and bedding surfaces, regolith-soil underflow, slump-block flow, and fault-zone discharge. Most perennial springs discharge along bedding surfaces (Fig. 6); however, the regolith-soil underflow type is the dominant ephemeral spring. Although fault-related springs are uncommon, damage zone discharge is responsible for some notable springs in the Star Point Sandstone. Fault-related springs often have a muted response to seasonal recharge.

Discharge rate data for 123 springs for which long-term records are available have been analyzed for seasonal and climatic recharge effects. These springs have been organized according to bedrock lithology (Table 1). About 80% of the springs are classified as low-

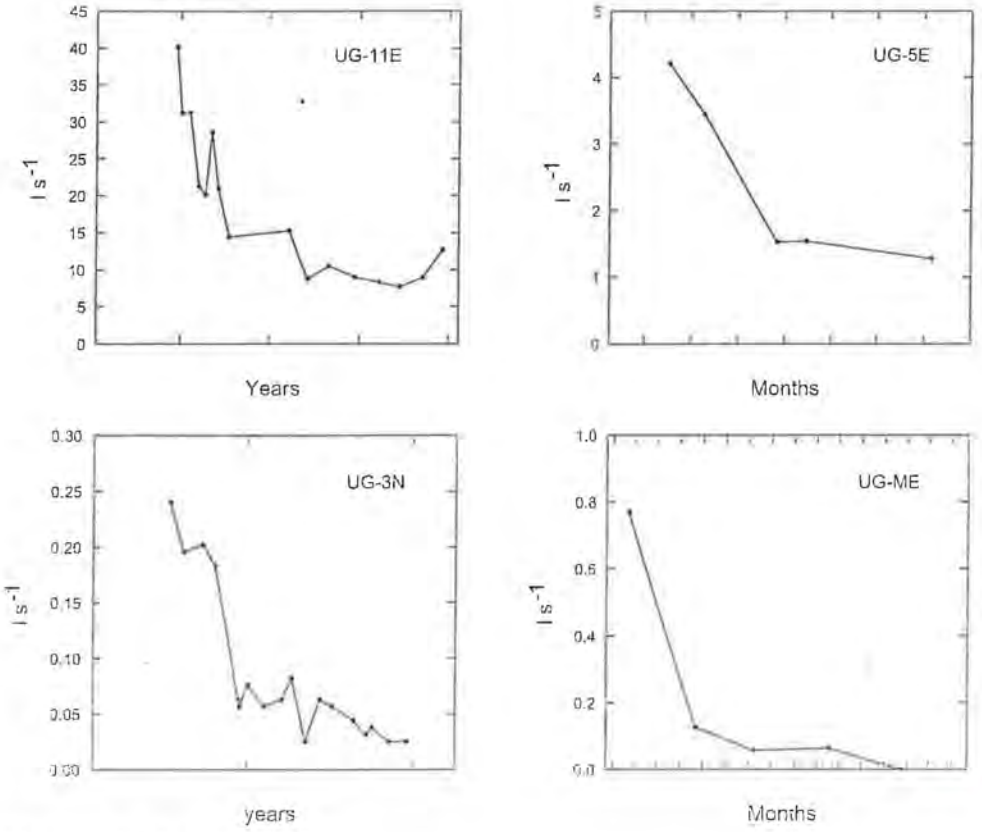

Figure 7. Typical hydrographs of in-mine roof drips.

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discharge rate (mean discharge < 0.65 l s^{-1}), and ~20% are classified as high-discharge rate (Fig. 4, C and D; and Fig. 5, B and C). In Table 1, the large standard deviations in discharge rate result from seasonal and climatic variability.

All spring types except for high-discharge springs in the Star Point Sandstone have similar bimodal discharge characteristics and are influenced by seasonal recharge (Fig. 4, C and 4D). Mean discharge rates in the spring and early summer are generally two to four times as great as are discharge rates in the late summer and fall (Fig. 4D). The elevated discharge rates reflect snowmelt-induced recharge and late spring and early summer rain. There is a one- to two-month lag between the end of snowmelt and the peak of spring discharge rates (Fig. 4, B and C). We interpret this lag to travel times between recharge and discharge areas (i.e., delayed drainage). There is also a lag between the beginning of increased summer precipitation and summer discharge rates. Springs generally exhibit a decrease in discharge in the late fall and early winter as the precipitation turns to snow. Birch Spring in the Star Point Sandstone is the only spring not affected by seasonal precipitation (Fig. 4D).

Discharge rates of both low- and high-discharge springs are also affected by multiyear climate variations. Flagstaff, Northhorn, Price River, and Castlegate Formation springs generally exhibit rapid response to wet and dry periods, whereas Blackhawk and Star Point Formation springs have a more muted response.

In-Mine Groundwater Discharges

The network of nearly horizontal underground mine openings provides an opportunity to examine and monitor groundwater responses in deep groundwater systems. These interconnected tunnels and longwall-mined areas may be thought of as large-diameter horizontal wells. Although openings are as much as 700 m below ground surface, most openings encounter little water and dry regions commonly occur. Dust suppression is required in many mine openings. Most groundwater inflows are from the mine roof, emanating from roof-bolt holes and small fractures. In some mines, water may locally discharge from the mine floor. Occasionally, substantial inflows issue from fault-related damage zone fractures (Mayo and Kuntz, 2000). Roof inflows are usually from sandstone channels in the Blackhawk Formation and floor inflows are usually from the Star Point Sandstone.

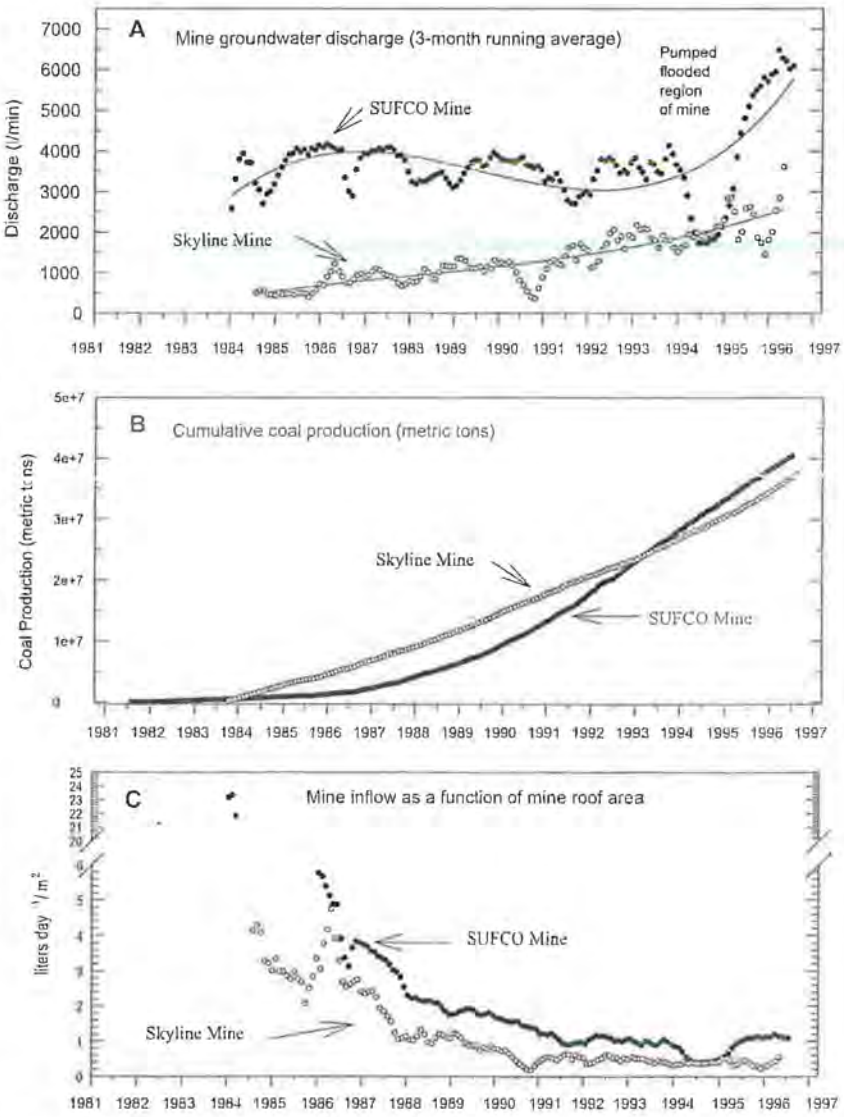

Figure 8. Relationships between (A) in-mine groundwater discharge rate, (B) coal production, and (C) area of exposed mine roof.

Mine inflows do not exhibit seasonal or climatic responses. Most roof drips are only reported anecdotally, as they dry up within a few days to a few weeks. The typical response of longer-term mine inflows is an initial rapid decline followed by a slower decline and ultimate extinction (Fig. 7).

The overall responses of in-mine groundwater inflows are consistent with hydrographs of individual roof drips. Groundwater inflows into the Skyline and Southern Utah Fuel Company (SUFCO) Mines illustrate this relationship (Fig. 8). Discharge into the SUFCO Mine was relatively constant between 1984 and 1997 (Fig. 8A). The major decrease in mid-1994 followed by the increase in 1995 was the result of mine storage of groundwater followed by mine pumping. The discharge rate in the Skyline Mine has been generally less than in the SUFCO mine, but it has gradually increased over time. Average monthly coal production from each mine was ~240,000 metric tons between 1984 and 1997. Cumulative production is shown in Figure 8B. The steady decline in groundwater inflow rates per unit of mined roof area (Fig. 8C) indicates that groundwater inflow is not steady state. Because mine workings are essentially horizontal

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and are parallel to bedding, the decline in inflow is attributed to rapid dewatering of old mine workings.

The similarity of the SUFCO and Skyline Mines dewatering trends (Fig. 8C) indicates that groundwater systems that drain into the mines have similar properties. This is particularly significant in that the mines are located more than 50 km from each other and the surfaces above the mines have different climates. SUFCO and Skyline Mines have mean annual precipitation of 38.1 and 60.7 cm/yr, respectively.

HYDROGEOCHEMISTRY

Solute Compositions

Mean solute compositions of spring and in-mine groundwater are listed in Table 1, and mean total dissolved solid contents are shown in Figure 9. Most groundwaters are of the Ca^{2+}-Mg^{2+}-HCO_3^- type; however, North Horn and in-mine waters have appreciable Na^+ contents due to ion exchange, and Star Point waters have appreciable SO_4^{2-} and Cl^- contents due to contact with primary evaporite minerals in the underlying and interfingering Mancos Shale.

Two statistical procedures, z-test and discriminant analysis (Ostle and Malone, 1988), were used to determine if groundwater chemistries from each stratigraphic unit and in-mine waters are chemically distinguishable from each other. Z-tests were performed on the regional data set to compare the mean total dissolved solids and major ion chemistry of groundwater samples from adjacent formations at the 95% confidence interval (Table 2). A z-score of $\pm$ 1.4, for example, represents only an 8% probability that the means of the two populations are the same and a z-score of $\pm$ 6.5 represents only a $4.64e^{-11}$% probability that the means of the two populations are the same. The z-test results indicate that the means of all groundwater solute compositions of adjacent formations are statistically different from each other.

Discriminant analyses were performed on the entire regional data set and on data sets from specific mining areas. Using the entire regional data set, Blackhawk Formation groundwater has the lowest probability of being correctly identified as Blackhawk Formation groundwater (31.75%), whereas Flagstaff Limestone groundwater has the highest probability (79.69%) of being correctly identified (Table 3). The low probability of Blackhawk Formation groundwater means that the variability in Blackhawk waters is so great that

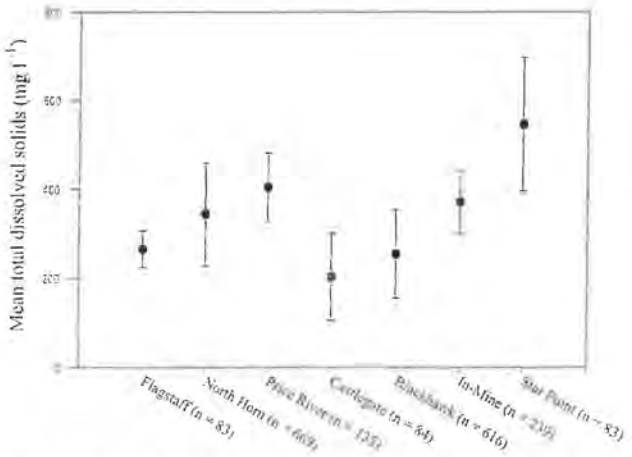

Figure 9. Mean total dissolved solid values of all measurement events for springs from and in-mine sources grouped according to bedrock lithology. Error bars represent 1 standard deviation.

TABLE 2. TWO SAMPLE MEANS Z-TEST STATISTICS FOR COMPOSTIONS OF SPRING AND IN-MINE GROUNDWATERS

Parameter	Flagstaff-North Horn	North Horn-Price River	Price River-Castlegate	Castlegate-Blackhawk	Blackhawk-Star Point	Blackhawk in-mine-Blackhawk spring
TDS	−11.33	−5.60	12.05	−1.31	−16.54	27.06
Ca	6.48	−6.70	9.77	−5.13	−11.47	0.55
Mg	−24.18	−3.38	7.13	1.14	−15.02	15.69
Na	−14.48	2.41	11.13	1.49	−9.66	15.69
HCO^3	−10.00	−8.54	12.48	−2.16	−26.90	27.75
SO^2	−1.68	−2.92	5.11	−0.44	−12.94	9.97

Note: Conditions of statistical analysis, $H_0: \mu = x$, $Ha: \mu = X$, $\alpha = 0.05$. Z-tests are based on the entire data set and are not location specific.

TABLE 3. SUMMARY OF DISCRIMINANT ANALYSIS, INCLUDING PROBABILITY COEFFICIENTS FOR THE ENTIRE DATA SET, REGARDLESS OF LOCATION

	Flagstaff	North Horn	Price River	Castlegate	Blackhawk	Star Point	In-mine	Total (%)
Flagstaff*	51	2	2	1	8	0	0	64
	79.69†	3.13	3.13	1.56	12.5	0	0	100
North Horn	61	341	67	45	61	59	39	673
	9.06	**50.67**	9.96	6.69	9.06	8.77	5.79	100
Price River	14	6	61	2	3	6	6	98
	14.29	6.12	**62.24**	2.04	3.06	6.12	6.12	100
Castlegate	1	14	4	32	3	0	0	54
	1.85	25.93	7.41	**59.26**	5.56	0	0	100
Blackhawk	123	82	45	145	194	9	13	611
	20.13	13.42	7.36	23.73	**31.75**	1.47	2.13	100
Star Point	4	6	25	0	0	42	1	78
	5.13	7.69	32.05	0	0	**53.85**	1.28	100
In-mine	4	26	70	33	8	24	114	279
	1.43	9.32	25.09	11.83	2.87	8.6	**40.86**	100
Total	258	477	274	258	277	140	173	1857
Percent	13.89	25.68	14.75	13.89	14.92	7.54	9.32	100
Error Rate	0.6825	0.4074	0.2031	0.4961	0.3776	0.4615	0.5914	0.4595
Priors	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	

*Table showing the results of regional discriminant analyses. The first set of numbers in each row is the number of sample categories having the chemistry of the formation listed in the column. The second set of numbers is the probability that a sample will be designated as belonging to the formation listed in the column. Groundwaters are initially assumed to be assigned to their correct formation and probability coefficients are generated under that assumption. An equation is generated describing each formation and each sample's data are evaluated by each equation. The sampling event is then categorized as the equation that yields the highest value. Percentages of sampling events correctly categorized are then tabulated for each formation. Probabilities for correct categorization as well as probabilities for incorrect categorization are displayed for each formation.

†Probability that a water initially designated as Flagstaff will be categorized as Flagstaff.

‡Probability that a water initially designated as Blackhawk will be categorized as Castlegate.

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individual spring discharges are often not statistically distinct from those in other formations. The remainder of the formation groundwater has only a 50–60% probability of being correctly categorized, and the overall probability of any sampling event of being correctly categorized is 45.9%. This means that with the exception of the Flagstaff Limestone, groundwaters issuing from these formations are only somewhat chemically distinct when viewed regionally. However, it is significant that in-mine Blackhawk groundwater has only a 2.9 and 8.6% probability of being identified as Blackhawk or Star Point spring water, respectively.

On a mine-by-mine basis, most formation groundwater had a 70–90% probability of being correctly categorized, and many had probabilities of 90–100%. The general low probabilities of the regional analysis and the high probabilities of mine-by-mine analyses are attributed to the spatial variability of the chemistry and mineralogy of the bedrock formations. Groundwater residence times are not considered to be a factor in the spatial variability, because most of the samples are from bedrock sources, many of which were sampled during times of low discharge. Thus, total dissolved solids and chemistry cannot categorize springs on a regional basis. However, solute chemistry is a good indication of bedrock type in each mine area.

To evaluate the potential for vertical groundwater migration between formations, the computer code NETPATH (Plummer et al., 1991) was used to evaluate plausible chemical evolutionary pathways at each mining area. Two chemical evolution scenarios were evaluated for each mining area: recharge to formation and formation to formation. Each model was based on the water chemistry of each mining area. Recharge to formation models assume: (1) groundwater issuing from springs is recharged from precipitation at the outcrop of the formation. Precipitation was assigned the mean composition of Wasatch Range snow (unpublished data), and (2) formation water was assigned the mean composition of spring water issuing from the formation at each mine area. Formation to formation models assume: (1) groundwater in the overlying formation has the mean composition of springs issuing from the formation, (2) the groundwater in the overlying formation is chemically fully evolved, and (3) the groundwater flows through the underlying formation before discharging. Formation to formation models used the mean compositions of specific formation groundwaters in each mine area.

TABLE 4. RESULTS OF NETPATH MODELING OF GEOCHEMICAL EVOLUTION FROM PRECIPITATION TO MEAN COMPOSITION OF GROUNDWATER IN EACH FORMATION AT EACH MINE SITE

Initial water Final water	Precip. Flagstaff	Precip. North Horn	Precip. Price River	Precip. Castlegate	Precip. Blackhawk	Precip. Star Point
Co-Op Mine						
Calcite	0.65					
CO_2	2.08	2.51			2.02	
Dolomite	0.90	0.97			1.09	
Exchange	−0.35	−0.38			−0.52	
Gypsum	0.03	0.05			0.05	
K-mica	0.02	0.05			0.03	
Plagioclase AN38		0.86			0.14	
East Mountain Mine						
Calcite	1.32				−1.50	
CO_2	1.75	2.60	3.33		1.94	
Dolomite	0.48	1.11	1.42		1.79	
Exchange		0.02	0.19			
Gypsum	0.30	0.38	0.66		0.78	
K-mica	0.04	0.04	0.05		0.07	
Plagioclase AN38	0.11	0.75	0.74		0.84	
Genwall Mine						
Calcite			−0.86		−0.60	−3.46
CO_2		1.55	1.18		4.89	2.22
Dolomite		0.54	1.40		1.85	3.72
Exchange		−0.30			−0.02	
Gypsum		0.14	0.26		0.38	0.74
K-mica		0.02	0.11		0.03	0.14
Plagioclase AN38		0.80	0.42			0.48
SUFCO Mine						
Calcite				0.18	0.07	−0.51
CO_2		4.31	3.70	0.58	1.57	3.09
Dolomite		1.33	1.49	0.44	1.00	1.92
Exchange		1.19	1.26	0.24	0.39	0.14
Gypsum		1.00	1.28	0.22	0.47	1.32
K-mica		0.07	0.08	0.03	0.04	0.07
Plagioclase AN38		1.60	1.08	0.16	0.05	
Trail Mountain Mine						
Calcite		−1.56	1.40	0.74	−0.74	
CO_2		3.53	1.88	2.51	2.41	
Dolomite		1.60	0.73	1.11	1.69	
Exchange						
Gypsum		0.49	0.04	0.28	0.62	
K-mica		0.04	0.02	0.02	0.03	
Plagioclase AN38		1.03	0.11	0.28	0.41	
US Fuel Mine						
Calcite		0.81		−0.69	−0.46	
CO_2		1.40		1.76	2.39	
Dolomite		0.75		1.82	1.80	
Exchange		0.02		0.05	0.14	
Gypsum		0.09		1.00	0.56	
K-mica		0.01		0.04	0.03	
Plagioclase AN38					0.29	
Willow Creek Mine						
Calcite		0.91		0.84	0.16	0.79
CO_2		0.61		1.13	1.27	2.44
Dolomite		0.4		0.43	1.15	0.77
Exchange						
Gypsum		0.26		0.10	0.29	0.30
K-mica		0.01		0.00	0.00	0.02
Plagioclase AN38		0.09		0.11	0.16	0.12

Note: Results in mmoles/L. Empty cell = no data from formation water or model result did not include the mineral phase. Positive results indicate mineral dissolution or gas consumption. Negative values indicate mineral precipitation or gas production.

A series of progressively complex model runs was performed. The first models included calcite, dolomite, carbonic acid, gypsum, clay-ion exchange, and zeolite-ion exchange. Plagioclase (AN38) and potassium mica were added to subsequent model runs. All of the mineral phases except zeolite occur in all bedrock formations. Zeolite is restricted to the Blackhawk Formation. Tables 4 and 5 show the NETPATH results for recharge-formation and formation-formation reactions, respectively. Similar results were obtained for the model runs without silicate mineral phases. In the tables, a positive value indicates dissolution and a negative value indicates precipitation.

In all cases, plausible reactions were modeled for recharge-formation groundwater flow paths for each mine area (Table 4). Attempts to model formation-formation chemical reactions were less successful (Table 5). Assuming

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TABLE 5. RESULTS OF NETPATH MODELING OF GEOCHEMICAL EVOLUTION OF MEAN COMPOSITION OF FORMATION GROUNDWATER TO MEAN COMPOSITION OF UNDERLYING FORMATION GROUNDWATER AT EACH MINE SITE

Initial water / final water	Flagstaff / North Horn	North Horn / Price River	Price River / Castlegate	Castlegate / Blackhawk	Blackhawk / Star Point
Co-Op Mine					
Calcite	nm				
CO_2	nm				
Dolomite	nm				
Exchange	nm				
Gypsum	nm				
K-mica	nm				
Plagioclase AN38	nm				
East Mountain Mine					
Calcite	−0.88	−0.01			
CO_2	0.88	0.74			
Dolomite	0.64	0.31			
Exchange	0.22	0.17			
Gypsum	0.08	0.28			
K-mica	ci	0.01			
Plagioclase AN38					
Genwall Mine					
Calcite		nm			nm
CO_2		nm			nm
Dolomite		nm			nm
Exchange		nm			nm
Gypsum		nm			nm
K-mica		nm			nm
Plagioclase AN38		nm			nm
SUFCO Mine					
Calcite		nm	nm	nm	0.45
CO_2		nm	nm	nm	1.83
Dolomite		nm	nm	nm	0.91
Exchange		nm	nm	nm	
Gypsum		nm	nm	nm	0.85
K-mica		nm	nm	nm	0.03
Plagioclase AN38		nm	nm	nm	0.39
Trail Mountain Mine					
Calcite		nm	−5.54	nm	
CO_2		nm	0.53	nm	
Dolomite		nm	0.39	nm	
Exchange		nm	ci	nm	
Gypsum		nm	ci	nm	
K-mica		nm	0.00	nm	
Plagioclase AN38		nm		nm	
Fuel Mine / Calcite				nm	
CO_2				nm	
Dolomite				nm	
Exchange				nm	
Gypsum				nm	
K-mica				nm	
Plagioclase AN38				nm	
Willow Creek Mine					
Calcite				−0.67	nm
CO_2				0.13	nm
Dolomite				0.72	nm
Exchange					nm
Gypsum				0.19	nm
K-mica					nm
Plagioclase AN38				0.05	nm

Note: Result in mmoles/L. ci—models returned only by ignoring one or more constraints—reaction not plausible; nm—no models returned; empty cell—no data or model result did not include mineral phase. Flow paths based on the mean chemical composition of formation groundwater at each mine. Positive results indicate mineral dissolution or gas consumption at each mine. Positive results indicate mineral dissolution or gas consumption. Negative values indicate mineral precipitation.

the overlying formation groundwater is fully evolved. NETPATH results suggest that the vertical movement of groundwater between formations is limited and may not occur at many locations. Of the 15 model runs, 10 were completely unsuccessful and three were successful by ignoring one or more constraints. Blackhawk in-mine models, not shown, were also unsuccessful. We attribute the failure of these models to the oxidation of pyrite and fugitive longwall-mining machine emulsion fluid that were not included in the models, because necessary $\delta^{13}C$ and $\delta^{34}S$ data are not available. Such reactions have been successfully modeled elsewhere in the Wasatch Plateau (Mayo et al., 2000).

Isotopic Compositions

The stable isotopic compositions of δ^2H and $\delta^{18}O$ were analyzed on a regional and mine-by-mine basis (Table 6). Isotopic compositions of waters in the more arid Book Cliffs tend to be heavier than the isotopic compositions of waters in the more humid Wasatch Plateau (Fig. 10). All of the waters plot near the meteoric water line, suggesting a meteoric origin.

At most mine locations, the average isotopic compositions of stream and spring waters are similar, suggesting similar histories (Fig. 11). Except for the Willow Creek and Energy West Mines, the mean compositions of in-mine groundwaters are 0.8–1.2‰ lighter in $\delta^{18}O$ and 6.0 to 8.9‰ lighter in δ^2H than their corresponding surface water counterparts. Willow Creek in-mine waters were collected from roof drips located near the mine entrance. Isotopic differences between spring and in-mine groundwaters indicate that near-surface groundwater does not have rapid hydraulic communication with deep in-mine water. The isotopic depletion of in-mine waters is likely the result of paleo-recharge during cooler climate conditions.

Radiogenic isotopic compositions indicate that spring and in-mine groundwaters have fundamentally different travel times. In-mine groundwater and fault-related springs typically have zero or near zero ^3H contents and mean ^{14}C residence times ("ages") of 500 to 20,000 yr (Fig. 12). Almost all springs contain anthropogenic ^{14}C (i.e., $\geq \approx 50$ pmc) and have ^3H contents of 5–30 tritium unit (TU). A few samples contain components of both old groundwater and modern water (i.e., they have ^{14}C and $\delta^{13}C$ contents that permit the calculation of a ^{14}C-age and contain measurable ^3H). These samples include three Blackhawk Formation springs, most of the wells, and a few in-mine fault and other in-mine samples.

GROUNDWATER FLOW MECHANISMS

Spring and in-mine discharge data, solute and isotopic compositions, and groundwater ages provide evidence that deep groundwater is chemically and isotopically different than near-surface groundwater. These differences suggest restricted hydraulic communication between shallow and deep groundwater systems and beg the question: Why does this restriction occur, and how does deep groundwater move within the interior of the plateau? To address this question, we examined the stratigraphy of the sedimentary successions studied

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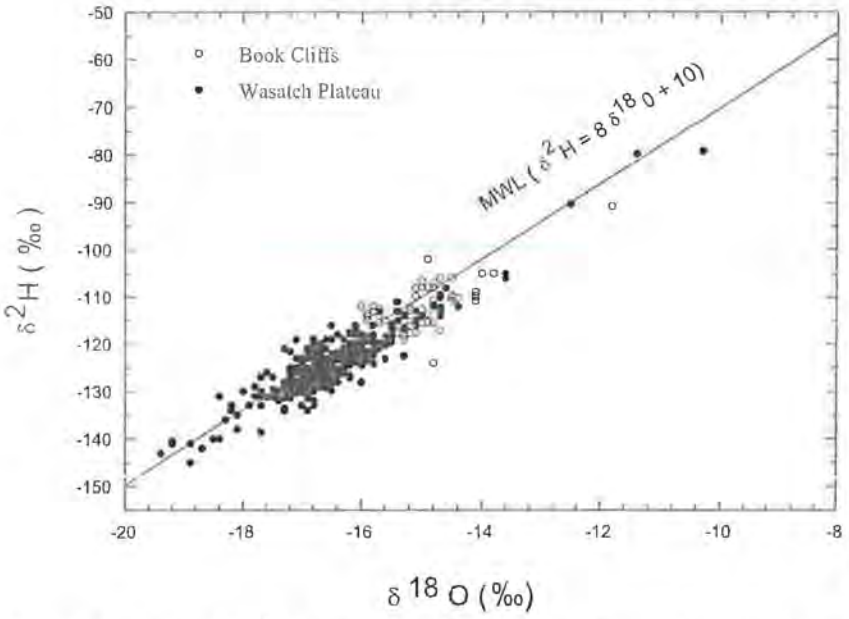

Figure 10. Scatter plot of stable isotopic compositions of all surface water and groundwater in Wasatch Plateau and Book Cliffs, Utah.

the two most laterally extensive reservoir-quality sandstone deposits in the region, and examined in-mine and surface-fault related groundwater inflows.

The sedimentary succession includes a heterogeneous combination aquifer-quality (i.e., water-bearing) sandstone and fractured limestone as well as nonwater-bearing shale, mudstone, siltstone, and nonfractured limestone (Chan and Pfaff, 1991; Kamola and Huntoon, 1995; Miall, 1993; Morris and Mayo, 2000). Above the Star Point Sandstone, most of the water-bearing rocks are channel-fill deposits and marine shoreface sandstone (Fig. 13). Within the aquifer-quality rocks, internal bounding surfaces (e.g., fluvial channel scours and mud drapes of multi-lateral accretion sets) and facies changes create additional horizontal and vertical barriers and baffles to fluid flow. Hence, lithologic heterogeneity at several scales restricts the potential for vertical and horizontal movement of water.

The North Horn Formation illustrates the potential for fine-grained sediments to limit vertical groundwater movement where laterally continuous mudstone beds are abundant. Aquifer-quality fractured limestone of the overlying Flagstaff Limestone and exposed reservoir-quality sandstones within the North

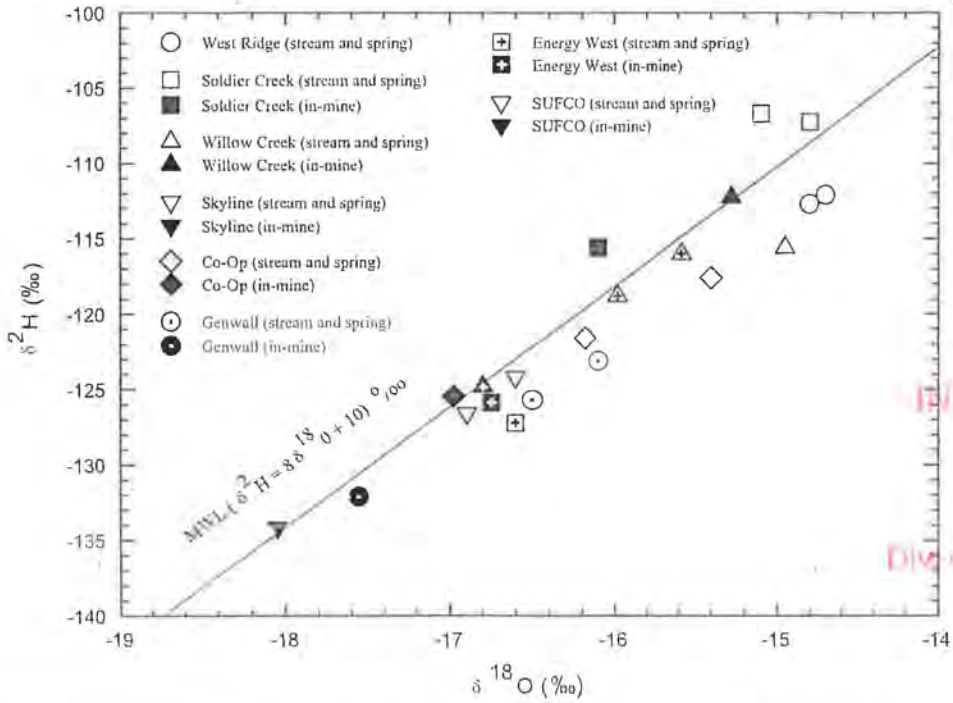

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Figure 11. Scatter plot of mean stable isotopic compositions of surface-water, groundwater, and in-mine groundwater samples in Wasatch Plateau and Book Cliffs. Data are sorted according to mine locations. SUFCO—Southern Utah Fuel Company.

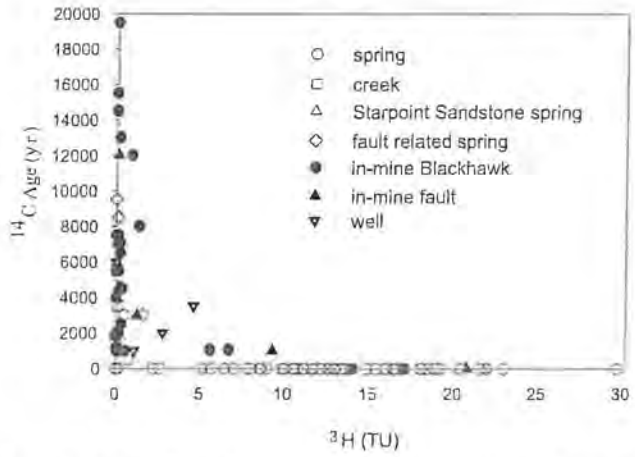

Figure 12. Scatter plot of ^{14}C mean residence times ("age") versus ^{3}H contents of surface water and groundwater.

Horn Formation provide vertical avenues for water movement. Where vertically flowing water encounters the lower permeability beds, vertical movement is impeded. This water becomes perched and flows laterally to surface outcrops to discharge as seeps or springs (Fig. 6). Such low-permeability horizons act as a "roof" to underlying formations.

Both low-permeability regions and unsaturated aquifer-quality sandstones occur in the coal-bearing Blackhawk Formation. Lines (1985) found hydraulic conductivities as low as 0.02 to 0.2 millidarcy (md) in cores of shale and siltstone and found one Blackhawk Formation Shale sample to be effectively impermeable under a hydraulic pressure of 5000 psi. Aquifer-quality rocks in the Blackhawk Formation occur in complex anastomosing to braided fluvial sandstone channels that are separated by abundant mudstones (Miall, 1993). Such channels are responsible for most mine inflows. These channel systems have been well mapped in the Energy West Mine (Fig. 14). In that mine, we installed a series of 4.5- to 7.5-m-long vertical wells into the recently exposed sandstone roof. Maximum water depth in the wells was ~1.5 m, demonstrating that the sandstone channel was not fully saturated and contained a perched, unconfined groundwater system. Extensive exploratory drilling by mining companies indicates that channel complexes are common, both vertically and horizontally, throughout the Blackhawk Formation.

Analysis of 134 core from the Castlegate Sandstone, a braided fluvial system, and from the Star Point Sandstone, a marine shoreface system, indicate that the sandstones have ample matrix porosity (10 to 25%) and intrinsic permeability (100–10,000 millidarcy (md)) to store and transmit groundwater (Fig. 15). However, low permeability of fifth-order bounding surfaces, which are common, greatly limits groundwater movement (Black, 2000). Fifth-order bounding surfaces define major channel bodies, the geometry of which can range from ribbon to sheet like. Such bodies may be laterally continuous for thousands of meters (Miall, 1988). Many of these bounding surfaces have horizontal permeability < 1 md, and all have vertical permeability <10 md. All vertical permeability measurements were made on sand-dominated samples. Attempts to core mud-dominated fifth-order

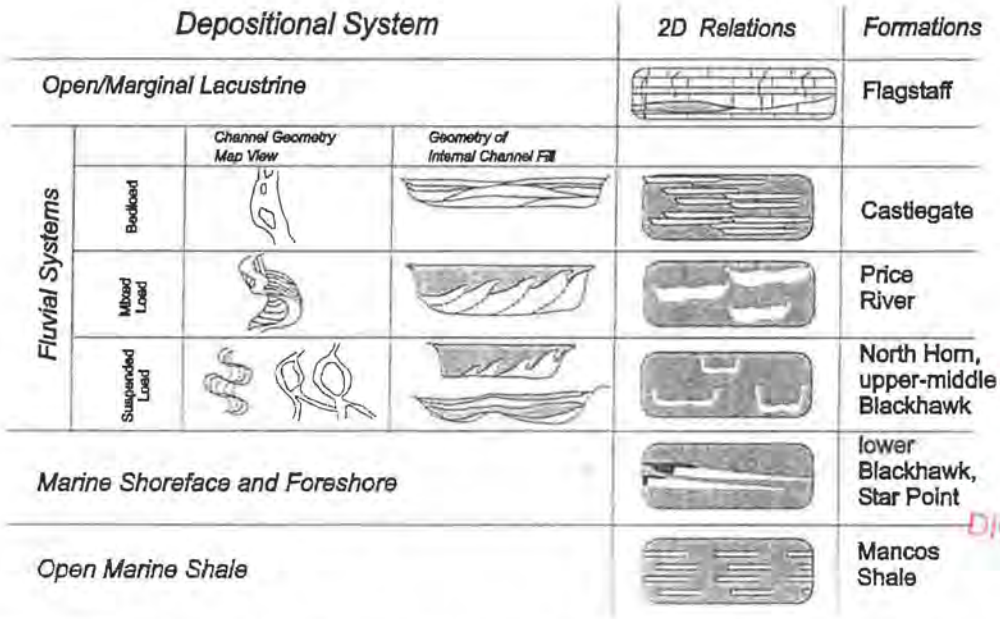

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Figure 13. Depositional environments and internal structure of bedrock formations in Book Cliffs and Wasatch Plateau, Utah (modified from Galloway and Hobday, 1983).

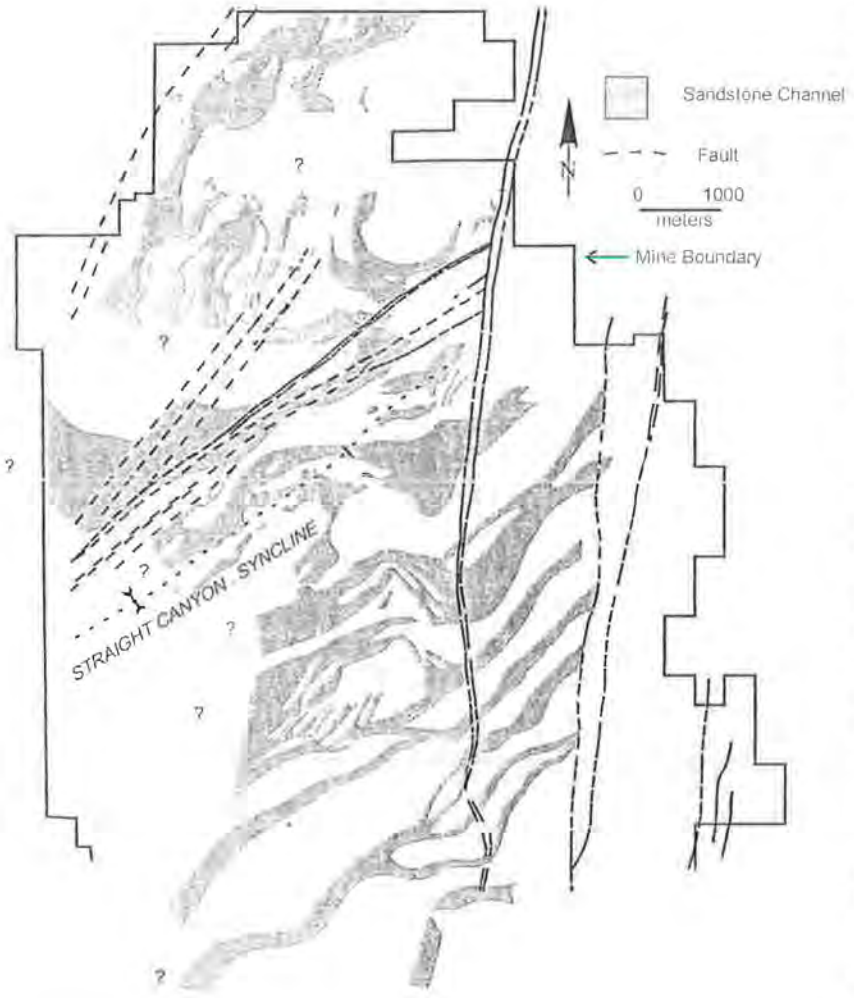

Figure 14. Map of lower Blackhawk Formation sandstone channel complex immediately above coal seams in Energy West Mine.

TABLE 6. AVERAGE δ^2H AND $\delta^{18}O$ COMPOSITIONS OF SURFACE AND GROUNDWATERS IN THE BOOK CLIFFS AND WASATCH PLATEAU, UTAH

	All samples			Streams			Springs			In-mine		
	n	δ^2H (‰)	$\delta^{18}O$ (‰)	n	δ^2H (‰)	$\delta^{18}O$ (‰)	n	δ^2H (‰)	$\delta^{18}O$ (‰)	n	δ^2H (‰)	$\delta^{18}O$ (‰)
Book Cliffs												
West Ridge Mine	26	−112.3	−14.8	9	−112.7	−14.8	17	−112.1	−14.7			
std.		5.8	0.8		4.6	0.5		6.5	0.9			
Soldier Creek Mine	15	−111.6	−15.6	4	−107.3	−14.8	3	−106.7	−15.1	8	−115.6	−16.1
std.		5.7	0.7		1.0	0.22		5.0	0.6		4.20	0.47
Willow Creek Mine	30	−115.2	−15.2	13	−115.6	−14.9	8	−117.7	−15.4	9	−112.3	−15.3
std.		4.6	0.5		5.3	0.7		2.8	0.4		3.5	0.4
Wasatch Plateau												
Skyline Mines	111	−126.9	−17.0	27	−124.2	−15.6	69	−126.6	−16.9	15	−134.1	−18.1
std.		4.7	0.6		3.4	0.4		3.3	0.3		5.4	0.5
Co-Op Mine	60	−122.3	−16.2	9	−117.6	−15.4	40	−122.6	−16.2	11	−125.5	−17.0
std.		5.5	0.8		4.0	0.6		5.4	0.7		4.2	0.2
Genwall Mine	84	−125.5	−16.5	20	−123.1	−16.1	26	−125.7	−16.6	15	−132.1	−17.6
std.		4.1	0.6		2.4	0.3		2.7	0.4		2.4	0.4
Energy West Mines	21	−126.9	−16.7				11	−127.2	−16.6	10	−125.9	−16.5
std.		3.4	0.5					3.8	0.6		3.0	0.4
SUFCO Mine	75	−119.2	−16.0	24	−116.1	−15.5	36	−118.8	−15.9	16	−124.8	−16.8
std.		6.3	0.9		7.4	1.0		4.7	0.6		4.0	0.6

Note: std—standard deviation.

bounding surfaces vertically were unsuccessful due to core splitting. We assume that mud-dominated surfaces would have even lower permeability than sand-dominated surfaces.

The Star Point Sandstone is fundamentally different than the other sandstone bodies (Maill, 1988, 1993) in that it is a succession of laterally and vertically stacked parasequences (Fig. 16; Holman, 2001). Facies shifts create permeability baffles that restrict flow between beds and bed sets both vertically and laterally. Large-scale facies shifts create permeability barriers (marine shale = 0.1 md) between reservoir quality facies of juxtaposed parasequences (Fig. 16). Horizontal permeabilities also vary greatly by facies. Average horizontal permeabilities are 220 md (foreshore), 93 md (upper shoreface), 52 md (middle shoreface), and only 4 md (lower shoreface). Backshore facies, which underlie coal beds, have an average horizontal permeability of 63 md. The large permeability differences explain aquifer partitioning commonly observed in in-mine monitoring wells.

Matrix-flow seepage velocities were calculated for the Castlegate and Star Point Sandstones based on core-plug permeability and the measured density of fifth-order bounding surfaces. On average, two to four fifth-order bounding surfaces occur horizontally every 100 m in fluvial sandstones of the Castlegate Sandstone. Assuming two fifth-order bounding surfaces per 100 m, with a permeability of 1 md and a width of 7.6 cm (based on core plug lengths), then 1.5 m of low-permeability rock exists for every 1000 m of aquifer. Conservative seepage calculations for the Castlegate Sandstone, assuming a unit gradient and a 5% specific retention, predict it would require 106 yr for groundwater to travel through 1000 m of aquifer: 56 yr to cross the fifth-order bounding surfaces and an additional 50 yr to travel the remaining 998.5 m. Similar calculations indicate that it would take ~284 and 506 yr for water to travel 1 km in the best reservoir quality Star Point Sandstone facies (foreshore and upper shoreface, respectively). A single surface of extremely low permeability would significantly increase travel times. Because many horizontal travel distances are more than 1 km and the reservoir-quality sandstones are not laterally continuous, these calculated long travel times for optimal aquifer

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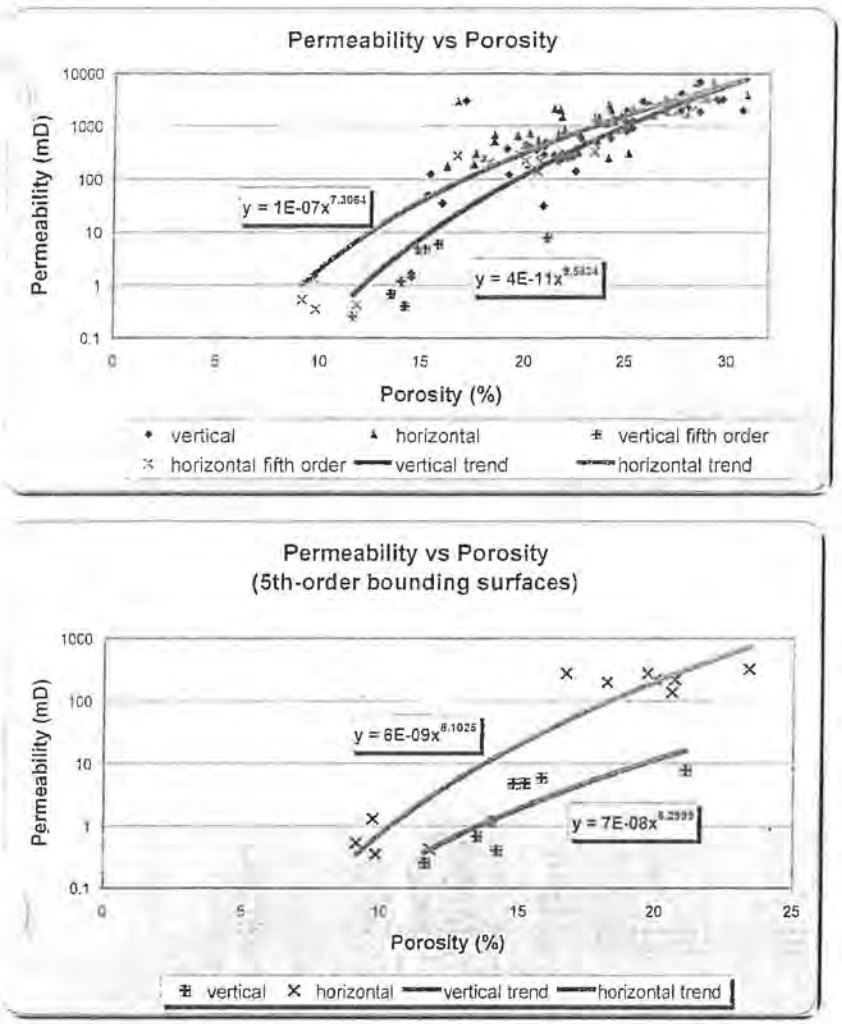

Figure 15. Scatter plots of permeability versus porosity from 120 cores of Castlegate Sandstone: A) all data, and B) fifth-order bounding surfaces only; md—millidarcy.

conditions are consistent with mean ^{14}C groundwater residence times of 500–20,000 yr.

Slow travel times in the Star Point Sandstone are confirmed by the ^{14}C ages of water in two wells completed at the Energy West Mine. The up-gradient and down-gradient wells have mean ^{14}C ages of 1000 and 6000 yr, respectively. Because geologic evidence suggests the two wells intercept groundwater along the same flow line, piston-flow travel times can be calculated using the method described by Mook (1980):

$$\Delta T = 8270 \ln(a^{14}_{up}/a^{14}_{down}) = 5,300 \text{ yr} \quad (1)$$

where:
ΔT is travel time (in years), a^{14} is ^{14}C activity of up-gradient sample, a^{14} is ^{14}C activity of down-gradient sample.

Assuming a travel time of 5300 yr and a distance between the wells of 6.5 km, it takes ~960 yr to travel 1000 m.

Fault-related groundwater, with initial inflows as great as 325 l s^{-1}, have been encountered in the Soldier Creek, Skyline, Genwall, Energy West, and SUFCO Mines and are responsible for several notable springs in the Star Point Sandstone. These groundwaters issue from damage zones associated with the extensive network of high-angle normal faults (Fig. 2). In-mine discharge rates decline rapidly after initial encounter and many completely cease. Groundwater ages of in-mine discharges are related to distance from cliff faces and graben structures. Groundwater ages range from modern, containing measurable tritium, to 12,000 ^{14}C yr (Fig. 12). Young fault-related groundwater only occurs along fault reaches where the stress field associated with the outward expansion of cliff faces creates aperture in the damage zone that can communicate with the surface. Elsewhere along the damage zone, the fault water does not contain tritium and has older ^{14}C ages. Damage-zone groundwater is compartmentalized and does not readily recharge adjacent aquifer-quality rock. For example, in the Genwall Mine, water issuing from a fractured sandstone channel in the mine roof, located 100 m from the Joes Valley fault (Fig. 2), contained 0.95 TU, indicating hydraulic communication with surface water. Elsewhere, water in the roof channel sandstone, located near the fault, had 0 TU and older ^{14}C ages. Water issuing from the mining face, located ~60 m from the fault, also contained 0 TU and had a ^{14}C age of 2500 yr. Additionally, modern water in the damage zone did not impact the deeper Star Point Sandstone where a sample from a well, located ~60 m from the fault, contained 0 TU and had a ^{14}C age of 5000 yr.

Skyline Mine fault-related inflows that are located away from an outward expanding cliff face or major damage zone lack hydraulic communication with modern surface water. In-mine inflows of ~325 l s^{-1} persisted for more than six months from the extensive damage zone. In-mine samples had essentially 0 TU and ^{14}C ages of 6000 to 12,000 yr. Water from a surface well drilled into the fault zone had 0.17 TU (near the detection limit) and a ^{14}C age of 4600 (Fig. 12).

Two significant Star Point Sandstone springs (Big Bear and Birch, Figs. 4D and 5D) discharge water from parallel faults, which bound the Co-Op Mine. In Figure 4D, Big Bear is one of the three Star Point springs. Although the faults are only ~900 m apart and extend for several km, they do not have hydraulic communication with each other. Based on several sampling events at different sampling locations, Big Bear Spring discharge contains anthropogenic ^{3}H and has 14–17 TU. Birch Spring discharges a mixture of old water (^{14}C age of 1100 to 3600 yr) and modern water (0.33 to 1.13 TU; Fig. 12). The groundwater ages and seasonal and climatic responses indicate that Big Bear Spring discharges modern recharge water. Birch Spring mostly discharges older water and does not have seasonal responses, although it appears to respond to long-term climatic effects. Water from one in-mine Star Point Sandstone well had a ^{14}C age of 3000 yr and contained 0.22 TU.

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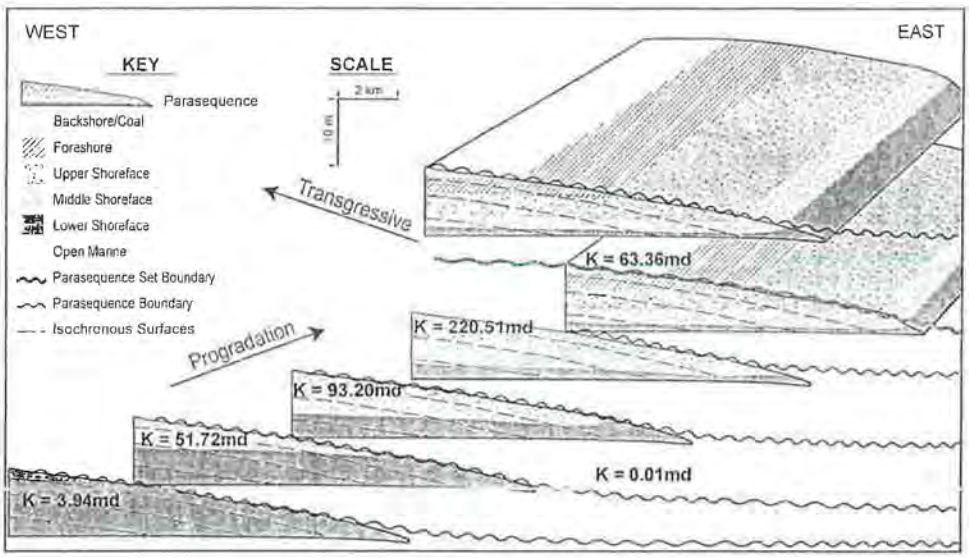

Figure 16. Schematic diagram of parasequences in Star Point Sandstone showing average horizontal permeability of Star Point sandstone facies. Diagram is not to scale; md—millidarcy.

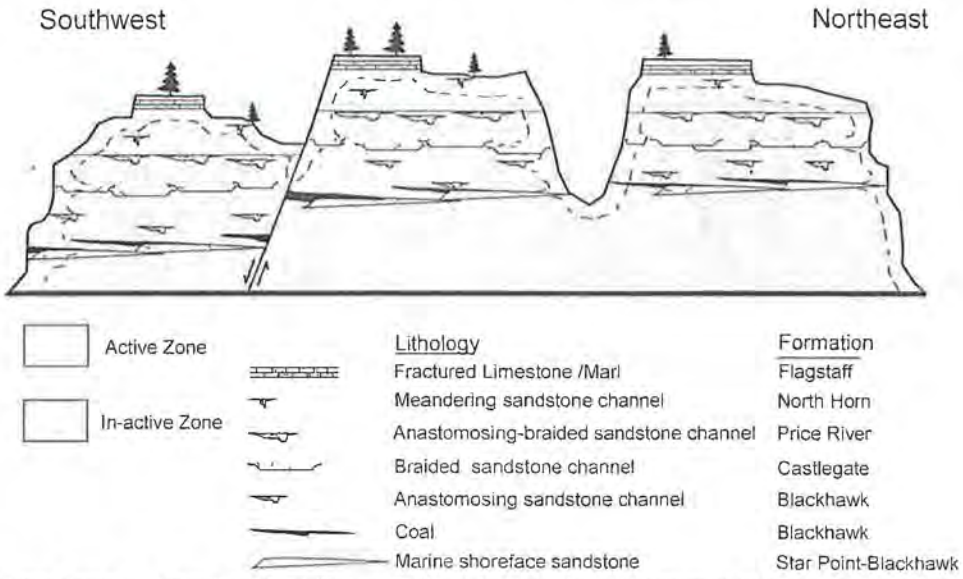

Figure 17. Conceptual model of hydrogeologic pathways. Active groundwater zone is exposed to meteoric water. Inactive groundwater zone is characterized by isolated reservoir quality sandstone disconnected from near-surface waters.

and therefore could have an affinity with Birch Spring. However, another nearby in-mine Star Point Sandstone well has a ^{14}C age of 900 yr and 0 TU.

DISCUSSION AND CONCLUSIONS

Two fundamentally different types of groundwater systems occur in the mountainous terrain of the Wasatch Plateau and Book Cliffs: shallow and deep. Shallow-circulating groundwater is envisioned in the traditional sense of groundwater flow. Recharge water becomes progressively older as it moves in the subsurface along saturated flow paths until it ultimately discharges as springs and seeps. Shallow circulating, short flow-path systems respond rapidly to seasonal and climatic variability. Locally, bedrock lithology controls solute compositions of the waters, but bedrock type does not control overall flow patterns.

Deep-circulating systems are encountered in mine openings as much as 700 m below ground surface. Most in-mine groundwater discharges from sandstone channels in mine roofs, although occasionally upwelling from the underlying Star Point Sandstone occurs.

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In-mine hydrographs, δ^2H and $\delta^{18}O$ isotopic compositions, and ^{14}C groundwater "ages" demonstrate that deeply circulating groundwater systems have poor hydraulic communication with near-surface groundwater. These deep groundwater systems dewater fairly rapidly when encountered. Geochemical evolution modeling indicates that the potential for vertical migration of groundwater between the surface and bedrock formations and between bedrock formations is limited. This limited vertical migration suggests that appreciable recharge water tends to move laterally and down dip within the formation.

The two types of groundwater systems can be described by a simple conceptual model involving both active and inactive flow regimes (Fig. 17). The active regime includes all near-surface exposures, regardless of lithology. The near surface extends 75–150 m below ground surface and 150–300 m into cliff faces. Many mine entries are wet near the surface and all are dry at distances greater than ~150 m from the mine opening. In the active region, fractures with aperture, weathered rock, and matrix flow in fluvial sands control groundwater flow. Fault zones occasionally extend the active zone from the surface to deeper regions. The active zone is in direct hydraulic communication with seasonal recharge. Most open voids, including matrix and fractures, that are located below the vadose region are saturated.

The inactive zone includes most of the interior regions of the Wasatch Plateau and Book Cliffs, including most mine workings. Exploration drilling and in-mine test holes indicated that much of the void space, including matrix and fractures, is not water-saturated. In-mine groundwater occurs in both vertically and horizontally isolated fluvial channel sands that have limited hydraulic communication with the surface. Most groundwater inflow is restricted to aquifer-quality sandstones. Some channels are fully saturated and others are only saturated in their lower portions. When encountered in mine workings, these sandstone channels usually drain quickly. The coal seams, clays, and silts are barriers to vertical flow. This suggests fracture flow in a system of poorly connected fractures or relatively isolated regions of matrix flow. Permeability and porosity data suggest that groundwater ages in the Star Point and Castlegate Sandstones are consistent with matrix flow, limited by fifth-order bounding surfaces and facies bounding surfaces. The relationship between fracture and matrix flow is currently being investigated.

Fault-related groundwater flows occur in fault damage zones, and most deep fault-related flow does not have rapid hydraulic communication with the surface. Rapid communication between the active zone and deep fault related flow, as evidenced by ^3H in the inactive zone, only exists where the stress field is such that fault-related fracture apertures can extend to surface as the result of outward expanding cliff faces or in complex fault damage zones.

Patterns of inactive zone groundwater flow do not occur in the traditional sense and are difficult to define. The ^{14}C ages of 20,000 yr or less suggest that groundwaters exist in slowly flowing systems (i.e., groundwater has finite ages). Yet, other data suggest that inactive zone groundwater occurs in discrete bodies that have extremely limited or no communication with annual recharge. Groundwater residence times have not been observed to progressively lengthen along plausible flow paths or become progressively older or younger as bodies of groundwater drain into mine openings. In the Wasatch Plateau and Book Cliffs, we suggest that recharge occurs during very wet climatic episodes and/or slowly along unsaturated fracture flow paths. Because inactive zone groundwater does not have an infinite age, it must discharge to the surface. Deep seepage is not plausible because of the thousands of feet of the very impermeable underlying Mancos Shale. Discharge locations and mechanism remain problematic. Only a few isolated springs, often fault-related and sometimes thermal, discharge old groundwater.

Beneath the coal horizons, the shoreface sandstones of the Star Point Sandstone are largely in the inactive zone and support groundwater flow. Generally, there is limited hydraulic communication between sand sheets. As with younger strata, active zone groundwater flow in the Star Point Sandstone is largely limited to fracture flow and the most significant flows are fault-zone related.

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Evaluation of the Factors Contributing to the TDS in Mine Discharge Water - Report

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Final Report

Evaluation of the Factors Contributing to the TDS in SUFCO's Mine Discharge Water

November 20, 1993

Mayo and Associates
P.O. Box 1960
Orem, UT 84059

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Prepared by

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Appendix A - Report on cation-anion balances
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Evaluation of the Factors Contributing to the TDS in SUFCO's Mine Discharge Water

BACKGROUND AND PURPOSE

The total dissolved solids (TDS) of the discharge water from the SUFCO Mine(PT003) has been increasing since early-1990 (Figure 1). Between January 1990 (month 121) and July 1993 (month 162), the mean TDS increased from about 650 mg/l to about 850 mg/l. Since mid-1991 the discharge has exceeded SUFCO's Utah Pollution Discharge Elimination System (UPDES) TDS limit of 800 mg/l.

The purpose of this investigation is to determine the factors responsible for the elevated TDS.

METHODS OF INVESTIGATION

Historical mine water quality and discharge data were obtained from SUFCO. Results of an early 1993 water quality sampling program performed by SUFCO personnel were evaluated. Approximately 50 roof drips and floor waters were sampled as part of this initial investigation. Because most of the water quality data had large cation-anion balance errors, this data set was not

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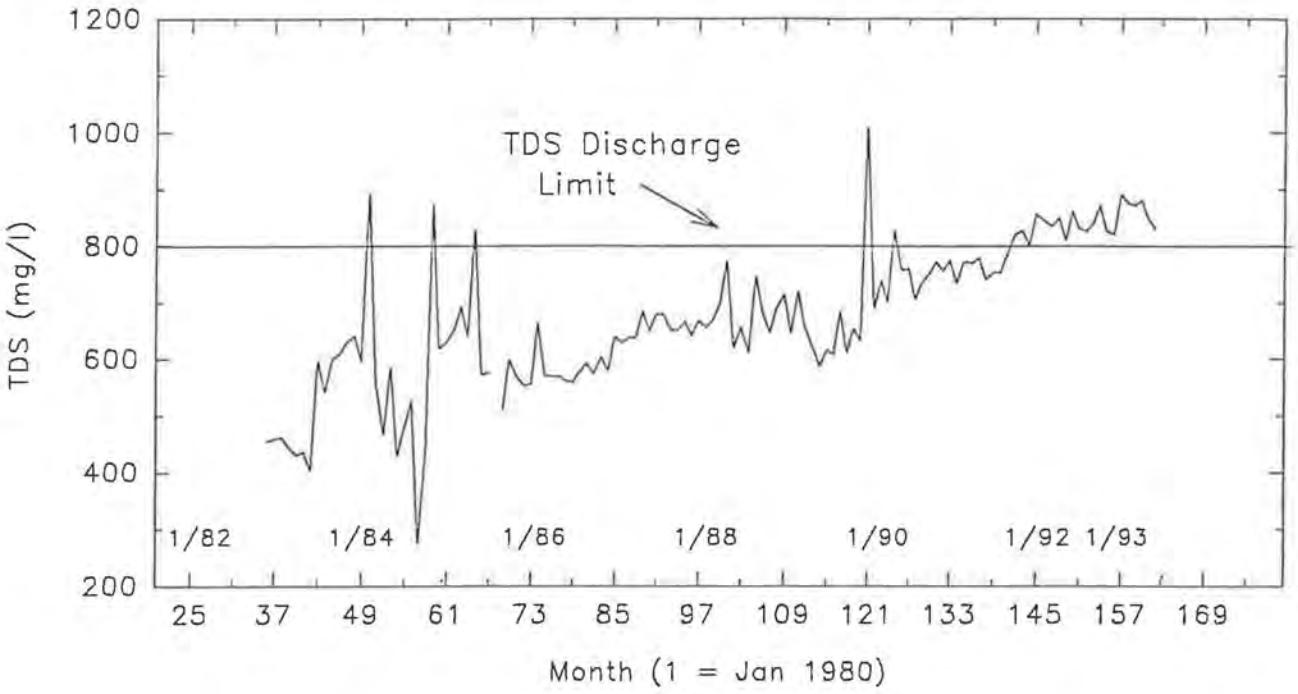
Figure 1 TDS hydrograph of SUFCO mine discharge from discharge point PT003.



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useful for quantitative evaluation. The source of the cation-anion balance errors was subsequently investigated by Mayo and Associates and the problem has been resolved (Appendix A).

A preliminary analysis of the existing data suggested that the elevated TDS of the mine discharge water was due to elevated TDS, particularly SO_4^2 , of the roof drip water in the new portion of the mine. This new mining area is located east of the surface feature Quitchupah Creek. Based on preliminary analysis of the existing data a plan of investigation was designed and implemented. The plan consisted of the following elements:

1. The collection of water quality samples from roof drips and floor waters at selected locations in the mine and at the mine discharge point PT003. Samples were collected on April 12 and 13, 1993. Samples were analyzed in the field for pH and temperature. Major ions and TDS concentrations were determined by Mountain States Analytical Laboratory in Salt Lake City, Utah. Stable isotopic analysis for δ^2H, $\delta^{18}O$, $\delta^{13}C$, and $\delta^{34}S$ were performed by Geochron Laboratories in Cambridge, Massachusetts. A few roof samples were also analyzed for the unstable isotopes ^3H and ^{14}C by Geochron Laboratories.

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Water samples were collected and analyzed following U.S.E.P.A. (1981) procedures. Solute data were plotted on a trilinear (Piper, 1944) diagram for visual inspection. Saturation indices were calculated with the computer code WATEQF (Plummer and others, 1976). Isotopic samples for δ^2H, $\delta^{18}O$, and ^3H were collected and preserved in sealed glass bottles. Isotopic samples for $\delta^{13}C$, $\delta^{34}S$, and ^{14}C were precipitated with $BaCl_2$.

2. A floor-water budget for the sampling period was developed by SUFCO personnel.

3. The geochemical and other data were analyzed by graphical, statistical and computer methods to:
   a. characterize mine hydrogeology,
   b. determine mass contributions of TDS of each potential source, and
   c. evaluate the potential for TDS changes in future mine discharge waters.

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OVERVIEW OF MINE OPERATIONS

Prior to 1985 mining operations only used continuous mining machines. These machines created the traditional room and pillar mine openings. The continuous mining machine makes openings similar to tunnels, called rooms, and the pillars are walls separating the rooms. Longwall mining requires prior development by continuous mining machines parallel to the direction of longwall mining along the entire length of the area to be longwall mined. In October 1985 SUFCO added a longwall mining machine to the existing inventory of continuous mining machines. Longwall mining has been conducted in three separate regions of the mine, herein designated as Longwall Areas 1, 2 and 3 (Figure 2). A brief history of each area follows:

Area 1 - mined from October 1985 to December 1989,

Area 2 - mined from January 1990 to January 1992, and

Area 3 - mined from February 1992; mining continues to date. Initial development for longwall mining began in December 1990.

Although the average height of the coal seam is 13.5 feet, the average height of mine openings is 9 feet. Coal is left in the floor and ceiling of mine openings to increase roof stability and ensure that foreign material does not mix with the mined coal.

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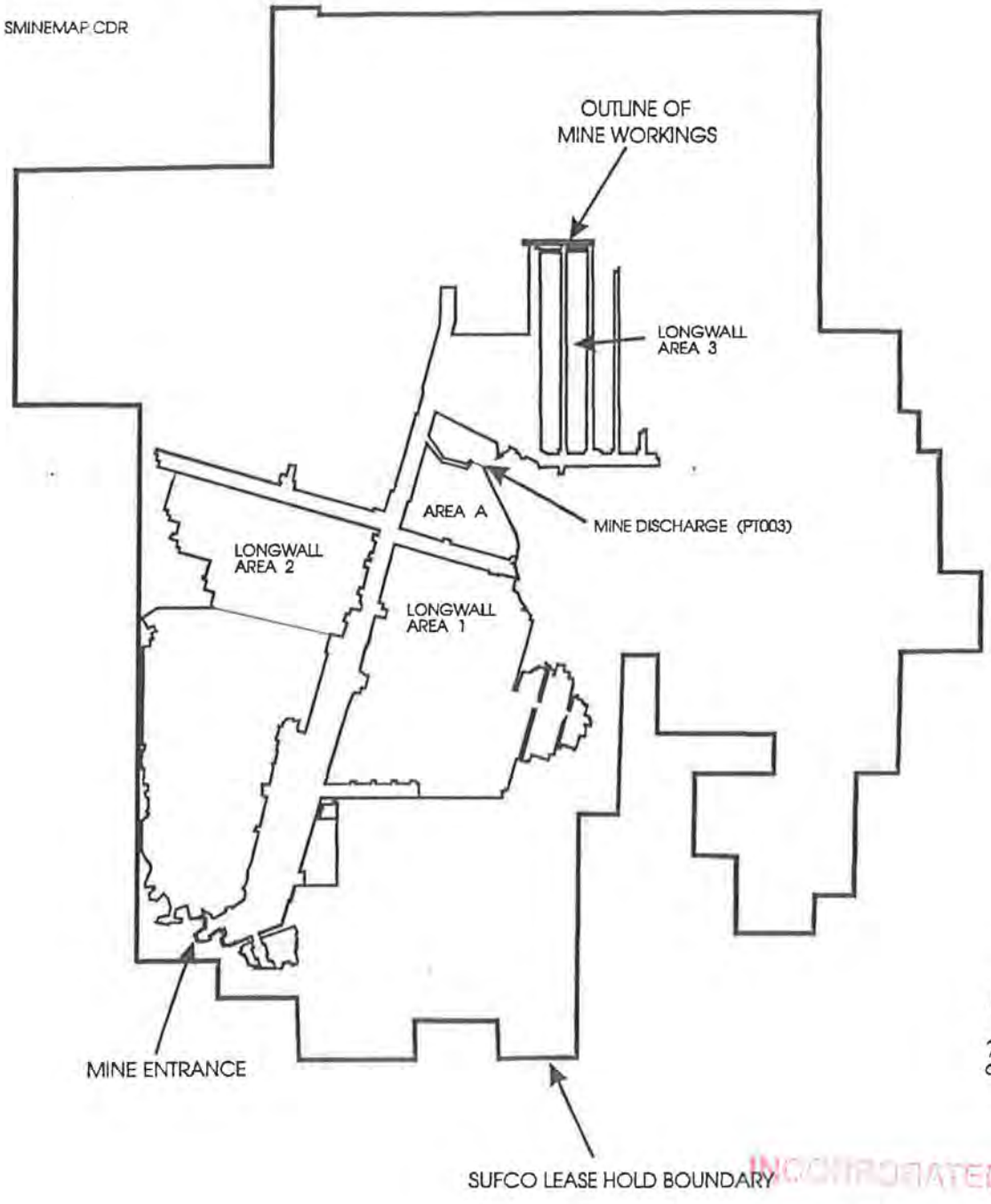
Figure 2 Map showing the location of mine workings relative to the SUFCO lease area. Longwall Areas 1, 2, and 3, and Area A are described in the text.



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The gentle regional dip of the bedrock results in mine tunnels and longwall openings that are nearly horizontal.

Coal is removed from the mine by means of a conveyer belt. Some mine water is used to suppress coal dust on the conveyer belt and in the truck loading area located outside the mine.

Continuous miners and the longwall miner create openings with fundamentally different structural properties. Continuous miners bore tunnels averaging 9 feet tall and 18 feet wide. Blocks of unmined coal (pillars) are left between individual tunnels. With appropriate shoring of weak sections these tunnels can remain open indefinitely. Old mined areas are either used as transportation and ventilation routes or are sealed where they connect with open tunnels used in mining operations.

Longwall mining creates openings 7 to 13 feet tall and up to 750 feet wide. The roof of the longwall mined area is unstable and collapses within hours to days after being mined. The net effect of longwall mining is to create a large rubble zone.

Until June 1993, all exposed mine floor, wall, and roof areas were dusted with gypsum rock dust ($CaSO_4 \cdot xH_2O$) to retard fire and prevent explosions. In July 1993 magnesium limestone $Mg_xCa_x(CO_3)_2$ was substituted for gypsum. Dusting is a continuous

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process in the open mine area. New areas are immediately dusted, and previously dusted areas are redusted as needed to decrease the bulk combustible content and replace dust lost to flowing mine waters.

The movement of water in the mine is managed by a system of collecting (sumps) and pumping stations, pipes, and free flow along the mine floor. The system is periodically modified as new mining proceeds.

The longwall mining machine uses hydraulically operated longwall shields to support the roof during mining. Longwall shields are powered by emulsion fluid consisting of 95% water and 5% soluble oil. Until a fugitive emulsion collection systems was install in June 1992 and became fully operational in August 1992, some emulsion fluid discharged into Longwall areas 1 and 2. The exact amount of fugitive fluid is hard to determine because it depends on the number of valves by-passing and the frequency of changes in mining heights. Only minimal amounts of emulsion currently leak from the longwall mining machine.

The emulsion is organic-based containing substantial amounts of sulfate (SO_4^{2-}), sodium (Na^+), and other inorganic ions. The exact composition of the emulsion used in Longwall Areas 1 and 2 is

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unknown. The inorganic content of currently used emulsion is listed in Appendix B.

Mining operations sometimes result in local low spots in the floor of the mine. In areas where water flows on the mine floor, these low spots become small ponds. Crushed carbonate rock is used to fill the ponded areas.

GEOLOGIC AND HYDROGEOLOGIC SETTING

Geology

The SUFCO mine is located approximately 30 miles east of Salina, Utah, in the High Plateaus Section of the Colorado Plateau Physiographic Province. The mine property encompasses approximately 17,000 acres. The surface topography consists of a rolling upland plateau that is deeply dissected by two major tributaries of Quitchupah Creek. The northwest trending North Fork of Quitchupah Creek bisects the mine property in half, and the west trending Convulsion Canyon forms the southern boundary of the mine property (Figure 3). The confluence of the two tributaries lies south of the mine property. Surface elevation of the plateau ranges from about 8,400 to 8,500 feet. Duncan Mountain and Big Ridge rise to about 9,200 feet along the western

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Table 1 Chemical and isotopic analyses of roof drip, floor water, and the mine discharge water taken during the April 12 and 13, 1993 sampling period.

Sample #	Location	T	pH	TDS* mg/l	TDS meq/l	meq/l Ca	Mg	Na	K	HCO3	SO4	Cl	o/oo 18O	2H	13C	34S	TU 3H	pmc 14C
						Roof Drips Longwall Area 3												
R1	4efacerd		7.95	460	16.96	3.50	4.20	0.72	0.11	5.46	2.46	0.51	-16.4	-122	-10.1	19.3		
R2	rebuild	11.5	7.60	700	25.77	6.85	5.41	0.62	0.10	8.17	3.98	0.64	-16.4	-123	-5.6	8.9	<3.0	7.2 • 1.2
R3	8L4EC34R		7.40	570	20.00	5.00	4.30	0.60	0.10	6.20	3.30	0.50	-16.5	-127	-7.5	10.7		
R4	NMRD	11.0	7.25	500	17.40	4.40	3.60	0.60	0.10	5.50	2.80	0.40	-16.6	-128	-7.7	11.6		
R5	nmfc210		7.65	480	17.64	4.42	3.57	0.71	0.06	5.86	2.56	0.46	-17.3	-128	-12.1	13.6	1.1 • 2.4	
R6	quitchrd		7.95	570	21.62	5.23	4.97	0.52	0.05	6.61	3.14	1.10	-17.2	-129	-6.6	8.0		
mean		11.3	7.63	547	19.90	4.90	4.34	0.63	0.09	6.30	3.04	0.60	-16.7	-126	-8.3	12.0		
std			0.26	80	3.09	1.03	0.67	0.07	0.02	0.93	0.51	0.23	0.4	3	2.2	3.7		
						Roof Drips Longwall Area 2												
R7	3WC62rd	14.0	7.65	290	10.40	2.70	1.90	0.50	0.00	4.30	0.70	0.30	-17.5	-130	-9.9	12.7		
R8	3wc44rd	13.0	7.60	290	10.40	2.70	1.80	0.50	0.00	4.40	0.70	0.30	---	---	---	---	1.1 • 2.4	
R9	3wc16rd		7.55	330	10.80	3.10	2.00	0.30	0.00	4.40	0.70	0.30	-17.4	-132	-9.6	15.9		
mean		13.5	7.6	303	10.53	2.83	1.90	0.43	0.00	4.37	0.70	0.30	-17.5	-131.0	-9.8	14.3		
std			0.0	19	0.19	0.19	0.08	0.09	0.00	0.05	0.00	0.00						
						Roof Drips Longwall Area 1												
R10	PT062rd	10.0	7.65	370	14.60	4.40	2.50	0.30	0.00	6.00	1.10	0.30	---	---	---	---		
R11	3ec8		7.25	380	14.59	4.20	2.71	0.38	0.04	5.62	1.33	0.31	-17.5	-127	-10.1	8.2		
R12	rmc128		8.05	400	15.23	4.36	2.84	0.32	0.03	6.02	1.33	0.33	-17.2	-125	-7.7	11.4	3.3 • 2.4	
R13	2[illegible]1rd		7.90	430	17.42	3.45	4.71	0.37	0.08	6.37	1.37	1.07	-16.9	-123	-11.2	9.3		
mean		10.0	7.7	395	15.46	4.10	3.19	0.34	0.04	6.00	1.28	0.50	-17.2	-125.0	-9.7	9.6		
std			0.3	23	1.16	0.38	0.89	0.03	0.03	0.27	0.11	0.33	0.2	1.6	1.5	1.3		

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Table 1 con't

Sample #	Location	T	pH	TDS* mg/l	TDS meq/l	meq/l Ca	Mg	Na	K	HCO3	SO4	Cl	o/oo 18O	2H	13C	34S	TU 3H	pmc 14C
						Roof Drips Longwall Areas 1 and 2												
mean		5.75	7.66	349	13.00	3.47	2.55	0.39	0.02	5.18	0.99	0.40	-12.27	-90.54	-6.88	8.38		
						Floor Waters												
F1	4Efp		7.60	2620	74.40	24.20	6.70	5.20	0.10	3.00	34.50	0.70	-15.0	-107	-4.3	16.0		
F2	8l4eface		7.65	1120	34.31	6.78	5.82	3.98	0.17	6.45	10.50	0.61	-16.9	-126	-7.6	13.8		
F3	nmface	11.0	7.25	2380	69.38	14.20	5.81	14.60	0.27	3.46	26.70	4.34	-15.9	-125	-6.9	16.3		
F4	NM4smpwp	11.0	8.00	710	19.60	5.00	3.80	0.90	0.10	5.20	4.20	0.40	---	---	---	---		
F5	NM4smpmw		7.50	850	26.60	5.20	5.20	2.90	0.10	5.00	7.70	0.50	-16.7	-126	-9.3	8.3		
F6	LWBAirpm	12.0	8.10	880	27.20	4.90	5.40	3.10	0.10	5.20	8.00	0.50	---	---	---	---		
F7	nm3sump	12.0	7.80	1400	42.62	9.80	7.50	3.49	0.12	4.94	16.00	0.77	-16.4	-122	-5.4	12.2		
F8	6nsump	15.0	8.10	770	22.60	4.02	3.99	3.15	0.10	6.65	4.33	0.36	-17.2	-124	-9.1	11.4		
F9	3wsump	14.0	7.75	630	22.94	4.15	3.85	3.30	0.09	7.13	4.08	0.34	---	---	---	---		
F10	1LNMseal	15.0	7.15	790	25.80	5.20	4.40	3.10	0.10	8.20	4.20	0.60	-17.3	-132	-11.7	10.6		
F11	6eseals		7.15	1170	37.39	7.85	8.15	2.48	0.14	8.99	9.35	0.43	-17.2	-122	-8.2	9.3		
F12	1L6ENS	15.0	7.05	1890	60.60	10.90	12.80	5.70	0.20	10.10	20.40	0.50	-17.3	-125	-8.1	6.8		
mean		13.1	7.59	1268	38.62	8.52	6.12	4.33	0.13	6.19	12.50	0.84	-12.5	-92	-5.9	8.7		
std			0.36	647	18.37	5.60	2.42	3.31	0.05	2.06	9.54	1.06	7.2	54	3.8	5.7		
						Mine Discharge												
D1	PT003s	12.0	7.15	850	27.41	5.27	4.97	3.24	0.12	5.58	7.74	0.49	-17.0	-130	-6.1	9.9		
D1	PT003e	12.0	7.25	840	25.71	5.02	4.78	3.14	0.11	5.50	6.66	0.50	-16.9	-128	-8.2	9.9		
mean		12.0	7.20	845	26.56	5.15	4.88	3.19	0.11	5.54	7.20	0.50	-17.0	-129	-7.1	9.9		
std		0.0	0.05	5	0.85	0.13	0.10	0.05	0.00	0.04	0.54	0.00	0.0	1	1.1			

* TDS of sample R2 has been assigned a content of 700 mg/l; laboratory value was 1340 mg/l; see text for discussion

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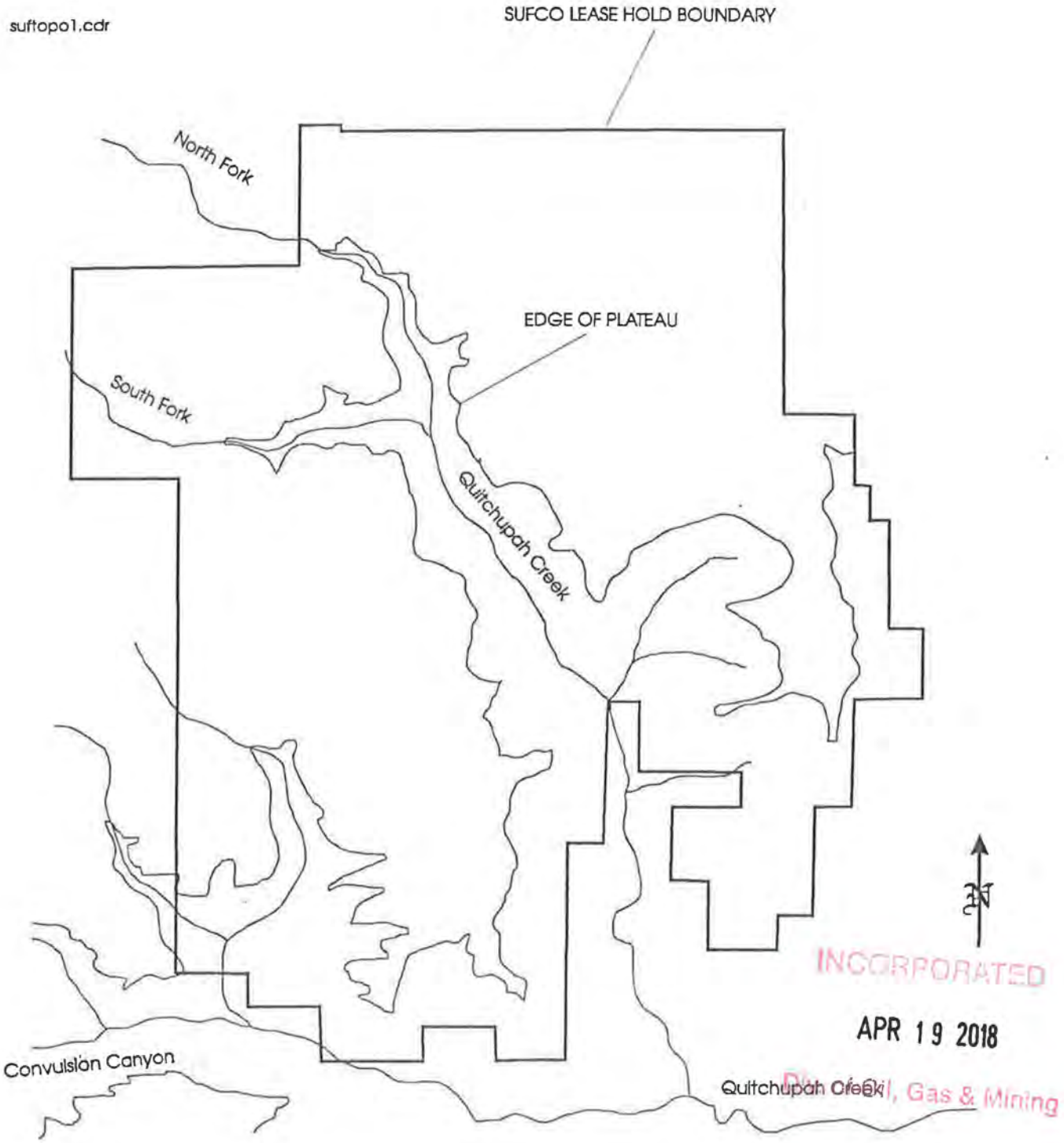
Figure 3 Map showing the major drainages and general topography of the SUFCO mine lease area.



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and northern edges of the mine property, respectively. The incised portion of the North Fork begins in the northwest portion of the mine property and cuts as much as 1,000 feet below the elevation of the plateau in the southeast portion of the mine property.

Six bedrock units are exposed on the mine property from the top of Duncan Mountain and Big Ridge to the bottom of the Quitchupah and Convulsion Canyons (Figures 4 and 5). From top to bottom the rock units are (Doelling, 1972):

(Tertiary-Cretaceous)

North Horn Formation - Variegated shales with subordinate sandstone, conglomerate and freshwater limestone; slope former; approximately 450 feet thick.

(Cretaceous)

Price River Formation, Upper Member - Gray to white gritty sandstone interbedded with subordinate shale and conglomerate; ledge and slope former; 400 to 600 feet thick.

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Figure 4 Generalized geologic map of the SUFCO mine lease area. Line A-A′ shows the location of cross section shown in Figure 5.

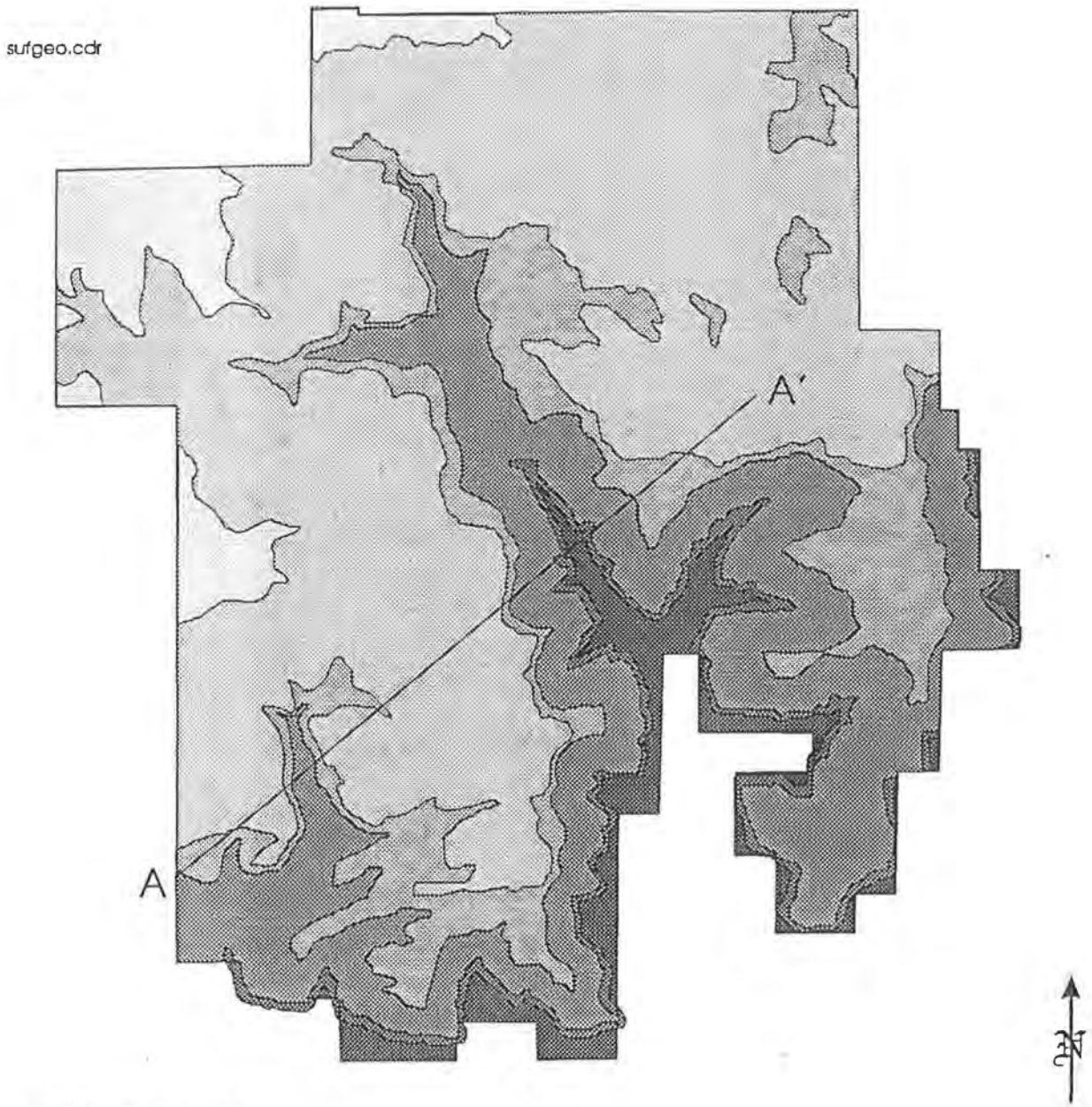

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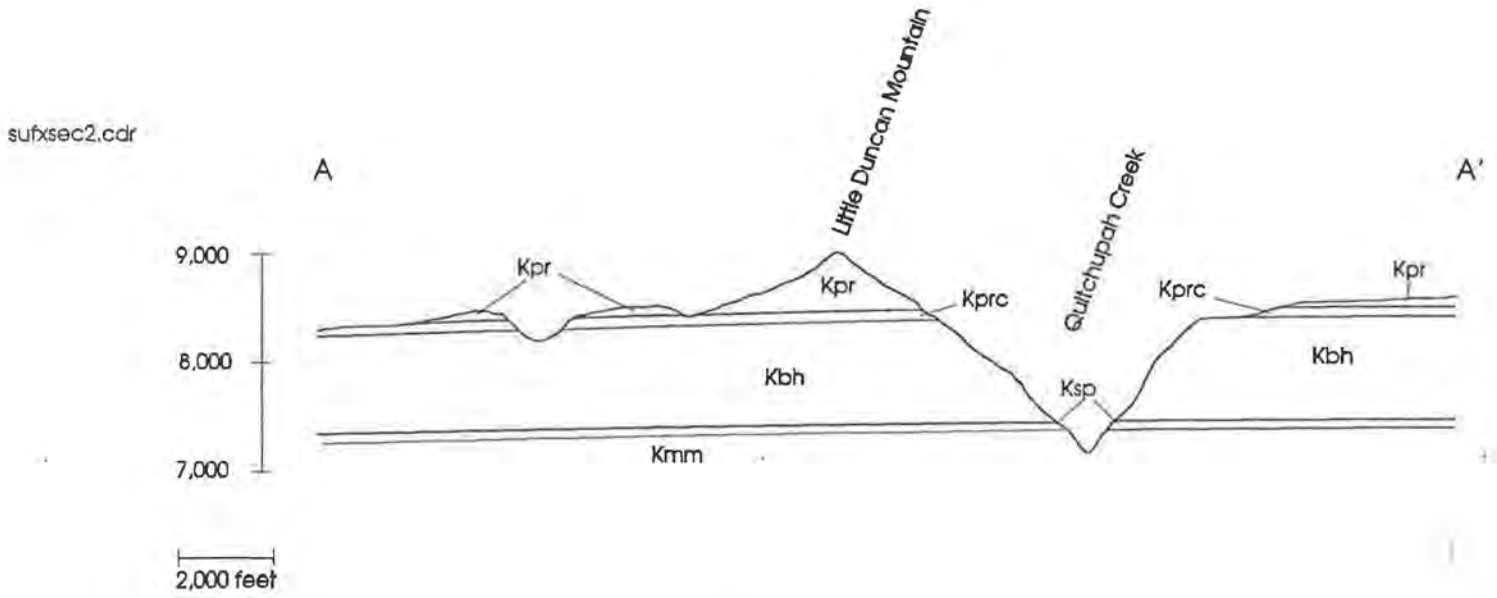
Figure 5 Northeast trending cross section across the SUFCO mine lease area. See Figure 4 for location.



Cretaceous

Kpr - Price River Fm. Upper Member

Kprc - Price River Fm. Castlegate SS Member

Kbh - Blackhawk Fm. Upper Member

Ksp - Blackhawk Fm. Starpoint SS Member

Kmm - Mancos Shale Masuk Member

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Price River Formation, Castlegate Sandstone Member - White to gray, coarse-grained conglomeratic sandstone; cliff former; approximately 100 feet thick.

(Unconformity)

Blackhawk Formation, Upper Member - Yellow to gray, fine- to medium-grained sandstone, interbedded with subordinate gray and carbonaceous shale, thick coal seams; approximately 800 feet thick.

Blackhawk Formation, Star Point Sandstone Member - Yellow-gray, massive cliff-forming sandstone, often in several tongues separated by Masuk Shale; approximately 80 feet thick.

Mancos Shale, Masuk Shale Member - Yellow to blue-gray shale, slope former; thickness exceeds 300 feet.

All bedrock units dip about 1.5° to 2° to the northwest (Figure 4). The Castlegate Sandstone forms the rim of the Canyons. The mine entrance is located along the north cliff face of Convulsion Canyon. The mine entrance is at an elevation of about 7,400 feet and is portalled into the Upper Hiawatha coal seam of the Upper Member of the Blackhawk Formation.

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The Upper Member of the Blackhawk Formation was deposited in a delta environment located landward of a barrier-lagoon complex. The Upper Member consists of interbedded sandstone, siltstone, shale, coal and rare limestone. Sandstone comprises approximately 65 percent, siltstone and shale 30 percent, and coal and limestone 5 percent of the thickness of the Upper Member. The sandstones are fine to medium-grained and tabular to lens-shaped with thickness from 2 to 50 feet and widths from 25 to 3,000 feet. The siltstones and shales are commonly interbedded and vary from 1 to 28 feet thick. Siltstones and shales generally bound the sandstones both vertically and horizontally (Marley and others, 1979).

The upper Hiawatha coal seam is located near the bottom of the Upper member of the Blackhawk Formation. The coal seam has an average thickness of 12 feet.

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Hydrology and Hydrogeology

The hydrology and hydrogeology of the coal producing region of the southern Wasatch Plateau has been investigated by Danielson and Sylla (1983), Danielson and others (1981), Lines (1985), Lines and Morrissey (1983), Price and Plantz (1987), and Seiler and Baskin (1988). A reconnaissance hydrogeologic investigation

of the Quitchupah Creek region has been performed by Thiros and Cordy (1991).

Two major tributaries of Quitchupah Creek dominate the surface drainage of the mine property and adjacent areas (Figure 3). Both the North Fork of Quitchupah Creek and the flow in Convulsion Canyon are perennial. Stream flows and water quality are monitored by SUFCO. Mine discharge waters issuing from PT003 are discharged into the North Fork of Quitchupah Creek.

Ground-water systems overlying the Hiawatha coal seam are poorly understood. Hydrostratigraphic units have not been defined; however, Thiros and Cordy (1991) have, in general terms, described the water-bearing characteristics of the overlying North Horn Formation, and Castlegate Sandstone and the Blackhawk Formation. A brief summary of their findings follows:

North Horn Formation - The North Horn Formation supports a significant ground-water system in the Ferron Mountain-Flagstaff Peak area, located about 4 miles north of the mine area. In this region about 90 percent of the inventoried springs and seeps discharge from the North Horn Formation. Only 1 spring discharges from the North Horn Formation near the SUFCO mine. Neither Thiros and Cordy (1991) nor Danielson and Sylla (1983)

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were able to determine if ground water in the North Horn Formation supports one or more hydraulically continuous aquifers or if the ground water is locally perched.

Thiros and Cordy (1991) concluded that much of the recharge to the North Horn Formation occurs west of the mine area in the upper portions of the Wasatch Plateau.

Price River Formation - Numerous springs issue from both the Upper and Castlegate Sandstone Members of the Price River Formation. Most of the springs issue from the base of the Castlegate Sandstone. Some of the ground waters issuing from the Castlegate Sandstone were identified as discharging from perched ground-water systems. A ground-water sample collected from East Spring (Castlegate Sandstone) had a ^{3}H content of 28.5 TU indicating ground-water recharge after 1953. Hydrographs of spring discharges show both seasonal and annual responses to precipitation.

Ground-water flow in the Castlegate Sandstone appears to be predominantly bedding controlled. Horizontally continuous water-bearing units have not been identified.

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Blackhawk Formation - Thiros and Cordy (1991) found that the Blackhawk Formation is "...usually saturated everywhere within the study area (mine area) except at outcrops at the edge of the plateau, in canyons incised into the plateau, and near the SUFCO mine where dewatering is occurring." They also suggest that impermeable layers within the Blackhawk Formation may create localized perched zones above a saturated zone. They do not, however, provide evidence for a continuous saturated zone or define the stratigraphic location or geometry of such a zone. They further suggest that the Blackhawk Formation is the principal source of water entering the SUFCO mine.

Because surface exposures of the Blackhawk Formation are limited, Thiros and Cordy (1991) suggest that the formation is largely recharged from vertical leakage through fractures in overlying rock units. They do not provide quantitative estimates of annual recharge or evidence supporting the idea of recharge from vertical leakage.

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VARIATIONS IN MINE DISCHARGE RATES AND TDS

Ground-water gradients in the mine are downward. Ground water is routinely encountered in the mine roof during mining. Most of this water issues from roof fractures, although some ground water issues from roof bolt holes drilled through the roof coal into the overlying rock units. Ground water is not encountered in the mine floor.

Because roof drip water is moved rapidly through the mine to the surface discharge location (PT003), the long-term record of the mine discharge rate and discharge TDS, combined with observational data regarding changes in roof drip rates, provides valuable insights into the hydrogeology of the Blackhawk Formation above the upper Hiawatha Coal seam.

Variations in Roof Drip and Mine Discharge Rates

The discharge rate of roof drips from recently mined areas tends to decline rapidly. Observations of individual fractures and the 10-year mine discharge hydrograph suggest that roof drip rates from recently mined areas decline rapidly. Although measurements of individual roof drip rates have not been routinely made, mine personnel report rapid declines in drip rates. Estimated changes

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in roof drip rates from the following two fractures are believed to be typical of the larger discharges (Kravits, Personal Communication):

Site (8L4E E3 C63)

6/6/93	40 gpm
7/7/93	15 gpm
8/9/93	10 gpm

Site R2 (Rebuild Station)

10/11/92	50 gpm
2/12/93	30 gpm
4/17/93	15 gpm
5/19/93	5 gpm
7/7/93	5 gpm
8/9/93	5 gpm

The 10-year mine discharge hydrograph has been plotted with monthly and 6-month running average data (Figure 6). The 6-month running average method helps smooth out monthly irregularities that result from: 1) changes in the mine floor water management system and, 2) the randomness inherent in taking discharge rate measurements only twice a month. Four conclusions may be drawn from the hydrographs:

1. The significant decline in discharge rate between months 95 and 116 (11/87 to 8/98) are the result of a change in the weir setting. It has subsequently been determined by SUFCO personnel that the weir readings

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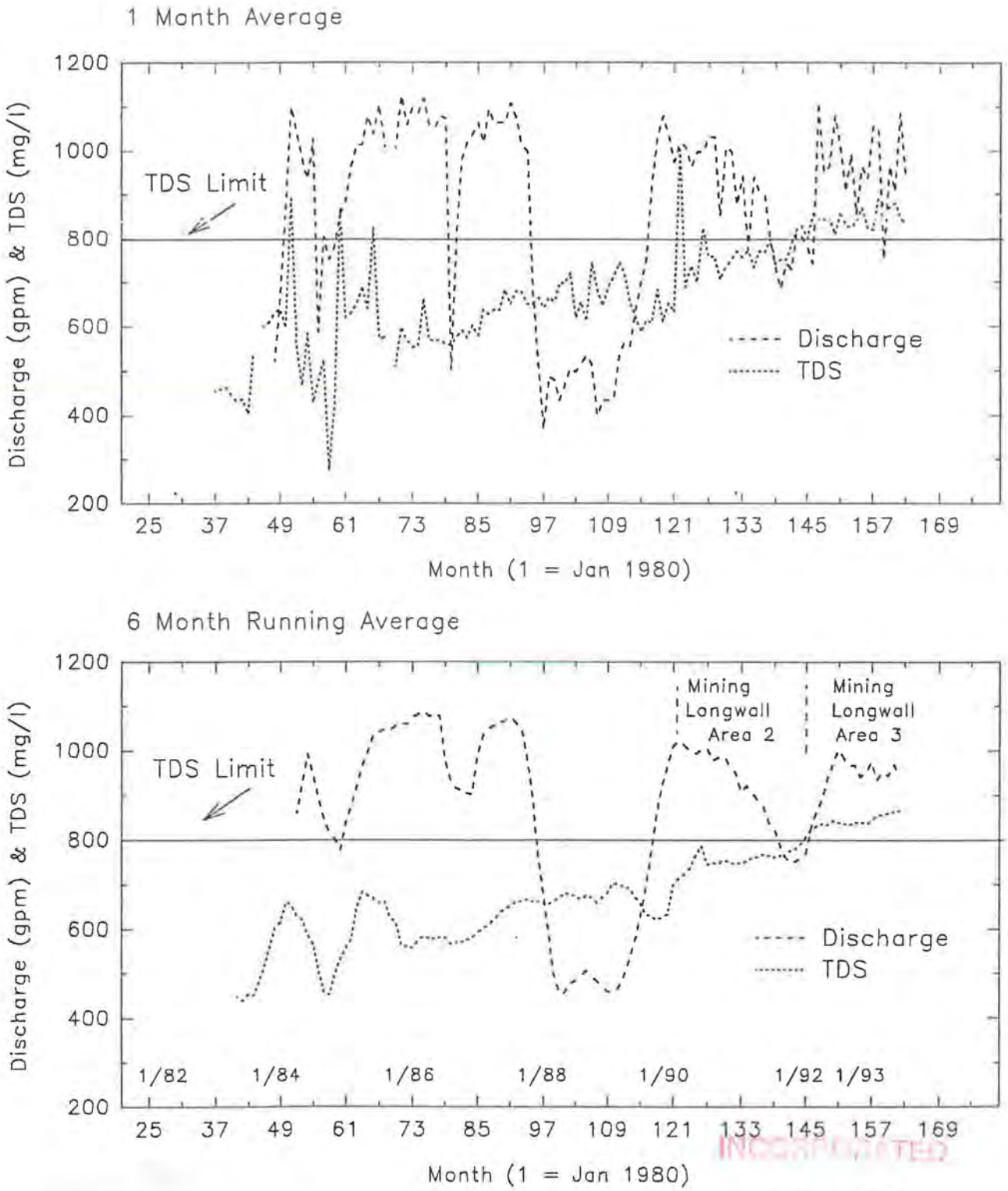
Figure 6 One month and six month running average discharge and TDS hydrographs of mine discharge water issuing from PT003.



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greatly underestimated discharge during this period (Kravits, Personal Communication). Therefore, the discharge data of this time period must be disregarded for quantitative analytical purposes.

2. The long-term maximum discharge rate from the mine is about 1,000 to 1,100 gpm. Seasonal variations are not evident in the hydrograph. Isotopic data are presented below which demonstrate that ground-water systems encountered by the mine are not quantitatively influenced by modern recharge and that discharge from the mine is not seasonally dependent.

3. Two cycles of hydrograph recession have occurred since 9/89 (month 117). Cycle 1 (9/89 to 3/92; months 117 to 147) corresponds to mining in Longwall Area 2. Cycle 2 (4/92 to present; months 148 to present) corresponds to mining in Longwall Area 3. The recession of Cycle 2 is best seen in the 6-month running average.

The cyclical character of hydrograph recessions is likely the result of the areally and vertically localized draining of ground water in hydraulic connection with the mining areas. Hydrograph recessions suggest that ground waters in hydraulic connection with each

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mining area are not part of a large horizontally continuous ground-water system. Instead, ground waters appear to occur in small regions that have limited horizontal hydraulic connection. Water chemistry data discussed in this report support this idea.

4. The quasi-steady state maximum discharge rate, the cyclical hydrograph recessions, and the fact that the mined area continuously increases suggest: a) the maximum discharge rate of the mine is approximately 1,100 gpm, b) in time, drainage from older mining areas will approach zero, and c) the mine discharge rate will decline substantially after the cessation of mining activities. These conclusions are predicated on coal production rates remaining relatively constant and the hydrogeology of new mining areas is similar to the hydrogeology of existing mining areas. The future interception of a major fracture or fractures which are hydraulically connected with aquifers located above the Upper Member of the Blackhawk Formation could change the hydrology of the mine.

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Variations in Mine Discharge TDS

TDS levels of mine discharge waters at PT003 are also plotted on the 1-month and 6-month running average hydrographs (Figure 6). TDS levels have been steadily increasing from about 550 mg/l in month 66 (July 1985) to about 850 mg/l in month 161 (June 1993). This trend is most easily observed in the 6-month running averages.

Although the overall trend of the TDS increase has been relatively steady, there are distinct variations in discharge TDS that correspond to drainage from Longwall Areas 2 and 3. The TDS declined substantially about the time mining in Longwall Area 2 began and then rapidly increased. There also appears to be an increase in TDS corresponding to the initial development of Longwall Area 3.

DATA COLLECTED DURING APRIL 1993 SAMPLING

The water quality sampling plan was designed to evaluate the contribution of each mining area on the total TDS of the mine discharge. Water quality sampling locations were selected to be representative of the spatial distribution of water quality entering

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the mine and water moving through the mine. Some desired sampling locations were either dry or physically inaccessible.

Explanation of Reporting Units and Terms

Water quality reporting units are: milliequivalent per liter (meq l^{-1}) for ionic solutes; milligrams per liter (mg l^{-1}) for laboratory TDS; and per mil ($^{o}/oo$) for stable isotopes. Copies of laboratory analytical reports are included in Appendixes B and C for solutes and isotopes, respectively. Stable isotopic reference standards are: Standard Mean Oceanic Water (SMOW) for $\delta^{2}H$ and $\delta^{18}O$; Pee Dee Formation Belemnite (PDB) for $\delta^{13}C$; and the Canyon Diablo meteorite (CD) for $\delta^{34}S$. The radioactive isotope ^{14}C is reported relative to percent modern carbon (pmc), and the radioactive isotope ^{3}H is reported in tritium units (TU). One TU is equivalent to 3.2 pCi l^{-1} (pico-Curies per liter).

Laboratory solute data have been converted to meq l^{-1} for analysis and reporting purposes (Tables 1 and 2). The meq l^{-1} unit allows direct comparison of reacting concentrations of cations and anions. For example, 1 meq l^{-1} of Ca^{2+} is the reacting equivalent of 1 meq l^{-1} of Mg^{2+} and SO_4^{2-}; in mg l^{-1} their equivalent concentrations are 20.0, 12.2, and 48.0, respectively. TDS is listed as both mg l^{-1} and meq l^{-1}. The mg l^{-1} is the reported

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Table 2 Summary of mean solute and isotopic analysis of roof drip, floor water, and mine discharge water taken during the April 12 and 13, 1993 sampling period.

			TDS	TDS	meq/l							o/oo			
Area	T	pH	mg/l	meq/l	Ca	Mg	Na	K	HCO3	SO4	Cl	18O	2H	13C	34S
							ROOF DRIPS								
Longwall Area 3															
mean	11.3	7.63	547	19.90	4.90	4.34	0.63	0.09	6.30	3.04	0.60	-16.7	-126	-8.3	12.0
std		0.26	80	3.09	1.03	0.67	0.07	0.02	0.93	0.51	0.23	0.4	3	2.2	3.7
Longwall Area 2															
mean	13.5	7.6	303	10.53	2.83	1.90	0.43	0.00	4.37	0.70	0.30	-17.5	-131.0	-9.8	14.3
std		0.0	19	0.19	0.19	0.08	0.09	0.00	0.05	0.00	0.00				
Longwall Area 1															
mean	10.0	7.7	395	15.46	4.10	3.19	0.34	0.04	6.00	1.28	0.50	-17.2	-125.0	-9.7	9.6
std		0.3	23	1.16	0.38	0.89	0.03	0.03	0.27	0.11	0.33	0.2	1.6	1.5	1.3
Longwall Areas 1 & 2															
mean	5.75	7.66	349	13.00	3.47	2.55	0.39	0.02	5.18	0.99	0.40	-12.27	-90.54	-6.88	8.38
							FLOOR WATERS								
mean	13.1	7.59	1268	38.62	8.52	6.12	4.33	0.13	6.19	12.50	0.84	-12.5	-92	-5.9	8.7
std		0.36	647	18.37	5.60	2.42	3.31	0.05	2.06	9.54	1.06	7.2	54	3.8	5.7
							MINE DISCHARGE								
mean	12.0	7.20	845	26.56	5.15	4.88	3.19	0.11	5.54	7.20	0.50	-17.0	-129	-7.1	9.9
std	0.0	0.05	5	0.85	0.13	0.10	0.05	0.00	0.04	0.54	0.00	0.0	1	1.1	

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laboratory content, and the meq l^{-1} is the sum of the cations and anions.

Saturation index (SI) is a calculated value based on the solute content and temperature of a water sample. It is a measure of the thermodynamic tendency of water either to dissolve or to precipitate a particular mineral and is often useful for evaluating the mineralogy of aquifers through which a ground water has traveled. SI is defined as:

$$SI = \frac{IAP}{K_{eq}} \qquad (1)$$

where IAP = the ion activity product and K_{eq} = the equilibrium constant of a specified mineral. Saturation is defined as log SI = 0.0 ± 0.1. Log SI < -0.1 means the water is undersaturated and the water has a thermodynamic tendency to dissolve the mineral. Log SI > +0.1 means the water is supersaturated and has a thermodynamic tendency to precipitate the mineral. The saturation index is normally calculated for the discharge temperature of the water. Discharge temperatures for many roof drips were not collected; a value of 11.5 °C has been used for SI calculations for these samples.

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The notations used for SI commonly include a subscript to denote the mineral phase. Notations used in this investigation are SI_a (aragonite: CaCO3), SI_c (calcite: CaCO3), SI_d (dolomite: $CaMg(CO3)_2$), SI_g (gypsum: $CaSO_4 \cdot xH2O$), SI_{an} (anhydrite: $CaSO_4$) and SI_h (halite: NaCl). Log P_{CO2} is the partial pressure of $CO_{2(g)}$ and Ca/Mg is the Ca^{2+}/Mg^{2+} molar ratio. The P_{CO2} content is listed in the tables as log P_{CO2} using the units atmospheres. Saturation indices and other parameters have been calculated using the computer code WATEQF (Plummer and others, 1976).

The stable isotopic composition of a sample is reported as the per mil ($^{o}/oo$) difference of the sample relative to the isotopic composition of a standard using the delta (δ) notation:

$$\delta = \frac{(R_{sample} - R_{standard})}{R_{standard}} \times 1000 \ (^{o}/oo) \qquad (2)$$

where R = $^{18}O/^{16}O$, $^{2}H/^{1}H$, $^{13}C/^{12}C$, and $^{34}S/^{32}S$. The δ notation is reported in terms of the heavy isotope in the ratio R (i.e., $\delta^{13}C$ for $^{13}C/^{12}C$).

Other isotopic terms and reference information are discussed as needed.

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Overview of Mine Water Geochemistry

Water quality and isotopic samples were collected from 13 roof drips, 12 floor waters, and the mine discharge. Because these data were collected during two consecutive days, they provide a clear picture of the contribution of each region of the mine to mine discharge TDS.

Sample collection locations are shown on Figure 7, and the geochemical data are listed in Table 1 and are summarized in Table 2. WATEQF calculated saturation indices and other parameters are listed in Table 3. Roof drips, floor waters, and mine discharge water are designated R1 through R13, F1 through F12, and D1, respectively. Sample D1s was collected at the start of the sampling period (4/12/93), and sample D1e was collected at the end of the sampling period (4/13/93).

The roof drips are from the water-bearing horizons in the overlying Blackhawk Formation. Their chemistries are representative of location specific mine waters prior to undergoing chemical reactions in the mine. The chemistries of the floor waters are representative of chemical changes to roof drip water that have occurred at various locations in the mine. The chemistry of the mine discharge water is representative of the weighted average chemistry of all the mine floor water.

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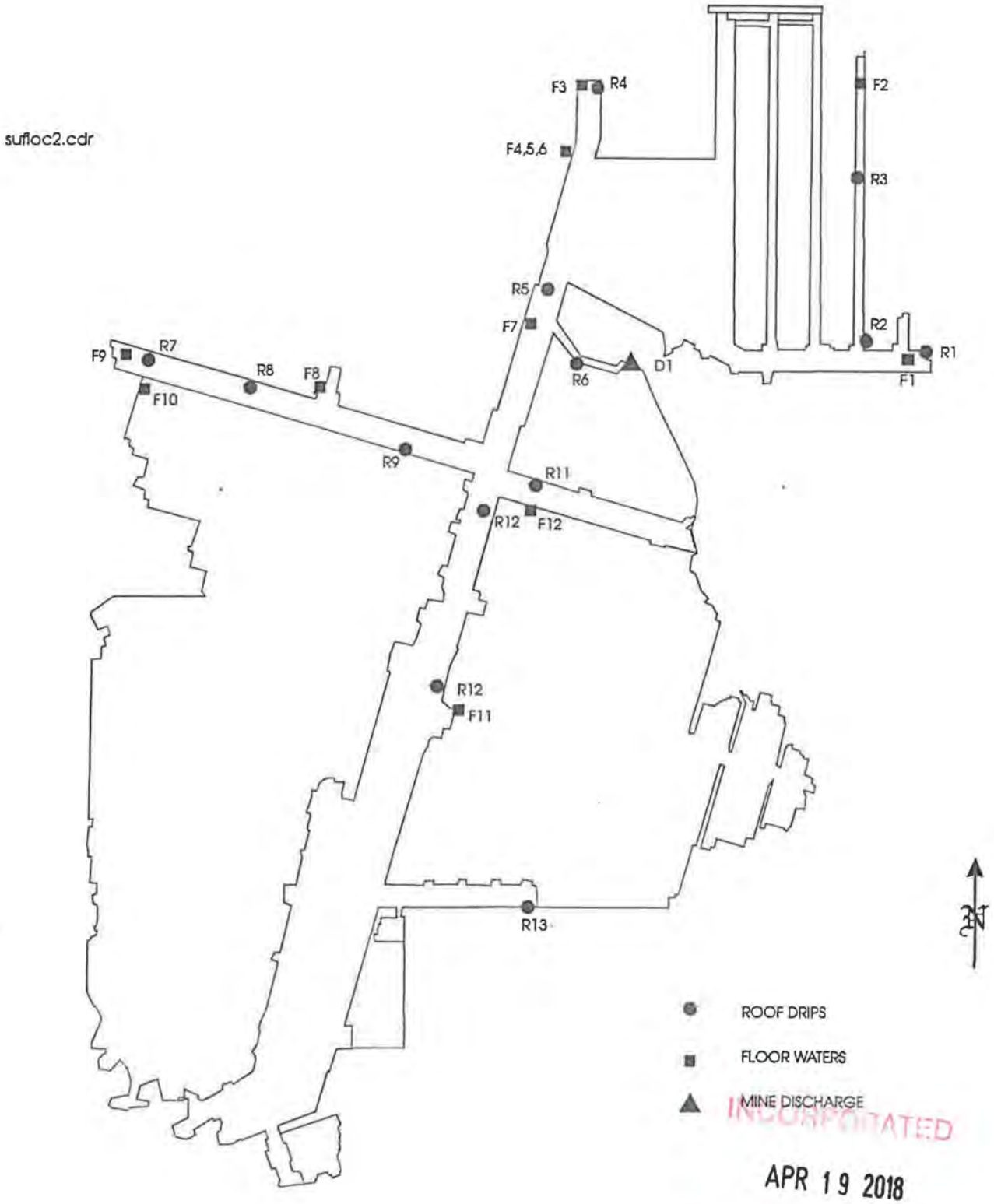
Figure 7 Roof drip (R), floor water (F), and mine discharge (D) sampling locations.



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Four distinct waters have been identified in the mine on the basis of their chemical compositions. The characteristics of these groups are described below. The four groups are:

1. Longwall Area 3 roof drips,
2. Longwall Area 2 roof drips,
3. Longwall Area 1 roof drips, and
4. floor waters

Roof Drip Water

Solute Chemistry

Roof drip waters entering the mine issue from three distinct hydrogeochemical units. The hydrogeochemical units have been identified on the basis of TDS and overall solute composition. The TDS (meq l^{-1}) vs. laboratory measured TDS (mg l^{-1}) plot (Figure 8) suggest that the laboratory reported TDS for site R2 (Rebuild Station) is an error. Figure 8 suggests the laboratory reported TDS (1340 mg l^{-1}) is about 2 times as great as the actual value. A sample collected in 3/93 had a TDS of 740 mg l^{-1}. Assuming the TDS of site R2 is about 700 mg l^{-1}, the mean TDS of roof drips in Longwall Area 3 is about 546 mg l^{-1} rather than the calculated 653 mg l^{-1}. A value of 700 mg l^{-1} is therefore

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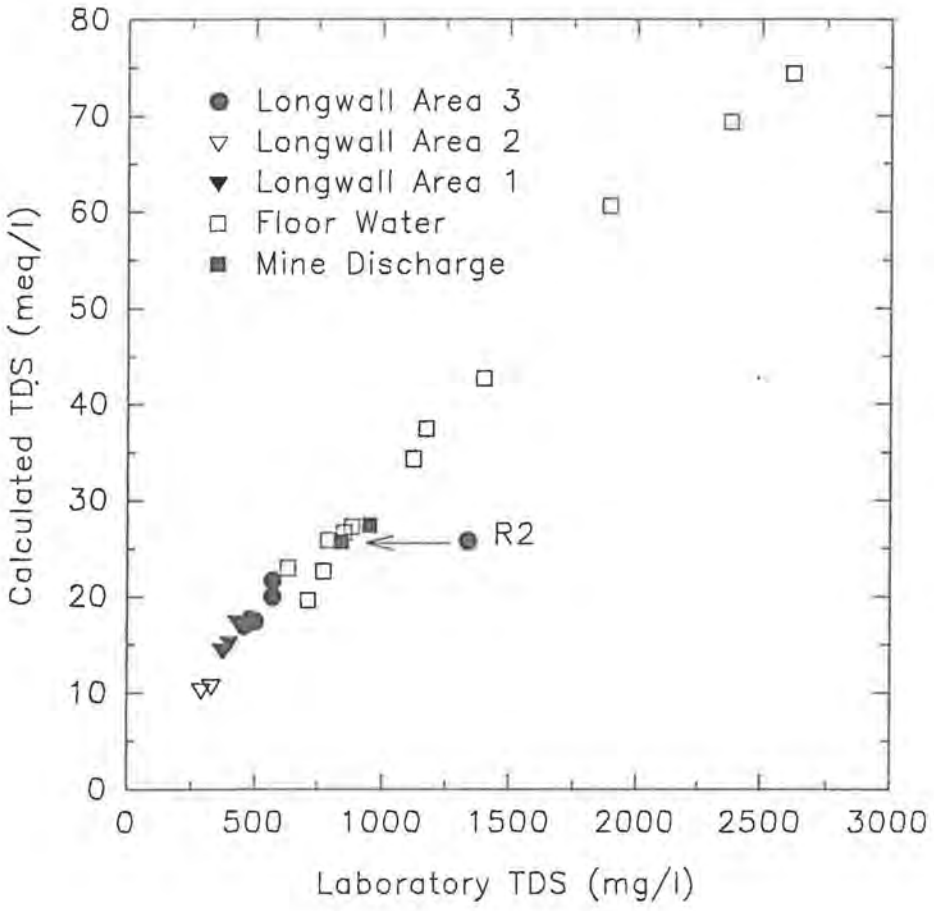
Figure 8 Scatter plot of laboratory reported TDS vs. calculated TDS. Calculated TDS is the sum of the laboratory reported cations and anions in meq l^{-1}. The arrow shows the plotting location of sample R2 after being adjusted for the error in the laboratory reported TDS (mg l^{-1}).



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reported in Table 1, and a mean value of 546 mg l^{-1} is used for analytical purposes in this report.

Although the spatial distribution of roof water collection points does not permit contouring roof water TDS or other chemical parameters, plots of some of the data do exhibit spatial trends. The TDS and SO_4^{2-} concentrations of roof drip waters are shown on Figure 9. Concentrations are lowest in the western portion of the mine area (Longwall Area 2), increase toward the southeast (Longwall Area 1), and are greatest in the northeast (Longwall Area 3). The mean TDS of the roof drip waters in each mining area are statistically distinguishable from each other at the 95 percent confidence interval using a standard T test. The mean TDS and SO_4^{2-} of roof drips in each mining area follow:

	----- TDS -----		SO_4^{2-}
	meq l^{-1}	mg l^{-1}	meq l^{-1}
Longwall Area 3:	19.90	546	3.04
Longwall Area 2:	10.53	303	0.70
Longwall Area 1:	17.42	430	1.28

The overall chemical differences between the Longwall Area roof drips are apparent on the trilinear diagram (Figure 10). The elevated TDS of Longwall Areas 3 and 1 roof drips relative to the

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Figure 9 Map showing the TDS and SO_4^{2-} (meq l^{-1}) of roof drip waters collected on April 12 and 13, 1993.

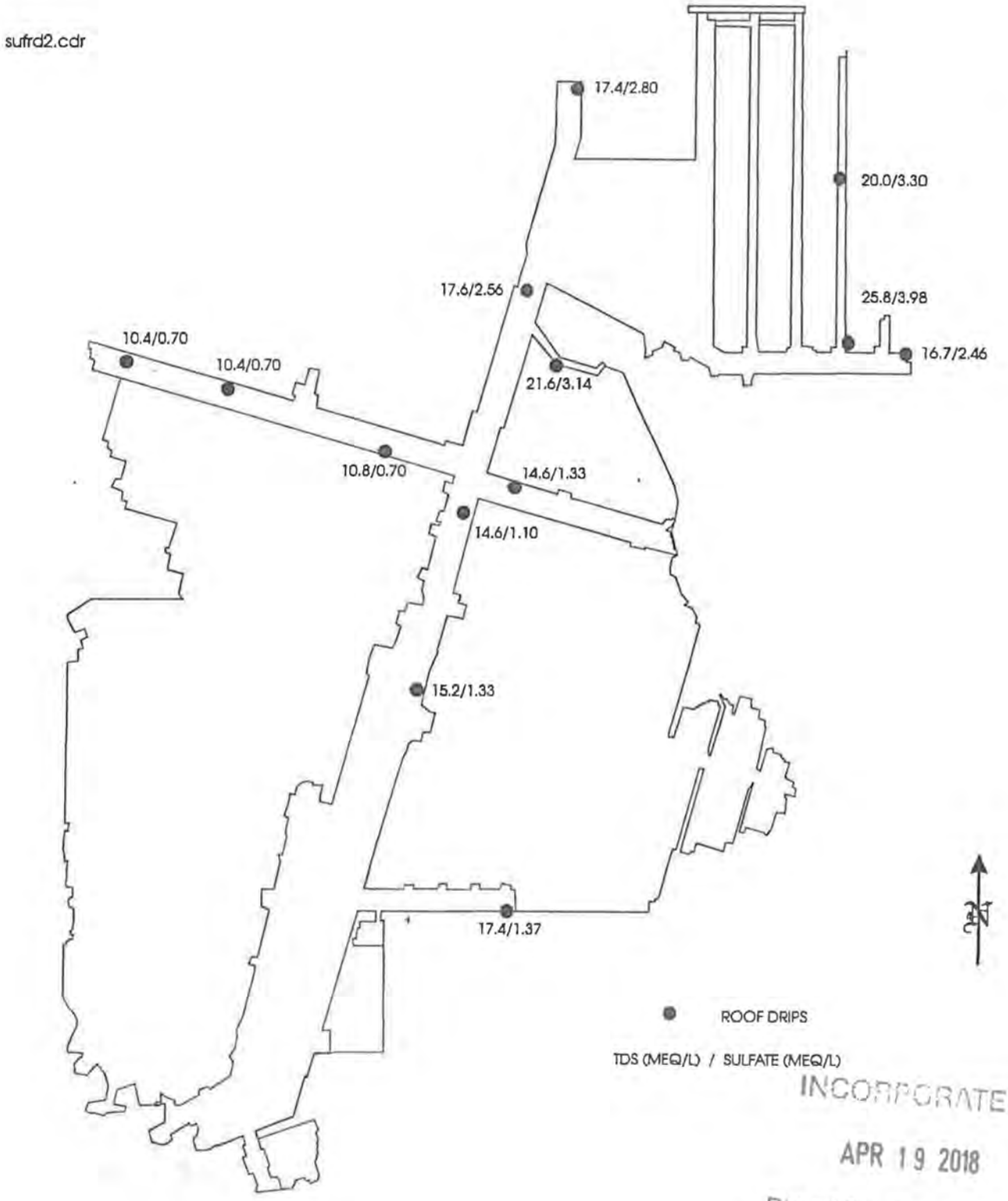

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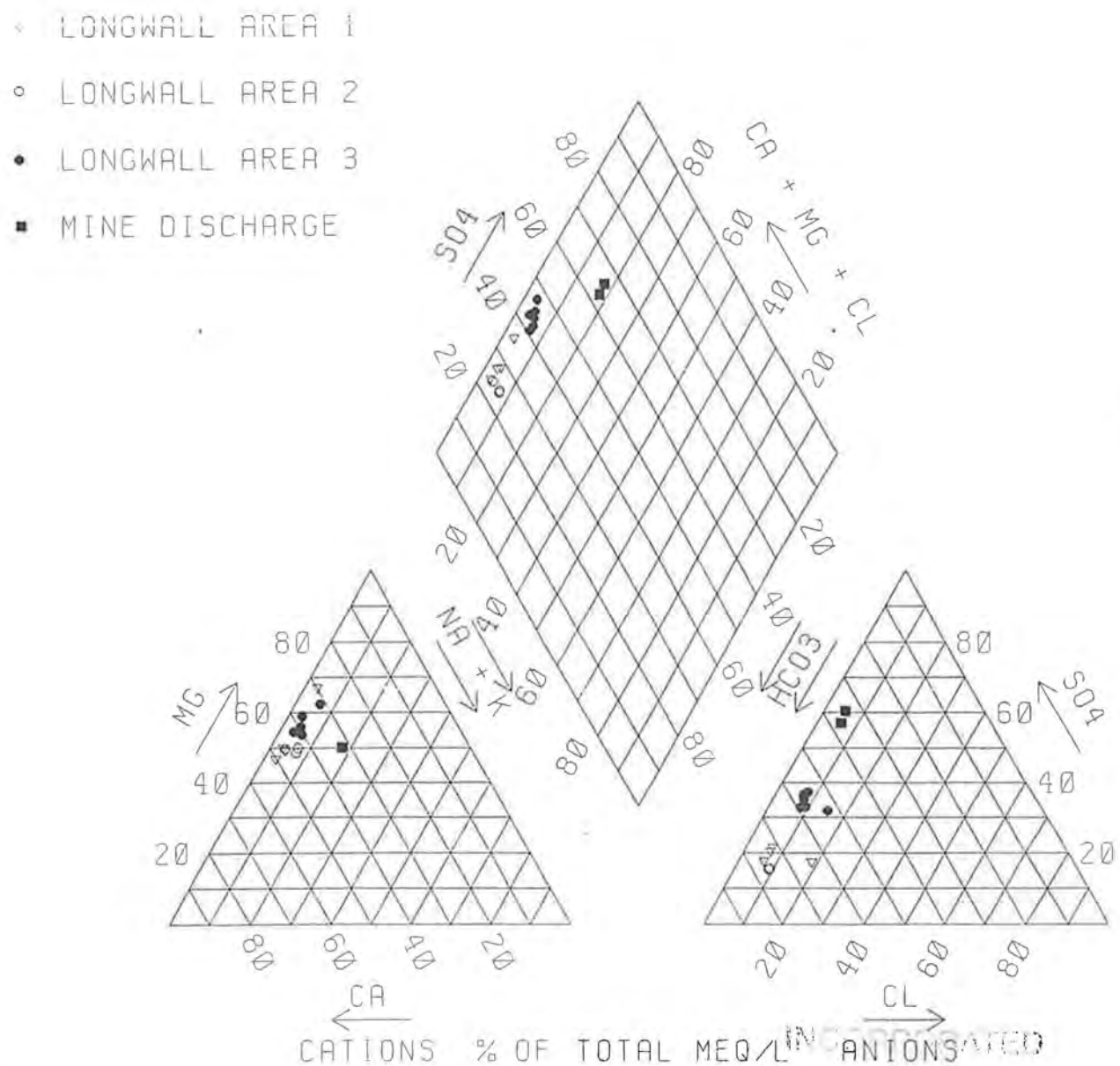
Figure 10 Trilinear diagram of roof drips and mine discharge water collected on April 12 and 13, 1993.



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TDS of Longwall Area 2 are due to the increased concentrations of most major cations and anions. Increased mean concentrations and percentage increases of Longwall Areas 3 and 1 roof drips relative to mean concentrations of Longwall Area 2 roof drips are:

	Longwall Area 3		Longwall Area 1	
Constituent	absolute increase (meq l^{-1})	percentage increase	absolute increase (meq l^{-1})	percentage increase
SO_4^{2-}	2.34	334	0.58	83
Mg^{2+}	2.44	128	1.29	68
Ca^{2+}	2.07	73	1.27	45
HCO_3^-	1.83	41	1.63	37

The mean Ca/Mg ratios of nearly all roof drip waters fall between 1 and 2 (Table 3), suggesting that dolomite is the major source of the elevated Mg^{2+} content. The Ca/Mg ratio in pure dolomite is 1, and the ratio in pure limestone often approaches 20. However, the mean SO_4^{2-} content of Longwall Area 3 drip waters suggests an additional Mg^{2+} source or the occurrence of other chemical reactions. The mean SO_4^{2-} content of 3.04 meq l^{-1} would have a corresponding Ca^{2+} content and would only leave 1.86 meq l^{-1} of Ca^{2+} to be contributed from dolomite dissolution. The cor-

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Table 3 Log SI and other WATEQF calculated parameters for water samples collected during the April 12 and 13, 1993 sampling period.

	log							
Sample	SIa	SIc	SId	SIg	SIan	SIh	PCO2	Ca/Mg
			Roof Drips Longwall Area 3					
R1	0.55	0.70	1.55	-1.59	-1.87	-8.10	-2.49	0.83
R2	0.48	0.64	1.12	-1.17	-1.55	-8.07	-2.02	1.27
R3	0.19	0.34	0.70	-1.35	-1.63	-8.20	-1.89	1.16
R4	-0.18	-0.03	-0.20	-1.41	-1.80	-8.27	-1.83	1.22
R5	0.38	0.53	1.05	-1.48	-1.76	-8.16	-2.16	1.24
R6	0.77	0.92	1.89	-1.38	-1.65	-7.92	-2.42	1.05
mean	0.37	0.52	1.02	-1.40	-1.71	-8.12	-2.13	1.13
std	0.30	0.30	0.67	0.13	0.11	0.11	0.25	0.15
			Roof Drips (all other areas)					
R7	0.02	0.17	0.17	-2.12	-2.46	-8.46	-2.31	1.42
R8	-0.03	0.12	0.03	-2.11	-2.47	-8.46	-2.26	1.50
R9	0.08	0.23	0.33	-2.09	-2.36	-8.70	-2.17	1.55
R10	0.27	0.43	0.52	-1.77	-2.17	-8.68	-2.20	1.76
R11	-0.02	0.13	0.14	-1.74	-2.02	-8.59	-1.77	1.55
R12	0.80	0.95	1.79	-1.74	-2.01	-8.64	-2.55	1.54
R13	0.57	0.72	1.64	-1.85	-2.12	-8.07	-2.38	0.73
mean	0.24	0.39	0.66	-1.92	-2.23	-8.51	-2.23	1.44
std	0.30	0.30	0.68	0.17	0.18	0.20	0.22	0.30
			Floor Waters					
F1	0.47	0.62	0.78	-0.07	-0.34	-7.19	-2.45	3.61
F2	0.48	0.63	1.28	-0.87	-1.14	-7.32	-2.13	1.17
F3	-0.14	0.01	-0.39	-0.31	-0.70	-5.92	-2.07	2.45
F4	0.56	0.72	1.26	-1.22	-1.61	-8.10	-2.62	1.32
F5	0.15	0.30	0.69	-1.05	-1.32	-7.53	-2.09	1.00
F6	0.60	0.76	1.53	-1.03	-1.41	-7.48	-2.72	0.91
F7	0.43	0.59	0.95	-0.56	-0.99	-7.26	-2.48	1.31
F8	0.72	0.87	1.75	-1.33	-1.66	-7.61	-2.59	1.01
F9	0.41	0.56	1.09	-1.33	-1.68	-7.62	-2.21	1.08
F10	-0.02	0.13	0.19	-1.26	-1.59	-7.40	-1.54	1.18
F11	0.19	0.34	0.78	-0.88	-1.15	-7.68	-1.49	0.96
F12	0.10	0.25	0.60	-0.53	-0.86	-7.27	-1.38	0.85
mean	0.33	0.48	0.87	-0.87	-1.20	-7.36	-2.15	1.46
std	0.26	0.26	0.56	0.40	0.41	0.50	0.44	0.78
			Mine Discharge					
D1s	-0.27	-0.11	-0.28	-1.01	-1.39	-7.47	-1.73	1.06
D1e	-0.18	-0.02	-0.11	-1.08	-1.45	-7.47	-1.83	1.05
mean	-0.22	-0.07	-0.20	-1.05	-1.42	-7.47	-1.78	1.06
std	0.04	0.04	0.09	0.03	0.03	0.00	0.05	0.00

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responding Ca/Mg ratio (1.86/4.34) is 0.42, which is considerably less than the ratio of dolomite (i.e., there is too much Mg^{2+}). The source of the elevated Mg^{2+} in Longwall Area 3 roof drips remains problematic.

All roof drip waters are supersaturated with respect to carbonate minerals (aragonite, calcite and dolomite). This means the water would like to precipitate calcium carbonate. Many ground waters attain saturation in the recharge zone, and supersaturated ground waters are not uncommon. The condition of supersaturation can persist in an aquifer because mineral precipitation is often kinetically impaired.

The extent of carbonate mineral supersaturation, particularly dolomite, in these waters is unusual and suggests the ground waters have chemically evolved since they recharged. Ground water can easily become carbonate mineral supersaturated if the aquifer temperature is substantially greater than the temperature of the recharge water. However, such major temperature differences do not occur in the mine waters. The mean temperature of roof drip waters is about 11.5°C, whereas the mean temperature of recharge waters is likely 2 to 5 °C.

A more likely cause of the carbonate mineral supersaturation is recharge water at or near carbonate mineral saturation encounter-

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ing gypsum in the aquifer. Dissolution of gypsum would cause carbonate mineral supersaturation because of the common ion effect of Ca^{2+}. Gypsum is more soluble than carbonate minerals and would therefore contribute Ca^{2+} ions that would in turn cause carbonate mineral supersaturation.

Stable Isotopic Chemistry

Samples of roof drip waters were collected in an attempt to help characterize the ground-water flow regime of the Blackhawk Formation above the Hiawatha Coal seam. Samples were collected for $\delta^{18}O$ and $\delta^{2}H$ to help evaluate the recharge history of the water, for $\delta^{13}C$ and $\delta^{34}S$ to help evaluate the evolution of the solute chemistry of the waters, and for the radioactive isotopes ^{3}H and ^{14}C to help determine the age of the water.

Oxygen-19 ($\delta^{18}O$) and Hydrogen-2 ($\delta^{2}H$)

Worldwide, the $\delta^{2}H$ and $\delta^{18}O$ of precipitation (rain and snow) generally follow the empirical relationship:

$$\delta^{2}H = s(\delta^{18}O) + d \ (^{o}/oo) \qquad (3)$$

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where s is the slope and d is the deuterium excess (Merlivant and Jouzel, 1983). Craig (1961) and Dansgaard (1964) have shown that, on the global scale, s approximates 8 and d approximates 10 for coastal meteoric water. The Meteoric Water Line (MWL) is therefore defined as:

$$\delta^2H = 8(\delta^{18}O) + 10 \ (^{o}/oo) \qquad (4)$$

The $\delta^{18}O$ and δ^2H composition of roof drips fall in the narrow range of -16.4 to -17.5 $^{o}/oo$ and from -122 to -132 $^{o}/oo$, respectively (Table 1; Figure 11). All of the data cluster about the MWL, and the data do not exhibit thermal isotopic shift in $\delta^{18}O$ or evaporative shifts in both $\delta^{18}O$ and δ^2H. This means the water recharges from the infiltration of rain or snow. The waters have not upwelled along deep seated faults and are not residual connate water from marine or backwater evaporative sedimentary environments.

The mean isotopic composition of data from Longwall Area 3 is slightly more positive than is the mean isotopic composition from the other mining areas. More positive compositions are usually correlated to warmer recharge temperatures. However, the tight cluster of the data and the results of statistical T-tests preclude a definitive analysis. The means of the recharge waters do not vary at the 95% percent confidence interval.

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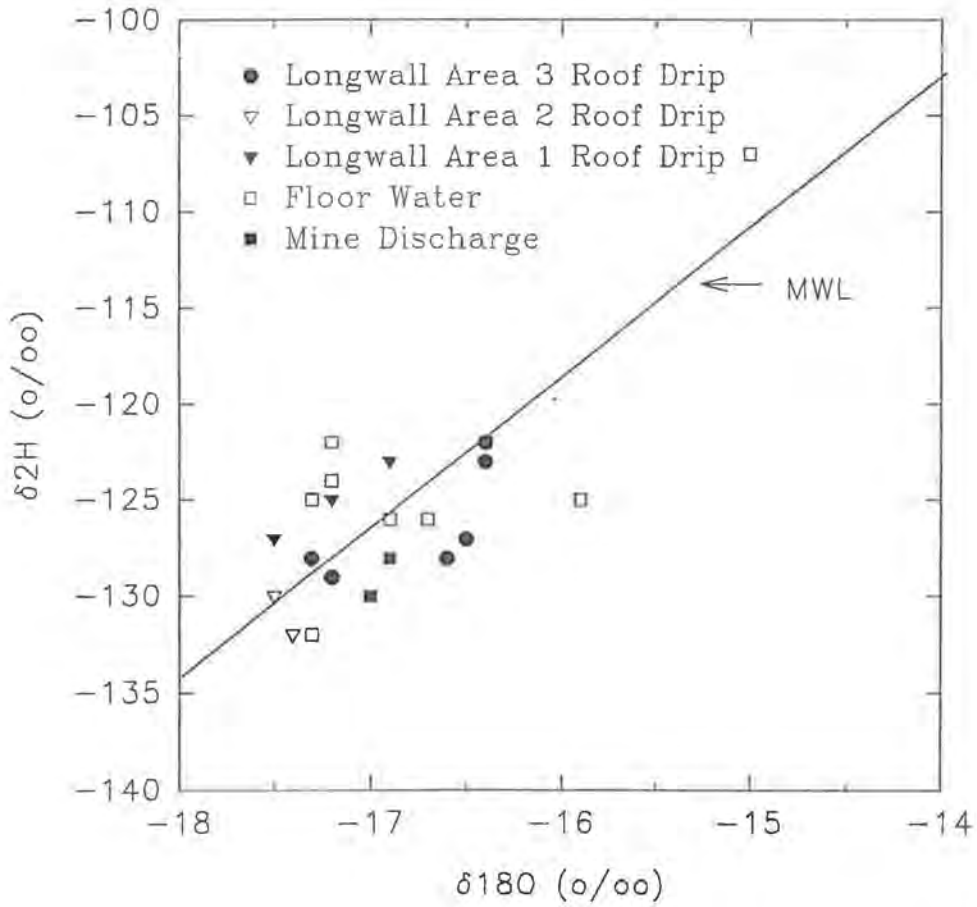
Figure 11 Plot of $\delta^{18}O$ and $\delta^{2}H$ data relative to the meteoric water line (MWL).



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(2H18Ox.SP5)

Carbon-13 ($\delta^{13}C$)

Roof drip waters have log $PCO_{2(g)}$ values (Tables 1 and 2) that are consistent with the dissolution of carbonate minerals in the presence of soil zone $CO_{2(g)}$. Most ground water acquires 50 percent of its carbon from soil zone water and 50 percent of its carbon from the dissolution of carbonate minerals in the soil zone or aquifer skeleton. Because the $\delta^{13}C$ of marine carbonate minerals is about 0 °/oo (Muller and Mayo, 1986), most ground waters have a $\delta^{13}C$ of ≈ -10 to -13 °/oo. The $\delta^{13}C$ of many roof drip waters is less than anticipated and may reflect carbonate mineral precipitation and dissolution reactions in the upper member of the Blackhawk Formation.

We had hoped the $\delta^{13}C$ data would help distinguish regions of roof drip water from each other, but the scatter of the data was too great to do so.

Sulfur-34 ($\delta^{34}S$)

The $\delta^{34}S$ data indicate that all roof drip water sulfate is derived from the dissolution of gypsum and/or anhydrite. The anticipated range of $\delta^{34}S$ values in Mesozoic early Tertiary gypsum and anhydrite is +10 to +20 °/oo (Holser and Kaplan, 1966). At

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non-thermal aquifer temperatures, isotopic fractionation accompanying gypsum dissolution may be represented as:

$$\underset{(\delta^{34}S \approx +15\ ^{o}/oo)}{CaSO_{4\,(s)}} \xrightarrow{^{34}S\ \text{enrichment}} \underset{(\delta^{34}S \approx +9\ ^{o}/oo)}{Ca^{2+} + SO_4^{2-}} \qquad (5)$$

where the value $\delta^{34}S \approx +15\ ^{o}/oo$ has been arbitrarily selected. The typical $\delta^{34}S$ value of magmatic pyrite is about 0 $^{o}/oo$ (Faure, 1986). A $\delta^{34}S$ of -2.2 $^{o}/oo$ has been reported for pyrite in the Park City District (Thode and others, 1961) and Mayo and Klauk (1991) found a mean $\delta^{34}S$ of $\pm$1.3 $^{o}/oo$ in ground water from non-carbonate (crystalline rock) aquifers in north central Utah.

In addition to identifying the source of the roof drip SO_4^{2}, we had hoped to use the $\delta^{34}S$ data to help distinguish regions of roof drip water from each other, but the scatter of the data were too great to do so. However, the large scatter of data do provide insight into the ground-water systems in the overlying Blackhawk Formation. The wide range of $\delta^{34}S$ isotopic compositions suggests that roof drip waters issue from numerous discrete ground-water systems that are not hydraulically connected. If roof drips issue from a single ground-water system, the $\delta^{34}S$ compositions of roof dip waters would have been similar or would have exhibited a spatial trend.

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Tritium (^3H)

The radioactive isotopes tritium (^3H) and carbon-14 (^{14}C) were collected at site R2 to estimate the age of roof drip water, and ^3H was collected at 3 other locations. Tritium (^3H), the radioactive isotope of hydrogen, has been used in ground-water investigations to differentiate between ground waters which recharged prior to or after the advent of atmospheric thermonuclear weapons testing. Tritium, whose half life is 12.26 years, forms naturally in the upper stratosphere by the interaction of ^{14}N with cosmic ray neutrons according to the reaction:

$$^{14}N + n \rightarrow {}^3H + {}^{12}C \qquad (6)$$

Tritium is rapidly incorporated into water molecules and is removed from the atmosphere by precipitation.

Prior to the advent of atmospheric thermonuclear weapons testing in 1952, tritium activity in precipitation ranged from 4 to 25 tritium units (TU). One TU equals one ^3H atom per 10^{18} hydrogen atoms. In mountainous areas, larger natural concentrations have been observed (Fontes, 1983). During the peak of atmospheric

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weapons testing, tritium levels in precipitation rose to more than 2200 TU in some northern hemisphere locations (Fontes, 1983). As of 1987, the ^{3}H concentrations in rain water varied from 25 to 50 TU. Unpublished data of 1991 and 1992 snow samples collected in the central Wasatch Range have TU concentrations greater than 20 TU.

The ^{3}H content of roof dip waters indicate that ground water entering the mine recharged prior to 1952. The ^{3}H contents of samples are: R2 < 3 TU (which is the detection limit for the analysis of that sample), R8 and R12 is 1.1 ± 2.4 and, sample R5 is 3.3 ± 2.4 (Table 1). The TU content of a sample collected in the mine by Thiros and Cordy (1991) was < 1 TU, which was the detection limit for that analysis.

Carbon-14 (^{14}C)

Carbon-14, the radioactive isotope of carbon, has a half-life of 5730 ± 30 years (Godwin, 1962). Carbon-14 is produced in the upper atmosphere by a variety of reactions that involve the collision of cosmic radiation (neutrons) with stable isotopes of nitrogen, oxygen, and carbon. The most important of these reactions is between neutrons and ^{14}N according to the reaction:

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$$n + {}^{14}N \rightarrow {}^{14}C + p \qquad (7)$$

where n is a neutron and p is a proton (Libby, 1955). Carbon-14 is incorporated into $CO_{2(g)}$ and rapidly mixes throughout the atmosphere and hydrosphere where steady state equilibrium between ^{14}C production and ^{14}C decay is attained (Faure, 1986).

The pre-industrial revolution atmospheric ^{14}C content has been assigned the steady state value of 100 percent modern carbon (pmc). The burning of fossil fuels and the advent of atmospheric thermonuclear weapons testing greatly altered the ^{14}C activity in the post-industrial revolution atmosphere. Burning of fossil fuels, whose ^{14}C had previously completely decayed away, decreased the ^{14}C content in the troposphere in the northern hemisphere by about 3% (Houtermans and others, 1967). Atmospheric weapons testing greatly increased the atmospheric ^{14}C activity by the mid 1960's (Ferronsky and Polyakov, 1982).

The post-industrial revolution atmospheric ^{14}C perturbations and laboratory measurement error in measuring the ^{14}C content of ground water make the reliable lower limit for ^{14}C dating about 450 years. The upper limit of ^{14}C dating, using conventional laboratory analytical methods, is about 35,000 years.

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Estimating the age of dead wood or other organic carbon is relatively simple. The ^{14}C activity of pre-industrial revolution organic material is assumed to be 100 pmc. The radiocarbon date is then corrected for systematic variations in atmospheric ^{14}C that have been established by comparing tree ring dates of the wood of sequoia and bristlecone pines with their corresponding radiocarbon ages (LaMarche and Harlan, 1973; Michael and Ralf, 1970).

Estimating the radiocarbon age of ground waters is not as straightforward as estimating the age of dead organic matter. Ground water acquires carbon from numerous sources, many of which had an initial ^{14}C activities of less than 100 pmc. The ^{14}C content of ground water is affected by four factors:

1) the addition of "live" carbon (i.e., $^{14}C \approx 100$ pmc) from the biogenic production of $CO_{2(g)}$ in the soil zone,
2) the addition of "dead" carbon from weathering of minerals in the soil zone and the dissolution of carbonate minerals in the soil zone or aquifer (i.e., $^{14}C \approx 0$ pmc),
3) the addition of "dead" carbon from the soil or aquifer during isotopic exchange reactions, and
4) the addition of both "live" and "dead" carbon by other processes.

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The crux of dating ground water is estimating the initial ^{14}C activity (A_o) of the water at the time of recharge. This may be accomplished by using the solute and isotopic chemistries of the ground water and by applying correction procedures. Correction procedures for estimating A_o are in the form of mathematical equations that attempt to account for the contribution of "dead" carbon and ^{14}C from various sources, and for the effects of the isotopic exchange and fractionation processes.

The ^{14}C activity of the Rebuild Station roof drip sample (R2) is 7.2 ± 1.2 pmc, and the $\delta^{13}C$ of the sample was -8.5 °/oo. Mean ground-water residence time of the sample (its age) was calculated using a proprietary computer code. The code incorporates 6 different mathematical models as described by Fontes and Garnier (1979). Based on modeling results, the calculated age of sample R2 is 15,500 to 16,500 years. This means the water in the Blackhawk Formation overlying the mine has been isolated from surface recharge since then.

Measured and estimated data used in the ground-water age calculation include: $\delta^{13}C$ of the sample = -8.5 °/oo (measured); $\delta^{13}C$ of the carbonate minerals in the recharge zone = 0 °/oo (estimated); $\delta^{13}C$ of the $CO_{2\ (g)}$ in the soil zone = -20 °/oo (estimated); ^{14}C of the sample = 7.2 pmc (measured); ^{14}C of aquifer minerals = 0 pmc (estimated); activity of HCO_3^{2-} in the water = 0.087956

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(calculated). Estimate values are consistent with values found in the mountainous terrains of Utah and elsewhere.

Floor Water

A schematic of the floor water management system during the sampling period (April 12 and 13) is shown on Figure 12. Most of the floor water is conveyed in pipes. Water moves along the floor in Longwall Areas 1, 2 and 3, and across the floor of an old room and pillar mined area before discharge at PT003. Floor water from Longwall Areas 1 and 2 discharges into open tunnels from seals that are used to close the longwall areas.

A summary of the floor water management scheme during the April 1993 sampling follows:

Longwall Area 1

Water discharges from this closed section of the mine at site F12 (1L6E North Seal). This water flows first along the floor and then is piped to the collection sump at F8 (6 North Sump). From sump (F8) it is piped to closed Room and Pillar area A, where it flows along floor of the area and ultimately discharges at PT003.

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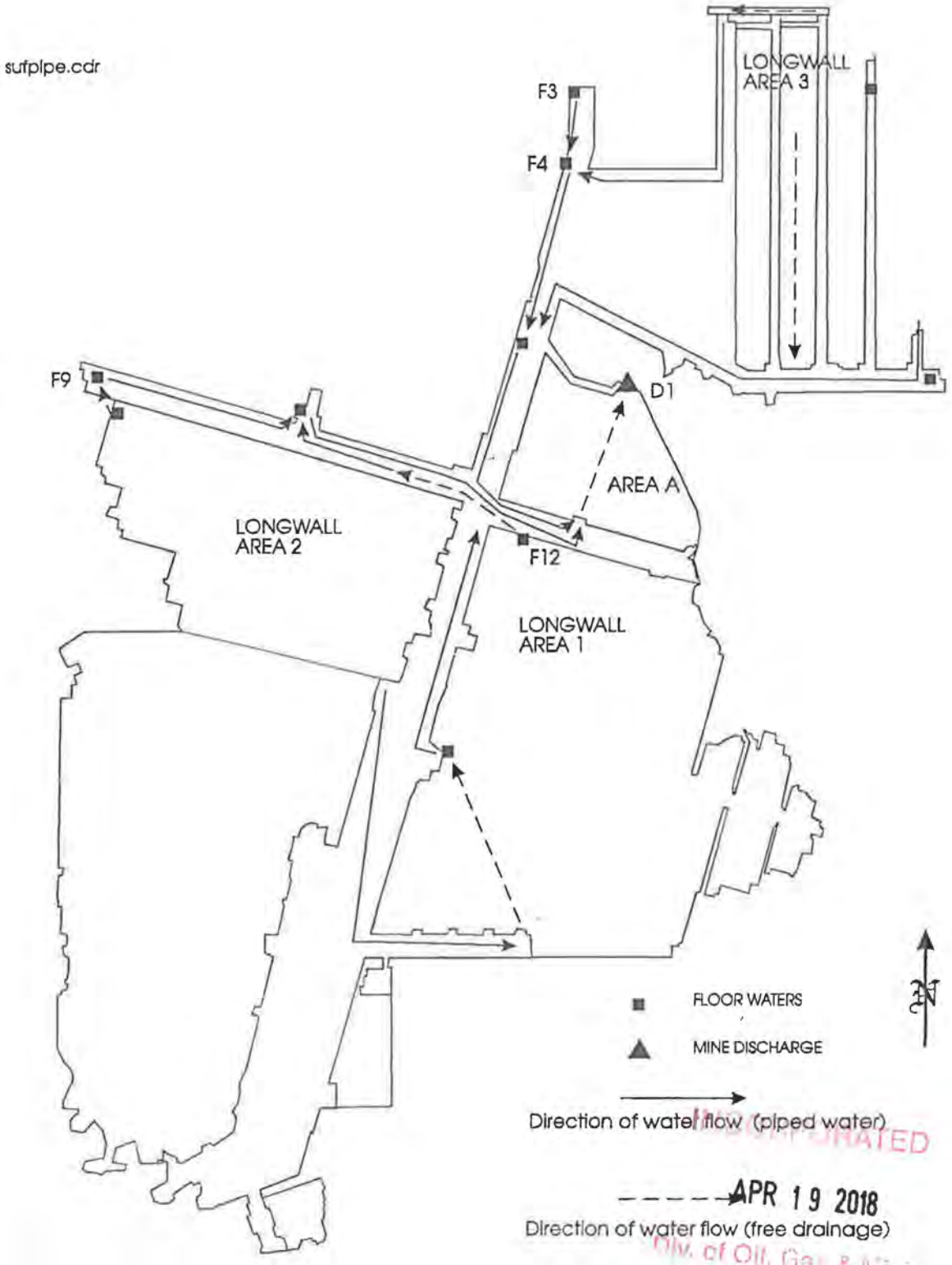
Figure 12 Diagram of the floor water management system on April 12 and 13, 1993. Sumps F3 and F4 are the collection locations for Longwall Area 3, sump F9 is the collection location for Longwall Area 2, and sump F12 is the collection location for Longwall Area 1. Location D1 is the mine discharge point (PT003).



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Water discharging from F11 (6East Seals) flows along the mine floor to the mine process water sumps and thus does not go directly to Area A where it would be discharged.

Longwall Area 2

Water discharges from this closed section of the mine at site F10 (1L North Main Seal) and flows over the mine floor to F9 (3 West Sump). This water is piped from F9 to the collection sump at F8 where it mixes with water from F12.

Longwall Area 3

Water from the active mining area is collected at two locations. Floor water in the northern portion of the area is collected and piped to site F4 (North Mains #4 sump) where it mixes with water from F3 (North Mains face pump). Floor water from the southern portion of the area is piped to site F7 (North Mains #3 sump) and mixes with water from F1 (4 East face pump). Water from both North Mains #3 and North Mains #4 sumps are then piped separately to closed room and pillar Area A, where they mix with water from the sump at F8. All

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of the floor waters mix in a large sump in the north part of Area A and ultimately discharge at D1 (mine discharge PT003).

The TDS of floor waters are highly variable, ranging from about 20 to 75 meq l^{-1} (Table 1; Figures 8 and 13). The chemistry of the floor water at various locations reflect:

1) chemical reactions between incoming roof drip water with gypsum rock dust, longwall emulsion, dolomite crushed rocks, and other materials introduced into the mine, and
2) the mixing of floor waters from other locations in the mine.

The TDS of individual floor waters is not particularly enlightening when examined in the absence of flow rate data, because the TDS of the mine discharge water is the integrated mean of the flow of floor waters weighted for TDS at critical locations in the mine. Water quality samples and flow rate measurements were made at four (4) critical locations during the April 1993 sampling. Floor water quality samples were also collected at sites where flow measurements were not made.

Water discharge and water quality budgets have been calculated for mine floor waters during the April 1993 sampling (Table 4).

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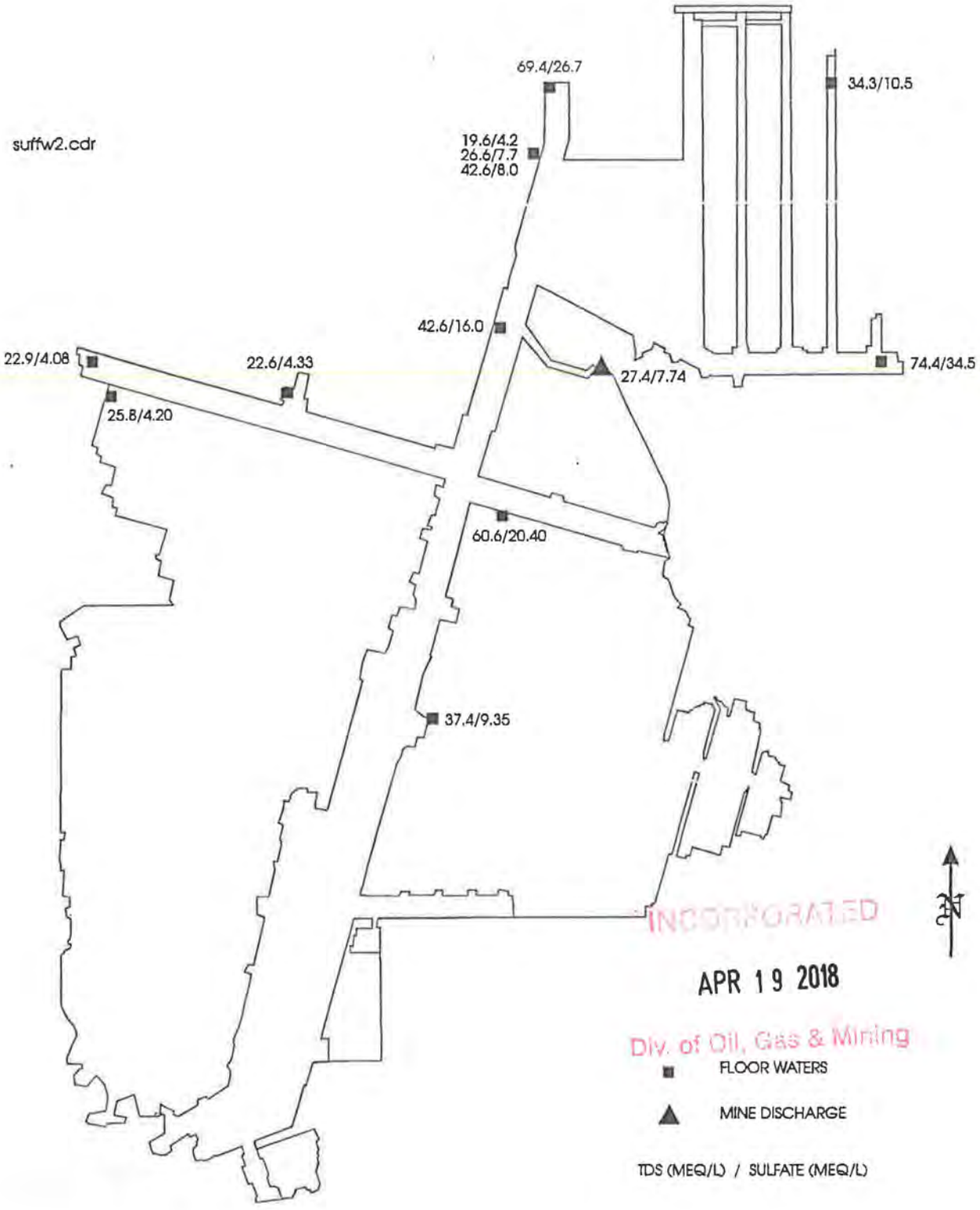
Figure 13 Map showing the TDS and SO_4^{2-} (meq l^{-1}) of floor waters collected on April 12 and 13, 1993.



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The contribution to the total mine discharge from the three mining areas was accounted for by flow measurements and water quality samples collected at the 4 critical locations. The critical sampling locations are:

Longwall Area 3 - sites F4 and F7
Longwall Area 2 - site F9
Longwall Area 1 - site F12

In Table 4 the %Q and %TDS columns list the percentage of the total mine discharge and TDS, respectively, which are contributed from each location to the total mine discharge rate and discharge TDS. The TDS, solute, and $\delta^{13}C$ and ^{34}S contents of each of floor waters are also listed. The TDS contribution from each location was calculated by multiplying the percentage of the total discharge attributed to the sample location by the solute or isotopic content of the water sample at the site. The calculated water quality of the mine discharge is the sum of the calculated contributions from each sampling location. The calculated TDS of the mine discharge was within about 3 percent of the measured TDS of discharge water from the mine.

The excellent agreement between calculated and measured TDS means that the data collected at the four critical sampling locations: 1) are representative of the 3 mining areas, 2) can be used to

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Table 4 Comparisons of calculated mass and isotopic compositions of mine discharge water with floor waters representative of the 3 long wall mining areas.

Source	% Q	TDS meq/l	TDS Contrib meq/l	% TDS Contrib	Ca meq/l	Ca Contrib meq/l	Mg meq/l	Mg Contrib meq/l	Na meq/l	Na Contrib meq/l	K meq/l	K Contrib meq/l	HCO3 meq/l	HCO3 Contrib meq/l	SO4 meq/l	SO4 Contrib meq/l	Cl meq/l	Cl Contrib meq/l
Longwall area 3																		
F4	44	19.60	8.62	31.4	5.00	2.20	3.80	1.67	0.90	0.40	0.10	0.04	5.20	2.29	4.20	1.85	0.40	0.18
F7	17	42.62	7.25	26.4	9.90	1.68	7.50	1.28	3.49	0.59	0.12	0.02	4.94	0.84	16.00	2.72	0.77	0.13
Longwall area 2																		
F9	32	22.90	7.33	26.7	4.15	1.33	3.85	1.23	3.30	1.06	0.09	0.03	7.13	2.28	4.08	1.31	0.34	0.11
Longwall area 1																		
F12	7	60.60	4.24	15.5	10.90	0.76	12.80	0.90	5.70	0.40	0.20	0.01	10.10	0.71	20.40	1.43	0.50	0.04
Calculated discharge			27.44			5.97		5.08		2.44		0.11		6.12		7.30		0.45
Measured discharge			26.56			5.15		4.88		3.19		0.11		5.54		7.20		0.50
Difference			0.88			0.82		0.20		-0.75		0.00		0.58		0.10		-0.05
% difference			3.31			16.00		4.00		-23.38		0.00		10.40		1.41		-9.86

Source	% Q	13C (o/oo)	13C Contrib (o/oo)	34S (o/oo)	34S Contrib (o/oo)
Longwall area 3					
F4	44	-9.30	-4.09	8.30	3.65
F7	17	-5.40	-0.92	12.20	2.07
Longwall area 2					
F9	32	-11.70	-3.74	10.60	3.39
Longwall area 1					
F12	7	-8.10	-0.57	6.80	0.48
Calculated discharge			-9.32		9.59
Measured discharge			-7.10		9.90
Difference			-2.22		-0.31
% difference			31.28		-3.09

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evaluate chemical reactions occurring in each region of the mine and, 3) can be used to calculate the mass contribution from each region of the mine to the overall TDS of the mine discharge water.

A plot of the percent TDS contribution versus the percent discharge contribution from the three longwall areas is shown on Figure 14. The diagonal line indicates plotting locations where percent TDS and percent discharge contributions are equal. The diagonal line may be thought of as representing a TDS of about 850 mg l^{-1} or about 27 meq l^{-1}, because the mine discharge water contains 100% of both the discharge and TDS (i.e., PT003 would plot at 100% on both axes). Points which plot below the line have a TDS which is less than 850 mg $^{-1}$, and points that plot above the line have a TDS which is greater than 850 mg l^{-1}. Floor water issuing from Longwall Areas 2 and 3 have TDS contents slightly less than that of the mine discharge, and water issuing from Longwall Area 1 has a TDS content considerably greater than that of the mine discharge.

GEOCHEMICAL EVOLUTION OF MINE WATER

Ground water entering the mine undergoes major chemical changes as it moves through the active and old mining areas. Changes in

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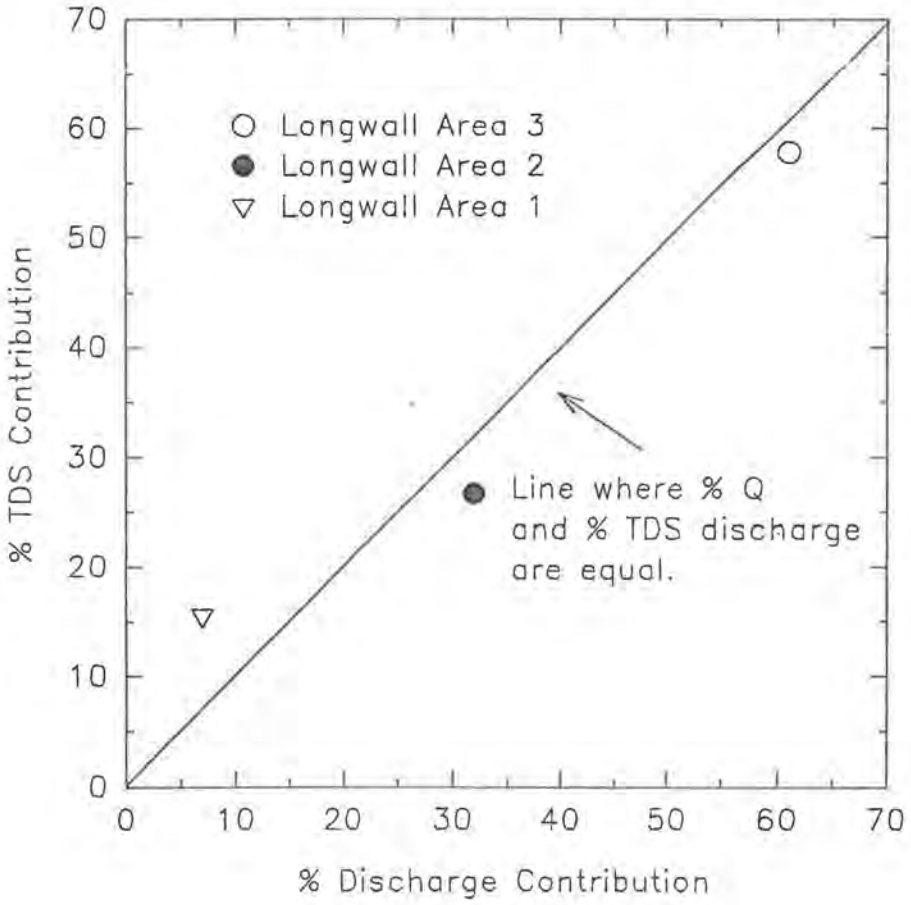
Figure 14 Plot of % TDS vs. % discharge contribution from each of the longwall mining areas relative to the total TDS and discharge of the mine discharge water. Data are representative of the April 1993 sampling period.



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(%TDSQ.SP5)

the solute chemistry of roof drip waters due to chemical reactions in the longwall areas are tabulated on Table 5. Because Longwall Areas 1 and 2 are now inaccessible, the chemical compositions of roof dip waters in these areas are somewhat uncertain. The chemical compositions of roof dips in the older mining areas have been assigned the mean values of the roof drips in the adjacent open mine areas. The following discussion is predicated on the idea that the assigned roof drip waters reasonably represent the chemistry of the roof drip water in each mining area.

Significant changes in Ca^{2+}, Mg^{2+}, Na^{+}, HCO_3^{2-}, and SO_4^{2-} concentrations and in the saturation indices (SI) of calcite, dolomite, and gypsum are observed in the floor waters of all mining areas relative to the mean compositions of the roof drips in their respective areas (Table 5; Figure 15). In the table and figure a positive change for a particular ion means that the floor water has a greater concentration of that ion than the incoming ground water. A positive change in SI means that the water has become more saturated with respect to the particular mineral. The mean SI's of roof drip waters may differ slightly from those listed in Table 3, because the SI's in Table 5 were calculated using the mean water chemistry of the roof drip water, whereas the mean values in Table 3 are the calculated mean of the individual SI's.

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Table 5 Comparisons of mining area roof drip and floor water solute compositions.

	Longwall Area 3						
Parameter	Mean Roof Drip	F4	F4 x 72.1%	F7	F7 x 29.7%	Mean Floor Water (F4 + F7)	Change
Temp (C)	11.00	11.00	7.93	7.50	2.09	10.02	
pH	7.63	8.00	5.77	7.80	2.18	7.94	0.31
Ca (meq/l)	4.90	5.00	3.61	9.80	2.73	6.34	1.44
Mg (meq/l)	4.34	3.80	2.74	7.50	2.09	4.83	0.49
Na (meq/l)	0.63	0.90	0.65	3.49	0.97	1.62	0.99
K (meq/l)	0.09	0.10	0.07	0.12	0.03	0.11	0.02
HCO3 (meq/l)	6.30	5.20	3.75	4.94	1.38	5.13	-1.17
SO4 (meq/l)	3.04	4.20	3.03	16.00	4.46	7.49	4.45
Cl (meq/l)	0.60	0.40	0.29	0.77	0.21	0.50	-0.10
SIc	0.42					0.68	0.26
SId	0.72					1.18	0.46
SIg	-1.36					-0.94	0.42

	Longwall Area 2			Longwall Area 1		
Parameter	Mean Roof Drip	Mean Floor Water F9	Change	Mean Roof Drip	Mean Floor Water F12	Change
Temp (C)	13.50	14.00		10.00	15.00	
pH	7.60	7.75	0.15	7.70	7.05	-0.65
Ca (meq/l)	2.83	4.15	1.32	4.10	10.90	6.80
Mg (meq/l)	1.90	3.85	1.95	3.19	12.80	9.61
Na (meq/l)	0.43	3.30	2.87	0.34	5.70	5.36
K (meq/l)	0.00	0.09	0.09	0.04	0.20	0.16
HCO3 (meq/l)	4.37	7.13	2.76	6.00	10.10	4.10
SO4 (meq/l)	0.70	4.08	3.38	1.28	20.40	19.12
Cl (meq/l)	0.30	0.34	0.04	0.50	0.50	0.00
SIc	0.12	0.56	0.44	0.42	0.25	-0.17
SId	0.04	1.09	1.05	0.65	0.60	-0.05
SIg	-2.10	-1.33	0.77	-1.74	-0.53	1.21

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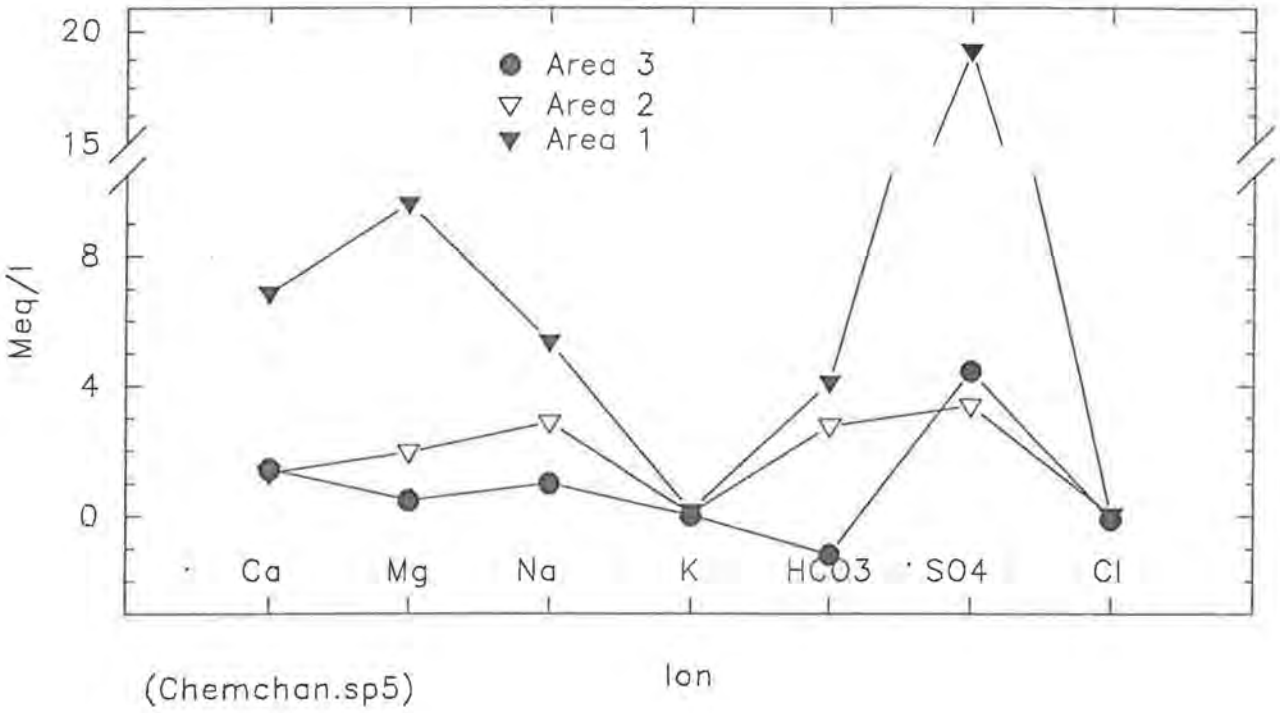
Figure 15 Plots of mean solute compositions and selected SI's of roof drip and floor waters, and changes in these parameters due to chemical reactions in the mine. Data are representative of the April 1993 sampling period.

A) Change in floor water chemistry.



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B) SI evolution of Longwall Area 3.

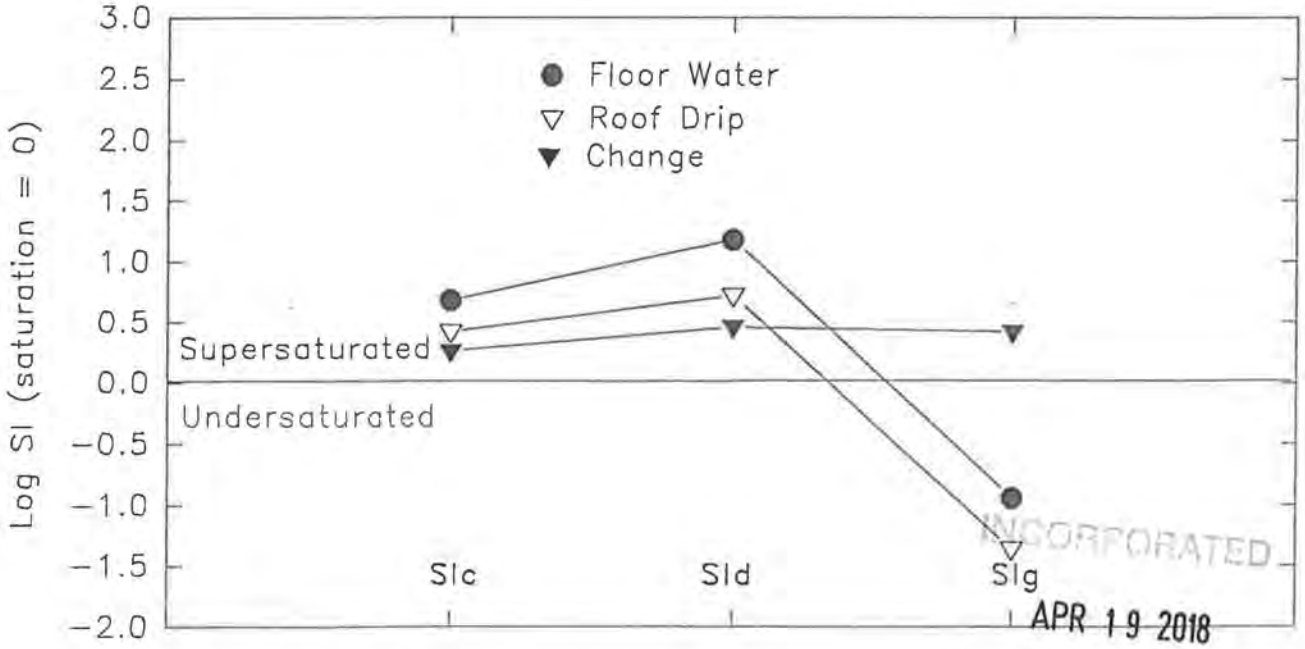

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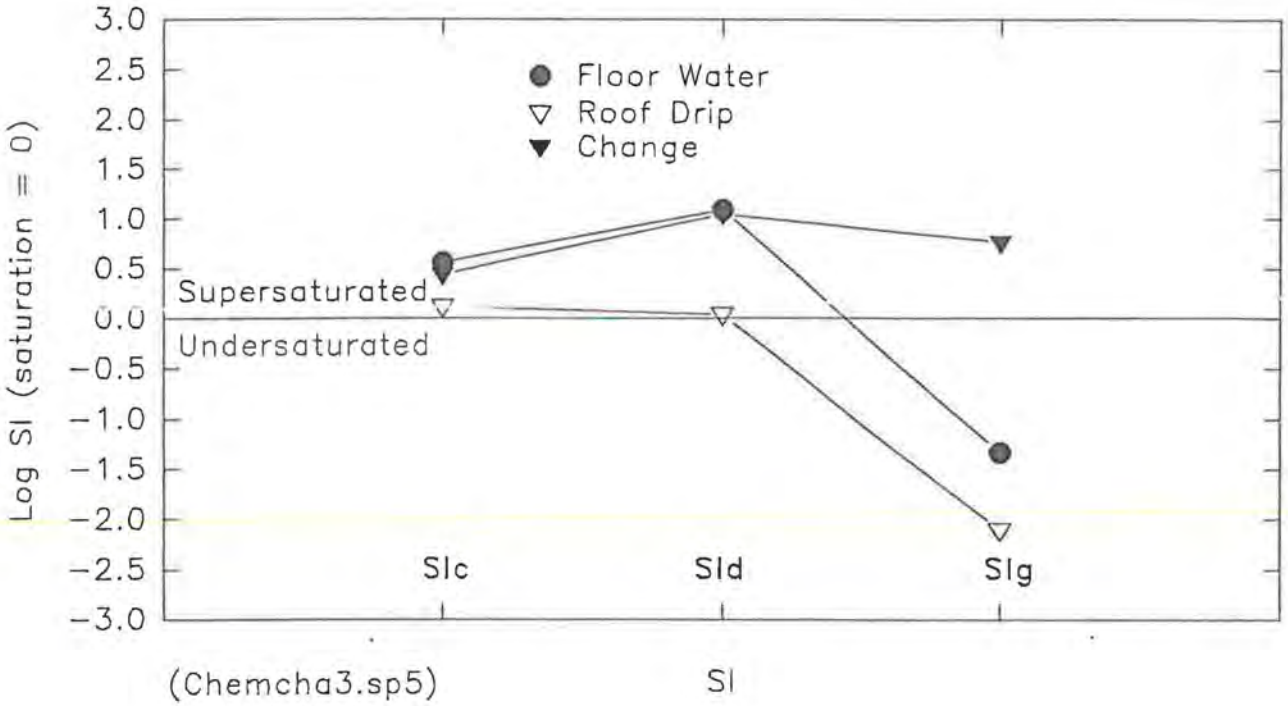
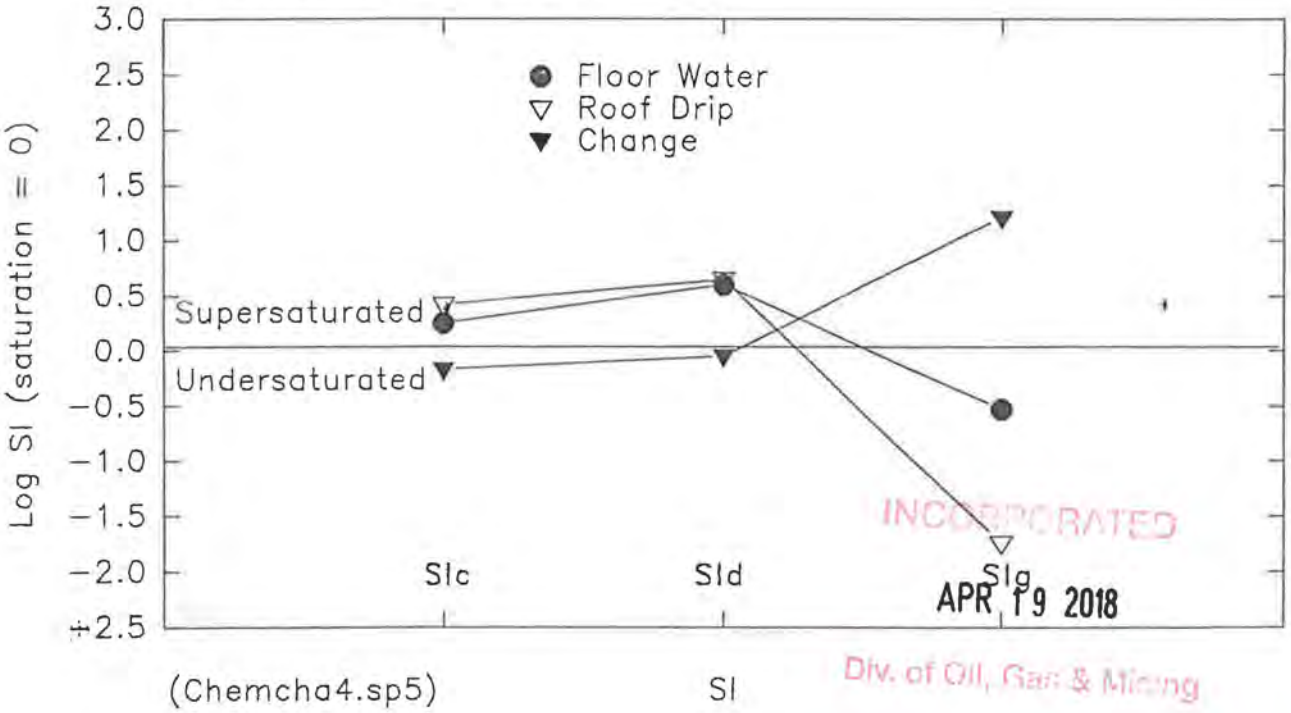
Figure 15 con't

C) SI evolution of Longwall Area 2.



D) SI evolution of Longwall Area 1.



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The chemical evolutionary pathways of floor waters in each mining area differ somewhat, with Longwall Area 1 experiencing the greatest change. Except for a decrease in the HCO_3^{2-} content in Longwall Area 3, all significant concentration changes are positive.

Four factors appear to contribute to the observed changes:

1) precipitation of carbonate minerals from the supersaturated roof drip waters,
2) bacterial oxidation of the organic content of the leaked emulsion used as hydraulic fluid in the longwall mining operation,
3) dissolution of carbonate rocks used to fill low spots it the mine, and
4) dissolution of gypsum rock dust that covers exposed mine surfaces.

The computer code Balance (Parkhurst and others, 1982) was used to calculate the mass transfer of potential chemical reactions in each of the longwall areas (Table 6). Positive numbers indicate dissolution, and negative numbers indicate precipitation or outgassing. Units are millimoles per liter (mmole l^{-1}). Mass transfer was calculated for two conditions. Condition 1 assumed that the emulsion leaked from the longwall mining operation does not contribute to the overall chemistry of the floor water, whereas

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Table 6 Calculated precipitation and dissolution of calcite, dolomite, gypsum and $CO_{2(g)}$ in mine floor waters due to chemical reactions between roof drip waters and substances in the mine.

	Phase Change (mmole/l)			
	Calcite	Dolomite	CO2 Gas	Gypsum
Area 3				
W/o Emulsion	-1.750	0.245	0.090	2.225
W/ Emulsion	-1.380	0.177	-0.651	1.836
Area 2				
W/o Emulsion	-2.005	0.975	2.815	1.690
W/ Emulsion	-0.974	0.780	1.448	0.642
Area 1				
W/o Emulsion	-10.965	4.905	8.445	9.560
W/ Emulsion	-9.863	4.441	5.369	8.361

---

negative phase change = precipitation
positive phase change = dissolution

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condition 2 assumed it did. Calculations of emulsion contributions were based on the idea that all excess Na^+ in the floor water was contributed from the emulsion. Appropriate percentage contributions of other ions from the emulsion were then calculated on the basis of the excess Na^+ in each mining area. Different percentage contributions were assigned to each longwall area, because the excess Na^+ content varied from one area to another.

Results of the mass transfer calculations are not consistent with purely inorganic reactions. The calculations indicate that dissolution of gypsum dust results in calcite precipitation and dolomite dissolution. Such reactions are thermodynamically plausible, considering the gypsum dust and the dolomite used in the mine. However, calculations of saturation indices indicate that floor waters in Longwall Areas 3 and 2 become more calcite supersaturated than the incoming roof drip waters. The condition of supersaturation is not unusual and is the result of kinetic factors. Mineral precipitation is often kinetically impaired; the energy required to initiate nucleation is greater that the thermodynamic energy needed to continue nucleation.

The calculations and the elevated HCO_3^{2-} content (Table 5) indicate that the floor waters in Longwall Areas 2 and 1 have acquired appreciable quantities of additional $CO_{2(g)}$. Plausible

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inorganic reactions in the mine, such as the decompostion of wood used as mine supports, are not capable of supplying extra $CO_{2(g)}$ at the necessary rate, and an external source is needed. Additional $CO_{2(g)}$ is needed to drive the dolomite dissolution reaction in Longwall Area 1. Sulfate reduction can liberate $CO_{2(g)}$, but the mine is an oxidizing environment, and no $HS^-_{(g)}$ has been noted. Bacterial oxidization of organic matter in the emulsion leaked from the longwall mining machine is the likely source of the extra $CO_{2(g)}$. The likely chemical reactions that contribute to the increase in the solute content of the floor waters are described below:

Gypsum dissolution

$$CaSO_4 = Ca^{2+} + SO_4^{2-} \quad (8)$$

Dolomite Dissolution

$$2H^+ + CaMg(CO_3)_2 = Ca^{2+} + Mg^{2+} + (HCO_3^-)^2 \quad (9)$$

Calcite Dissolution and Precipitation

$$H^+ + CaCO_3 = Ca^{2+} + HCO_3 \quad (10)$$

Acquisition of $CO_{2(g)}$

Oxidation of Organic Matter

$$\underset{\text{(organic matter)}}{COOH} + H_2O = CO_{2(g)} + H_2O + H^+ \quad (11)$$

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Formation and Dissociation of Carbonic Acid

$$CO_{2(g)} + H_2O = H_2CO_3 \quad (12)$$

$$H_2CO_3 + H^+ + HCO_3^- \quad (13)$$

The two key reactions are the dissolution of gypsum and the oxidation of residual emulsion in the older longwall areas. The dissolution of gypsum, which does not require free H^+ ions, increases the TDS by liberating both Ca^{2+} and SO_4^{2-}. Gypsum is very soluble and can greatly elevate the TDS. Elevated TDS's can cause the activity coefficients of all ionic species to decrease, thus permitting potential dissolution of additional carbonate minerals. Because Ca^{2+} is an ion common to gypsum and calcite, the dissolution of the more soluble gypsum causes precipitation of the less soluble calcite. The common ion effect does not influence dolomite in the same way because gypsum does not contain Mg^{2+}.

Increases in Ca^{2+} and Mg^{2+} from the dissolution of carbonate minerals requires the introduction of free H^+ ions. In the mine, the dissociation of carbonic acid (H_2CO_3) formed from $CO_{2(g)}$ that has been liberated by the oxidation of the residual emulsion provides ample H^+ ions. This series of reactions, combined with the dissolution of residual gypsum, appears to be most active in Longwall Area 1, where the increase in solute content of all major ions is the greatest.

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CONCLUSIONS

1. Nature of the Ground-Water System in the Upper Blackhawk Formation

Ground-water systems in the Upper Blackhawk Formation overlying the SUFCO mine are highly compartmentalized both horizontally and vertically. Variations in roof drip chemistry, the steady declines in roof drip rates after cessation of mining, and the variation in $\delta^{34}S$ in roof drip waters demonstrates that there are limited horizontal hydraulic connections between the various regions of the Upper Blackhawk Formation.

The age of the ground water, the perched water zones identified by the U.S. Geological Survey in the overlying aquifers, and the rapid decline in roof drip rates suggest that the Upper Blackhawk Formation has a poor hydraulic connection with potential recharge areas, the land surface, and overlying aquifers.

The horizontal and vertical compartmentalization of the ground-water systems above the Hiawatha Coal seam suggest that mining will rapidly dewater the ground-water system lo-

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cated just above the coal seam but will have a limited effect on ground-water systems above and beyond that layer.

2. Causes of Mine Discharge Elevated TDS

The chemistry of the roof water leaking into the mine varies greatly between longwall areas. The TDS increases toward the eastern and northeastern portions of the mine and is greatest in the current mining area. However, the elevated TDS from roof drips in the current mining area is not the sole cause of the excessive TDS in the mine discharge water.

The 10-year hydrograph of mine water TDS indicates that the TDS has been steadily increasing during this time. This long-term increase is the result of three factors:

a. dissolution of gypsum rock dust used as a fire and explosion retardant,
b. bacterial oxidation of leaked longwall mining operation emulsion in the older longwall areas, and
c. dissolution of carbonate crushed rock used to fill low tegions in the mine floor.

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Dissolution of gypsum dust is the principal factor in the current longwall area, whereas oxidation of leaked longwall emulsion is a very important factor in the older longwall areas. Although the discharge from the oldest longwall area is relatively small, this area contributes a disproportionate share of TDS.

3. Possible Future Trends in Mine TDS and Discharge Rates

Assuming that mining proceeds at a nearly constant rate and that unusual hydrogeologic conditions are not encountered in the mine, the maximum discharge rate from the mine will be about 1,000 to 1,100 gpm. The discharge rate will decline as the active mining area is mined out and will increase as new mining areas are developed.

Sealed mining areas will continue to contribute TDS to the mine discharge water. The TDS content of floor waters from sealed mining areas will not decline, but the mass contribution of TDS will decline because of reduced discharge rates. The effects of gypsum rock dust and leaked emulsion will not be appreciably lessened in the closed areas, because the collapse of gypsum rock dusted roof and wall areas will continue to bring gypsum into contact with mine floor water.

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The recent substitution of calcite/dolomite rock dust for gypsum dust will reduce the TDS of mine discharge water. This reduction will result from the dilution of higher TDS floor water from the gypsum rock dusted portions of the mine with lower TDS floor water from calcite/dolomite rock dusted portions of the mine.

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APPENDIX A

REPORT ON CATION-ANION BALANCES
PREPARED BY MAYO AND ASSOCIATES
May 17, 1993

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MAYO AND ASSOCIATES

CONSULTANTS IN HYDROGEOLOGY

P.O. Box 1960
Orem, UT 84059

Tel # (801) 224-7402
Fax # (801) 224-9882

May 17, 1993

Mr. Chris Kravits
Southern Utah Fuel Company
397 S 800 W
Salina, UT 84654

RE: Completion of Task 1 - Resolution of cation-anion balance problem

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Background

This report contains a summary of the activities that Mayo and Associates undertook between March and April 1993 to resolve the cation-anion balance error problem in the water quality analysis performed by Mountain States Analytical.

In late 1992 SUFCO personnel collected approximately 50 water and other fluid samples from the mine. The samples were collected in an attempt to understand the causes of elevated TDS in the mine discharge water. The samples were analyzed by Mountain States Analytical Laboratory in Salt Lake City, Utah. Most cation-anion

balance errors reported by Mountain States Analytical Laboratory exceeded the commonly accepted 5% error criteria, and balance errors as great 37.22% were reported. Balance errors do not affect TDS determinations. Balance errors are calculated as follows:

$$\text{error \%} = \frac{\Sigma \text{ cations} - \Sigma \text{ anions}}{\Sigma \text{ cations} + \text{anions}} \times 100$$

Because it is not possible to perform accurate quantitative analysis of water quality data having such large balance errors, it was necessary to resolve the cation-anion balance error problem before we could begin to answer the larger questions: 1) what has been responsible for the increased TDS levels in the discharge water? and 2) what is the best way to resolve the TDS problem?

Analysis of the Problem and Conclusion

Possible causes of the cation-anion imbalance included problems in sampling, sample preservation, sample holding, laboratory analytical methods, or some combination of these problems. After discussing the potential problems with personnel of SUFCO and Mountain States Analytical and reviewing the available data, we designed and undertook a test field sampling and laboratory analytical program. The sampling plan was executed on February 2, 1993. The sampling and analytical plan was as follows:

1. Samples were collected from 3 different locations in the mine. Sampling locations were selected to represent the anticipated range of water chemistries occurring in the mine. The locations chosen were Rebuild Station, #4 Sump, and 3 West C 44.

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2. At each site four sets of samples were collected for cation and anion analysis. Two sample sets were preserved using the standard SUFCO-Mountain States Analytical procedures. These standard procedures included 1) field acidification of cation samples without field filtration (i.e., 0.45 micron), and 2) laboratory titration for bicarbonate. The other two sample sets were preserved by field filtration of cation samples prior to acidification and field titration of bicarbonate. All samples were preserved by placed in coolers and immediately delivered to the laboratories for analysis.

   Two sample sets, one utilizing each of the two field preservation techniques, were analyzed by Mountain States Analytical; and two identical sample sets were analyzed by Mayo and Associates. Results were compared between preservation techniques and between laboratories.

A third set of identical samples was sent to Ford Laboratory in order to obtain an independent check of the other laboratory results. Ford Laboratory was dropped from latter sampling rounds because they had similar high balance errors (5 to 8%) and their turn around time was too slow.

Laboratory results were disappointing. The field filtered cation results gave a slightly better cation-anion balance; however, all laboratory results had balance errors of less than 5%. Based on these laboratory results, which were completed on February 10, 1993, we concluded that the Mountain States Analytical had a laboratory problem that had subsequently been corrected.

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On March 3, 1993, Mountain States Analytical reported water quality results for a routine sampling of mine discharge water. A balance error of 14.38 % was reported. Obviously the balance error problem had not been resolved by Mountain States Analytical.

Because the test program strongly suggested that field sampling and preservation techniques were not the problem, we focused our attention on the analytical procedures used by Mountain States Analytical. Mountain States Analytical uses an ICP for metal analysis. Their results were generally consistent with the AA results of Mayo and Associates and were considered a less likely source of error than the anion analysis. Mountain States Analytical uses wet chemical methods (titration) for bicarbonate and chloride, and a turbidimetric meter for sulfate. Chloride was ruled out as the probable cause because chloride concentrations are low in most samples and because Mountain States Analytical obtained results similar to those of Mayo and Associates, which uses a "state of the art" IC.

The two major anions in SUFCO waters are bicarbonate and sulfate. Mountain States Analytical routinely reported bicarbonate concentrations about 20% less than results of Mayo and Associates using similar titration methods. Mayo and Associates checked Mountain States' titration acid and standard solution against their own acid and standard solution and obtained similar results. It was found that Mountain States Analytical had been reporting total alkalinity ($CaCO_3$) as bicarbonate. The 20% error was due to Mountain States Analytical reporting $CaCO_3$ as HCO_3^-. This failure to report alkalinity properly did not ultimately affect the cation-anion balance error, because Mountain States Analytical did do the conversion before calculating the balance error.

After bicarbonate was ruled out, sulfate remained the likely candidate for the cation-anion imbalance. Turbidity meters are a very old technology and often have difficulty with elevated levels of sulfate and in those cases where other interferences occur.

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It is our opinion that most of the balance error problems were due to sulfate analysis using the turbidity meter. We believe that with very careful work using appropriate dilutions, Mountain

States Analytical can achieve acceptable balance errors. In mid-April 1993, Mayo and Associates and SUFCO personnel executed an extensive water quality sampling program. Mountain States Analytical performed the laboratory analysis of the samples and had acceptable balance errors.

Sincerely,

Alan L. Mayo

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APPENDIX A

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Sincerely,

Alan L. Mayo

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APPENDIX B

SOLUTE ANALYTICAL REPORTS
PREPARED BY MOUNTAIN STATES ANALYTICAL

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001715
Sample Set: 000343S
Date Reported: 16 DEC 1992
Date Received: 3 DEC 1992
Disposal Date: 18 JAN 1993

Attention: Chris Kravits
Project: Waste Water
Case Number:
Purchase Order: SA6135

Customer Number: Head of 3 West Pump
Date Sampled: 1 DEC 1992
Matrix: Water/Waste Water
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Calcium	00250	EPA 600 Series 215.1	212		mg/l
Iron	00254	EPA 600 Series 236.1	1.21		mg/l
Magnesium	00257	EPA 600 Series 242.1	140		mg/l
Potassium	00262	EPA 600 Series 258.1	6.96		mg/l
Sodium	00267	EPA 600 Series 273.1	120		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	500	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	21.5	mg/l
Fluoride	00263	EPA 600 Series 340.2	0.4	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.12	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.7	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	1850	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	996	mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

14 Analyses for Sample Number 0001715

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 07-Jan-93

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 0001715
Analyst: RA/GS
Date: 01/07/93

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	212.00	10.57880	1	Chloride	21.50	0.60652
2	Magnesium	140.00	11.51640	2	Bicarbonate	500.00	8.19500
3	Iron	1.21	0.06500	3	Sulfate	996.00	20.73672
4	Sodium	120.00	5.22000	4	Fluoride	0.40	0.02106
5	Potassium	6.96	0.17797	5	Nitrate	0.12	0.00194
	Cation Total =		27.558168		Anion Total =		29.5612266

Percentage Error = 7.01% $\left(\frac{C-A}{C}\right)$

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001240
Sample Set: 000255S
Date Reported: 8 DEC 1992
Date Received: 19 NOV 1992
Disposal Date: 4 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number: 11/18/92
Purchase Order: SA6135

Customer Number: Floor of Quitch Port
Date Sampled: 16 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1		110	mg/l
Iron	00254	EPA 600 Series 236.1	<	0.05	mg/l
Magnesium	00257	EPA 600 Series 242.1		72.7	mg/l
Potassium	00262	EPA 600 Series 258.1		4.58	mg/l
Sodium	00267	EPA 600 Series 273.1		76.9	mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	190	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	21.9	mg/l
Fluoride	00263	EPA 600 Series 340.2	0.5	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	44.9	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.95	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	950	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	464	mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

APR 19 2018

15 Analyses for Sample Number 0001240

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 03-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1240
Analyst: RA/GS
Date: 12/03/92

	Cations	mg/l	meq/l
1	Calcium	110.00	5.48900
2	Magnesium	72.70	5.98030
3	Iron	0.00	0.00000
4	Sodium	76.90	3.34515
5	Potassium	4.58	0.11711
	Cation Total =		14.931562

	Anions	mg/l	meq/l
1	Chloride	21.90	0.61780
2	Bicarbonate	190.00	3.11410
3	Sulfate	464.00	9.66048
4	Fluoride	0.50	0.02632
5	Nitrate	44.90	0.72424
	Anion Total =		14.142936

Percentage Error = 5.42%

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001241
Sample Set: 000255S
Date Reported: 8 DEC 1992
Date Received: 19 NOV 1992
Disposal Date: 4 JAN 1993

3 WEST C 8

Attention: Chris Kravits
Project: Water Samples
Case Number: 11/18/92
Purchase Order: SA6135

Customer Number: Floor at #1 Entry
Date Sampled: 16 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1		196	mg/l
Iron	00254	EPA 600 Series 236.1	<	0.05	mg/l
Magnesium	00257	EPA 600 Series 242.1		154	mg/l
Potassium	00262	EPA 600 Series 258.1		6.7	mg/l
Sodium	00267	EPA 600 Series 273.1		120	mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B		362	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3		24.3	mg/l
Fluoride	00263	EPA 600 Series 340.2		0.4	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3		44.6	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040		7.77	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1		1800	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4		960	mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

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15 Analyses for Sample Number 0001241

Mountain States Analytical
The Quality Solution

Cation Anion Balance 03-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1241
Analyst: RA/GS
Date: 12/03/92

	Cations	mg/l	meq/l
1	Calcium	196.00	9.78040
2	Magnesium	154.00	12.66804
3	Iron	0.00	0.00000
4	Sodium	120.00	5.22000
5	Potassium	6.70	0.17132
	Cation Total =		27.839759

	Anions	mg/l	meq/l
1	Chloride	24.30	0.68550
2	Bicarbonate	362.00	5.93318
3	Sulfate	960.00	19.98720
4	Fluoride	0.40	0.02106
5	Nitrate	44.60	0.71940
	Anion Total =		27.346337

Percentage Error = 1.79%

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001239
Sample Set: 000255S
Date Reported: 8 DEC 1992
Date Received: 19 NOV 1992
Disposal Date: 4 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number: 11/18/92
Purchase Order: SA6135

Customer Number: 7L4E E3 C62 Roof
Date Sampled: 16 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1		75.8	mg/l
Iron	00254	EPA 600 Series 236.1	<	0.05	mg/l
Magnesium	00257	EPA 600 Series 242.1		43.5	mg/l
Potassium	00262	EPA 600 Series 258.1		3.28	mg/l
Sodium	00267	EPA 600 Series 273.1		70.3	mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	250	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	13.4	mg/l
Fluoride	00263	EPA 600 Series 340.2	0.3	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	9.55	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.49	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	420	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	110	mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

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15 Analyses for Sample Number 0001239

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Cation Anion Balance 14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1607
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l
1	Calcium	50.30	2.50997
2	Magnesium	21.10	1.73569
3	Iron	0.26	0.01397
4	Sodium	12.50	0.54375
5	Potassium	1.50	0.03836
	Cation Total =		4.8417282

	Anions	mg/l	meq/l
1	Chloride	9.70	0.27364
2	Bicarbonate	215.00	3.52385
3	Sulfate	35.00	0.72870
4	Fluoride	0.20	0.01053
5	Nitrate	0.11	0.00177
	Anion Total =		4.5384893

Percentage Error = 6.47%

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001606
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: 6L4E Bldr RD 89-20-2
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		
1 Analysis for Inorganics			Reviewed and approved by Glenn Sorensen, B.S. Manager, Inorganics Department		
Calcium	00250	EPA 600 Series 215.1	104		mg/l
Iron	00254	EPA 600 Series 236.1	0.078		mg/l
Magnesium	00257	EPA 600 Series 242.1	50		mg/l
Potassium	00262	EPA 600 Series 258.1	3.38		mg/l
Sodium	00267	EPA 600 Series 273.1	11.9		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		
7 Analyses for Metals			Reviewed and approved by Glenn Sorensen, B.S. Manager, Inorganics Department		
Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	289		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	29.1		mg/l
Fluoride	00263	EPA 600 Series 340.2	0.3		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.15		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.6		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	630		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	216		mg/l
7 Analyses for Wet Chemistry			Reviewed and approved by Glenn Sorensen, B.S. Manager, Inorganics Department		

15 Analyses for Sample Number 0001606

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Cation Anion Balance 14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1606
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	104.00	5.18960	1	Chloride	29.10	0.82091
2	Magnesium	50.00	4.11300	2	Bicarbonate	289.00	4.73671
3	Iron	0.08	0.00430	3	Sulfate	216.00	4.49712
4	Sodium	11.90	0.51765	4	Fluoride	0.30	0.01579
5	Potassium	3.38	0.08643	5	Nitrate	0.15	0.00242
	Cation Total =		9.9109742		Anion Total =		10.0729525

Percentage Error = 1.62%

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Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001605
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: Seals-End of 3 West
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method		Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83		See Attached		
1 Analysis for Inorganics				Reviewed and approved by Glenn Sorensen, B.S. Manager, Inorganics Department		
Calcium	00250	EPA 600 Series 215.1		93.5		mg/l
Iron	00254	EPA 600 Series 236.1	<	0.05		mg/l
Magnesium	00257	EPA 600 Series 242.1		49.8		mg/l
Potassium	00262	EPA 600 Series 258.1		4.23		mg/l
Sodium	00267	EPA 600 Series 273.1		77.4		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005		Complete		
Metals Prep.	00820	EPA SW-846 3005		Complete		
7 Analyses for Metals				Reviewed and approved by Glenn Sorensen, B.S. Manager, Inorganics Department		
Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B		388		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3		12.1		mg/l
Fluoride	00263	EPA 600 Series 340.2		5.7		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	<	0.05		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040		7.23		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1		770		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4		268		mg/l
7 Analyses for Wet Chemistry				Reviewed and approved by Glenn Sorensen, B.S. Manager, Inorganics Department		

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15 Analyses for Sample Number 0001605

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The Quality Solution

Cation Anion Balance 14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1605
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	93.50	4.66565	1	Chloride	12.10	0.34134
2	Magnesium	49.80	4.09655	2	Bicarbonate	388.00	6.35932
3	Iron	0.00	0.00000	3	Sulfate	268.00	5.57976
4	Sodium	77.40	3.36690	4	Fluoride	5.70	0.30005
5	Potassium	4.23	0.10816	5	Nitrate	0.00	0.00000
	Cation Total =		12.237259		Anion Total =		12.580469

Percentage Error = 2.77%

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The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001604
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: 3 West E4 C43 RDF
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1	60		mg/l
Iron	00254	EPA 600 Series 236.1	0.287		mg/l
Magnesium	00257	EPA 600 Series 242.1	20.6		mg/l
Potassium	00262	EPA 600 Series 258.1	1.51		mg/l
Sodium	00267	EPA 600 Series 273.1	11.3		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	215		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	10.9		mg/l
Fluoride	00263	EPA 600 Series 340.2	0.2		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	< 0.05		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.6		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	290		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	35		mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

APR 19 2018

15 Analyses for Sample Number 0001604

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Cation Anion Balance

14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1604
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l
1	Calcium	60.00	2.99400
2	Magnesium	20.60	1.69456
3	Iron	0.29	0.01558
4	Sodium	11.30	0.49155
5	Potassium	1.51	0.03861
	Cation Total =		5.2342955

	Anions	mg/l	meq/l
1	Chloride	10.90	0.30749
2	Bicarbonate	215.00	3.52385
3	Sulfate	35.00	0.72870
4	Fluoride	0.20	0.01053
5	Nitrate	0.00	0.00000
	Anion Total =		4.570567

Percentage Error = 13.54%

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The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001603
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: N M E4 C127 R D
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1	143		mg/l
Iron	00254	EPA 600 Series 236.1	2.39		mg/l
Magnesium	00257	EPA 600 Series 242.1	62.3		mg/l
Potassium	00262	EPA 600 Series 258.1	6.45		mg/l
Sodium	00267	EPA 600 Series 273.1	89.9		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	259		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	26.7		mg/l
Fluoride	00263	EPA 600 Series 340.2	1.6		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.08		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.87		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	950		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	453		mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

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15 Analyses for Sample Number 0001603

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Cation Anion Balance 14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1603
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l
1	Calcium	143.00	7.13570
2	Magnesium	62.30	5.12480
3	Iron	2.39	0.12839
4	Sodium	89.90	3.91065
5	Potassium	6.45	0.16493
	Cation Total =		16.464465

	Anions	mg/l	meq/l
1	Chloride	26.70	0.75321
2	Bicarbonate	259.00	4.24501
3	Sulfate	453.00	9.43146
4	Fluoride	1.60	0.08422
5	Nitrate	0.08	0.00129
	Anion Total =		14.5151914

Percentage Error = 12.58%

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The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001602
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: N M E4 C137 Sump
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1	108		mg/l
Iron	00254	EPA 600 Series 236.1	0.086		mg/l
Magnesium	00257	EPA 600 Series 242.1	54.4		mg/l
Potassium	00262	EPA 600 Series 258.1	5.75		mg/l
Sodium	00267	EPA 600 Series 273.1	98.3		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	219		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	31.6		mg/l
Fluoride	00263	EPA 600 Series 340.2	1.4		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.11		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	8.07		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	1000		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	509		mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

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15 Analyses for Sample Number 0001602

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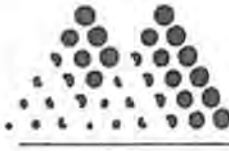

Mountain States Analytical

The Quality Solution

Cation Anion Balance 14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1602
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	108.00	5.38920	1	Chloride	31.60	0.89144
2	Magnesium	54.40	4.47494	2	Bicarbonate	219.00	3.58941
3	Iron	0.09	0.00483	3	Sulfate	509.00	10.59738
4	Sodium	98.30	4.27605	4	Fluoride	1.40	0.07370
5	Potassium	5.75	0.14703	5	Nitrate	0.11	0.00177
	Cation Total =		14.292056		Anion Total =		15.1536963

Percentage Error = 5.85%

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1645 West 2200 South, Salt Lake City, Utah 84119 (801) 973-0050 FAX (801) 972-6278

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The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001601
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: N Mains E4 C128 R D
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1	84.3		mg/l
Iron	00254	EPA 600 Series 236.1	0.096		mg/l
Magnesium	00257	EPA 600 Series 242.1	32.1		mg/l
Potassium	00262	EPA 600 Series 258.1	1.45		mg/l
Sodium	00267	EPA 600 Series 273.1	6.49		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	320		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	14.6		mg/l
Fluoride	00263	EPA 600 Series 340.2	0.3		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	< 0.05		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	8.06		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	360		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	64		mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

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15 Analyses for Sample Number 0001601

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Cation Anion Balance 14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1601
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	84.30	4.20657	1	Chloride	14.60	0.41187
2	Magnesium	32.10	2.64055	2	Bicarbonate	320.00	5.24480
3	Iron	0.10	0.00537	3	Sulfate	64.00	1.33248
4	Sodium	6.49	0.28232	4	Fluoride	0.30	0.01579
5	Potassium	1.45	0.03708	5	Nitrate	0.05	0.00081
	Cation Total =		7.1718795		Anion Total =		7.0057445

Percentage Error = 2.34%

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Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001600
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: N Mains E4 C128 Smp
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1	231		mg/l
Iron	00254	EPA 600 Series 236.1	0.077		mg/l
Magnesium	00257	EPA 600 Series 242.1	96.9		mg/l
Potassium	00262	EPA 600 Series 258.1	3.24		mg/l
Sodium	00267	EPA 600 Series 273.1	59.6		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	179		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	168		mg/l
Fluoride	00263	EPA 600 Series 340.2	0.9		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.05		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.95		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	1510		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	702		mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

15 Analyses for Sample Number 0001600

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 14-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1600
Analyst: RA/GS
Date: 12/14/92

	Cations	mg/l	meq/l
1	Calcium	231.00	11.52690
2	Magnesium	96.90	7.97099
3	Iron	0.08	0.00430
4	Sodium	59.60	2.59260
5	Potassium	3.24	0.08285
	Cation Total =		22.177638

	Anions	mg/l	meq/l
1	Chloride	168.00	4.73928
2	Bicarbonate	179.00	2.93381
3	Sulfate	702.00	14.61564
4	Fluoride	0.90	0.04738
5	Nitrate	0.05	0.00081
	Anion Total =		22.3369125

Percentage Error = 0.72%

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001716
Sample Set: 000343S
Date Reported: 16 DEC 1992
Date Received: 3 DEC 1992
Disposal Date: 18 JAN 1993

Attention: Chris Kravits
Project: Waste Water
Case Number:
Purchase Order: SA6135

Customer Number: 1L6E N Seal Bleeder
Date Sampled: 1 DEC 1992
Matrix: Water/Waste Water
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Calcium	00250	EPA 600 Series 215.1	193		mg/l
Iron	00254	EPA 600 Series 236.1	0.084		mg/l
Magnesium	00257	EPA 600 Series 242.1	134		mg/l
Potassium	00262	EPA 600 Series 258.1	6.56		mg/l
Sodium	00267	EPA 600 Series 273.1	124		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	484		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	19.9		mg/l
Fluoride	00263	EPA 600 Series 340.2	0.4		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	< 0.05		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.09		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	2240		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	988		mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

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14 Analyses for Sample Number 0001716

Mountain States Analytical
The Quality Solution

Cation Anion Balance 07-Jan-93

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 0001716
Analyst: RA/GS
Date: 01/07/93

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	193.00	9.63070	1	Chloride	19.90	0.56138
2	Magnesium	134.00	11.02284	2	Bicarbonate	484.00	7.93276
3	Iron	0.08	0.00451	3	Sulfate	988.00	20.57016
4	Sodium	124.00	5.39400	4	Fluoride	0.40	0.02106
5	Potassium	6.56	0.16774	5	Nitrate	0.00	0.00000
	Cation Total =		26.219791		Anion Total =		29.085355

Percentage Error = 10.36%

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Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001714
Sample Set: 000343S
Date Reported: 16 DEC 1992
Date Received: 3 DEC 1992
Disposal Date: 18 JAN 1993

Attention: Chris Kravits
Project: Waste Water
Case Number:
Purchase Order: SA6135

Customer Number: Head of 6 East Seal
Date Sampled: 1 DEC 1992
Matrix: Water/Waste Water
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Calcium	00250	EPA 600 Series 215.1	149		mg/l
Iron	00254	EPA 600 Series 236.1	0.28		mg/l
Magnesium	00257	EPA 600 Series 242.1	96.6		mg/l
Potassium	00262	EPA 600 Series 258.1	5.95		mg/l
Sodium	00267	EPA 600 Series 273.1	60.7		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	458		mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	18.2		mg/l
Fluoride	00263	EPA 600 Series 340.2	0.6		mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.17		mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.37		
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	1270		mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	543		mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

14 Analyses for Sample Number 0001714

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Cation Anion Balance 07-Jan-93

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 0001714
Analyst: RA/GS
Date: 01/07/93

	Cations	mg/l	meq/l
1	Calcium	149.00	7.43510
2	Magnesium	96.60	7.94632
3	Iron	0.28	0.01504
4	Sodium	60.70	2.64045
5	Potassium	5.95	0.15214
	Cation Total =		18.189049

	Anions	mg/l	meq/l
1	Chloride	18.20	0.51342
2	Bicarbonate	458.00	7.50662
3	Sulfate	543.00	11.30526
4	Fluoride	0.60	0.03158
5	Nitrate	0.17	0.00274
	Anion Total =		19.3596281

Percentage Error = 6.23%

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Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001713
Sample Set: 000343S
Date Reported: 16 DEC 1992
Date Received: 3 DEC 1992
Disposal Date: 18 JAN 1993

Attention: Chris Kravits
Project: Waste Water
Case Number:
Purchase Order: SA6135

Customer Number: N Mains C120 Pump
Date Sampled: 1 DEC 1992
Matrix: Water/Waste Water
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Calcium	00250	EPA 600 Series 215.1	208		mg/l
Iron	00254	EPA 600 Series 236.1	0.294		mg/l
Magnesium	00257	EPA 600 Series 242.1	74.1		mg/l
Potassium	00262	EPA 600 Series 258.1	4.14		mg/l
Sodium	00267	EPA 600 Series 273.1	71.2		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	320	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	20.3	mg/l
Fluoride	00263	EPA 600 Series 340.2	0.4	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.61	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.85	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	1190	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	579	mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

14 Analyses for Sample Number 0001713

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 07-Jan-93

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1713
Analyst: RA/GS
Date: 01/07/93

	Cations	mg/l	meq/l
1	Calcium	208.00	10.37920
2	Magnesium	74.10	6.09547
3	Iron	0.29	0.01558
4	Sodium	71.20	3.09720
5	Potassium	4.14	0.10586
	Cation Total =		19.693304

	Anions	mg/l	meq/l
1	Chloride	20.30	0.57266
2	Bicarbonate	320.00	5.24480
3	Sulfate	579.00	12.05478
4	Fluoride	0.40	0.02106
5	Nitrate	0.60	0.00968
	Anion Total =		17.902977

Percentage Error = 9.52%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36426
Analyst: RA/CS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	928.00	46.30720	1	Chloride	4780.00	134.84380
2	Magnesium	1734.00	142.63884	2	Bicarbonate	200.00	3.27800
3	Iron	0.05	0.00269	3	Sulfate	3300.00	68.70600
4	Sodium	260.00	11.31000	4	Fluoride	0.40	0.02106
5	Potassium	18.40	0.47049	5	Nitrate	0.11	0.00177
	Cation Total =		200.72921		Anion Total =		206.850630

Percentage Error = 3.00%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36427
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l
1	Calcium	684.00	34.13160
2	Magnesium	69.30	5.70062
3	Iron	0.05	0.00269
4	Sodium	30.80	1.33980
5	Potassium	3.85	0.09844
	Cation Total =		41.273148

	Anions	mg/l	meq/l
1	Chloride	16.00	0.45136
2	Bicarbonate	236.00	3.86804
3	Sulfate	1150.00	23.94300
4	Fluoride	0.30	0.01579
5	Nitrate	2.71	0.04371
	Anion Total =		28.3219043

Percentage Error = 37.22%

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The Quality Solution

Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36428
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	122.00	6.08780	1	Chloride	24.30	0.68550
2	Magnesium	63.70	5.23996	2	Bicarbonate	354.00	5.80206
3	Iron	0.05	0.00269	3	Sulfate	147.00	3.06054
4	Sodium	13.30	0.57855	4	Fluoride	0.30	0.01579
5	Potassium	4.18	0.10688	5	Nitrate	0.00	0.00000
	Cation Total =		12.015880		Anion Total =		9.563895

Percentage Error = 22.72%

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36429
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	631.00	31.48690	1	Chloride	65.60	1.85058
2	Magnesium	95.20	7.83115	2	Bicarbonate	226.00	3.70414
3	Iron	0.75	0.04029	3	Sulfate	1600.00	33.31200
4	Sodium	105.00	4.56750	4	Fluoride	0.40	0.02106
5	Potassium	5.24	0.13399	5	Nitrate	1.59	0.02565
	Cation Total =		44.059828		Anion Total =		38.9134187

Percentage Error = 12.40%

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36430
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	867.00	43.26330	1	Chloride	874.00	24.65554
2	Magnesium	371.00	30.51846	2	Bicarbonate	119.00	1.95041
3	Iron	0.05	0.00269	3	Sulfate	2070.00	43.09740
4	Sodium	208.00	9.04800	4	Fluoride	0.50	0.02632
5	Potassium	10.10	0.25826	5	Nitrate	0.08	0.00129
	Cation Total =		83.090703		Anion Total =		69.7309604

Percentage Error = 17.48%

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1645 West 2200 South, Salt Lake City, Utah 84119 (801) 973-0050 FAX (801) 972-6278

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Mountain States Analytical

The Quality Solution

CLIENT: Southern Utah Fuel Co.
397 South 800 West
Salina, UT 84654-
Phone: 801-637-4880 801-534-3296 (FAX)
ATTN: Mr. Chris Kravits
Project:

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9177
Sample Matrix: Aqueous
Report Date: 11/09/92
P.O. Number: SA6135

LAB SAMPLE NO.	SAMP DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
36419	10/22/92	0	North Main #3 Sump	Calcium, FAA w/ww	447 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	1.43 mg/l
				Magnesium, FAA w/ww	148 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	5.19 mg/l
				Sodium, FAA w/ww	78.5 mg/l
				Alkalinity, Bicarbonate	273 mg/l CaCO3
				Chloride, Titrimetric w	129 mg/l
				Fluoride, SIE w/ww	0.4 mg/l
				Nitrate/Nitrite w/ww	0.56 mg/l N
				pH, Aqueous	7.67 ---
				Solids, Dissolved TDS	2,130 mg/l
				Sulfate, Turbidimetric	943 mg/l
36420	10/22/92	0	North Main #4 Sump	Calcium, FAA w/ww	143 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	0.22 mg/l
				Magnesium, FAA w/ww	77.6 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	6.23 mg/l
				Sodium, FAA w/ww	54.5 mg/l
				Alkalinity, Bicarbonate	234 mg/l CaCO3
				Chloride, Titrimetric w	18.9 mg/l
				Fluoride, SIE w/ww	0.5 mg/l
				Nitrate/Nitrite w/ww	0.27 mg/l N
				pH, Aqueous	7.97 ---
				Solids, Dissolved TDS	900 mg/l
				Sulfate, Turbidimetric	454 mg/l
36421	10/22/92	0	North Main Face Pump	Calcium, FAA w/ww	107 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	0.07 mg/l
				Magnesium, FAA w/ww	57.0 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	5.00 mg/l

APR 19 2018

Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001607
Sample Set: 000316S
Date Reported: 18 DEC 1992
Date Received: 30 NOV 1992
Disposal Date: 15 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number:
Purchase Order: SA 6135

Customer Number: 3 West E4 C44 RD
Date Sampled: 24 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1	50.3		mg/l
Iron	00254	EPA 600 Series 236.1	0.256		mg/l
Magnesium	00257	EPA 600 Series 242.1	21.1		mg/l
Potassium	00262	EPA 600 Series 258.1	1.5		mg/l
Sodium	00267	EPA 600 Series 273.1	12.5		mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	215	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	9.7	mg/l
Fluoride	00263	EPA 600 Series 340.2	0.2	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	0.11	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.92	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	300	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	35	mg/l

7 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

APR 19 2018

15 Analyses for Sample Number 0001607

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Cation Anion Balance 03-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1239
Analyst: RA/GS
Date: 12/03/92

	Cations	mg/l	meq/l
1	Calcium	75.80	3.78242
2	Magnesium	43.50	3.57831
3	Iron	0.00	0.00000
4	Sodium	12.70	0.55245
5	Potassium	3.28	0.08387
	Cation Total =		7.9970496

	Anions	mg/l	meq/l
1	Chloride	13.40	0.37801
2	Bicarbonate	250.00	4.09750
3	Sulfate	110.00	2.29020
4	Fluoride	0.30	0.01579
5	Nitrate	9.55	0.15404
	Anion Total =		6.9355475

Percentage Error = 14.22%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36431
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	801.00	39.96990	1	Chloride	79.60	2.24552
2	Magnesium	78.70	6.47386	2	Bicarbonate	535.00	8.76865
3	Iron	0.31	0.01665	3	Sulfate	1660.00	34.56120
4	Sodium	225.00	9.78750	4	Fluoride	0.40	0.02106
5	Potassium	7.61	0.19459	5	Nitrate	0.05	0.00081
	Cation Total =		56.442502		Anion Total =		45.5972285

Percentage Error = 21.26%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36432
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	70.50	3.51795	1	Chloride	9.70	0.27364
2	Magnesium	38.10	3.13411	2	Bicarbonate	248.00	4.06472
3	Iron	0.05	0.00269	3	Sulfate	79.00	1.64478
4	Sodium	11.20	0.48720	4	Fluoride	0.30	0.01579
5	Potassium	2.72	0.06955	5	Nitrate	0.05	0.00081
	Cation Total =		7.2114924		Anion Total =		5.9997355

Percentage Error = 18.34%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36433
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l
1	Calcium	203.00	10.12970
2	Magnesium	62.50	5.14125
3	Iron	0.05	0.00269
4	Sodium	41.00	1.78350
5	Potassium	3.68	0.09410
	Cation Total =		17.151233

	Anions	mg/l	meq/l
1	Chloride	21.40	0.60369
2	Bicarbonate	180.00	2.95020
3	Sulfate	588.00	12.24216
4	Fluoride	0.30	0.01579
5	Nitrate	0.12	0.00194
	Anion Total =		15.8137816

Percentage Error = 8.11%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36434
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l
1	Calcium	114.00	5.68860
2	Magnesium	60.40	4.96850
3	Iron	0.05	0.00269
4	Sodium	15.70	0.68295
5	Potassium	4.45	0.11379
	Cation Total =		11.456526

	Anions	mg/l	meq/l
1	Chloride	21.40	0.60369
2	Bicarbonate	334.00	5.47426
3	Sulfate	159.00	3.31038
4	Fluoride	0.50	0.02632
5	Nitrate	0.81	0.01307
	Anion Total =		9.4277193

Percentage Error = 19.43%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36435
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	108.00	5.38920	1	Chloride	36.40	1.02684
2	Magnesium	97.20	7.99567	2	Bicarbonate	343.00	5.62177
3	Iron	1.51	0.08112	3	Sulfate	480.00	9.99360
4	Sodium	103.00	4.48050	4	Fluoride	0.30	0.01579
5	Potassium	4.62	0.11813	5	Nitrate	0.05	0.00081
	Cation Total =		18.064622		Anion Total =		16.6588125

Percentage Error = 8.10%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36436
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	118.00	5.88820	1	Chloride	15.50	0.43726
2	Magnesium	70.70	5.81578	2	Bicarbonate	212.00	3.47468
3	Iron	0.05	0.00269	3	Sulfate	407.00	8.47374
4	Sodium	48.00	2.08800	4	Fluoride	0.50	0.02632
5	Potassium	5.75	0.14703	5	Nitrate	0.42	0.00677
	Cation Total =		13.941695		Anion Total =		12.4187696

Percentage Error = 11.55%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36437
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	150.00	7.48500	1	Chloride	340.00	9.59140
2	Magnesium	67.60	5.56078	2	Bicarbonate	72.00	1.18008
3	Iron	4.32	0.23207	3	Sulfate	2250.00	46.84500
4	Sodium	796.00	34.62600	4	Fluoride	0.40	0.02106
5	Potassium	5.43	0.13885	5	Nitrate	0.00	0.00000
	Cation Total =		48.042691		Anion Total =		57.637536

Percentage Error = 18.16%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36438
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l
1	Calcium	448.00	22.35520
2	Magnesium	204.00	16.78104
3	Iron	64.20	3.44882
4	Sodium	144.00	6.26400
5	Potassium	8.48	0.21683
	Cation Total =		49.065897

	Anions	mg/l	meq/l
1	Chloride	60.70	1.71235
2	Bicarbonate	0.00	0.00000
3	Sulfate	2820.00	58.71240
4	Fluoride	0.70	0.03685
5	Nitrate	11.90	0.19195
	Anion Total =		60.653542

Percentage Error = 21.12%

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Cation Anion Balance 16-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 565
Analyst: RA/GS
Date: 11/16/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	47.60	2.37524	1	Chloride	10.70	0.30185
2	Magnesium	44.50	3.66057	2	Bicarbonate	257.00	4.21223
3	Iron	0.17	0.00913	3	Sulfate	318.00	6.62076
4	Sodium	120.00	5.22000	4	Fluoride	0.50	0.02632
5	Potassium	3.56	0.09103	5	Nitrate	0.16	0.00258
	Cation Total =		11.355971		Anion Total =		11.1637378

Percentage Error = 1.71%

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Cation Anion Balance 16-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 568
Analyst: RA/GS
Date: 11/16/92

	Cations	mg/l	meq/l
1	Calcium	80.00	3.99200
2	Magnesium	51.10	4.20349
3	Iron	0.10	0.00537
4	Sodium	64.00	2.78400
5	Potassium	3.68	0.09410
	Cation Total =		11.078955

	Anions	mg/l	meq/l
1	Chloride	27.20	0.76731
2	Bicarbonate	196.00	3.21244
3	Sulfate	455.00	9.47310
4	Fluoride	0.50	0.02632
5	Nitrate	0.20	0.00323
	Anion Total =		13.482398

Percentage Error = 19.57%

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Cation Anion Balance 16-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 569
Analyst: RA/GS
Date: 11/16/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	140.00	6.98600	1	Chloride	47.60	1.34280
2	Magnesium	65.30	5.37158	2	Bicarbonate	178.00	2.91742
3	Iron	0.68	0.03653	3	Sulfate	843.00	17.55126
4	Sodium	148.00	6.43800	4	Fluoride	0.80	0.04211
5	Potassium	4.73	0.12095	5	Nitrate	0.06	0.00097
	Cation Total =		18.953053		Anion Total =		21.8545558

Percentage Error = 14.22%

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Cation Anion Balance 16-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 563
Analyst: RA/GS
Date: 11/16/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	142.00	7.08580	1	Chloride	14.60	0.41187
2	Magnesium	47.70	3.92380	2	Bicarbonate	329.00	5.39231
3	Iron	0.38	0.02041	3	Sulfate	262.00	5.45484
4	Sodium	65.40	2.84490	4	Fluoride	0.50	0.02632
5	Potassium	3.40	0.08694	5	Nitrate	0.28	0.00452
	Cation Total =		13.961853		Anion Total =		11.2898524

Percentage Error = 21.16%

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Cation Anion Balance

16-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 564
Analyst: RA/GS
Date: 11/16/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	101.00	5.03990	1	Chloride	10.70	0.30185
2	Magnesium	23.30	1.91666	2	Bicarbonate	196.00	3.21244
3	Iron	0.61	0.03277	3	Sulfate	165.00	3.43530
4	Sodium	50.30	2.18805	4	Fluoride	0.40	0.02106
5	Potassium	2.39	0.06111	5	Nitrate	0.44	0.00710
	Cation Total =		9.2384895		Anion Total =		6.9777402

Percentage Error = 27.88%

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Cation Anion Balance 16-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 566
Analyst: RA/GS
Date: 11/16/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	61.50	3.06885	1	Chloride	12.60	0.35545
2	Magnesium	54.70	4.49962	2	Bicarbonate	317.00	5.19563
3	Iron	0.05	0.00269	3	Sulfate	281.00	5.85042
4	Sodium	67.20	2.92320	4	Fluoride	0.50	0.02632
5	Potassium	3.40	0.08694	5	Nitrate	0.25	0.00403
	Cation Total =		10.581296		Anion Total =		11.4318485

Percentage Error = 7.73%

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Cation Anion Balance 16-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 567
Analyst: RA/GS
Date: 11/16/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	77.20	3.85228	1	Chloride	15.50	0.43726
2	Magnesium	90.20	7.41985	2	Bicarbonate	248.00	4.06472
3	Iron	0.15	0.00806	3	Sulfate	620.00	12.90840
4	Sodium	78.70	3.42345	4	Fluoride	0.30	0.01579
5	Potassium	3.92	0.10023	5	Nitrate	0.08	0.00129
	Cation Total =		14.803874		Anion Total =		17.4274574

Percentage Error = 16.28%

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CLIENT: Southern Utah Fuel Company
397 South 800 West
Salina, UT 84654
Phone: 801-637-4880 Fax: 801-534-3296
ATTN: Chris Kravits
Job No.:

Date Samples Rec'd: 29-Oct-92
MSAI Group No.: 000112S
Sample Matrix: Aqueous
Report Date: 16-Nov-92
P.O. Number: SA6135

LAB NO.	SAMPLE DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
0000565	28-Oct-92	0	3 West C37	Bicarbonate (inc. Alkalinity),	257 mg/l
				Calcium, FAA, w/ww	47.6 mg/l
				Cation/Anion Balance	See Attach---
				Chloride, Titrimentric, w/ww	10.7 mg/l
				Fluoride, Sie, w/ww	0.5 mg/l
				Iron, FAA, w/ww	0.17 mg/l
				Magnesium, FAA, w/ww	44.5 mg/l
				Metals Prep. FAA, w/ww	Complete ---
				Metals Preparation, w/ww	Complete ---
				Nitrate Nitrogen, W/ww	0.16 mg/l
				pH, Aqueous, w/ww	8.14 mg/l
				Potassium, FAA, w/ww	3.56 mg/l
				Sodium, FAA, w/ww	120 mg/l
				Solids, Dissolved TDS (Filterable), w/ww	810 mg/l
				Sulfate, Turbidimetric, w/ww	318 mg/l
0000566	28-Oct-92	0	6 North Sump	Bicarbonate (inc. Alkalinity),	317 mg/l
				Calcium, FAA, w/ww	61.5 mg/l
				Cation/Anion Balance	See Attach---
				Chloride, Titrimentric, w/ww	12.6 mg/l
				Fluoride, Sie, w/ww	0.5 mg/l
				Iron, FAA, w/ww	<0.05 mg/l
				Magnesium, FAA, w/ww	54.7 mg/l
				Metals Prep. FAA, w/ww	Complete ---
				Metals Preparation, w/ww	Complete ---
				Nitrate Nitrogen, W/ww	0.25 mg/l
				pH, Aqueous, w/ww	8.14 mg/l
				Potassium, FAA, w/ww	3.4 mg/l
				Sodium, FAA, w/ww	67.2 mg/l
				Solids, Dissolved TDS (Filterable), w/ww	750 mg/l
				Sulfate, Turbidimetric, w/ww	281 mg/l

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Analytical Report

Mountain States Analytical

The Quality Solution

CLIENT: Southern Utah Fuel Company
397 South 800 West
Salina, UT 84654
Phone: 801-637-4880 Fax: 801-534-3296
ATTN: Chris Kravits
Job No.:

Date Samples Rec'd: 29-Oct-92
MSAI Group No.: 000112S
Sample Matrix: Aqueous
Report Date: 16-Nov-92
P.O. Number: SA6135

LAB NO.	SAMPLE DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
0000567	28-Oct-92	0	3 West C22	Bicarbonate (inc. Alkalinity),	248 mg/l
				Calcium, FAA, w/ww	77.2 mg/l
				Cation/Anion Balance	See Attach---
				Chloride, Titrimentric, w/ww	15.5 mg/l
				Fluoride, Sie, w/ww	0.3 mg/l
				Iron, FAA, w/ww	0.15 mg/l
				Magnesium, FAA, w/ww	90.2 mg/l
				Metals Prep. FAA, w/ww	Complete ---
				Metals Preparation, w/ww	Complete ---
				Nitrate Nitrogen, W/ww	0.08 mg/l
				pH, Aqueous, w/ww	8.10 [illegible]
				Potassium, FAA, w/ww	3.92 mg/l
				Sodium, FAA, w/ww	78.7 mg/l
				Solids, Dissolved TDS (Filterable), w/ww	1,120 mg/l
				Sulfate, Turbidimetric, w/ww	620 mg/l
0000568	28-Oct-92	0	N. Mains #2 Sump	Bicarbonate (inc. Alkalinity),	196 mg/l
				Calcium, FAA, w/ww	80 mg/l
				Cation/Anion Balance	See Attach---
				Chloride, Titrimentric, w/ww	27.2 mg/l
				Fluoride, Sie, w/ww	0.5 mg/l
				Iron, FAA, w/ww	0.1 mg/l
				Magnesium, FAA, w/ww	51.1 mg/l
				Metals Prep. FAA, w/ww	Complete ---
				Metals Preparation, w/ww	Complete ---
				Nitrate Nitrogen, W/ww	0.20 mg/l
				pH, Aqueous, w/ww	8.07 mg/l
				Potassium, FAA, w/ww	3.68 mg/l
				Sodium, FAA, w/ww	64 mg/l
				Solids, Dissolved TDS (Filterable), w/ww	910 mg/l
				Sulfate, Turbidimetric, w/ww	455 mg/l

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Analytical Report

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CLIENT: Southern Utah Fuel Company
397 South 800 West
Salina, UT 84654
Phone: 801-637-4880 Fax: 801-534-3296
ATTN: Chris Kravits
Job No.:

Date Samples Rec'd: 29-Oct-92
MSAI Group No.: 000112S
Sample Matrix: Aqueous
Report Date: 16-Nov-92
P.O. Number: SA6135

LAB NO.	SAMPLE DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
0000569	28-Oct-92	0	Lake SUFCO	Bicarbonate (inc. Alkalinity),	178 mg/l
				Calcium, FAA, w/ww	140 mg/l
				Cation/Anion Balance	See Attach---
				Chloride, Titrimentric, w/ww	47.6 mg/l
				Fluoride, Sie, w/ww	0.8 mg/l
				Iron, FAA, w/ww	0.68 mg/l
				Magnesium, FAA, w/ww	65.3 mg/l
				Metals Prep. FAA, w/ww	Complete ---
				Metals Preparation, w/ww	Complete ---
				Nitrate Nitrogen, W/ww	0.06 mg/l
				pH, Aqueous, w/ww	7.63 mg/l
				Sodium, FAA, w/ww	148 mg/l
				Potassium, FAA, w/ww	4.73 mg/l
				Solids, Dissolved TDS (Filterable), w/ww	1,540 mg/l
				Sulfate, Turbidimetric, w/ww	843 mg/l

Respectfully submitted,

Douglas W. Later

Douglas W. Later, Ph.D.
Laboratory Director

Glenn A. Sorensen

Glenn A. Sorensen, B.S.
Manager, Technical Operations

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Analytical Report

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CLIENT: Southern Utah Fuel Company
397 South 800 West
Salina, UT 84654
Phone: 801-637-4880 Fax: 801-534-3296
ATTN: Chris Kravits
Job No.:

Date Samples Rec'd: 29-Oct-92
MSAI Group No.: 000112S
Sample Matrix: Aqueous
Report Date: 16-Nov-92
P.O. Number: SA6135

LAB NO.	SAMPLE DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
0000563	28-Oct-92		0 3 West Sump	Bicarbonate (inc. Alkalinity),	329 mg/l
				Calcium, FAA, w/ww	142 mg/l
				Cation/Anion Balance	See Attach---
				Chloride, Titrimentric, w/ww	14.6 mg/l
				Fluoride, Sie, w/ww	0.5 mg/l
				Iron, FAA, w/ww	0.38 mg/l
				Magnesium, FAA, w/ww	47.7 mg/l
				Metals Prep. FAA, w/ww	Complete ---
				Metals Preparation, w/ww	Complete ---
				Nitrate Nitrogen, W/ww	0.28 mg/l
				pH, Aqueous, w/ww	7.70 [illegible]
				Sodium, FAA, w/ww	65.4 mg/l
				Potassium, FAA, w/ww	3.4 mg/l
				Solids, Dissolved TDS (Filterable), w/ww	680 mg/l
				Sulfate, Turbidimetric, w/ww	262 mg/l
0000564	28-Oct-92		0 3 West C44	Bicarbonate (inc. Alkalinity),	196 mg/l
				Calcium, FAA, w/ww	101 mg/l
				Cation/Anion Balance	See Attach---
				Chloride, Titrimentric, w/ww	10.7 mg/l
				Fluoride, Sie, w/ww	0.4 mg/l
				Iron, FAA, w/ww	0.61 mg/l
				Magnesium, FAA, w/ww	23.3 mg/l
				Metals Prep. FAA, w/ww	Complete ---
				Metals Preparation, w/ww	Complete ---
				Nitrate Nitrogen, W/ww	0.44 mg/l
				pH, Aqueous, w/ww	8.10 mg/l
				Sodium, FAA, w/ww	50.3 mg/l
				Potassium, FAA, w/ww	2.39 mg/l
				Solids, Dissolved TDS (Filterable), w/ww	430 mg/l
				Sulfate, Turbidimetric, w/ww	165 mg/l

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36419
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l
1	Calcium	447.00	22.30530
2	Magnesium	148.00	12.17448
3	Iron	1.43	0.07682
4	Sodium	78.50	3.41475
5	Potassium	5.19	0.13271
	Cation Total =		38.104057

	Anions	mg/l	meq/l
1	Chloride	129.00	3.63909
2	Bicarbonate	273.00	4.47447
3	Sulfate	943.00	19.63326
4	Fluoride	0.40	0.02106
5	Nitrate	0.56	0.00903
	Anion Total =		27.7769088

Percentage Error = 31.35%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36420
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	143.00	7.13570	1	Chloride	18.90	0.53317
2	Magnesium	77.60	6.38338	2	Bicarbonate	234.00	3.83526
3	Iron	0.22	0.01182	3	Sulfate	454.00	9.45228
4	Sodium	54.50	2.37075	4	Fluoride	0.50	0.02632
5	Potassium	6.23	0.15930	5	Nitrate	0.27	0.00436
	Cation Total =		16.060945		Anion Total =		13.8513841

Percentage Error = 14.77%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36421
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l
1	Calcium	107.00	5.33930
2	Magnesium	57.00	4.68882
3	Iron	0.07	0.00376
4	Sodium	38.70	1.68345
5	Potassium	5.00	0.12785
	Cation Total =		11.843180

	Anions	mg/l	meq/l
1	Chloride	35.90	1.01274
2	Bicarbonate	224.00	3.67136
3	Sulfate	240.00	4.99680
4	Fluoride	0.40	0.02106
5	Nitrate	0.24	0.00387
	Anion Total =		9.7058262

Percentage Error = 19.84%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36422
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	103.00	5.13970	1	Chloride	14.60	0.41187
2	Magnesium	48.50	3.98961	2	Bicarbonate	277.00	4.54003
3	Iron	0.31	0.01665	3	Sulfate	147.00	3.06054
4	Sodium	14.90	0.64815	4	Fluoride	0.30	0.01579
5	Potassium	3.62	0.09256	5	Nitrate	0.39	0.00629
	Cation Total =		9.8866766		Anion Total =		8.0345187

Percentage Error = 20.67%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36423
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l
1	Calcium	223.00	11.12770
2	Magnesium	78.50	6.45741
3	Iron	0.37	0.01988
4	Sodium	45.60	1.98360
5	Potassium	5.55	0.14191
	Cation Total =		19.730499

	Anions	mg/l	meq/l
1	Chloride	54.40	1.53462
2	Bicarbonate	123.00	2.01597
3	Sulfate	597.00	12.42954
4	Fluoride	0.40	0.02106
5	Nitrate	0.14	0.00226
	Anion Total =		16.0034482

Percentage Error = 20.86%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36424
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	258.00	12.87420	1	Chloride	32.10	0.90554
2	Magnesium	103.00	8.47278	2	Bicarbonate	182.00	2.98298
3	Iron	0.36	0.01934	3	Sulfate	951.00	19.79982
4	Sodium	124.00	5.39400	4	Fluoride	0.40	0.02106
5	Potassium	5.07	0.12964	5	Nitrate	1.88	0.03032
	Cation Total =		26.889959		Anion Total =		23.7397214

Percentage Error = 12.44%

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Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36425
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	702.00	35.02980	1	Chloride	1360.00	38.36560
2	Magnesium	604.00	49.68504	2	Bicarbonate	163.00	2.67157
3	Iron	0.05	0.00269	3	Sulfate	2490.00	51.84180
4	Sodium	259.00	11.26650	4	Fluoride	0.40	0.02106
5	Potassium	8.88	0.22706	5	Nitrate	0.28	0.00452
	Cation Total =		96.211087		Anion Total =		92.9045424

Percentage Error = 3.50%

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Analytical Report

Mountain States Analytical

The Quality Solution

CLIENT: Southern Utah Fuel Co.
397 South 800 West
Salina, UT 84654-

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9177

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	SAMP DATE	TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
36421	10/22/92	0	North Main Face Pump	Sodium, FAA w/ww	38.7 mg/l
				Alkalinity, Bicarbonate	224 mg/l CaCO3
				Chloride, Titrimetric w	35.9 mg/l
				Fluoride, SIE w/ww	0.4 mg/l
				Nitrate/Nitrite w/ww	0.24 mg/l N
				pH, Aqueous	7.92 ---
				Solids, Dissolved TDS	690 mg/l
				Sulfate, Turbidimetric	240 mg/l
36422	10/22/92	0	North Main Face Roof Drip	Calcium, FAA w/ww	103 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	0.31 mg/l
				Magnesium, FAA w/ww	48.5 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	3.62 mg/l
				Sodium, FAA w/ww	14.9 mg/l
				Alkalinity, Bicarbonate	277 mg/l CaCO3
				Chloride, Titrimetric w	14.6 mg/l
				Fluoride, SIE w/ww	0.3 mg/l
				Nitrate/Nitrite w/ww	0.39 mg/l N
				pH, Aqueous	7.38 ---
				Solids, Dissolved TDS	550 mg/l
				Sulfate, Turbidimetric	147 mg/l
36423	10/22/92	0	North Main C 235 Pump	Calcium, FAA w/ww	223 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	0.37 mg/l
				Magnesium, FAA w/ww	78.5 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	5.55 mg/l
				Sodium, FAA w/ww	45.6 mg/l
				Alkalinity, Bicarbonate	123 mg/l CaCO3
				Chloride, Titrimetric w	54.4 mg/l
				Fluoride, SIE w/ww	0.4 mg/l
				Nitrate/Nitrite w/ww	0.14 mg/l N
				pH, Aqueous	7.84 ---
				Solids, Dissolved TDS	1,190 mg/l
				Sulfate, Turbidimetric	597 mg/l
36424	10/22/92	0	4 East C4 Pump	Calcium, FAA w/ww	258 mg/l

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Analytical Report

Mountain States Analytical

The Quality Solution

CLIENT: Southern Utah Fuel Co.
397 South 800 West
Salina, UT 84654-

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9177

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	SAMP DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
36424	10/22/92	0	4 East C4 Pump	Cation/Anion Balance	See Attach
				Iron, FAA w/ww	0.36 mg/l
				Magnesium, FAA w/ww	103 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	5.07 mg/l
				Sodium, FAA w/ww	124 mg/l
				Alkalinity, Bicarbonate	182 mg/l CaCO3
				Chloride, Titrimetric w	32.1 mg/l
				Fluoride, SIE w/ww	0.4 mg/l
				Nitrate/Nitrite w/ww	1.88 mg/l N
				pH, Aqueous	7.74 ---
				Solids, Dissolved TDS	1,750 mg/l
				Sulfate, Turbidimetric	951 mg/l
36425	10/22/92	0	4 East C11 Pump	Calcium, FAA w/ww	702 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	<0.05 mg/l
				Magnesium, FAA w/ww	604 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	8.88 mg/l
				Sodium, FAA w/ww	259 mg/l
				Alkalinity, Bicarbonate	163 mg/l CaCO3
				Chloride, Titrimetric w	1,360 mg/l
				Fluoride, SIE w/ww	0.4 mg/l
				Nitrate/Nitrite w/ww	0.28 mg/l N
				pH, Aqueous	7.68 ---
				Solids, Dissolved TDS	5,600 mg/l
				Sulfate, Turbidimetric	2,490 mg/l
36426	10/22/92	0	4 East C16 Pump	Calcium, FAA w/ww	928 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	<0.05 mg/l
				Magnesium, FAA w/ww	1734 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	18.4 mg/l
				Sodium, FAA w/ww	260 mg/l
				Alkalinity, Bicarbonate	200 mg/l CaCO3
				Chloride, Titrimetric w	4,780 mg/l

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CLIENT: Southern Utah Fuel Co.
397 South 800 West
Salina, UT 84654-

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9177

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	SAMP DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT	
36426	10/22/92	0	4 East C16 Pump	Fluoride, SIE w/ww	0.4	mg/l
				Nitrate/Nitrite w/ww	0.11	mg/l N
				pH, Aqueous	7.64	---
				Solids, Dissolved TDS	11,300	mg/l
				Sulfate, Turbidimetric	3,300	mg/l
36427	10/22/92	0	4 East Face Pump	Calcium, FAA w/ww	684	mg/l
				Cation/Anion Balance	See Attach	
				Iron, FAA w/ww	<0.05	mg/l
				Magnesium, FAA w/ww	69.3	mg/l
				Metals Digestion w/ww	Complete	---
				Metals Prep. FAA	Complete	---
				Potassium, FAA w/ww	3.39	mg/l
				Sodium, FAA w/ww	30.8	mg/l
				Alkalinity, Bicarbonate	236	mg/l CaCO3
				Chloride, Titrimetric w	16.0	mg/l
				Fluoride, SIE w/ww	0.3	mg/l
				Nitrate/Nitrite w/ww	2.71	mg/l N
				pH, Aqueous	7.32	---
				Solids, Dissolved TDS	2,100	mg/l
				Sulfate, Turbidimetric	1,150	mg/l

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CLIENT: Southern Utah Fuel Co.
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Salina, UT 84654-

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9177

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	SAMP DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT	
36428	10/22/92	0 4	East Face Roof Drip	Calcium, FAA w/ww	122	mg/l
				Cation/Anion Balance	See Attach	
				Iron, FAA w/ww	<0.05	mg/l
				Magnesium, FAA w/ww	63.7	mg/l
				Metals Digestion w/ww	Complete	---
				Metals Prep. FAA	Complete	---
				Potassium, FAA w/ww	3.61	mg/l
				Sodium, FAA w/ww	13.3	mg/l
				Alkalinity, Bicarbonate	354	mg/l CaCO3
				Chloride, Titrimetric w	24.3	mg/l
				Fluoride, SIE w/ww	0.3	mg/l
				Nitrate/Nitrite w/ww	<0.05	mg/l N
				pH, Aqueous	7.47	---
				Solids, Dissolved TDS	660	mg/l
				Sulfate, Turbidimetric	147	mg/l

Respectfully submitted,

Douglas W. Later

Douglas W. Later, Ph.D.
Laboratory Director

Glenn A. Sorensen

Glenn A. Sorensen, B.S.
Manager, Technical Operations

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CLIENT: Southern Utah Fuel Co.
397 South 800 West
Salina, UT 84654-
Phone: 801-637-4880 801-534-3296 (FAX)
ATTN: Mr. Chris Kravits
Project:

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9178
Sample Matrix: Aqueous
Report Date: 11/10/92
P.O. Number: SA6135

LAB SAMPLE NO.	DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT	
36429	10/22/92	0	6L4E Belt Drive Sump	Calcium, FAA w/ww	631	mg/l
				Cation/Anion Balance	See Attach	
				Iron, FAA w/ww	0.75	mg/l
				Magnesium, FAA w/ww	95.2	mg/l
				Metals Digestion w/ww	Complete	---
				Metals Prep. FAA	Complete	---
				Potassium, FAA w/ww	5.24	mg/l
				Sodium, FAA w/ww	105	mg/l
				Alkalinity, Bicarbonate	226	mg/l CaCO3
				Chloride, Titrimetric w	65.6	mg/l
				Fluoride, SIE w/ww	0.4	mg/l
				Nitrate/Nitrite w/ww	1.59	mg/l N
				pH, Aqueous	7.60	---
				Solids, Dissolved TDS	2,690	mg/l
				Sulfate, Turbidimetric	1,600	mg/l
36430	10/22/92	0	7L4E C28 Pump (Cr Rock)	Calcium, FAA w/ww	867	mg/l
				Cation/Anion Balance	See Attach	
				Iron, FAA w/ww	<0.05	mg/l
				Magnesium, FAA w/ww	371	mg/l
				Metals Digestion w/ww	Complete	---
				Metals Prep. FAA	Complete	---
				Potassium, FAA w/ww	10.1	mg/l
				Sodium, FAA w/ww	208	mg/l
				Alkalinity, Bicarbonate	119	mg/l CaCO3
				Chloride, Titrimetric w	874	mg/l
				Fluoride, SIE w/ww	0.5	mg/l
				Nitrate/Nitrite w/ww	0.08	mg/l N
				pH, Aqueous	7.53	---
				Solids, Dissolved TDS	4,450	mg/l
				Sulfate, Turbidimetric	2,070	mg/l
36431	10/22/92	0	7L4E Face Pump	Calcium, FAA w/ww	801	mg/l
				Cation/Anion Balance	See Attach	
				Iron, FAA w/ww	0.31	mg/l
				Magnesium, FAA w/ww	78.7	mg/l
				Metals Digestion w/ww	Complete	---
				Metals Prep. FAA	Complete	---
				Potassium, FAA w/ww	7.61	mg/l

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MSAI Group No.: 9178

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
36431	10/22/92	0	7L4E Face Pump	Sodium, FAA w/ww	225 mg/l
				Alkalinity, Bicarbonate	535 mg/l CaCO3
				Chloride, Titrimetric w	79.6 mg/l
				Fluoride, SIE w/ww	0.4 mg/l
				Nitrate/Nitrite w/ww	<0.05 mg/l N
				pH, Aqueous	7.42 ---
				Solids, Dissolved TDS	3,080 mg/l
				Sulfate, Turbidimetric	1,660 mg/l
36432	10/22/92	0	7L4E Face Roof Drip (FAULT IN SETUP BLEEDER)	Calcium, FAA w/ww	70.5 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	0.05 mg/l
				Magnesium, FAA w/ww	38.1 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	2.72 mg/l
				Sodium, FAA w/ww	11.2 mg/l
				Alkalinity, Bicarbonate	248 mg/l CaCO3
				Chloride, Titrimetric w	9.7 mg/l
				Fluoride, SIE w/ww	0.3 mg/l
				Nitrate/Nitrite w/ww	<0.05 mg/l N
				pH, Aqueous	7.85 ---
				Solids, Dissolved TDS	450 mg/l
				Sulfate, Turbidimetric	79 mg/l
36433	10/22/92	0	8L4E Face Pump	Calcium, FAA w/ww	203 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	<0.05 mg/l
				Magnesium, FAA w/ww	62.5 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	3.68 mg/l
				Sodium, FAA w/ww	41.0 mg/l
				Alkalinity, Bicarbonate	180 mg/l CaCO3
				Chloride, Titrimetric w	21.4 mg/l
				Fluoride, SIE w/ww	0.3 mg/l
				Nitrate/Nitrite w/ww	0.12 mg/l N
				pH, Aqueous	7.66 ---
				Solids, Dissolved TDS	1,190 mg/l
				Sulfate, Turbidimetric	588 mg/l
36434	10/22/92	0	8L4E Face Roof Drip	Calcium, FAA w/ww	114 mg/l

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Date Samples Rec'd: 10/27/92
MSAI Group No.: 9178

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	SAMP DATE	TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT		
36434	10/22/92	0	8L4E Face Roof Drip	Cation/Anion Balance	See Attach		
				Iron, FAA w/ww	<0.05	mg/l	
				Magnesium, FAA w/ww	60.4	mg/l	
				Metals Digestion w/ww	Complete	---	
				Metals Prep. FAA	Complete	---	
				Potassium, FAA w/ww	4.45	mg/l	
				Sodium, FAA w/ww	15.7	mg/l	
				Alkalinity, Bicarbonate	339	mg/l	CaCO3
				Chloride, Titrimetric w	21.4	mg/l	
				Fluoride, SIE w/ww	0.5	mg/l	
				Nitrate/Nitrite w/ww	0.81	mg/l	N
				pH, Aqueous	7.79	---	
				Solids, Dissolved TDS	660	mg/l	
				Sulfate, Turbidimetric	159	mg/l	
36435	10/22/92	0	LW Face	Calcium, FAA w/ww	108	mg/l	
				Cation/Anion Balance	See Attach		
				Iron, FAA w/ww	1.51	mg/l	
				Magnesium, FAA w/ww	97.2	mg/l	
				Metals Digestion w/ww	Complete	---	
				Metals Prep. FAA	Complete	---	
				Potassium, FAA w/ww	4.62	mg/l	
				Sodium, FAA w/ww	103	mg/l	
				Alkalinity, Bicarbonate	343	mg/l	CaCO3
				Chloride, Titrimetric w	36.4	mg/l	
				Fluoride, SIE w/ww	0.3	mg/l	
				Nitrate/Nitrite w/ww	<0.05	mg/l	N
				pH, Aqueous	7.70	---	
				Solids, Dissolved TDS	1,230	mg/l	
				Sulfate, Turbidimetric	480	mg/l	
36436	10/22/92	0	LW Bleeders(Air Pumps)	Calcium, FAA w/ww	118	mg/l	
				Cation/Anion Balance	See Attach		
				Iron, FAA w/ww	0.05	mg/l	
				Magnesium, FAA w/ww	70.7	mg/l	
				Metals Digestion w/ww	Complete	---	
				Metals Prep. FAA	Complete	---	
				Potassium, FAA w/ww	5.75	mg/l	
				Sodium, FAA w/ww	48.0	mg/l	
				Alkalinity, Bicarbonate	212	mg/l	CaCO3
				Chloride, Titrimetric w	15.5	mg/l	

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The Quality Solution

CLIENT: Southern Utah Fuel Co.
397 South 800 West
Salina, UT 84654-

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9178

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	SAMP DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
36436	10/22/92	0	LW Bleeders(Air Pumps)	Fluoride, SIE w/ww	0.5 mg/l
				Nitrate/Nitrite w/ww	.42 mg/l N
				pH, Aqueous	8.00 ---
				Solids, Dissolved TDS	980 mg/l
				Sulfate, Turbidimetric	407 mg/l
36437	10/22/92	0	LW Emulsion	Calcium, FAA w/ww	150 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	4.32 mg/l
				Magnesium, FAA w/ww	67.6 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	5.43 mg/l
				Sodium, FAA w/ww	796 mg/l
				Alkalinity, Bicarbonate	1,460 mg/l CaCO
				Chloride, Titrimetric w	340 mg/l
				Fluoride, SIE w/ww	0.4 mg/l
				Nitrate/Nitrite w/ww	See Memo ---
				pH, Aqueous	9.25 ---
				Solids, Dissolved TDS	7,980 mg/l
				Sulfate, Turbidimetric	2250 mg/l

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Mountain States Analytical
The Quality Solution

CLIENT: Southern Utah Fuel Co.
397 South 800 West
Salina, UT 84654-

Date Samples Rec'd: 10/27/92
MSAI Group No.: 9178

ATTN: Mr. Chris Kravits
Project:

LAB SAMPLE NO.	SAMP DATE	SAMP TIME	SAMPLE DESCRIPTION	ANALYSES PERFORMED	RESULT
36438	10/22/92	0	Wagner Scrubber	Calcium, FAA w/ww	448 mg/l
				Cation/Anion Balance	See Attach
				Iron, FAA w/ww	64.2 mg/l
				Magnesium, FAA w/ww	204 mg/l
				Metals Digestion w/ww	Complete ---
				Metals Prep. FAA	Complete ---
				Potassium, FAA w/ww	8.48 mg/l
				Sodium, FAA w/ww	144 mg/l
				Alkalinity, Bicarbonate	<1 mg/l CaCO3
				Chloride, Titrimetric w	60.7 mg/l
				Fluoride, SIE w/ww	0.7 mg/l
				Nitrate/Nitrite w/ww	11.9 mg/l
				pH, Aqueous	2.23 ---
				Solids, Dissolved TDS	3,250 mg/l
				Sulfate, Turbidimetric	2,820 mg/l

Respectfully submitted,

Douglas W. Later

Douglas W. Later, Ph.D.
Laboratory Director

Glenn A. Sorensen

Glenn A. Sorensen, B.S.
Manager, Technical Operations

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number:	0001238
Sample Set:	000254S
Date Reported:	8 DEC 1992
Date Received:	19 NOV 1992
Disposal Date:	4 JAN 1993

Attention:	Chris Kravits
Project:	Water Samples
Case Number:	11/18/92
Purchase Order:	SA6135

Customer Number:	PT003111892
Date Sampled:	18 NOV 1992
Matrix:	Wastewater
Containers:	5

Analysis	Catalog Number	Method		Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83		See Attached		

1 Analysis for Inorganics

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Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1		118.4	mg/l
Iron	00254	EPA 600 Series 236.1	<	0.05	mg/l
Magnesium	00257	EPA 600 Series 242.1		66.1	mg/l
Potassium	00262	EPA 600 Series 258.1		4.75	mg/l
Sodium	00267	EPA 600 Series 273.1		70.3	mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005		Complete	
Metals Prep.	00820	EPA SW-846 3005		Complete	

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B		283	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3		21.9	mg/l
Fluoride	00263	EPA 600 Series 340.2		0.5	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3		307	mg/l
Oil & Grease, Gravimetric	00231	EPA 600 Series 413.1	<	2	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040		7.38	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1		890	mg/l
Solids, Suspended TSS (Non-filterable)	00206	EPA 600 Series 160.2	<	4	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4		374	mg/l

9 Analyses for Wet Chemistry

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Mountain States Analytical
The Quality Solution

Southern Utah Fuel Company
Customer Number: PT003111892

Sample Number: 0001238
Sample Set: 000254S

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units

Sample 0001238 continued from previous page...

17 Analyses for Sample Number 0001238

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 03-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1238
Analyst: RA/GS
Date: 12/03/92

	Cations	mg/l	meq/l
1	Calcium	118.00	5.88820
2	Magnesium	66.10	5.43739
3	Iron	0.00	0.00000
4	Sodium	70.30	3.05805
5	Potassium	4.75	0.12146
	Cation Total =		14.505093

	Anions	mg/l	meq/l
1	Chloride	21.90	0.61780
2	Bicarbonate	283.00	4.63837
3	Sulfate	374.00	7.78668
4	Fluoride	0.50	0.02632
5	Nitrate	307.00	4.95191
	Anion Total =		18.021079

Percentage Error = 21.62%

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Mountain States Analytical

The Quality Solution

Southern Utah Fuel Company
397 South 800 West
Salina, Utah 84654
Telephone: (801) 637-4880
Facsimile: (801) 534-3296

Sample Number: 0001242
Sample Set: 000255S
Date Reported: 8 DEC 1992
Date Received: 19 NOV 1992
Disposal Date: 4 JAN 1993

Attention: Chris Kravits
Project: Water Samples
Case Number: 11/18/92
Purchase Order: SA6135

Customer Number: PT062
Date Sampled: 18 NOV 1992
Matrix: Wastewater
Containers: 3

Analysis	Catalog Number	Method	Result	Dry Result	Reporting Units
Cation/Anion Balance	00009	ASTM D-596-83	See Attached		

1 Analysis for Inorganics

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Calcium	00250	EPA 600 Series 215.1		95.8	mg/l
Iron	00254	EPA 600 Series 236.1	<	0.05	mg/l
Magnesium	00257	EPA 600 Series 242.1		33.6	mg/l
Potassium	00262	EPA 600 Series 258.1		1.19	mg/l
Sodium	00267	EPA 600 Series 273.1		7.45	mg/l
Metals Acid Digestion, Waters	00392	EPA SW-846 3005	Complete		
Metals Prep.	00820	EPA SW-846 3005	Complete		

7 Analyses for Metals

Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

Bicarbonate (Includes Alkalinity)	01454	Std. Methods 17th Ed. 2320B	281	mg/l CaCO3
Chloride, Titrimetric	01124	EPA 600 Series 325.3	9.7	mg/l
Fluoride	00263	EPA 600 Series 340.2	0.1	mg/l
Nitrate-Nitrogen	00368	EPA 600 Series 353.3	35.9	mg/l
Ph, Aqueous	00200	EPA 600 Series 150.1 or SW-846 9040	7.76	
Solids, Dissolved TDS (Filterable)	00212	EPA 600 Series 160.1	410	mg/l
Sulfate, Turbidimetric	01125	EPA 600 Series 375.4	63	mg/l

7 Analyses for Wet Chemistry

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Reviewed and approved by
Glenn Sorensen, B.S.
Manager, Inorganics Department

15 Analyses for Sample Number 0001242

Mountain States Analytical
The Quality Solution

Cation Anion Balance 03-Dec-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 1242
Analyst: RA/GS
Date: 12/03/92

	Cations	mg/l	meq/l
1	Calcium	95.80	4.78042
2	Magnesium	33.60	2.76394
3	Iron	0.00	0.00000
4	Sodium	7.45	0.32408
5	Potassium	1.19	0.03043
	Cation Total =		7.8988593

	Anions	mg/l	meq/l
1	Chloride	9.70	0.27364
2	Bicarbonate	281.00	4.60559
3	Sulfate	63.00	1.31166
4	Fluoride	0.10	0.00526
5	Nitrate	35.90	0.57907
	Anion Total =		6.775218

Percentage Error = 15.31%

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Mountain States Analytical
The Quality Solution

Cation Anion Balance 09-Nov-92

Cation Anion Balance Spreadsheet

Project: SUFCO
Sample #: 36429
Analyst: RA/GS
Date: 11/09/92

	Cations	mg/l	meq/l		Anions	mg/l	meq/l
1	Calcium	631.00	31.48690	1	Chloride	65.60	1.85058
2	Magnesium	95.20	7.83115	2	Bicarbonate	226.00	3.70414
3	Iron	0.75	0.04029	3	Sulfate	1600.00	33.31200
4	Sodium	105.00	4.56750	4	Fluoride	0.40	0.02106
5	Potassium	5.24	0.13399	5	Nitrate	1.59	0.02565
	Cation Total. =		44.059828		Anion Total. =		38.9134187

Percentage Error = 12.40%

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APPENDIX C

ISOTOPIC LABORATORY REPORTS
PREPARED BY GEOCHRON LABORATORIES

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GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.

711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138 ✦ U.S.A
TELEPHONE: (617) 876-3691 TELEFAX: (617) 661-0148

Alan Mayo
P.O. Box 1960
Orem, UT 84059

Date Received: 08/24/93
Date Reported: 09/02/93
Reference: Mayo letter
Aug. 23, 1993.

REPORT OF TRITIUM ANALYSES

Our Lab. No	Your Sample No.	Tritium Units
T-4774	North Mains C128 RD	1.1 +/- 2.4
T-4775	3 West C44 RD	1.1 +/- 2.4
T-4776	North Mains Face Test RD	3.3 +/- 2.4

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APPENDIX 7-27

Greens Hollow Tract

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Greens Hollow Lease Appendix 7-27

Cirrus Surface and Groundwater Technical Report

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SURFACE AND GROUND WATER TECHNICAL REPORT GREENS HOLLOW COAL LEASE TRACT

Prepared for:
Bureau of Land Management
Price Field Office
125 South 600 West
Price, Utah 84501

Manti-La Sal National Forest
599 West Price River Drive
Price, Utah 84501

Fishlake National Forest
115 East 900 North
Richfield, Utah 84701

Prepared by:
Cirrus Ecological Solutions, LC
965 South 100 West, Suite 200
Logan, Utah 84321

Norwest Applied Hydrology
950 South Cherry Street, Suite 800
Denver, Colorado 80248

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2014

1.0 INTRODUCTION

This report describes the existing surface and ground water resources occurring in the analysis area. It also evaluates potential hydrologic issues to these resources under several alternative mining scenarios, including a no action alternative, and two action alternatives.

The analysis area for the Surface and Ground Water Technical Report includes the Greens Hollow Federal Coal Lease Tract (Greens Hollow tract) as well as adjacent coal lease tracts that may be mined in conjunction with the Greens Hollow tract. In general terms, the Greens Hollow analysis area is located west of Emery, Utah, near the east edge of the Wasatch Plateau, in the Muddy and North Fork Quitchupah Creek drainages. The exact location of the Greens Hollow tract, topography, surface water monitoring stations, drainage basins, and nearby features is shown in Figure 1. In addition, the analysis area includes a 900-foot buffer to include the area that may be affected by subsidence that could extend beyond the mined area (Figure 2). The entire analysis area includes surface lands of both the Manti-LaSal and Fishlake National Forests.

1.1 STATEMENT OF PROJECT OBJECTIVES

The U.S. Department of Interior, Bureau of Land Management (BLM) is the leasing authority on the federal coal estates within the Greens Hollow Coal Lease Tract on National Forest System land. Under the Mineral Leasing Act of 1920, as amended by the Federal Coal Leasing Amendments Act of 1975, leases can only be issued by the BLM with consent from the Forest Service with lease conditions determined necessary for protection of non-mineral resources. As federal actions subject to NEPA, both the BLM leasing decisions and the Forest Service consent decisions must be based on an environmental and socio-economic analysis and appropriate NEPA documentation.

Under the Surface Mine Control and Reclamation Act of 1977 and Utah Coal Rules, the Forest Service must consent to the mine plan prior to mine development and can impose requirements for the protection of non-coal resources. The Forest Service decisions, as federal actions, are subject to the requirements of NEPA, requiring environmental analysis and appropriate NEPA documents.

Much of this technical report is based on a previous three-year study of the Muddy Creek Tract and a 2-mile buffer surrounding the tract (Cirrus 2004a, Cirrus 2004b) as well as on-going water resource monitoring in the analysis area (DOGM 2013a). Additional data were obtained from government and private entities and a review of previous work completed on areas adjacent to the Greens Hollow tract. This technical report will form the basis for an analysis of impacts on surface and ground water in the analysis area in the Supplemental Environmental Impact Statement (SEIS) for the Greens Hollow tract on the Manti-LaSal and Fishlake National Forests.

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2.0 METHODS

2.1 CONTACTS MADE

The field data for this report was compiled by Cirrus Ecological Solutions. LC (Cirrus). Additional information was obtained from the SUFCO mine as well as government agencies at the local. state. and federal level. Agencies and individual resource specialists are listed below.

United States Forest Service - Manti LaSal National Forest

- Carter Reed – Geologist Manti LaSal National Forest
- Dale Harber – Geologist. Manti LaSal National Forest
- Katherine Foster – Hydrologist. Manti LaSal National Forest
- Adam Solt – Hydrologist. Fishlake National Forest
- Karl Boyer – Geologist. Manti LaSal National Forest
- Pete Kilbourne – G.I.S. Coordinator. Manti LaSal National Forest
- William Broadbear – Forester. Manti LaSal National Forest
- John Healy – Rangeland Management Specialist. Manti LaSal National Forest
- Don Riddle – Law Enforcement Officer. Manti LaSal National Forest

United States Geological Survey

- Mike Enright – Supervisor Hydrology Technician. West Valley City Field Office
- Vic Heilweil – Hydrologist. West Valley City. District Office
- Johnny Wheat – Engineering Technician. Stennis Space Center. Mississippi

Utah Division of Oil. Gas and Mining

- Susan White – RDCC and NEPA Coordinator
- Mark Mesch – Program Administrator (retired)
- Dana Dean – Associate Director - Mining
- Dave Darby – Hydrogeologist
- Ken Wyatt – Senior Reclamation Specialist (retired)
- Jim Smith – Senior Reclamation Hydrologist

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Utah Division of Water Rights

- Scott Clark. Water Rights Specialist. North Region
- Marc Stilson. Regional Engineer. Southeastern Regional Office

Utah Division of Drinking Water
- Mark Jensen, Environmental Scientist, Ground Water Source Protection and GIS Development
- Kate Johnson, Environmental Scientist, Surface Water Protection

University of Utah
- Jim Ehleringer - Professor
- Craig Cook – Laboratory Manager

Emery Water Conservancy District
- Jay Humphrey – District Manager

Muddy Creek Irrigation Company
- Morris Sorenson – Board member
- Wayne Staley – Board member

Canyon Fuel Company
- Mike Davies – Construction Engineer, SUFCO mine
- Chris Hansen – Environmental monitoring, Skyline mine

Petersen Hydrologic
- Erik Petersen – Senior Hydrogeologist

ChemTech Ford Laboratory (EPA-certified)
- David Gayer – Laboratory Manager

CT&E Laboratory (EPA-certified)
- Brandon Pierce – Laboratory Manager

GeoChron Laboratory (EPA-certified)
- Dick Ressman – Laboratory Manager, Stable Isotope
- Alex Cherkinski – Laboratory Manager, Age Dating

Sequoia Scientific
- Lydia Sundman – Electronic Engineer, AquaRod Division

Additional information was obtained from data repositories maintained by the Manti-LaSal National Forest, U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), Utah Division of Water Quality, (Utah DWQ), Utah Division of Drinking Water (Utah DDW), Utah Division of Water Rights (Utah DWRi), Utah Department of Water Resources (Utah DWRe), Utah Automated Geographic Reference Center (AGRC), and the Utah Division of Oil, Gas, and Mining (DOGM).

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2.2 SOURCES AND DESCRIPTIONS OF EXISTING INFORMATION

This baseline evaluation included a review of reports and data from Utah and Federal agencies concerning water resources of the region. Canyon Fuel's SUFCO Mine, has extracted coal from

the lease tract areas adjacent to the Greens Hollow tract including parts of the Pines Tract and the Quitchupah Tract lease (Figure 1). Consequently, existing information has also been obtained from the Permit Application Package (PAP) and the Hydrologic Monitoring Reports for the SUFCO Mine. USGS investigations (Thiros and Cordy 1991), the Probable Hydrologic Consequences for the SUFCO Mine (Mayo and Associates 1999) the hydrologic information developed for the Final EIS of the Pines Tract (USDA-FS 1999), the Cumulative Hydrologic Impact Assessment prepared by DOGM (2003a) for the SUFCO Mine, water quality monitoring assessments completed in the Muddy Creek drainage (Utah DWQ 2004), the Muddy Creek Water Resources technical report (Cirrus 2004a), ongoing monitoring data collected by SUFCO (DOGM 2013a) field geology surveys (Anderson 2008a), and evaluations of exploratory drill-hole log information (Anderson 2008b).

Thiros and Cordy (1991) described the hydrology and potential effects of mining in the Quitchupah and Pines Coal Lease Tracts. The geologic formations and ground water bearing units in the Muddy Creek Tract are essentially the same as in the adjacent Quitchupah and Pines Coal Lease Tracts, although the North Horn Formation occurs over a large portion of the Muddy Creek Tract and the Flagstaff Limestone is found at the tops of ridges and mountains on the far west side of the analysis area. A generalized stratigraphy of the Muddy Creek Tract is depicted in Figure 3.

A gain loss study of flows in North Fork Quitchupah Creek found an apparent gain in flow where the creek crossed the Castlegate Sandstone, a loss of flow as it crossed the upper part of the Blackhawk Formation, a slight gain in flow crossing the lower Blackhawk formation, a considerable gain in flow crossing Star Point Sandstone, and a loss in flow crossing the Mancos Shale (Thiros and Cordy 1991)

Mayo and Associates (1999) used carbon-14 (C^{14}) radiocarbon dating and tritium (^3H) analysis of spring water and ground water in the Pines Tract and surrounding area, including mine water in the SUFCO Mine, to conclude that the ground-water encountered in the mine was distinct from the near-surface ground-water systems associated with the springs. Most of the near-surface systems contain abundant ^3H and anthropogenic (human-caused) radiocarbon while the waters in the mine have a mean residence time of 7,000 to 20,000 years and contain no ^3H. The cause of this disconnect is attributed to shale and mudstone in the Blackhawk Formation that hinder the downward migration of water. This conclusion was consistent with the unsaturated horizons encountered in exploration drill-holes at the SUFCO Mine.

The Final EIS for the Pines Tract (USDA-FS 1999) described the surface and ground water systems and projected mining-related hydrologic impacts in the adjacent Pines Tract Lease. Water in the springs that were apparently discharging from the Castlegate Sandstone was relatively low in TDS and undersaturated with respect to carbonate minerals. The waters from Price River Formation springs exhibited considerably higher TDS and were oversaturated with respect to carbonate minerals. These results showed that the water in the Castlegate Sandstone springs had not been in contact with the Price River Formation and that the source water for the springs was direct recharge of the Castlegate Sandstone outcrop in the plateau areas along the perimeter of the canyon rims. The springs and seeps issuing from the base of the Castlegate Sandstone are apparently the result of perching caused by shales and siltstones in the upper portion of the Blackhawk Formation (DOGM 2003a). The Star Point Sandstone underlies the coal bearing portion of the lower Blackhawk Formation. The base of the Star Point Sandstone consists of thin interbedded sandstones, siltstones and shales. The upper portion of the Star Point Sandstone consists of three massive sandstone layers (Thiros and Cordy 1991). Underlying the Star Point Sandstone is the Masuk Member of the Mancos Shale (also known as the Blue Gate

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Shale Member of the Mancos Shale). The Mancos Shale is a regional aquaclude that limits downward flow and acts as a lower boundary for the regional ground water system.

A Total Maximum Daily Load (TMDL) study was completed on Muddy Creek and tributaries in January 2004 as part of a water quality study completed by the Utah DWQ that examined concentrations of Total Dissolved Solids (TDS) on the West Colorado Management Unit (Utah DWQ 2004). The study indicated that several water bodies in the Muddy Creek drainage were not supporting their assigned Class 4A agricultural beneficial use due to TDS concentrations that exceeded the recommended criterion of 1,200 mg/l. These water bodies include the following:

- Muddy Creek and its tributaries from Ivie Creek confluence to the Utah Highway 10 bridge.
- Quitchupah Creek from the confluence with Ivie Creek to the Utah Highway 10 bridge.
- Ivie Creek and its tributaries from the confluence with Muddy Creek to Utah Highway 10.
- Muddy Creek from the confluence with the Fremont River to Quitchupah Creek confluence.

Historic monitoring of these water bodies indicates that TDS concentrations in the upper areas of the Muddy Creek watershed are below the 1,200 mg/l criterion and are considered to be in full support of beneficial uses. Much of the upper Muddy Creek watershed is comprised of lands administered by the MLNF. The average TDS concentration reported in the TMDL for Quitchupah Creek above the MLNF boundary was 675 mg/L, based on 10 samples (Utah DWQ 2004) collected during 1997-98. SUFCO monitoring data near this location has a mean of 663 during the same time period (based on 6 available samples) and a 20-year mean of 682 mg/l TDS during 1993-2012 (based on 53 samples) (DOGM 2013a). The mid-to-lower portions of the watershed are a mixture of urban and agricultural land uses. Measured TDS concentrations in these areas consistently exceed the 1,200 mg/l criterion. Some of the known sources of TDS in the Muddy Creek watershed include land areas where the Mancos Shale and Blackhawk formations are exposed to erosion processes and are in contact with surface water bodies. Other sources were noted to include agricultural and urban land use and some coal mining. Instream TDS concentrations were observed to be highest during periods of low flow when ground water and irrigation return flows with elevated TDS concentrations provide the main source of water to streams and canals.

Pollutant loads were calculated for point and non-point sources of pollution in the Muddy Creek watershed. Point source pollution was determined to contribute 3,595 tons/year or roughly 7 percent of existing loads while non-point sources contributed 50,767 tons/year or approximately 93 percent of TDS loads in the watershed. Discharge from the SUFCO mine outfall was determined to contribute 2,500 tons/year or approximately 70 percent of point source loading. In order to meet the TDS criterion of 1,200 mg/l in the Muddy Creek watershed, pollutant loads from non-point sources would need to be reduced by 86 percent. No reductions from point source loads were recommended. As a result of the TMDL, site specific standards are currently in place for the impaired segments listed above. However, the TDS standard for Muddy Creek upstream of Utah Highway 10 and Quitchupah Creek above the MLNF boundary remains at 1,200 mg/l.

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The Muddy Creek Water Resources technical report (Cirrus 2004a) summarizes the 2001-2004 data collection effort completed to assess subsidence impacts on water resources in the Muddy Creek and Quitchupah Creek drainages. Measurements of flow and water quality were collected from all springs and selected stream segments in the analysis area during the spring and fall season. Additional measurements were collected on a quarterly basis from selected spring and stream monitoring sites. The number and type of measurements were defined by the MLNF and the Utah Division of Oil Gas and Mining (DOGM). All data collected as a result of this effort was uploaded to the DOGM online monitoring database. The technical report identified subsidence impacts on water resources under two mining scenarios. A detailed record of all data used in the technical report is compiled in Appendix 1 to the Muddy Creek Water Resources technical report (Cirrus 2004b).

SUFCO has been required to monitor stream and spring monitoring sites in and adjacent to the Greens Hollow tract as part of the DOGM permitting process (DOGM2013a). SUFCO monitoring sites applicable to this project include three stream and six spring locations. Monitoring of two sites on Quitchupah Creek began in 1982. Stream monitoring at one location on Greens Hollow and six spring sites commenced in 2006 when the SITLA Coal Lease Tract was added. SUFCO is continuing to monitor each of the three stream and six spring sites. All monitoring data collected from these sites was reviewed as part of this assessment.

Geologic contact lines in the analysis area were assessed during field surveys completed in 2008 to determine the nature of the Castlegate Sandstone/Price River contact and to estimate physical properties of material directly overlaying this formation (Anderson 2008a). Field observations indicated that stream channel segments in Greens Hollow and Cowboy Creek located on Castlegate Sandstone were primarily comprised of consolidated fine-textured material and estimated to contain 90% clay. Channel segments of North Fork Quitchupah Creek that occurred on Castlegate Sandstone were comprised of unconsolidated deposits that varied from clay-rich, well stratified material to young alluvium containing a matrix of clay with sand, and pebble-boulder sized clasts (mostly limestone with minor sandstone). Additional geologic information was obtained through an evaluation of exploratory drill-hole data (Anderson 2008b). This assessment defined the structural position of the top of the Castlegate Sandstone as well as the lithologic content of the stratigraphic interval 50 feet directly above this formation. Data records were provided by the SUFCO mine for approximately 20 exploratory drill-hole logs in the analysis area including both geophysical and sample recordings. Results of the study produced structural elevation contours at 20 foot intervals and also indicated that rock in the 50 foot interval above Castlegate Sandstone contained an average of 74 percent silt/mudstone and 26 percent sandstone.

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2.4 DESCRIPTION OF INVENTORIES AND DATA COLLECTED BY THE CONSULTANT

Surface and ground water resources in the Greens Hollow tract area were monitored by Cirrus during 2001-2004. All flow and water quality measurements collected during this time adhered to USGS and EPA standards including collection procedures, sample hold times, laboratory certification, and cleaning and maintenance of field equipment. All water quality sampling procedures were guided by information obtained from the National Field Manual for the Collection of Water Quality Data (USGS 2003), recommendations from USGS scientists in Salt Lake City and water chemistry specialists employed at EPA-certified laboratories. All laboratory samples were stored on ice immediately after they were collected and delivered to an EPA certified laboratory located in Huntington, Utah or Salt Lake City, Utah within the allotted holding period associated with the parameters being tested. All water quality samples tested for dissolved metals were vacuum-filtered in the field through a 0.45 µm cellulose-nitrate filter. The measurement devices used during field measurements of flow and water quality included the following instruments:

Discharge measurements

- Price AA current meter
- Pygmy current meter
- Baski eight inch cutthroat flume
- Modified Parshall flume with three inch throat (Rantz 1982)
- PVC pipe (three inch diameter) and bucket

Water quality measurements

- YSI63 (temperature, pH, conductivity, salinity)
- YSI55 (temperature, dissolved oxygen in mg/l and percent saturation)
- LaMotte turbidimeter (turbidity in ntu)
- Global Water WQ770 turbidimeter (turbidity in ntu)

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Calibration of these sensors to traceable standards occurred at recommended intervals throughout the monitoring period. Calibration data during 2001-2004 is included in the project record

accompanying the Muddy Creek Water Resources technical report. A description is provided below of the work completed to collect water resource data in the analysis area.

2.4.1 GROUND WATER AQUIFERS

Field information on the location and extent of ground water discharge points (springs) in the Greens Hollow tract was collected during the early 2001 spring season as part of the spring and seep survey associated with the Muddy Creek Tract area. The initial spring coverage was added to in subsequent years as more information was obtained identifying new points of ground water discharge. The majority of spring monitoring was limited to 2001-2004. SUFCO has continued to monitor a select number of springs and stream locations in the Greens Hollow tract since that time. The geologic formation associated with each spring was determined from a geologic map completed by Anderson (2004). This map also contains structural geologic profiles for the Tract area, fence diagrams based on information obtained from exploratory drilling, and mapped alluvial deposits (Anderson 2004). Some information defining the piezometric surface in the analysis area was obtained from exploratory wells completed by private mining companies. Additional information defining the timing of recharge to aquifers was obtained from stable isotope measurements collected at points of ground water discharge (springs). A detailed discussion of aquifer properties associated with the geologic layers that underlay the analysis area is included in Section 3.1.1 Ground water Aquifers and Springs.

2.4.2 WELLS

The effort to identify wells in the analysis area included a search of government databases including the DOGM well information database, Utah DWRi water rights database (including the well information program and water rights database), and the USGS NWIS online database. This search failed to identify well monitoring sites, including water production wells in the analysis area. A review of monitoring data collected from wells adjacent to the analysis area indicated that measurements were limited to water level. Water quality parameters were not measured due to the fact that material surrounding the well borehole had not been developed (similar to a culinary well) and were contaminated from drilling fluids.

2.4.3 SPRINGS AND SEEPS

A survey of existing water features was conducted in the analysis area to identify springs and seeps with measurable flow. The initial field survey of springs in the Greens Hollow tract was completed in the summer of 2001 as part of the work effort associated with the Muddy Creek Tract assessment. Prior to conducting the survey, the Muddy Creek Tract was subdivided into priority areas on the basis for the potential for subsidence from mining activities to impact a spring or surface water body (Figure 2). These areas were used to guide field efforts, resulting in areas of higher priority being inventoried before lower priority areas. However all areas have been inventoried for the presence of springs and seeps with measurable flow.

The areas of highest priority (Priority 1) included all locations in the Muddy Creek Tract with low overburden cover as shown in Figure 2. Priority 2 areas included all locations in the Tract where the overburden cover was at least 400 feet, which is sufficient to reduce substantial impacts of subsidence. Priority 3 areas are located stratigraphically above Priority 2 areas and encompass the remainder of the analysis area. A single spring with measurable flow (M_SP87) was located in the Priority 1 area. All springs with measurable flow located inside the Tract boundary in the

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Priority 2 area were selected for baseline monitoring. Discharge rates and location were used to prioritize the springs retained for monitoring in the Priority 3 buffer area.

Additional information on springs and seeps was obtained from range allotment files for the Emery and Ferron allotments, and recommendations provided by grazing permitees. All springs found during the initial field effort were checked against this information and springs that had not been previously identified were located and assessed for measurable flow.

All spring locations were defined with a Trimble GeoExplorer3 GPS unit accurate to +/- 2 meters in the horizontal plane. A digital photo was taken of the spring or seep for descriptive purposes. A report including a date-stamped digital photo, probable source and apparent use of each spring is included in Cirrus (2004b). Field measurements were also taken at each location including flow (gpm), water temperature (°C), pH, conductivity (umhos/cm), and salinity (ppt). Flow measurements were collected from springs using a pipe and bucket, and were typically measured three times from each spring in order to get an average flow value.

Information from the initial field effort was submitted to the MLNF during the summer of 2001 for review and selection of springs for intensive water quality measurements during the spring and fall seasons, including eight springs that were located in the Greens Hollow tract. Additional water samples collected during fall 2001 (base flow) from the eight spring monitoring sites were measured for ^{3}H, deuterium (^{2}H), oxygen-18 (^{18}O), and carbon-14 (C^{14}). In July of 2002, DOGM requested that additional parameters be measured on a quarterly basis at spring monitoring sites previously selected by the MLNF for laboratory testing. Quarterly monitoring of the eight springs continued from that time through 2004. All springs with measurable flow in the Muddy Creek Tract analysis area were monitored for flow and field water quality parameters during the spring and fall seasons from fall 2001 through spring 2004. SUFCO has continued to collect field measurements since that time from five of the eight springs selected for intensive measurement. The geographic locations of all springs in and immediately adjacent to the Greens Hollow tract that support measurable flow are included in Figure 4. A definition and discussion of spring value is presented below in Section 3.1.1.8 Ground Water Summary. The results of all flow and water quality measurements collected from springs identified in the analysis area, including the SUFCO monitoring data, can be found in Cirrus (2004b).

Several springs were instrumented for measurement of continuous flow including one spring (M_SP02) that is located in the Greens Hollow tract boundary. These springs were selected following discussions with MLNF personnel and individuals from the Emery Water Conservancy District (EWCD). Following approval by the MLNF, members of the EWCD installed two inch inline vortex flowmeters capable of measuring continuous flow (gpm) at the selected spring sites during the summer of 2002. Flow sensors were accessed using remote telemetry and provided 30-minute averages of flow readings collected at five-minute intervals from each spring. Some difficulty was encountered in maintaining a continuous flow record for each spring as sensors would be periodically disturbed by cattlemen, livestock and wildlife using the area for grazing and watering purposes. Maintenance of spring flow monitoring locations was discontinued after 2004 due to vandalism of monitoring equipment.

Probable source area for each spring or group of springs was determined from a combination of measured field data, laboratory analysis of water quality samples, and available mapping information. Potential inputs included geology, topography, field observations, spring flow rates, water quality parameters, and isotopic analysis. Nearby springs were grouped together when their probable source areas overlapped substantially. Many of the springs appear to be topographically controlled with fairly localized source areas. Based on the spring flow rates and water quality

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parameters, an estimate was made of how far the probable source area extended upgradient above the point of discharge.

2.4.4 STREAMS

A total of 10 stream monitoring sites were established in and adjacent to the Greens Hollow tract. The main stem of Muddy Creek was not considered for collection of field data under this project. SUFCO established stream monitoring sites in 1982 at two locations on North Fork Quitchupah Creek. Monitoring has continued at these locations on a quarterly basis since that time. The initial effort to identify stream monitoring locations in the Greens Hollow, Cowboy Creek, and Greens Canyon area was based upon GIS stream coverage obtained from the MLNF. A total of six sites were selected for monitoring including four sites with continuous flow sensors and two non-instrumented sites. An effort was made to select monitor locations that appeared to support perennial flow and were free of debris jams or bank sloughing. Other factors that were considered included channel features such as near-vertical, confining channel banks and linear channel segments with high amounts of riffles and few meanders or pools. Flow sensors were installed in June 2002 following a field visit with MLNF personnel. Monitoring of the two non-instrumented sites began at this time as well. In July of 2002, DOGM requested that two additional stream channel locations be instrumented for continuous flow. These sites were established in August 2002. The geographic locations of all 10 stream monitoring sites considered in this report are included in Figure 1.

Continuous flow measurements were collected with AquaRod water depth sensors that measured water level in a stilling well located adjacent to the stream channel. Data were downloaded from each sensor at approximately 6 week intervals throughout the season. At the end of the field season, all data were removed from the datalogger in each sensor, providing approximately 6 months of data storage for water measurements collected during the winter months. New lithium batteries were also installed in each sensor at the end of the field season.

The relationship between water level (stage) measured by AquaRod sensors and stream discharge is defined with a stage discharge curve. This curve was defined with manual readings of stream discharge collected during a range of flows. The method used to measure stream discharge was dependent upon the flow rate occurring in the stream channel during the field visit. An effort was made to obtain high-flow readings during the early spring season in order to provide a more accurate stage-discharge curve. Due to the restricted access produced by snow depth, snowmelt, and high soil moisture levels in Greens Canyon, the lower portion of Cowboy Creek, and the mine tract area in general, streamflow measurements could not be made until the latter part of April through mid-May. As a result, the number of high flow readings is limited for some sites. Stream monitoring sites instrumented with AquaRod sensors were visually monitored for significant changes throughout the extent of the monitoring period to identify any changes in channel shape that would influence the stage-discharge relationship. No changes of this nature were observed at any stream monitoring site during the life of the project. A complete listing of all data used to develop stage-discharge curves is included in Cirrus (2004b).

Water quality measurements were collected from (2002-2004) at the six instrumented stream monitoring sites four times during the year including early spring as soon as the site was accessible, late spring/early summer, mid-summer, and fall. The two non-instrumented stream sites and the two stream locations maintained by SUFCO were monitored on a quarterly basis. As a result, measurements at these sites were typically collected only three times per year as adverse conditions prohibited access during the winter quarter. A complete listing of all water quality data collected at stream monitoring sites during the Muddy Creek Tract survey (2001-

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2004) is included in Cirrus (2004b). SUFCO has continued to visit one of the original six instrumented monitoring sites on a quarterly basis as well as the two other stream locations they maintain (DOGM 2013a).

A longitudinal profile survey was completed on all of Greens Canyon, and portions of Cowboy Creek, and Greens Hollow that were either perennial in nature or maintained perennially functioning riparian vegetation. Stream channel elevation and distance measurements were obtained with a TOPCON total station and recorded with a Trimble datalogger. Survey points were typically measured in the channel thalweg and usually separated by distances no greater than 150 feet. Occasionally this distance was exceeded due to vegetation or topography interfering with the line of sight needed to complete a measurement. Additional efforts were made to survey channel elevation at the top and bottom of extreme changes in channel gradient such as waterfalls or large debris jams. Following the survey, all measurements were downloaded to a CAD viewing program and the false X, Y and Z coordinates associated with the original survey were transferred to actual UTM NAD 1927 coordinates. Differences in horizontal and vertical coordinates were used to determine channel slope. All data associated with the longitudinal profile survey is included in Cirrus (2004b).

A gain-loss study was conducted on perennial stream segments of Greens Hollow, Cowboy Creek, and Greens Canyon during baseline (fall) conditions. During the gain-loss survey, flow and water quality measurements were taken at the mainstem of Greens Hollow and a flowing tributary to the stream, located near the headwater area. Flow in this tributary was supported by discharge from M_SP04, M_SP05, and M_SP06 and was the only flowing tributary present during base flow conditions. Flow below this point continued in the main stem of Greens Hollow to a point approximately 0.5 miles above the confluence with Cowboy Creek. No flowing tributaries were identified along Cowboy Creek or in Greens Canyon. Additional flow measurements were collected at the established stream monitoring sites including M_STR6, M_STR4, and M_STR3. All measurements were taken within a 24-hour time period. Streamflow was measured by routing all flow through a three inch PVC pipe and measuring the flow rate with a bucket and stopwatch. Water quality samples were collected on the main stem and flowing tributary approximately 25 feet above the point of confluence. A second gain-loss study was scheduled for these same stream reaches during 2002. However, continued drought conditions during 2002 produced streamflows that were significantly less than those observed during 2001. In order to obtain a greater range of measured flows, the study was rescheduled for 2003. Drought conditions continued throughout much of 2003 resulting in no flowing tributaries to the mainstream channels measured during 2001. As a result, a gain-loss survey during 2003 was not possible.

All streams maintaining perennial flow in the analysis area were mapped during baseline (fall season) conditions in 2001 through 2003. Locations where flow started and stopped were measured using GPS technology or marked on 1:24,000 scale USGS quad maps. Due to continued drought conditions during the project, the extent of perennial flow observed during fall of 2001 was greater than during any following year. As a result, this coverage was used for the assessment of impacts on perennial streams. Although no substantial changes were observed in the extent of perennial flow between 2001 through 2003, several stream channels that were noted to be continuously flowing in fall 2001 became intermittent in fall 2002 and fall 2003 with some segments drying up completely. The extent of perennial flow during fall 2001 is shown in Figure 4.

A review of historic precipitation and stream flow data provides some perspective with regards to climate patterns that occur in the analysis area. Annual precipitation totals recorded at several

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nearby Snowpack Telemetry (SNOTEL) stations including Buck Flat and Seely Creek, indicate that water year 2002 was well below the historic (1980-2013) total (USDA-NRCS 2013) and water years 2001 and 2003 were only slightly below average. Average annual flows during 2001-2004 for Muddy Creek near Emery, Ut were all below the historic (1952-2012) annual average flow of 37.5 cfs (USGS 2013). Annual average streamflow during the 2001 water year was 33.2 cfs or approximately 11 percent lower than the historic average.

2.4.5 Floodplains and Alluvial Valleys

The presence of floodplains and alluvial valleys adjacent to proposed surface facilities located in the analysis area were identified from a combination of field reconnaissance and review of existing mapping information. Maps prepared by the Office of Surface Mining and Reclamation were reviewed in order to determine the presence of alluvial valley floors in the analysis area. Additional information was obtained from DOGM pertaining to the amount and volume of water contained by unconsolidated alluvial deposits located in the analysis area drainages, including Muddy Creek and North Fork Quitchupah Creek.

2.4.6 Reservoirs and Ponds

The effort to identify reservoirs and ponds in the analysis area included a review of USGS 7.5 minute topographical maps, aerial photographs, range allotment information, MLNF GIS coverages, and consultation with MLNF rangeland resource specialists. No reservoirs were identified in the analysis area. Ponds were subsequently field-verified during 2001–2003.

In July of 2002, DOGM requested a field inventory of all ponds in and adjacent to the analysis area. During the field reconnaissance effort, the location of both natural ponds and stock ponds (i.e. constructed ponds) were measured using a Trimble GeoExplorer3 GPS unit that is accurate to +/- 2 meters in the horizontal plane. Several physical parameters were also measured or estimated for each pond including surface area, presence of water, source of water, and maximum depth capacity. Field reconnaissance information was compiled into a report and submitted to DOGM for review. A subset of ponds were then selected for quarterly monitoring of water depth including three stock ponds in or immediately adjacent to the Greens Hollow tract. Maximum water depth was first determined by measuring the vertical distance from a benchmark placed near the discharge channel of each pond, to the lowest point in the impoundment. In order to do this, a horizontal plane was established by stretching a leveled string from the benchmark to a location directly above the lowest point in the pond, and measuring the vertical difference. Subsequent measurements were made on a quarterly basis by completing the same process. Additional information on the location of ponds outside of the Tract boundary was obtained from MLNF range allotment files for the Ferron and Emery grazing allotments. All data collected from ponds is provided in Cirrus (2004b).

2.4.7 Water Rights

Water rights associated with springs and streams in the analysis area were identified using water rights files, hydrographic survey maps, and GIS information obtained from Utah DWRi. Discussion with Utah DWRi specialists indicated that GIS locations of water rights were typically estimated and would likely not correspond precisely with GPS locations of water features. Additional information was obtained from hydrographic survey maps regarding the geographic locations of water rights. A comprehensive assessment of all water rights in the analysis area was completed using GPS locations of springs, hydrographic survey maps, and GIS information to

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determine potential water rights associated with identified water features. A complete listing of all water rights and their associated water features identified during the Muddy Creek Tract field survey is contained in Cirrus (2004b). A more recent review of all water rights in the mining analysis area boundary identified additional perfected or approved water rights acquired on springs and streams during the past 10 years. These additional water rights included 28 held by the U.S. Forest Service and 1 additional water right held by Canyon Fuel Company (Cirrus 2014). Additional discussion of existing water rights in the mining analysis area is included below in Section 3.1.3.

2.4.8 Drinking Water Source Areas

Map coverage of drinking water source areas, including protection zones for surface and ground water sources, as well as points of diversion were obtained from the Utah DDW. Although many of these areas were located at nearby locations outside of the analysis area, it was determined these should be addressed due to the potential for indirect impacts to occur. Additional information on drinking water source areas was obtained through discussions with surface and ground water resource specialists at the Utah DDW. A complete listing of all drinking water source areas and their respective protection zones is contained in Cirrus (2004b). More recent discussions with the Utah DDW have confirmed these source areas and protection zones have not changed since the Muddy Creek Tract survey was finished (Jensen 2013).

3.0 RESULTS AND DISCUSSION

This section of the technical report describes surface and ground water resources in the analysis area (Section 3.1) and then determines potential effects of the conceptual mine operation on these resources (Section 3.2). The source of data used to describe existing water resources was described in detail in Sections 2.2, 2.3, and 2.4. A description of the alternatives that define conceptual mine operations is included in Section 1.3.

3.1 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Greens Hollow tract comprises an area of about 10 square miles located in the southern Wasatch Coal Field, approximately 60 miles southwest of Price, Utah, and about 6 miles northwest of Emery, Utah. The analysis area is 17.2 square miles including the Greens Hollow tract and a 900 foot buffer zone surrounding the tract (Figure 2). Elevations within the analysis area range from approximately 7,400 feet near Muddy Creek on the east to about 9,700 feet on the east flank of White Mountain, located on the west side of the analysis area. The two primary streams draining this area are Muddy Creek and North Fork Quitchupah Creek. The Muddy Creek watershed above USGS Station 09330500, Muddy Creek near Emery, Utah, is approximately 108 square miles. The North Fork Quitchupah Creek watershed above the SUFCO Mine monitoring station 042 is approximately 24 square miles. Approximately 10.8 square miles (63 percent) of the analysis area is contained in the Muddy Creek drainage and 6.4 square miles (37 percent) are found in the North Fork Quitchupah Creek drainage.

Water resources in the analysis area include springs, streams, and ponds that are primarily used for wildlife and stock watering purposes. There are no registered water supply wells in the analysis area and ground water is only used at the point of surface discharge at springs and seeps.

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Water yield from upper watersheds, including the analysis area, provides most of the domestic and agricultural water needs for the lower valley.

3.1.1 GROUND WATER AQUIFERS AND SPRINGS

The ground water baseline assessment provides a description of pre-mine conditions for each water-bearing stratum, including the coal seam, and any potentially impacted strata above and below the coal seam. Lithology and structure of the analysis area have been described by Anderson (2004) and include the Blackhawk, Price River, Castlegate, and North Horn geologic formations as well as landslide deposits overlaying the North Horn formation. Figure 4 provides the locations of springs with measurable flow and geologic formations within or in reasonable proximity to the Greens Hollow tract. As mentioned previously, Figure 3 depicts the lithology in the analysis area.

The Masuk Member of the Mancos Shale (also known as the Blue Gate Shale Member of the Mancos Shale) outcrops along the eastern edge of the Wasatch Plateau, including along the lower portion of Muddy Creek to the east of the analysis area. The Masuk Member of Mancos Shale consists of blue-gray shale or silty claystone that weathers light blue-gray to light tan. The unit does not feature springs or comprise an aquifer.

The Mesaverde Group overlies the Mancos Shale and consists of the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, and Price River Formation which all contain ground water and are capable of transmitting ground water flow.

The Star Point Sandstone consists of three massive sandstone layers, the uppermost of which intertongues with the Blackhawk Formation (Thiros and Cordy 1991). The Star Point Sandstone is the lowest aquifer unit that could be affected by proposed mining. The target coal seam (Lower Hiawatha) is located near the base of the Blackhawk Formation. The Blackhawk Formation is comprised of interbedded coals, sandstones, shale and mudstone. Sandstone decreases towards the base of the Blackhawk while the coals are present in the lower part of the Blackhawk. The finer-grained rocks in the Blackhawk can contain abundant swelling clays (Mayo and Associates 1997a). Vertical flow is restricted but may occur as unsaturated flow along fractures through perching beds (Lines 1985). The target coal and the Star Point Sandstone are likely to be saturated everywhere in the Greens Hollow tract but may be unsaturated beyond the Tract near outcrops at the edge of the plateau and in canyons (Thiros and Cordy 1991). Thiros and Cordy (1991) also note that artesian pressures ranging from 129 to 315 feet were measured in four observation wells completed in the upper Hiawatha coal seam by SUFCO in the vicinity of Duncan Mountain. Three other monitoring wells completed in the upper Hiawatha coal near the edge of the Wasatch Plateau were found to be dry. Most of the ground water in the Blackhawk formation is found in sandstone paleochannels or as localized perched zones above the saturated portion of the Blackhawk Formation. Vertical or horizontal hydraulic communication between sandstone channels is prevented by the shale and mudstone layers that surround sandstone paleochannels

Thiros and Cordy (1991) observed that ground water flow in the Castlegate Sandstone occurs as perched water flowing laterally along bedding planes in the direction of dip. Ground water flow in the Castlegate Sandstone is limited, as indicated by the occurrence of only one spring discharging from this formation in the Greens Hollow tract. The Castlegate Sandstone is overlain by the Price River Formation. The Price River Formation consists of medium- to coarse-grained sandstone, interbedded shale, and some thin beds of conglomerate. Mudstone drapes deposited during low-flow periods separate fluvial sandstones from each other both horizontally and

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vertically (USDA-FS 1999). Siltstones and shales in the Price River Formation were found to include 15 percent smectite (swelling) clays (DOGM 1992). It appears that much of the ground water recharge for the Price River Formation flows laterally where it discharges as springs and seeps. Some ground water flows vertically into the Castlegate Sandstone, where it is perched above the Blackhawk Formation, although only one Castlegate spring occurs in the Tract. Vertical flow from the Castlegate Sandstone into the Blackhawk Formation is restricted by shales and clays although some vertical movement still occurs as unsaturated flow along fractures in the Blackhawk.

The North Horn Formation overlies the Mesaverde Group and is the uppermost consolidated formation in the Greens Hollow tract. The North Horn Formation occurs over a large portion of the Tract. Flagstaff Limestone is found at the tops of ridges and mountains west of the analysis area. The North Horn Formation is considered to be the uppermost unit that could be affected by proposed mining because the Flagstaff Limestone outcrop is more than one-half mile to the west of the Tract. Unconsolidated deposits formed by weathering and erosion occur as colluvium, alluvium and soils. Slumping and landslides associated with clay-rich units in the Price River and North Horn Formations also occur further back from the escarpments and can be identified by the hummocky topography. The slumps and landslides vary in size from a few acres to hundreds of acres (Anderson 2004). Based on the geologic characteristics of the North Horn and the large number of springs and seeps, it appears that most ground water in the North Horn Formation moves laterally and ultimately discharges in the form of springs and seeps. Vertical flow into the Price River Formation is restricted by shales and clays in the North Horn Formation. Danielson and Sylla (1983) found that 90 percent of springs and seeps that were inventoried in coal-resource areas in the southern Wasatch Plateau, discharged from the North Horn Formation. The data from this study were not sufficient to determine if ground water in the North Horn Formation is perched or part of a continuous saturated zone. In either event, it is clear that shales and clays in the North Horn Formation restrict vertical flow of ground water.

During the spring and fall of 2001-2004 Cirrus monitored all springs with measurable flow located in the Greens Hollow tract and adjacent areas. A detailed description of monitoring efforts is provided in Section 2.4. Location information for each spring along with measurements of flow and specific conductance are summarized in Table 1. Electronic data files with field measurements and water quality analysis results are provided in DOGM (2013a). Figure 5 and Figure 6 show the range of measurements for flow and specific conductance, respectively, for springs associated with each geologic formation, based on all measurements collected at these sites from 2001 to 2012. Eight springs were also monitored in the analysis area on a seasonal basis (i.e. four times per year) for baseline flow and water quality. The rationale for selection of these springs is described in Section 2.3. No monitoring wells were installed for the baseline program, although several monitoring wells have previously been installed on nearby coal leases. Water level data from these wells were used where applicable, to support the discussion of ground water resources.

The Utah DWQ is responsible for monitoring water quality of all waters of the State and works cooperatively with other agencies to achieve this task. Water quality samples collected from the eight monitored springs were assessed for compliance with applicable numeric criteria and pollution indicator values used by the Utah DWQ. Numeric criteria and pollution indicator values have been assigned to all water bodies in Utah (including streams, rivers, lakes, and reservoirs) with the objective of protecting the highest beneficial use of the water resource. Beneficial use categories associated with the analysis area include Class 1C (Drinking Water), Class 2B (Secondary Contact Recreation), Class 3A (Cold Water Aquatic Life), Class 3C (Non game Fish), and Class 4 (Agriculture).

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Water quality of springs and streams is considered dynamic and can exhibit seasonal and interannual variations. These patterns can be observed at disturbed sites as well as at locations that are considered pristine and without anthropogenic influence. Naturally high concentrations of some water quality constituents can also occur as water comes in contact with parent materials found in Utah and surrounding areas that have high ambient concentrations of certain constituents such as saline Mancos Shale. A threshold is used by the Utah DWQ to account for normal levels of variation when water quality samples are evaluated. If less than 10 percent of samples violate standards or pollution indicator values, water quality is considered to fully support the assigned beneficial use. If more than 10 percent of samples are in violation, the water body is considered impaired and further investigation is warranted. The number of samples and length of monitoring required for an evaluation varies according to the water quality parameter in question.

Samples collected in the fall of 2001 from eight springs were also analyzed for stable and unstable isotopes. The unstable isotopes ^{14}C and ^{3}H were measured to provide estimates of the approximate age or residence time of water issuing from springs, while the stable isotope ratios of oxygen ($^{18}O/^{16}O$ reported as $\delta^{18}O$) and hydrogen ($^{2}H/H$ reported as δD) were measured to help characterize likely recharge sources and mechanisms for springs and the underlying aquifers. The stable isotope ratio of dissolved inorganic carbon ($^{13}C/^{12}C$ reported as $\delta^{13}C$) is typically collected to help in the age adjustment of the carbon-14 results. The isotope analysis results for the analysis area springs are included in Figure 7 and are discussed below.

Tritium is a naturally occurring radioactive isotope of hydrogen that has a half-life of 12.43 years. Tritium levels in rainfall dramatically increased above natural background levels starting in about 1954 as a result of nuclear testing. Tritium is measured in ^{3}H units (TU) and, if detectable, provides a qualitative indicator that the ground water has a component of water that recharged since about 1954. Because ^{3}H is part of the water molecule, ^{3}H is not affected by reactions other than radioactive decay; therefore, ^{3}H is an excellent tracer of recent ground water recharge. Ground water that recharged prior to 1954 will contain little to no ^{3}H. Interpretation of ^{3}H results are often qualitative due to processes that influence ^{3}H concentrations. Actual ^{3}H concentrations could be the result of 1) recent low-concentration recharge, 2) older "bomb" ^{3}H that has decayed to the measured levels, or 3) a mixture of young and old ground water.

Carbon-14 provides information regarding the number of years that have elapsed since the ground water recharged. A direct estimate of age from the ^{14}C analysis overestimates actual age due to geochemical processes in ground water flow that act to reduce concentrations of ^{14}C and make the water appear older. Some of the processes that act to reduce ^{14}C include reactions with carbonate and silicate rocks, sulfate reduction, and methanogenesis.

Carbon-13 (^{13}C), a naturally occurring stable isotope of carbon, is sometimes used in conjunction with chemical and mineralogic data to evaluate chemical reactions that occur in aquifers and to adjust ages determined from ^{14}C analysis. These chemical and mineralogic reactions may add carbon that does not contain ^{14}C to the dissolved phase or remove carbon that may contain ^{14}C from the dissolved phase. Carbon-13 data are expressed in delta notation (δ) as per mil (parts per thousand) differences relative to the ratio of ^{13}C to ^{12}C in a standard Peedee belemnite (PDB) reference. The large range of $\delta^{13}C$ in various carbon reservoirs is largely a result of carbonate geochemistry and isotope selectivity by bacteria.

Understanding the distribution of isotopes in the carbon cycle begins with carbonate geochemistry. Soil water typically exhibits a $\delta^{13}C$ in the range of –22 to –24 due to CO_2 generated from decaying vegetation. Reactions of CO_2 with carbonate rocks act to enrich ^{13}C or

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increase the $\delta^{13}C$ to a level of about −12.7 expected for an equilibrium with calcite at a pH of about 7.6 (Clark and Fritz 1997a). Further ^{13}C enrichment can occur at higher pH and with dissolution of dolomite. The $\delta^{13}C$ observed at most of the analysis area springs was in the range of −12.6 to −10.8. Carbon-13 results have been used to try and adjust ^{14}C ages. However, the corrections result in over correction to the ^{14}C ground water age because of insufficient information to model reactions that add or remove carbon from ground water along flow paths that represent different geochemical settings in the analysis area. The corrections were based on the assumption that the presence of dissolved carbonate species originated from calcite dissolution along the flowpath and is presumed to be ^{14}C free. Both the North Horn and Flagstaff formations are comprised of significant amounts of limestone. Additionally, secondary calcite cements are typically found in sandstone, siltstone, and shale formations. The dissolved inorganic carbon (DIC) isotope ratios ($\delta^{13}C$) typically increase as carbonate is dissolved and result in a dilution factor of approximately 85 percent (Clark and Fritz 1997a). Dilution calculations were carried out using the $\delta^{13}C$ values. The equation used to calculate the dilutions is based on the measured DIC $\delta^{13}C$ values measured from field samples and empirical $\delta^{13}C$ values for soil CO_2 (-14 to -23 ‰) and calcite (0 ‰) available for dissolution (Equation 1). Common values used in Equation 1 including $\delta^{13}C$ values for soil CO_2 and calcite are found in Clark and Fritz (1997a). However, these values may not reflect values that correctly represent the hydrogeologic system in the Greens Hollow tract. Reviewing the $\delta^{13}C$ of soil CO_2 values as a function of pH indicates a value closer to -15 ‰ with pH values near 7.5 (Clark and Fritz 1997b). The results indicate the potential for dilution from ^{14}C free carbonates is easily attributable to less than 100 percent modern carbon (PMC) associated with the samples. The amount of error in this type of analysis and lack of sufficient data make it difficult to determine exact values.

Equation 1

$$dilution = \frac{\delta^{13}C_{DIC} - \delta^{13}C_{carbonate}}{\delta^{13}C_{Soil\ CO_2} - \delta^{13}C_{carbonate}}$$

Tritium and ^{14}C were also used previously to evaluate mean residence time (age) of ground water in the Pines Tract Area and the SUFCO Mine area. Based on comparison of the ^{14}C and ^{3}H compositions in SUFCO Mine ground water with near-surface ground water, it was determined that a hydrologic disconnect exists between near-surface ground water systems and ground water systems encountered in the SUFCO Mine (Mayo and Associates 1999). Ground water inflows collected in the mine have mean ground water residence times of 7,000 years to 20,000 years and contain no ^{3}H, while near-surface ground waters have modern ^{14}C and abundant concentrations of ^{3}H. Carbon-14 and ^{3}H data were collected from nine springs and two creek segments in the Pines Coal Lease Tract (Mayo and Associates 1998). Abundant ^{3}H and anthropogenic ^{14}C content in ground waters discharging from the Castlegate Sandstone indicated that ground water at these springs recharged during the last 50 years. Two of the Blackhawk Formation springs also had consistent modern isotopic contents. The three other Blackhawk Formation springs that were sampled showed small amounts of ^{3}H (0.08-0.74 TU) and indicated uncorrected radiocarbon ages of 500 years to 4,000 years. The apparent inconsistency in these results was attributable to the dilution by ^{14}C free carbonate dissolution as indicated by $\delta^{13}C$ values for DIC. Due to a lack of data, mixing of older and modern ground waters discharging from these springs cannot be ruled out as a possible reason for the discrepancy.

For qualitative evaluation, the ^{3}H and ^{14}C measured from springs in the Greens Hollow tract are plotted in Figure 8. These results show that water issuing from most springs in the analysis area contains ^{3}H and is considered to be of relatively recent recharge despite having unadjusted ^{14}C ages ranging from zero to 1,910 years. Although measurements of unadjusted ^{14}C could reflect mixtures of older ground water it is typical for dilutions of 85 percent to occur due to carbonate

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dissolution and is most likely the reason for lower than 100 percent pmc carbon values. However, the water issuing from Price River Formation spring M_SP18 is much older than ground water issuing from the other springs based on the absence of ^{3}H and the older unadjusted ^{14}C age of 1,910 years.

The stable isotopes of hydrogen (^{2}H) and oxygen (^{18}O) are naturally occurring components of water in the hydrologic cycle. The ratios of $^{2}H/H$ and $^{18}O/^{16}O$ change during evaporation and condensation. These ratios also change during ground water transport through the process of mixing and dispersion with other water sources. Interpretation of changes in isotope ratios in ground water can help identify flow paths and recharge sources. The stable isotope ratios of $^{2}H/H$ and $^{18}O/^{16}O$ in water samples are expressed in terms of per mille difference (δ ‰), with respect to an international standard for Vienna Standard Mean Ocean Water (VSMOW):

Equation 2 $\quad \delta$ ‰ = {(R sample/Rvsmow)-1}x1000

where R is the isotope ratio $^{2}H/H$ or $^{18}O/^{16}O$. A sample which has a $\delta\ ^{18}O$ of -15 has an ^{18}O content of 0.015 less than that of the reference standard, VSMOW. Evaporation changes the isotope composition, as the lighter molecules of water, $H_2{}^{16}O$, are more volatile than the heavier water molecules containing the isotopes ^{2}H and ^{18}O. Thus, water vapor that evaporates from the ocean at 25 °C features a δ ‰ of ^{18}O of –9.3 and a δ ‰ of ^{2}H of -76 (Clark and Fritz 1997b). When the atmospheric water condenses, the heavier water molecules condense first leaving the residual atmospheric water vapor more depleted in ^{2}H and ^{18}O. Since the degree of condensation increases at lower temperatures, variations in the isotope contents of precipitation are primarily due to temperature effects. The δ ‰ for ^{2}H and the δ ‰ for ^{18}O in precipitation are highly correlated. A plot of this correlation is referred to as the global meteoric water line, a generic line ($\delta\ ^{2}H = 8 * \delta\ ^{18}O + 10$) developed by Craig (1961). Values along the meteoric water line indicate changes due to condensation temperature of precipitation. This usually matches precipitation quite well for coastal areas, but for precipitation in continental interior locations and arid climates, the intercept usually increases while the slope usually remains at eight.

Evaporation processes and sublimation of snow also result in changes in the isotope ratios after precipitation reaches the land surface. Water in lakes and rivers may become enriched in heavy isotopes through evaporation. Evapotranspiration also increases the heavy isotopes in ground water recharge. The isotopic composition of ground water changes through mixing, dispersion and dissolution of oxygen based minerals. If areal recharge is the main component of ground water flow, the isotopic composition of ground water corresponds to the average composition in areal recharge. Likewise, if recharge from a surface water body is the main component of ground water flow, then the isotopic composition of ground water will correspond to the average isotopic composition in the water body as long as there is no significant increase in dissolved ions. Stable isotope analyses can also be used to assess the contribution of cool and warm season precipitation to the recharge budget, and to evaluate the timing and extent of evaporation during recharge. For example, cool season precipitation in the Sierra Nevada Mountains (mostly snowfall) has an average deuterium value that is 40 to 70 permil lighter than average summer rainfall (Rademacher et al 2002).

The δ ‰ for ^{2}H and the δ ‰ for ^{18}O for each sampled spring are plotted in Figure 9. Without analysis of the δ ‰ for ^{2}H and the δ ‰ for ^{18}O measured in precipitation at various times of the year, it is not possible to determine the local meteoric water line for interpreting the spring results. The global meteoric water line from Craig (1961) and the local meteoric water line for snow in Yellowstone are shown on Figure 9. Deviation to the right of the meteoric water line

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indicates the relative extent of enrichment of ^{18}O due to evaporation of water and sublimation of snow. Deviations to the left of the local meteoric water line are less common but could occur as a result of recharge of ground water from snow that includes a water component from condensation on cold snow surfaces or from earlier climates that had a different local meteoric water line.

The results in Figure 9 show varying degrees of evaporation or sublimation influences at most of the springs. The results for spring M_SP08 and M_SP18 are slightly right of the local meteoric water line for snow in Yellowstone, indicating that evaporation or sublimation influences may have been minimal for the recharge sources for these springs. The results also show that the water issuing from springs in the analysis area are predominantly recharge that originates from snow, with perhaps slight but varying degrees of contribution from warm period precipitation. The water isotopes also show no ^{3}H in M_SP18 and less ^{14}C, indicating older ground water. The apparent age based on ^{14}C may not be as old as indicated in Figure 8 due to dissolution of carbonates that are low in ^{14}C. The water isotopes from M_SP18 also show relatively depleted values when compared to the other springs (M_SP01, M_SP02, M_SP04, M_SP07, M_SP08, and M_SP14) indicating a potentially colder temperature at the time or area of recharge. This could be related to a different time period with a cooler temperature or water from a different recharge area of colder temperatures.

3.1.1.1 Springs and Ground water in the Flagstaff Formation

The Flagstaff Limestone is the uppermost consolidated formation near the analysis area, located west of the analysis area boundary. The spring and seep survey for the Greens Hollow project found no ground water issuing from the Flagstaff Formation.

3.1.1.2 Springs and Ground water in the North Horn Formation and Landslide Deposits Overlying the North Horn Formation

The majority of the springs identified in the analysis area were issuing from the North Horn Formation. The North Horn Formation is estimated to be up to 1,490 feet thick in the analysis area based on the geologic report by Anderson (2004). No drilling in the area has penetrated both the upper and lower contacts of the formation. The shaley nature of the formation and its occurrence at higher elevations that receive more precipitation makes it vulnerable to mass movement, slope failures, and landslides. The shales and clays of the North Horn Formation serve to retard the vertical flow of water causing ground water to move horizontally along bedding planes or through fractures. It is uncertain whether ground water aquifers in the North Horn and Upper Price River Formations are continuously saturated or whether unsaturated zones occur beneath perched saturated zones. Indications of extensive unsaturated horizons in the Price River and Castlegate Sandstone in drill-holes and wells in the adjacent SUFCO Mine and Pines Lease Tract, as reported in the Pines Tract EIS, suggests that perched ground water conditions are likely. In any event, it is clear that the clays and shales in the North Horn and Price River Formations severely restrict vertical flow of ground water to deeper units in the analysis area as indicated by the large number of springs in these units and the occurrence of only one spring, M_SP87, in the underlying Castlegate Sandstone.

The springs in Figure 5 appear to have no preference as to slope direction. Anderson (2004) observed a similar lack of pattern for the location of landslides and slumps relative to slope directions. The diameter of the circles associated with each spring in Figure 5 shows the flow range for both maximum and minimum flows measured during the baseline monitoring period. Most of the springs issuing from the North Horn Formation were either seasonal springs exhibiting very low flows during the late summer and fall or exhibited very low flow throughout the year. As mentioned above in Section 2.4.4, a review of annual streamflow from Muddy

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Creek and precipitation levels recorded at nearby SNOTEL stations, indicate that water year 2002 (October 1, 2001 through September 30, 2002) was well below historic averages and in the lower tenth percentile of historic annual precipitation totals (USGS 2013, USDA-NRCS 2013).

Monitoring results for field parameters for the North Horn Formation springs are summarized in Table 2. These results are compared with relevant water quality standards for surface waters located in the analysis area. These standards are found in R317-2, Utah Administrative Code(UAC). The Utah DWQ has classified surface waters in the analysis area as:

- 1C – raw water source for domestic water systems
- 2B - protected for secondary contact recreation.
- 3C - protected for nongame fish and other aquatic life
- 4 - protected for agricultural uses including irrigation and stock watering

The relevant water quality criteria for field parameters in surface water in the analysis area are: $6.5 > pH < 9$; temperature $< 27^{\circ}$ C; and dissolved oxygen > 3.0 mg/l. It should be noted here that the 3C beneficial use classification is used for springs in preference to class 3A – cold water aquatic life. Generally speaking, the 3C classification is considered to protect forms of aquatic life that include nongame fish as well as non-fish aquatic species such as amphibians and macroinvertebrates. This assessment assumes that the topographical locations and discharge rates from springs in the analysis area would not support fish populations, therefore measured water quality parameters from springs are compared to the 3C classification.

The results in Table 2 show that water from all North Horn Formation springs meets the relevant pH and temperature criteria but that many of the dissolved oxygen values do not meet relevant water quality criteria. This is not unexpected, because the spring water is derived from ground water that is typically very low in dissolved oxygen.

North Horn Formation springs M_SP04, M_SP07, M_SP08, and M_SP14 were also sampled for water quality analysis as well as monitored for field parameters. Monitoring results from individual springs are described below. A summary of the laboratory analysis results for all four of the North Horn Formation springs is included in Table 3, which provides a comparison with relevant water quality criteria for inorganic constituents and dissolved metals. The relevant aquatic criterion for ammonia nitrogen depends upon temperature and pH and the relationship is tabulated in R317-2, UAC. Monitoring of total manganese and total iron is required by Utah DOGM rules, although there is no Utah water quality standard for either of these parameters.

The Table 3 results show that all North Horn Formation Springs and the springs issuing from landslide deposits overlying the bedrock of the North Horn Formation generally meet the relevant criteria and pollution indicator values associated with each constituent. Occasional violations of the Class 1, Class 3, and Class 4 criteria were noted at two springs for arsenic (one violation) and selenium (two violations). All violations occurred on the same sample date. The remaining measurements of arsenic and selenium are well below numeric criteria. It is assumed the limited number of water quality violations observed at these springs are within the normal range of water quality variations and do not indicate impairment. The results shown in Table 3 provide a baseline for comparison with water quality monitoring results obtained in the future.

Spring M_SP04 issues from the North Horn Formation in a small drainage to the south of Greens Hollow, on the west side of the Tract. The slope above the spring appeared to be stable with no indications of slumping/soil movement. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for this spring are provided in Figure 10. These results show

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modest seasonal fluctuation in flow and field parameters. Flows ranged from less than 1 gpm to about 3 gpm. Specific conductance ranges from about 380 to 930 uS/cm and did not appear to correlate with the measured flow rate. The spring water is a mixed cation bicarbonate water with sodium being the dominant cation. It exhibits consistent ion chemistry that does not change with flow or specific conductance.

Spring M_SP07 is located on the boundary of the Greens Hollow tract and issues from the base of the North Horn Formation near the outcrop of the Price River Formation. Water from this spring flows from the base of a slump down to a wide, flat-bottomed drainage swale connected to Cowboy Creek. This water forms a small wet pocket at the bottom of the drainage but does not reach Cowboy Creek. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for this spring are provided in Figure 11. These results show slight seasonal fluctuation in flow and field parameters. Flows generally ranged from about 0.2 gpm to about 0.6 gpm, although a flow of 1.14 gpm was measured on June 20, 2001. Specific conductance ranged from about 440 to about 880 uS/cm and did not appear to correlate with the measured flow rate. The spring water is a mixed cation bicarbonate water. It exhibits consistent ion chemistry that does not change with flow or specific conductance.

Spring M_SP08 issues from the North Horn Formation and is located toward the south east portion of the Tract. This is a developed spring that feeds a spring box and a cattle trough. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for this spring are provided in Figure 12. These results show seasonal fluctuation in flows. Flows ranged from 0 to about 1.2 gpm. Specific conductance and conductance ranged from about 330 to about 1,000 uS/cm and did not appear to correlate with the measured flow rate. The spring water is a mixed cation bicarbonate water.

Spring M_SP14 is located near the head of Cowboy Creek to the west of the Greens Hollow tract. Spring M_SP14 is developed for water supply and supports a spring box located about 50 feet downstream from the source and a cattle trough, located about 250 feet down slope. Water from the spring and overflow from the trough, flow down into small tributary drainages of Cowboy Creek. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for this spring are provided in Figure 13. The discharge is highly variable and seasonal with high flow rates noted in May or June of 2001, 2003, and 2004 and discharge drying up in the fall of the year. The maximum discharge rate noted was 61.4 gpm in May 2004. Specific conductance ranged from about 300 to about 540 uS/cm with the lower specific conductance corresponding with the higher flow rates. The spring water is a calcium bicarbonate water which did not vary among the samples collected.

3.1.1.3 Springs and Ground water in the Price River Formation and Landslide Deposits Overlying the Price River Formation

The lithology of the Price River Formation is genetically similar to the underlying Castlegate Sandstone but the formation contains finer-grained clastics or more shale and siltstone, with minor conglomerate. The unit is semi-resistant and generally a slope-former (Anderson 2004). Like the North Horn Formation, the outcrop of the Price River Formation is susceptible to slumping and landslides due to the occurrence of shales and clays.

Laboratory measurements of spring discharge from the Price River Formation are summarized in Table 4 and compared to relevant water quality standards. Figure 5, Figure 6, and the summary in Table 2 show that springs issuing from the Price River Formation generally exhibit higher levels of specific conductance and lower flow rates as compared to the springs issuing from the

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North Horn Formation. Table 2 results also show that water from all Price River Formation springs meet the relevant criteria for pH and temperature but do not meet relevant criteria for dissolved oxygen. The low dissolved oxygen values are to be expected as ground water is typically very low in dissolved oxygen.

The highest flow from Price River Formation springs was observed at Spring M_SP02. Price River Formation Springs selected for baseline water quality analysis included Springs M_SP01, M_SP02, M_SP18, and M_SP39.

Spring M_SP01 is located along Greens Hollow, at Rough Brothers cabin. The spring was developed sometime during 1930-40 and has been used for culinary and irrigation purposes at the cabin since that time. Discussions held with the owner of the cabin during the Muddy Creek Tract survey, indicated that flow from the spring has been steadily dropping from 1999- 2004 due to drought conditions. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for this spring are provided in Figure 14. These results show slight seasonal fluctuation in flow and field parameters. Flows generally ranged from about 0.2 gpm to about 0.9 gpm. Specific conductance ranged from about 435 uS/cm to slightly over 900 uS/cm and did not appear to correlate with the measured flow rate. The spring water is a mixed cation bicarbonate water with calcium being the dominant cation similar to Spring M_SP02. It exhibits consistent ion chemistry that does not change with flow or specific conductance.

Spring M_SP02 is located near the Greens Hollow stream crossing and provides water for a cattle trough located about 100 feet to the east and eventually for pond P1. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for Spring M_SP02 are provided in Figure 15. The Emery Water Conservancy District (EWCD) is also monitoring flow at this spring. The daily flow summaries for the time period from July 3, 2002 through November 14, 2003 are also plotted in Figure 15. These results show some differences between the continuous flow measurements by the EWCD and the seasonal manual flow measurements taken at the time of sampling for baseline characterization for this study. As discussed previously, some of the discrepancy may be explained if the EWCD flow monitors are not capable of detecting low flows. However, at this location, a zero flow was reported by the EWCD gauge on May 20, 2003 while a flow measurement of 6.86 gpm was recorded at the spring box. On the same date, a flow measurement of 0.57 gpm was recorded by Cirrus at the pipe entering the cattle trough, which is the same location as the EWCD gage. The EWCD meters may have also been disturbed by ranch hands during maintenance of the spring box and cattle trough. Manual flow measurements at this spring suggest seasonal fluctuations with flows ranging from 0 to about 13.4 gpm. Specific conductance is fairly constant at this spring and ranges from 469 to 499 uS/cm for the 2001 to 2004 with specific conductivity increasing to the 800 uS/cm range for measurements in 2006 and 2007, with no correlation with flow rates. The spring water is a mixed cation bicarbonate water with calcium being the dominant cation. It exhibits consistent ion chemistry that does not change with flow or specific conductance.

Spring M_SP18 is a developed spring located at the south end of a wide, gently sloped tributary to Muddy Creek. The spring box is heavily corroded. Its outlet appeared to be plugged or partially plugged during some of the sampling visits and water inside the spring box looked stagnant. At one time, this spring box was connected to a cattle trough. During the Muddy Creek Tract survey, the line was broken just below the cattle exclosure surrounding the spring box. Another large cattle trough located approximately ¾ mile north of the spring may have also been filled by this same spring. It was dry during the baseline monitoring period. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for this spring are provided in Figure 16. These results show seasonal fluctuation in discharge with flows ranging from 0 to

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about 0.5 gpm. Specific conductance ranged from 726 to 1,435 uS/cm and did not appear to correlate with the measured flow rate. The spring water is a mixed cation mixed anion water. The changes in specific conductance and changes in anion composition observed at this spring may be due to the poor condition and maintenance of the spring box, including the corroded condition, stagnant water, and dead animals that were occasionally found in the spring box.

Spring M_SP39 is located in the Greens Hollow tract, adjacent to Cowboy Creek. It is developed, with a series of three spring boxes. The top spring box is disconnected and does not appear to be flowing anymore (water in the spring box appeared to be stagnant). The middle spring box discharges into the lower spring box, which discharges into Cowboy Creek. Time series plots of flow, field parameters, and Stiff diagrams of major ion chemistry for this spring are provided in Figure 17. The EWCD has monitored flow at this spring. The daily flow summaries for the time period from July 3, 2002 through November 14, 2003 are also plotted in Figure 17. These results initially show good agreement with the manual measurements, with discrepancies starting to appear in November 2002. As noted, some discrepancy may be explained if EWCD flow monitors are not capable of detecting low flows. Furthermore, the initial agreement between manual and instrument measurements followed by a period of disagreement seems to indicate tampering by humans. The manual measurement results show large seasonal fluctuation in flows. Flows ranged from 0.27 to 4.66 gpm. Specific conductance ranged from 573 to 1,035 uS/cm with higher values occurring at the lower measured flow rates. The spring water is a mixed cation bicarbonate water.

Laboratory analysis results for all four Price River formation springs are compared with the relevant water quality criteria for inorganic constituents and dissolved metals in Table 4. These results show the Price River Formation springs that were sampled for baseline water quality generally met all relevant criteria for all constituents except for slight exceedances of arsenic, cadmium, lead, TDS, and zinc

Arsenic exceeded the 1C standard of 0.01 mg/l for one of six sample dates at two spring monitoring sites. Factors contributing to a higher concentration on this date (November 2002) are not known at this time. However, it is assumed these violations do not characterize typical fluctuations in water quality from these springs. All other measurements from these springs were well below the 1C standard. As a result, it is assumed these violations do not represent water quality impairment.

All measurements of cadmium and lead were below the Method Detection Limit (MDL) used to measure each sample including 0.005 mg/l and 0.07 mg/l, respectively. Due to the slight differences between water quality standards and the laboratory's MDL for each parameter, it is not possible to determine if these measurements exceed the associated 1C, 3A and 3C standards. However, based on local knowledge of geology, soil, and land use/development in the analysis area, it is likely that water chemistry at these sites generally reflects natural conditions, is not a danger to animal or human health, and is in support of the assigned beneficial use.

Measurements of TDS and zinc both had single measurements that exceeded water quality standards including a TDS measurement of 1,214 mg/l collected from Spring M_SP39 on May 12, 2004 and a zinc value of 0.13 mg/l collected from Spring M_SP01 on October 7, 2003. It is assumed these single violations do not indicate water quality impairment at either spring.

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3.1.1.4 Springs and Ground water in the Castlegate Sandstone

The Castlegate Sandstone forms a steep cliff escarpment along most stream valley segments of Muddy Creek, Box Canyon, and Greens Canyon. This unit is between 195 and 326 feet thick, with an average thickness of 239 feet (Anderson 2004). Near cliff exposures and in stream bottoms, the Castlegate Sandstone becomes friable due to the dissolution of the carbonate cement thus becoming more capable of supporting active ground water systems (USDA-FS 1999).

Spring M_SP87 is the only Castlegate Sandstone spring identified in the Greens Hollow tract. It issues from the base of an overhanging cliff at the contact with the Blackhawk Formation at an elevation of about 250 feet above the south side of Muddy Creek. Flows at this spring ranged from about 2.2 to about 3.1 gpm with little seasonal fluctuation. Specific conductance ranged from 627 to 1,277 uS/cm with no correlation with the flow rate. Spring M_SP87, like other Castlegate Sandstone springs in the Muddy Creek Tract analysis area and Pines Coal Tract, issues from the base of the sandstone at the contact with the Blackhawk Formation, where the occurrence of abundant swelling clays serves to impede downward movement of ground water, causing lateral movement. Structure appears to influence ground water flow in the Castlegate Sandstone in the Muddy Creek Tract analysis area as all of the springs are located on the east or southeast side of the canyons, as would be expected for ground water following the dip slope. No springs were found to issue from the Castlegate Sandstone in Greens Canyon. This suggests that either the recharge area between Greens Canyon and Box Canyon is insufficient to sustain ground water flow in the downdip direction in the Castlegate Sandstone or that an absence of shales and swelling clays in the upper part of the Blackhawk Formation in this area does not allow ground water levels to rise sufficiently to sustain spring flows.

Ground water issuing from spring M_SP87 exhibits much higher levels of specific conductance than Castlegate Sandstone springs located in Box Canyon that were measured during monitoring of the Muddy Creek Tract. Spring M_SP87 also exhibits a somewhat higher pH that is similar to the Price River Formation. These results, together with consistent flow from the spring, suggest that recharge for the spring passes through the Price River Formation. Spring M_SP87 is located near the mouth of an unnamed tributary to Muddy Creek. It is likely that much of the recharge for this spring occurs along this stream valley.

3.1.1.5 Springs and Ground water in the Blackhawk Formation

The average thickness of the Blackhawk Formation in the analysis area is 825 feet with a minimum thickness of 714 feet. The mineable coal is found in the lower quarter of the formation (Anderson 2004). The sandstone units become more separated and isolated towards the base of the Blackhawk. The interbedded claystones, siltstones, and sandstones of the Wasatch Plateau are rich in swelling clay minerals of the montmorillonite or smectite group. Material from the Blackhawk Formation was examined by X-ray diffraction and found to contain an average of 24 percent smectite, a swelling clay. (DOGM 1992) These swelling clays decrease the vertical hydraulic conductivity, which impedes the vertical flow of ground water in the Blackhawk Formation. No springs issuing from the Blackhawk Formation were noted in the analysis area.

3.1.1.6 Springs and Ground water in the Star Point Sandstone

The upper Star Point Sandstone consists of three massive sandstone layers (USDA-FS 1999); the lower Star Point Sandstone is an upward prograding sequence of thin sandstones, siltstones, and shales, which intertongue with the underlying Masuk Member of the Mancos Shale (USDA-FS 1999). The Masuk member of Mancos Shale acts as a low permeability base or boundary such

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that Star Point Sandstone is the lowermost ground water bearing bedrock formation evaluated in this study. The Muddy Creek Tract spring and seep survey found no ground water issuing from the Star Point Sandstone, including the Greens Hollow tract. As discussed in Section 2.2, Thiros and Cordy (1991) conducted a gain-loss study of North Fork Quitchupah Creek that found an increase in flows where the creek crossed the Star Point Sandstone outcrop. The Pines Tract EIS determined that recharge of the Blackhawk formation and underlying Star Point Sandstone is quite low and occurs primarily in the vicinity of the outcrops (USDA-FS 1999).

3.1.1.7 Ground water in Alluvium

Thin alluvial deposits are found along the bedrock-dominated channels in the canyon bottoms. Mapped alluvial deposits occur along Muddy Creek below Box Canyon, east of the analysis area. Muddy Creek does have a floodplain and unmapped alluvial deposits along most of the stream channel in the analysis area. Although ground water undoubtedly occurs in the alluvium of Muddy Creek, ground water levels would vary seasonally with flows in the creek. Ground water in the alluvium does not support any direct use for wells. However, the alluvium likely serves to store surface runoff water during high flows and release water as levels in the creek drop, helping maintain perennial flow in the lower portions of the Muddy Creek Canyon. Muddy Creek's gradient, as measured from the USGS 7.5-minute topography, averages about 3 percent in this area.

The Office of Surface Mining and Reclamation (1985) has prepared reconnaissance maps to assist in identifying Alluvial Valley Floors for the coal regions of central Utah. These maps show no subirrigated alluvium or potentially flood irrigable alluvium in the analysis area.

The Utah DOGM has also made a negative determination on the existence of unconsolidated stream laid deposits holding streams and sufficient water to support agricultural activities in the SUFCO Mine Plan Area and adjacent area. This area and determination includes Muddy Creek and the North Fork Quitchupah Creek.

3.1.1.8 Ground water Summary

The general pattern for ground water flow in the vicinity of Greens Hollow is from recharge areas at the higher topographic elevations to discharge areas at the lower topographic elevations along the stream valleys. Of course, the site geology controls the patterns, pathways and rates of ground water flow. Ground water recharge and discharge is localized in the North Horn and Price River Formations. These geologic units contain the majority of springs found in the analysis area. The location of springs has no apparent relationship with geologic structure and no preference as to the slope direction. It is apparent that clays and shales in the North Horn and Price River Formations restrict vertical flow of ground water to deeper units in the analysis area, causing the springs to appear at higher topographic positions.

Geologic structure appears to influence the location of springs issuing from the Castlegate Sandstone. Spring M_SP87 is the only Castlegate Sandstone spring in the Greens Hollow tract. This spring is located south of Muddy Creek on the north side of the coal tract and exhibits much higher specific conductance than the other Castlegate Sandstone springs located east of the analysis area in the Box Canyon drainage and a somewhat higher pH that is similar to the Price River Formation. These results, together with the consistent flow of the spring, suggest the recharge for this spring passes through the Price River Formation. Spring M_SP87 is located near the mouth of an unnamed tributary to Muddy Creek and it is likely that much of the recharge for this spring occurs along the stream valley.

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No springs were identified that discharge from the Blackhawk Formation in the Greens Hollow tract.

The assessment and discussion of measured flows in the above sections is not meant to assign significance or importance to certain springs based on discharge volumes or length of flow. All springs in the analysis area are considered important. However, some springs can be considered to have a higher value as a result of investments in development or due to the support provided by these springs to dependent ecosystems. Systematically identifying the values associated with individual springs can provide guidance for mine plan development and/or mitigation measures. While it is unlikely that mining developments can occur in a way that would avoid all springs, some knowledge of the value of individual springs could be used to design a practical mine plan with a relatively high probability of minimizing impacts on high value springs. Springs located adjacent to wetlands are a significant source of water to vegetation and wildlife that utilize these areas as primary or secondary habitat. Improvements to livestock management can result following spring development as animals are drawn to troughs located away from fragile areas of ground water discharge. Springs located in upgradient source areas for wetlands and riparian corridors can be some distance away, yet still provide seasonal or perennial flows that support these features. The following factors were used to define the value of each spring in the analysis area.

> High Value: Springs that are located within 25 feet of wetland areas, provide surface tributary flow to the adjacent wetland, or developed in support of human or livestock use.
>
> Moderate Value: Springs located within 500 feet of wetland areas or riparian corridors.
>
> Unknown Value: Springs not classified as High or Moderate Value.

Table 5 and Figure 4 indicate the classification of each spring. Note that four springs were classified as Unknown value. The remaining springs are either located in source areas, adjacent to wetlands and riparian corridors, or provide tributary support to these features. A total of 14 springs were classified as High value and 15 springs were classified as Moderate value. A total of eight springs in the analysis area have been developed for human use (Rough Brothers of the Hills cabin) or livestock use. Additional detail on vegetation and wildlife species that depend on springs as a primary source of water is provided in their respective sections of the Greens Hollow SEIS.

3.1.2 Surface Water

Surface water resources include streams and associated floodplains, reservoirs, stock ponds, and springs. As springs are a surface manifestation of ground water, they are described above in Section 3.1.1. The remaining surface water resources are described in detail below.

The mine plan indicates that North Fork Quitchupah Creek would receive discharge associated with mining of the Greens Hollow tract. The northern and central portions of the Tract drain into Muddy Creek while the southern portion of the Tract drains into North Fork Quitchupah Creek as shown in Figure 1. The remaining area of the Tract is comprised of portions of several drainages that contribute flow to Muddy Creek or North Fork Quitchupah Creek. These drainages include North Fork Muddy Creek, South Fork Muddy Creek, Horse Creek, and several unnamed tributaries. Major drainages located adjacent to the Greens Hollow tract include North Fork Muddy Creek, Horse Creek, Box Canyon, lower North Fork Quitchupah Creek, and South Fork Muddy Creek. The divide between the Muddy Creek and North Fork Quitchupah Creek drainages

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is locally known as Big Ridge and extends across the southern end of the analysis area. This feature separates headwater areas of Cowboy Creek and North Fork Quitchupah Creek. The headwater areas for Greens Hollow, Cowboy Creek, and North Fork Quitchupah Creek extend to the west of the Tract.

The mainstem of Muddy Creek is perennial as it passes across the northern end of the Greens Hollow tract. During 2001-2004, Greens Canyon contributed seasonal flow into the mainstem of Muddy Creek, while upper portions of Cowboy Creek and Greens Hollow were noted to be perennial. North Fork Quitchupah Creek is the only perennial stream located within the Greens Hollow tract that does not flow into Muddy Creek. The extent of perennial flow was observed during the fall of 2001 through 2003. The most extensive coverage of perennial flow was observed during fall 2001 and was used to assess impacts on perennial streams. The extent of perennial streams observed during the fall of 2001 is shown in Figure 4. By definition, perennial stream channel segments contain flowing water throughout each year. In order for flows to be maintained outside of periods of surface runoff, ground water must intersect perennial stream channels in amounts that offset any loss to seepage (Mosley and McKerchar 1993). The amount and extent of perennial flow is therefore influenced by annual precipitation levels, surface runoff, and shallow ground water recharge. As mentioned above in Section 2.4.4, annual streamflow levels recorded from Muddy Creek indicate that water years 2001-2003 were below historic averages. Based on all available, approved records, the historic (1952-2012) annual average for Muddy Creek near Emery is 37.5 cfs (USGS 2013). Annual average streamflow during the 2001 water year was 33.2 cfs or approximately 11 percent lower than the historic average.

Baseline stream monitoring stations were established at several locations along Greens Canyon (M_STR1, M_STR2), Greens Hollow (M_STR6), and Cowboy Creek (M_STR3, M_STR4, M_STR5) as shown in Figure 4. Additional monitoring locations were established on the South Fork Muddy Creek just above its confluence with the North Fork Muddy Creek (M_STR8) and on the unnamed tributary that enters Muddy Creek near the north boundary of the analysis area (Figure 4). Other monitoring has been performed by the SUFCO Mine at two locations on North Fork Quitchupah Creek inside the analysis area including M_STR9 and M_STR10 (Figure 4).

Table 6 summarizes field measurements of water quality for each station. These results are described in more detail in the following sections for individual drainages. The statistics in Table 6 are based on visits when flow was measured. In addition to periodic monitoring, continuous flow measurements were collected at six stream monitoring stations on Greens Canyon and its tributaries. These measurements are described in more detail below.

3.1.2.1 Muddy Creek

As it traverses the northern edge of the analysis area Muddy Creek flows in a narrow, deep canyon with steep cliffs formed by the Castlegate Sandstone. Below its confluence with lower Box Canyon Creek, the valley bottom becomes somewhat wider (averaging about 300 feet) and the sinuosity of the channel increases. However, the channel is still entrenched, and is confined in a narrow valley bottom. Mapped alluvium and a small floodplain occur in this reach below Box Canyon. As defined by the extent of Castlegate Sandstone outcrops, cliff escarpments may extend upstream along both sides of Muddy Creek above the confluence of North Fork and South Fork Muddy Creek (Anderson 2004).

Muddy Creek has been gauged by the USGS at Station 09330500, located about 5 miles downstream of the analysis area and about 4 miles north of the town of Emery. The drainage area above this gage is reported to be 105 square miles by the USGS but was determined to be 108.8

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square miles in this study. Muddy Creek is a source of drinking water and irrigation water for the town of Emery. Annual average discharge at this gage for water years 1953 through 2012 (October 1952 through September 2012) is 37.5 cubic feet per second (cfs) (USGS 2013). Variations in annual discharge were common with a low mean discharge of 9.4 cfs reported for water year 1977 and a high mean discharge of 86.1 cfs in water year 1983. The baseline monitoring period for the Muddy Creek Tract study began in the summer of 2001, just before the beginning of water year 2002, and extended through June 2004. The average annual flows for water years 2002 and 2003 were 18.4 and 31.8 cfs, respectively, which are below the average annual flow for the period of record as indicated in Figure 18.

Flows are seasonal with the highest monthly flows occurring as a result of snowmelt runoff in May and June and the lowest monthly flows occurring in December, January, and February, as indicated in Figure 19. There is a vast difference between the highest and lowest monthly flows for the period of record, particularly during the peak snowmelt runoff months of May and June, as indicated in Figure 19. Monthly flows during the baseline water year 2002 were well below the corresponding average flows for all months. Monthly flows during water year 2003 matched the average monthly flows quite closely, although all months except March 2003 were below the period of record average flow.

Intense summer thunderstorms occasionally result in short-term flash flooding that produce high peak flows but not large volumes of runoff. Peak flows for various return periods were determined for the USGS Station 09330500, located on Muddy Creek about 5 miles downstream of the analysis area. Two methods were used for estimating flood flow frequency, including the regional regression analysis methods for ungaged locations as outlined in "The National Flood-Frequency Program—Methods for Estimating Flood Magnitude and Frequency in Rural Areas in Utah" (Mason et al. 1999) and a log-Pearson Type III Frequency Analysis of the 60 years of annual maximum flow data available for the USGS Station 09330500 on Muddy Creek. The flood frequency results for this location determined from each of these methods compare favorably as indicated in Table 7 and Figure 20. This provides greater confidence in the frequency results determined for the other relevant drainage basins using the procedures in USGS Fact Sheet 124–9.

Muddy Creek and its tributaries from the Utah Highway 10 crossing to the headwaters has been assigned several beneficial use classifications under Utah legislation R317-2 Standards of Quality for Waters of the State including the following:

- 1C – raw water source for domestic water systems
- 2B – protected for secondary contact recreation.
- 3A - protected for coldwater species of aquatic life.
- 4 – protected for agricultural uses including irrigation and stock watering.

The portion of Muddy Creek and tributaries that are located in the outer boundary of the Manti-LaSal National Forest is classified as a Category 1 - High Quality Water. This segment is subject to stringent antidegradation limits that preclude new point source discharges. Before it is used for domestic purposes, Muddy Creek water undergoes full conventional treatment (USDA-FS 1999). Additional information regarding the use of Muddy Creek as a domestic water source is included below under Section 3.1.4 Drinking Water Source Areas.

Baseline monitoring has been performed at M_STR8 on the South Fork Muddy Creek near the Tract boundary as shown on Figure 4. Monitoring at this station began on 9/26/02. A summary of field monitoring results is provided in Table 6 and Figure 21. A summary of the water quality

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results is shown in Table 8. Measured flow rates ranged from 968 to 15,644 gpm for the six reported measurements. The baseline water quality results show low TDS and nitrate/nitrite. None of the analyzed parameters exceeded the respective standards.

3.1.2.2 Greens Canyon and Tributaries

Greens Canyon and its primary tributaries, Greens Hollow and Cowboy Creek, drain the majority of the surface of the Greens Hollow tract as shown in Figure 1. The headwaters of Greens Hollow and Cowboy Creek extend slightly west of the coal lease. Baseline stream monitoring stations were established at several locations along Greens Canyon, Greens Hollow, and Cowboy Creek as shown in Figure 1. Moving upstream from the confluence of Greens Canyon and Muddy Creek, the stations are M_STR1, M_STR2, M_STR3, M_STR5, and M_STR4. Station M_STR6 is upstream of M_STR2 in Greens Hollow. A summary of the field measurements for each station is shown in Table 6 and plotted in Figures 22, 23, 24, 25, 26 and 27, including stations M_STR1 through M_STR6, respectively.

Station M_STR1 is located approximately 900 feet above the confluence of Greens Canyon and Muddy Creek. Of the 16 visits reported between 6/6/01 and 5/10/04, the site was dry 13 times. The field and water quality measurements met the standards as shown in Table 6 and Table 9 with the exception of arsenic. Arsenic exceeded the IC standard of 0.01 mg/l for one of the three sample dates. This violation was equal to the laboratory's MDL and is likely within the normal range of water quality variation experienced in many streams during the spring runoff season. The other two samples were well below the IC standard. It is anticipated this violation is not indicative of water quality impairment for Greens Canyon and does not pose risks to human or animal health.

Station M_STR2 is located mid-way along Greens Canyon, beginning at the confluence of Cowboy Creek and Greens Hollow and continuing downstream to where Greens Canyon joins Muddy Creek. The stream channel above the station, up to the confluence of Cowboy Creek and Greens Hollow, is primarily bedrock. This station was installed per DOGM request in August 2002 and was monitored eight times between 8/7/02 and 5/10/04. The station was dry only for the first visit, with flows averaging 12.4 gpm and a maximum flow recorded of 74.2 gpm for the six visits before 2004. The 5/10/04 visit reported a flow rate of 460 gpm. All standards and pollution indicator values that were used to evaluate field and laboratory samples were met, as shown in Table 6 and Table 10, with the exception of total phosphorus. Measurements of total phosphorus had a maximum value of 0.12 mg/l and exceeded the pollution indicator value of 0.05 mg/l assigned to Class 2B and Class 3A beneficial uses. The remaining samples were slightly above or below 0.05 mg/l. Visual inspection of the stream channel did not indicate the presence of algal growth and dissolved oxygen measurements were all above desired levels at this station for Class 3A aquatic life forms. Therefore it is likely that nutrient concentrations at this station are not contributing to eutrophic conditions resulting in water quality impairment. Total phosphorus concentrations measured from streams, ponds, and springs in the analysis area are influenced by a combination of natural and anthropogenic sources. Natural sources include stream erosion, wild animal wastes and leaf fall. Anthropogenic sources are primarily livestock manures captured by surface runoff, or deposited directly by grazing animals. The total amount contributed by each source varies according to location, season, precipitation, wildlife population dynamics and grazing management practices. The 0.05 mg/l concentration used to evaluate total phosphorus is a pollution indicator value and not a numeric criteria or water quality standard. Concentrations of total phosphorus greater than 0.05 mg/l are not inherently toxic to human or animal life. Total phosphorus concentrations greater than 0.05 mg/l have potential to contribute

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to algae growth and eutrophic conditions that result in low levels of dissolved oxygen which are hazardous or even lethal to aquatic life.

Station M_STR3 is located on Cowboy Creek approximately 400 feet above the confluence with Green's Hollow. This station was monitored 16 times between 6/6/01 and 5/10/04. The station was dry for only two of those visits, with flow averaging 8.5 gpm and a maximum flow of 54.9 gpm for the 15 visits before 2004. A flow rate of 491 gpm was reported on the 5/10/2004 visit. It was noted on several visits that flow in Cowboy Creek had dried up shortly downstream of the station. The dissolved oxygen level was measured slightly below 4 mg/l during two visits. Other pollution indicator values and water quality standards were met as shown in Table 6 and Table 11 with the exception of total phosphorus and arsenic. Total phosphorus had a maximum value of 0.13 mg/l which exceeds the 0.05 mg/l pollution indicator value. The median of the remaining total phosphorus samples was 0.05 mg/l. Arsenic was detected in nine of 12 samples at levels that were below the Class 1C standard of 0.01 mg/l. The three remaining arsenic samples were measured using a test associated with a detection limit of 0.1 mg/l. Two of these samples had concentrations < 0.1 mg/l while the remaining sample had a measured arsenic concentration of 0.1 mg/l and equal to the detection limit. It is assumed these violations are not indicative of water quality impairment for Cowboy Creek and do not pose risks to human or animal health.

Station M_STR4 is located in upper Cowboy Creek, where the canyon begins to narrow and become confined. This station was monitored during 37 visits between 6/7/01 and 9/25/12, although laboratory measurements were only collected during 2001-2004. This site was dry during 21 of the 37 visits. The pollution indicator values and water quality standards were all met, as shown in Table 6 and Table 12 with the exception of total phosphorus and arsenic. Total phosphorus had a maximum value of 0.10 mg/l. The five remaining total phosphorus samples were at or below 0.05 mg/l. Arsenic had a maximum value of 0.1 mg/l while four of six total samples that were measured were below the standards associated with Class 1C and Class 3A beneficial use. The remaining sample had a concentration < 0.1 mg/l as defined by the MDL. It is assumed these violations are not indicative of water quality impairment for Cowboy Creek and do not pose risks to human or animal health.

Station M_STR5 is located on Cowboy Creek, approximately 1,150 feet upstream from station STR3. This station was installed per DOGM request in August 2002 and was monitored on eight sample dates between 8/8/02 and 5/11/04. Flow was noted during each visit to the station. This section of Cowboy Creek was observed to be perennial during 2001. Field notes indicated the source of water came from below a large outcrop approximately 300 feet upstream. Flow in the creek ranged from 1.4 to 61.6 gpm for the seven visits before 2004. A flow rate of 598 gpm was reported on the 5/11/2004 visit. The water was relatively cold and highly oxygenated (minimum measurement of 7.23 mg/l). The water quality standards and pollution indicator values were all met as shown in Table 6 and Table 13.

Station M_STR6 is located in Greens Hollow. This station was monitored 16 times between 6/7/01 and 5/11/04 and was dry five times. The field standard for temperature was exceeded two times and the dissolved oxygen standard was exceeded once. The other water quality standards were met, as shown in Table 6 and Table 14. Measurements of total phosphorus showed that five of the nine samples exceeded the 0.05 mg/l pollution indicator value. The maximum value of total phosphorus was 0.14 mg/l and one sample measured 0.10 mg/l. The remaining seven samples were measured slightly above, equal to, or below 0.05 mg/l. Measurements of dissolved cyanide identified two sample measurements in excess of the Class 3A standard of 0.0052 mg/l. The remaining seven samples were below the MDL as well as the Class 3A standard. It is likely

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these exceedances are in the range of natural water quality variations and do not pose risks to human or animal health.

A longitudinal survey was conducted for Greens Canyon and its tributaries, Greens Hollow and Cowboy Creek. The extent of the longitudinal survey is shown on Figure 28. The survey shows Cowboy Creek being steeper in the headwaters and near the confluence with Greens Canyon, as the creek enters the Castlegate and Blackhawk formations. Greens Hollow has a relatively consistent slope until it enters the Blackhawk formation. The Greens Canyon stream channel is entirely in the Blackhawk formation, with a noticeable increase in the channel slope approximately 2,500 feet above the confluence with Muddy Creek.

A gain/loss study for Greens Canyon and its tributaries, Greens Hollow and Cowboy Creek, was conducted in September, 2001. These results are shown on Figure 29. The only Greens Hollow inflow noted was from Springs M_SP04, M_SP05, and M_SP06. The stream was flowing until the Castlegate Sandstone below M_STR6, where it was dry to the confluence with Greens Canyon. There was a loss of approximately 1.7 gpm where the stream flowed primarily over the Price River Formation and another loss of 1.9 gpm in the Castlegate Sandstone downstream of M_STR6.

Flow was noted in Cowboy Canyon until the middle of the Price River Formation. The Canyon was dry again until approximately 300 feet upstream of M_STR5, where water is coming from below a rock outcrop associated with the Blackhawk Formation. The stream loses and then gains water from M_STR5 to M_STR2 all along the Blackhawk Formation with flow disappearing below M_STR2. This study showed losses for both streams in the Blackhawk Formation and the Castlegate Sandstone. Greens Hollow did not flow in the Blackhawk Formation. Cowboy Creek and Greens Canyon had both gains and losses in the Blackhawk Formation. This was not unexpected given the variability in geologic conditions within these formations. Also, given the seasonal and year-to-year fluctuations in spring flows and associated ground water conditions within these formations, the results may not be representative of the gains and losses that may occur during other seasons or other years.

3.1.2.3 Unnamed Tributaries To Muddy Creek

Several small unnamed tributaries drain into Muddy Creek from the northern part of the Greens Hollow tract. A baseline monitoring station, M_STR7, has been maintained on the largest of these tributaries as shown in Figure 4. No flow was noted at this location during six monitoring visits between 9/25/02 and 5/13/04.

3.1.2.4 North Fork Quitchupah Creek

North Fork Quitchupah Creek flows into Quitchupah Creek, which eventually flows into Ivie Creek. Ivie Creek joins Muddy Creek about 10 miles south of the town of Emery. The average yield in North Fork Quitchupah Creek was estimated at 3.4 cfs (1,526 gallons/minute) by Thiros and Cordy (1991), using regional regression relationships. This report included a gain loss study of North Fork Quitchupah Creek, which showed an apparent gain in flow where the creek crossed the Castlegate Sandstone, a loss of flow as it crossed the upper part of the Blackhawk Formation, a slight gain in flow crossing the lower Blackhawk Formation, a considerable gain in flow crossing Star Point Sandstone and a loss in flow crossing the Mancos Shale.

The North Fork Quitchupah Creek is a perennial stream. SUFCO Station 006 (M_STR9) monitors the South Fork of North Fork Quitchupah Creek and Station 007 (M_STR10) monitors the upper segments of North Fork Quitchupah Creek. These stations are located near the

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confluence of these streams, just before the deep canyon that forms downstream of the Castlegate Sandstone outcrop. A summary of water quality parameters is shown on Tables 6, 15, and 16 and Figures 30 and 31. Most of the parameters for these stations were analyzed on a totals basis while many of the standards are for dissolved constituents. M_STR9 had occasional violations of the temperature standard and exceeds the pollution indicator value for total phosphorous of 0.05 mg/l over half the time with a maximum reported concentration of 1.12 mg/l. The highest concentrations of total phosphorus were typically measured in the spring season. Concentrations of total phosphorus during other times of the year were slightly above or below 0.05 mg/l. M_STR10 had one violation of the pH standard and occasional violations of the temperature standard. The water at this station exceeds the pollution indicator value for total phosphorous of 0.05 mg/l over half the time with a maximum reported concentration of 1.64 mg/l. Peak concentrations of total phosphorus were observed during the spring season as well as the fall season.

As mentioned above in Section 3.1.2.2, total phosphorous concentrations come from both natural and anthropogenic sources. The relative amounts contributed by each source can vary by location, season, year, wildlife population dynamics and livestock management practices employed in the analysis area. The seasonal peaks observed during monitoring at these two sites are typical of patterns associated with surface runoff from snowmelt or intense storm events. Peaks during the fall season are less common but could also be influenced by decaying organic matter, direct manure deposition, and low base flows. Although total phosphorus concentrations do exceed the 0.05 mg/l pollution indicator value, Utah DWQ monitoring has not identified problems due to high phosphorus in downstream segments of North Fork Quitchupah Creek. At the present time, the upper segment of Quitchupah Creek is not supporting the beneficial use for cold water aquatic life due to poor condition of benthic macroinvertebrates, as indicated in the 2010 303(d) list of impaired waters for Utah (Utah DWQ 2012). The upper segment extends from State Highway 10 to the headwaters and includes North and South Fork Quitchupah Creek. The pollutant sources leading to this condition are currently unknown and the priority to develop a TMDL and identify each source is low.

South Fork joins North Fork Quitchupah Creek from the west near the analysis area boundary as shown on Figure 1. Dry Fork enters the North Fork Quitchupah Canyon further downstream and SUFCO Station 042 monitors the North Fork just above its confluence with Quitchupah Creek.

Since 1982, SUFCO Mine discharges have increased base flows in North Fork Quitchupah Creek. Before September 1982, mine water was discharged into East Spring Canyon. Since 1983, Canyon Fuel has been discharging excess intercepted ground water from their underground workings, via a UPDES discharge point, into North Fork Quitchupah Creek. This discharge averaged approximately 1,000 gpm during the period of 1983 through 1994 (Mayo and Associates 1999). Between 1994 and 1996, discharge averaged approximately 1,500 gpm (Mayo and Associates 1997b). Discharge rates tend to relate to coal production rates and are not seasonally affected (DOGM 2005).

Mayo and Associates (1997b) studied the current and past influence of the mine water discharge on Quitchupah Creek. They note that flow in North Fork Quitchupah Creek above the mine discharge point averages about 2,650 gpm in spring (5.9 cfs) and about 290 gpm (0.6 cfs) in low, base flow conditions in late fall. The average increase in flow due to mine discharge is therefore substantial, about 37 percent in spring and 337 percent in fall. The source of the additional water is from the Blackhawk Formation zones immediately above coal seams. This water is deeper ground water and otherwise disconnected from shallow ground water zones that naturally support

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stream flows in the channel. Adverse impacts on Quitchupah Creek's stream morphology and/or stability due to 15 years of increased flows were not noted in this report. In the Cumulative Hydrologic Impact Assessment of the SUFCO Mine, DOGM (2003a) states that "no adverse impacts have been identified from discharging mine water". However, no information on channel characteristics or monitoring of channel changes was included in either of these reports.

3.1.2.5 Floodplains

Below its confluence with lower Box Canyon Creek, Muddy Creek Canyon becomes somewhat wider (averaging about 300 feet) and the channel's sinuosity increases. However, the channel is still entrenched, and is confined within a narrow valley bottom. As discussed previously in Section 3.1.2.1, a small floodplain occurs in this reach of Muddy Creek, immediately below the confluence with Box Canyon. Muddy Creek's gradient, as measured from the USGS 7.5-minute topography, averages about 3 percent in this area.

The estimated 100-year peak flow on Muddy Creek at the confluence with Box Canyon is 3,423 cfs. Flows of this magnitude would inundate most of the 300-foot bottom of the valley.

The North Fork Quitchupah Creek downstream of the Greens Hollow tract flows in a narrow, deep canyon with steep cliffs formed by the Castlegate Sandstone and bedrock channel conditions. Below its confluence with Quitchupah Creek, the valley bottom becomes wider with low terraces of limited extent. The channel is incised such that there is no broad flood plain.

3.1.2.6 Ponds

A total of 19 ponds were identified in or adjacent to the analysis area including 11 natural ponds and eight stock ponds. Natural ponds are formed in depressions that occur at topographic breaks in slope (e.g. benches, slumps, etc) or in low lying areas of drainages. Natural ponds are filled through a combination of surface runoff from snowmelt and high intensity precipitation events as well as shallow ground water discharge. The presence of water in natural ponds throughout the summer is more likely influenced by the rate of ground water discharge than the ability to capture surface runoff. Overstory vegetation that surrounds natural ponds can also provide shade and reduce evaporation levels. Natural ponds are utilized by livestock and wildlife as a water source. Although water levels in natural ponds were noted to decrease during the summer, few natural ponds dried up entirely.

Stock ponds are designed and constructed by humans. All stock ponds are fed by surface runoff occurring from snowmelt and high intensity precipitation events. A total of nine cattle troughs were also identified in the analysis area. The location of stock ponds, natural ponds, and cattle troughs are shown on Figure 32. Quarterly field visits to five stock ponds in the Muddy Creek Tract boundary from summer 2002 through fall 2003 (including several in the Greens Hollow tract) indicated that most stock ponds were dry by the early summer season. All monitoring data collected from stock ponds is contained in Cirrus (2004b).

3.1.2.7 Surface Water Summary

All of the surface water in the Greens Hollow tract drains into either the North Fork Quitchupah Creek or Muddy Creek. Field monitoring of tributary stream channels during 2001-2004 indicated that little perennial surface flow from the Greens Hollow tract reached Muddy Creek. Seasonal flow was observed at station STR1 during the spring of two monitored years including 2003 and 2004. No flow was observed at this station later than the end of June during any year of monitoring. No flow was observed at station STR7 during quarterly monitoring visits which were generally made in June, August, and October. Perennial surface flow in North Fork

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Quitchupah Creek, which crosses the Greens Hollow tract, does reach Quitchupah Creek. As mentioned above in Section 2.4.4, flow monitoring data was collected during below average water years. This conclusion is based on more than 30 years of record at stations on Muddy Creek and nearby SNOTEL stations (USGS 2013, USDA-NRCS 2013).

Nineteen ponds and nine cattle troughs are located in or immediately adjacent to the Greens Hollow tract boundary. Field observations indicated that inflows to stock ponds are characterized by surface runoff occurring from snowmelt and high intensity precipitation events.

3.1.3 Water Rights

Water on National Forest System lands is used consumptively for livestock and wildlife watering. Some, but not all, springs have been developed. Forest Service claims for water rights were prepared in the 1980's as part of a general adjudication process. It appears that there was direction at the time of the filings to emphasize point to point claims on streams. Since that time, the Forest Service has continued to work with the Utah DWRi to develop an efficient and comprehensive method for documenting and claiming water uses on lands administered by the Forest Service. To that end, subbasin claims are being developed that would assert a claim of right for all developed and undeveloped waters on National Forest System lands. Therefore, all developed and undeveloped springs in the permit modification area should be assumed to have a claim of right associated with them, irrespective of whether there is a specific filing in the Division of Water Rights database.

There are no registered water rights for water production wells used for municipal, domestic, or irrigation purposes in the analysis area. Points of diversion were obtained from the Utah DWRi. A complete listing of all water rights in the analysis area and their associated water features is provided in Cirrus (2004b) and Cirrus (2014).

Spring M_SP01 is located adjacent to Rough Brothers of the Hills cabin, on the south side of Greens Hollow. The water right number associated with this spring is 94-472, as shown on the Heliotrope Mountain hydrographic survey map. The water use for water right 94-472 described in the Utah DWRi database is stock watering. The owner of this water right is listed as the USFS. As mentioned above in Section 3.1.1.3, this spring has been developed with a spring box and pipeline system and is currently used for culinary water and irrigation use.

All points of diversion in the analysis area are shown in Figure 33, with each symbol potentially representing multiple water rights. A total of 70 water rights that are approved or perfected were identified (Cirrus 2014). The majority of these rights (65) belong to the USFS for stock watering along streams and from springs. Canyon Fuel Company holds 5 water rights that are approved or perfected in the analysis area. Water is used by Canyon Fuel Company for temporary water mitigation and exploratory drilling incident to coal mining.

A search of all water rights associated with Muddy Creek down to the confluence with the Dirty Devil River indicated that water is primarily used for irrigation purposes. The Utah Division of Water Resources has identified a total of 17,000 ac-ft/yr that are diverted from Muddy Creek for irrigation purposes (Utah DWRe 2001). Use of culinary water is described below in Section 3.3.2.5. Industrial use of water from Muddy Creek is limited to temporary (short-term) use by construction and privately owned mining operations. These water rights are generally limited to less than 2 ac-ft/yr. Applications for large water rights (>1,000 ac-ft/yr) have been submitted in the past by Utah Power and Light and Consolidation Coal Company. These applications were denied.

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3.1.4 Drinking Water Source Areas

Drinking water source protection zones are designated areas surrounding a well, spring, tunnel or surface water body through which pollution could move and eventually contaminate a water source (Utah DDW 2005, Utah DDW 2012). These areas are typically divided into zones that define the time of travel to the intake structure. Analysis of drinking water source protection zones was restricted to only those zones that intercepted the analysis area. A general description of the protection zones that were found in the analysis area includes the following (Utah DDW 2005):

Zone 1:

Surface Water: One-half mile from the high water mark of each side of the stream channel and from 100 feet below intake up to 15 miles above intake.

Zone 2:

Surface Water: Begins at the end of zone one and extends up to 50 miles upstream, 1000 feet from each side of stream channel (bank-full).

Zone 3:

Surface Water: Begins at the end of zone two and extends up to watershed boundary and 500 feet on each side measured from high water mark of the source. Note: The Utah DDW has not defined this zone for surface water bodies in the analysis area.

Zone 4:

Surface Water: All of the watershed contributions to the source that is not part of zones one through three.

No regulatory overtones are established for each of these zones (Jensen 2004, Jensen 2013). However, it should be noted that a greater potential exists for contamination of drinking water from activities in the lower number zones.

Three surface water protection zones were identified in the analysis area for a diversion from Muddy Creek, near the town of Emery (Figure 34). Water from Muddy Creek is initially diverted into a canal at a point immediately below a USGS stream gage (Station 09330500) located near the mouth of Muddy Creek Canyon. Water is then diverted from the canal at a site located approximately 2,000 feet north of the town. Information from the Utah DDW indicates this diversion is capable of supplying 250 gpm and serves a population of 293 individuals. All domestic water used from this source is fully treated before entering the culinary water system. Culinary water is supplied to Emery and other nearby towns by the Castle Valley Special Service District. Per capita use of culinary water for the District has been calculated at 191 gallons/day (Utah DWRe 2001). Based on the population numbers above, the annual culinary water use for Emery is approximately 63 acre-ft per year. The surface water protection zones associated with this diversion are included in Figure 34 and extend upstream from the diversion point to include the upper portion of the Muddy Creek watershed.

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5.0 LIST OF PREPARERS WITH QUALIFICATIONS OF PREPARERS

Eric K. Duffin MS, Watershed Scientist/Hydrologist, Cirrus Ecological Solutions. Mr. Duffin has 17 years of experience in watershed science including hydrology, water quality, soil physics, fluvial geomorphology, and computer science. His graduate and post-graduate work examined snowmelt runoff, soil erosion, infiltration, evapotranspiration, and unsaturated soil moisture flow in sagebrush-steppe ecosystems. His experience includes evaluation and analysis of proposed watershed improvements, conducting hydrologic inventories, quantifying point and non-point source pollution, computer modeling, stream surveying, water quality sampling, datalogger programming and remote data retrieval. He has managed TMDL projects, served on several NEPA project teams, and provided technical writing and editing for other physical and human-resource disciplines.

Arthur O'Hayre, Ph.D. Dr O'Hayre has over 30 years of professional experience as a hydrologist, including 24 years working with the coal mining industry working on hydrologic characterization, operational planning, and environmental permitting and compliance. He has participated in the preparation of baseline surface and ground water information and development of the probable hydrologic consequences (PHC) analyses for a number underground coal mining operations, including San Juan Coal Company's Deep Mine in New Mexico, Twentymile Coal Company's Foidel Creek Mine in Colorado, Mountain Coal Company's Mt. Gunnison No. 1 Mine in Colorado, and Meridian Coal Company's Bull Mountains No. 1 Mine in Montana. Dr. O'Hayre also managed the hydrologic analyses and related permit application submittals for BHP's Alton Coal Project and ARCO's Huntington Canyon No. 4 Mine in Utah. He also developed the surface water control and reclamation plans for these projects.

Seth Okeson. Mr. Okeson is a water resources engineer with 12 years of varied consulting experience with specialization in hydrologic modeling. He is experienced in data collection, management, and interpretation. Modeling projects include coal-bed methane impact assessment, transport from mill tailings, ground water flow at a landfill, and integrated surface water ground water modeling. He worked on the calibration and application of the ground water model used for impact analysis of proposed CBM development for the Wyoming Powder River Basin Oil and Gas EIS. He also worked on developing the ground water model used to evaluate produced water production volumes and the potential effects of withdrawal of water on the shallow aquifer and springs for a prospective CBM project in Australia. He also worked on the salt loading model used to evaluate various water management strategies for this project.

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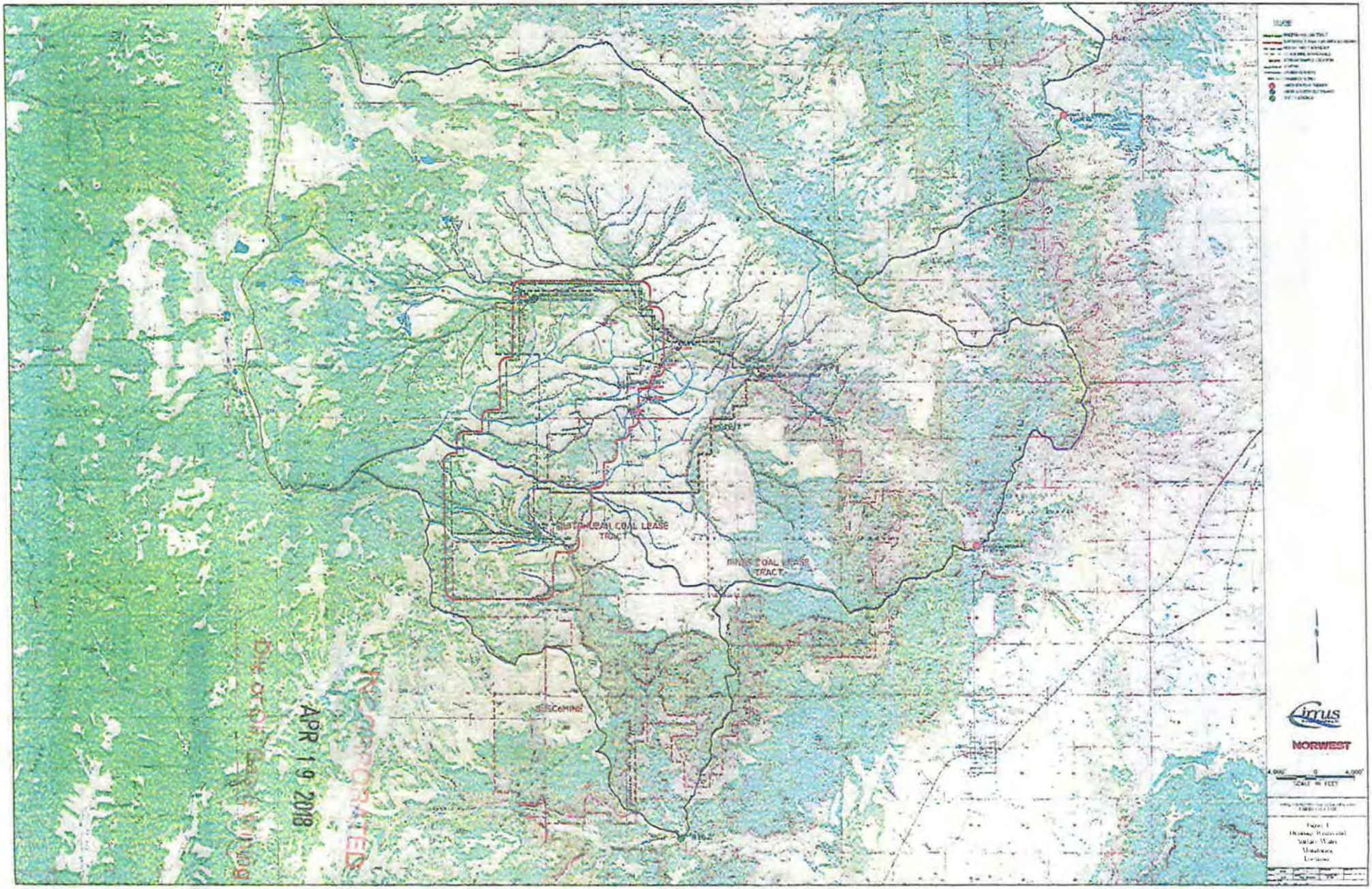

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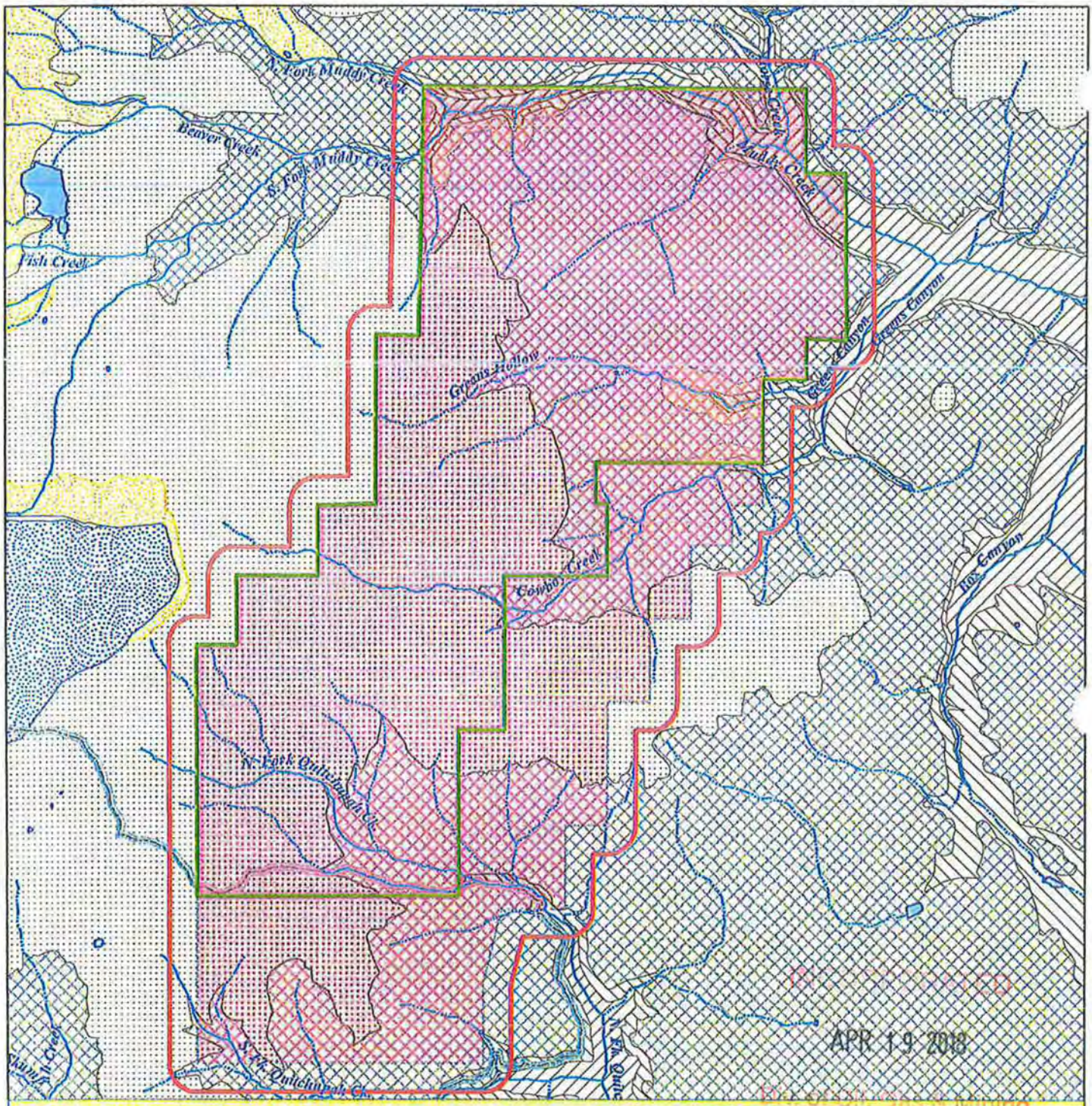


Figure 2. Greens Hollow Tract Analysis Area

1 0.5 0 1 Miles

1:53,500

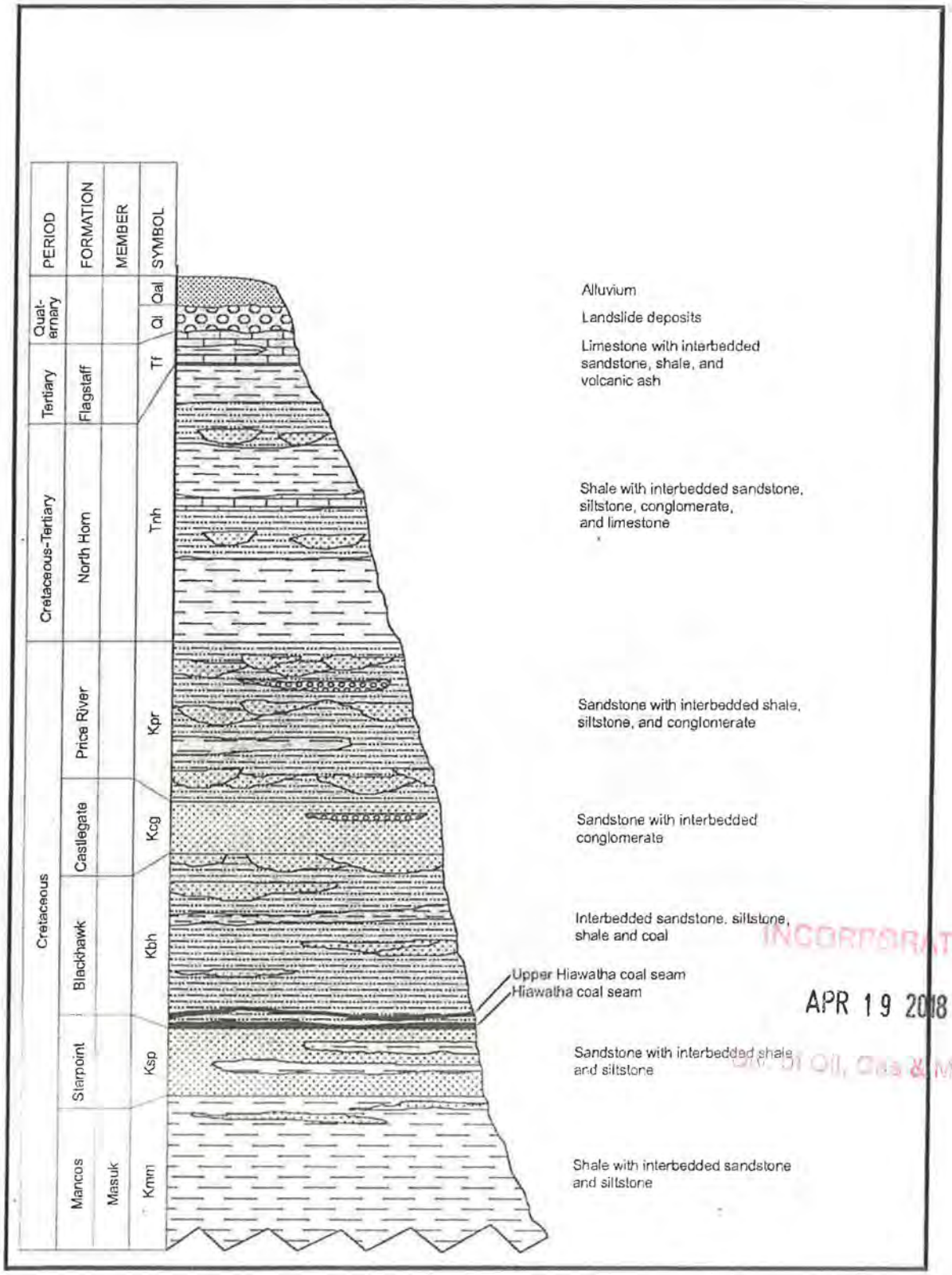
Legend

- National Forest Boundary
- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- Area of Subsidence Mining
- AreaOfNoSubsidenceMining
- Perennial Streams (USGS)
- Intermittent Streams (USGS)

Priority Areas

- Priority 1 - Blackhawk Formation
- Priority 1 - Castlegate Formation
- Priority 2 - Price River Formation
- Priority 3 - North Horn Formation
- Priority 3 - Landslide
- Priority 3 - Flagstaff Formation

Figure 3. Generalized Stratigraphy of the Greens Hollow tract (Anderson 2004).



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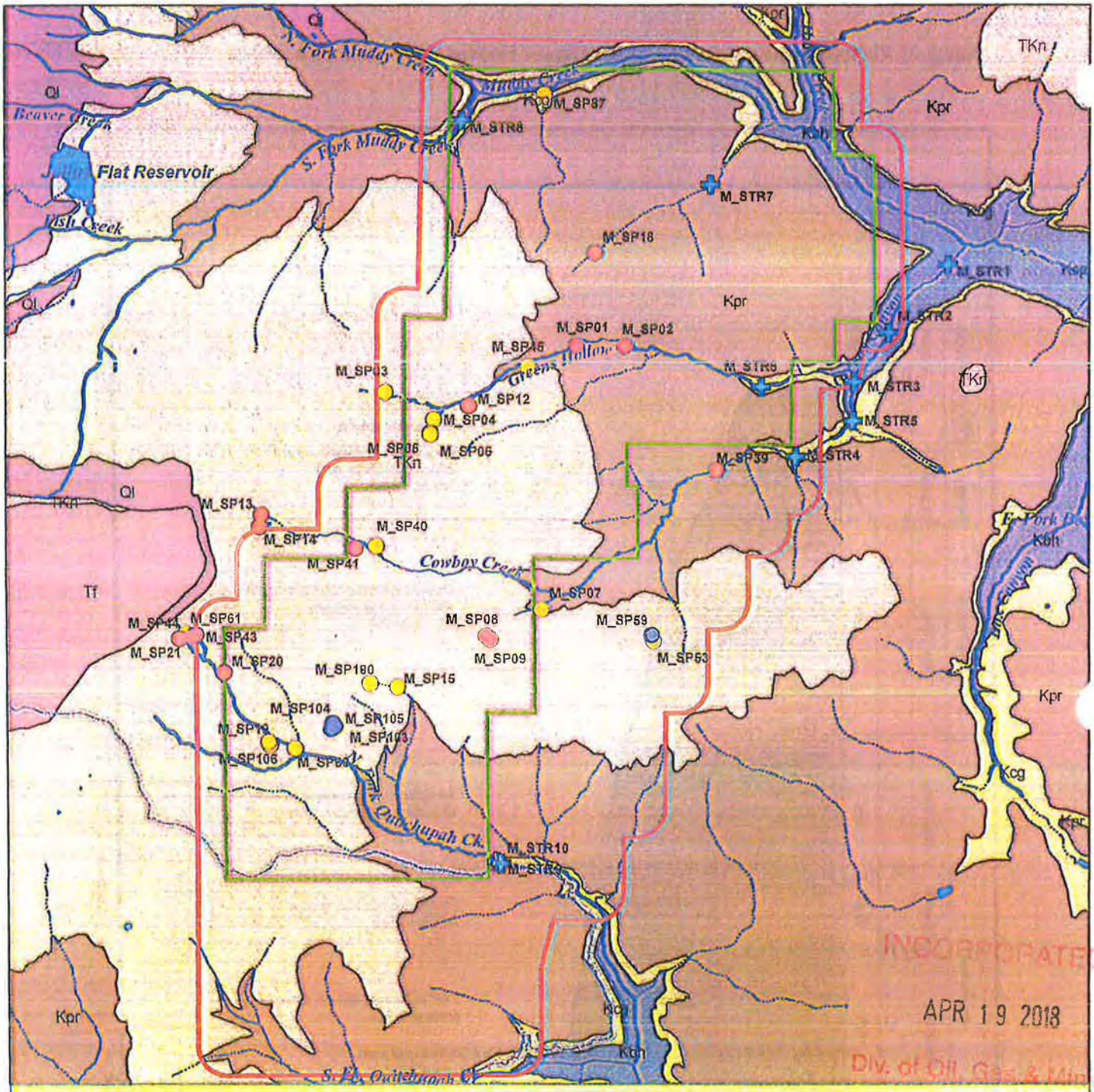

Figure 4. Greens Hollow water resources and geology.

1 0.5 0 1 Miles

1:53,500

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- National Forest Boundary
- Perennial Streams (USGS)
- Intermittent Streams (USGS)
- Perennial Flow 2001
- Stream Monitor Sites

Greens Hollow Springs

- High Value
- Moderate Value
- Unknown Value

Geology

- Ql Landslide/mass movement
- Tf Flagstaff Limestone
- TKn North Horn Formation
- Kpr Price River Formation
- Kcg Castlegate Sandstone
- Kbh Blackhawk Formation

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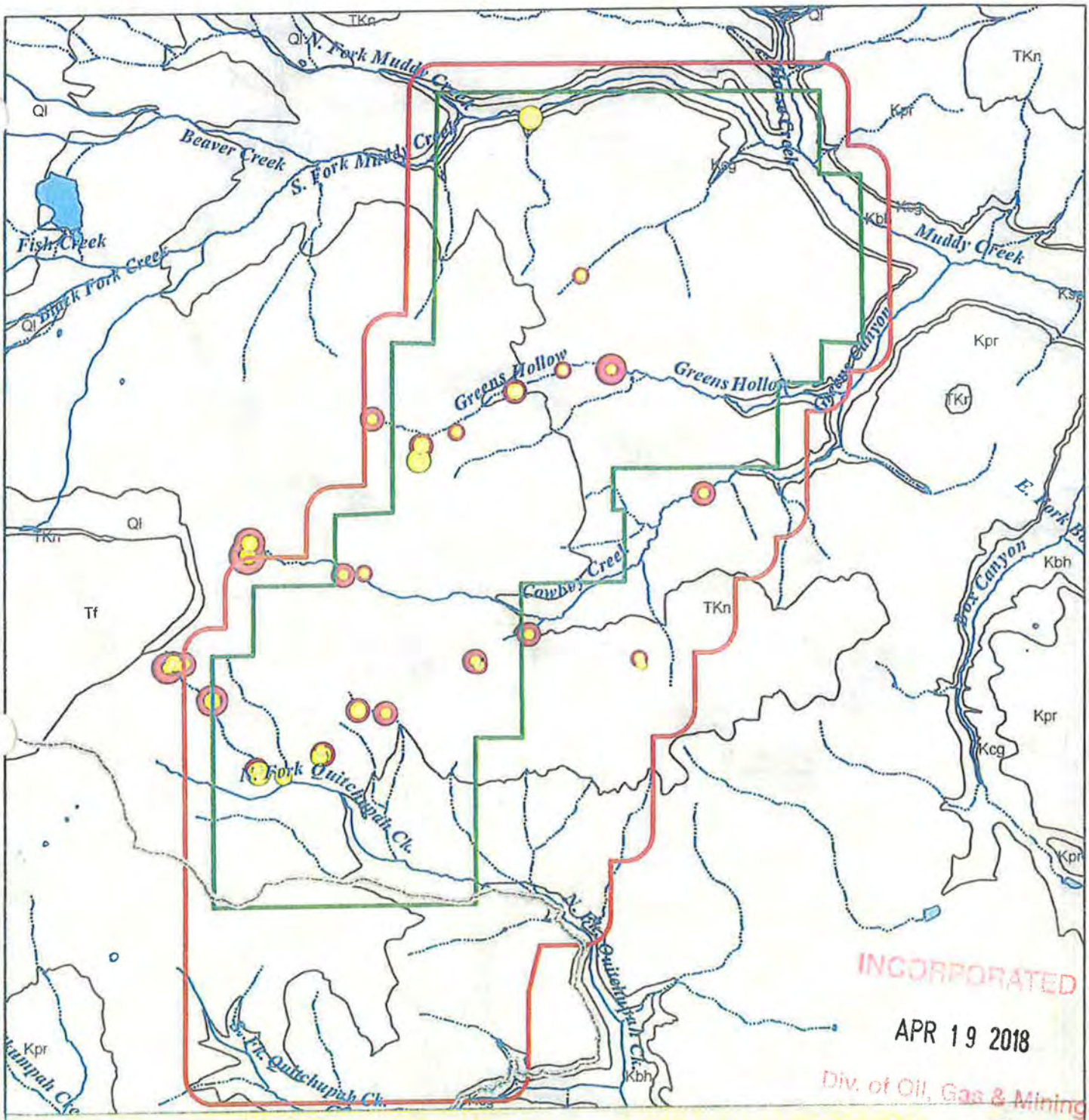

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Figure 5. Flow Range for Measurable Springs

1 0.5 0 1 Miles

1:53,500

N W E S

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- National Forest Boundary
- Perennial Streams (USGS)
- Intermittent Streams (USGS)

Min. Flow (gpm)	Max. Flow (gpm)
0 - 0.5	0 - 0.5
0.5 - 1	0.5 - 1
1 - 5	1 - 5
5 - 20	5 - 20
20 - 65	20 - 65

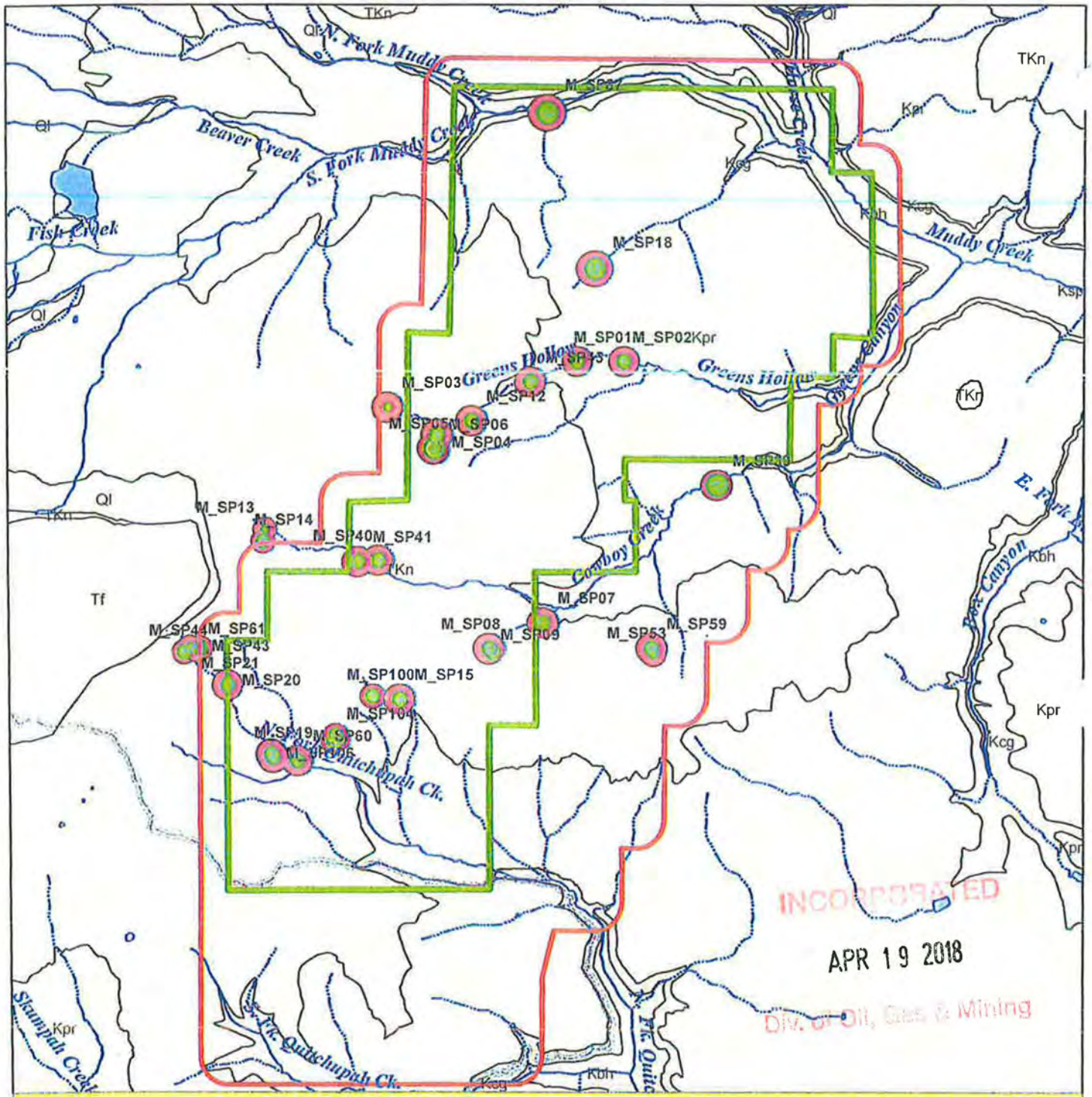

Figure 6. Specific Conductance Range for Measurable Springs

1 0.5 0 1 Miles

1:53,500

GEOLOGY SYMBOLS
Ql Landslide Mass movement
Tf Flagstaff Limestone
Tkn North Horn Formation
Kpr Price River Formation
Kcg Castlegate Sandstone
Kbh Blackhawk Formation

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- National Forest Boundary
- Perennial Streams (USGS)
- Intermittent Streams (USGS)

Min. Spec. Cond. (mmhos/cm)	Max. Spec. Cond. (mmhos/cm)
0-250	0-250
250-500	250-500
500-750	500-750
750-1100	750-1100
1100-1500	1100-1500

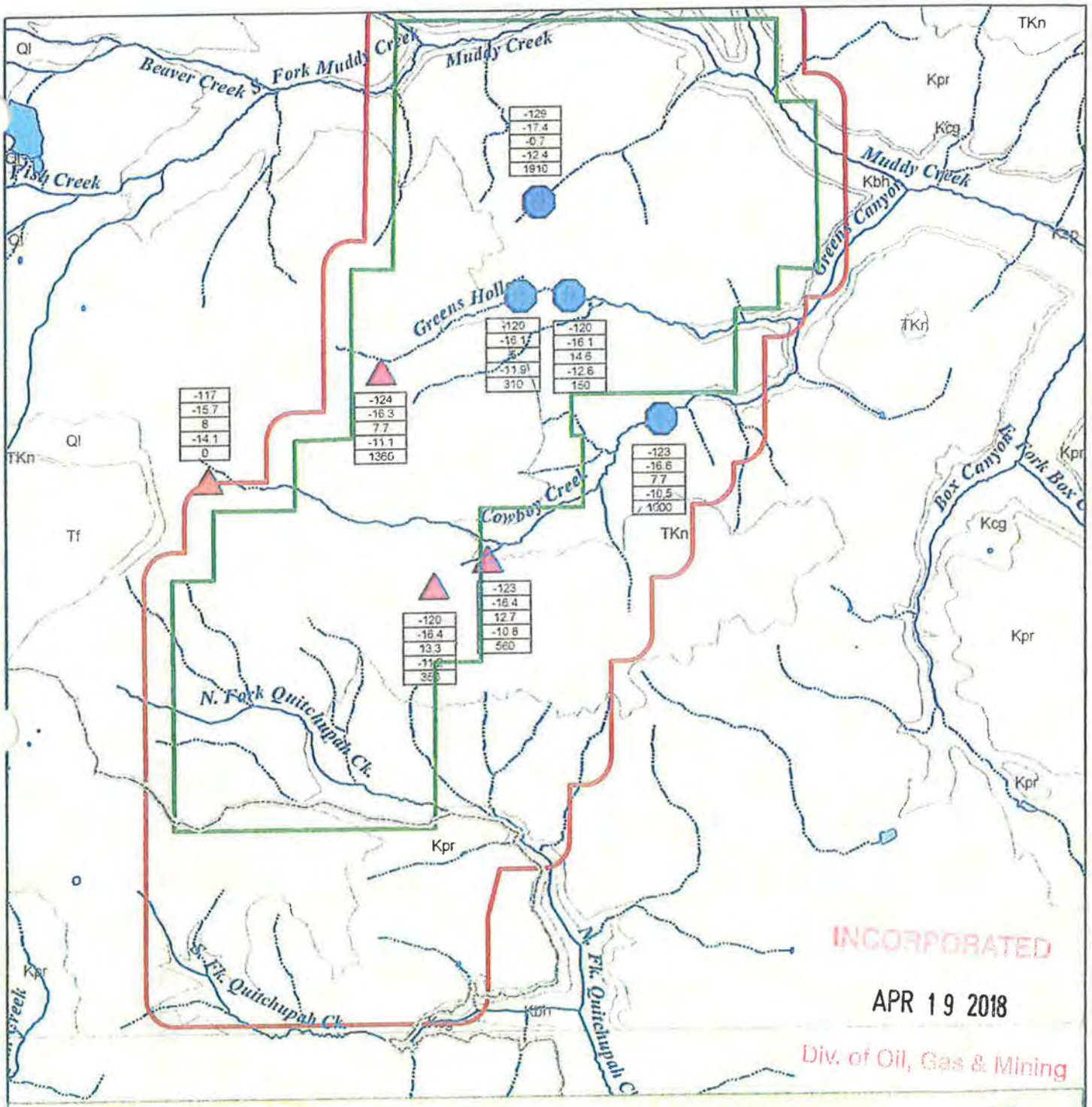

Figure 7. Spring Water Isotope Sampling

1 0.5 0 1 Miles

1:53,500

GEOLOGY SYMBOLS
Qal - Alluvium
Ql - Landslide/Mass movement
Tf - Flagstaff Limestone
Tkn - North Horn Formation
Kpr - Price River Formation
Kcg - Castlegate Sandstone
Kbh - Blackhawk Formation
Ksp - Starpoint Sandstone
Kms - Mancos Shale

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- National Forest Boundary
- Perennial Streams (USGS)
- Intermittent Streams (USGS)

Isotope Sampling - Springs

- North Horn Formation
- Price River Formation

Isotope Measurements

Deuterium (^{2}H)	-120	Per Mil
^{18}O	-16.1	Per Mil
Tritium (^{3}H)	5	Tritium Units
^{13}C	-11.9	Per Mil
^{14}C	310	Year-Unadjusted

Figure 8. Greens Hollow Tract Springs Unstable Isotope Results

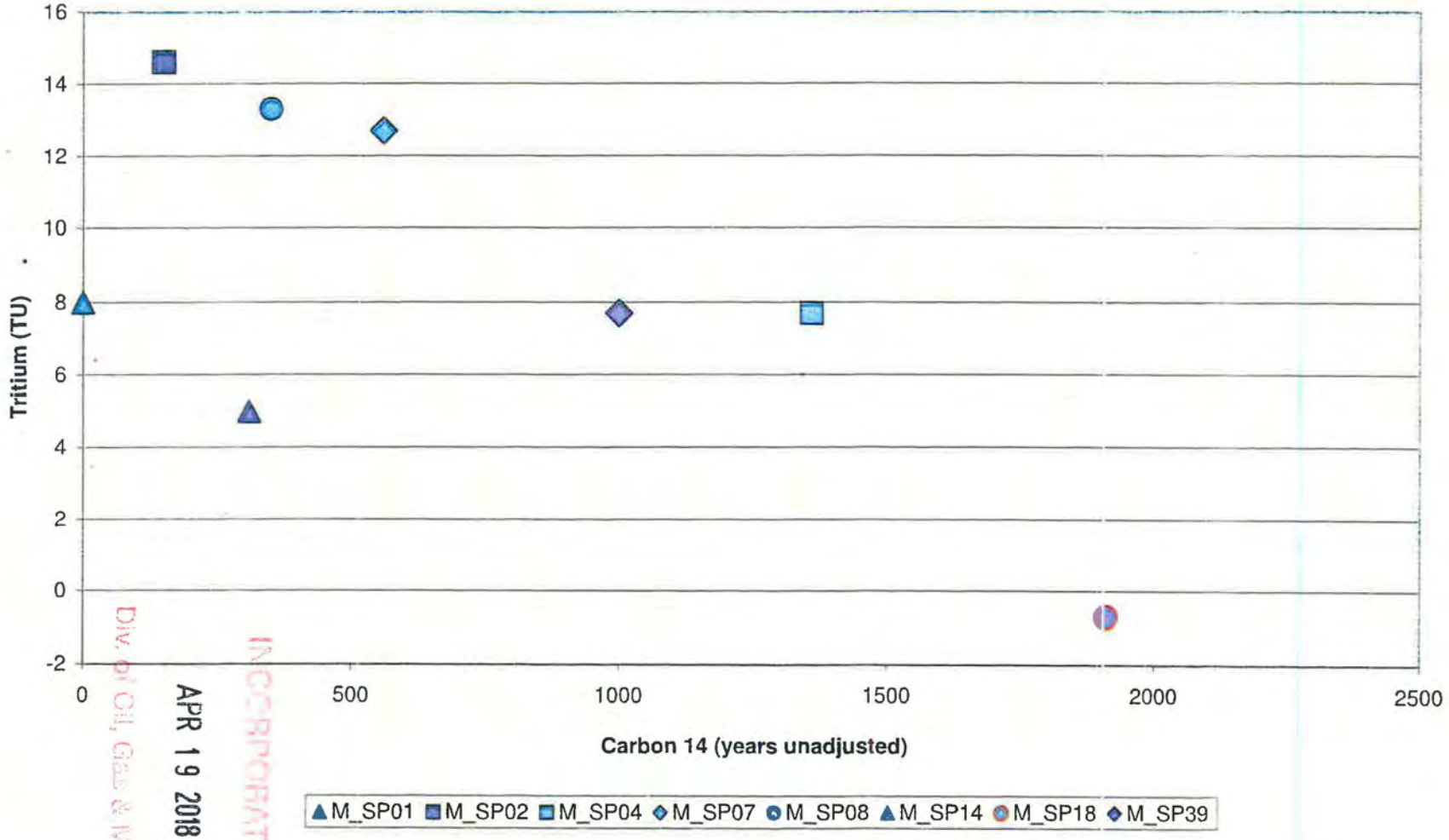

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Figure 9. Greens Hollow Tract Springs Stable Isotope Results

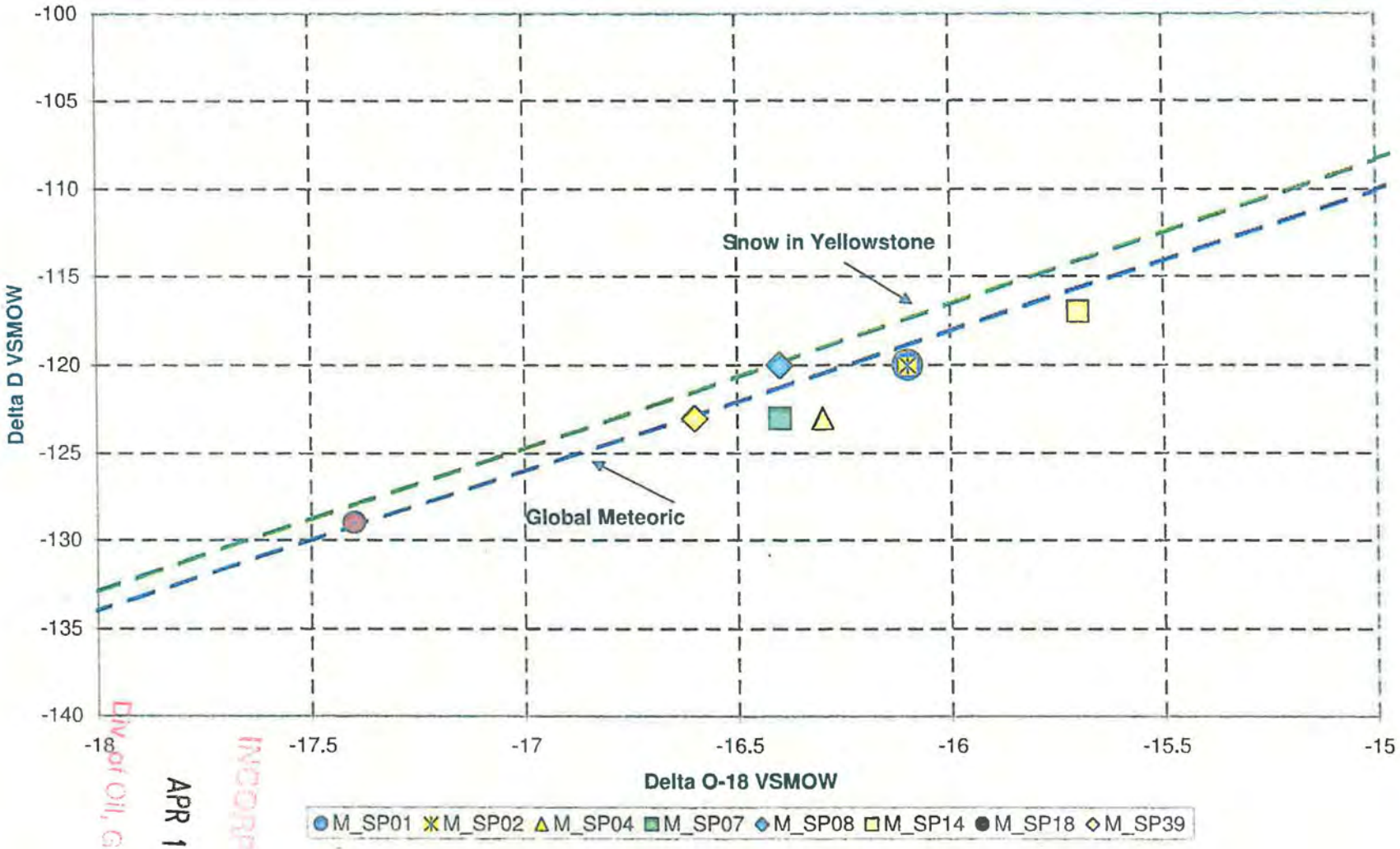

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Figure 10. North Horn Formation Spring M_SP04

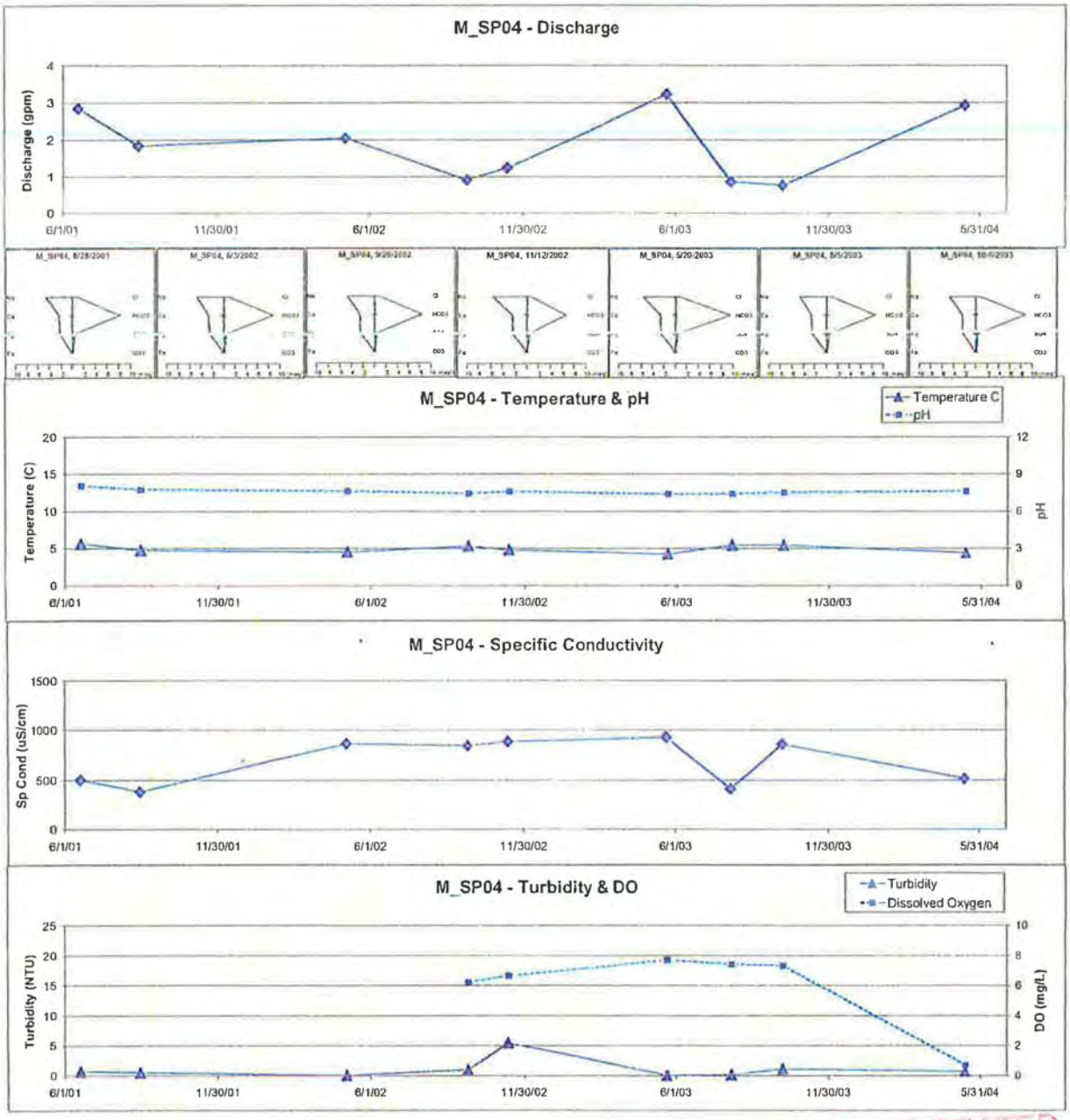

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Figure 11. North Horn Formation Spring M_SP07

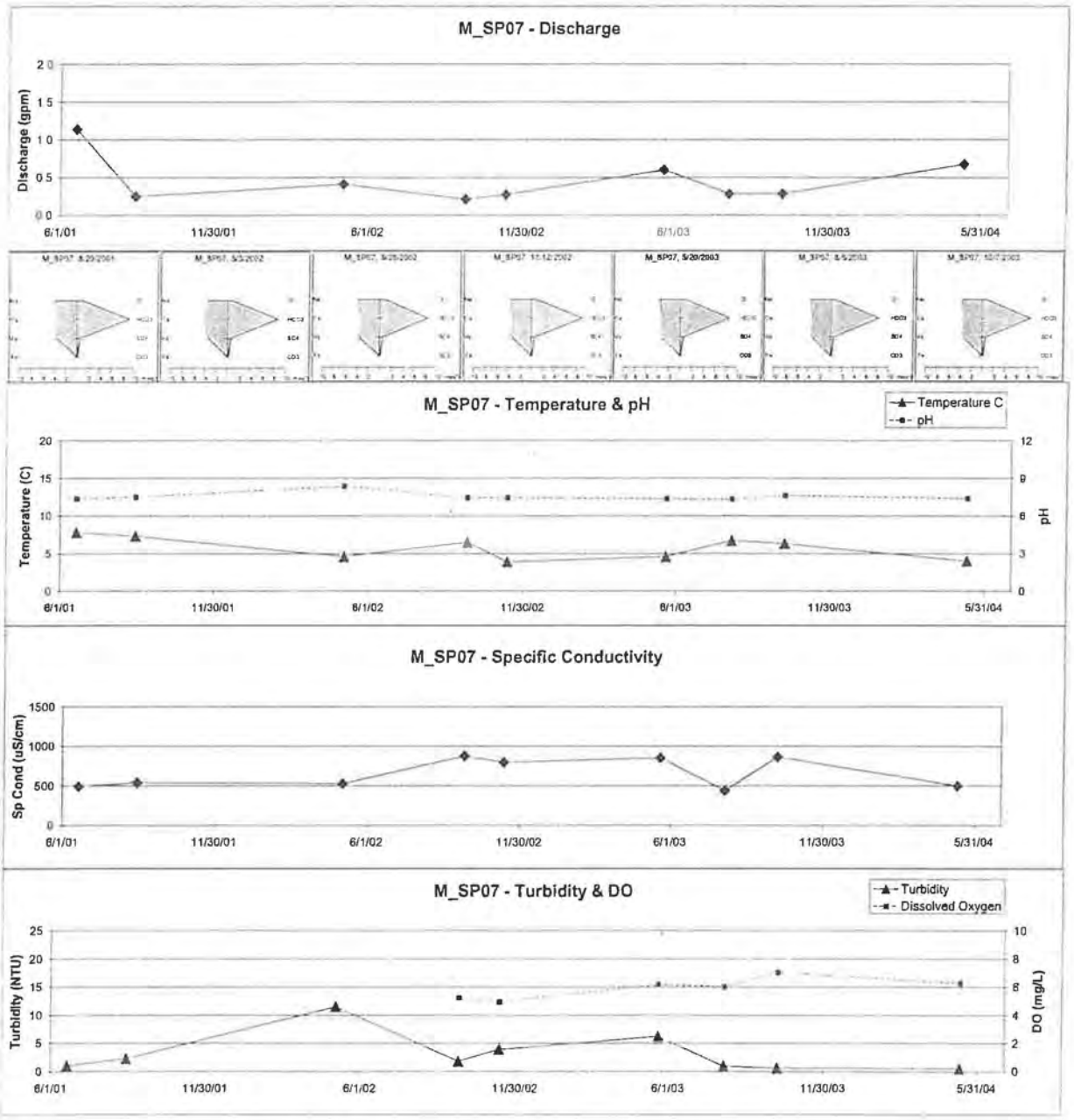

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Figure 12. North Horn Formation Spring M_SP08

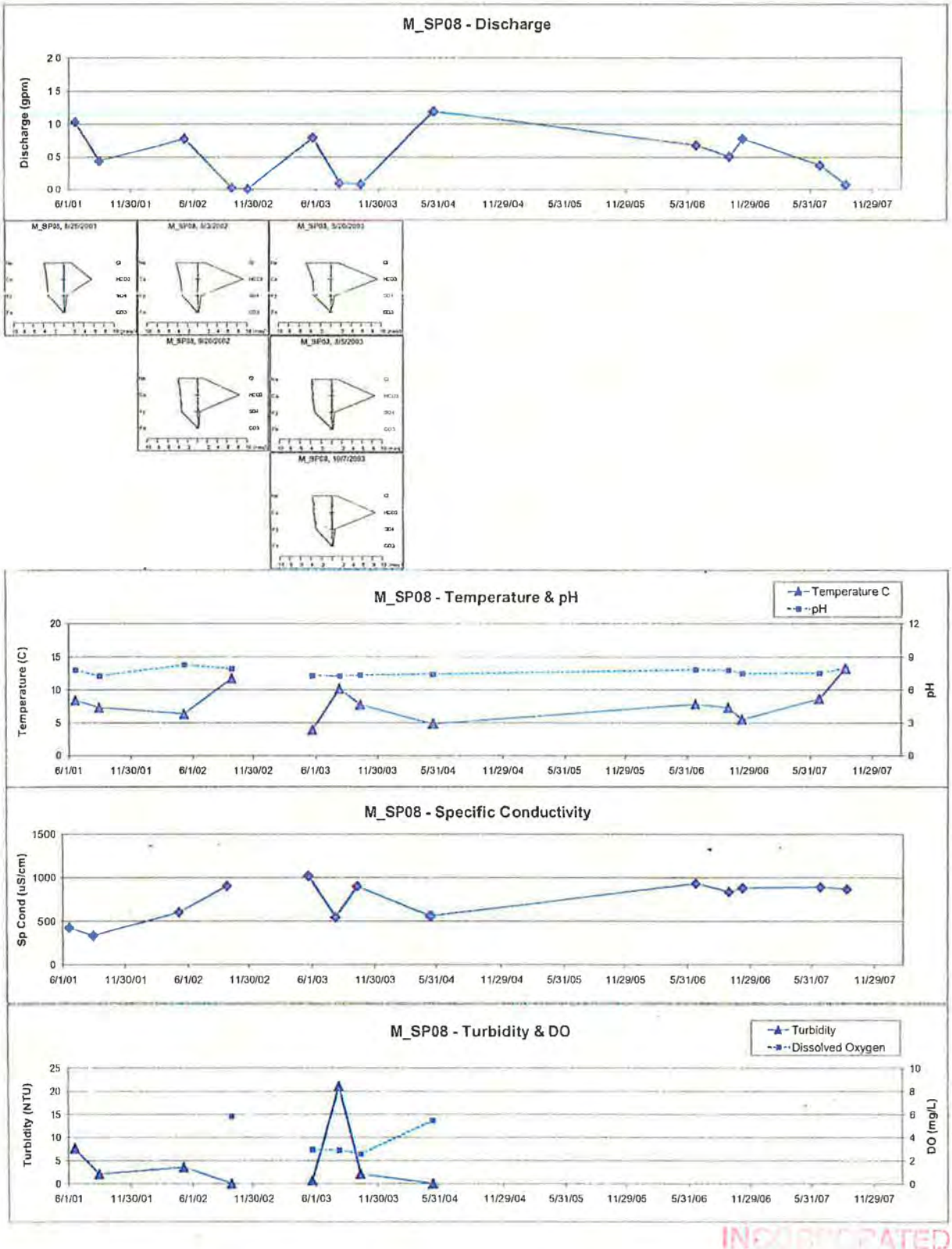

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Figure 13. North Horn Formation Spring M_SP14

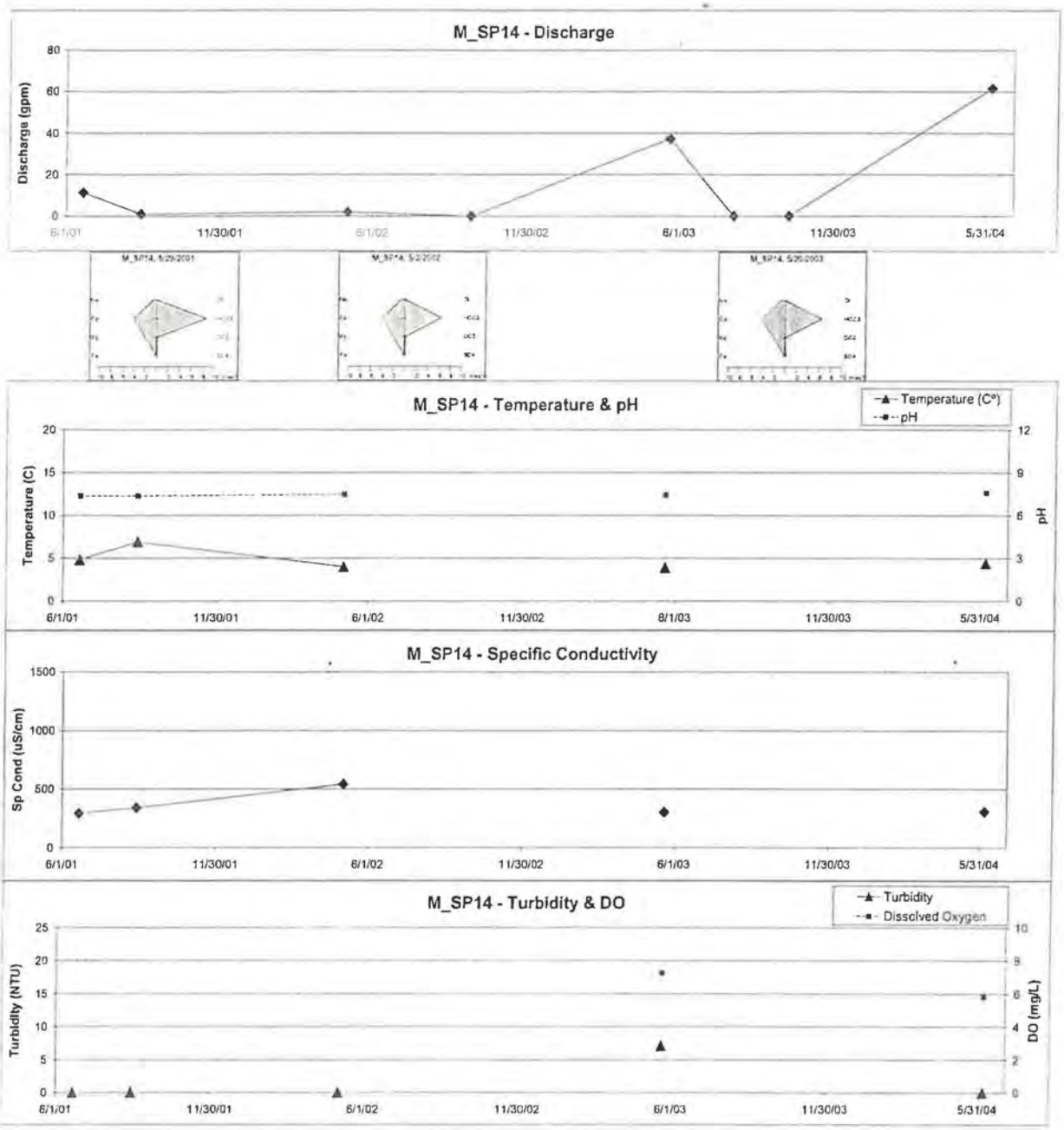

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Figure 14. Price River Formation Spring M_SP01

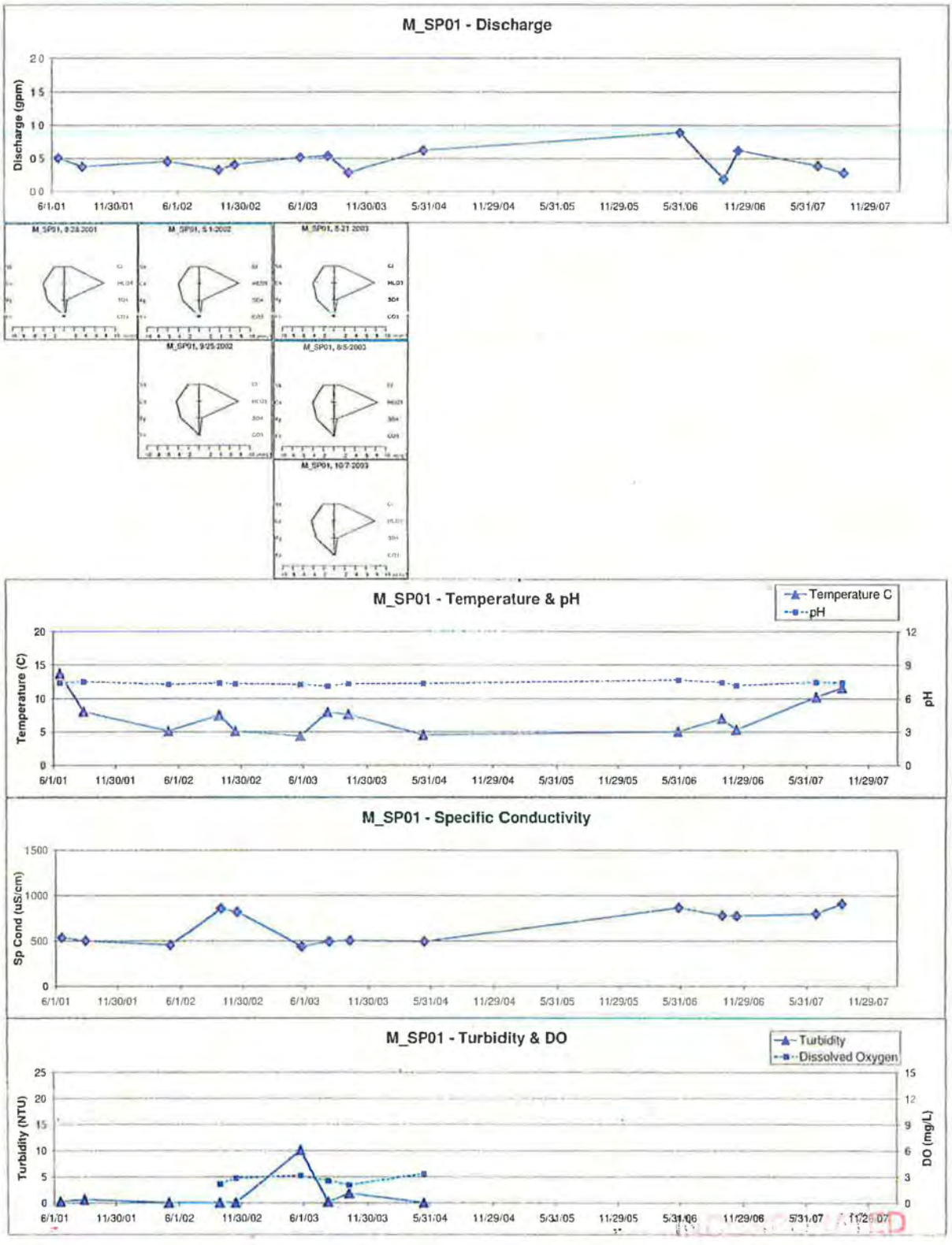

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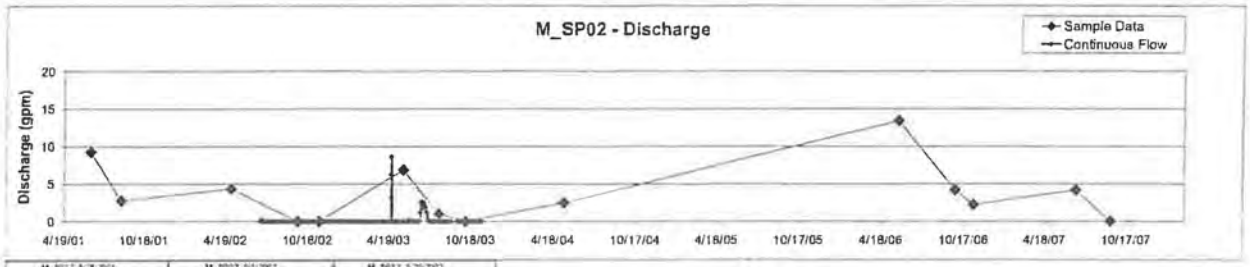
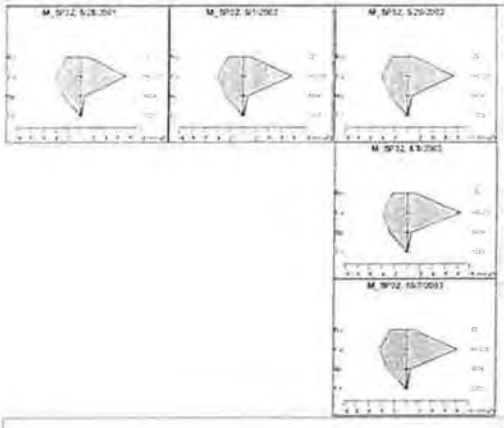
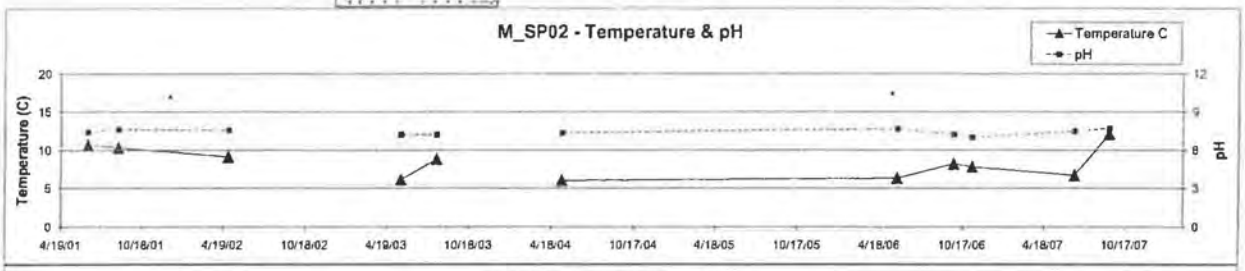
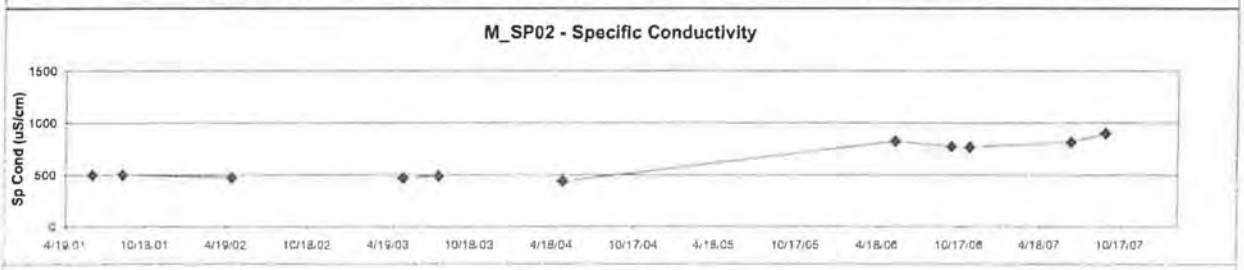
Figure 15. Price River Formation Spring M_SP02









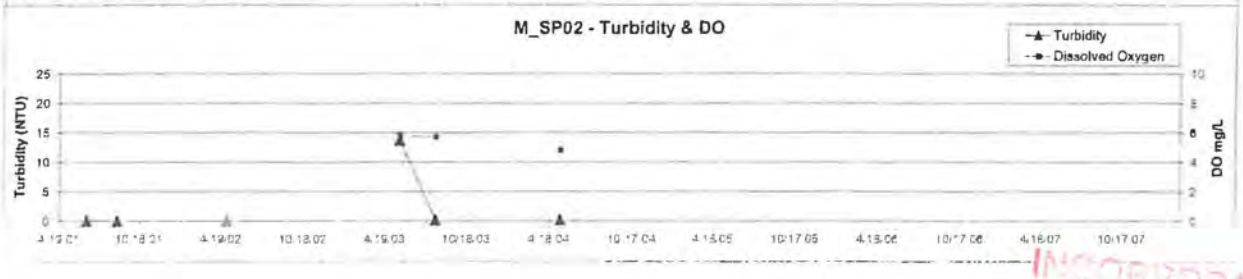


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Figure 16. Price River Formation Spring M_SP18

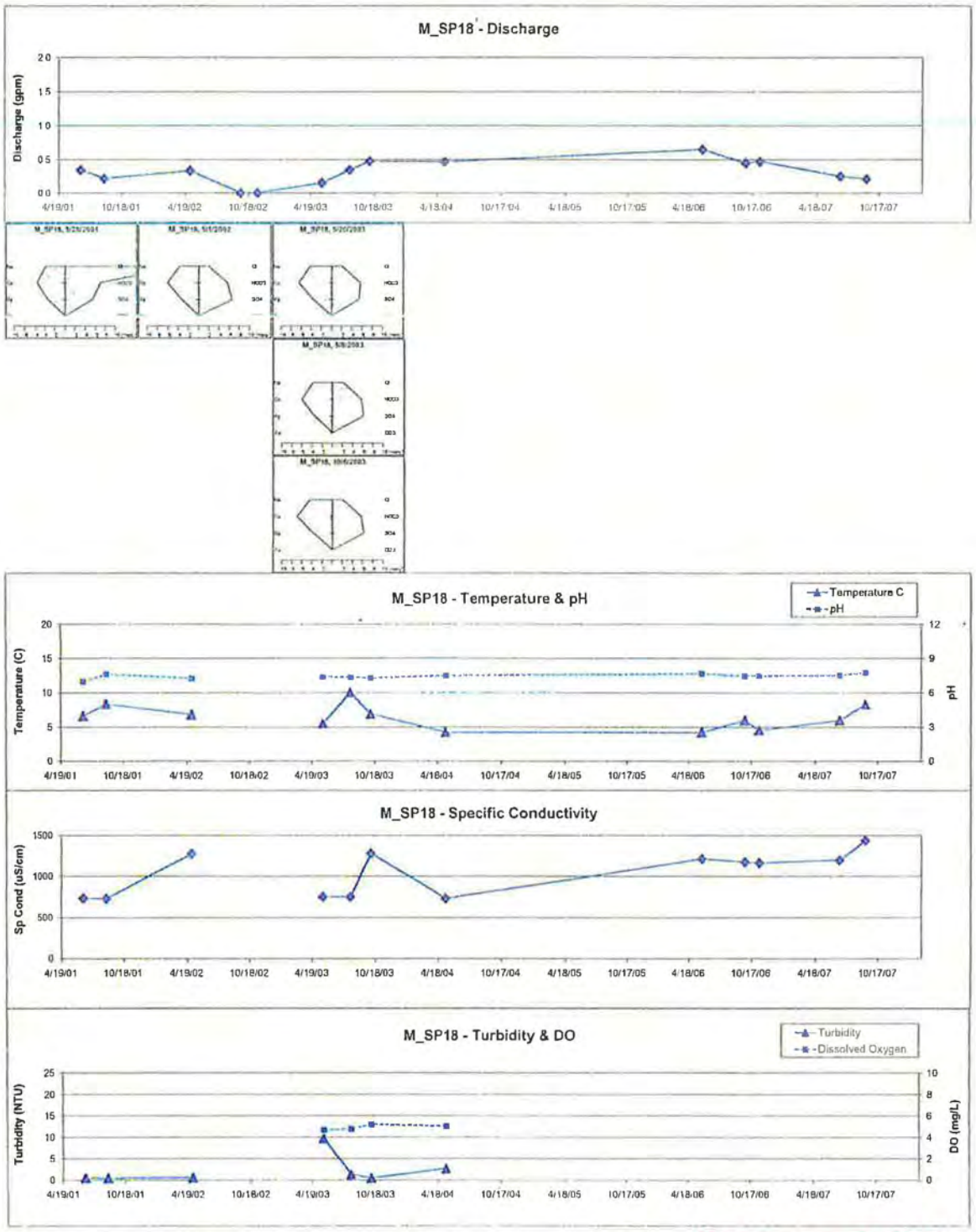

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Figure 17. Price River Formation Spring M_SP39

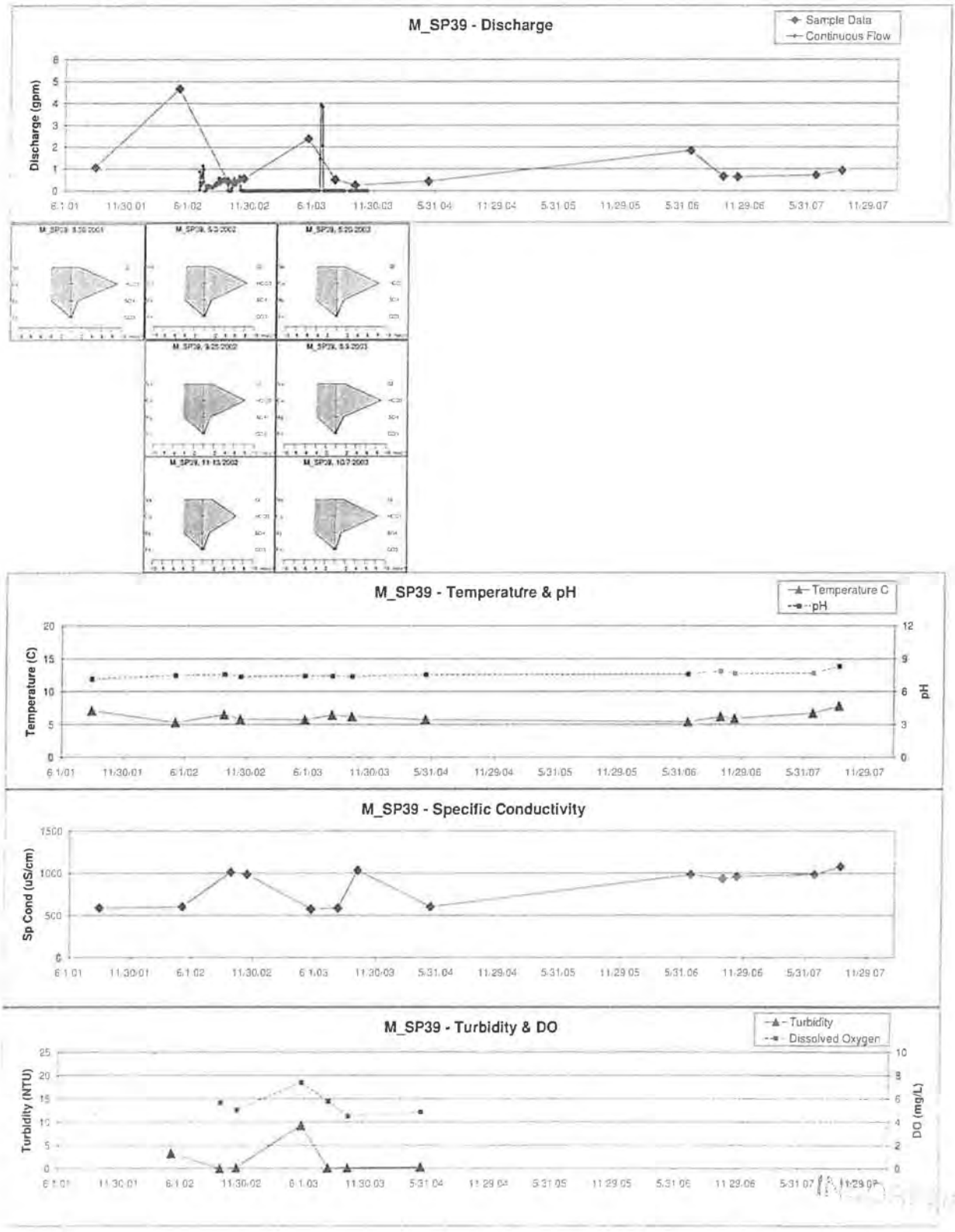

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Figure 18. Average Water Year Flows (Oct.-Sept), Muddy Creek near Emery, Station 09330500

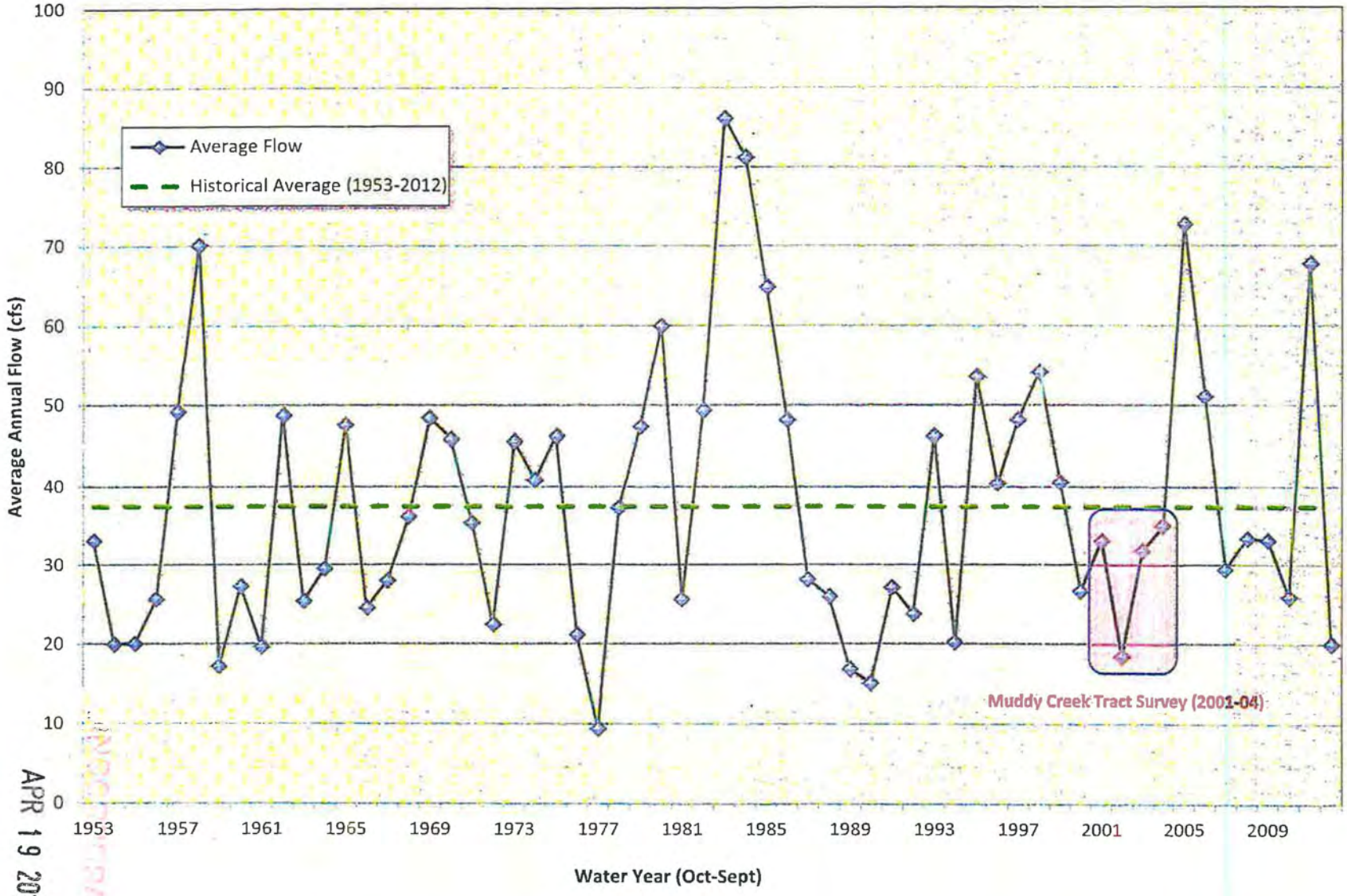

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Figure 19. Average Monthly Flows (1950-2007) for Muddy Creek near Emery, Station 09330500

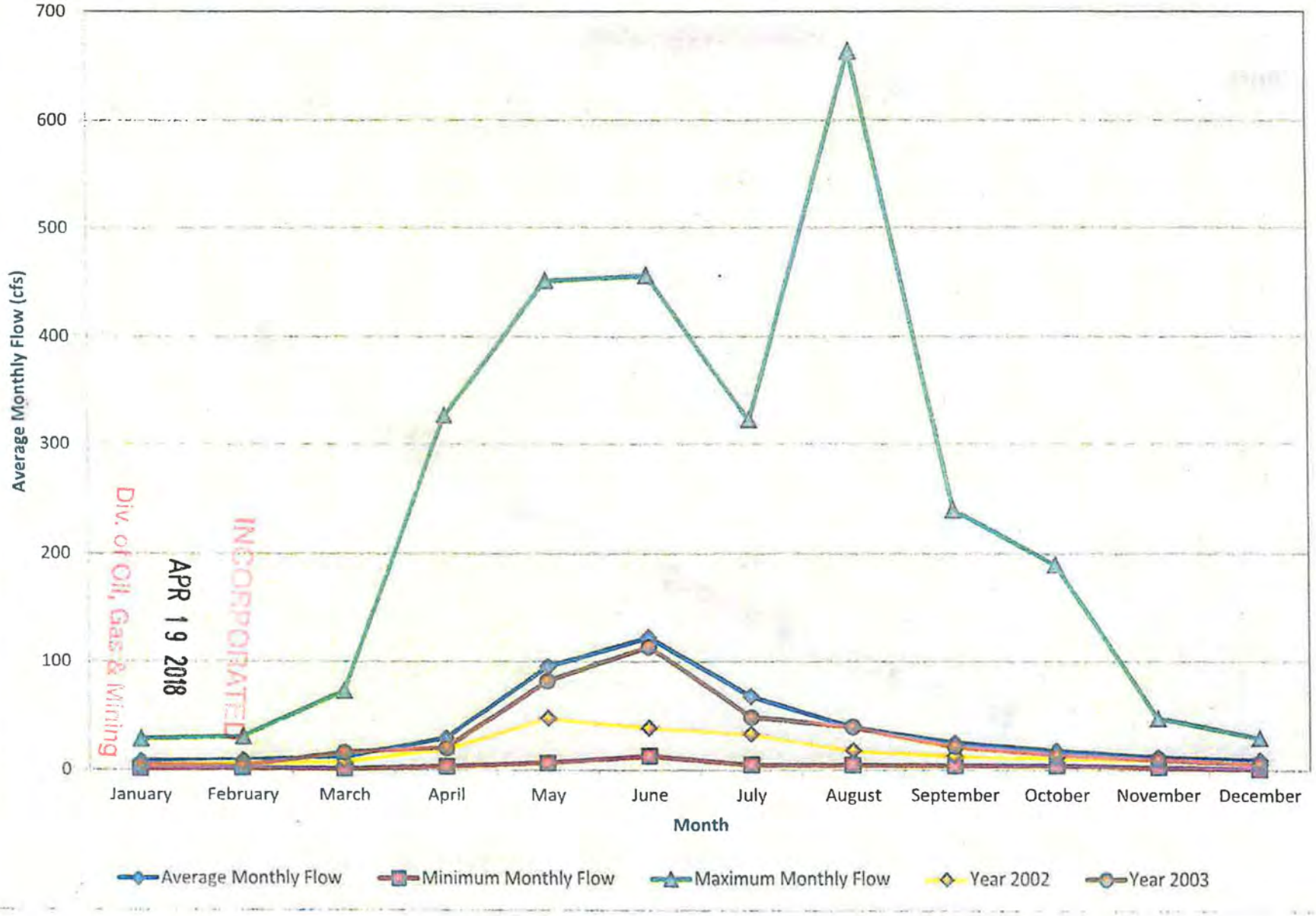

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Figure 20. Flood Frequency Analysis Annual Maximum for 60-Year Record @ Muddy Creek near Emery, Station 09330500

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Figure 21. M_STR8 Field Parameters

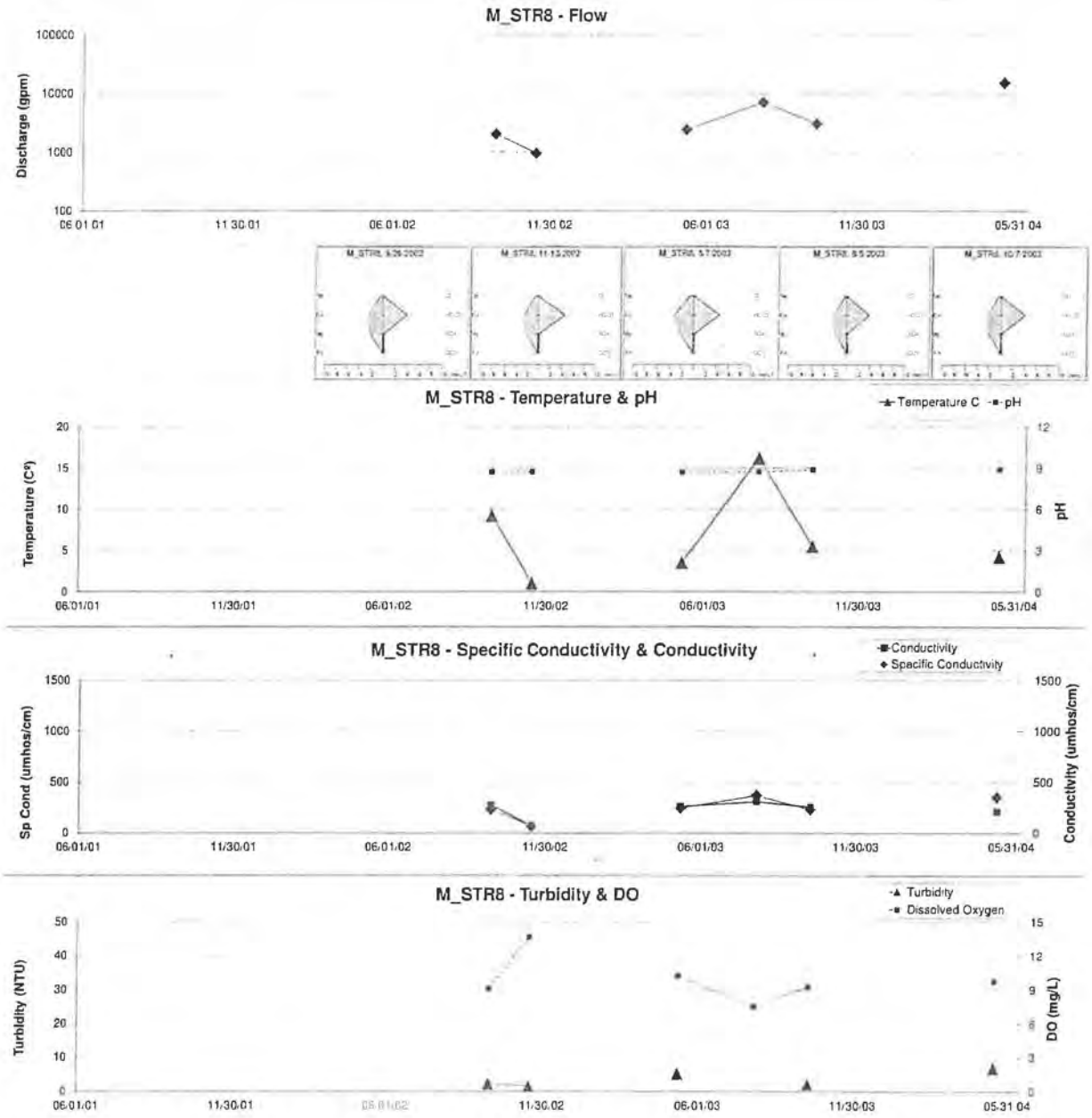

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Figure 22. M_STR1 Field Parameters

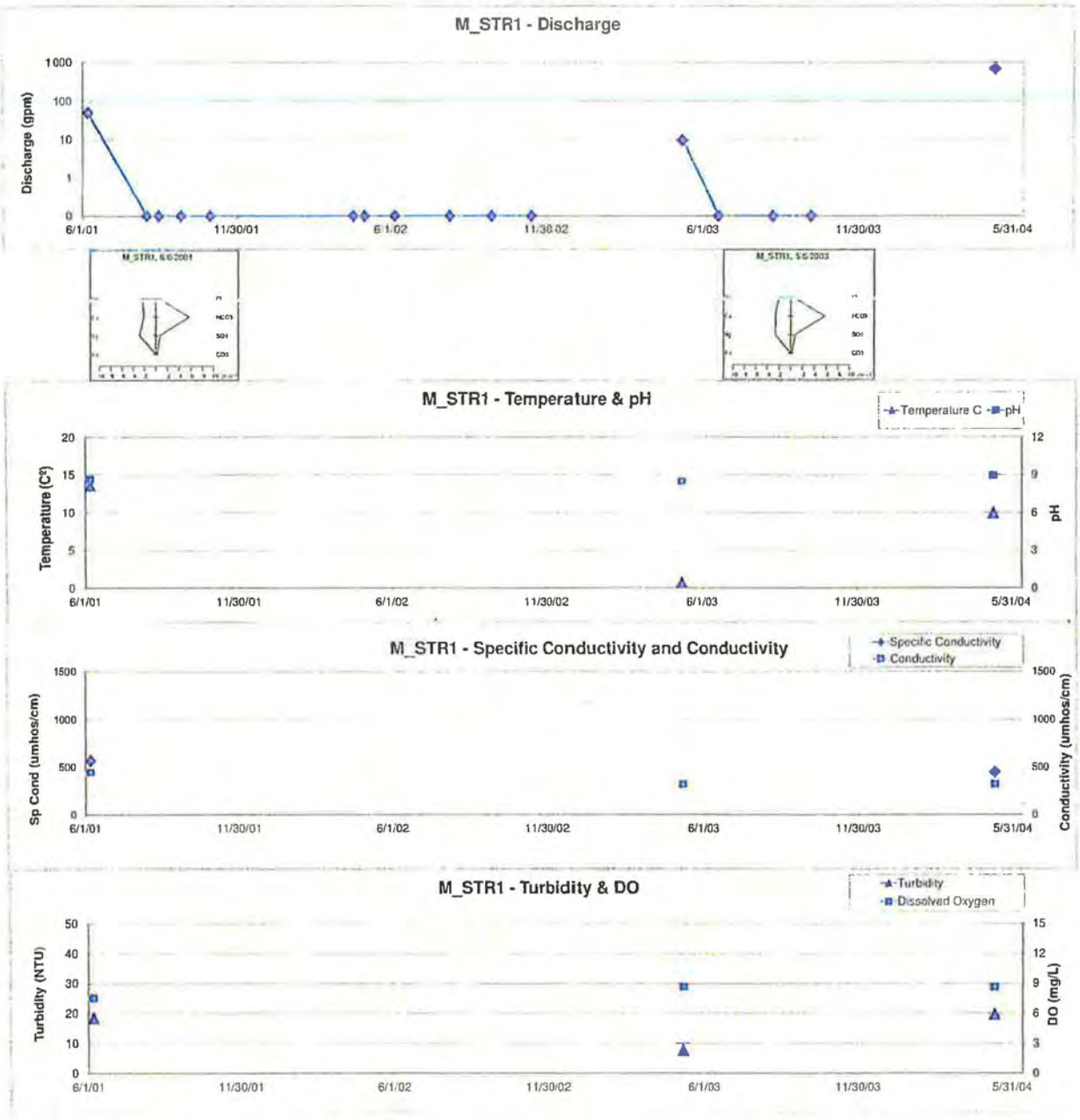

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Figure 23. M_STR2 Field Parameters

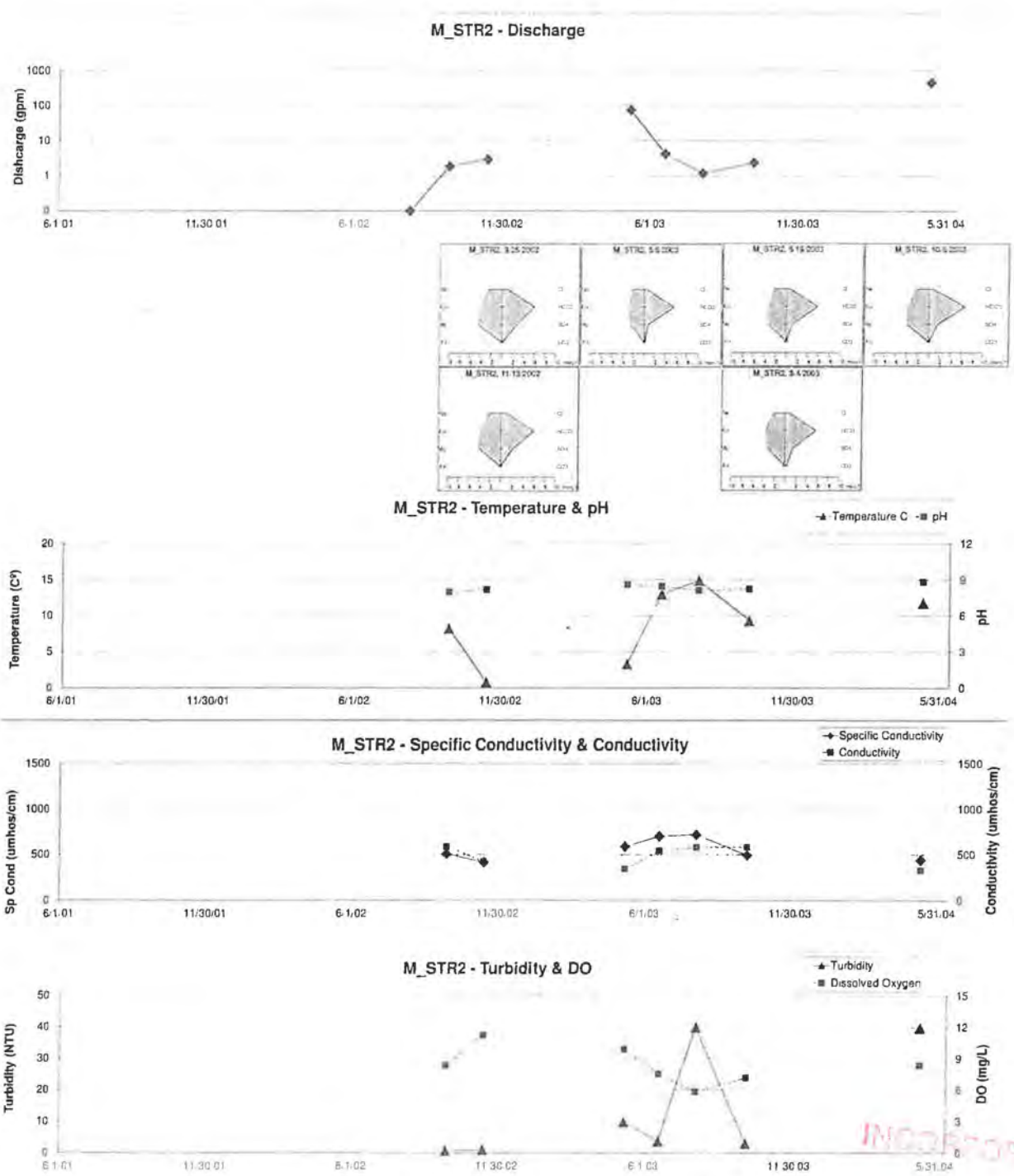

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Figure 24. M_STR3 Field Parameters

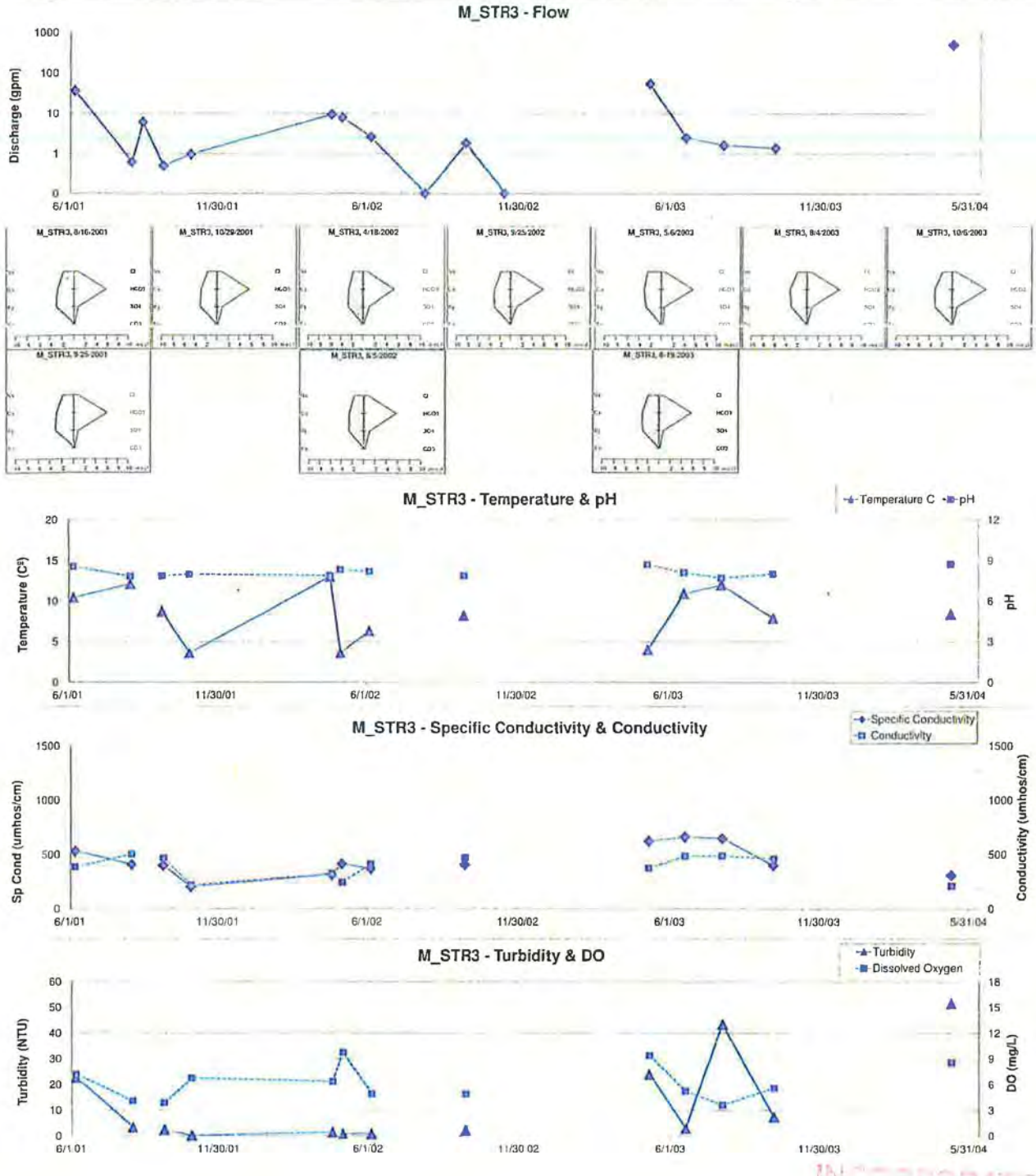

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Figure 25. M_STR4 Field Parameters

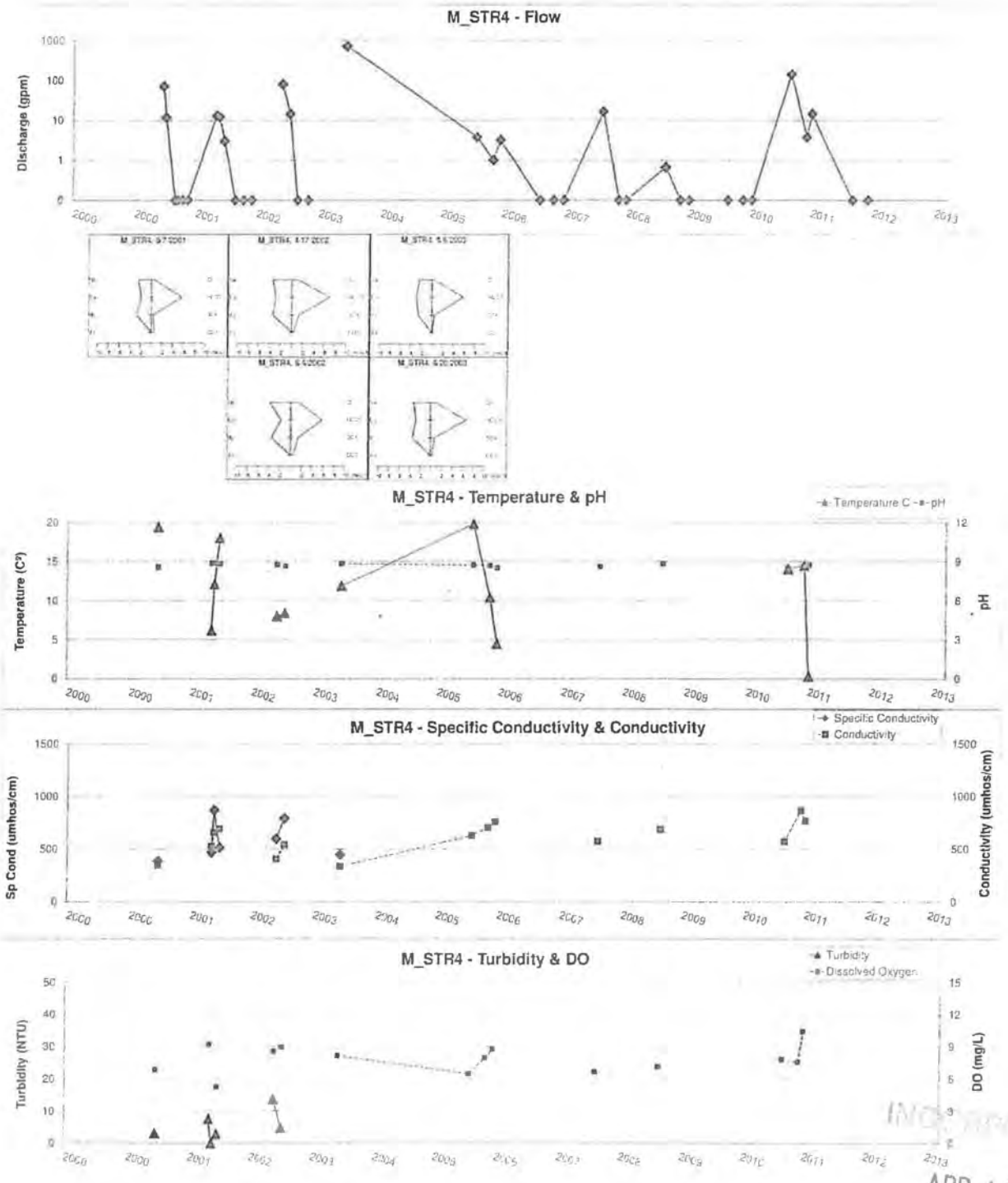

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Figure 26. M_STR5 Field Parameters

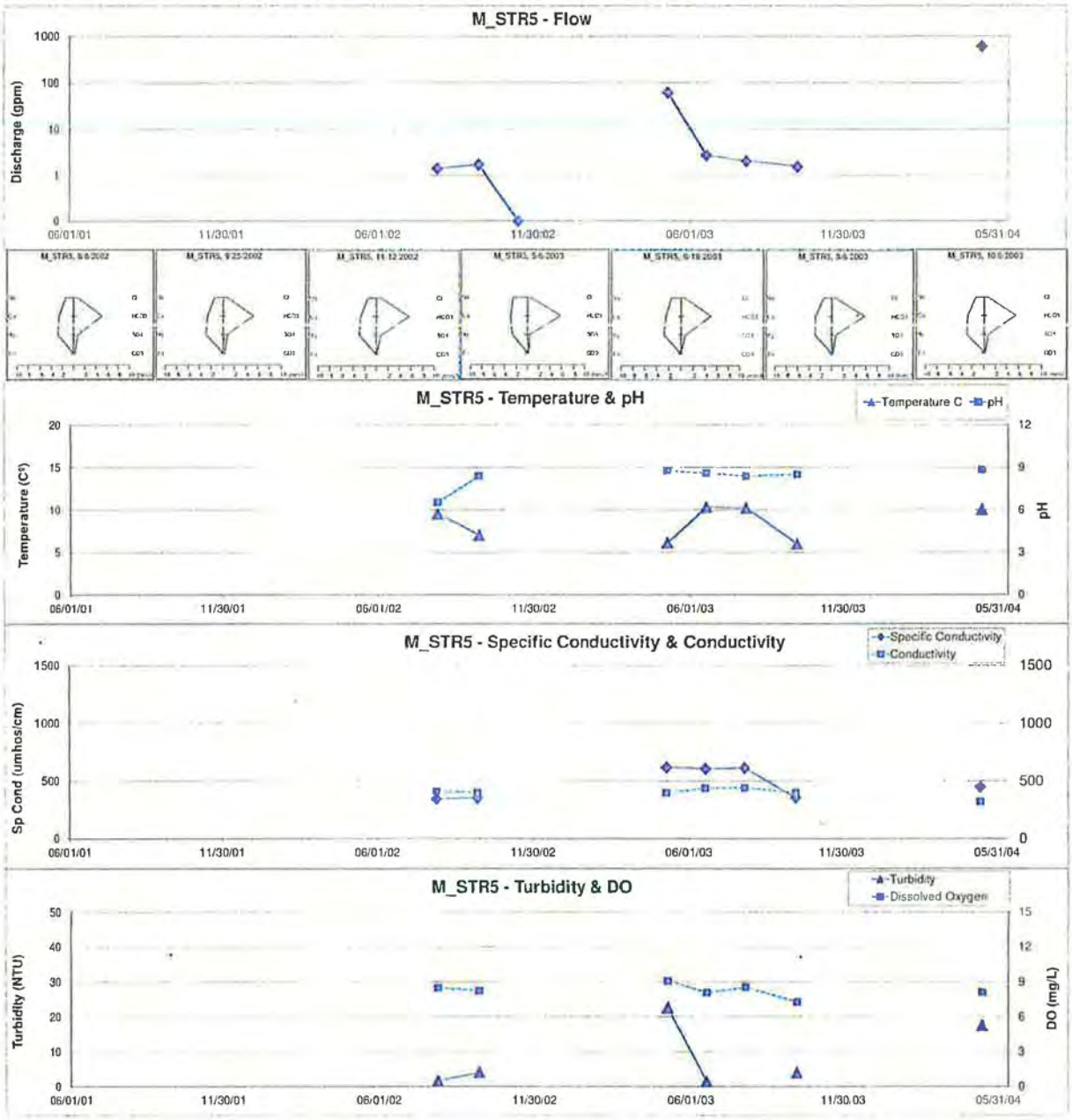

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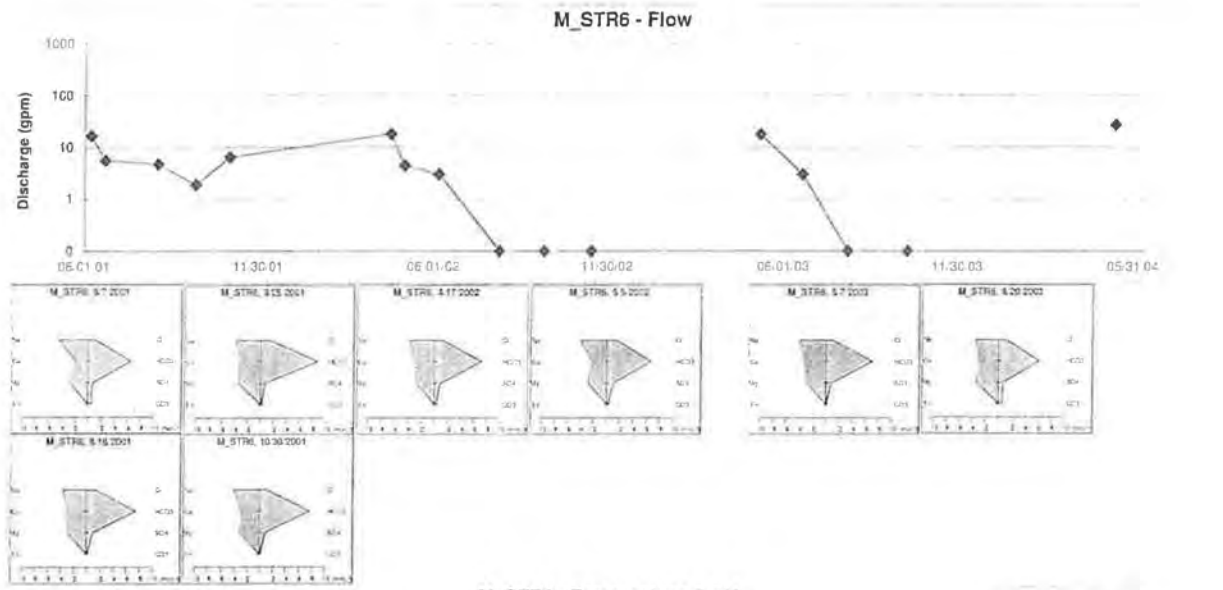
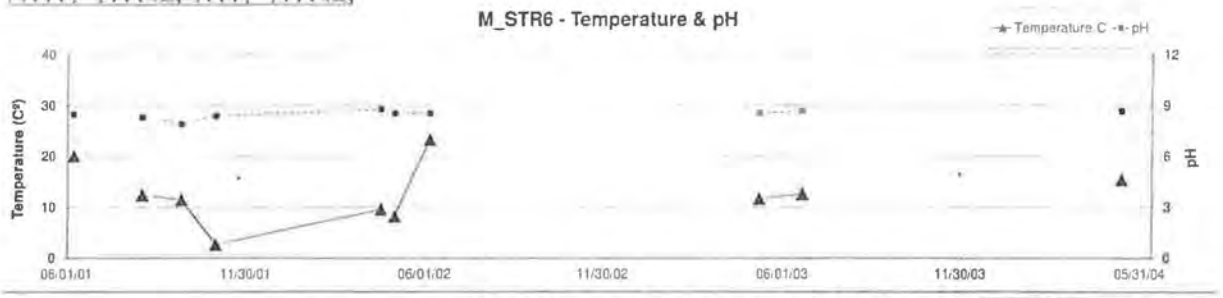
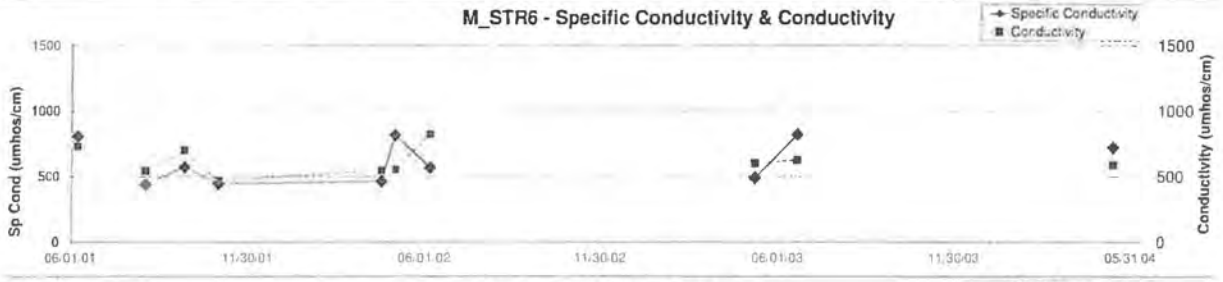
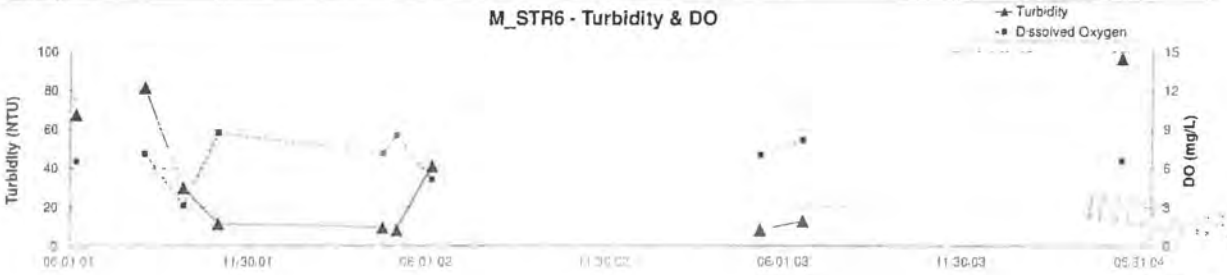
Figure 27. M_STR6 Field Parameters









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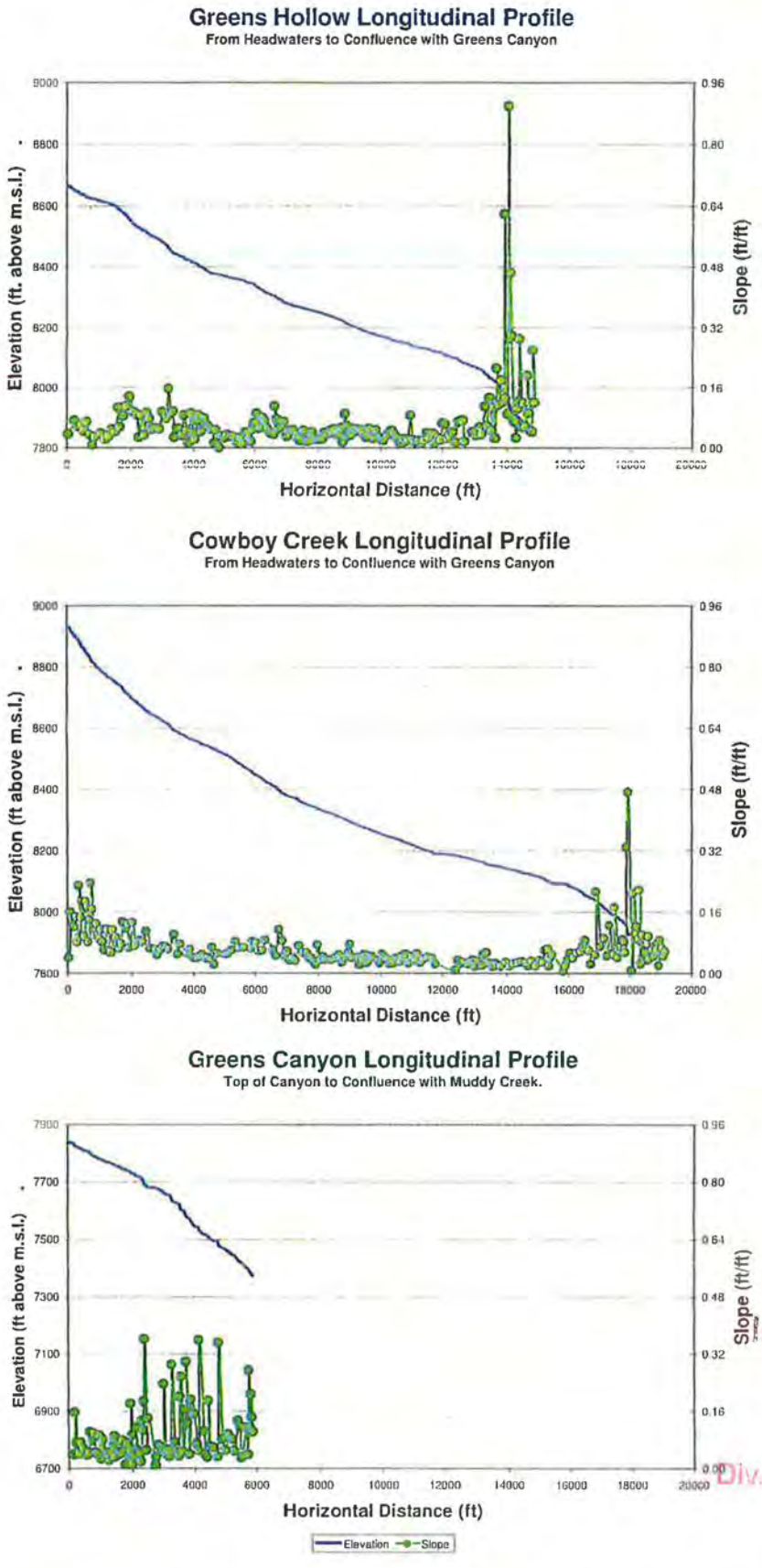

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Figure 28. Longitudinal Survey of Greens Canyon and Tributaries. Note the dotted line represents channel slope (right axis) and the smoothed line represents channel elevation (left axis).

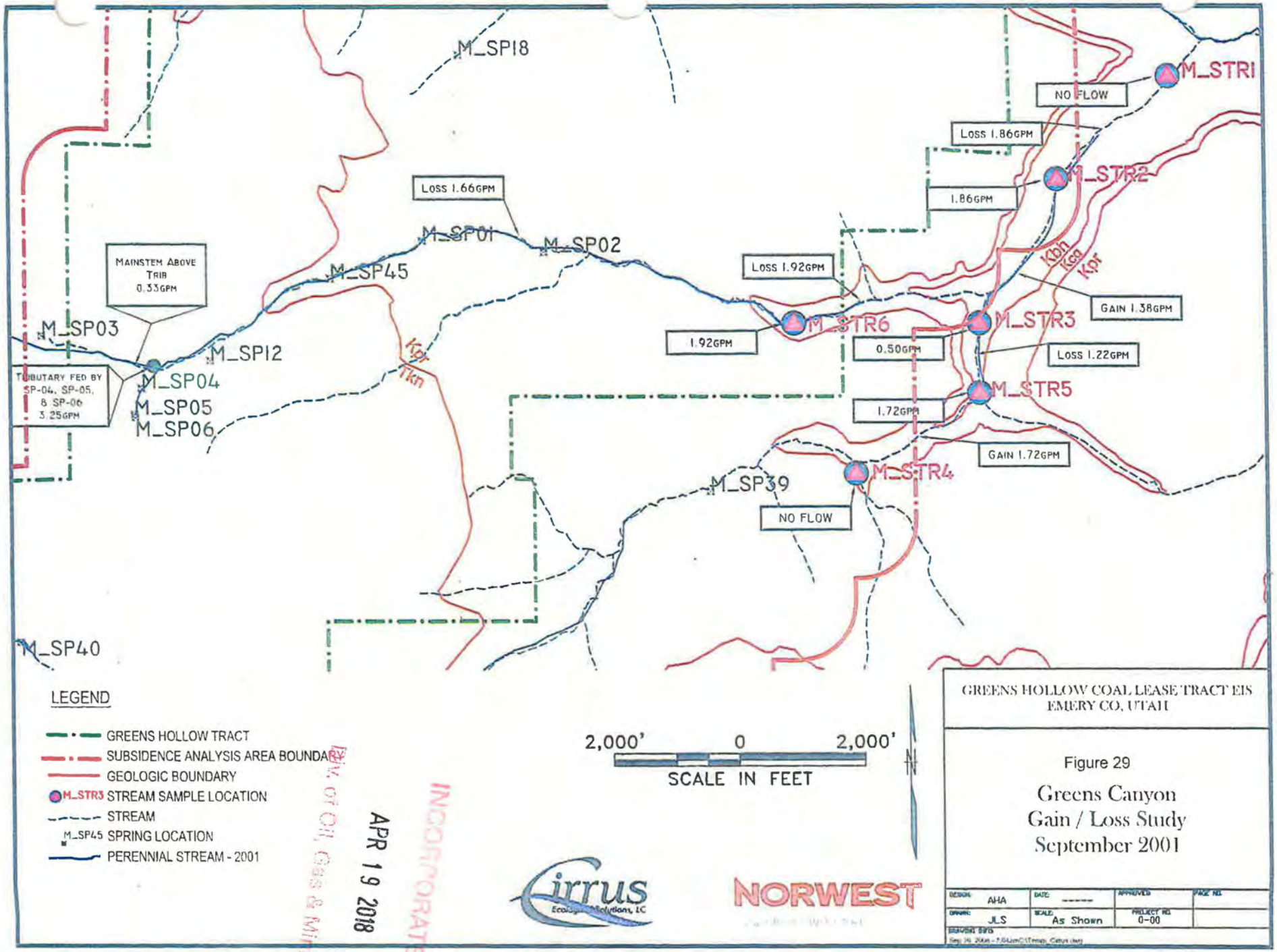
M_SP18
M_STR1
NO FLOW
LOSS 1.86GPM
M_STR2
1.86GPM
LOSS 1.66GPM
M_SP01
M_SP02
M_SP45
MAINSTEM ABOVE TRIB 0.33GPM
LOSS 1.92GPM
Kdn
Kgs
Kpr
GAIN 1.38GPM
M_SP03
M_STR6
M_STR3
1.92GPM
0.50GPM
LOSS 1.22GPM
M_SP12
Kpr
Tkn
TRIBUTARY FED BY SP-04, SP-05, & SP-06 3.25GPM
M_SP04
M_SP05
M_SP06
M_STR5
1.72GPM
GAIN 1.72GPM
M_STR4
M_SP39
NO FLOW
M_SP40
LEGEND
GREENS HOLLOW TRACT
SUBSIDENCE ANALYSIS AREA BOUNDARY
GEOLOGIC BOUNDARY
M_STR3 STREAM SAMPLE LOCATION
STREAM
M_SP45 SPRING LOCATION
PERENNIAL STREAM - 2001
2,000' 0 2,000'
SCALE IN FEET
N
GREENS HOLLOW COAL LEASE TRACT EIS
EMERY CO, UTAH
Figure 29
Greens Canyon
Gain / Loss Study
September 2001
DESIGN AHA
DRAWN JLS
DATE
SCALE As Shown
APPROVED
PROJECT NO. 0-00
PAGE NO.
Cirrus Ecological Solutions, LC
NORWEST
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Figure 30 M_STR9 Field Parameters

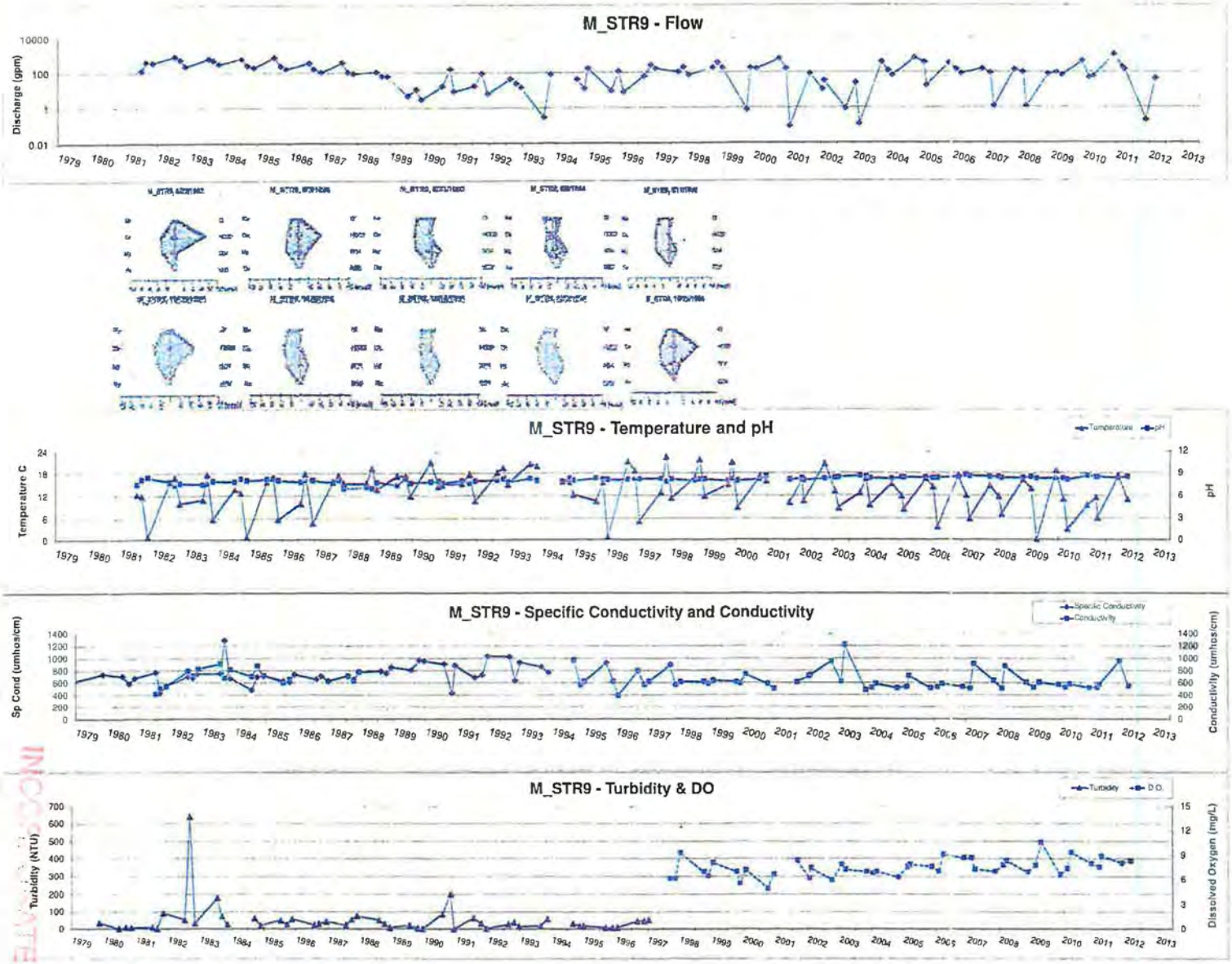

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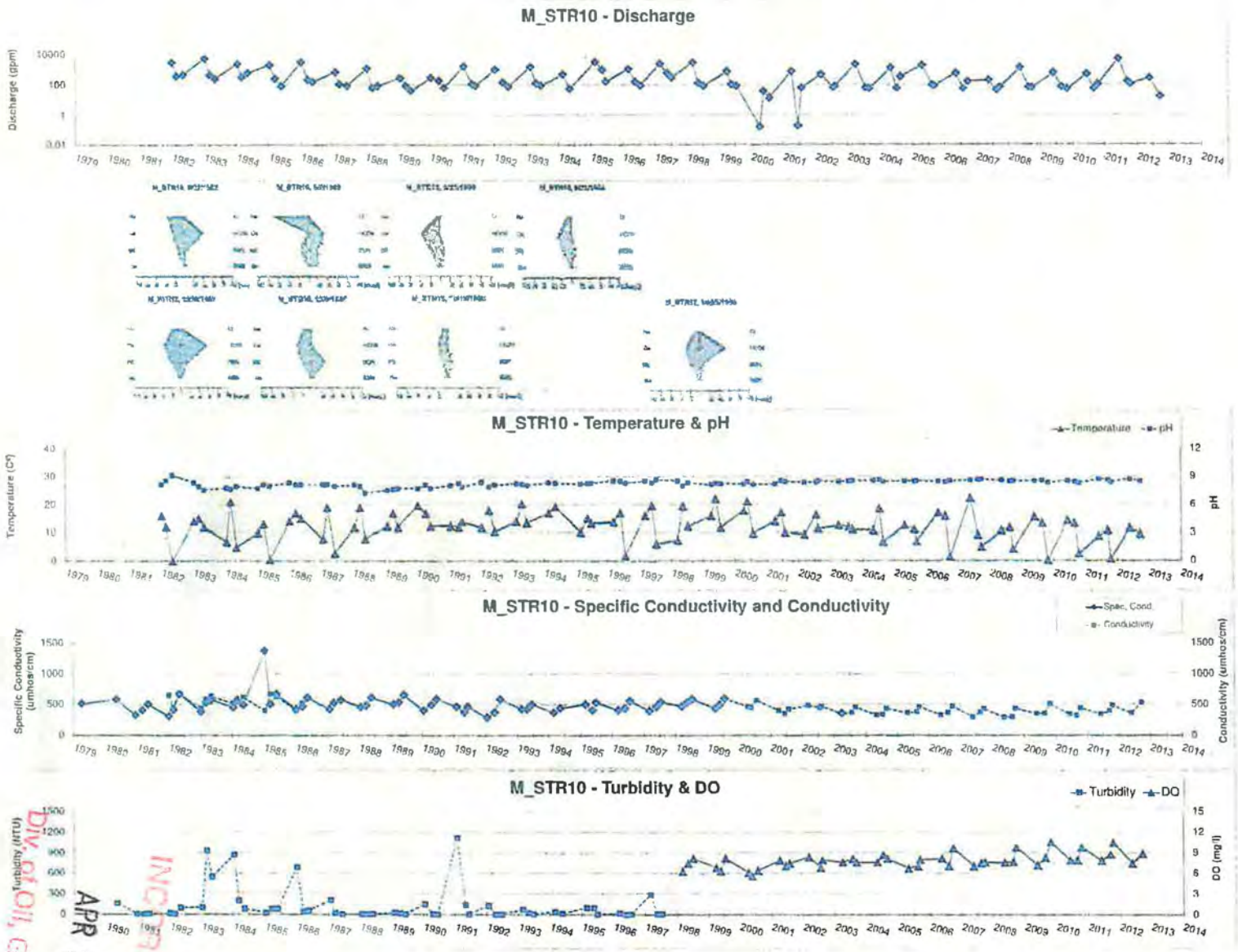
Figure 31. M_STR10 Field Parameters



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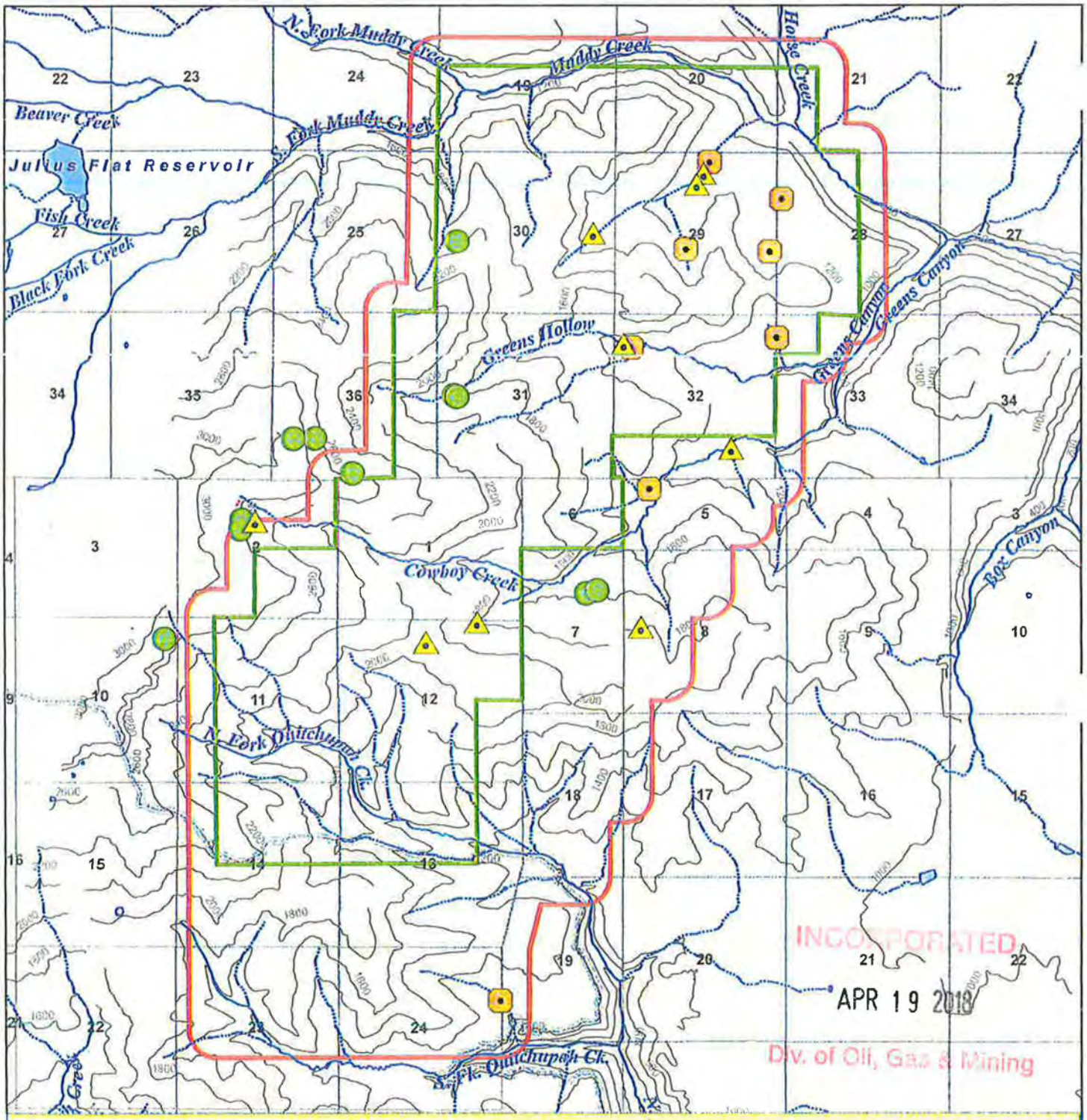

Figure 32. Surface Water Features

1 0.5 0 1 Miles

1:53,500

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- National Forest Boundary
- Perennial Streams (USGS)
- Intermittent Streams (USGS)
- Overburden (200 ft contours)
- Section Boundaries
- Cattle Troughs
- Natural Ponds
- Stock Ponds

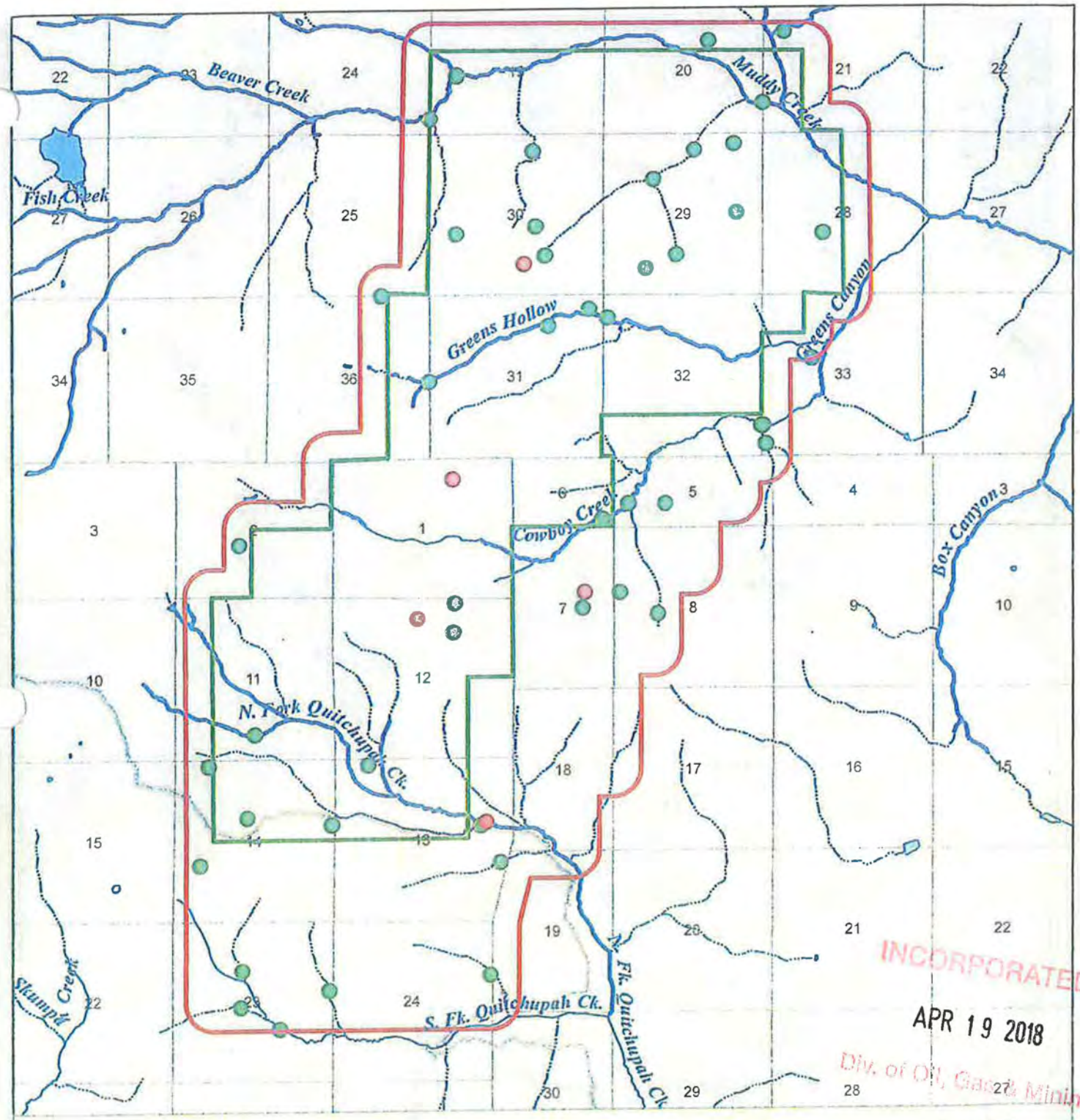

Figure 33. Water Rights Ownership

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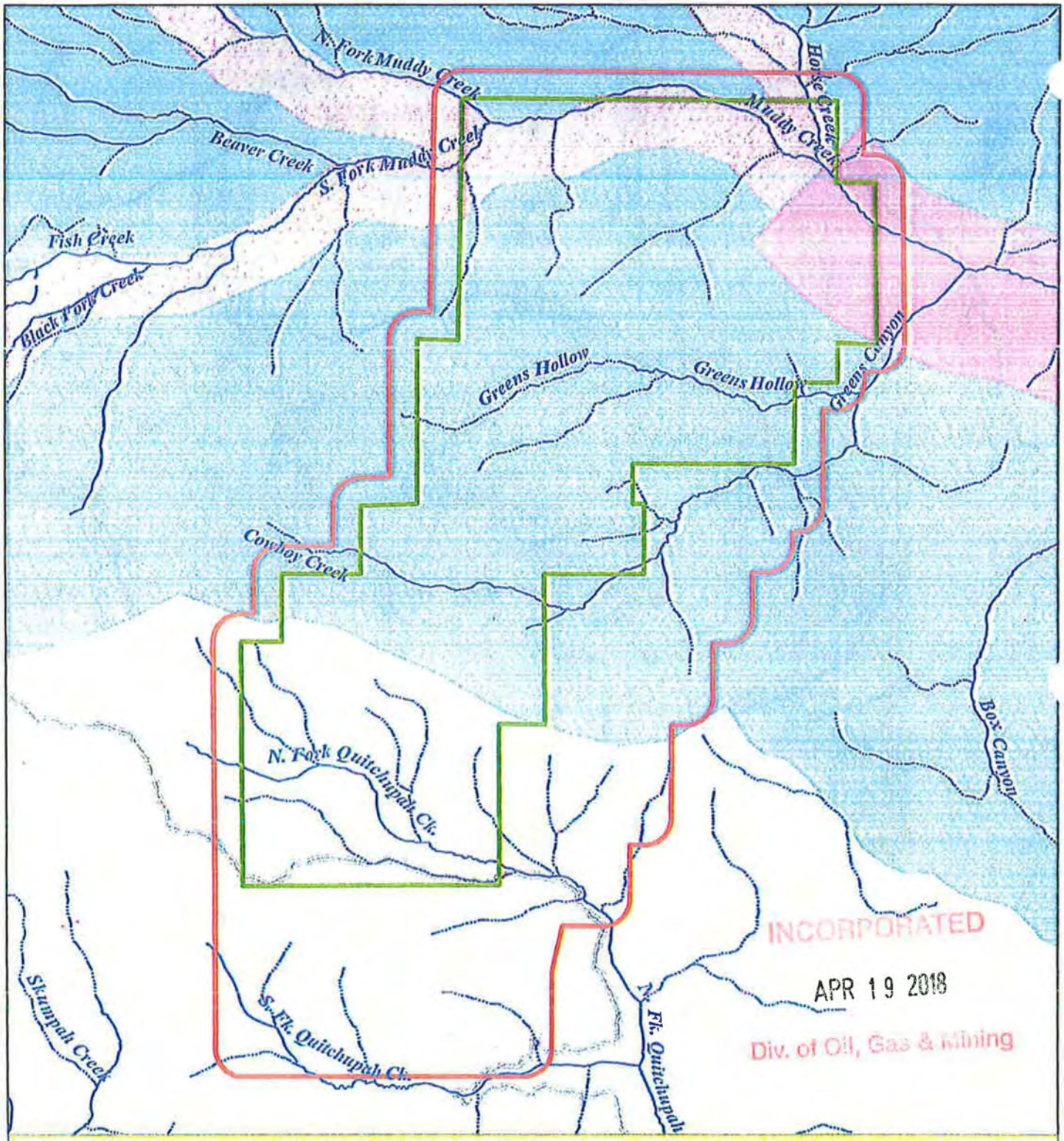

Figure 34. Drinking Water Protection Zones

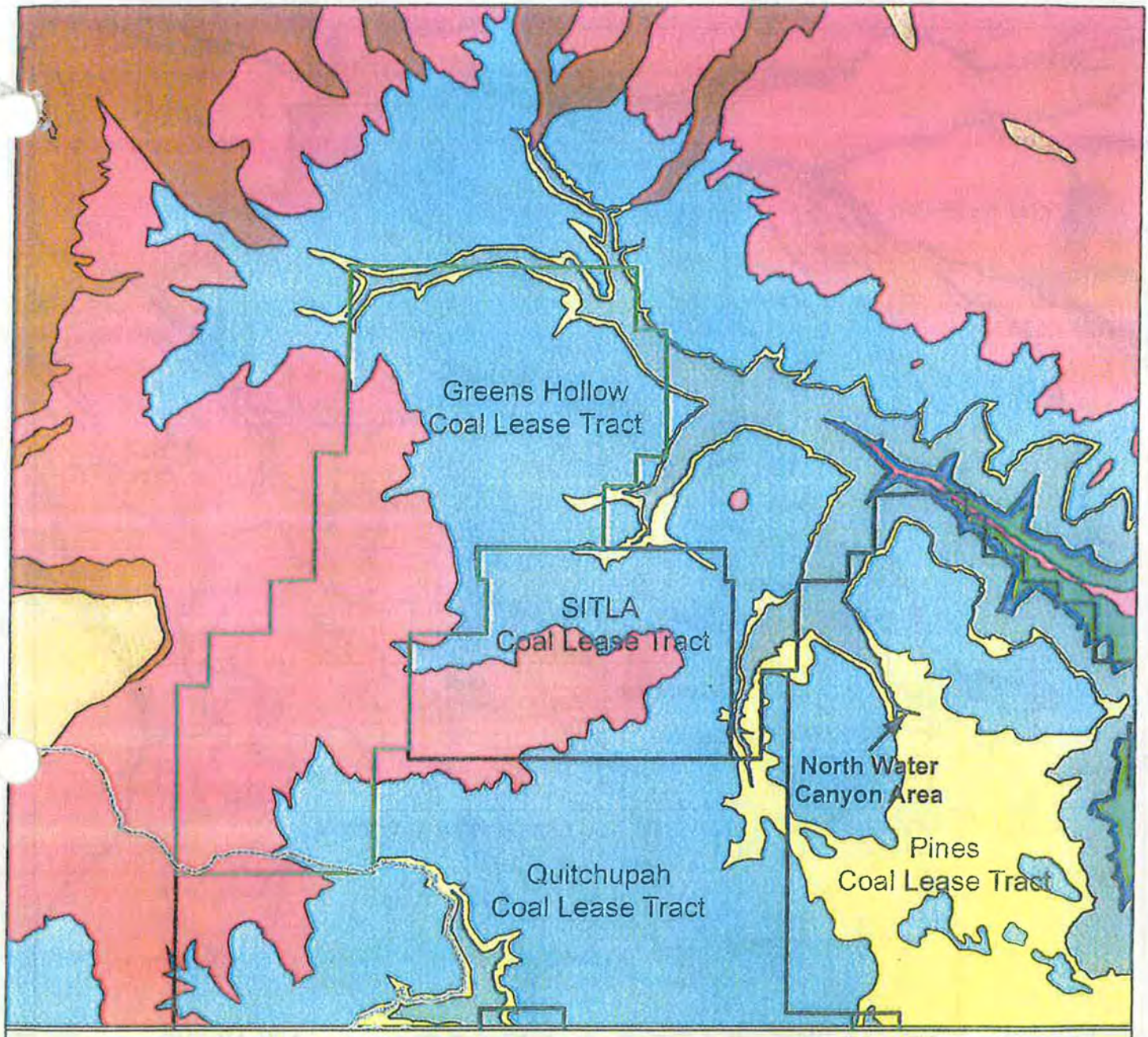

Figure 35. Bedrock geologic map of the Greens Hollow Coal Lease Tract and adjoining leases.

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N
W E
S

1 0.5 0 1 Miles

1:75,000

Legend

- Greens Hollow Coal Lease Tract
- Adjacent Mine Tracts
- Manti-La Sal/Fishlake Forest Boundary
- Alluvium
- Landslide/mass movement
- Flagstaff Limestone
- North Horn Formation
- Price River Formation
- Castlegate Sandstone
- Blackhawk Formation
- Star Point Sandstone
- Mancos Shale

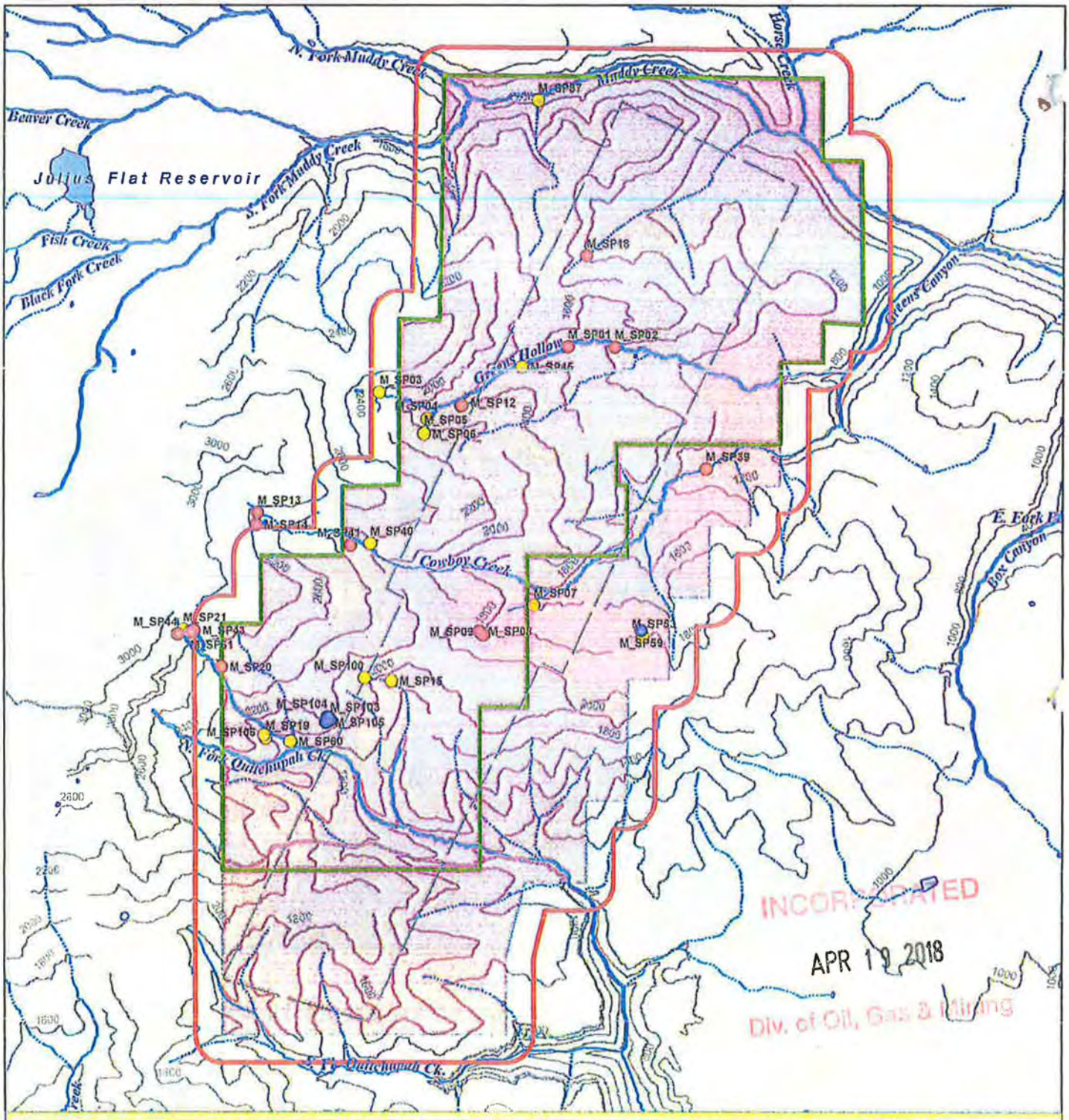


Figure 36. Alternative 2 - Spring Locations with Proposed Mine Area and Overburden Thickness

1 0.5 0 1 Miles

1:53,500

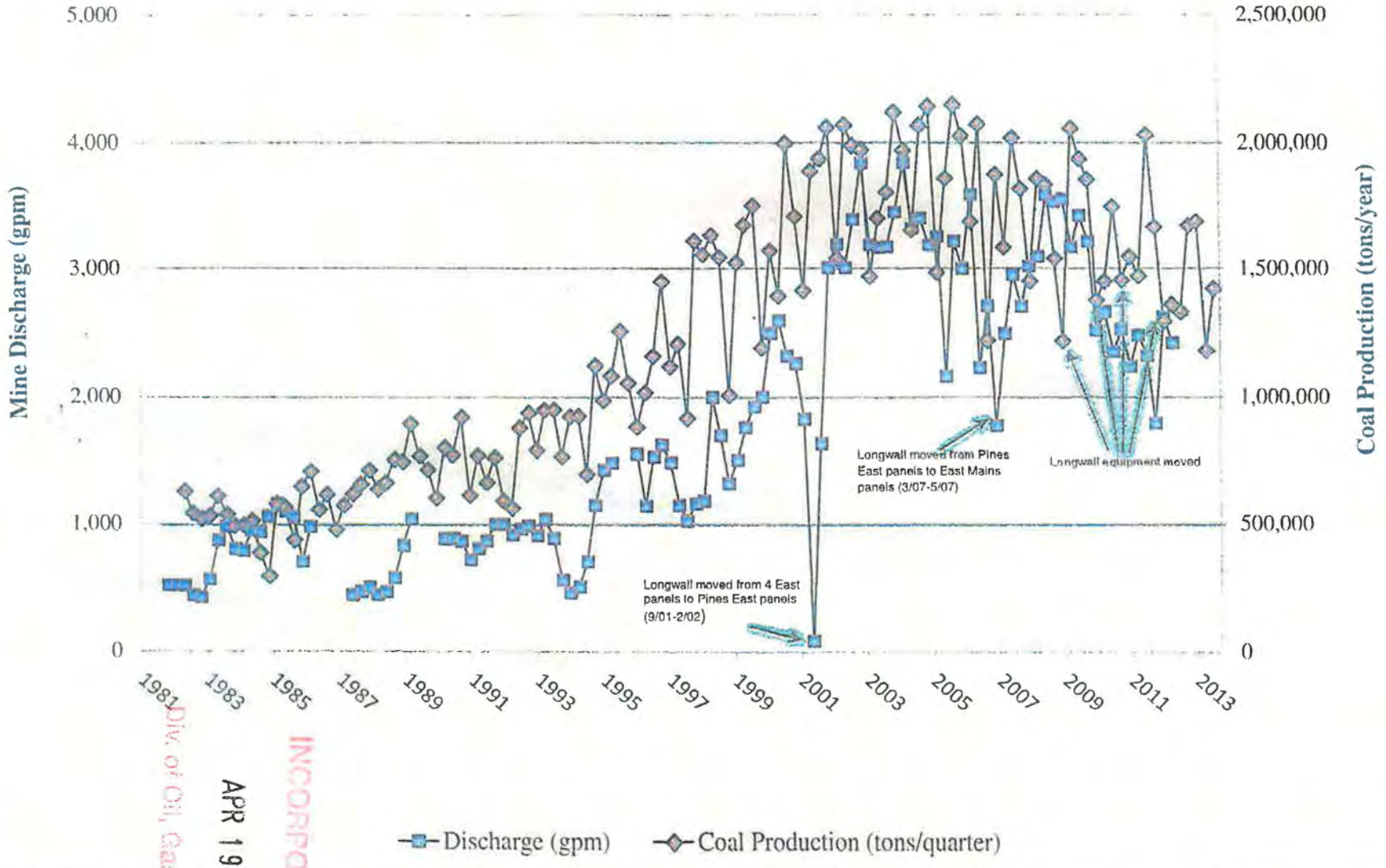
Legend

- Greens Hollow Coal Lease Tract
- Ark Land Company Proposed Mining Area
- Area of Subsidence Mining
- Mining Analysis Area Boundary
- National Forest Boundary
- Overburden contours (200 ft)
- Perennial Flow 2001
- Perennial Streams (USGS)
- Intermittent Streams (USGS)

Greens Hollow Springs

- High Value
- Moderate Value
- Unknown Value

Figure 37. SUFCO Mine Discharge and Coal Production (1982-2013)



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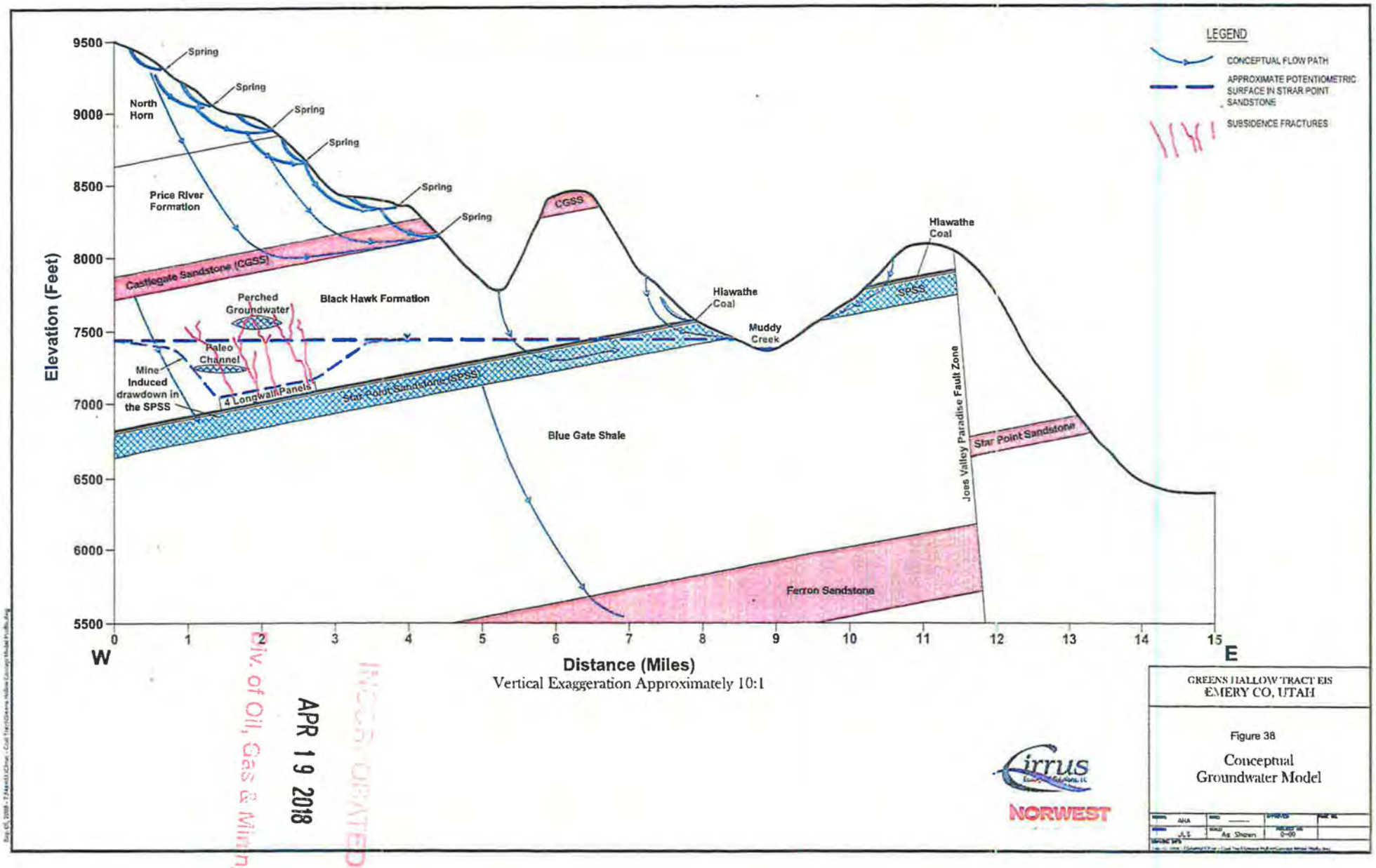

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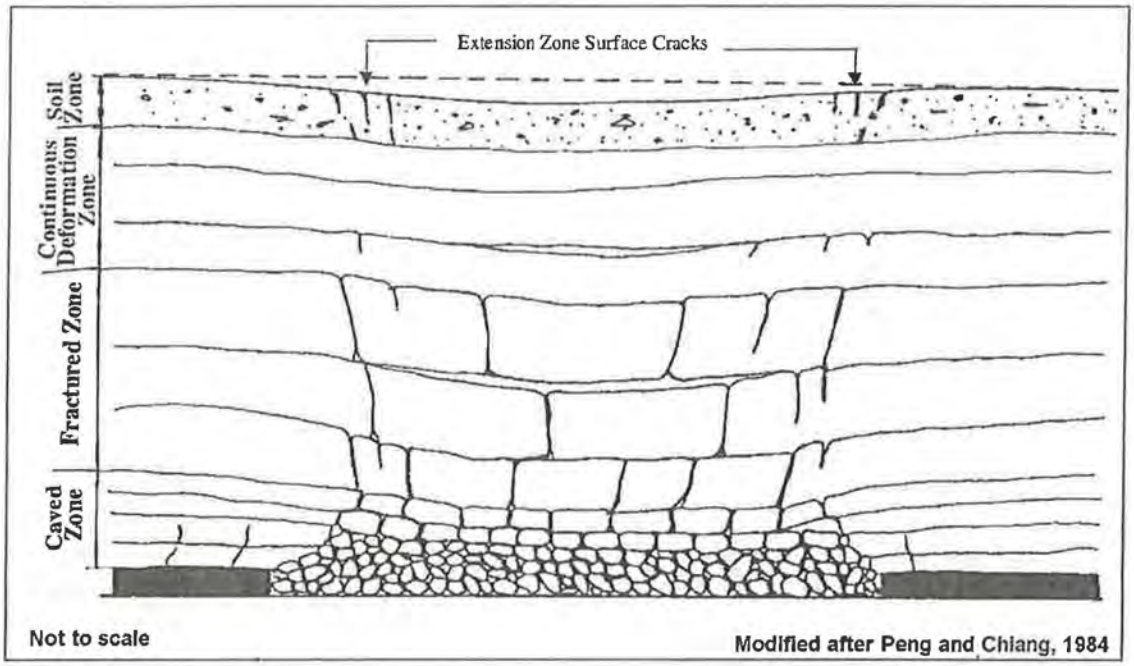
GREENS HOLLOW TRACT EIS
EMERY CO, UTAH

Figure 38

Conceptual Groundwater Model

Figure 39. Subsidence Zones above a Longwall Panel.



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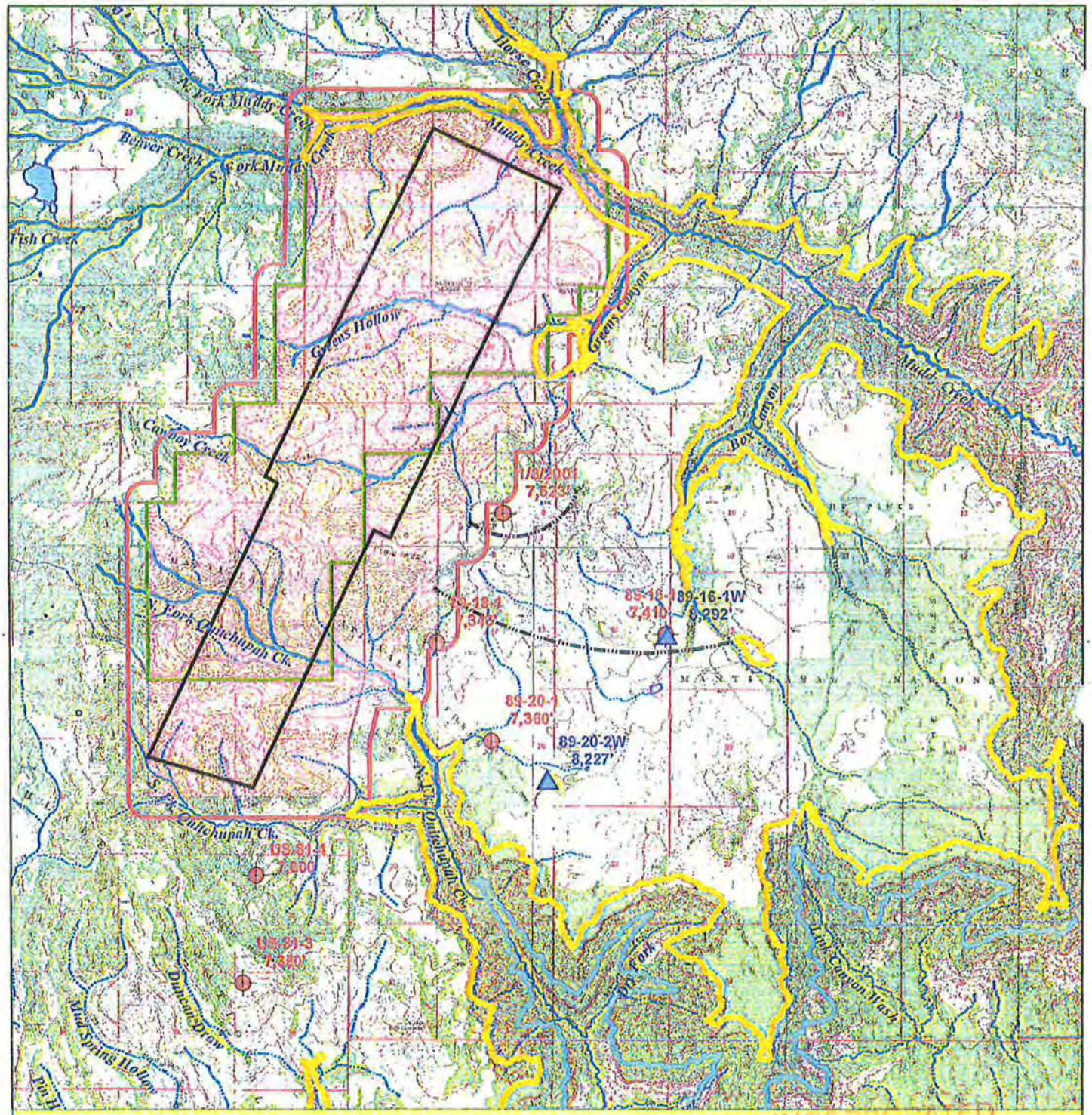

Figure 40. Water Level Elevation in Castlegate Sandstone and Blackhawk Formations.

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1 0.5 0 1 Miles

1:75,500

Legend

- Greens Hollow Coal Lease Tract
- Ark Land Company Proposed Mining Area
- Area of Subsidence Mining
- Mining Analysis Area Boundary
- National Forest Boundary
- Perennial Flow 2001
- Perennial Streams (USGS)
- Intermittent Streams (USGS)
- Base of Blackhawk Formation
- Castlegate Wells
- Blackhawk Wells
- Potentiometric contour for Hiawatha Coal
- Top of Blackhawk/Base of Castlegate

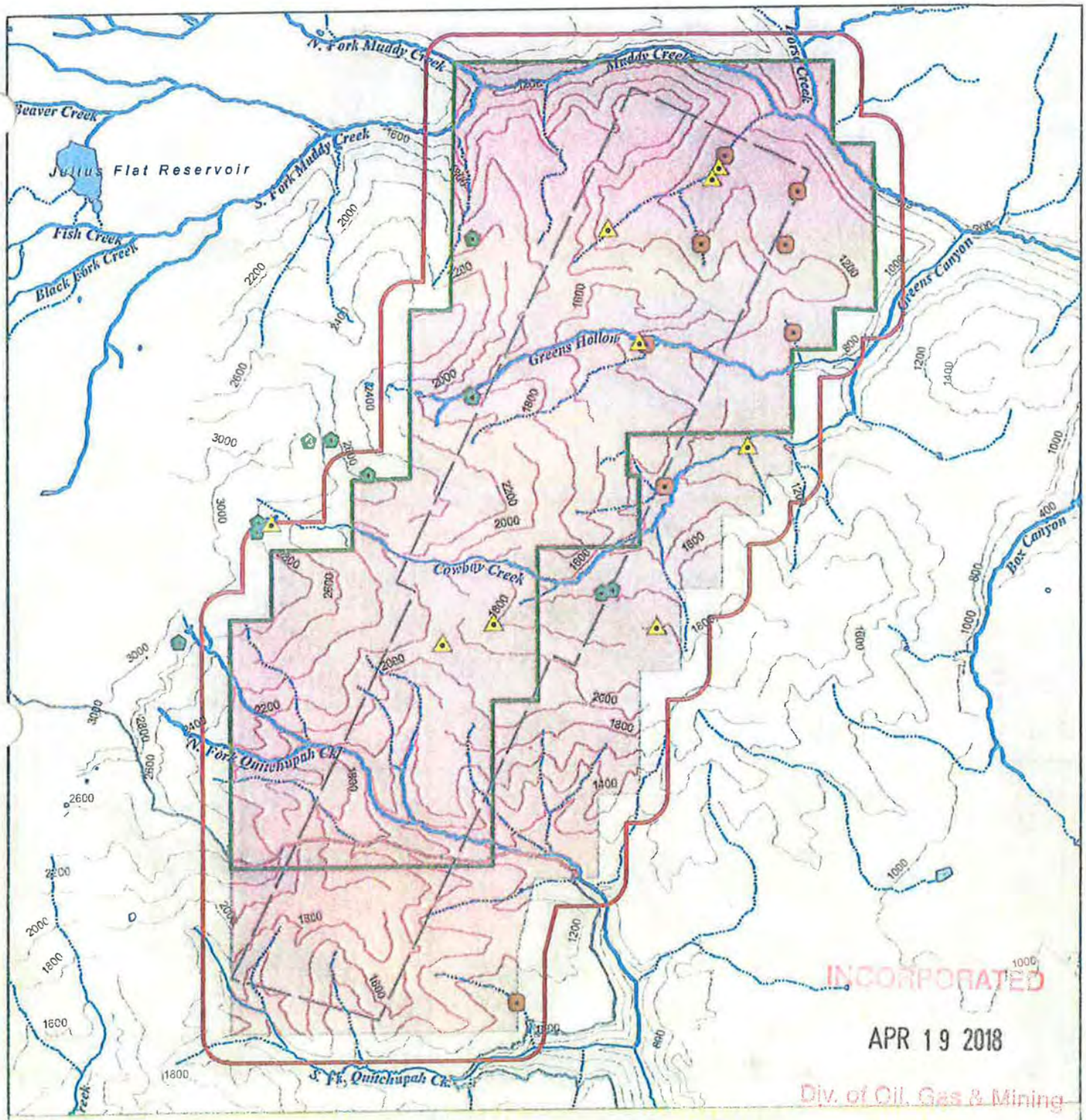

Figure 41. Alternative 2 - Surface Water Features with Mine Plan and Overburden Thickness

1 0.5 0 1 Miles

1:53,500

Legend

- Greens Hollow Coal Lease Tract
- Ark Land Company Proposed Mining Area
- Area of Subsidence Mining
- Mining Analysis Area Boundary
- National Forest Boundary
- Overburden contours (200 ft)
- Perennial Flow 2001
- Perennial Streams (USGS)
- Intermittent Streams (USGS)
- Cattle Troughs
- Natural Ponds
- Stock Ponds

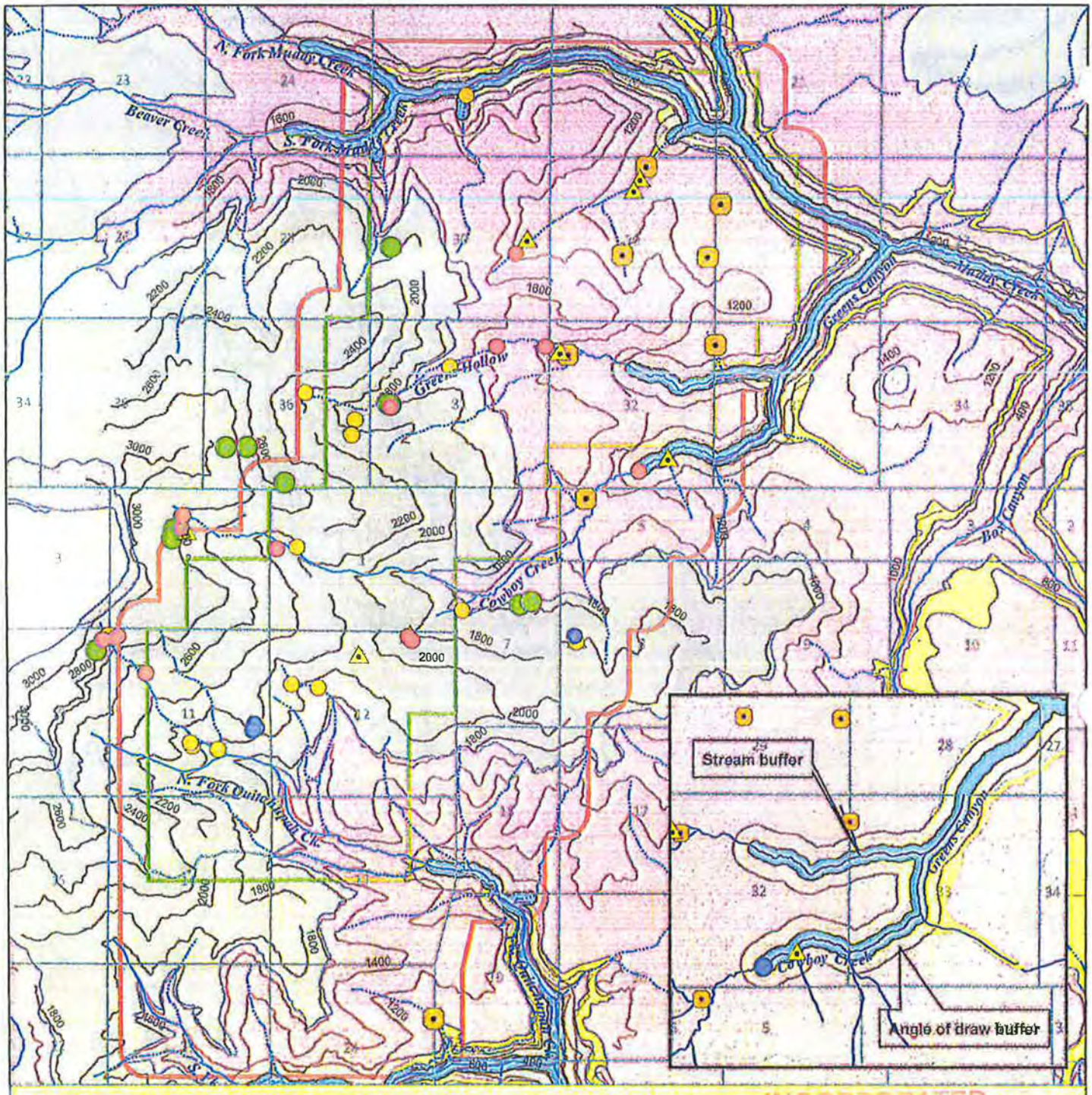

Figure 42. Stream Buffer Development

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1 0.5 0 1 Miles

1:53,500

Legend

- National Forest Boundary
- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- Stream Buffer
- Angle of Draw Buffer
- Cattle Troughs
- Natural Ponds
- Stock Ponds
- Section Boundaries

Greens Hollow Springs

- High Value
- Moderate Value
- Unknown Value

Geology

- Ql Landslide
- Tf Flagstaff
- TKn North Horn
- Kpr Price River
- Kcg Castlegate
- Kbh Blackhawk

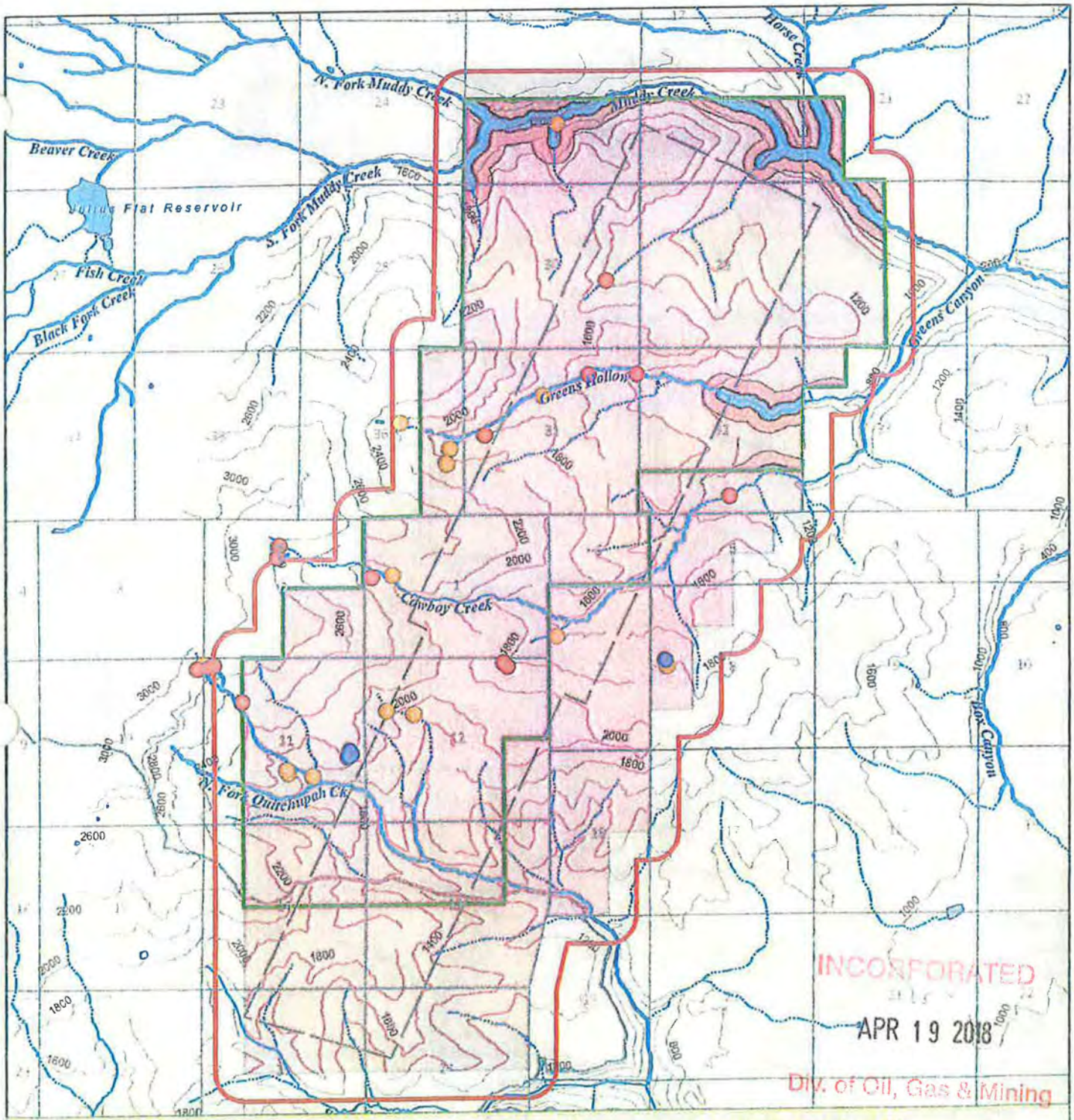

Figure 43. Spring Locations with Areas of High Impact (Alternative 3) and Overburden Thickness

1 0.5 0 1 Miles

1:53,500

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- Area of Subsidence Mining
- National Forest Boundary
- Conceptual Mining Area
- Section Boundaries
- Overburden contours (200 ft)
- Perennial Flow 2001
- Perennial Streams (USGS)
- Intermittent Streams (USGS)

Greens Hollow Springs

- High
- Moderate
- Unknown
- Stream Buffer
- Angle of Draw Buffer

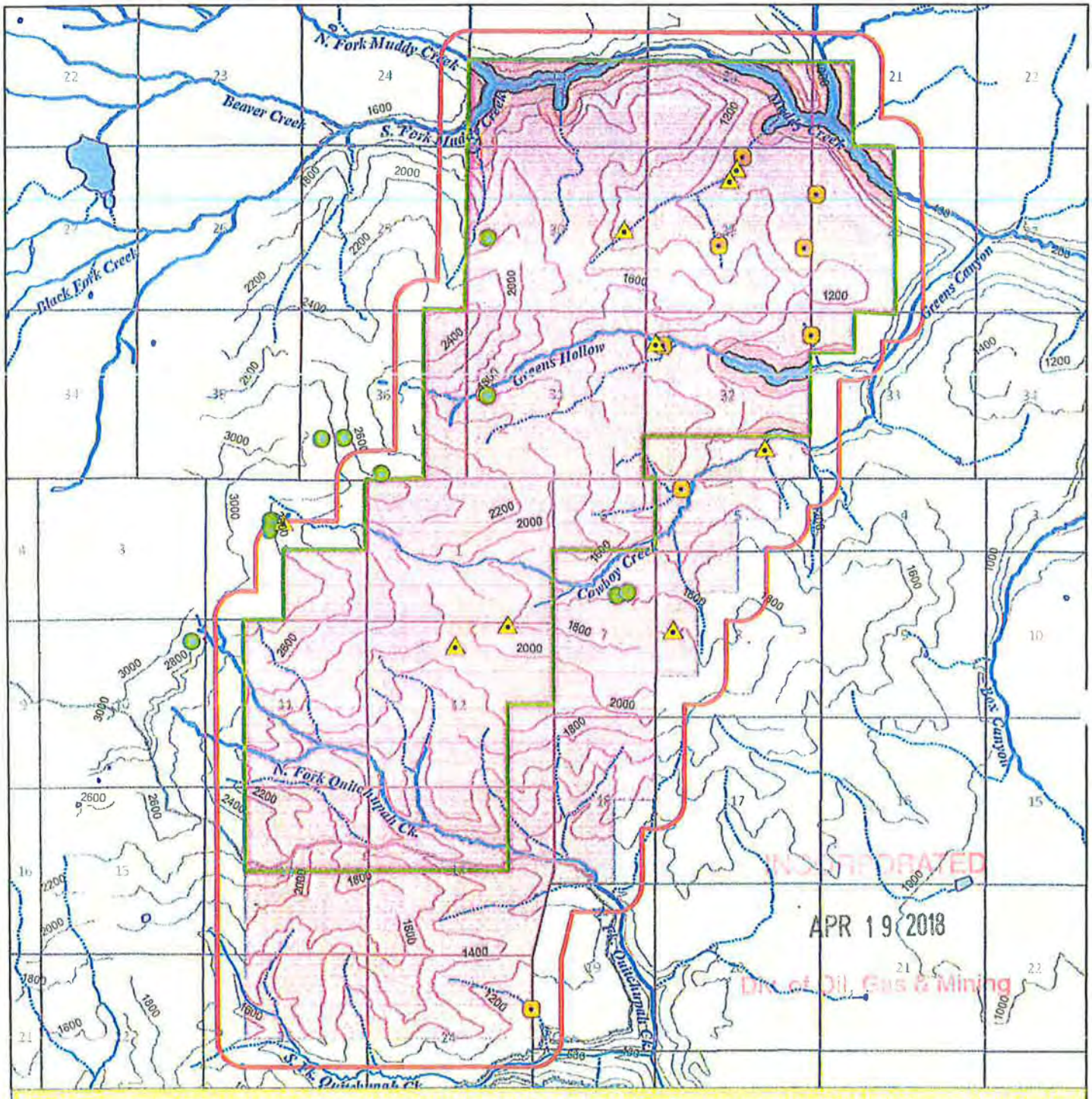

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Figure 44. Surface Water Features with Areas of High Impact (Alternative 3) and Overburden Thickness

1 0.5 0 1 Miles

1:53,500

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- Area of Subsidence Mining
- National Forest Boundary
- Section Boundaries
- Overburden contours (200 ft)
- Perennial Flow 2001
- Perennial Streams (USGS)
- Intermittent Streams (USGS)
- Stream Buffer
- Angle of Draw Buffer
- Cattle Troughs
- Natural Ponds
- Stock Ponds

TABLES

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Table 1. Spring Location and Field Monitoring Summary of Springs with Measurable Flow.

		LOCATION			MONITORING RESULTS										
			UTM Coordinates		Date		Discharge (gpm)					Specific Conductance (uS/cm)			
FORMATION	NAME	Elevation (ft)	Easting	Northing	Start	End	Average	Maximum	Minimum	Count	No Flow	Average	Maximum	Minimum	Count
North Horn Formation	M_SP03	8961	463762	4319529	6/19/01	6/3/04	1.04	1.95	0.08	4	3	378.58	824	76.80	4
	M_SP04	8812	464246	4319267	6/19/01	5/12/04	1.84	3.23	0.75	9	0	687.04	929	379.40	9
	M_SP05	8937	464212	4319133	9/26/02	5/12/04	0.17	0.26	0.08	4	0	686.75	910	524.00	4
	M_SP06	8952	464215	4319121	6/19/01	5/12/04	1.79	2.30	1.47	3	0	682.57	918	474.00	7
	M_SP07	8709	465280	4317433	6/20/01	5/10/04	0.46	1.14	0.21	9	0	655.50	878	441.50	9
	M_SP08	8820	464754	4317178	6/20/01	9/25/12	0.41	1.19	0.01	25	5	657.91	1013	331.70	8
	M_SP09	8849	464791	4317141	6/20/01	5/10/04	0.63	1.00	0.25	2	5	446.70	464	429.40	2
	M_SP12	8739	464583	4319397	6/19/01	6/3/04	0.60	0.94	0.26	6	1	544.18	785	398.70	6
	M_SP13	9637	462562	4318345	6/21/01	6/6/04	6.06	19.00	0.52	4	3	373.03	543	206.10	4
	M_SP14	9584	462545	4318227	6/21/01	6/6/04	22.53	61.40	0.86	5	3	357.80	542	294.70	5
	M_SP15	8811	463884	4316685	7/11/01	6/5/04	1.56	4.82	0.27	5	2	588.26	930	433.20	5
	M_SP19	8968	462644	4316124	7/11/01	6/5/04	2.56	3.13	1.98	7	0	520.50	851	442.90	7
	M_SP20	9395	462191	4316826	7/11/01	6/5/04	2.34	8.62	0.71	7	0	502.36	814	420.30	7
	M_SP21	9616	461814	4317195	7/11/01	6/5/04	1.84	3.66	0.98	4	3	350.88	558	240.00	4
	M_SP40	9163	463677	4318041	9/26/01	6/6/04	0.40	0.66	0.18	6	0	638.00	900	483.00	6
	M_SP41	9223	463475	4318025	9/26/01	6/6/04	0.75	2.25	0.40	6	0	483.93	799	285.40	6
	M_SP43	9568	461919	4317186	10/3/01	6/5/04	1.03	2.08	0.38	6	0	427.63	638	344.00	6
	M_SP44	9599	461759	4317150	10/3/01	6/5/04	3.48	13.03	0.20	6	0	416.27	721	269.00	6
	M_SP53	8941	466373	4317126	10/24/01	9/25/12	0.11	0.48	0.06	27	0	452.34	694	368.20	5
	M_SP59	8920	466357	4317186	10/24/01	6/6/04	0.31	0.69	0.12	5	1	548.66	859	445.90	5
	M_SP60	8801	462887	4316092	5/2/02	6/5/04	0.73	0.89	0.60	5	0	555.34	943	402.70	5
	M_SP61	9596	461881	4317168	5/2/02	6/5/04	0.32	0.37	0.25	5	0	316.12	593	36.10	5
	M_SP100	8975	463616	4316719	9/27/02	6/5/04	0.87	1.08	0.77	4	0	433.83	683	291.60	4
	M_SP103	8999	463271	4316302	5/21/03	6/5/04	1.21	1.51	0.94	3	0	499.40	706	376.60	3
	M_SP104	9052	463250	4316335	5/21/03	6/5/04	0.25	0.38	0.12	2	1	506.50	686	327.00	2
	M_SP105	8971	463233	4316280	5/21/03	6/5/04	0.79	0.95	0.62	3	0	479.97	696	362.90	3
	M_SP106	8997	462626	4316155	5/21/03	6/5/04	0.75	1.10	0.48	3	0	586.40	878	430.20	3
Price River Formation	M_SP01	8420	465615	4319979	6/19/01	9/6/12	0.47	1.11	0.16	29	0	562.23	851	434.70	9
	M_SP02	8335	466086	4319977	6/19/01	9/6/12	3.71	13.40	0.05	19	10	476.22	499	437.30	6
	M_SP18	8295	465794	4320892	6/22/01	9/6/12	0.31	0.77	0.06	27	2	889.71	1276	726.00	7
	M_SP39	8225	466990	4318775	8/30/01	9/6/12	1.22	4.66	0.22	28	0	748.38	1035	573.00	8
	M_SP45	8505	465156	4319780	10/4/01	6/3/04	1.64	2.23	0.67	6	0	724.23	977	369.40	6
Castlegate Formation	M_SP87	7922	465309	4322427	5/26/02	5/13/04	2.60	3.08	2.19	5	0	810.80	1277	627.00	5

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Table 2. Field Monitoring Summary of Springs by Geologic Formation.				
Formation	**Castlegate**	**Price River**	**North Horn**	**Project Area**
Number of Springs	1	5	27	33
Discharge (gpm)				
Number of Measurements	5	109	179	293
Maximum	3.08	13.40	61.40	61.40
Minimum	2.19	0.05	0.01	0.01
Median	2.52	0.54	0.56	0.57
Average	2.60	1.25	1.65	1.52
pH - Criteria: 6.5 - 9.0				
Number of Measurements	5	113	180	298
Maximum	8.39	8.49	8.72	8.72
Minimum	7.86	6.96	7.10	6.96
Median	8.14	7.43	7.72	7.62
Average	8.17	7.45	7.76	7.65
Dissolved Oxygen (mg/l) - Criteria : >3				
Number of Measurements	1	19	19	39
Maximum	6.60	7.39	7.69	7.69
Minimum	6.60	2.03	0.69	0.69
Median	6.60	4.82	6.03	5.21
Average	6.60	4.47	5.49	5.02
Water Temperature (Degree C) - Criteria : <27				
Number of Measurements	5	113	180	298
Maximum	6.10	16.50	27.60	27.60
Minimum	3.60	2.20	2.70	2.20
Median	5.20	6.30	7.25	6.70
Average	4.84	7.08	7.75	7.45
Specific Conductivity (uS/cm)				
Number of Measurements	5	36	140	181
Maximum	1,277	1,276	1,013	1,277
Minimum	627	369	36	36
Median	699	588	479	499
Average	811	680	528	566

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Table 3. Water Quality Results - North Horn Formation Springs (including M_SP04, MSP07, M_SP08, and M_SP14).

Parameter Name	Criteria (mg/l)					Concentration[a] (mg/l)			Mean	No. of Samples	No. of Detects	No. of Non-Detects
	Criteria 1C	Criteria 2B	Criteria 3A	Criteria 3C	Criteria 4	Max	Min	Median				
Acidity, as $CaCO_3$						38	7	17	19	19	19	
Aluminum (D)			0.75	0.75		0.05	0.03	0.05	0.04	19	5	14
Ammonia, as N			[b]	[b]		0.2	0.2	0.2	0.2	19	1	18
Arsenic (D)	0.01	0.1	0.340	0.340		0.1	0.0006	0.00125	0.01	19	18	1
Bicarbonate, as HC03-						580	340	530	516	27	27	
Boron (D)					0.75	0.11	0.06	0.07	0.08	19	17	2
Cadmium (D)	0.01		[c]0.002	[c]0.002	0.01	<0.005	<0.005	<0.005	<0.005	19	0	19
Calcium (D)						79	45	63	61	19	19	
Calcium (T)						83	48	64	65	27	27	
Carbonate, as CO_3						7	7	7	7	25	1	24
Chloride						60	2.1	29	30	27	27	
Copper (D)			[c]0.013	[c]0.013	0.2	<0.01	<0.01	<0.01	<0.01	19	0	19
Iron (D)			1	1		0.41	0.02	0.105	0.16	19	4	15
Iron (T)						2.5	0.03	0.36	0.7	24	17	7
Lead (D)	0.015		[c]0.065	[c]0.065	0.1	<0.07	<0.07	<0.07	<0.07	19	0	19
Magnesium (D)						43	24	37	35	19	19	
Magnesium (T)						43	24	38	35	27	27	
Manganese (D)						0.02	0.01	0.02	0.02	19	3	16
Manganese (T)						0.05	0.01	0.02	0.02	19	8	11
Molybdenum (D)						<0.02	<0.02	<0.02	<0.02	19	0	19
Nitrite, as N						<0.03	<0.03	<0.03	<0.03	19	0	19
NO2+NO3, as N						0.33	0.07	0.15	0.18	19	19	
Ortho-Phosphate						0.09	0.09	0.09	0.09	19	1	18
Potassium (D)						2.7	0.7	1.8	1.8	19	19	
Potassium (T)						6.7	0.7	2	2	22	20	2
Selenium (D)	0.05		0.0184	0.0184	0.05	0.1	0.0005	0.0026	0.01	18	17	1
Sodium (D)						130	15	87	92	19	19	
Sodium (T)						130	15	89	84	22	22	
Sulfate						44	6	24	23	27	27	
Total Alkalinity, as $CaCO_3$						480	279	440	419	27	27	
Total Anions						12	6.6	10	10	15	15	
Total Cations						12	6.7	10	10	15	15	
Total Dissolved Solids					[d]1,200 [e]2,000	651	238	501	486	27	27	
Total Hardness, as $CaCO_3$						340	230	310	296	19	19	
Zinc (D)			[c]0.12	[c]0.12		0.02	0.01	0.01	0.01	19	8	11

[a] Concentrations are based on sample measurements above detection limits (No. of Detects).

[b] Specific criterion varies with pH per Utah Administrative Code R317-2, Table 2.14.2.

[c] Specific criterion varies with hardness per Utah Administrative Code R317-2, Table 2.14.3b.

[d] For irrigation.

[e] For stock watering.

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Table 4. Water Quality Results - Price River Formation Springs (including M_SP01, M_SP02, M_SP18, and M_SP39).

Parameter Name	Criteria (mg/l)					Concentration[a] (mg/l)			Mean	No. of Samples	No. of Detects	No. of Non-Detects
	Criteria 1C	Criteria 2B	Criteria 3A	Criteria 3C	Criteria 4	Max	Min	Median				
Acidity, as $CaCO_3$						56	11	18	22	19	19	0
Aluminum (D)			0.75	0.75		0.06	0.04	0.05	0.05	19	4	15
Ammonia, as N			[b]	[b]		<0.02	<0.02	<0.02	<0.02	19	0	19
Arsenic (D)	0.01		0.340	0.340	0.1	0.1	0.0005	0.00095	0.01	19	18	1
Bicarbonate, as HC03-						552	344	473	464	31	31	0
Boron (D)					0.75	0.19	0.05	0.07	0.08	19	18	1
Cadmium (D)	0.01		[c]0.002	[c]0.002	0.01	<0.005	<0.005	<0.005	<0.005	19	0	19
Calcium (D)						130	73	80	90	19	19	0
Calcium (T)						140	73	81	90	27	27	0
Carbonate, as CO_3						<5	<5	<5	<5	31	0	31
Chloride						833	35	56	82	27	27	0
Copper (D)			[c]0.013	[c]0.013	0.2	<0.01	<0.01	<0.01	<0.01	19	0	19
Iron (D)			1	1		0.08	0.02	0.04	0.05	19	5	14
Iron (T)						37	0.02	0.15	3	26	12	14
Lead (D)	0.015		[c]0.065	[c]0.065	0.1	<0.07	<0.07	<0.07	<0.07	19	0	19
Magnesium (D)						50	33	42	43	19	19	0
Magnesium (T)						50	33	42	42	27	27	0
Manganese (D)						0.01	0.01	0.01	0.01	19	3	16
Manganese (T)						0.24	0.01	0.01	0.09	19	3	16
Molybdenum (D)						<0.02	<0.02	<0.02	<0.02	19	0	19
Nitrite, as N						<0.03	<0.03	<0.03	<0.03	19	0	19
NO2+NO3, as N						0.12	0.03	0.075	0.07	19	12	7
Ortho-Phosphate						<0.05	<0.05	<0.05	<0.05	19	0	19
Potassium (D)						5.2	1.7	2.1	2.7	19	19	0
Potassium (T)						6.6	1	2.1	3	21	21	0
Selenium (D)	0.05		0.0184	0.0184	0.05	0.0088	0.0019	0.0033	0.0039	19	17	2
Sodium (D)						96	43	82	70	19	19	0
Sodium (T)						100	43	80	71	21	21	0
Sulfate						330	26	65	101	27	27	0
Total Alkalinity, as $CaCO_3$						453	282	385	375	31	31	0
Total Anions						15	9.1	10.5	11	16	16	0
Total Cations						14	9.1	10.5	11	16	16	0
Total Dissolved Solids					[d]1,200 [e]2,000	1214	449	553	618	27	27	0
Total Hardness, as $CaCO_3$						510	330	390	400	19	19	0
Zinc (D)			[c]0.12	[c]0.12		0.13	0.01	0.01	0.03	19	13	6

[a] Concentrations are based on sample measurements above detection limits (No. of Detects).

[b] Specific criterion varies with pH per Utah Administrative Code R317-2, Table 2.14.2.

[c] Specific criterion varies with hardness per Utah Administrative Code R317-2, Table 2.14.3b.

[d] For irrigation.

[e] For stock watering.

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Table 5. Value of springs in the Greens Hollow Tract project area.					
Spring Site ID	< 500 ft to Wetland	< 25 ft to Wetland	< 500 ft to Riparian	Developed	Value
M_SP01			X	X	High
M_SP02		X	X	X	High
M_SP03			X		Moderate
M_SP04			X		Moderate
M_SP05			X		Moderate
M_SP06			X		Moderate
M_SP07	X		X		Moderate
M_SP08		X		X	High
M_SP09		X			High
M_SP12		X	X		High
M_SP13		X	X		High
M_SP14		X		X	High
M_SP15			X		Moderate
M_SP18				X	High
M_SP19			X		Moderate
M_SP20		X	X		High
M_SP21			X		Moderate
M_SP39		X	X	X	High
M_SP40			X		Moderate
M_SP41		X	X		High
M_SP43		X			High
M_SP44		X			High
M_SP45			X		Moderate
M_SP53				X	Moderate
M_SP59					Unknown
M_SP60			X		Moderate
M_SP61		X	X		High
M_SP87			X		Moderate
M_SP100			X		Moderate
M_SP103					Unknown
M_SP104					Unknown
M_SP105					Unknown
M_SP106			X		Moderate

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Table 6. Field Monitoring Summary for Greens Hollow Tract Surface Water Monitoring Stations.										
Station ID	M_STR1	M_STR2	M_STR3	M_STR4	M_STR5	M_STR6	M_STR7	M_STR8	M_STR9	M_STR10
Location	Greens Canyon	Greens Canyon	Lower Cowboy Creek	Upper Cowboy Creek	Cowboy Creek	Greens Hollow	Unnamed Drainage	South Fork Muddy Ck.	S. Fork of N. Fork Quitchupah Ck.	Upper N. Fork Quitchupah Ck.
Start	6/6/01	8/7/02	6/6/01	6/7/01	8/8/02	6/7/01	9/25/02	9/26/02	10/5/79	10/5/79
End	5/10/04	5/10/04	5/10/04	9/25/12	5/11/04	5/11/04	5/13/04	5/13/04	9/12/12	9/26/12
# Visits	16	8	16	37	8	16	6	6	94	98
Flow (GPM)										
# NOF	13	1	2	21	1	5	6	0	1	0
# Samples	3	7	14	16	7	11	0	6	90	91
Maximum	672	460	491	717	598	27	0	15,644	1,116	6,032
Minimum	9.7	1.2	0.5	0.7	1.4	1.9	0.0	967.7	0.1	0.2
Median	50.1	2.9	2.6	12.6	2.0	5.7	0.0	2,767.0	112.2	188.5
Average	243.9	78.1	44.2	69.2	95.6	10.0	0.0	5,225.5	196.5	715.9
pH - Criteria: 6.5-9.0										
# Samples	3	7	13	15	7	10	0	6	90	91
Maximum	8.92	8.84	8.73	8.87	8.82	8.77	0.00	8.90	8.89	9.20
Minimum	8.48	7.97	7.72	8.48	6.50	7.92	0.00	8.69	7.10	7.30
Median	8.61	8.25	8.01	8.72	8.47	8.52	0.00	8.73	8.34	8.40
Average	8.7	8.3	8.1	8.7	8.3	8.5	0.0	8.8	8.3	8.3
Dissolved Oxygen (mg/l) - Criteria >4 (or >8 when early life stages are present)										
# Samples	3	7	13	14	7	10	0	6	43	44
Maximum	8.65	11.19	9.70	10.40	9.04	8.73	0.00	13.66	10.60	10.60
Minimum	7.53	5.84	3.58	5.23	7.23	3.14	0.00	7.51	5.00	5.65
Median	8.6	8.4	5.6	7.9	8.2	7.1	0.0	9.5	7.4	7.7
Average	8.3	8.3	6.1	7.8	8.2	6.8	0.0	9.9	7.5	7.8
Water Temperature (Degree C) - Criteria: <20										
# Samples	3	7	13	15	7	10	0	6	90	91
Maximum	13.6	14.9	13.0	21.2	10.3	23.3	0.0	16.2	22.8	22.5
Minimum	0.7	0.8	3.6	0.3	6.0	2.7	0.0	1.0	0.3	0.0
Median	9.9	9.3	8.4	12.1	9.5	12.1	0.0	4.9	14.7	12.5
Average	8.1	8.8	8.4	12.6	8.4	12.8	0.0	6.6	13.5	12.5
Specific Conductivity (uS/cm)										
# Samples	2	7	13	7	7	10	0	6	58	63
Maximum	567	722	659	869	616	822	0	371	1,300	1,384
Minimum	448	416	202	386	346	439	0	65	398	294
Median	507.7	509.0	404.7	514.0	445.8	572.0	0.0	240.4	710.0	490.0
Average	507.7	554.5	434.6	582.1	475.9	615.3	0.0	250.0	729.6	500.8
Turbidity (ntu)										
# Samples	3	7	13	7	6	10	0	5	50	53
Maximum	19.6	39.9	51.4	76.3	22.5	96.3	0.0	6.8	640.0	1125.0
Minimum	7.5	0.7	0.0	0.0	1.4	8.3	0.0	1.5	1.7	0.9
Median	18.4	3.7	2.8	4.7	4.0	21.4	0.0	2.2	29.7	24.0
Average	15.2	14.0	12.4	15.4	8.5	36.7	0.0	3.5	50.6	143.4

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Table 7. Flood Flow Analysis for Greens Hollow Drainages									
Drainage Basin Location	**Area (ares)**	**Area (sq Mi)**	**Mean Elevation (ft. msl)**	**Q2**	**Q5**	**Q10**	**Q25**	**Q50**	**Q100**
Greens Canyon @ STR-1	5,859	9.15	8720	199	443	656	1,017	1,351	1,716
Greens Hollow @ STR-6	1,573	2.46	8786	102	243	371	592	800	1,033
Cowboy Creek @ STR-3	3,580	5.59	8795	154	351	526	823	1,101	1,406
Unnamed Tributary @ STR-7	555	0.87	8296	64	164	258	424	582	764
NF. Quitchupah @ Sufco 042	15,373	24.02	8382	336	718	1,045	1,591	2,092	2,628
Muddy Creek @ Sufco 405	46,372	72.46	9254	528	1,039	1,455	2,143	2,763	3,405
Muddy Creek @ USGS 09330500	69,639	108.8	8879	676	1,315	1,832	2,685	3,451	4,239
Frequency Analysis Estimate for Muddy Creek @ USGS 09330500	69,639	108.8		441	959	1,502	2,495	3,523	4,866

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Table 8. Water Quality Results (2002-2004) - Stream Monitoring Station M_STR8, South Fork of Muddy Creek.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					na	na	na	BDL	6	0	6
Aluminum (D)			0.75[a]		0.04	0.03	0.035	0.04	6	2	4
Ammonia, as N			[b]		na	na	na	BDL	6	0	6
Arsenic (D)	0.01		0.15	0.1	0.0011	0.0009	0.001	0.001	6	4	2
Bicarbonate, as HC03-					280	230	255	258	6	6	0
Boron (D)				0.75	na	na	na	BDL	6	0	6
Cadmium (D)	0.01		2[c]	0.01	na	na	na	BDL	6	0	6
Calcium (D)					54	43	47.5	49	6	6	0
Calcium (T)					63	46	48	52	3	3	0
Carbonate, as CO3--					9	2	7	6	6	5	1
Chloride					3.1	1.4	1.95	2.1	6	6	0
Chromium (D)	0.05		0.016	0.1	na	na	na	na	0	0	0
Copper (D)			0.013[c]	0.2	na	na	na	BDL	6	0	6
Cyanide (D)			0.0052		na	na	na	na	0	0	0
Hydroxide					na	na	na	BDL	2	0	2
Iron (D)			1		na	na	na	BDL	6	0	6
Iron (T)					0.45	0.02	0.11	0.19	6	6	0
Lead (D)	0.015		0.065[c]	0.1	na	na	na	BDL	6	0	6
Magnesium (D)					27	22	24.5	25	6	6	0
Magnesium (T)					28	25	25	26	3	3	0
Manganese (D)					na	na	na	BDL	6	0	6
Manganese (T)					0.02	0.01	0.02	0.02	6	3	3
Mercury (D)	0.002		0.0024		na	na	na	na	0	0	0
Molybdenum (D)					na	na	na	BDL	6	0	6
Nickel (D)			0.468[c]		na	na	na	na	0	0	0
Nitrite, as N					na	na	na	BDL	6	0	6
NO2+NO3, as N					0.8	0.54	0.675	0.7	6	6	0
Ortho-Phosphate					na	na	na	BDL	6	0	6
Potassium (D)					0.7	0.6	0.6	0.6	6	6	0
Potassium (T)					na	na	na	na	0	0	0
Selenium (D)	0.05	0.05	0.0184		0.0008	0.0006	0.00065	0.0007	6	4	2
Silver (D)	0.05		0.0016[c]		na	na	na	na	0	0	0
Sodium (D)					12	5.5	8.95	9	6	6	0
Sodium (T)					na	na	na	na	0	0	0
Sulfate					12	6.6	8.85	9	6	6	0
Total Alkalinity, as CaCO3					230	200	221	219	6	6	0
Total Anions					5	4.2	4.6	5	5	5	0
Total Cations					5.2	4.4	4.9	4.9	5	5	0
Total Dissolved Solids				1,200[d] 2,000[e]	270	208	238	238	6	6	0
Total Hardness, as CaCO3					230	210	220	222	6	6	0
Total Phosphorus		0.05	0.05		na	na	na	na	0	0	0
Total Suspended Solids					44	5	12	18	6	6	0
Zinc (D)			0.120[c]		0.01	0.01	0.01	0.01	6	2	4

a = Criterion varies with pH and hardness.
b = Criterion varies with pH and temperature.
c = Criterion varies with hardness.
d = For irrigation.
e = For stock watering.

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Table 9. Water Quality Results (2001-2004) - Stream Monitoring Station M_STR1, Lower Greens Canyon.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					na	na	na	BDL	2	0	2
Aluminum (D)			0.75[a]		0.03	0.03	0.03	0.03	3	1	2
Ammonia, as N			[b]		na	na	na	BDL	2	0	2
Arsenic (D)	0.01		0.15	0.1	0.1	0.0008	0.001	0.03	3	3	0
Bicarbonate, as HC03-					350	260	349	320	3	3	0
Boron (D)				0.75	na	na	na	BDL	2	0	2
Cadmium (D)	0.01		2[c]	0.01	na	na	na	BDL	3	0	3
Calcium (D)					50	45	47.5	48	2	2	0
Calcium (T)					53	43	50	49	3	3	0
Carbonate, as CO3--					18	5	7	10	3	3	0
Chloride					24	7.4	18	16	3	3	0
Chromium (D)	0.05		0.016	0.1	0.0034	0.0034	0.0034	0.0034	3	1	2
Copper (D)			0.013[c]	0.2	0.0013	0.0013	0.0013	0.0013	3	1	2
Cyanide (D)			0.0052		0.002	0.002	0.002	0.002	3	1	2
Hydroxide					na	na	na	BDL	1	0	1
Iron (D)			1		na	na	na	BDL	2	0	2
Iron (T)					0.57	0.15	0.5	0.41	3	3	0
Lead (D)	0.015		0.065[c]	0.1	na	na	na	BDL	3	0	3
Magnesium (D)					27	19	na	23	2	2	0
Magnesium (T)					35	19	32	29	3	3	0
Manganese (D)					na	na	na	BDL	2	0	2
Manganese (T)					0.02	0.02	0.02	0.02	2	1	1
Mercury (D)	0.002		0.0024		0.0002	0.0002	0.0002	0.0002	3	2	1
Molybdenum (D)					na	na	na	BDL	2	0	2
Nickel (D)			0.468[c]		0.0016	0.0016	0.0016	0.002	3	1	2
Nitrite, as N					na	na	na	BDL	3	0	3
NO2+NO3, as N					na	na	na	BDL	3	0	3
Ortho-Phosphate					0.07	0.07	0.07	0.07	3	1	2
Potassium (D)					2.3	1.8	2.05	2.1	2	2	0
Potassium (T)					3.1	2	2.7	3	3	3	0
Selenium (D)	0.05	0.05	0.0184		0.001	0.0005	0.00075	0.00075	3	2	1
Silver (D)	0.05		0.0016[c]		na	na	na	BDL	3	0	3
Sodium (D)					42	32	37	37	2	2	0
Sodium (T)					54	30	48	44	3	3	0
Sulfate					34	13	34	27	3	3	0
Total Alkalinity, as CaCO3					298	250	290	279	3	3	0
Total Anions					7.1	5.3	6.2	6.2	2	2	0
Total Cations					6.3	5.5	5.9	5.9	2	2	0
Total Dissolved Solids				1,200[d] 2,000[e]	570	378	401	450	3	3	0
Total Hardness, as CaCO3					220	200	210	210	2	2	0
Total Phosphorus		0.05	0.05		0.05	0.03	0.05	0.04	3	3	0
Total Suspended Solids					15	7	11	11	2	2	0
Zinc (D)			0.120[c]		0.02	0.02	0.02	0.02	3	1	2

a = Criterion varies with pH and hardness.
b = Criterion varies with pH and temperature.
c = Criterion varies with hardness.
d = For irrigation.
e = For stock watering.

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Table 10. Water Quality Results (2002-2004) - Stream Monitoring Station M_STR2, Greens Canyon.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					na	na	na	BDL	6	0	6
Aluminum (D)			0.75[a]		0.06	0.05	0.04	0.06	7	2	5
Ammonia, as N			[b]		na	na	na	BDL	6	0	6
Arsenic (D)	0.01		0.15	0.1	0.0016	0.0009	0.001	0.001	7	4	3
Bicarbonate, as HC03-					411	280	356	355	7	7	0
Boron (D)				0.75	0.07	0.05	0.055	0.06	6	4	2
Cadmium (D)	0.01		2[c]	0.01	na	na	na	BDL	7	0	7
Calcium (D)					77	48	58	64	6	6	0
Calcium (T)					77	58	56.5	67	7	7	0
Carbonate, as CO3--					14	5	6	8	7	3	4
Chloride					38	5.3	26.4	25	7	7	0
Chromium (D)	0.05		0.016	0.1	na	na	na	BDL	6	0	6
Copper (D)			0.013[c]	0.2	na	na	na	BDL	7	0	7
Cyanide (D)			0.0052		na	na	na	BDL	6	0	6
Hydroxide					na	na	na	BDL	2	0	2
Iron (D)			1		na	na	na	BDL	6	0	6
Iron (T)					1.6	0.05	0.41	0.6	7	6	1
Lead (D)	0.015		0.065[c]	0.1	na	na	na	BDL	7	0	7
Magnesium (D)					53	18	33	38	6	6	0
Magnesium (T)					52	20	35	39	7	7	0
Manganese (D)					0.02	0.02	0.015	0.02	6	1	5
Manganese (T)					0.07	0.01	0.02	0.04	6	4	2
Mercury (D)	0.002		0.0024		na	na	na	BDL	6	0	6
Molybdenum (D)					na	na	na	BDL	6	0	6
Nickel (D)			0.468[c]		na	na	na	BDL	6	0	6
Nitrite, as N					na	na	na	BDL	6	0	6
NO2+NO3, as N					0.11	0.11	0.085	0.11	7	1	6
Ortho-Phosphate					0.08	0.08	0.07	0.08	7	1	6
Potassium (D)					4.1	2.4	2.7	3.1	6	6	0
Potassium (T)					4.8	2.7	2.75	3.6	6	6	0
Selenium (D)	0.05	0.05	0.0184		0.0021	0.0006	0.00135	0.0012	7	5	2
Silver (D)	0.05		0.0016[c]		na	na	na	BDL	6	0	6
Sodium (D)					54	28	41	44	6	6	0
Sodium (T)					52	28	41.5	44	6	6	0
Sulfate					140	9.1	41.5	74	7	7	0
Total Alkalinity, as CaCO3					337	230	292.5	295	7	7	0
Total Anions					10	4.9	7.25	8	5	5	0
Total Cations					11	5.1	7.3	8	5	5	0
Total Dissolved Solids				1,200[d] 2,000[e]	531	271	394.5	438	7	7	0
Total Hardness, as CaCO3					410	190	280	315	6	6	0
Total Phosphorus		0.05	0.05		0.12	0.03	0.05	0.07	6	6	0
Total Suspended Solids					83	9	41	33	6	5	1
Zinc (D)			0.120[c]		0.02	0.01	0.02	0.01	7	4	3

a = Criterion varies with pH and hardness
b = Criterion varies with pH and temperature
c = Criterion varies with hardness
d = For irrigation
e = For stock watering

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Table 11. Water Quality Results (2001-2004) - Stream Monitoring Station M_STR3, Lower Cowboy Creek.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					6	6	6	6	5	1	4
Aluminum (D)			0.75[a]		0.05	0.03	0.04	0.04	12	5	7
Ammonia, as N			[b]		na	na	na	BDL	5	0	5
Arsenic (D)	0.01		0.15	0.1	0.1	0.0008	0.001	0.01	12	9	3
Bicarbonate, as HC03-					373	250	356	346	12	12	0
Boron (D)				0.75	0.07	0.05	0.055	0.06	5	4	1
Cadmium (D)	0.01		2[c]	0.01	na	na	na	BDL	12	0	12
Calcium (D)					62	42	58	55	5	5	0
Calcium (T)					63	41	56.5	56	12	12	0
Carbonate, as CO3--					6	6	6	6	12	2	10
Chloride					30	4.5	26.4	24	12	12	0
Chromium (D)	0.05		0.016	0.1	0.0037	0.001	0.0036	0.003	12	3	9
Copper (D)			0.013[c]	0.2	0.001	0.0007	0.0008	0.001	12	3	9
Cyanide (D)			0.0052		0.005	0.002	0.003	0.003	12	3	9
Hydroxide					na	na	na	BDL	2	0	2
Iron (D)			1		0.02	0.02	0.02	0.02	5	1	4
Iron (T)					1.7	0.1	0.41	0.6	12	8	4
Lead (D)	0.015		0.065[c]	0.1	na	na	na	BDL	12	0	12
Magnesium (D)					39	14	33	30	5	5	0
Magnesium (T)					39	16	35	34	12	12	0
Manganese (D)					0.02	0.01	0.015	0.02	5	2	3
Manganese (T)					0.06	0.02	0.02	0.03	7	5	2
Mercury (D)	0.002		0.0024		na	na	na	BDL	12	0	12
Molybdenum (D)					na	na	na	BDL	5	0	5
Nickel (D)			0.468[c]		0.01	0.0013	0.0022	0.004	12	5	7
Nitrite, as N					na	na	na	BDL	7	0	7
NO2+NO3, as N					0.31	0.03	0.085	0.12	12	6	6
Ortho-Phosphate					0.07	0.07	0.07	0.07	7	1	6
Potassium (D)					3.4	2.1	2.7	2.6	5	5	0
Potassium (T)					4.5	2	2.75	3	12	12	0
Selenium (D)	0.05	0.05	0.0184		0.0027	0.0005	0.00135	0.0014	12	10	2
Silver (D)	0.05		0.0016[c]		na	na	na	BDL	12	0	12
Sodium (D)					50	23	41	39	5	5	0
Sodium (T)					57	22	41.5	42	12	12	0
Sulfate					55	7.4	41.5	39	12	12	0
Total Alkalinity, as CaCO3					306	210	292.5	286	12	12	0
Total Anions					8	4.3	7.25	7	4	4	0
Total Cations					8.1	4.3	7.3	6.8	4	4	0
Total Dissolved Solids				1,200[d] 2,000[e]	418	247	394.5	382	12	12	0
Total Hardness, as CaCO3					310	160	280	258	5	5	0
Total Phosphorus		0.05	0.05		0.13	0.03	0.05	0.06	12	9	3
Total Suspended Solids					113	7	41	42	7	7	0
Zinc (D)			0.120[c]		0.04	0.01	0.02	0.02	12	5	7

a = Criterion varies with pH and hardness.
b = Criterion varies with pH and temperature.
c = Criterion varies with hardness.
d = For irrigation.
e = For stock watering

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Table 12. Water Quality Results (2001-2004) - Stream Monitoring Station M_STR4, Upper Cowboy Creek.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					na	na	na	BDL	2	0	2
Aluminum (D)			0.75[a]		0.06	0.03	0.045	0.05	6	2	4
Ammonia, as N			[b]		na	na	na	BDL	2	0	2
Arsenic (D)	0.01		0.15	0.1	0.1	0.0008	0.00125	0.03	6	4	2
Bicarbonate, as HC03-					431	280	360.5	364	6	6	0
Boron (D)				0.75	na	na	na	BDL	2	0	2
Cadmium (D)	0.01		2[c]	0.01	na	na	na	BDL	6	0	6
Calcium (D)					52	50	51	51	2	2	0
Calcium (T)					60	34	55.5	50	6	6	0
Carbonate, as CO3--					17	5	12	12	6	6	0
Chloride					60	5.6	29	31	6	6	0
Chromium (D)	0.05		0.016	0.1	0.0039	0.0039	0.0039	0.0039	6	1	5
Copper (D)			0.013[c]	0.2	0.0011	0.0011	0.0011	0.0011	6	1	5
Cyanide (D)			0.0052		0.004	0.004	0.004	0.004	6	1	5
Hydroxide					na	na	na	BDL	1	0	1
Iron (D)			1		na	na	na	BDL	2	0	2
Iron (T)					0.57	0.18	0.29	0.33	6	5	1
Lead (D)	0.015		0.065[c]	0.1	na	na	na	BDL	6	0	6
Magnesium (D)					27	18	22.5	23	2	2	0
Magnesium (T)					43	19	37.5	35	6	6	0
Manganese (D)					0.01	0.01	0.01	0.01	2	2	0
Manganese (T)					0.03	0.02	0.025	0.03	3	2	1
Mercury (D)	0.002		0.0024		na	na	na	BDL	6	0	6
Molybdenum (D)					na	na	na	BDL	2	0	2
Nickel (D)			0.468[c]		0.01	0.0016	0.0019	0.005	6	3	3
Nitrite, as N					na	na	na	BDL	3	0	3
NO2+NO3, as N					0.05	0.05	0.05	0.05	6	1	5
Ortho-Phosphate					na	na	na	BDL	4	0	4
Potassium (D)					2	1.6	1.8	2	2	2	0
Potassium (T)					3	1	2.15	2	6	6	0
Selenium (D)	0.05	0.05	0.0184		0.0016	0.0006	0.00095	0.0010	6	4	2
Silver (D)	0.05		0.0016[c]		na	na	na	BDL	6	0	6
Sodium (D)					49	27	38	38	2	2	0
Sodium (T)					87	25	65.5	63	6	6	0
Sulfate					71	9.3	30	38	6	6	0
Total Alkalinity, as CaCO3					372	240	317.5	318	6	6	0
Total Anions					7.1	5.2	6.15	6.2	2	2	0
Total Cations					6.9	5.3	6.1	6.1	2	2	0
Total Dissolved Solids				1,200[d] 2,000[e]	548	280	414	420	6	6	0
Total Hardness, as CaCO3					240	200	220	220	2	2	0
Total Phosphorus		0.05	0.05		0.1	0.01	0.035	0.0	6	4	2
Total Suspended Solids					21	17	19	19	2	2	0
Zinc (D)			0.120[c]		0.01	0.01	0.01	0.01	6	2	4

a = Criterion varies with pH and hardness.
b = Criterion varies with pH and temperature.
c = Criterion varies with hardness.
d = For irrigation.
e = For stock watering.

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Table 13. Water Quality Results (2002-2004) - Stream Monitoring Station M_STR5, Cowboy Creek.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					na	na	na	BDL	6	0	6
Aluminum (D)			0.75_a		0.05	0.03	0.04	0.04	8	3	5
Ammonia, as N			$_b$		na	na	na	BDL	6	0	6
Arsenic (D)	0.01		0.15	0.1	0.0009	0.0006	0.0008	0.0008	8	5	3
Bicarbonate, as HC03-					360	290	318	331	8	8	0
Boron (D)				0.75	0.06	0.05	0.05	0.05	6	4	2
Cadmium (D)	0.01		2_c	0.01	na	na	na	BDL	8	0	8
Calcium (D)					55	51	53	53	6	6	0
Calcium (T)					60	51	54.5	55	8	8	0
Carbonate, as CO3--					10	6	7	8	8	5	3
Chloride					29	5.6	24	22	8	8	0
Chromium (D)	0.05		0.016	0.1	0.0034	0.0034	0.0034	0.0034	7	1	6
Copper (D)			0.013_c	0.2	na	na	na	BDL	8	0	8
Cyanide (D)			0.0052		0.002	0.002	0.002	0.002	6	0	6
Hydroxide					na	na	na	BDL	2	0	2
Iron (D)			1		na	na	na	BDL	6	0	6
Iron (T)					0.68	0.02	0.13	0.29	8	7	1
Lead (D)	0.015		0.065_c	0.1	na	na	na	BDL	8	0	8
Magnesium (D)					36	18	34.5	31	6	6	0
Magnesium (T)					36	19	34.5	33	8	8	0
Manganese (D)					na	na	na	BDL	6	0	6
Manganese (T)					0.02	0.01	0.02	0.02	7	4	3
Mercury (D)	0.002		0.0024		na	na	na	BDL	6	0	6
Mercury (T)					na	na	na	BDL	1	0	1
Molybdenum (D)					na	na	na	BDL	6	0	6
Nickel (D)			0.468_c		0.01	0.0069	0.01	0.01	7	3	4
Nitrite, as N					na	na	na	BDL	6	0	6
NO2+NO3, as N					0.27	0.03	0.14	0.14	8	6	2
Ortho-Phosphate					na	na	na	BDL	7	0	7
Potassium (D)					2.2	1.7	2	2	6	6	0
Potassium (T)					2.6	2	2.1	2.2	7	7	0
Selenium (D)	0.05	0.05	0.0184		0.0035	0.0006	0.002	0.002	8	5	3
Silver (D)	0.05		0.0016_c		na	na	na	BDL	7	0	7
Sodium (D)					52	27	32.5	35	6	6	0
Sodium (T)					59	25	33	36	7	7	0
Sulfate					39	9.1	35	31	8	8	0
Total Alkalinity, as CaCO3					300	240	268.5	274	8	8	0
Total Anions					7.4	5.1	7.1	6.8	5	5	0
Total Cations					7.2	5.3	7	7	5	5	0
Total Dissolved Solids				$1{,}200_d$ $2{,}000_e$	405	290	348.5	350	8	8	0
Total Hardness, as CaCO3					300	200	275	263	6	6	0
Total Phosphorus		0.05	0.05		0.05	0.01	0.02	0.03	7	6	1
Total Suspended Solids					400	6	21	84	6	6	0
Zinc (D)			0.120_c		0.08	0.01	0.01	0.03	8	5	3

a = Criterion varies with pH and hardness.
b = Criterion varies with pH and temperature.
c = Criterion varies with hardness.
d = For irrigation.
e = For stock watering

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Table 14. Water Quality Results (2001-2004) - Stream Monitoring Station M_STR6, Greens Hollow.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					na	na	na	BDL	2	0	2
Aluminum (D)			0.75[a]		0.05	0.03	0.045	0.04	9	4	5
Ammonia, as N			[b]		na	na	na	BDL	2	0	2
Arsenic (D)	0.01		0.15	0.1	0.0025	0.0015	0.0016	0.0019	9	5	4
Bicarbonate, as HC03-					538	381	430	439	9	9	0
Boron (D)				0.75	0.06	0.05	0.055	0.06	2	2	0
Cadmium (D)	0.01		2[c]	0.01	na	na	na	BDL	9	0	9
Calcium (D)					55	55	55	55	2	2	0
Calcium (T)					66	37	58	56	9	9	0
Carbonate, as CO3--					17	2	9.5	10	9	6	3
Chloride					57.9	21	40	41	9	9	0
Chromium (D)	0.05		0.016	0.1	0.006	0.0045	0.0051	0.005	9	3	6
Copper (D)			0.013[c]	0.2	0.0019	0.0014	0.00165	0.002	9	2	7
Cyanide (D)			0.0052		0.015	0.008	0.0115	0.01	9	2	7
Hydroxide					na	na	na	BDL	1	0	1
Iron (D)			1		na	na	na	BDL	2	0	2
Iron (T)					1.7	0.3	0.54	0.8	9	9	0
Lead (D)	0.015		0.065[c]	0.1	na	na	na	BDL	9	0	9
Magnesium (D)					31	25	28	28	2	2	0
Magnesium (T)					42	25	36	35	9	9	0
Manganese (D)					0.01	0.01	0.01	0.01	2	1	1
Manganese (T)					0.04	0.03	0.035	0.04	3	2	1
Mercury (D)	0.002		0.0024		na	na	na	BDL	9	0	9
Molybdenum (D)					na	na	na	BDL	2	0	2
Nickel (D)			0.468[c]		0.01	0.0014	0.0027	0.004	9	5	4
Nitrite, as N					na	na	na	BDL	4	0	4
NO2+NO3, as N					0.08	0.04	0.05	0.06	9	3	6
Ortho-Phosphate					na	na	na	BDL	4	0	4
Potassium (D)					2.8	2.7	2.75	2.8	2	2	0
Potassium (T)					9	2	3.2	4	9	9	0
Selenium (D)	0.05	0.05	0.0184		0.0014	0.0008	0.0009	0.0010	9	7	2
Silver (D)	0.05		0.0016[c]		na	na	na	BDL	9	0	9
Sodium (D)					85	80	82.5	83	2	2	0
Sodium (T)					101	77	86	87	9	9	0
Sulfate					53	21	41	40	9	9	0
Total Alkalinity, as CaCO3					441	341	373	373	9	9	0
Total Anions					8.8	8.3	8.55	8.6	2	2	0
Total Cations					8.8	8.6	8.7	8.7	2	2	0
Total Dissolved Solids				1,200[d] 2,000[e]	595	451	515	508	9	9	0
Total Hardness, as CaCO3					260	240	250	250	2	2	0
Total Phosphorus		0.05	0.05		0.14	0.03	0.06	0.07	9	8	1
Total Suspended Solids					42	21	25	29	3	3	0
Zinc (D)			0.120[c]		0.02	0.01	0.01	0.01	9	4	5

a = Criterion varies with pH and hardness.
b = Criterion varies with pH and temperature
c = Criterion varies with hardness.
d = For irrigation.
e = For stock watering

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Table 15. Water Quality Results (1980-2012) - Stream Monitoring Station M_STR9, South Fork of North Fork Quitchupah Creek.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					34.2	0.01	2.5	8.4	15	13	2
Ammonia, as N			a		na	na	na	BDL	2	0	2
Arsenic (T)					0.003	0.002	0.003	0.003	3	2	1
Bicarbonate, as HC03-					549	128	306.70	320	79	79	0
Boron (T)					1.08	0.04	0.106	0.18	48	44	4
Cadmium (T)					na	na	na	BDL	3	0	3
Calcium (D)					94.7	49	56.0	59	44	44	0
Calcium (T)					156	22.4	63.03	65	51	51	0
Carbonate, as CO3--					79	0.01	9	14	60	28	32
Chloride					45	2.9	10.2	15	92	92	0
Chromium (T)					na	na	na	BDL	2	0	2
Copper (T)					0.012	0.01	0.011	0.01	2	2	0
Hydroxide					0.1	0.01	0.1	0.1	43	14	29
Iron (D)			1		0.51	0.006	0.03	0.08	93	37	56
Iron (T)					24.6	0.018	0.71	1.4	93	91	2
Lead (T)					0.003	0.001	0.002	0.002	2	2	0
Magnesium (D)					56.4	30	33	34	44	44	0
Magnesium (T)					108	2.88	34.1	35	51	50	1
Manganese (D)					0.14	0.002	0.02	0.03	89	49	40
Manganese (T)					0.73	0.005	0.05	0.07	93	75	18
Mercury (T)					<0.1	0.1	0.1	0.1	2	1	1
Nickel (T)					na	na	na	BDL	2	0	2
Nitrite, as N					na	na	na	BDL	3	0	3
NO2+NO3, as N					0.08	0.08	0.08	0.08	8	1	7
Ortho-Phosphate					0.7	0.01	0.03	0.1	11	11	0
Potassium (D)					6.47	0.93	1.68	1.96	43	42	1
Potassium (T)					4	1	3.5	3	13	13	0
Selenium (T)					na	na	na	BDL	3	0	3
Silver (T)					na	na	na	BDL	2	0	2
Sodium (D)					110	10.9	19.1	28	44	44	0
Sodium (T)					100	10.8	46.1	49	50	50	0
Sulfate					405	18	90.0	95	91	91	0
Total Alkalinity, as CaCO3					450	184	251.4	269	89	89	0
Total Anions					14.5	4.5	6.50	7.1	49	49	0
Total Cations					14.3	4.7	6.3	7.1	49	49	0
Total Dissolved Solids				1,200[b] 2,000[c]	850	269	401.0	428	91	91	0
Total Hardness, as CaCO3					610	203	294	307	77	77	0
Total Phosphorus		0.05	0.05		1.12	0.014	0.1	0.2	18	18	0
Total Suspended Solids					13	13	13	13	1	1	0
Zinc (T)					0.003	0.003	0.003	0.003	2	1	1

a = Criterion varies with hardness.
b = For irrigation.
c = For stock watering.

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Table 16. Water Quality Results (1979-2012) - Stream Monitoring Station M_STR10, Upper North Fork Quitchupah Creek.

Parameter Name	Criteria (mg/l)				Detected Values (mg/l)				# Samples	# Detects	# BDL
	1C	2B	3A	4	Max	Min	Median	Mean			
Acidity, as CaCO3					18	0	1.2	4	15	13	2
Ammonia, as N			[a]		na	na	na	BDL	2	0	2
Arsenic (T)					0.001	0.001	0.001	0.001	4	2	2
Bicarbonate, as HC03-					493	156	246.6	257	81	81	0
Boron (T)					0.82	0.01	0.10	0.15	48	40	8
Cadmium (T)					na	na	na	BDL	4	0	4
Calcium (D)					66	37	50	49	45	45	0
Calcium (T)					144	20.5	54.80	57	52	52	0
Carbonate, as CO3--					21	0	8	9	62	23	39
Chloride					86	1	7	9	96	94	2
Chromium (T)					na	na	na	BDL	2	0	2
Copper (T)					0.01	0.01	0.01	0.01	2	2	0
Hardness, (calc)					0.2	0	0.1	0.1	45	16	29
Iron (D)			1		1	0.008	0.04	0.14	94	31	63
Iron (T)					29.6	0.02	0.4	2.1	95	82	13
Lead (T)					0.005	0.004	0.0045	0.005	2	2	0
Magnesium (D)					26	12.1	17.0	18	45	45	0
Magnesium (T)					240	0.48	21.33	28	52	51	1
Manganese (D)					0.2	0.002	0.01	0.03	91	40	51
Manganese (T)					1.46	0.002	0.02	0.09	94	66	28
Mercury (T)					na	na	na	BDL	2	0	2
Nickel (T)					na	na	na	BDL	2	0	2
Nitrite, as N					na	na	na	BDL	5	0	5
NO2+NO3, as N					na	na	na	BDL	8	0	8
Ortho-Phosphate					0.23	0.01	0.025	0.06	10	8	2
Potassium (D)					1.65	0.48	0.83	0.90	44	34	10
Potassium (T)					9.1	0.67	2	3	14	13	1
Selenium (T)					na	na	na	BDL	4	0	4
Silver (T)					na	na	na	BDL	2	0	2
Sodium (D)					39	4.80	18.60	18	45	45	0
Sodium (T)					163.9	6	22.32	30	52	52	0
Sulfate					475	9	25.0	36	96	96	0
Total Alkalinity, as CaCO3					404	165	206.0	215	91	91	0
Total Anions					7.8	3.6	4.7	4.8	50	50	0
Total Cations					7.5	3.6	4.8	4.9	50	50	0
Total Dissolved Solids				1,200[b] 2,000[c]	904	128	263	275	96	96	0
Total Hardness, as CaCO3					720	150	210	221	81	81	0
Total Phosphorus		0.05	0.05		1.64	0.005	0.06	0.27	22	17	5
Total Suspended Solids					1	1	1	1	2	2	0
Zinc (T)					0.01	0.01	0.01	0.01	2	2	0

a = Criterion varies with hardness
b = For irrigation.
c = For stock watering.

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Tract	Muddy
Date of inventory	19 June 2001
Name	M_SP01, Rough Bros. Spring
GPS location	
Northing	4319979
Easting	465615
Comments	Developed spring at Rough Brothers cabin. Water is used as a culinary source of water and for irrigation purposes. Cabin and yard are fenced. Stainless steel spring box is located to the back of the cabin under an old barrel and discharges into a galvanized pipe leading to an underground storage tank and to a trough next to the cabin. Water quality samples were collected periodically for laboratory testing.

Tract	Muddy
Date of inventory	19 June 2001
Name	M_SP02
GPS location	
Northing	4319977
Easting	466086
Comments	Spring box is located next to Greens Hollow road crossing and instrumented by EWCD. Water quality samples were collected periodically for laboratory testing. Information obtained from ranchers indicates that this spring box is the water source for the trough located about 100 feet to the east on the south side of Greens Hollow. Water overflows the cattle trough at down slope end and continues to flow along the south side of Greens Hollow, eventually entering a pond.

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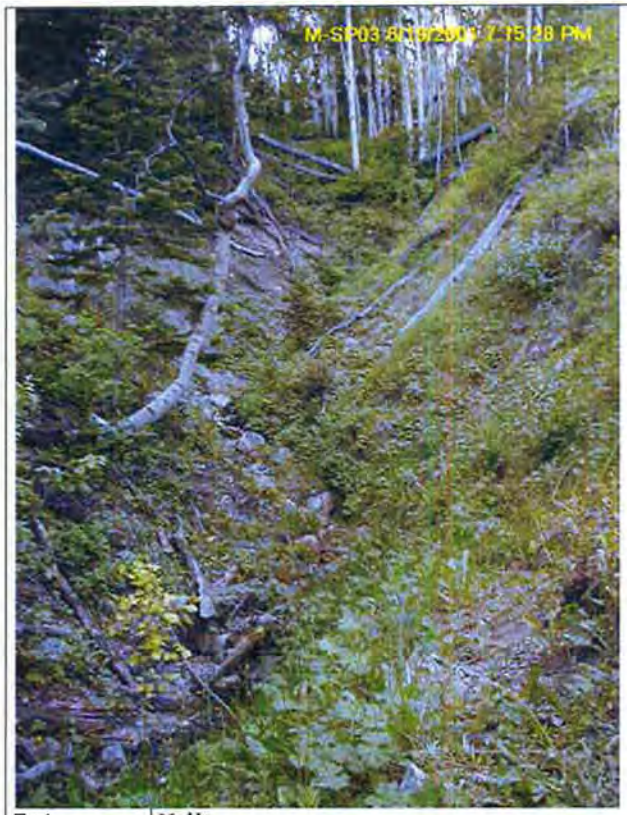

Tract	Muddy
Date of inventory	19 June 2001
Name	M_SP03
GPS location	
Northing	4319529
Easting	463762
Comments	Appears to be headwater spring for Greens Hollow. Water originates in stream channel (about 15 feet deep) with some riparian/wetland vegetation growing in the bottom. Channel ends approximately 30 feet upstream from measurement point.

Tract	Muddy
Date of inventory	19 June 2001
Name	M_SP04
GPS location	
Northing	4319267
Easting	464246
Comments	Water originates near base of 2 firs in a small drainage off Greens Hollow. There is no stream channel above the spring. Water flows downstream about 5 feet into tributary, surrounded by a wetland with sedge vegetation. The slope is moderate above the spring's source. Slope appears stable, no evidence of slumping/soil movement. Water quality samples were collected periodically for laboratory testing.

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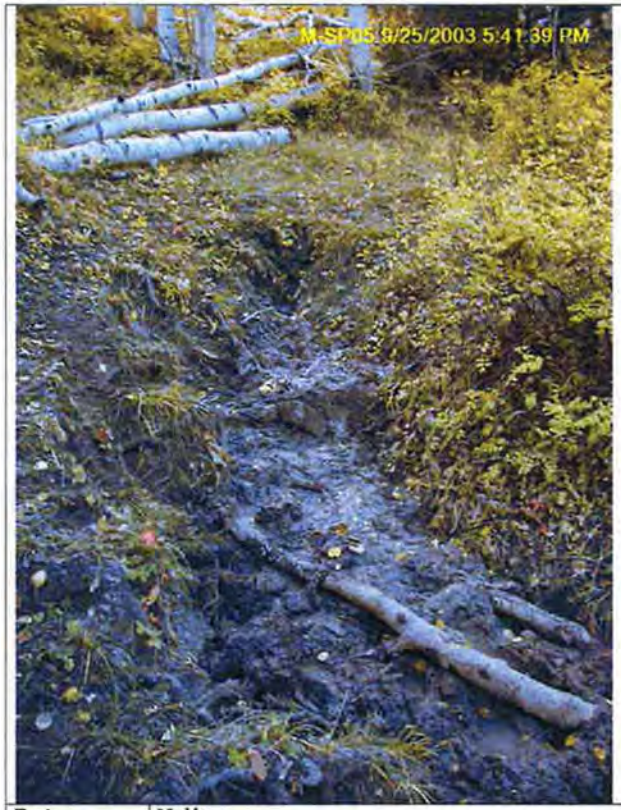

Tract	Muddy
Date of inventory	26 September 2002
Name	M_SP05
GPS location	
Northing	4319133
Easting	464212
Comments	SP05 is seeping out of a small depression, mid-slope and north of SP06, and has very low flow. It was originally considered to be a part of SP06 and field measurements for SP06 were taken below the confluence of the two springs. Starting Sept 2002, both springs were measured separately because cattle heavily trampled the area of confluence.

Tract	Muddy
Date of inventory	19 June 2001
Name	M_SP06
GPS location	
Northing	4319121
Easting	464215
Comments	Field water quality measurements were originally taken below the confluence of two spring/seeps (SP05 and SP06) located in the upper portion of a tributary flowing into Greens Hollow. SP06 is located at the base of an aspen-covered slope (small bench), has much greater discharge than SP05, and forms a small pond. The two springs were measured separately starting Sept 2002 because cattle heavily trampled the area of confluence.

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Tract	Muddy
Date of inventory	20 June 2001
Name	M_SP07
GPS location	
Northing	4317433
Easting	465280
Comments	Water originates near the base of slump in an aspen/fir stand. Water flows from this source down to a moderately wide, flat-bottomed drainage (no channel) connected to Cowboy Creek. Water accumulates in floor of drainage, forms small wet pocket, but flow does not reach Cowboy Creek. Water quality samples were collected periodically for laboratory testing.

Tract	Muddy
Date of inventory	20 June 2001
Name	M_SP08
GPS location	
Northing	4317178
Easting	464754
Comments	Developed spring that feeds into cattle trough. Water originates near base of hummock in aspen stand. Originally, most of the flow from spring did not enter pipe but flowed to the side of it. Spring was worked on in 2003. Old pipe was removed and replaced with a new pipe discharging into a different trough. No water in old channel anymore: apparently the new pipe captures all the flow. New trench below spring box with perforated pipe and gravel also captures water from seepy area below the spring. Water quality samples were collected periodically for laboratory testing.

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Tract	Muddy
Date of inventory	20 June 2001
Name	M_SP09
GPS location	
Northing	4317141
Easting	464791
Comments	Small seep that enters top of meadow to east of SP08. Water discharges from base of slope in aspen stand, disperses into broad flow after entering meadow. Cattle trample area.

Tract	Muddy
Date of inventory	20 June 2001
Name	M_SP10
GPS location	
Northing	4317562
Easting	467693
Comments	Developed spring with cattle trough (Lowery Springs?). Spring box is about 20 feet up slope of trough on east side of drainage leading down to Cowboy Creek. Water flows from trough across slope, eventually entering channel. Small pocket of sedge below trough (north). Not certain if sedge is supported by a seep or overflow from trough. No water in channel above this location. Instrumented spring, monitored by EWCD. Water quality samples were collected periodically for laboratory testing.

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Tract	Muddy
Date of inventory	21 June 2001
Name	M_SP11
GPS location	
Northing	4319958
Easting	462772
Comments	Spring/Pond located approximately 150' up slope of road. Pond appears to collect snowmelt runoff, may also receive some shallow ground water discharge. Field wate quality measured in pond, flow measured at discharge side of culvert. Gradual slope in topography to north. A second pond is located about 50 feet west of SP11 and is likely hydrologically connected to it.

Tract	Muddy
Date of inventory	19 June 2001
Name	M_SP12
GPS location	
Northing	4319397
Easting	464583
Comments	Water originates near toe of slope on small bench above Greens Hollow, discharges through silt bank along a 10 – 20 feet face into pond/wetland area. Flow eventually concentrates into a channel and flows into a second pond below, then into Greens Hollow.

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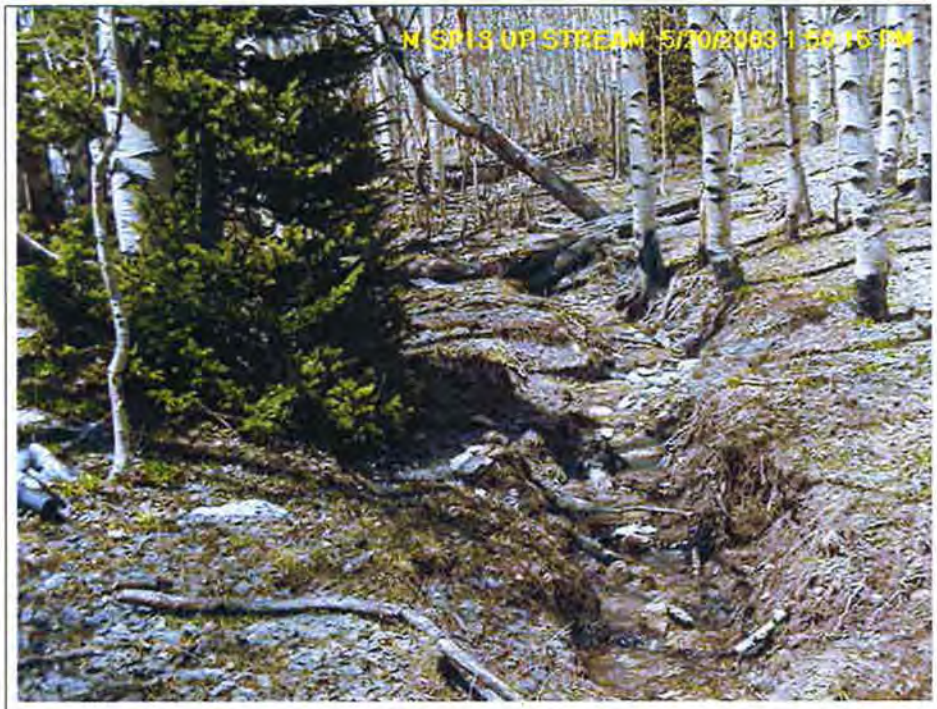

Tract	Muddy
Date of inventory	21 June 2001
Name	M_SP13
GPS location	
Northing	4318345
Easting	462562
Comments	Appears to be the uppermost source of water in Cowboy Creek. Moderately sloped, wide valley. Spring source is located in a slightly incised channel in an aspen stand, just below a point where the channel drops about 2 feet and becomes more incised. This site is usually dry in the fall.

Tract	Muddy
Date of inventory	21 June 2001
Name	M_SP14
GPS location	
Northing	4318227
Easting	462545
Comments	Developed spring originating on gentle slope; spring box located about 50 feet downstream from source. Spring box does not capture all the flow from spring. Cattle trough located 250 feet down slope. Water from spring and overflow from trough enter drainage, eventually reach Cowboy Creek, about 1/4 mile downstream. Flow in Cowboy Creek approximately doubles below confluence. Water quality samples were collected periodically for laboratory testing.

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Tract	Muddy
Date of inventory	11 July 2001
Name	M_SP15
GPS location	
Northing	4316685
Easting	463884
Comments	Fairly large seep or wallow on left side of channel near headwater of tributary to North Fork Quitchupah Creek. Good stand of willow and other shrubs around it. This spot is usually pretty well trampled by September. In 2001, flow of tributary below spring was measured instead of spring itself. The area drained by this tributary falls completely within the boundary of the project area. It was assumed that flow in stream was contributed primarily from spring flow, although recent rain activity may have been contributing surface/subsurface flows.

Tract	Muddy
Date of inventory	21 June 2001
Name	M_SP17
GPS location	
Northing	4319385
Easting	461746
Comments	Water originates from seep face at toe of slope in small bowl (bench area) near base of 3 pines, about 50 feet from edge of bench. The water flows through a wet meadow on bench then converges into a steep rocky channel draining the bench area. It enters another wet meadow about 200' down.

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Tract	Muddy
Date of inventory	22 June 2001
Name	M_SP18
GPS location	
Northing	4320892
Easting	465794
Comments	Developed spring located at south end of wide, gently sloped valley above Muddy Creek. Field water quality was measured in spring box, which is heavily corroded. Line is broken below spring box, just below fence crossing, and no water reaches trough. Pipe appeared to be plugged or partially plugged on some visits, water appeared stagnant, and dead rodents were found in spring box. Water quality sample were collected periodically for laboratory testing.

Tract	Muddy
Date of inventory	11 July 2001
Name	M_SP19
GPS location	
Northing	4316124
Easting	462644
Comments	Spring originates on a small bench, about 100 feet above an unnamed tributary of North Fork Quitchupah Creek. Two seeps located below have immeasurable flow. Field water quality parameters measured at spring source, flow measured below springs and seeps to obtain total flow from this location. Some evidence of slumping Best way to locate it is to stay in main channel and look for the confluence with a smaller incised channel.

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Tract	Muddy
Date of inventory	11 July 2001
Name	M_SP20
GPS location	
Northing	4316826
Easting	462191
Comments	Spring flows into large (1 acre) meadow that is drained by tributary to North Fork Quitchupah Creek. Spring found in aspen grove near toe of slope. This area is usually trampled by cattle in the fall. Collect field water quality measurements at the first point where steady surface flow is observed. Flow is measured at the downslope edge of meadow where channel drops off. Flow from this spring usually reaches the channel.

Tract	Muddy
Date of inventory	11 July 2001
Name	M_SP21
GPS location	
Northing	4317195
Easting	461814
Comments	First point in channel where flow surfaces; headwater of tributary to North Fork Quitchupah Creek. Look for flagging or tag on small bush or aspen tree at top of channel bank. This site is usually dry during the fall season. Best access is from the end of a spur road coming off the main ATV trail along Big Ridge. 5 minute hike from end of spur road.

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Tract	Muddy
Date of inventory	13 July 2001
Name	M_SP25
GPS location	
Northing	4319509
Easting	461537
Comments	Wet area located above road. Small network of seeps drained by a single channel. Many areas appear to have settled: wet areas are as much as 1 – 2 feet below the surrounding soil surface. Field water quality and flow taken immediately below the point of confluence. In May, need to subtract flow discharging from wetland above spring into the channel. This flow comes from snowmelt runoff and SP75 and is not present in the fall.

Tract	Muddy
Date of inventory	13 July 2001
Name	M_SP26
GPS location	
Northing	4319737
Easting	461132
Comments	Developed spring near White Mountain Cabin, surrounded by large seep face on stream bank upstream and downstream from spring. During springtime, measured flow in stream channel above and below spring and seeps in order to calculate entire contribution from spring and seeps. No flow in channel above spring and seeps in the fall.

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Tract	Muddy
Date of inventory	13 July 2001
Name	M_SP27
GPS location	
Northing	4320838
Easting	460549
Comments	Water originates in small open bowl, no stream channel evident above this point. Flow from this spring feeds a large beaver pond located 200 feet below. Water discharges from the beaver pond into Black Fork. Field water quality parameters were measured at source, flow was measured about 50 feet upstream from inlet to pond, using a collapsible flume.

Tract	Muddy
Date of inventory	5 October 2001
Name	M_SP28
GPS location	
Northing	4321948
Easting	460757
Comments	SP28 and SP29 are located next to each other on either side of a medium-size spruce tree, on bench area immediately north of Julius Flat reservoir spillway and dam. These springs appear to be above the elevation of the reservoir bottom. During the spring, this area was hiked and appears to be covered by seep flow.

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Tract	Muddy
Date of inventory	5 October 2001
Name	M_SP29
GPS location	
Northing	4321956
Easting	460755
Comments	SP28 and SP29 are located next to each other on either side of a medium-size spruce tree, on bench area immediately north of Julius Flat reservoir spillway and dam. These springs appear to be above the elevation of the reservoir bottom. During the spring, this area was hiked and appears to be covered by seep flow.

Tract	Muddy
Date of inventory	19 July 2001
Name	M_SP32
GPS location	
Northing	4323808
Easting	462159
Comments	Confluence of 2 small springs and a larger stream channel that drains a wet meadow above. The wet meadow appears to be a groundwater discharge point and likely collects surface runoff during the snowmelt season. Surface runoff from areas above the meadow was observed in the spring of 2003. Look for a flag and/or metal tag on a small aspen near the confluence of the small tributaries and the larger stream channel. This site is usually dry during the fall. Best access is to follow the cow path along the fence, spring is located about 200 feet below fenceline.

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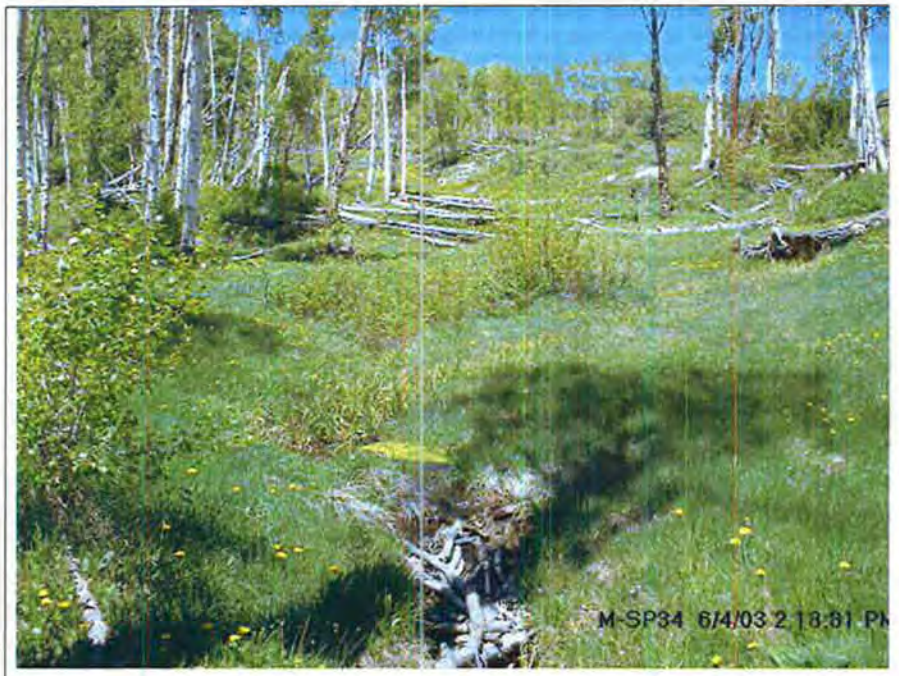
Tract	Muddy
Date of inventory	19 July 2001
Name	M_SP33
GPS location	
Northing	4324453
Easting	462370
Comments	Discharge from a pond, winds through a wetland area then drops into a stream channel and disappears. Stream channel eventually enters North Fork Muddy Creek. Field water quality and flow measured at a 4-foot drop into the stream channel, immediately below the small wetland located below the pond. This site is usually dry during the fall.



Tract	Muddy
Date of inventory	19 July 2001
Name	M_SP34
GPS location	
Northing	4324813
Easting	462246
Comments	Combined flows from several seeps and a few springs are concentrated in a stream channel that drops into a large pond. Field water quality parameters measured in this channel, below confluence of flows, about 100 feet above where it drops off to pond. Flow measured at point where channel drops off to pond. Look for flag on large aspen tree.

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Tract	Muddy
Date of inventory	19 July 2001
Name	M_SP35
GPS location	
Northing	4324550
Easting	461790
Comments	Discharge from a pond fed by a series of other ponds above it. During springtime, water breaches a berm/old beaver dam and flows through some areas covered with tall grass, eventually dropping down a steeper slope to another pond located on a small bench. Flow and WQ are usually measured where the slope begins to drop. This site is usually dry during the fall.

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Tract	Muddy
Date of inventory	20 July 2001
Name	M_SP36
GPS location	
Northing	4321859
Easting	463401
Comments	Water originates about mid-slope on a small bench (8 – 10 feet wide) in a stand of aspen/fir with thick brushy understory. Water flows down to a lower bench area where it enters a small channel, eventually reaching the South Fork Muddy Creek about 250 feet below.

UNCORRELATED

Tract	Muddy
Date of inventory	20 July 2001
Name	M_SP37
GPS location	
Northing	4321868
Easting	463357
Comments	This spring is located approximately 200 feet west of SP36, on a moderate slope above the South Fork Muddy Creek. Small amount of slumping noted above water source. Some white crust on soil surface surrounding this location.

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Tract	Muddy
Date of inventory	20 July 2001
Name	M_SP38
GPS location	
Northing	4321782
Easting	462767
Comments	Spring originates from base of large rock about 250 feet above South Fork Muddy Creek. Water flows downhill a short distance then splits into two streams. Flow measured at drop created by water flowing across small game trail. Spring is hard to see from above, surrounded by sedge/willow mix. Water quality samples were collected periodically for laboratory testing.

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Tract	Muddy
Date of inventory	30 August 2001
Name	M_SP39
GPS location	
Northing	4318775
Easting	466990
Comments	Developed spring located along Cowboy Creek. Includes three spring boxes: top spring box is disconnected and has no flow, only stagnant water; water from middle spring box flows into lower spring box, which discharges into Cowboy Creek. Instrumented spring, monitored by EWCD. Water quality samples were collected periodically for laboratory testing.

Tract	Muddy
Date of inventory	26 September 2001
Name	M_SP40
GPS location	
Northing	4318041
Easting	463677
Comments	Spring originates at the base of a dead tree, on a small bench above Cowboy Creek, approximately 30 feet north of the Creek. Area is usually trampled by cattle.

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Tract	Muddy
Date of inventory	26 September 2001
Name	M_SP41
GPS location	
Northing	4318025
Easting	463475
Comments	Water originates near base of a moderate slope covered by aspen/fir. Spring feeds a wetland area adjacent to Cowboy Creek, on south side of creek. Wetland discharges into Cowboy Creek. Best access is from ATV trail along Big Ridge. Short spur road (25 feet) stops at good dropoff point above a barren slope. Hike downslope through opening in trees. Look for wetland/marsh fed by spring along cowboy Creek.

Tract	Muddy
Date of inventory	19 July 2001
Name	M_SP42
GPS location	
Northing	4324682
Easting	462141
Comments	This is the discharge point from what is left of Brush Reservoir. This pond is fed by several seep faces located on the north end. The dam is breached. There is usually a smaller pond/wetland below the larger pond. We measured water quality parameters and flow at the outlet point below the smaller pond on the far south end. Discharge from the smaller pond is concentrated in a small channel that allows flow measurements to be taken. Look for flag or metal tag at brush on cut bank, east side. This site is usually dry in the fall.

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Tract	Muddy
Date of inventory	3 October 2001
Name	M_SP43
GPS location	
Northing	4317186
Easting	461919
Comments	This spring originates at the edge of a large clearing at upslope end of a bench above a tributary to the North Fork Quitchupah Creek. No recent slumping observed in the area. The clearing is heavily trampled. Flow is usually measured about 25 feet below the source. Flow usually dries up about 250 feet below source, does not make it to the stream channel.

Tract	Muddy
Date of inventory	3 October 2001
Name	M_SP44
GPS location	
Northing	4317150
Easting	461759
Comments	Water originates near a willow/shrub stand, near the source of an unnamed tributary to the North Fork Quitchupah Creek (M_SP21). Water bubbles up in sand/silt pocket Area is heavily trampled and flow is usually hard to measure near source. Flow eventually confines into measurable form about 50' below source. May enter tributary at more than one location during springtime. Look for flag and metal tag on willows.

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Tract	Muddy
Date of inventory	4 October 2001
Name	M_SP45
GPS location	
Northing	4319780
Easting	465156
Comments	Source is on a narrow bench, approximately 10 – 15 feet wide, above Greens Hollow. Water is discharged from the toe of a small band of rock/shrub. Area immediately around source is fairly undisturbed, area below is heavily trampled.

Tract	Muddy
Date of inventory	5 October 2001
Name	M_SP46
GPS location	
Northing	4322996
Easting	460933
Comments	Spring originates in stump hole left by falling tree. Water flows downhill from this source, eventually reaching an unnamed tributary of the North Fork Muddy Creek. Spring is located in thick timber on bench area approximately 20 feet wide.

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Tract	Muddy
Date of inventory	6 October 2001
Name	M_SP47
GPS location	
Northing	4324444
Easting	462151
Comments	Water originates from several locations on a dispersed seep face near a pole fence. Field water quality measured at middle source in a small pool near the base of an aspen. Flow measured down slope from seep face at two different locations, on the east and west side of the slope, where water is concentrated into two stream channels.

Tract	Muddy
Date of inventory	19 October 2001
Name	M_SP48
GPS location	
Northing	4321475
Easting	462500
Comments	Water source is about 350 feet above South Fork Muddy Creek. Slope is mostly barren above a bench area/wet meadow. No surface formations of rock located above this point, as seen at SP38.

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Tract	Muddy
Date of inventory	19 October 2001
Name	M_SP49
GPS location	
Northing	4321192
Easting	461704
Comments	Seep face located on small bench approximately 20 x 10 feet, above South Fork Muddy Creek. Area is heavily trampled. Water concentrates as it flows off of bench area and flow can be measured at that point. Second small seep face located immediately to the North (downstream) of this site.

Tract	Muddy
Date of inventory	19 October 2001
Name	M_SP50
GPS location	
Northing	4320883
Easting	461150
Comments	Spring originates near base of steep slope and forms a pool in a wet area about 50 fee below source. Flow measured at pool. Discharge from pool goes subsurface before entering Black Fork Creek as a dispersed seep face, near confluence with South Fork Muddy Creek.

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Tract	Muddy
Date of inventory	19 October 2001
Name	M_SP52
GPS location	
Northing	4321061
Easting	461044
Comments	Water source is located in the bottom third of steep slope above South Fork Muddy Creek. Water discharges in small depression, consisting of clay material. This soil type appears consistent with the nearby slope. Slope is mostly open above. Field water quality measured at source, flow measured at first point of concentration.

Tract	Muddy
Date of inventory	24 October 2001
Name	M_SP53
GPS location	
Northing	4317126
Easting	466373
Comments	This is a developed spring that was connected to a cattle trough (now broken, smashed by fallen tree). Flow is measured from a pipe that appears to run back 10 feet upslope to a pole fence enclosure. Could not find spring box inside enclosure. Surface water disappears about 15 feet below discharge from pipe. Best access is to drop down from ATV trail along Big Ridge. Hike down west side of dry drainage, cut over to the west to spring. Look for old cow path leading to spring.

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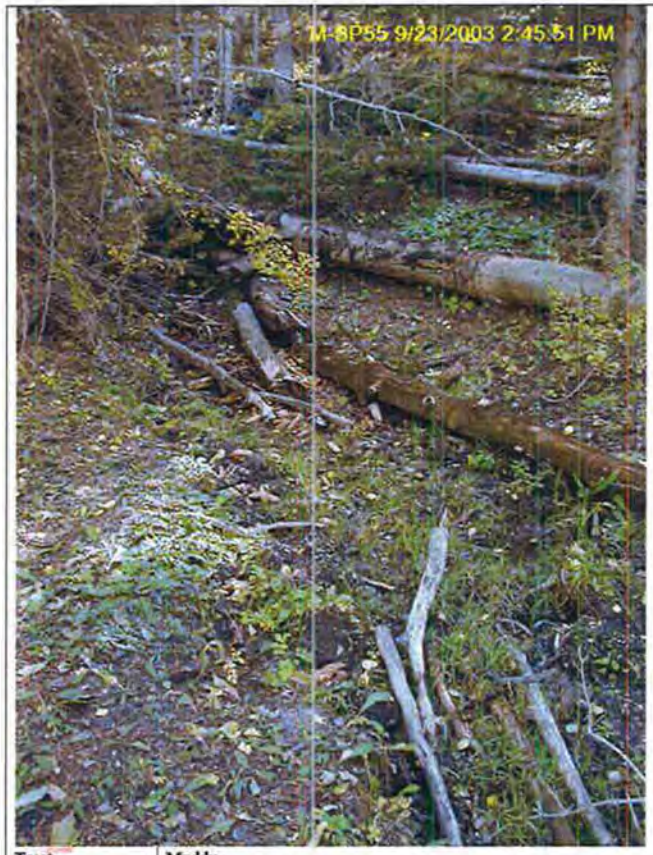
Tract	Muddy
Date of inventory	25 October 2001
Name	M_SP54
GPS location	
Northing	4321203
Easting	462320
Comments	Spring originates at the base of a large rock near edge of bench. Water meanders along edge of small meadow before dropping into South Fork Muddy Creek.



Tract	Muddy
Date of inventory	25 October 2001
Name	M_SP55
GPS location	
Northing	4321330
Easting	462585
Comments	Spring originates at base of slope under a dead tree, in a deadfall area. Water flows down into a wet meadow, then into South Fork Muddy Creek.

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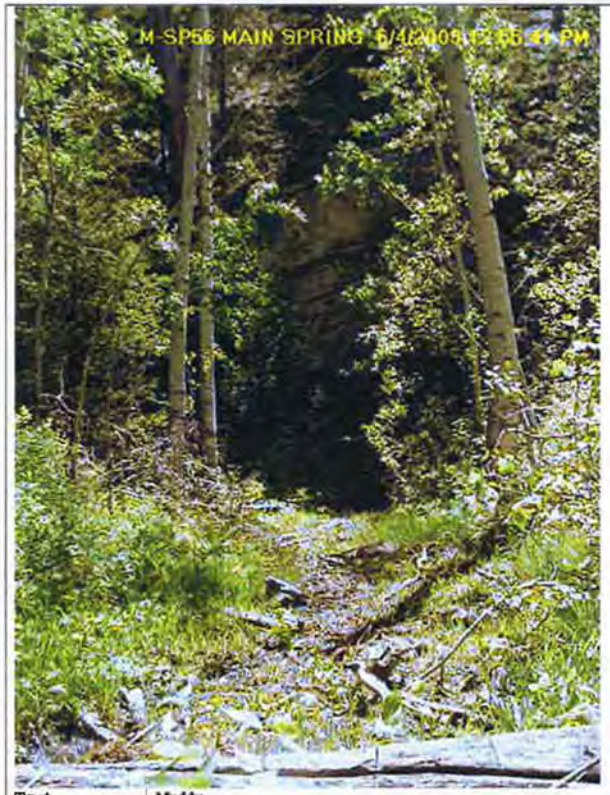

Tract	Muddy
Date of inventory	25 October 2001
Name	M_SP56
GPS location	
Northing	4321469
Easting	462792
Comments	This site conbins several small springs and seeps discharging into a wet meadow located on a bench above the South Fork Muddy Creek. Field water quality parameters were measured at the largest spring and flow was measured at the outlet o the wet meadow, at the edge of the bench, below the confluence of all the springs and seeps.

Tract	Muddy
Date of inventory	25 October 2001
Name	M_SP57
GPS location	
Northing	4321845
Easting	463278
Comments	Water source is located approximately 100 feet from the base of a gentle slope. Some evidence of recent slumping above. White crust observed on soil near source. Water moves downslope into a small channel, and then into South Fork Muddy Creek. There is typically no water above this point in the stream channel. Best way to find this site is to follow water up the stream channel to the point where water is seeping down the channel bank. Climb out of channel and follow to source.

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Tract	Muddy
Date of inventory	24 October 2001
Name	M_SP59
GPS location	
Northing	4317186
Easting	466357
Comments	Water originates in small bowl (100 square feet), barren and surrounded by pines. Water is somewhat dispersed from source, concentrates about 10 – 20 feet below. Area is usually trampled in the fall. Water flows over edge of bench towards a stream channel located about 150 feet down slope. Water usually disappears about 5(feet or so below the source and does not reach the stream channel. Best access is to drop down from M_SP53.

Tract	Muddy
Date of inventory	2 May 2002
Name	M_SP60
GPS location	
Northing	4316092
Easting	462887
Comments	Water discharges from a depression in the north channel bank (river's left) about 20 feet above the North Fork of Quitclupah Creek. Turbidity influenced by bank erosion.

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Tract	Muddy
Date of inventory	2 May 2002
Name	M_SP61
GPS location	
Northing	4317168
Easting	461881
Comments	Small seep located just west of M_SP43. Area below point of discharge is heavily trampled. Flow disappears about50 feet below source. Measurable flow on north side of wallow.

Tract	Muddy
Date of inventory	23 May 2002
Name	M_SP62
GPS location	
Northing	4321249
Easting	460688
Comments	The location of this seasonal spring was recorded in October 2001 but no measurements were taken until 2002. Water flows on the surface for about 40 feet below the source then appears to go subsurface for a while and to re-surface about 20 feet above the creek. Spring is located in an area of heavy timber, below a canal diverting water to Julius Flat Reservoir.

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Tract	Muddy
Date of inventory	23 May 2002
Name	M_SP63
GPS location	
Northing	4322332
Easting	462054
Comments	Spring location was recorded in 2001 but no measurements were taken until 2002. Spring is located under a large conifer tree on a gentle slope leading to Beaver Creek, below the two-track road going around Julius Flat. Area used by wildlife and cattle a evidenced by trails on adjacent slopes.

Tract	Muddy
Date of inventory	23 May 2002
Name	M_SP64
GPS location	
Northing	4322516
Easting	461310
Comments	Spring location was recorded in 2001 but no measurements were taken until 2002. This spring is located on the North side of an unnamed tributary to Beaver Creek.

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Tract	**Muddy**
Date of inventory	**23 May 2002**
Name	**M_SP65**
GPS location	
Northing	**4323039**
Easting	**461178**
Comments	**Spring is located about 150 feet east of a fence, on the south side of an unnamed tributary to the North Fork Muddy Creek. Water issues from the toe of a slope that appears to have slipped. Very hummocky area, close to the creek.**

Muddy	
23 May 2002	
M_SP66	
4323061	
461221	
Spring is located on the north side of an unnamed tributary to the North Fork Muddy Creek, on a gentle, grassy slope with downed timber, about 100 feet above the creek. Many leeches in water near source.	

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Tract	Muddy
Date of inventory	24 May 2002
Name	M_SP67
GPS location	
Northing	4323044
Easting	463654
Comments	Spring is located on a slope about 500 feet above and to the north of the North Fork o Muddy Creek. The spring is surrounded by a patch of juniper trees with a few willows. It crosses over a well-used cattle/wildlife trail.

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Tract	Muddy
Date of inventory	24 May 2002
Name	M_SP68
GPS location	
Northing	4323038
Easting	463429
Comments	This spring is located on the North side of the North Fork Muddy Creek, on a steep slope with dense tree and brush cover. It originates at the northwest corner of an aspen stand, just below a stand of Juniper trees. Flow from the spring crosses a well-used trail on its way down to the North Fork. There is a small seep with no measurable flow directly to the east of the spring, about 5-10 feet away.

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Tract	Muddy
Date of inventory	24 May 2002
Name	M_SP69
GPS location	
Northing	4323019
Easting	463388
Comments	This spring is located about 300 feet north of the North Fork Muddy Creek, on a steep slope covered with trees and brush. About 50 feet below the source, flow from M_SP70 joins the flow from this spring. Below the confluence, the water crosses a well-used wildlife/cattle trail, then discharges into a small wetland area on a bench on the north bank of the North Fork.

Tract	Muddy
Date of inventory	24 May 2002
Name	M_SP70
GPS location	
Northing	4323017
Easting	463370
Comments	This spring is located about 300 feet north of the North Fork Muddy Creek, on a steep slope covered with trees and brush. It originates in the middle of a tangle of deadfall and is difficult to access. About 50 feet below source, flow from this spring joins flow from SP_69. Below the confluence, the water crosses a well-used wildlife/cattle trail then discharges into a small wetland area on a bench on the north bank of North Fork

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Tract	Muddy
Date of inventory	25 May 2002
Name	M_SP72
GPS location	
Northing	4324210
Easting	461591
Comments	Water originates from a series of seeps around the remains of an old beaver pond, near the top of a small, narrow valley/drainage channel, on nearly level ground. Water spreads out near origin but eventually concentrates in a single channel about 200 feet from source. This is where water quality parameters and flow were measured. Water moves down from this point through a wet meadow and collects in a pond that appears to have been mechanically created ago. This spring is usually dry in the fall.

Tract	Muddy
Date of inventory	25 May 2002
Name	M_SP73
GPS location	
Northing	4323056
Easting	461246
Comments	This spring is located about 100 feet east of SP66. Water originates under some deadfall, about 75 feet up the slope to the north of an unnamed tributary to the North Fork Muddy Creek.

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Tract	Muddy
Date of inventory	22 May 2002
Name	M_SP75
GPS location	
Northing	4319322
Easting	461676
Comments	Located about 200 - 300 feet above SP25. Flow may be influenced by snowmelt. This spring is usually dry in the fall.

Tract	Muddy
Date of inventory	22 May 2002
Name	M_SP76
GPS location	
Northing	4320377
Easting	461497
Comments	Located above an unnamed tributary to Mill Fork Creek. Spring consists of a large seep and 1 - 3 springs. Flow measured below confluence. Water quality parameters measured on west side. Water does not appear to reach stream channel. Usually no flow in the fall.

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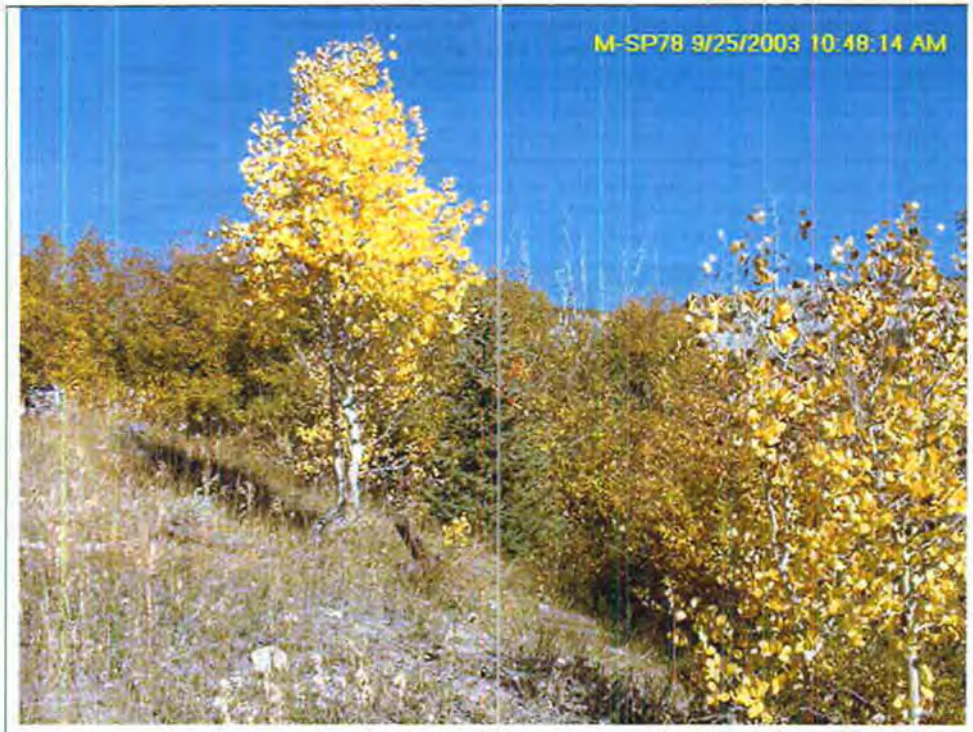
Tract	Muddy
Date of inventory	23 May 2002
Name	M_SP77
GPS location	
Northing	4324562
Easting	462136
Comments	Flow comes from 2 springs (north and east) located near a clump of willows. Confluence is about 20 feet below each source. These springs discharge into a stream below. There is a small pond above the north spring but no surface flow is coming from the pond to the spring.



Tract	Muddy
Date of inventory	23 May 2002
Name	M_SP78
GPS location	
Northing	4324492
Easting	462208
Comments	Source is located at the base of a clump of willows. Flow decreases about 100 feet below. Signs of recent slumping above the source. This site is usually dry in the fall.

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Tract	Muddy
Date of inventory	23 May 2002
Name	M_SP79
GPS location	
Northing	4323902
Easting	462016
Comments	Large seep that originates just below a barbed wire fence, just west of SP32. Water concentrates into a channel about 30 feet below the fence. Moderate slope, some minor slumping. This site is usually dry in the fall. Best way to access site is to follow fence line from M_SP72.

Tract	Muddy
Date of inventory	24 May 2002
Name	M_SP80
GPS location	
Northing	4324971
Easting	467127
Comments	Spring is first point of water discharge within stream channel of unnamed tributary to Horse Creek. Appears to be general groundwater inflow into heavily incised channel WQ and flow measured about 100' below origin, at flag on willow bush located on west side. Low flow in fall.

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Tract	Muddy
Date of inventory	24 May 2002
Name	M_SP81
GPS location	
Northing	4325475
Easting	466804
Comments	Seep at break in slope/small bench above channel of unnamed tributary to Horse Creek. Flow confines about 20' below source.

Tract	Muddy
Date of inventory	25 May 2002
Name	M_SP82
GPS location	
Northing	4323447
Easting	465886
Comments	Spring originates from a rock outcropping at the toe of a slope. Water flows through small riparian area with some willow bushes before joining stream. Look for flagging on pine tree. Best access is from ATV trail (259) directly south of this site. Only about 5 minute walk from ATV trail.

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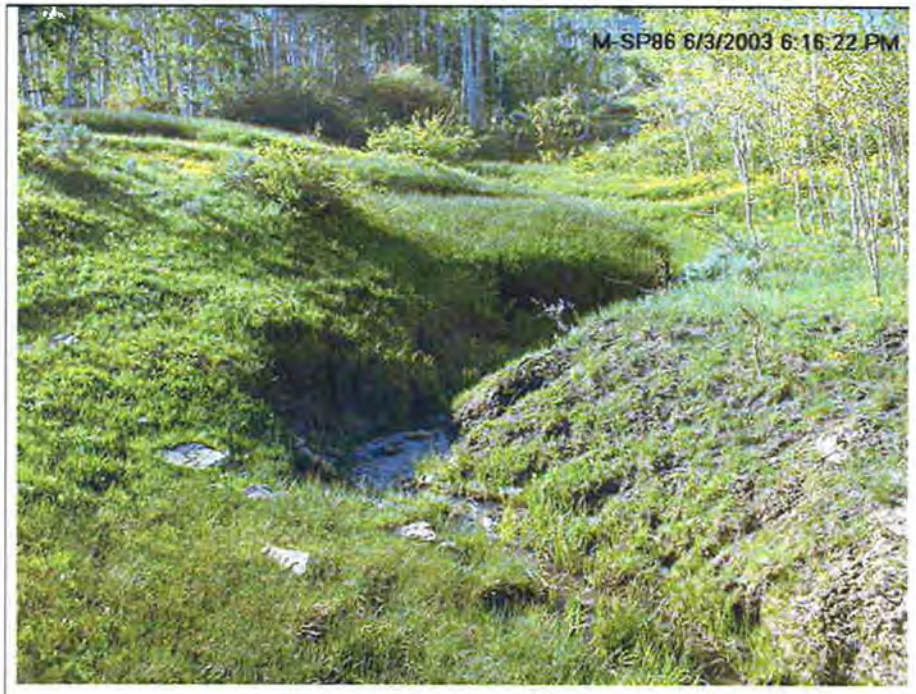
Tract	Muddy
Date of inventory	26 May 2002
Name	M_SP85
GPS location	
Northing	4325418
Easting	463713
Comments	Series of springs/seeps located along a stream channel near the boundary of the tract buffer. Flow and water quality measurements taken on the stream, below a large pond/seep area. GPS location is for that measurement point. Total discharge from seeps/springs calculated by substracting flow in stream channel at tract buffer boundary from flow in stream channel below the seeps. Need flume to measure flow at this site.



Tract	Muddy
Date of inventory	26 May 2002
Name	M_SP86
GPS location	
Northing	4325195
Easting	463889
Comments	Seep/spring area located downstream of SP85 along same stream channel. Water quality and flow measurements taken in stream channel at a small wildlife crossing, just below the lowest seep. Small seep area just above on left side when looking upstream. Total discharge from seeps/springs calculated by subtracting flow in stream channel below M_SP85 from flow in channel below M_SP86. Need flume to measure flow at this site.

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Tract	Muddy
Date of inventory	26 May 2002
Name	M_SP87
GPS location	
Northing	4322427
Easting	465309
Comments	Spring originates under a large overhang about 250 feet above Muddy Creek. Can be hard to find as GPS usually does not work. Take ATV trail down to a good cattle trail that parallels Muddy Creek. Follow cattle trail downstream until it crosses a side-drainage, move past drainage, drop down below trail, and look for flagging.

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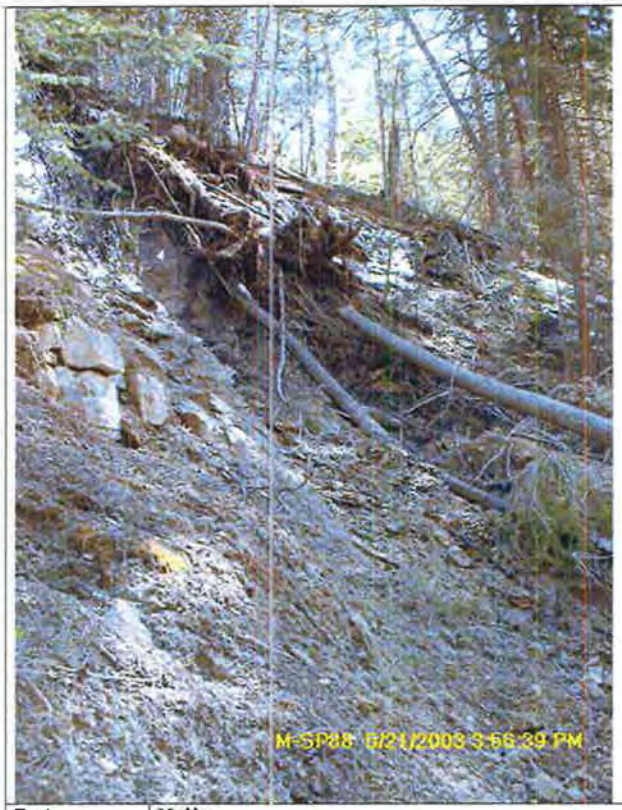
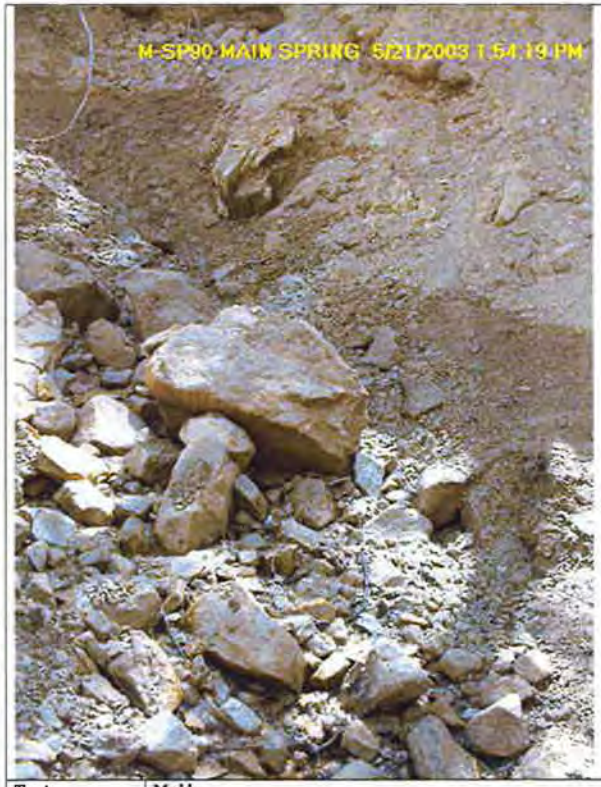


Tract	Muddy
Date of inventory	25 June 2002
Name	M_SP88
GPS location	
Northing	4318191
Easting	470255
Comments	Spring located in Box Canyon main stem above confluence with East Fork Box Canyon. Appears to be Pines #307. Water emerges above and below a rock face near the bottom of the canyon, just above the stream.

Tract	Maddy
Date of inventory	25 June 2002
Name	M_SP89
GPS location	
Northing	4318092
Easting	470404
Comments	This spring is located in a stand of aspen/fir about mid-slope in Box Canyon, just above the confluence with the East Fork Box Canyon. Water originates in a small depression with scattered rock outcroppings around and above the spring.



Tract	Maddy
Date of inventory	26 June 2002
Name	M_SP90
GPS location	
Northing	4318157
Easting	470201
Comments	Water discharges from a large muddy slump about 100 feet above Box Canyon creek. Slump appears fairly recent (15 - 25 years). The whole sloughed off area is seeping and discharging into the creek in many places. Could not measure total flow for the whole seep. Water quality was measured at the largest spring and flow at the two main springs. The other seeps were immeasurable. Slope is saturated with water and keeps sliding down in mudslides when walked on, making measurements difficult.

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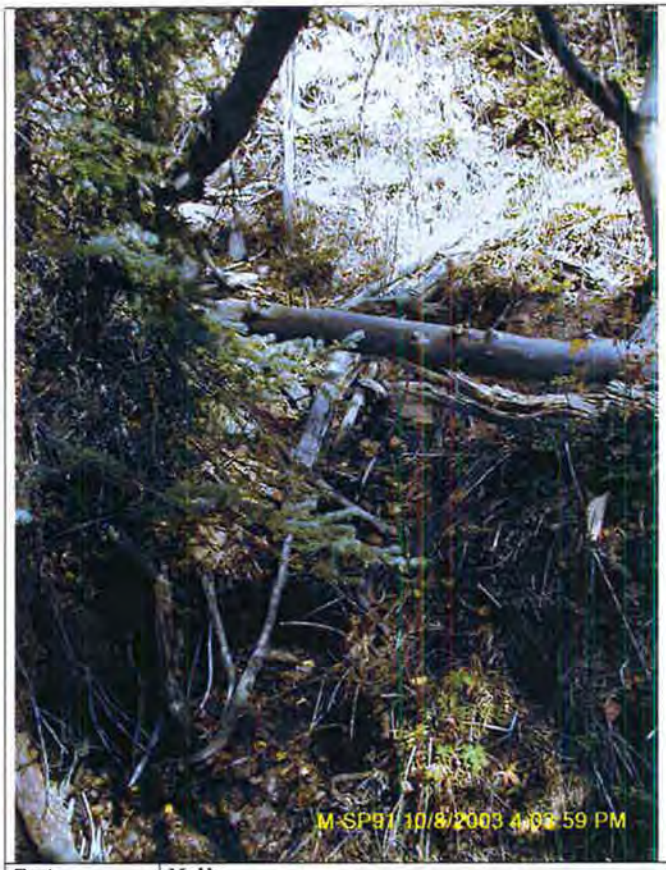

Tract	**Muddy**
Date of inventory	**26 June 2002**
Name	**M_SP91 (Pines 202)**
GPS location	
Northing	**4317250**
Easting	**469623**
Comments	**Appears to be Pines #202. Originates on very steep, unstable slope, about 100 feet above Box Canyon creek. Seepy area to the south of spring has no measurable flow.**

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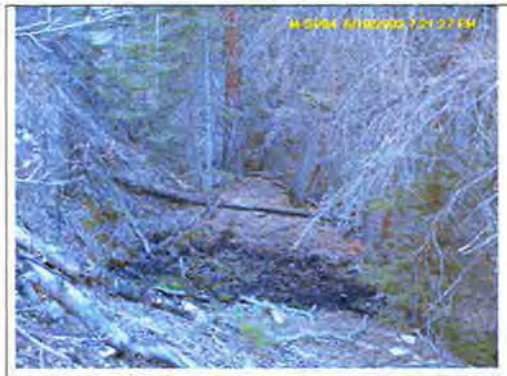
Tract	Muddy
Date of inventory	25 June 2002
Name	M_SP93 (Pines 216)
GPS location	
Northing	4317428
Easting	471356
Comments	This spring originates on the northeast side of the East Fork Box Canyon, on a narrow bench below a cliff, and crosses a well-used wildlife/cattle path. This spring appears to be Pines #216 and is marked with a stake labeled "EFB52(N)". The spring/seep 20 feet to the east was flowing very slowly at the time of the first visit, not measurable. On subsequent visits, it was measured as SP98. After SUFCO mined under the East Fork Box Canyon in the winter of 2003-2004, both springs stopped flowing and were covered by a rockslide.



Tract	Muddy
Date of inventory	25 June 2002
Name	M_SP94 (Pines 217)
GPS location	
Northing	4317389
Easting	471375
Comments	This spring originates on the northeast side of the East Fork Box Canyon, on a narrov bench below a rock face, and crosses a well-used wildlife/cattle path. This spring appear to be Pines #217 and is marked with a stake labeled "EFB53(N)". There is another spring/seep about 50 feet to the south that was not flowing at the time of the first visit. On subsequent visits, that second spring was measured as SP99. After SUFCO mined under the East Fork Box Canyon in the winter of 2003-2004, both springs stopped flowing (unlike SP93 and SP98, they were untouched by rockslides).

Tract	**Muddy**
Date of inventory	**26 June 2002**
Name	**M_SP95**
GPS location	
Northing	**4317704**
Easting	**469914**
Comments	**This measurement point is located in same channel as SP97, lower in the channel, in a thick stand of trees just above Pines #206. Some of the water is coming from SP97, with some additional flow coming from seeps/springs just above this point. Snowdrifts also contribute to flow in the spring.**

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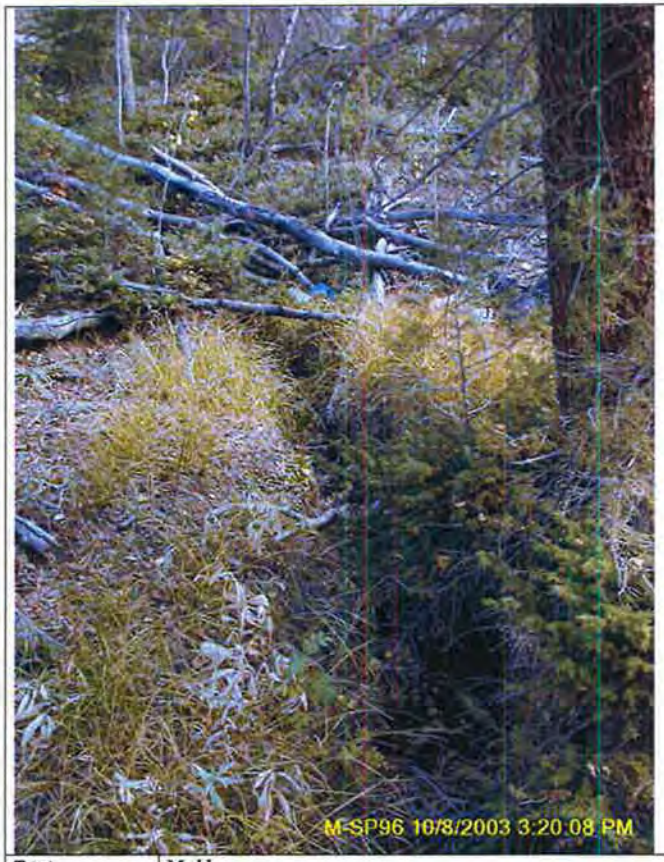

Tract	Muddy
Date of inventory	26 June 2002
Name	M_SP96 (Pines 211A)
GPS location	
Northing	4317260
Easting	469657
Comments	This spring is located in a stand of aspen/fir mix above the main stem of Box Canyon A metal tag at source is labeled Pines 211A. A tag found at creek nearby has 212 and 203 written on it.

Tract	Muddy
Date of inventory	28 September 2002
Name	M_SP97 (Pines 207)
GPS location	
Northing	4317699
Easting	469937
Comments	Water appears from under a big boulder in the stream channel. Metal tag near source is labeled Pines 207. This spring is difficult and somewhat dangerous to get to, due to extremely steep slopes and cliffs surrounding it. Water is dripping from a big overhang just upstream of the spring but no measurable flow there. Water flows on surface for about 70 feet below spring then disappears. It reappears with additional flow from other seeps/springs at SP95.

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Tract	Muddy
Date of inventory	27 September 2002
Name	M_SP98 (Pines 216A)
GPS location	
Northing	4317434
Easting	471365
Comments	This spring originates on the northeast side of the East Fork Box Canyon, on a narrov bench below a cliff, and crosses a well-used wildlife/cattle path. This spring appears to be Pines #216A and is marked with a stake labeled "EFB52(S)". It is located just east of SP93. After SUFCO mined under the East Fork Box Canyon in the winter of 2003-2004, both springs stopped flowing and were covered by a rockslide.

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Tract	Muddy
Date of inventory	27 September 2002
Name	M_SP99 (Pines 217A)
GPS location	
Northing	4317375
Easting	471376
Comments	This spring originates on the northeast side of the East Fork Box Canyon, on a narrov bench below a rock face, and crosses a well-used wildlife/cattle path. Water disappears underground near edge of bench and reappears on slope just below bench. This spring appear to be Pines #217A and is marked with a stake labeled "EFB53(S)' It is located about 50 feet south of SP94. After SUFCO mined under the East Fork Box Canyon in the winter of 2003-2004, both springs stopped flowing (unlike SP93 and SP98, they were untouched by rockslides).

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Tract	Muddy
Date of inventory	27 September 2002
Name	M_SP100
GPS location	
Northing	4316719
Easting	463616
Comments	This spring is located 75 feet above the stream channel of an unnamed tributary to Quitchupah Creek, upstream of SP15. A seep face is located 10 feet upstream of this spring. No flow in channel above this point.

Muddy	
28 September 2002	
M_SP101	
4322527	
461364	
This spring is located on a gentle slope above an unnamed tributary to Beaver Creek, about 150 feet east of SP64 and 75 feet east of SP110. Flow from a seep directly to the west of this spring joins flow from SP101 before discharging into the creek.	

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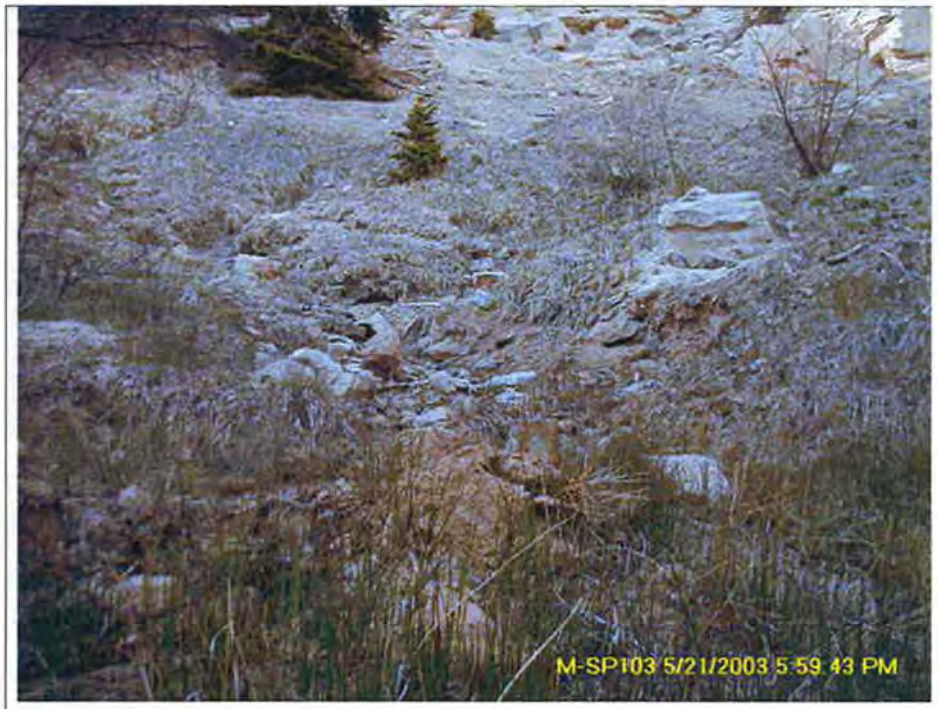
Tract	Muddy
Date of inventory	8 October 2002
Name	M_SP102
GPS location	
Northing	4322997
Easting	463336
Comments	This spring is located on the North side of the North Fork Muddy Creek, on a steep slope covered with trees and brush. Flow from the spring crosses a well-used game trail on its way down to the North Fork. Many leeches in water near source.



Tract	Muddy
Date of inventory	21 May 2003
Name	M_SP103
GPS location	
Northing	4316302
Easting	463271
Comments	Found this new spring on the way to M_SP60 is a small slide area. Flow originates a base of cliff. Not certain how far down the water travels; it does not appear to reach the river below. Located just east of SP104.

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Tract	Muddy
Date of inventory	21 May 2003
Name	M_SP104
GPS location	
Northing	4316335
Easting	463250
Comments	This spring is located just west of M_SP103. Flow disappears 30 feet below source. Water picks up a lot of silt, making it very turbid.

Tract	Muddy
Date of inventory	21 May 2003
Name	M_SP105
GPS location	
Northing	4316280
Easting	463233
Comments	This spring was found about 150 feet southwest of SP104.

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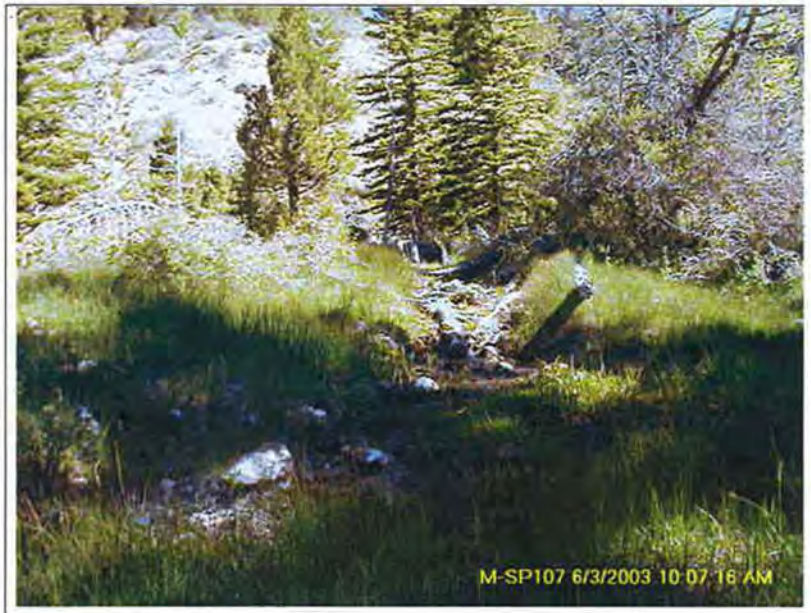
Tract	Muddy
Date of inventory	21 May 2003
Name	M_SP106
GPS location	
Northing	4316155
Easting	462626
Comments	Spring is located about 100 feet west of M_SP19, above an unnamed tributary of the North Fork Quitchupah Creek.



Tract	Muddy
Date of inventory	24 May 2002
Name	M_SP107
GPS location	
Northing	4323024
Easting	463091
Comments	Spring is located above and feeds an extensive pond/wetland complex located on several benches to the north of the North Fork Muddy Creek. Very light cattle/wildlife use. Very nice. Thick grass and moss. Pond is about 75 x 100 feet and has fish (Pond E). Water goes from pond down into creek. (Note: somehow this spring and SP_70 were assigned the same ID and were mixed up when the data was entered after this first visit. As a result, this spring was not visited in the fall of 2002 because we didn't realize it existed.)

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Tract	Muddy
Date of inventory	3 June 2003
Name	M_SP108
GPS location	
Northing	4322999
Easting	463359
Comments	Located between SP70 and SP102.

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Tract	Muddy
Date of inventory	4 June 2003
Name	M_SP109
GPS location	
Northing	4321387
Easting	462075
Comments	This spring was found while walking between SP49 and SP48. Spring is on the hillside just above a small wetland, on the north side of the North Fork Muddy Creek There are a few large fir trees in the area. Water comes out of the ground, stays abov ground for only a few feet, then disappears for about 5 ft, then flows above ground again

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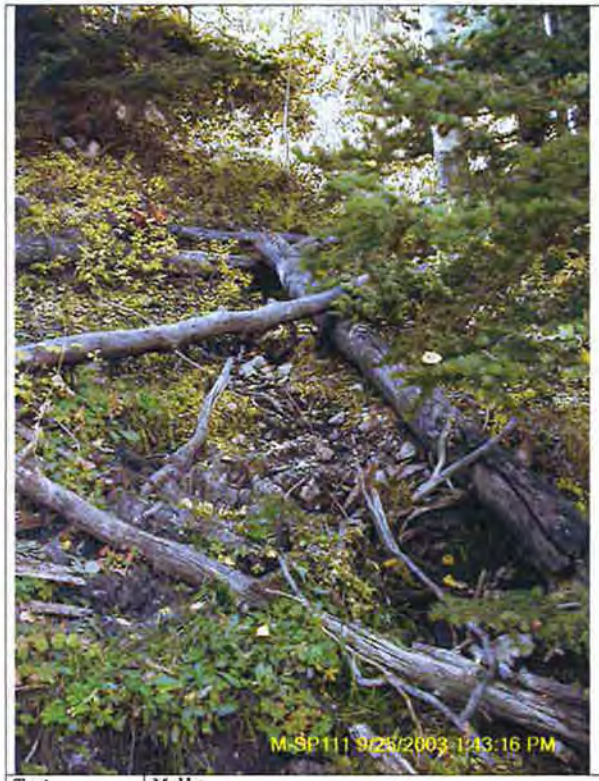
Tract	Muddy
Date of inventory	25 September 2003
Name	M_SP110
GPS location	
Northing	4322520
Easting	461347
Comments	Small spring located approximately midway between SP64 and SP101, on a gentle slope above an unnamed tributary to Beaver Creek.



Tract	Muddy
Date of inventory	7 October 2002
Name	M_SP111
GPS location	
Northing	4320391
Easting	461597
Comments	This spring was originally mistaken for SP76, which was not flowing at the time, but later proved to be a new spring. It is located on a fairly steep, forested north-facing slope with some deadfall, 300 – 400 feet to the east of the actual SP76. Elk and elk sign were observed near this spring.

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Greens Hollow Lease Appendix 7-27

EIS February 2015

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FINAL SUPPLEMENTAL
ENVIRONMENTAL IMPACT STATEMENT
FOR THE LEASING AND UNDERGROUND MINING OF THE
GREENS HOLLOW FEDERAL COAL LEASE TRACT
UTU-84102

SANPETE AND SEVIER COUNTIES, UTAH

Lead Agencies:

U.S. Department of the Interior
Bureau of Land Management
Price Field Office
Price, Utah

U.S. Department of Agriculture
Forest Service
Manti-La Sal National Forest
Price, Utah

U.S. Department of Agriculture
Forest Service
Fishlake National Forest
Richfield, Utah

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Cooperating Agency:

U.S. Department of Interior
Office of Surface Mining Reclamation and Enforcement
Denver, Colorado

February 2015

4.0 CHAPTER 4 – ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

4.1 INTRODUCTION

This chapter discusses the environmental consequences of implementing the Proposed Action and alternatives as described in Chapter 2. It compares the impacts associated with each action alternative to the No Action Alternative. Under NEPA, actions which could significantly affect the quality of the human environment must be disclosed and analyzed in terms of the "context and intensity" that makes them significant. For an action to have an effect, it must have a demonstrable causal relationship, which can be direct, indirect, or cumulative in nature (40 CFR 1508.27). In the discussion that follows, the potential effects of each alternative are identified and discussed by each resource described in Chapter 3. Impacts are discussed with respect to each issue statement developed from public and agency scoping. The treatment of effects for the alternatives and elements is considerably more detailed than the summary of potential impacts in Chapter 2 (Table 2.2).

Leasing results in a conveyance of rights to the mineral resource, and thus has no direct effects on the ground; however, indirect effects could occur as a result of leasing and subsequent receipt of a permit for development. This analysis includes conditions for the Proposed Action and Alternative 3. Recommended measures to reduce the potential effects of the action alternatives and the likely effectiveness of these measures are presented at the end of each resource discipline discussion of direct and indirect impacts. In addition, cumulative effects are described for each resource as identified in Chapter 2 (Table 2.1). Where pertinent, each resource section also includes sections describing unavoidable adverse impacts, effects related to short-term uses versus long-term productivity, and the irreversible or irretrievable commitment of resources.

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4.1.1 EXISTING MINE AND RELATIONSHIP TO THE GREENS HOLLOW TRACT

The Greens Hollow tract is located in the southern Wasatch Plateau where there are other coal leases, including the Quitchupah, Pines, and SITLA leases. These existing leases have been mined using longwall methods, and mining is continuing in portions of these leases. Subsidence impacts of the mining have been studied and documented in Anderson (2008a), Bigelow (2009), Canyon Fuel Company (2007), Mayo and Associates (1999), Petersen (2006, 2007, and 2009), and Thiros and Cordy (1991). A primary concern with subsidence mining is potential impacts to water resources and corresponding impacts on dependent resources, including vegetation, wildlife, and rangelands.

Beginning in late 2003, mining in the Pines Coal Lease undermined and subsequently subsided the North Water area, a tributary to the East Fork of Box Canyon (see Figure 4.1). Subsidence of the North Water Canyon area of the East Fork of Box Canyon in the winter of 2005 to 2006 resulted in the loss of flow at three springs (Pines 105, Pines 311, and Pines 310 Lower), the loss of water in two ponds, relocation of spring discharge at 3 springs and the depletion of surface and alluvial (subsurface) flow supporting a major riparian area (Petersen 2009). No flow to these areas has been restored (Weiser 2009). A mitigation plan to restore the North Water spring area has been finalized (Canyon Fuel Company 2013) and recently approved (DOGM 2013b). Although surface discharge is currently lost from 3 springs, stream monitoring below the springs has indicated the Castlegate Sandstone groundwater system that supported surface discharge from these springs, continues to function and provides groundwater flow at pre-subsidence levels in the East Fork of Box Canyon Creek (Petersen 2009). Subsidence has also

occurred beneath many other springs along the East Fork of Box Canyon in the Pines Coal Lease without impacting discharge.

Surface tensile cracks also occur in upland areas post subsidence, particularly where cover above the Castlegate Sandstone is limited. In these areas, hydrologic impacts could occur during periods of overland flow if cracks remain open. Due to the lack of overburden above the Castlegate Sandstone layer, "healing" of the cracks has been much slower. In order to draw inferences between the impacts that were observed in the North Water area and the potential for similar impacts to occur in the Greens Hollow tract, this section compares the geology and hydrology of the North Water Canyon area of the Pines Coal Lease with the Greens Hollow tract.

The sedimentary geology is the dominant factor influencing the hydrologic system of the area. The geology also determines how subsidence affects the surface resources of the area. The geologic units of importance for this comparison, listed from bottom to top (oldest to youngest), with their dominant characteristics that could influence hydrology and other resources, are as follows (see also Figure 3.2):

Blackhawk Formation: This unit consists of interbedded sandstone, siltstone, shale, and coal. The economic coal seams occur near the base of the Blackhawk Formation. The shale from the Blackhawk Formation was examined by X-ray diffraction and found to contain an average of 24 percent smectite, a swelling clay. (DOGM 2005). These swelling clays decrease the vertical hydraulic conductivity, which impedes the vertical flow of ground water in the Blackhawk Formation. Therefore, the upper portion of this formation is nearly impervious and generally perches water in the basal portion of the Castlegate Sandstone.

Castlegate Sandstone: This unit is a massive (blocky) fluvial sandstone with minor interbedded conglomerate and rare siltstone or shale. The unit is porous and permeable and is an important aquifer. The Castlegate Sandstone has a prominent fracture pattern and prominent bedding planes. Minor thin lenses of gray to carbonaceous shale as well as coal pods may be present. Weathered Castlegate Sandstone results in sandy sediments that are ineffective in sealing cracks in the surface-exposed, consolidated sandstone and does not prevent the downward flow of water. Abundant swelling clays at the contact border with the Blackhawk Formation impede downward movement of ground water and result in lateral movement. Structure appears to influence groundwater flow in the Castlegate Sandstone in the Greens Hollow and Pines Lease tracts as all of the springs are located on the east or southeast side of the canyons in these areas (Cirrus 2004), as would be expected for ground water following the dip slope.

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Price River Formation: This unit is a deposit of chiefly sandstone with interbedded siltstone and shale, with minor conglomerate. Where it occurs, shale deposits severely restrict vertical flow of ground water to deeper units. This process is indicated by the relatively larger number of springs that issue from the Price River Formation in comparison to other geologic formations such as the Castlegate Sandstone. Indications of extensive unsaturated horizons in the Price River and Castlegate Sandstone Formations found in drill holes and wells in the Pines Coal Lease Tract, suggest that perched ground water conditions are likely (Forest Service 1999).

North Horn Formation: This unit is similar to the Price River Formation, but is mostly shale with interbedded siltstone and sandstone. The shaley nature of the formation and its occurrence at higher elevations that receive more precipitation make it vulnerable to mass movement, slope failures, and landslides. The shales and clays of the North Horn Formation serve to retard the vertical flow of water causing ground water to move horizontally along bedding planes or through fractures. Similar to the Price River Formation, this process is evident due to the relatively larger number of springs that discharge from this formation in comparison to the Castlegate Sandstone Formation.

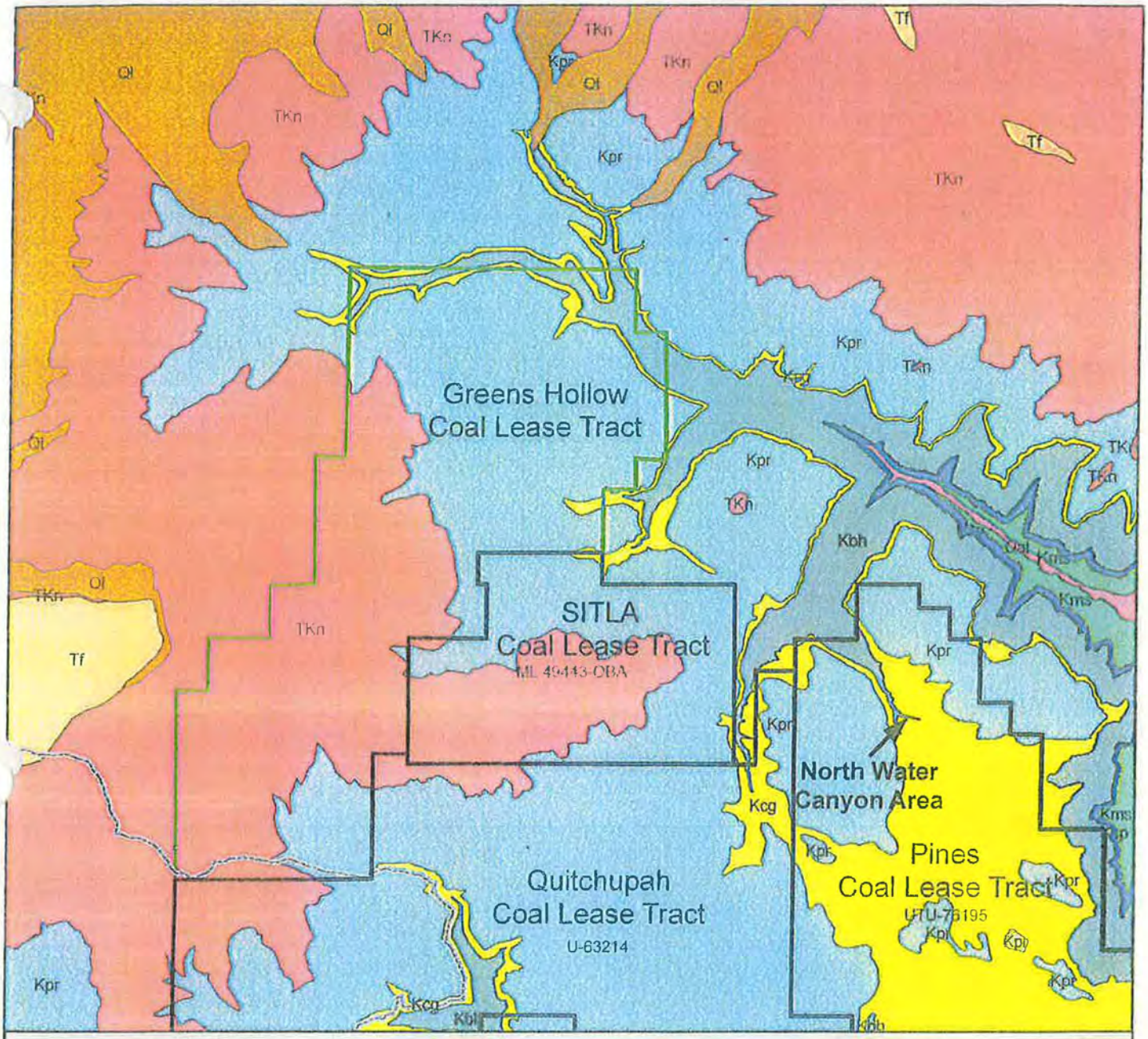

Figure 4.1. Bedrock geologic map of the Greens Hollow tract and adjoining leases.

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Legend

- Adjacent Mine Tract
- Manti-La Sal/Fishlake Forest Boundary
- Greens Hollow Coal Lease Tract

Geology

- Qal Alluvium
- Ql Landslide/mass movement
- Tf Flagstaff Limestone
- TKn North Horn Formation
- Kpr Price River Formation
- Kcg Castlegate Sandstone
- Kbh Blackhawk Formation
- Ksp Star Point Sandstone
- Kms Mancos Shale

N W E S

1 0.5 0 1 Miles

1:75,000

A primary difference between the Greens Hollow tract and the Pines Tract is the geologic units or stratigraphy exposed on the surface of the tracts (Figure 4.1). The Price River Formation is present over only about 25 percent of the Pines Tract. The majority of the Price River Formation in the Pines Coal Lease Tract ranges in depth from 0 to 50 feet with some areas ranging in depth from 100 to 500 feet. Most of the surface of the tract consists of Castlegate Sandstone with little soil cover. The North Water Canyon area of the Pines Coal Lease, where the springs, ponds, and alluvial flow were lost, is very near the top of the Castlegate Sandstone where the unit is exposed at the surface (Figure 4.1). Hence, soils in the North Water Canyon area are derived from the Castlegate Sandstone and predominantly clean, well-sorted sand with very little silt or clay-sized material. When undermined, fractures form in zones of permanent tension, around the margins of each longwall panel, which tend to remain open. Over time, the surface tension fractures tend to fill with the available sandy soil. However, because this material is sand, with little silt and clay, it has a high porosity and permeability and has little potential to hydraulically seal the fractures. Therefore, springs and drainages lost to the subsidence cracks or fractures can be permanently dewatered and surface fractures outside the riparian habitat can remain permanently open to water flow.

In contrast, over most of the Greens Hollow tract, the Price River and North Horn Formations are mapped as the surface-exposed bedrock units and overlay the Castlegate Sandstone (Figure 4.1). Exposed or shallowly buried Castlegate Sandstone layers in the Greens Hollow tract are limited to the extreme north and northeast edge of the tract in the lower Cowboy Creek, lower Greens Hollow, and Muddy Creek drainages. These areas, approximately 3 percent of the tract, correspond to the upper extent of the Castlegate Sandstone and are the only places on the tract where it is exposed on the surface. South and west of these areas the Price River Formation thickness increases quickly and then transitions to the North Horn Formation (gaining up to 1,700 feet in thickness above the top of the Castlegate Sandstone). The soils formed on the Price River and North Horn Formations contain abundant silts and clays. When compared to the Castlegate Sandstone, the silts and clays in the Price River and North Horn Formations are more likely to deform and are less likely to propagate subsidence-caused tension fractures to the surface. Thicker cover above the Castlegate Sandstone reduces the severity of subsidence impacts at the surface due to the dampening effect of the increased thickness.

It is the judgment of professionals (i.e., Hamid Maleki [mining engineer], Paul Anderson [project geologist], Katherine Foster [FS Hydrologist], and Art O'Hayre [hydrogeologist]), that where the Castlegate Sandstone is buried by 50 feet or more of overburden of the Price River and North Horn Formations, silts and clays are present in sufficient quantities to seal subsidence cracks over time (the period varies depending on precipitation levels and erosion rates) through the processes of weathering, surface erosion, and deposition. The clays contain about 24 percent smectite clay (DOGM 2005), which swells when hydrated, effectively sealing fractures and stopping the downward flow of water. Therefore, the areas where hydrologic impacts similar to those experienced in the North Water Canyon area could occur are limited to the lower Cowboy Creek, lower Greens Hollow, and Muddy Creek drainages where the Castlegate Sandstone is at or near the surface. Widespread subsidence impacts across the Greens Hollow tract similar to those experienced in the North Water Canyon area would not be expected. Excluding areas where hydrologic impacts could be similar to those experienced in the North Water Canyon area was a large factor in the formulation of Alternative 3. The potential impacts for Alternative 2, however, in the area where the Castlegate Sandstone is at or near the surface could be similar to those experienced in the North Water Canyon area.

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Based on the geology/stratigraphy and hydrology of the two tracts, anticipated impacts to other resources would also be quite different between the Pines Tract and the Greens Hollow tract and are discussed in this EIS on a resource by resource basis.

Greens Hollow Lease Appendix 7-27

Manti-Lasal Forest Water Monitoring

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GREENS HOLLOW LEASE

SITLA MUDDY LEASE

QUITCHUPAH LEAS

M-SP73 (8702)
M-SP107 (8276)
M-SP69 (8192)
M-SP67 (8191)
M-SP102 (8164)
M-SP70 (8196)
M-SP108 (8174)
M-SP101 (8767)
M-SP110 (8759)
M-SP63 (8666)
M-SP37 (8235)
M-SP38 (8273)
M-SP57 (8184)
M-SP36 (8253)
M-SP48
M-SP109 (8467)
M-SP56 (8332)
M-SP55 (8324)
M-SP49 (8552)
M-SP54 (8370)
M-SP111
P76 004) (8857)
M-SP11 (9237)
M-SP25 (9410)
M-SP97 (9329)
M-SP75 (9395)
M-SP13 (9637)
COWBOY SPRING 10
M-SP14 (9584)
M-SP41 COWBOY SPRING 8 (9223)
M-SP40 COWBOY SPRING 7 (9163)
COWBOY SPRING 11
M-SP21 (9616)
M-SP43 (9568)
M-SP44 (9598)
M-SP61 (9596)
GREEN HOLLOW SPRING 33
M-SP20 (9395)
GREEN HOLLOW SPRING 32
GREEN HOLLOW SPRING 27
GREEN HOLLOW SPRING 28
M-SP104 (9052)
M-SP103 (8999)
M-SP106 (8997)
M-SP105 (8971)
M-SP60 (8801)
M-SP19 (8968)
GREEN HOLLOW SPRING 20
GREEN HOLLOW SPRING 21
GREEN HOLLOW SPRING 24
Green Hollow Spring 31
M-SP03 (8961)
M-SP04 (8812)
GREEN HOLLOW SPRING 25
M-SP05 (8937)
GREEN HOLLOW SPRING 26B
GREEN HOLLOW SPRING 26
M-SP06 (8932)
M-SP12 (8739)
GREEN HOLLOW SPRING 19
GREEN HOLLOW SPRING 18A
GREEN HOLLOW SPRING 18B
GREEN HOLLOW SPRING 18C
GREEN HOLLOW SPRING 29
GREEN HOLLOW SPRING 15
GREEN HOLLOW SPRING 16
M-SP100 (8975)
M-SP15 (8811)
GREEN HOLLOW SPRING 17
M-SP08 (8820)
M-SP09 (8849)
M-SP01 GREEN HOLLOW SPRING 5 (8420)
M-SP02 GREEN HOLLOW SPRING 3 (8335)
M-SP45 GREEN HOLLOW SPRING 6 (8505)
M-SP87 (7922)
U-MUD
M-STR8 (7930)
GREEN HOLLOW SPRING 7
M-STR7 (8015)
GREEN HOLLOW TROUGH 1
CLAY SPRING
M-SP18 GREEN HOLLOW SPRING 1 (8805)
M-STR6 (8170)
M-STR1 (7462)
M-STR2 (7740)
M-STR3 (7927)
M-STR5 (7980)
M-STR4 (8164)
GREEN HOLLOW SPRING 4
COWBOY SPRING 13, 14
M-SP39 (8225)
COWBOY SPRING 16
COWBOY SPRING 5
COWBOY SPRING 12
COWBOY SPRING 3
COWBOY SPRING 4
M-SP07 (8709)
GW-13 (8600)
M-SP10 (8718)
M-SP59 (8920)
M-SP53 (8941)
01-8-1 (8988)
Big Ridge Spring 1A
Big Ridge Spring 1B
89-18-1 (8405)
89-20-1 (8271)
89-21-1 (8389)
89-20-2 89-20-2W (8358)
SUFCO-007 (8240)
HANSEN SEEP (8399)
94-113 (8317)
AMANDA SPRING (8050)
(8000)
WEDGE SPRING (8014)
SUFCO-006C
SUFCO-006D (7750)
SUFCO-006A (8319)
SPRING 006A (8345)
RS-A (8280)
RS-B (8291)
SUFCO-006 (8227)
SUFCO-006B (8211)
ROBERTS SPRING (8294)
US-81-4 (8388)
057A (8720)

UTU-84102
ML 49443-OBA
U-63214
U-47080
FEE

EXPLANATION

- SUFCO MINE EXTERIOR LEASE BOUNDARY
- SUFCO MINE INTERIOR LEASE BOUNDARY
- 100000 NC — MINE COORDINATES
- 2020000 SPC — STATE PLANE COORDINATES
- FOREST SERVICE AND SUFCO MONITORING
- FS — FOREST SERVICE 2014 MONITORING
- HISTORIC STREAM
- STREAM MONITORING
- HISTORIC MONITORING WELL
- MONITORING WELL SITE
- HISTORIC SPRING MONITORING SITE
- SPRING MONITORING
- UPDES MONITORING POINT
- (U) — IN MINE MONITORING SITE
- (7600) — ELEVATION OF SITE
- PERENNIAL FLOW LOCATION MONITORING POINT
- PERENNIAL FLOWS
- SPRING NOT MONITORED

(M-SP00) CIRRUS BASELINE 2001-2004
(M-SP00) SUFCO MONITORING 2006
(M-SP00) SUFCO MONITORING 2014
(M-SP00) SUFCO MONITORING 2015

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
2	9/22/2017	V.M.	B.R.	Updated Water Monitoring
3	3/27/2018	V.M.	B.R.	GREENS HOLLOW TECHNICAL ANALYSIS

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

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WATER MONITORING
USFS SITES

PEN TBL: _1Stndrd-SUFENP1.ctb
SHT SET: ####
PROJECT NUMBER: ####
SCALE: 1" = 1200'
DATE: 6/2015
DRAWN BY: JKM
ENGINEER: X.X.X.
CHECKED BY: VM
SHEET NO. 2 GH
FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. - 1-1-18\WaterMonitoring2015B GH.dwg

Brandon Rees: 3/28/2018 11:24 AM

Comparision of Manti-LaSal Forest Water Monitoring and Sufco Water Monitoring 2004, 2013, 2014, 2015

Manti-LaSal Forest Name of Spring	Sufco Monitoring Site No.	Source Type	X Coordinate (FS)	Y Coordinate (FS)	2004 & 2013 Sufco Historic Flow	2013 (FS) Flow Rate (gal/min)	2013 (FS) Date	2014 Sufco Historic Flow	2014 (FS) Flow Rate (gal/min)	2014 (FS) Date	2015 (FS) Flow Rate (gal/min)	2015 (FS) Date	Field Notes (FS)
Green Hollow Spring 1	M-SP18 (M)	Seep	465730	4321098	0.115 6/30/13	None	6/27/2013	<0.05 6/29/14	None	6/4/2014	0.23	6/22/2015	Cylinder in ground, no flow in cylinder seen, ground wet around cylinder
Green Hollow Spring 3	M-SP02 (M)	Seep	466021	4320183	0.063 6/30/13	0.03	6/27/2013	Seep 6/29/14	None	6/9/2014	None	6/22/2015	Developed box, but no flow, water inside and down from box
Green Hollow Spring 4	M-SP39 (M)	Spring	466922	4318979	1.44 6/28/13	1.4	6/27/2013	1.61 6/29/14	1.6932	6/4/2014	0.99	6/24/2015	flow we added in, not sure where flow is going. We got the flow by turning valves. This spring is in a cluster with Cowboy Springs 13 & 14.
Green Hollow Spring 5	M-SP01 (M)	Spring	465519	4320142	0.292 6/30/13	0.31	6/27/2013	0.32 6/29/14	0.55696	6/9/2014	0.36	7/8/2015	Right by a cabin and fenced in. Very inconsistent flow out of pipe. Pipes bring water to a barrel trough.
Green Hollow Spring 6	M-SP45	Spring	465106	4320014	0.673 6/3/04		6/27/2013	----	1.2941	6/10/2014	0.93	6/23/2015	No development. There is a cabin about 800 ft. downstream
Green Hollow Spring 7		Spring	465420	4321861		None	7/2/2013		0.14458	6/9/2014	.08	6/22/2015	Lots of fallen trees over the spring, measurement difficult due to slow flow
Green Hollow Spring 15	M-SP100(M)	Spring	463580	4316947	1.076 6/5/04	0.31	7/9/2013		0.2652	6/2/2014	None	7/22/2015	Trampled by cows, flow from MSP 100 flows in close by. Track name is correctly entered.
Green Hollow Spring 16	M-SP15	Spring	463810	4316882	0.268 6/5/04	None	7/9/2013	----	0.259	6/2/2014	None	7/22/2015	Trampled by cows
Green Hollow Spring 17	M-SP15	Spring	463894	4316844	0.268 6/5/04	0.21	7/9/2013		0.29596	6/2/2014	None	7/22/2015	This spring flows only 1 foot before it joins the main creek
Green Hollow Spring 18A		Spring	463855	4316094		None	7/9/2013		0.1756	6/2/2014	None	7/26/2015	Spring was very difficult to measure
Green Hollow Spring 18B		Spring	463842	4316060		0.23	7/9/2013		0.235	6/2/2014	None	7/26/2015	Flows may have contained flow from GRNHLWSP18A
Green Hollow Spring 18C		Spring	463852	4316079							0.28	7/27/2015	Difficult to measure seeping over a large area, measured a distance below source
Green Hollow Spring 19		Spring	463863	4315573		0.24	7/9/2013		1.0761	6/3/2014	0.28	7/26/2015	Spring flows about 6 feet to creek
Green Hollow Spring 20	M-SP60 (M)	Spring	462825	4316290	0.676 6/5/04	0.68	7/9/2013	0.72 6/30/14	0.7034	6/3/2014	0.49	7/22/2015	Flows directly to Quitchumpah Creek
Green Hollow Spring 21	M-SP 19	Spring	462602	4316374	0.476 6/5/04	1.95			0.1176	6/3/2014	0.38	7/22/2015	Spring on edge of stream, very easy to miss, flows for 1 foot before entering main stream. Possibly underground flow from main stream.
Green Hollow Spring 24	M-SP03	Spring	463717	4319726	1.949 6/3/04	None	7/16/2013	----	1.5469	6/10/2014	0.89	6/25/2015	Couldn't pinpoint one spring. Creek starts flowing much fuller than above after it goes through section.
Green Hollow Spring 25	M-SP04	Spring	464182	4319466	2.921 5/12/04	0.76	7/16/2013	----	2.4146	6/10/2014	1.53	6/25/2015	No development, spring runs directly to stream, no wetland around it
Green Hollow Spring 26	M-SP06 (M)	Spring	464144	4319328	1.624 5/12/04	1.44	7/16/2013	1.47 6/30/14	1.4488	6/10/2014	1.37	6/25/2015	Smelled like sulphur, flow combined for 26 and 26 B
Green Hollow Spring 26 B	M-SP05	Spring	464148	4319344	0.264 5/12/04			----	0.1841	6/10/2014	0.13	6/25/2015	Close to GRNHLWSP26
Green Hollow Spring 27	M-SP 106	Spring	462589	4316428	0.476 6/5/04				0.1295	6/3/2014	None	7/22/2015	Trampled by cows (could be composite of Springs 21, 27, 28 as flow for MSP-19 in 2004)
Green Hollow Spring 28	M-SP 106	Spring	462606	4316393	0.476 6/5/04				0.597	6/3/2014	None	7/22/2015	Flows about 3 feet until it reaches large creek, much colder than main stream though.
Green Hollow Spring 29		Spring	463294	4316888					0.7444	6/2/2014	0.47	7/22/2015	Trampled by cows
Green Hollow Spring 31	M-SP03	Spring	463958	4319425							0.18	6/25/2015	No development. The track is the head of the spring where there is a small wetland area
Green Hollow Spring 32		Spring	462590	4316362							2.11	7/22/2015	Very difficult to navigate. The head is direcly west , difficult due to deadfall
Green Hollow Spring 33		Seep	463087	4317259							0.036	7/22/2015	No development, So slow it is difficult to get an accurate flow.
Cowboy Spring 3		Spring	465542	4317857		0.12			0.1877	6/4/2014	0.11	7/8/2015	Some flow, mostly large seep. Flows were hard to collect. Trampled by cows.
Cowboy Spring 4		Spring	465169	4317821		None	7/10/2013		0.2183	6/4/2014	0.12	7/8/2015	Source is about 65 higher than waypoint.
Cowboy Spring 5		Spring	464847	4317966		0.33	7/31/2013		0.9542	6/4/2014	0.43	7/8/2015	Source is 105 feet higher than waypoint, stream flows into stagnant pond.
Cowboy Spring 7	M-SP40	Spring	463613	4318245	0.447 6/6/04	0.24	8/7/2013	----	0.3023	6/12/2014	0.17	7/20/2015	No development and trampled
Cowboy Spring 8	M-SP41 (M)	Spring	463407	4318235	0.509 6/6/04	0.28	8/7/2013	----	1.633	6/12/2014	1.14	7/20/2015	No development
Cowboy Spring 10	M-SP14	Spring/creek	462477	4318430	61.402 6/6/04	None	8/12/2013	----	20.09	6/12/2014	4.33	7/6/2015	Cylinder box in creek, trough (empty) downstream 200 ft. Basically a creek springing out of the ground.
Cowboy Spring 11		Spring	462853	4318087		None	8/12/2013		0.0938	6/12/2014	0.15	7/6/2015	Trampled, hard to determine flow
Cowboy Spring 12		Spring	464979	4317937					0.5093	6/4/2014	None	7/8/2015	Dry, may have been spring at one time due to vegetation
Cowboy Spring 13	M-SP39 (M)	Seep	466911	4318985	1.44 6/28/13			1.61 6/29/14	None	6/4/2014	None	6/24/2015	Trampled, we couldn't decide which springs matched up with last year's, so we made new spring names/waypoints. Outside of fenced area. In cluster with GRNHLWSP4and Cowboy Spring 14
Cowboy Spring 14	M-SP39 (M)	Spring	466916	4318981	1.44 6/28/13			1.61 6/29/14	1.1964	6/4/2014	0.88	6/24/2015	Cylinder contains spring, flow exits through a hole in cylinder- about 2 ft diameter. Not sure which waypoint referred to which springs, so we created new waypoints.
Cowboy Spring 16		Spring	464614	4317948							0.11	7/29/2015	No development, elk wallow at bottom
Cowboy Trough/Spring	M-SP53 (M)	Trough	466304	4317351	0.091 6/28/13	0.08	7/30/2013	0.07 6/21/14	0.0735	6/2/2014	0.06	6/24/2015	There was a disconnect in the pipes leading to the trough, so the water was not reaching the trough.
Cowboy Spring 2		Spring	467027	4319014					1.1892	6/4/2014	None	6/24/2015	Piped water out of ground.
Clay Spring 4		Spring	464013	4320609							0.26	7/8/2015	Spring box, with green and black piping, rough at the bottom
MSP 100	M-SP100(M)	Spring	463555	4316929	1.076 6/5/04			----	0.7514	6/3/2014	0.35	7/22/2015	
Big Ridge Spring 1A		Spring	465560	4316155	0.173 6/6/04						0.13	7/29/2015	No development combined flow 1A & 1B
Big Ridge Spring 1B		Spring	465555	4316158	0.173 6/6/04						0.13	7/29/2015	No development combined flow 1A & 1B

(M) Currently Monitored by Sufco, if no (M) site was historically monitored and there is some data available

(FS) Forest Service monitoring

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GREENS HOLLOW LEASE

NATURAL AND STOCK PONDS

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Greens Hollow Pond Monitoring 2016

Pond	4/13/2016	5/10/2016	5/20/2016	6/21/2016	6/22/2016	7/13/2016	7/14/2016	7/18/2016
Slab (M-P01)	Dry		2" Water on bottom					
M-P02		1/2 Full		1/4 Full				
M-P03							1/2 Full	
M-P04				Dry				
M-P05				Dry				
West Pine (M-P06)						Dry		
M-P07					Dry			
M-P08							Dry	
M-P09							Dry	
M-P10				Dry				
M-P11					Dry			
GH-P01								Dry
GH-P02								Dry
GH-P03								Damp
GH-P04								1/2 Full
GH-P05								Dry
GH-P06								Dry
GH-P07								Puddle/Mud
GH-P08								Dry
GH-P09								Puddle/Mud

INCORPORATED
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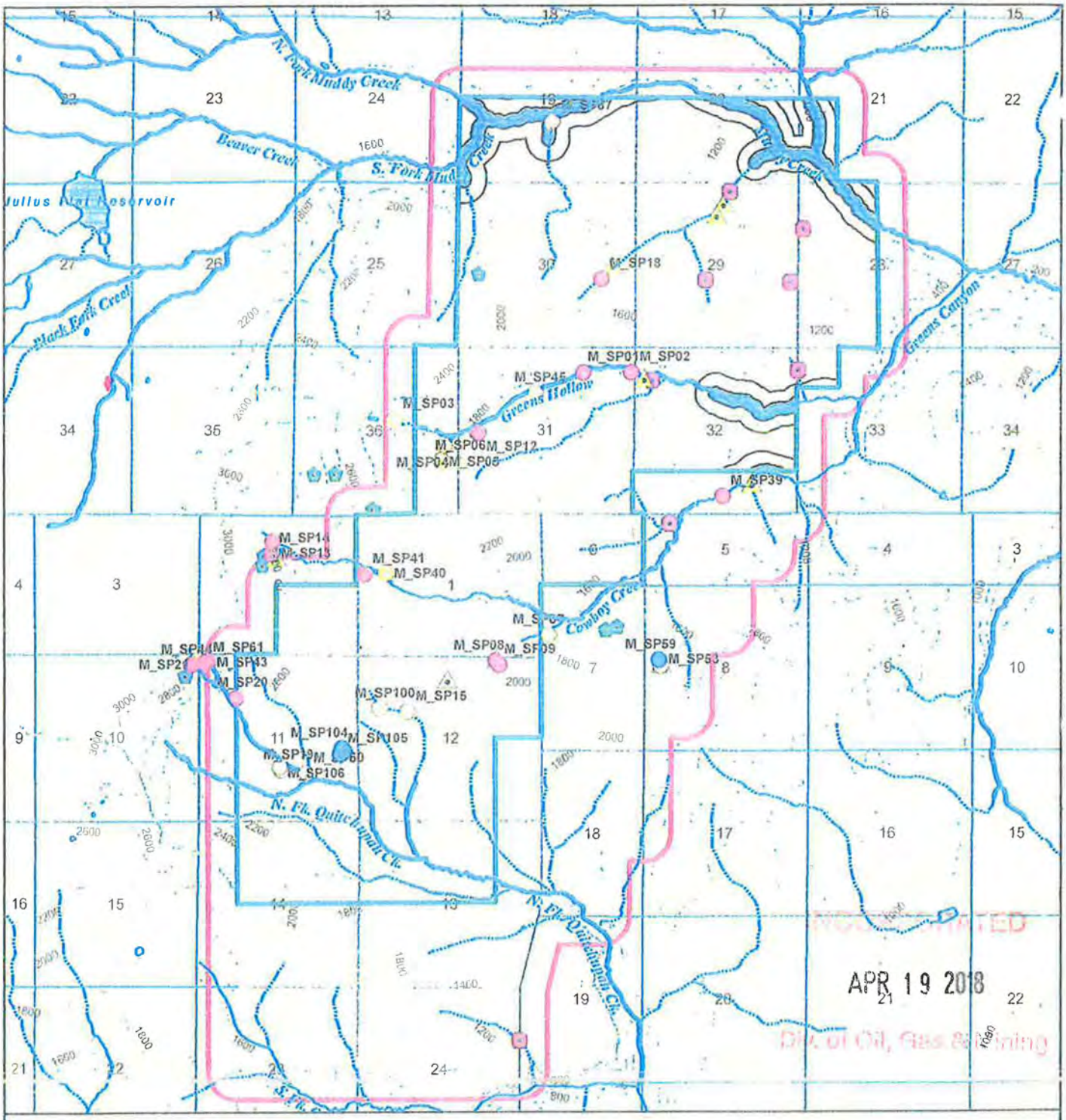

Figure 4.4. Alternative 3 - surface and ground water features with stream buffers and overburden thickness.

1 0.5 0 1 Miles

1:53,500

Legend

- Greens Hollow Coal Lease Tract
- Mining Analysis Area Boundary
- Area of Subsidence Mining
- National Forest Boundary
- GreensHollowSectionsPLSS
- Overburden contours (200 ft)
- Perennial Flow 2001
- Perennial Streams (USGS)
- Intermittent Streams (USGS)
- Springs
  - High
  - Moderate
  - Unknown
- Cattle Troughs
- Natural Ponds
- Stock Ponds
- Stream Buffer
- Angle of Draw Buffer

Pond Coordinates Associated with Greens Hollow Lease

	UTM Coordinates (WGS 1984)		
Pond	**Easting**	**Northing**	**Description**
M-P01 (Slab)	470453	4315207	
M-P02	469087	4318985	
M-P03	463346	4319903	Good pond with plenty of water (7-14-2016).
M-P04	466990	4321940	
M-P05	467661	4320195	
M-P06 (West Pine)	470134	4317663	
M-P07	466409	4318707	
M-P08	465776	4317694	Natural depression. Shallow and dry. Likely fills after high precip events, but probably does not retain water for long.
M-P09	465906	4317716	Natural depression. Shallow and dry. Likely fills after high precip events, but probably does not retain water for long.
M-P10	467598	4321056	
M-P11	468775	4317115	
GH-P01	467706	4321564	Catchment pond. Dry on 7-14-2016.
GH-P02	466226	4320098	Small catchment pond. Dry on 7-14-2016.
GH-P03	464509	4321158	May or may not be pond in EIS. Possibly may be further downhill than this one. This one is a natural depression. Looks like it has held water up until recently (7-14-2016). Has sedges growing in it.
GH-P04	462921	4319030	Natural depression with fair amount of water (7-14-2016). Shaded by trees.
GH-P05	463051	4318992	Natural depression. Dry on 7-14-2016. Likely holds water in spring and after heavy precip events.
GH-P06	463482	4318853	Took picture from 0.25 mi away. Appears to be dry to somewhat muddy (7-14-2016). Good runoff pond
GH-P07	462388	4318326	Natural depression. Marshy with some water in it. Cows drinking out of it (7-14-2016).
GH-P08	464483	4319649	Natural depression. May have been spring fed, or is spring fed during springtime, but has no water or mud in it. Likely catches water after high precip events.
GH-P09	464511	4319616	Natural depression. Actively being fed by a spring. Has some water and mud in it. Likely catches water after high precip events also.

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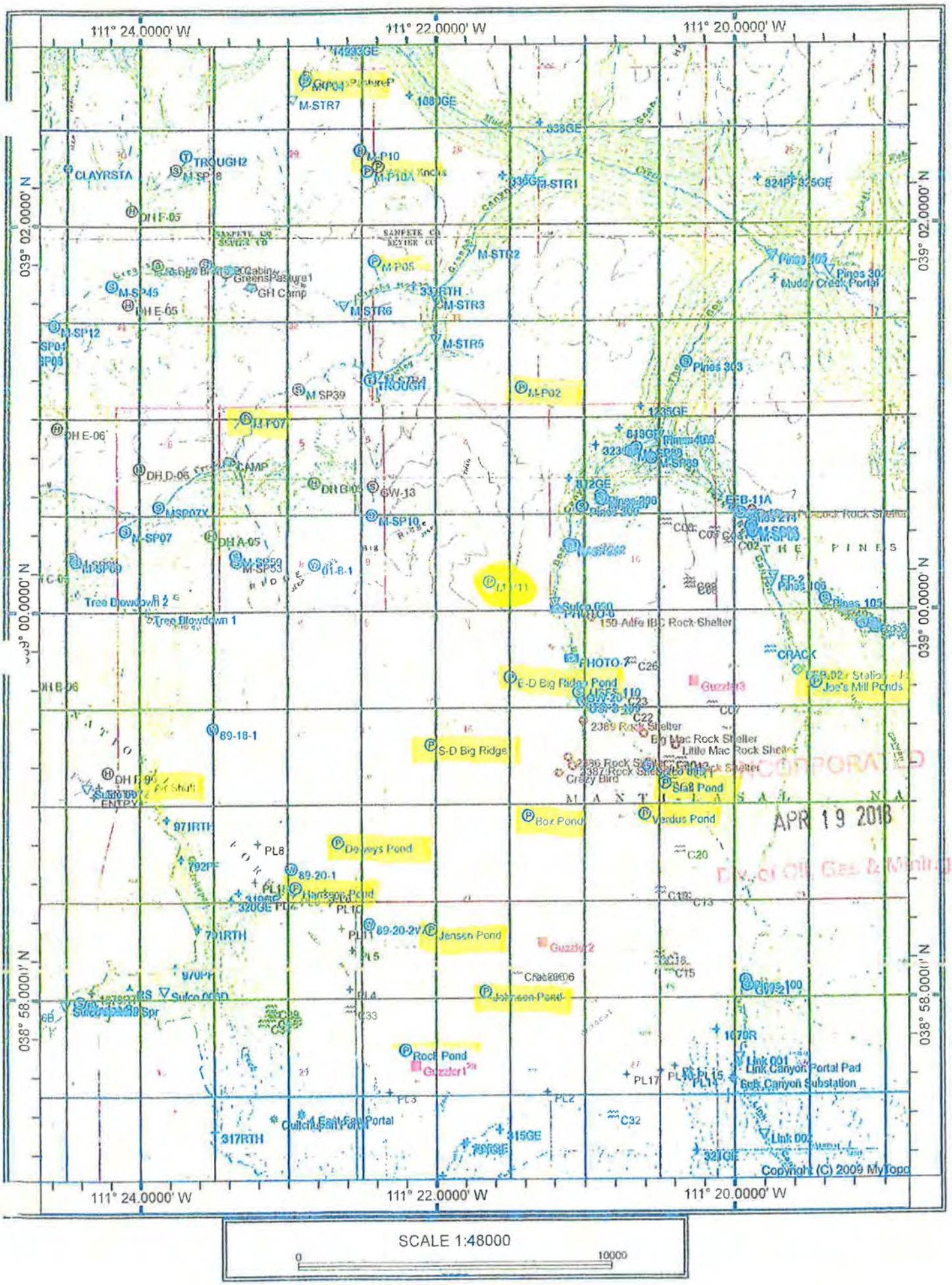
Water Source Described As Pond In Greens Hollow EIS Determined Not To Be A Pond

ID	**Easting**	**Northing**	**Description**
Water Source #1	461697	4317345	Not a pond or depression, just a slightly graded medow with a small stream running through it.
Water Source #2	462499	4318431	Marshy slow-moving stream. Not pond-like in any way.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111° 22.0000' W
111° 20.0000' W
039° 02.0000' N
039° 00.0000' N
038° 58.0000' N
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M-P10
M-P10A
M-STR1
M-STR2
M-P05
M-STR6
M-STR3
M-STR5
M-P02
M-P07
M-SP10
M-P11
S-D Big Ridge Pond
S-D Big Ridges
Box Pond
Vendus Pond
Deweys Pond
Harrison Pond
Jensen Pond
Johnson Pond
Rock Pond
Sfa2 Pond
Joe's Mill Ponds
Pines 303
Pines 105
Pines 302
Muddy Creek Portal
THE PINES
CRACK
Tree Blowdown 1
Tree Blowdown 2
159-Alfa IBC Rock-Shelter
2389 Rock Shelter
Big Mac Rock Shelter
Little Mac Rock Shelter
Crazy Bird
Guzzler1
Guzzler2
Guzzler3
Link 001
Link Canyon Portal Pad
Salt Canyon Substation
Link 002
East Fork Portal
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SCALE 1:48000
0
10000
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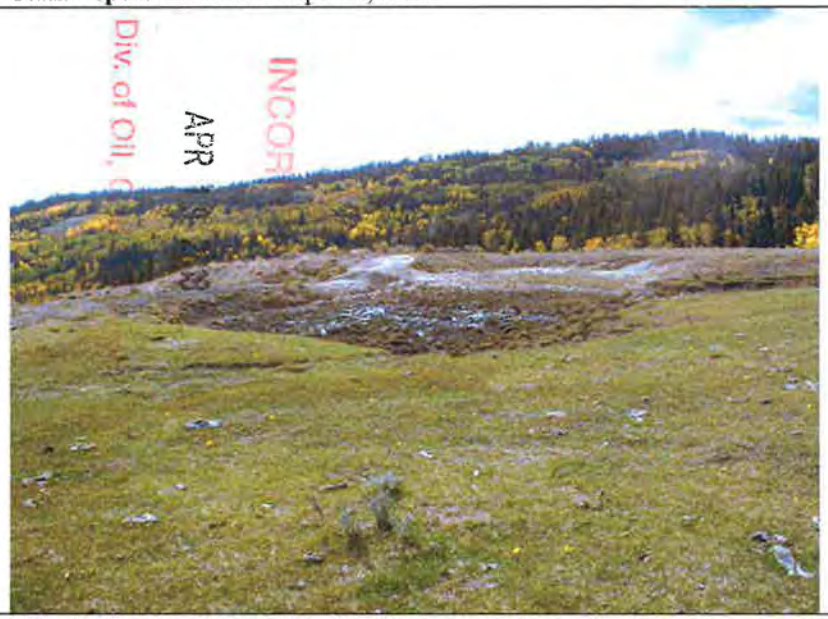
Pond Identification: MP1. **Pond Type:** Berm across drainage.
Water Source: Runoff. **Size:** 185 ft. x 420 ft. 1.59 ac. **Depth:** Dry.
Max Depth: 4 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP2. **Pond Type:** Berm across drainage.
Water Source: Runoff. **Size:** 95 ft. x 125 ft. 0.21 ac. **Depth:** 1.5 ft.
Max Depth: 3 ft. **Date:** Sept. 28, 2002.



Pond Identification: MP3. **Pond Type:** Basin dug in spring.
Water Source: S. **Size:** 70 ft. x 90 ft. 0.1 ac. **Depth:** 0.25.
Max Depth: 0.25 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP4. **Pond Type:** Basin.
Water Source: Piped spring. **Size:** 40 ft. x 60 ft. 0.04 ac. **Depth:** 0.25.
Max Depth: 4 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP5. **Pond Type:** Berm across drainage.
Water Source: Runoff. **Size:** 70 ft. x 80 ft. 0.1 ac. **Depth:** Dry.
Max Depth: 1 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP6. **Pond Type:** Berm across drainage.
Water Source: Runoff. **Size:** 50 ft. dia. 0.05 ac. **Depth:** Dry.
Max Depth: 2.5 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP7. **Pond Type:** Berm across drainage.
Water Source: S. **Size:** 60 ft. x 120 ft. 0.11 ac. **Depth:** Dry.
Max Depth: 3 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP8. **Pond Type:** Natural Basin.
Water Source: Shallow groundwater. **Size:** 50 ft. x 150 ft. 0.12 ac.
Depth: Dry. **Max Depth:** 1 ft. **Date:** Sept. 28, 2002.

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Pond Identification: MP9. **Pond Type:** Natural Basin.
Water Source: Shallow groundwater. **Size:** 80 ft. dia. 0.11 ac. **Depth:** Dry.
Max Depth: 1 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP10. **Pond Type:** Natural Basin.
Water Source: Runoff. **Size:** 35 ft. x 62 ft. 0.05 ac. **Depth:** Dry.
Max Depth: 1.5 ft. **Date:** Sept. 28, 2002.

Pond Identification: MP11. **Pond Type:** Berm across Drainage.
Water Source: Runoff. **Size:** 25 ft. x 80 ft. 0.05 ac. **Depth:** Dry.
Max Depth: 1.0 ft. **Date:** Sept. 28, 2002.

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M-P01 (Slab Pond)

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M-P02

M-P03

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M-P04

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M-P05

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M-P06
(West Pine Pond)

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M-P07

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M-P08

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M-P11

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GH-P01

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GH-P02

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Greens Hollow Lease - SUFCO Mine
Ponds, Troughs, and Water Monitoring Locations

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Base Map: AGRC USGS Topo
All Locations Are Approximate

Miles
0 0.25 0.5 1 1.5 2

N
W E
S

Legend

- Monitoring Stream (Historic)
- Monitoring Stream
- Monitoring Spring (Historic)
- Monitoring Spring
- Troughs
- Stock Ponds

June 2008	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	1.5	95 x 125	No	75% FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		F	M	P
M-P05	YES	DRY	No		70 x 80	No		F	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES		No	0.5	35 x 62	No	15% FULL	G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

July/August 2008	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	2	95 x 125	No	FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES		No	0.5	40 x 60	No	30% FULL	G	M	P
M-P05	YES	DRY	No		70 x 80	No		F	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

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October 2008	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	1.2	95 x 125	No	20% FULL	F	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		F	M	P
M-P05	NO	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY			35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P

GH-P02	NS	48 Diameter	M	P
GH-P03	NS	55 x 80	N	P
GH-P04	NS	70 x 40	N	P
GH-P05	NS	30 x 40	N	P
GH-P06	NS	35 x 65	M	P
GH-P07	NS	40 x 60	N	P
GH-P08	NS	30 x 50	M	P
GH-P09	NS	30 x 45	N	S

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April 2009	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	1.2	95 x 125	No	40% FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES		No		40 x 60	No	DAMP	G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES		No	0.5	35 x 62	No	25% FULL	G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

July 2009	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	0.2	95 x 125	No	PUDDLE	F	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	YES	DRY	No		70 x 80	No		F	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

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October 2009	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		F	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P

GH-P02	NS	48 Diameter	M	P
GH-P03	NS	55 x 80	N	P
GH-P04	NS	70 x 40	N	P
GH-P05	NS	30 x 40	N	P
GH-P06	NS	35 x 65	M	P
GH-P07	NS	40 x 60	N	P
GH-P08	NS	30 x 50	M	P
GH-P09	NS	30 x 45	N	S

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June 2010	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	1.3	95 x 125	No	30% FULL	F	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

July/August 2010	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		F	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES		No	0.1	60 x120	No	PUDDLE	G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

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October 2010	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	1	95 x 125	No	45% FULL	F	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	YES		No	0.5	70 x 80	No	30% FULL	G	M	P
M-P07	YES		No	0.6	60 x120	No	33% FULL	G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES		No	1.5	35 x 62	No	FULL	G	N	P
GH-P01		NS			50 x 60				M	P

GH-P02	NS	48 Diameter	M	P
GH-P03	NS	55 x 80	N	P
GH-P04	NS	70 x 40	N	P
GH-P05	NS	30 x 40	N	P
GH-P06	NS	35 x 65	M	P
GH-P07	NS	40 x 60	N	P
GH-P08	NS	30 x 50	M	P
GH-P09	NS	30 x 45	N	S

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May/June 2011	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	1.3	95 x 125	No	40% FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES		No	0.4	40 x 60	No	20% FULL	G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	NO		No	0.6	60 x120	No	25% FULL	G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES		No	0.7	35 x 62	No	33% FULL	G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

August 2011	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		F	M	P
M-P03		NS			70 x 90				M	S
M-P04		NS			40 x 60				M	P
M-P05		NS			70 x 80				M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				N	P
GH-P09		NS			30 x 45				N	S

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September 2011	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		F	M	P
M-P03		NS			70 x 90				M	S
M-P04		NS			40 x 60				M	P
M-P05		NS			70 x 80				M	P
M-P07		NS			60 x120				M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10		NS			35 x 62				N	P
GH-P01		NS			50 x 60				M	P

GH-P02	NS	48 Diameter	M	P
GH-P03	NS	55 x 80	N	P
GH-P04	NS	70 x 40	N	P
GH-P05	NS	30 x 40	N	P
GH-P06	NS	35 x 65	M	P
GH-P07	NS	40 x 60	N	P
GH-P08	NS	30 x 50	M	P
GH-P09	NS	30 x 45	N	S

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May 2012	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	0.2	95 x 125	No	PUDDLE	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05		NS			70 x 80				M	P
M-P07	YES	DRY	No		60 x120	No		F	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

August 2012	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		F	M	P
M-P05		NS			70 x 80				M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

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October 2012	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES		No	0.75	95 x 125	No	25% FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		F	M	P
M-P05		NS			70 x 80				M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P

GH-P02	NS	48 Diameter	M	P
GH-P03	NS	55 x 80	N	P
GH-P04	NS	70 x 40	N	P
GH-P05	NS	30 x 40	N	P
GH-P06	NS	35 x 65	M	P
GH-P07	NS	40 x 60	N	P
GH-P08	NS	30 x 50	M	P
GH-P09	NS	30 x 45	N	S

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May 2013	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		F	M	P
M-P05		DRY	No		70 x 80	No		G	M	P
M-P07		DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10		DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

July 2013	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	NO	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		DRY	No		48 Diameter	No		G	M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

September 2013	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	NO		No	2.75	95 x 125	No	FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04		NS			40 x 60				M	P
M-P05	NO		No	0.5	70 x 80	No	30% FULL	G	M	P
M-P07		NS			60 x120				M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10		NS			35 x 62				N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 diameter				M	P

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GH-P03	NS	55 x 80	N	P
GH-P04	NS	70 x 40	N	P
GH-P05	NS	30 x 40	N	P
GH-P06	NS	35 x 65	M	P
GH-P07	NS	40 x 60	N	P
GH-P08	NS	30 x 50	M	P
GH-P09	NS	30 x 45	N	S

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June 2014	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES				95 x 125		DAMP	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	NO	DRY	No		40 x 60	No		G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES		No	0.25	60 x120	No	PUDDLE	G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10		DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

July 2014	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES	DRY	No		95 x 125	No		G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		F	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES		No	2.5	95 x 125	No	75% FULL	G	M	P
M-P03					70 x 90				M	S
M-P04					40 x 60				M	P
M-P05					70 x 80				M	P
M-P07					60 x120				M	P
M-P08					50 x 150				N	P
M-P09					80 Diameter				N	P
M-P10					35 x 62				N	P
GH-P01					50 x 60				M	P
GH-P02					48 Diameter				M	P
GH-P03					55 x 80				N	P

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GH-P04	70 x 40	N	P
GH-P05	30 x 40	N	P
GH-P06	35 x 65	M	P
GH-P07	40 x 60	N	P
GH-P08	30 x 50	M	P
GH-P09	30 x 45	N	S

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June 2015	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	2.6	95 x 125	No	75% FULL	G	M	P
M-P03	YES		No	0.25	70 x 90	No	30% FULL	G	M	S
M-P04	YES		No	0.5	40 x 60	No	50% FULL	G	M	P
M-P05	NO	DRY	No		70 x 80	No		G	M	P
M-P07	NO	DRY	No		60 x120	No		G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES		No	0.8	35 x 62	No	25% FULL	G	N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03	YES		No		55 x 80	No	DAMP	G	N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

July 2015	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	NO		No	1.75	95 x 125	No	80% FULL	G	M	P
M-P03		NS	No		70 x 90				M	S
M-P04		NS	No		40 x 60				M	P
M-P05	NO	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08		NS	No		50 x 150				N	P
M-P09		NS	No		80 Diameter				N	P
M-P10	YES		No	0.8	35 x 62	No	FULL	G	N	P
GH-P01		NS	No		50 x 60				M	P
GH-P02		NS	No		48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS	No		70 x 40				N	P
GH-P05		NS	No		30 x 40				N	P
GH-P06		NS	No		35 x 65				M	P
GH-P07		NS	No		40 x 60				N	P
GH-P08		NS	No		30 x 50				M	P
GH-P09		NS	No		30 x 45				N	S

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May 2016	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	1.25	95 x 125	No	50% FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04		NS			40 x 60				M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07		NS			60 x120				M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10		NS			35 x 62				N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 Diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08	NO		No		30 x 50	No	DAMP	G	M	P
GH-P09	NO		No		30 x 45	No	DAMP	G	N	S

June/July 2016	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES		No	0.8	95 x 125	No	25% FULL	G	M	P
M-P03	YES		No	0.5	70 x 90	No	25% FULL	F	M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES	DRY	No		60 x120	No		G	M	P
M-P08	NO	DRY	No		50 x 150	No		G	N	P
M-P09	NO	DRY	No		80 Diameter	No		G	N	P
M-P10	NO	DRY	No		35 x 62	No		G	N	P
GH-P01	YES	DRY	No		50 x 60	No		G	M	P
GH-P02	YES	DRY	No		48 Diameter	No		G	M	P
GH-P03	YES		No		55 x 80	No	DAMP	G	N	P
GH-P04	YES		No	0.5	70 x 40	No	50% FULL	G	N	P
GH-P05	YES	DRY	No		30 x 40	No		G	N	P
GH-P06	YES		No	0.1	35 x 65	No	10% FULL	G	M	P
GH-P07	NO	DRY	No		40 x 60	No		G	N	P
GH-P08	YES	DRY	No		30 x 50	No		G	M	P
GH-P09	YES		No		30 x 45	No	DAMP	G	N	S

August/September 2016	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	
POND NAMES										
M-P02	YES		No	0.75	95 x 125	No	20% FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	NO	DRY	No		70 x 80	No		G	M	P
M-P07		NS			60 x120				M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No		G	N	P
GH-P01	NO	DRY	No		50 x 60	No		G	M	P

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GH-P02	NO	DRY	No		48 Diameter	No		G		M	P
GH-P03	NO		No		55 x 80	No	DAMP	G		N	P
GH-P04	NO		No	0.7	70 x 40	No	50% FULL	G		N	P
GH-P05	NO	DRY	No		30 x 40	No		G		N	P
GH-P06	NO	DRY	No		35 x 65	No		G		M	P
GH-P07	YES		No		40 x 60	No	PUDDLE	G		N	P
GH-P08	NO	DRY	No		30 x 50	No		G		M	P
GH-P09	NO		No		30 x 45	No	PUDDLE	G		N	S

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August 2017	Photo (Yes/No)	Pond (Dry) Not Sampled (NS)	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	0.5	95 x 125	No	15% FULL	G	M	P
M-P03	YES		No	1	70 x 90	No	FULL	G	M	S
M-P04	YES	DRY	No		40 x 60	No		G	M	P
M-P05	YES	DRY	No		70 x 80	No		G	M	P
M-P07	YES		No	0.9	60 x120	No	FULL	G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10	YES	DRY	No		35 x 62	No			N	P
GH-P01	YES	DRY	No		50 x 60	No			M	P
GH-P02	YES	DRY	No		48 diameter	No			M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

September 2017	Photo (Yes/No)	Pond Dry	Pond Cracking (Yes/No)	Estimated Depth at Center (feet)	Estimated Size (feet)	Surface Cracking (Yes/No)	Moisture In Pond (Yes/No)	General Condtion Pond (G-Good), (F-Fair) (P-Poor)	Manmade (M) or Natural (N)	Fed by Precipitation (P) or Spring (S)
POND NAMES										
M-P02	YES		No	2.1	95 x 125	No	65% FULL	G	M	P
M-P03		NS			70 x 90				M	S
M-P04		NS			40 x 60				M	P
M-P05	NO	DRY			70 x 80			G	M	P
M-P07	NO	DRY			60 x120			G	M	P
M-P08		NS			50 x 150				N	P
M-P09		NS			80 Diameter				N	P
M-P10		NS			35 x 62				N	P
GH-P01		NS			50 x 60				M	P
GH-P02		NS			48 diameter				M	P
GH-P03		NS			55 x 80				N	P
GH-P04		NS			70 x 40				N	P
GH-P05		NS			30 x 40				N	P
GH-P06		NS			35 x 65				M	P
GH-P07		NS			40 x 60				N	P
GH-P08		NS			30 x 50				M	P
GH-P09		NS			30 x 45				N	S

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Basin Pond (M-P02)

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Bridger Pond (M-P03)

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Buck Pond (M-P04)

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Tropical Pond (M-P05)

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Cowboy Pond (M-P07)

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Ute Pond (M-P08)

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Cougar Pond (M-P09)

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Doe Pond (M-P10)

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Hugh's Pond (GH-P01)

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Greens Hollow Pond (GH-P02)

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Ridge Pond (GH-P03)

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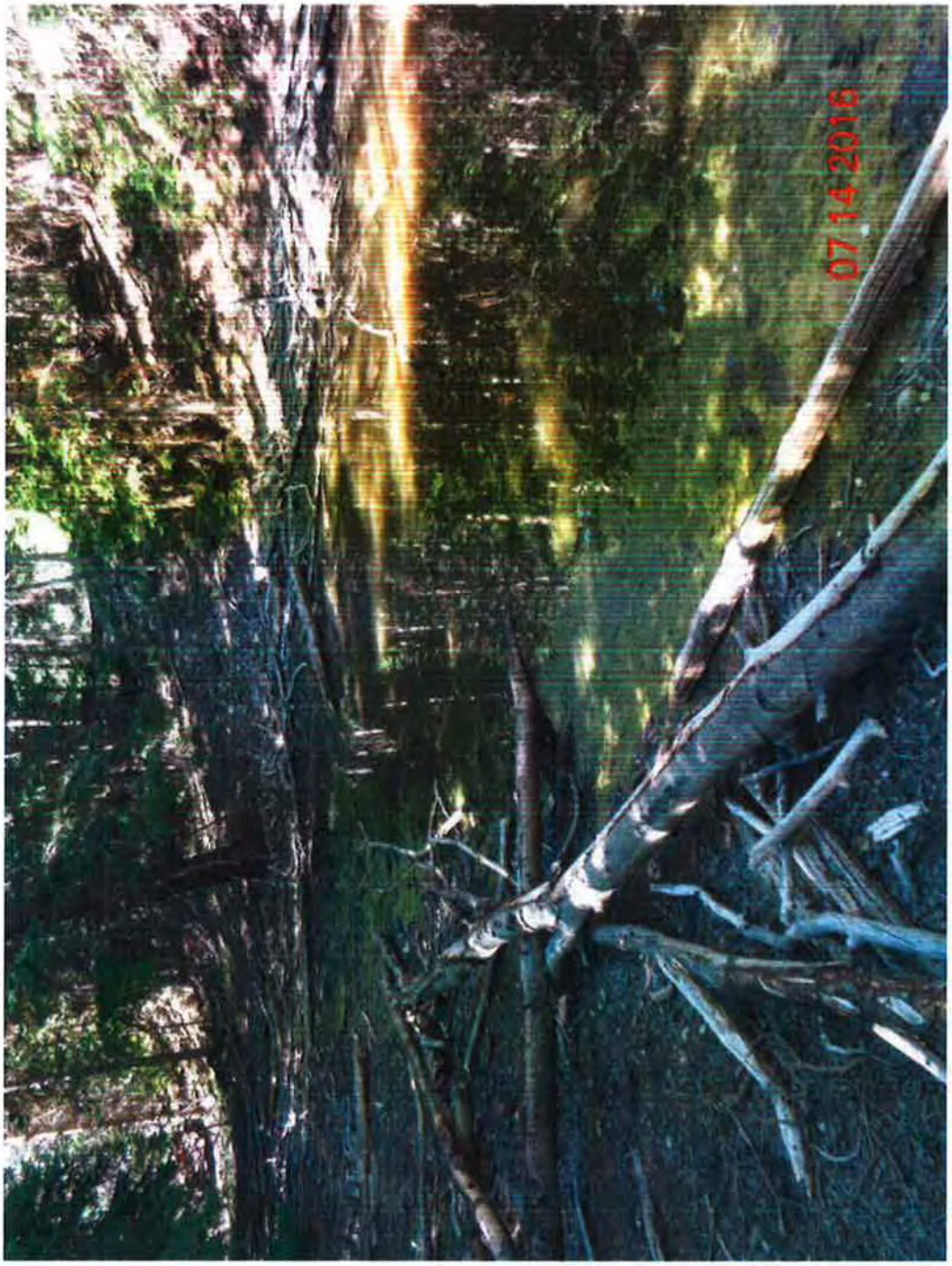
Duke Pond (GH-P04)



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Daisy Pond (GH-P05)

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Dove Pond (GH-P06)

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Sweet Water Pond (GH-P07)

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Bugle 1 Pond (GH-P08)

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Bugle 2 Pond (GH-P09)

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GREENS HOLLOW LEASE
ADJACENT AREA
UNDERGROUND WATER
SAMPLING LOCATIONS

REFER TO PHC FOR ANALYSES AND DISCUSSION OF SAMPLING

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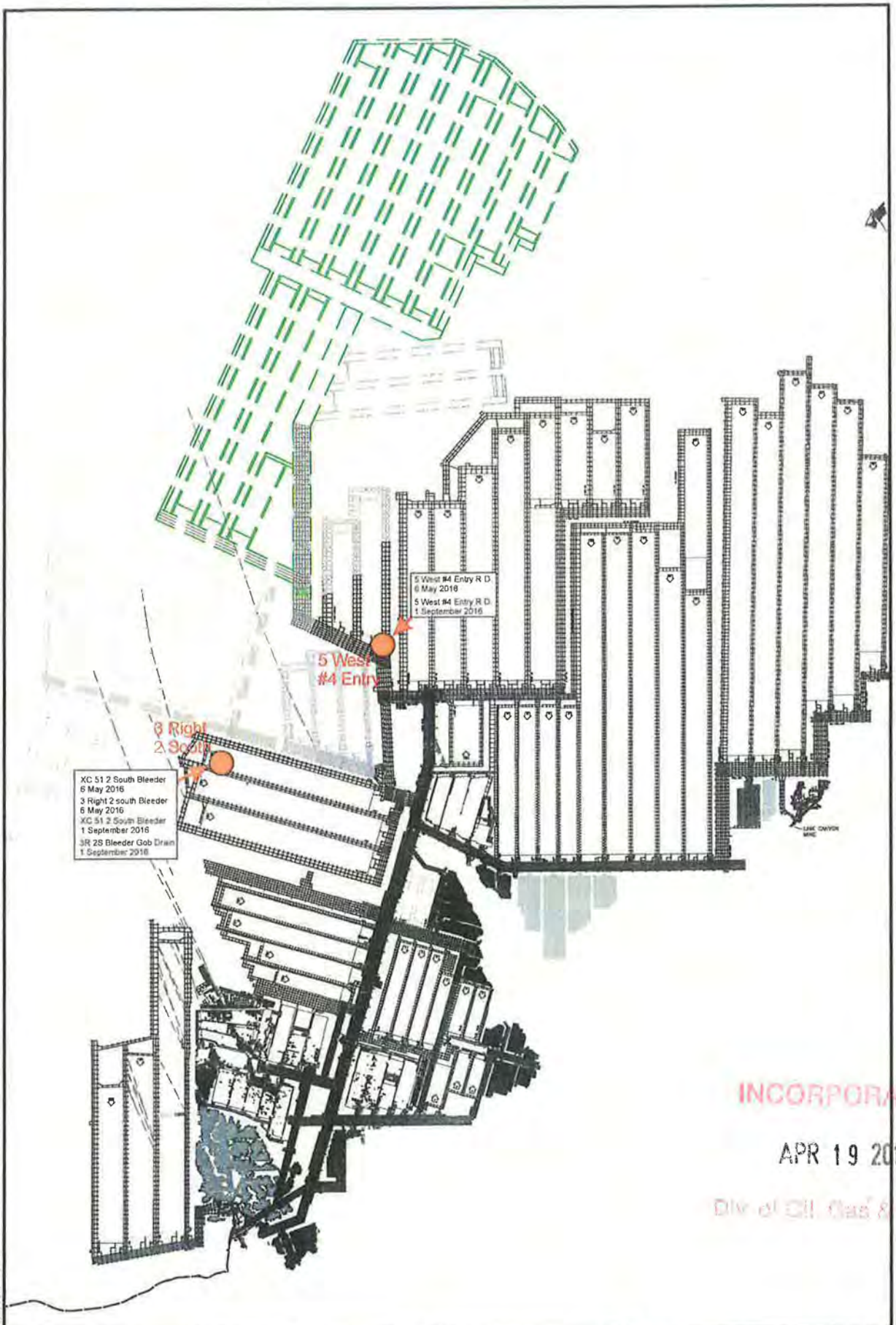

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Div of Oil, Gas & Mining

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(435) 286-4499 Fax

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Figure 2

Carbon-14 and tritium sampling locations.

Greens Hollow Lease Appendix 7-27

MONITORING LOCATIONS ABOVE AND BELOW MINING PANELS

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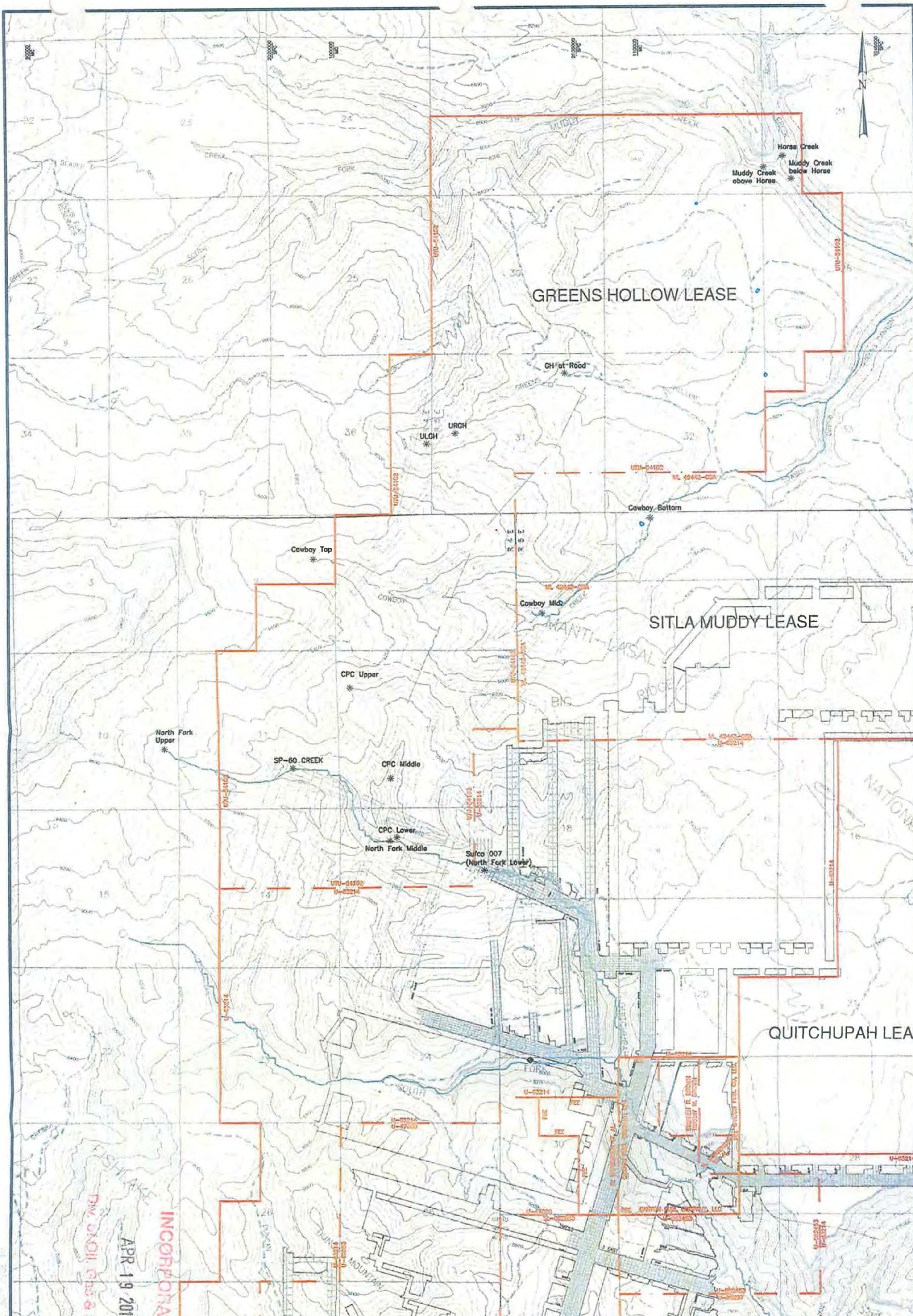

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 - Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

MONITORING LOCATIONS ABOVE AND BELOW MINING PANELS			SHEET NO. FIGURE 1 APPENDIX 7-27
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Canyon Fuel Company, LLC - Sufco Mine

Hydrologic monitoring field data report

Monitoring interval: 2nd, 3rd & 4th Quarters 2017

	Date	Time	Flow (gpm)	Water Level (feet)	T (°C)	pH (S.U.)	Sp. Cond. (µS/cm)	D.O. (mg/L)	Comments
Cowboy Top	29-Jun-17	18:10	1.74		13.8	8.43	540	7.49	Cowboy Creek at lease edge
Cowboy Mid	29-Jun-17	20:15	10.1		15.2	8.55	668	7.50	
Cowboy Bottom	29-Jun-17	21:00	0.51		13.6	8.80	610	7.49	
SP60 Creek	30-Jun-17	18:00	37.5		14.5	8.64	545	8.11	Tributary to North Fork near spring M-SP60
North Fork Upper	30-Jun-17	19:00	718		11.5	8.64	329	8.54	North Fork at lease edge
CPC-Upper	30-Jun-17	19:00	0.103		12.9	8.58	645	8.13	
CPC-Middle	30-Jun-17	21:30	<0.01		11.4	7.86	1136	8.10	Slow drip; stagnant pools
CPC-Lower	30-Jun-17	22:00	3.13		11.2	8.30	853	7.78	CPC just above North Fork Confluence
North Fork Middle	30-Jun-17	22:30	581		10.3	8.66	355	8.44	North Fork just above CPC confluence
North Fork Lower (007)	30-Jun-17	23:15	622		10.0	8.65	357	8.43	Same monitoring site as Sufco 007
ULGH	28-Jun-17	16:45	6.88		12.6	8.66	902	7.42	Upper Left Fork Greens Hollow Creek
URGH	28-Jun-17	17:00	1.01		14.5	8.48	770	6.85	Upper Right Fork Greens Hollow Creek
GH at Road	28-Jun-17	19:00	2.94		18.8	8.79	847	7.31	Greens Hollow at Road Crossing
Horse Creek	27-Jun-17	16:00	11 cfs		16.5	8.77	446	7.48	Horse Creek trib to Muddy at conf. with Muddy Creek
Muddy Ck. Ab. Horse	27-Jun-17	18:00	96 cfs		15.3	8.76	360	7.52	Muddy Creek above the Horse Canyon Creek confluence
Muddy C. B. Horse	27-Jun-17	17:45	107 cfs		14.9	8.76	366	7.52	Muddy Creek a short distance below Horse Canyon Creek

Cowboy Creek at the road crossing and the upper right fork of Cowboy Creek were both dry at the end of June 2017 when the other sites listed above were monitored.

Cowboy Top	29-Sep-17	16:45	NOF						Cowboy Creek at lease edge
Cowboy Mid	30-Sep-17	19:45	12.1		8.5	8.58	743	8.86	
Cowboy Bottom	30-Sep-17	20:25	1.41		8.9	8.75	693	7.94	
SP60 Creek	28-Sep-17	14:15	15.7		6.9	8.67	635	8.97	Tributary to North Fork near spring M-SP60
North Fork Upper	28-Sep-17	15:25	128		6	8.53	345	8.93	North Fork at lease edge
CPC-Upper	28-Sep-17	18:30	NOF						
CPC-Middle	28-Sep-17	19:15	0.62		7.7	8.77	795	8.98	Slow drip; stagnant pools
CPC-Lower	28-Sep-17	19:45	3.6		7.5	8.60	884	9.13	CPC just above North Fork Confluence
North Fork Middle	28-Sep-17	20:00	26		6.2	8.6	457	9.45	North Fork just above CPC confluence
North Fork Lower (007)	28-Sep-17	21:15	28		6.9	8.6	540	8.89	Same monitoring site as Sufco 007
ULGH	27-Sep-17	17:15	3.49		6	8.67	872	8.45	Upper Left Fork Greens Hollow Creek
URGH	27-Sep-17	17:30	0.19		5.1	8.51	944	7.92	Upper Right Fork Greens Hollow Creek
GH at Road	27-Sep-17	19:00	2.68		8.8	8.66	874	7.73	Greens Hollow at Road Crossing

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	Date	Time	Flow (gpm)	Water Level (feet)	T (°C)	pH (S.U.)	Sp. Cond. (µS/cm)	D.O. (mg/L)	Comments
Horse Creek	30-Sep-17	12:20	585		8.5	8.8	476	8.62	Horse Creek trib to Muddy at conf. with Muddy Creek
Muddy Ck. Ab. Horse	30-Sep-17	12:30	9030		6.2	8.76	396	9.08	Muddy Creek above the Horse Canyon Creek confluence
Muddy C. B. Horse	30-Sep-17	12:45	9620		6.7	8.75	399	8.93	Muddy Creek a short distance below Horse Canyon Creek

Cowboy Creek at the road crossing had flow of 0.47 gpm when the other sites listed above were monitored.

Cowboy Top	9-Nov-17	14:10	NOF		-	-	-	-	Cowboy Creek at lease edge
Cowboy Mid	15-Nov-17	15:45	2.23		0.6	8.55	832	9.58	
Cowboy Bottom	15-Nov-17	16:50	0.88		1.1	8.66	643	9.64	
SP60 Creek	10-Nov-17	12:30	10.7		0.7	8.54	737	11.28	Tributary to North Fork near spring M-SP60
North Fork Upper	10-Nov-17	13:00	106		0.4	8.53	358	11.9	North Fork at lease edge
CPC-Upper	10-Nov-17	16:10	NOF		-	-	-	-	
CPC-Middle	10-Nov-17	17:20	NOF		-	-	-	-	
CPC-Lower	10-Nov-17	17:45	3.05		1.5	8.38	850	12.1	CPC just above North Fork Confluence
North Fork Middle	10-Nov-17	18:00	139		0.4	8.59	412	12.4	North Fork just above CPC confluence
North Fork Lower (007)	10-Nov-17	19:15	144		0.4	8.47	439	11.57	Same monitoring site as Sufco 007
ULGH	13-Nov-17	17:00	3.16		0.8	8.66	834	12.98	Upper Left Fork Greens Hollow Creek
URGH	13-Nov-17	15:40	NOF		-	-	-	-	Upper Right Fork Greens Hollow Creek
GH at Road	13-Nov-17	18:45	1.19		0.5	8.51	981	10.9	Greens Hollow at Road Crossing
Horse Creek	14-Nov-17	13:45	832		1.3	8.8	474	10.88	Horse Creek trib to Muddy at conf. with Muddy Creek
Muddy Ck. Ab. Horse	14-Nov-17	13:00	3,777		1	8.76	414	10.9	Muddy Creek above the Horse Canyon Creek confluence
Muddy C. B. Horse	14-Nov-17	14:30	4,609		1.2	8.77	423	10.91	Muddy Creek a short distance below Horse Canyon Creek

Cowboy Creek at the road crossing had flow of 0.44 gpm when the other sites listed above were monitored.

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APPENDIX 7-28

Probable Hydrologic Consequences - Greens Hollow Tract

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Investigation of Groundwater And Surface-Water Systems in The Greens Hollow Tract Area; Probable Hydrologic Consequences of Coal Mining

2 October 2017

Canyon Fuel Company, LLC
Sufco Mine
Salina, Utah

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PETERSEN HYDROLOGIC
CONSULTANTS IN HYDROGEOLOGY

Investigation of Groundwater And Surface-Water Systems in The Greens Hollow Tract Area; Probable Hydrologic Consequences of Coal Mining

2 October 2017

Canyon Fuel Company, LLC
Sufco Mine
Salina, Utah

Prepared by:

Erik C. Petersen, P.G.

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List of Attachments

Attachment A	Discharge hydrographs and plots of temperature, pH, specific conductance, and the Palmer Hydrologic Drought Index for springs in the Greens Hollow Tract area.
Attachment B	Discharge hydrographs and plots of temperature, pH, specific conductance, and the Palmer Hydrologic Drought Index for streams in the Greens Hollow Tract area.
Attachment C	Water level hydrographs for monitoring wells.

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1.0 INTRODUCTION

The Canyon Fuel Company, LLC (CFC) Sufco Mine surface facilities are located approximately 25 miles east of Salina, Utah and about 9 miles west of Emery, Utah in the Wasatch Plateau coal mining district (Figures 1 and 2). The mine produces bituminous coal and has been in operation since 1941. Coal mining operations at the Sufco Mine are carried out using longwall mining and continuous miner techniques. Continuous mining techniques are primarily utilized to construct the development entries for the longwall panels.

CFC has recently been awarded the rights to mine in the Federal Greens Hollow Tract (UTU-84102), which is contiguous with the existing Sufco Mine permit area (Figure 1). It is proposed that the existing underground Sufco Mine workings be extended into the Greens Hollow Tract. Access to the Greens Hollow Tract will be made using the existing mine portals and surface facilities in Convulsion Canyon.

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Canyon Fuel is seeking to obtain a permit from the Utah Division of Oil, Gas and Mining (DOGM) to conduct mining and reclamation activities in the Greens Hollow Tract. This report contains a description of groundwater and surface-water systems in the Greens Hollow Tract and a description of the probable hydrologic consequences of coal mining in the Greens Hollow Tract and adjacent areas as required by Utah Coal Mining rule R645-301-728. This report is written in support of Chapter 7 (Hydrology) of the Mining and Reclamation Plan (MRP) for the Sufco Mine.

2.0 METHODS OF INVESTIGATION

The hydrology and hydrogeology of the Greens Hollow Tract and adjacent areas has been evaluated based on an analysis of: 1) solute and isotopic compositions of groundwaters and surface waters, 2) surface water and groundwater discharge data, 3) piezometric data, and 4) geologic information. Specific methods of investigation are described below.

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Maps and reports

Existing published and unpublished hydrologic, hydrogeologic, and geologic maps were obtained and reviewed. Several investigations of the hydrogeology and hydrology of the Sufco Mine permit and adjacent areas have been completed prior to this investigation. The USGS, in cooperation with the BLM (Thiros and Cordy, 1991), described the hydrology and potential effects of mining in the Quitchupah and Pines Tract. Mayo and Associates (1997) described surface water and groundwater systems and mining-related hydrologic impacts in the adjacent existing SUFCO Mine permit area. The US Forest Service (1999) completed a Final Environmental Impact Statement and Record of Decision (2011) for the Greens Hollow Tract. The US Forest Service completed a supplemental Environmental Impact Statement in 2014. Petersen Hydrologic (2009) characterized groundwater and surface-water systems and evaluated the effects of subsidence of Castlegate Sandstone springs and streams in the East Fork of Box Canyon Creek drainage.

Collection of water quality and flow data

Beginning in 2001, a spring and seep survey and baseline monitoring program was performed in the Greens Hollow Tract and adjacent areas by Cirrus Ecological Solutions, LC (Cirrus) of Logan, Utah. These investigations were performed for the Manti-LaSal National Forest in conjunction with NEPA analysis for the Greens Hollow Tract. As part of these activities, discharge rates and field water quality parameters were measured (including water temperature, pH, specific conductance, turbidity, and dissolved oxygen). Spring and seep locations were determined in the field using hand-held GPS units. Baseline monitoring for laboratory water quality parameters was performed by Cirrus personnel at selected spring and stream monitoring stations through the second quarter of 2004. Details of the Cirrus monitoring activities are included in the Technical Report for Groundwater and Surface Water for the Greens Hollow Tract (USFS, 2005).

Monitoring of springs, seeps, and streams located in and around the Greens Hollow Tract has been performed by Petersen Hydrologic, LLC through 2016. The specific methods of study utilized by Petersen Hydrologic personnel to collect groundwater and surface-water quantity and quality data in the Greens Hollow Tract area are described below.

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Discharge Measurements

Discharge measurements for springs were typically performed using a calibrated container and a stopwatch. Generally, spring discharge measurements were performed by damming and diverting the spring discharge through a pipe. Using an appropriately sized container, time-to-fill measurements were typically performed at least 3 times at each location. An

average time-to-fill value was used to calculate the reported discharge measurement. In a few instances where the discharge from a spring was diffuse and the discharge rate was very low, discharge rates were approximated (i.e. providing "less than" values).

Discharge measurements on streams were typically performed using a Marsh-McBirney brand electromagnetic current velocity meter and wading rod using methods described by the United States Geological Survey (1995). In instances on Muddy Creek where stream discharges exceeded rates where streams could safely be waded, surface-water discharge velocities were sometimes measured by timing the passage of a floating object as it passed through a specified distance of the stream course.

Discharge Temperature Measurements

Temperature measurements were performed using a Taylor brand electronic digital thermometer. Temperature measurements on streams were performed in actively flowing, shaded areas where possible. Discharge temperature measurements at springs were performed as close to the spring discharge locations as possible.

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Specific Conductance Measurements

Specific conductance measurements were performed using an Extech brand model EC400 conductivity meter or a Hanna brand conductivity meter, both with automatic temperature compensation. The instruments were regularly calibrated using traceable ASTM conductivity standard solutions.

pH Measurements

pH Measurements were performed using an Oakton brand Acorn 6 model electronic pH meter with automatic temperature compensation, an Oakton model pH Testr 30 with automatic temperature compensation, or a Hanna brand pHep 5 pH meter with automatic temperature compensation. The instruments were regularly calibrated using traceable ASTM pH standard solutions.

Water Quality Laboratory Measurements

Water quality laboratory analyses were performed by SGS Minerals Services of Huntington, Utah and Chemtech-Ford Analytical Laboratories of Sandy, Utah.

Dissolved Oxygen

Dissolved oxygen measurements were performed using a YSI brand Model 55 dissolved oxygen meter. The meter utilizes a replaceable membrane and was regularly calibrated.

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Collection and analysis of isotopic data

Water samples from the Greens Hollow Tract and the surrounding Sufco Mine permit area were collected by Cirrus Ecological Solutions personnel during low-flow conditions in 2001 for stable and unstable isotopic analysis. Samples for radiocarbon were analyzed using Accelerator Mass Spectrometry (AMS) by Geochron Laboratories of Cambridge, Massachusetts. Tritium analyses were performed using direct counting methods by Geochron Laboratories (with error of +/- 2.7 TU). Stable isotopic carbon-13, deuterium, and oxygen-18 analyses were also performed by Geochron Laboratories.

Groundwater samples were also collected from the Greens Hollow Tract and adjacent areas by Petersen Hydrologic, LLC and Mayo and Associates, LC personnel. Samples were also collected from the underground Sufco Mine workings adjacent to the proposed Greens Hollow Tract mining areas. Isotopic samples were collected in appropriate, tightly sealed HDPE or glass sample bottles. Radiocarbon analyses on these samples were performed by Geochron Laboratories and the BYU Geology Department Isotopic Laboratory using either Conventional methods, or by AMS. Tritium analyses for the Mayo and Associates and Petersen Hydrologic samples were performed by the Tritium Laboratory at the University of Miami, Florida and BYU Geology Department Isotopic Laboratory using electrolytic enrichment and low level counting methods (with error of +/- 0.1 TU). Stable isotopic δ^2H and $\delta^{18}O$ analyses were performed by Mountain Mass Spectrometry of Evergreen, Colorado.

Groundwater mean residence times were determined using methods described by Pearson and Hanshaw (1970), Fontes (1980), and Mookes (1980).

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Data compilation

Data used in this study were obtained from several sources. Water quality and water quantity data were downloaded electronically from the DOGM on-line hydrology database located at http://ogm.utah.gov/coal/edi/wqdb.htm. Additional data were compiled from electronic media provided by the Manti-LaSal National Forest. Data were also obtained in paper-copy and electronic format laboratory reports from the Sufco Mine. The data were compiled into a coherent electronic database for analysis. Hydrologic monitoring site details are presented in

Table 1. A compilation of baseline monitoring data from the Greens Hollow Tract and adjacent area is presented in Table 2.

Data analysis

Geochemical, isotopic, discharge rate, and other data were analyzed by graphical and statistical methods. Solute compositions were graphically analyzed using Stiff (1951) diagrams. Mineral saturation indices were calculated using the computer code WATEQF (Plummer et. al, 1976).

3.0 PHYSIOGRAPHIC SETTING

The Greens Hollow Tract is situated in the Wasatch Plateau region of central Utah. Important physiographic features in the tract area include the deep Muddy Creek and Cowboy Creek canyon areas that form the approximate northern and northeastern boundary of the area. North of the tract area, the land surface rises precipitously towards Heliotrope and Ferron Mountains, with maximum elevations on those peaks of 11,130 feet and 10,678 feet, respectively. The northwestern portion of the tract is bordered by the generally north-sloping upland areas that drain toward the South Fork of Muddy Creek. The southern portions of the tract area include the eastward and southward sloping flanks of White Mountain that drain to the North Fork of Quitchupah Creek. To the west, White Mountain rises precipitously to elevations exceeding 10,800 feet. In the southeast portion of the tract area, Big Ridge is a prominent east-west trending ridge that rises to more than 9,200 feet and separates the Muddy Creek drainage to the north from the Quitchupah Creek drainage to the

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south. In the northern portions of the tract area are broad expanses of gently sloping plateaus of generally low relief that are vegetated primarily with grasses and sage brush. These relatively smooth features are dissected abruptly by the deeply incised, steep walled Muddy Creek Canyon, Greens Canyon, and the North and South Forks of Quitchupah Canyon. The east-west trending Greens Hollow Creek and Cowboy Creek drainages cut across the central portions of the Greens Hollow Tract, dividing the northern from the southern portions of the tract area.

Topographic elevations within the delineated Greens Hollow Tract range from about 7,440 feet in the bottom of Muddy Creek canyon along the eastern margins of the tract, to about 9,720 feet where Big Ridge merges into the flanks of White Mountain along the western margin of the tract. Total surface relief in the tract is about 2,280 feet.

The upland plateau area rolls gently and is vegetated primarily with sagebrush, grasslands, and isolated stands of Ponderosa Pines. The mountainous regions are vegetated primarily with conifer and aspen forests interspersed with sagebrush and grasslands. Vegetation on the sheer rock cliff faces in the deep canyons is sparse. The narrow canyon bottoms are commonly more heavily vegetated with bushes and grasses.

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4.0 CLIMATE

Precipitation in the vicinity of the Sufco Mine area is dependent on elevation. Annual precipitation in the vicinity ranges from 12 inches in the lower elevations to more than 20 inches in the higher elevations. Localized thunderstorms occur from July through November and contribute about half of the total annual precipitation (Thiros and Cordy, 1991). Mean monthly temperatures measured at the Emery 15 SW weather station, located about seven miles southeast of the study area, are below freezing from November to March. Snow depths measured between 1945 and 1985 at the Blacks Forks snow course, located about six miles northwest of the study area at an elevation of 9,200 feet, averaged 44 inches, with a water content of 14.4 inches (Whaley and Lytton, 1979). Historic precipitation data from the NOAA Salina 24E weather station, which has been maintained at the Sufco Mine surface facilities area since 1984, is presented in Table 3.

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Climatic conditions in the study area have varied substantially during the period of baseline monitoring at the Greens Hollow Tract (2001 – 2016). This is illustrated in a plot of the Palmer Hydrologic Drought Index (PHDI) for Utah Region 4 (Figure 3). The PHDI is a monthly value generated by the National Climatic Data Center using a variety of hydrologic parameters that indicates wet and dry spells. The PHDI is calculated from several hydrologic parameters including precipitation, temperature, evapotranspiration, soil water recharge, soil water loss, and runoff. Consequently, it is a useful tool for evaluating the relationship between climate and groundwater and surface water discharge data. It is apparent in Figure 3 that from late-2000 through mid-2001 the region was experiencing a period of mild to

moderate wetness. Beginning in mid-2001 the region began to transition to a notable period of drought that persisted until late-2004. The region then rapidly transitioned to a period of extreme wetness that peaked in mid-2005. The four-year period from 2006 through 2009 was characterized by generally dry conditions with mild to moderate drought prevailing. By mid-2010 the region was transitioning to a period of extreme wetness that peaked in mid-2011 and continued through the end of 2011. By early 2012, the region had returned to dry conditions with varying drought intensity. Other than a five-month period during the winter of 2015-2016 when conditions were mildly wet, the region has recently experienced a prolonged period of dryness. During the fifty-seven month period from early 2012 through the end of 2016, fifty one of those months had negative PHDI values (Figure 3).

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5.0 GEOLOGY

Four Cretaceous- to Tertiary-age bedrock formations crop out in the Greens Hollow Tract. These include, in descending order, the North Horn Formation, Price River Formation, Castlegate Sandstone, and the Blackhawk Formation. The Flagstaff Limestone is present on mountain tops adjacent to the Greens Hollow Tract. The Star Point Sandstone and Masuk Member of the Mancos Shale are present beneath the Blackhawk Formation within the tract area. Deposits of Quaternary alluvium are also present within and adjacent to the Greens Hollow Tract. These geologic formations are shown on a geologic map in Figure 4, in cross-section on Figure 4a, and on a stratigraphic column in Figure 5. These geologic formations are described below.

Quaternary deposits

The most significant quaternary deposits in and adjacent to the Greens Hollow Tract area include landslide deposits and stream alluvium. Landslide deposits are most common along steep slopes that are underlain by the North Horn Formation, which is known to be prone to slope failure and slumping regionally. A large landslide deposit is mapped along the steep margins of White Mountain immediately west of the Greens Hollow Tract and also on the steep slopes north of Muddy Creek (Figure 4). Quaternary alluvium is present locally throughout the tract. Significant alluvial deposits are present along the major stream valleys. The quaternary alluvial deposits consist of clays, silts, sands, gravels, and boulders derived from the erosion of the geologic strata in the area.

Flagstaff Limestone

Although not present within the Greens Hollow Tract boundary, the Flagstaff Limestone is present immediately east of the tract where it forms the conspicuous white cap rock on White Mountain and the surrounding high mountain peaks. The Flagstaff Limestone consists of freshwater limestone with some interbedded sandstone, shale, and volcanic ash. The formation is commonly light gray to white in color where it is exposed in the mountainous regions that surround the Greens Hollow Tract.

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North Horn Formation

The North Horn Formation consists of variegated (mainly shades of red) shales with minor sandstone, conglomerate, and freshwater limestone (Doelling, 1972). It is estimated to be about 1,490 feet thick in the study area, although no drilling in the area has penetrated both

the upper and lower contacts of the formation. The lower contact of the formation is transitional with the underlying Price River Formation. The formation is vulnerable to mass movement, slope failures, and landslides (USFS, 2005).

Price River Formation

The Price River Formation consists of gray to white gritty sandstone, interbedded with shale and conglomerate deposited in a fluvial environment. The unit forms ledges and slopes below the North Horn Formation due to interbedding of resistant sandstones with less resistant shales and claystones. The Price River Formation is present at or near the surface over most of the broad gently sloping plateau surfaces below the adjacent mountainous regions. The formation is reported to be approximately 550 feet thick in the existing Sufco permit area (Figure 4a).

While individual fluvial sandstones (paleochannels) in the Price River Formation are capable of transmitting water, groundwater is typically not transmitted over great vertical or horizontal distances in the formation. This is because of the lenticular geometry of the sandstone units and the interbedded low-permeability shales and claystone layers present in the formation.

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Castlegate Sandstone

The Castlegate Sandstone is present disconformably beneath the overlying Price River Formation. The Castlegate Sandstone is a cliff-forming unit that comprises the rim rocks and near-vertical walls of the deeply incised canyons in the northern and northeastern portions of

the Greens Hollow Tract and adjacent area (Figure 4). The Castlegate Sandstone is also present at the surface along the cliffs of the North Fork of Quitchupah Canyon area immediately southeast of the tract (Figure 4). Commonly, the sandstone is directly exposed or covered by only a thin soil veneer on the plateau along the rims of the canyons. The Castlegate Sandstone, which is about 200 feet thick in the study and adjacent area, is predominately massively bedded, coarse-grained sandstone with some interbeds of shale, siltstone, and conglomerate. Pervasive silica and carbonate cement makes the formation well indurated and brittle. The Castlegate Sandstone was formed in a braided fluvial depositional system.

Castlegate Sandstone bedrock is present at or near the ground surface in the Greens Hollow Tract along the Muddy Creek drainage in the northern portion of the tract and also near the steep cliff escarpments of the Cowboy Creek and Greens Hollow canyon areas in the northeastern portion of the tract (Figure 4). In order to protect hydrologic resources along perennial stream drainages, the lease stipulations for the Greens Hollow Lease specify the use of non-subsidence (full-support) mining methods in areas within the lease where the Castlegate Sandstone is exposed at the surface or covered by less than 50 feet of Price River Formation or North Horn Formation sediments. By preventing mining-related subsidence of the Castlegate Sandstone near the surface in these buffer zones, subsidence impacts to Castlegate Sandstone groundwater systems can be prevented. Accordingly, as shown on Plate 7-3, the mining plan for the Greens Hollow Tract has been designed such that no subsidence will occur in these buffer zone areas. Thus, the proposed mine plan ensures that

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subsidence-related hydrologic impacts to Castlegate Sandstone groundwater systems potentially present in these areas can be prevented.

It is noted here that based on the refined geologic mapping of surface outcrops of the Castlegate Sandstone performed through field surveys as part of this investigation (Figure 4), the Castlegate Sandstone buffer zone protection areas delineated in the western half of Section 19 and the northwestern portion of Section 30, Township 20 South, Range 5 East, exist in areas that are not within the Castlegate Sandstone outcrop area, but rather within the Price River Formation.

Blackhawk Formation

The Blackhawk Formation consists of lenticular, discontinuous beds of sandstone, siltstone, mudstone, shale, and coal. Within the Greens Hollow Tract, the Blackhawk Formation is exposed in the bottom of Muddy Creek Canyon along the northern and northeastern portions of the tract. In areas adjacent to the Greens Hollow Tract, the Blackhawk is exposed in the bottoms of the North and South Forks of Quitchupah Creek and also Box Canyon.

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Most of the coal production in the Greens Hollow Tract will occur in the Upper Hiawatha Seam of the Blackhawk Formation. Some mining (mostly development entries) will also occur in the Lower Hiawatha Seam. The Upper Hiawatha Coal seam is underlain in the region by a sequence of shaley lagoonal deposits, ranging in thickness from 2 to 29 feet, which includes the Lower Hiawatha Coal Seam (Mayo and Associates, 1997).

In the Sufco Mine area, the upper 500 feet of the formation generally has massive, fine- to medium-grained, cliff-forming sandstone units (Thiros and Cordy, 1991). The number and thicknesses of sandstone units decreases toward the base of the unit. The lower 300 feet of the formation contains thinly-bedded sandstone and shale. The thickness of the Blackhawk Formation in the region is about 800 feet.

Star Point Sandstone

The upper Star Point Sandstone consists of three massive sandstone layers, the uppermost of which intertongues with the Blackhawk Formation (Thiros and Cordy, 1991). The Star Point does not crop out in the Greens Hollow Tract, but it is exposed in the bottom of Muddy Creek Canyon near the confluence with Box Canyon and in regions south and east of the tract along the margins of the Wasatch Plateau escarpment. The Star Point Sandstone is a tan to gray, fine- to medium- grained, friable, usually well-sorted sandstone containing minor thin interbeds of siltstone or claystone. The lower Star Point Sandstone is an upward prograding sequence that intertongues with the underlying Masuk Member of the Mancos Shale. The thickness of the Star Point Sandstone is about 200 feet in the region.

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Mancos Shale, Masuk Member

The Masuk Member of the Mancos Shale is 500 to 600 feet thick in the Muddy Creek Canyon area. It does not crop out in the Greens Hollow Tract, but is visible regionally along the margins of the Wasatch Plateau escarpment. It consists of blue-gray fissile claystone or silty claystone which weathers light blue-gray to light tan. The unit contains thin calcareous

sandy or silty interbeds that increase in frequency toward the top of the unit. The member forms the lower slopes of Muddy Creek Canyon and the surrounding lowlands. It forms steep, barren, easily eroded slopes with occasional ledges of more resistant fine-grained sandstone, siltstone, or sandy claystone.

Structure

Major faulting has not been identified in the Greens Hollow Tract. However, small displacement faults with apparent vertical displacement of about three feet or less have been encountered in the Sufco Mine. Rarely, some faults with somewhat greater displacements have also been encountered within the mine. The faults in the Sufco Mine area most commonly strike approximately N10° to 15°W and are inclined nearly vertical. Joints are both parallel and normal to the prevailing fault trend. Both minor faults and joints likely exist in the Greens Hollow Tract area. Joints in the Castlegate Sandstone are common. The surface traces of these joints are up to a 1,000 feet in length and are spaced about 16 to 33 feet apart.

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In the Acord Lakes area along the western margins of the Sufco Mine lease, an approximately north-south trending normal fault has been mapped along the eastern edge of the valley that has created a closed basin with at least 200 feet of vertical offset (Thiros and Cordy, 1991). This structural feature is likely responsible for the impoundment of water that creates Acord Lakes (i.e. in the absence of the fault uplift, the surface water would have drained eastward into Convulsion Canyon). The Joes Valley Fault system, which has a

displacement of several hundreds of feet, trends along the eastern margins of the Sufco Mine permit area and is visible in outcrop in the Muddy Creek Canyon area.

Rock units in the study area strike roughly 40°E and dip 1 to 2° (about 250 feet per mile) to the northwest. Local dips of the coal seam may range up to 10 degrees in areas where underlying paleochannels caused significant differential compaction.

6.0 PRESENTATION OF DATA

Baseline hydrologic monitoring location details are listed on Table 1. Information presented in Table 1 includes monitoring site geographic coordinates, elevations, associated geologic formations, monitoring periods, baseline monitoring parameters, and information on water usage. Monitoring locations are plotted on Figure 2. Discharge and water-quality data for springs and streams in the study area, including field and laboratory water quality measurements are presented in Table 2a (major ion chemical compositions), and Table 2b (trace constituents). Discharge hydrographs for springs in the study area are shown on Attachment A. Discharge hydrographs for streams are shown on Attachment B. The information plotted on Attachments A and B also includes plots of temperature, pH, specific conductance, and the Palmer Hydrologic Drought Index. A geologic map of the Greens Hollow Tract and surrounding area, that also includes spring and stream monitoring locations, is presented in Figure 4. The mapping location of the Castlegate Sandstone outcrop along Muddy Creek near the northern lease boundary was refined based on field

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observations in the area. A southeast-northwest geologic cross-section through the tract area is presented in Figure 4a. A stratigraphic column is presented in Figure 5. Average discharge and solute compositions and mineral saturation indices are listed in Table 5. Stiff diagrams depicting the solute compositions of streams and springs are presented in Figure 6. A map showing the surface water drainages in the Greens Hollow Tract and adjacent areas is presented in Figure 7. Stable and unstable isotopic compositions and groundwater mean residence times for springs and in-mine locations are presented in Table 6.

7.0 GROUNDWATER AND SURFACE-WATER GEOCHEMISTRY

Stiff diagrams depicting the solute chemical composition of groundwaters and surface waters in the Greens Hollow Tract area are shown on Figure 7. Stiff diagrams are a useful analytical tool that allows the graphical representation of water solute compositions. The shape of the Stiff diagram is a reflection of the geochemical type, while the size of the diagram is related to the total dissolved solids concentration of the water.

Groundwaters discharging from springs and flowing in streams in and adjacent to the Greens Hollow Tract commonly acquire their solute compositions through a series of well-documented chemical reactions. These are summarized below.

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Carbon dioxide gas is produced naturally in the soil at concentrations greatly exceeding atmospheric concentrations by root-zone respiration and also by the decay of organic matter.

Recharge water (rain and snow melt), upon entering the soil mantle, reacts with CO_2 to produce carbonic acid according to:

$$CO_2 + H_2O = H_2CO_3 \text{ (carbonic acid)} \quad \text{(Equation 1)}$$

The produced carbonic acid subsequently dissociates into hydrogen ions (acid) and bicarbonate according to:

$$H_2CO_3 = H^+ + HCO_3^- \quad \text{(Equation 2)}$$

The H^+ produced from Equation 2 reacts with carbonate minerals that are pervasive in the rocks of the Wasatch Plateau coal field, yielding calcium and magnesium ions and additional bicarbonate ions to the water according to:

$$CaCO_3 \text{ (calcite)} + H^+ = Ca^{2+} + HCO_3^- \quad \text{(Equation 3)}$$

and

$$CaMg(CO_3)_2 \text{ (dolomite)} + 2H^+ = Ca^{2+} + Mg^{2+} + 2\ HCO_3^- \quad \text{(Equation 4)}$$

Because of the limited solubility of calcite and dolomite in the absence of an additional source of CO_2, waters acquiring their solute compositions through the geochemical evolutionary pathway described in Equations 1 through 4 typically have relatively low TDS concentrations.

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Groundwaters from formations containing soluble evaporite minerals often acquire a different solute geochemical type, and dissolved solids concentrations that are sometimes appreciably greater than that typically resulting from geochemical evolutionary pathway as

described by equations 1-4 above. Surface waters flowing over sediments containing soluble evaporite minerals may also acquire elevated TDS concentrations and changed solute geochemical type. The geochemical reactions often responsible for these changes in chemical composition include:

$$CaSO_4 \cdot 2H_2O_{(gypsum)} = Ca^{2+} + SO_4^{2-} + 2H_2O \quad \text{(Equation 5)}$$

$$NaCl_{(halite)} = Na^{+} + Cl^{-} \quad \text{(Equation 6)}$$

Waters rich in Ca^{2+} resulting from the dissolution of gypsum (Equation 5) may undergo ion exchange on clay minerals, resulting in an increase in Na^{+} concentrations at the expense of exchanged Ca^{2+} ions according to:

$$Ca^{2+} + \text{Na-clay} = 2Na^{+} + \text{Ca-Clay} \quad \text{(Equation 7)}$$

Ion exchange may also occur on zeolite minerals such as the sodium zeolite analcime according to:

$$2NaAlSi_2O_6 \cdot H_2O + Ca^{2+} = Ca(AlSi_2O6)_2 \cdot H_2O + 2Na^{+} \quad \text{(Equation 8)}$$

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Ratios of chloride to sodium (Table 5) indicate that most of the sodium contained in groundwaters and surface waters is likely acquired through ion exchange reactions described in Equations 7 and 8 above. This is evident in the fact that the sodium concentrations (expressed as milliequivalents per liter) greatly exceed the chloride concentrations in both groundwaters and surface waters (Table 5). If halite dissolution (Equation 6) was the

primary source, it would be anticipated that the ratios of chloride to sodium would be near unity.

It is apparent in the Stiff diagrams plotted in Figure 6 and from the solute chemical compositions listed in Table 5 that the solute geochemical types of groundwaters vary appreciably over the Greens Hollow Tract and adjacent area. Chemical variability is present spatially within individual geologic formations (Table 5). This observation suggests the likelihood that groundwaters discharging to springs in the tract area are sourced by local type groundwater systems that are highly influenced by variability in the local hydrogeochemical regime. If the springs were discharging from large-scale, regional type groundwater system (i.e. appreciable flow over long distances with groundwater flow potentially through multiple stratigraphic units) , it would seem likely that groundwater discharging from various locations sourced by the regional system would have a more homogeneous and uniform composition. The notion of local groundwater flow conditions at the springs (i.e. shallow groundwater flow with groundwater recharge and groundwater discharge locations being near each other) is also supported by the active-zone characteristics of the spring discharges, including appreciable tritium contents and rapid response to seasonal and climatic recharge variability.

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8.0 ISOTOPE GEOCHEMISTRY

Radiocarbon (^{14}C) and tritium (^{3}H) isotopic information have been used together in this investigation to determine groundwater mean residence times.

8.1 Carbon-14

Carbon-14 analyses have been performed on 12 springs in the Greens Hollow Tract study area (Table 6). Additionally, carbon-14 analyses have been performed on groundwater samples from several underground inflow locations in the Sufco Mine (Mayo and Associates, 1997, 1999; Petersen Hydrologic, 2005, 2016). In considering the radiocarbon "age" of groundwater it is important to consider that groundwater arriving at groundwater discharge points (i.e. springs or wells) rarely travels via pure piston flow (i.e. pipe-like flow conditions where all flowpaths are the same length with equal travel times along flowpaths). Rather, it is not uncommon for the water molecules discharging at springs or wells to have migrated to the discharge point from several different recharge locations, each having recharged at different times. Consequently, the term "mean groundwater residence time", which is the average age of all of the water molecules sampled, is commonly used when evaluating the age of groundwater.

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The radiocarbon (^{14}C) content of a groundwater is used to calculate the number of years that have elapsed since the groundwater became isolated from soil-zone gasses and near-surface groundwaters. Groundwaters with radiocarbon activities greater than about 50 pmC in

carbonate-rich terrains are usually indicative of modern groundwater. Groundwaters with radiocarbon activities significantly greater than about 50 pmC can indicate the presence of anthropogenic carbon that is typically associated with atmospheric thermonuclear weapons testing, which also suggests a modern origin.

Based on the known half-life of radiocarbon (approximately 5,570 years), it is possible to calculate the time since a groundwater became isolated from soil-zone CO_2 gas and shallow recharge sources. However, estimating the radiocarbon age of groundwaters is not as straightforward as estimating the age of dead organic matter. This is because groundwater acquires carbon from numerous sources, each of which must be accounted for in calculating a groundwater age. These sources may include "live" carbon from biogenic production of CO_2 in the soil zone, "dead" carbon from the dissolution of carbonate minerals in the soil zone, and the addition of both "live" and "dead" carbon by other processes. In the Wasatch Plateau region, groundwater commonly acquires its carbon through the series of chemical reactions described below.

The partial pressure of CO_2 in the soil zone, which is largely derived through root-zone respiration, greatly exceeds that of the atmosphere. The CO_2 reacts with water to produce carbonic acid according to:

$$CO_2 + H_2O = H_2CO_3$$

Carbonic acid dissociates to produce acid (H^+) and bicarbonate according to:

$$H_2CO_3 = H^+ + HCO_3^-$$

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In western coal mines, where carbonate rocks are pervasive, the acid produced from the above equation rapidly reacts with carbonate minerals, which releases additional bicarbonate and calcium and/or magnesium ions according to:

$$CaCO_{3\,(calcite)} + H^+ = Ca^{2+} + HCO_3^-$$

Or

$$CaMg(CO_3)_{2\,(dolomite)} + 2H^+ = Ca^{2+} + Mg^{2+} + 2HCO_3^-$$

Thus, groundwater that follows this evolutionary pathway will acquire 50% of its carbon from soil-zone CO_2 and 50% of its carbon from the dissolution of carbonate minerals near the recharge zone. Because soil-zone CO_2 typically has a $\delta^{13}C$ value between about –18 and –27 ‰, most groundwaters that follow this geochemical evolutionary pathway have a $\delta^{13}C$ value in the range of approximately -9 to -13 ‰ (Mayo and Associates, 1999). The fact that the $\delta^{13}C$ values for most radiocarbon samples analyzed in this investigation are in or near this range supports the conclusion that groundwaters in the study area likely follow this geochemical evolutionary pathway. Where the dissolved inorganic carbon $\delta^{13}C$ falls appreciably outside of this range, other factors in the water's carbon evolutionary pathway must be considered to determine a groundwater mean residence time.

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Like tritium, radiocarbon can also be used to determine whether groundwater has a component of recent anthropogenic (human induced) carbon. As a result of atmospheric thermonuclear weapons testing, atmospheric ^{14}C levels increased dramatically above background levels. ^{14}C levels reached a peak of approximately two times background levels

(200 pmC) in 1963. Thus, groundwaters with ^{14}C contents significantly greater than about 50 percent modern carbon (pmC) have a component of carbon with an activity significantly greater than 100 pmC. Groundwater that acquires its carbon through the dissolution of carbonate minerals in the presence of soil-zone CO_2 should have an A_o near 50 pmC (50% "live" soil-zone carbon with ≈ 100 pmC, and 50% "dead" carbonate mineral carbon with ≈ 0 pmC). As a result of above-ground thermonuclear testing, the ^{14}C activity of the atmosphere increased significantly above 100 pmC (with the modern 100 pmC standard being based on the 1950 radiocarbon activity; Clark and Fritz, 1997). Thus, it possible for a groundwater that recharged after about 1950 to have a ^{14}C activity greater than 50 pmC. For this reason, groundwater age dating models that do not take this into account may not correctly determine the actual residence time of the groundwater, sometimes even calculating a recharge date in the future (Mayo and Associates, 1999).

As indicated in Table 6, all springs analyzed for carbon-14 composition in the Greens Hollow Tract study area have modern radiocarbon ages and most contain appreciable anthropogenic carbon. In contrast, all groundwaters analyzed for radiocarbon content in the underground Sufco Mine workings in the study area are of ancient origin, with mean residence times ranging from about 4,000 to 15,000 years (Table 6).

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It should be noted that the radiocarbon ages determined for groundwater from springs in the Greens Hollow Tract as reported in the Groundwater Technical Report for the U.S. Forest Service are substantially different from those reported in Table 6 (see Technical Report for the Environmental Impact Statement for the Greens Hollow Tract; 2005) . The groundwater

ages reported in the Technical Report are generally much older than those determined in this investigation. We suspect that this is because the carbon history and geochemical evolutionary pathways of groundwaters in the study area were apparently not incorporated into the calculation of groundwater ages in the investigation (i.e., all the carbon in the water was apparently assumed to have been derived from "live" sources, while not considering the dilution of ^{14}C from "dead" sources in the recharge zone). Consequently, while the groundwater ages (uncorrected) of springs in the Greens Hollow Tract were determined to range from 0 to 3,830 years in the Technical Report, all spring waters in the Greens Hollow Tract area (as calculated by Petersen Hydrologic) were determined in this investigation to be modern in origin based on radiocarbon compositions.

Groundwater has been sampled from the Sufco Mine underground workings previously and also as part of this investigation. The underground sampling locations include mining areas underlying the Quitchupah area, Box Canyon area, Big Ridge area, and locations adjacent to proposed mining areas in the Greens Hollow Tract. Radiocarbon compositions and groundwater mean residence times ("ages") for these samples are listed in Table 6. It is evident from the information in Table 6 that the groundwaters intercepted during mining operations at the Sufco Mine are of ancient origin, with radiocarbon mean residence times ranging from about 4,000 to 15,000 years.

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8.2 Tritium (3H)

Tritium is a radioactive isotope of hydrogen that is commonly used in groundwater investigations to identify recharge components that are less than about 50 years old. In

previous decades, the presence of appreciable tritium concentrations has been used to identify groundwaters that recharged prior to or after the advent of atmospheric thermonuclear weapons testing. During the period from 1952-1962, large quantities of tritium were released into the atmosphere as a result of atmospheric thermonuclear weapons testing. After peaking in 1962, in 1963 a Soviet-American atmospheric nuclear weapons test ban treaty went into effect, which reduced in rapid declines in the atmospheric tritium concentrations. It is noted, however, that minor amounts of tritium continued to be released to the atmosphere as a result of minor French and Chinese testing until 1980 (Clark and Fritz, 1997). Tritium, whose half-life is 12.43 years, forms naturally in the upper stratosphere by the interaction of ^{14}N with cosmic ray neutrons. Tritium is rapidly incorporated into water molecules and is removed from the atmosphere by precipitation. As several decades have now past since the cessation of atmospheric thermonuclear weapons testing, the tritium concentrations in the atmosphere have now largely declined to near natural cosmogenic background levels as a result of radioactive decay. In continental regions, current tritium concentrations are on the order of 5 – 15 TU (Clark and Fritz, 1997). Similar (or somewhat lower) tritium concentrations have been routinely measured in streams and lakes in the Wasatch Plateau coal district of central Utah in recent years. Consequently, tritium concentrations in groundwaters and surface waters are now generally evaluated in the context of the natural cosmogenic production of tritium (background levels) rather than the identification of a thermonuclear weapons peak in groundwater as was done in previous decades.

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Tritium has been widely utilized in the hydrogeologic community using both qualitative and quantitative dating approaches (Clark and Fritz, 1997). However, in this investigation, tritium has been used only as a qualitative tool to determine whether a modern component of recharge (< ~50 years old) is present or whether the groundwater has been isolated from the surface for at least the 50 year period. No attempt to calculate an absolute "age" of groundwater has been attempted using tritium content. This is primarily because of uncertainties determining the initial tritium input level of the recharge water source(s).

Tritium concentrations in groundwaters sampled from 12 of the 13 springs analyzed for tritium content in the Greens Hollow Tract study area range from 2.8 to 14.6 TU (Table 6), indicating modern recharge components at each of these springs. Groundwater sampled from spring M-SP18 contained no tritium (Table 6), potentially indicating that the groundwater system that supports discharge at the spring has been isolated from the surface for at least approximately 50 years. However, because the tritium analysis for this sample was performed using direct counting methods (with an error range of +/- 2.7 TU), the interpretation of the measured low tritium result is somewhat ambiguous. The modern radiocarbon age and anthropogenic ^{14}C content in spring M-SP18 (Table 6) considered together with the assumed absence of tritium, may suggest a mean groundwater residence time on the order of about 50 years.

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The appreciable tritium concentrations measured in the groundwater from all but one of the 13 springs, considered together with the modern radiocarbon mean residence times and the presence of anthropogenic ^{14}C in the springs, are supportive of a determination of modern

groundwater flow. This also indicates that the springs are from active-zone groundwater systems in the Greens Hollow Tract area.

The lack of appreciable concentrations of tritium, combined with the radiocarbon mean residence times of several thousands of years in the groundwaters sampled within the Sufco Mine underground workings is supportive of a determination of ancient groundwater with no communication with the overlying surface for at least 50 years or more. Accordingly, the deep in-mine groundwaters are classified as being from inactive-zone groundwater systems.

The finding that the springs in the Greens Hollow Tract area discharge modern water, primarily from shallow groundwater systems, while the groundwater encountered in the underground mine workings is many thousands of years old and is not in communication with shallow groundwaters, is consistent with conditions noted elsewhere in the Wasatch Plateau coal district (Mayo et. al 2003).

9.0 DESCRIPTION OF GROUNDWATER SYSTEMS

Baseline information quantifying seasonal variation in water quality and water quality in the groundwater resources in the Greens Hollow Tract and adjacent areas is presented in Table 2. Monitoring site locations are shown on Figure 2 and monitoring site details are listed on Table 1.

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Groundwater in the Greens Hollow Tract naturally discharges from springs and seeps from the North Horn Formation, Price River Formation, and the Castlegate Sandstone. Groundwater discharge from the Blackhawk Formation and Star Point Sandstone occurs in surrounding regions at the Sufco Mine permit area. Additionally, groundwater discharges from the Blackhawk Formation in the Sufco Mine underground workings in response to human activities (i.e. the creation of mine voids and the pumping of accumulated groundwater from the mine workings to the surface).

Discharge hydrographs for selected springs in the Greens Hollow Tract and surrounding areas are presented in Attachment A. Discharge hydrographs for selected streams in the Greens Hollow Tract and surrounding areas are presented in Attachment B. Also plotted in Attachments A and B are water discharge temperatures, specific conductance values, and, for reference, plots of the Palmer Hydrologic Drought Index. Water level hydrographs for wells in the study area are presented in Attachment C.

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It is noted here that continuously saturated groundwater systems (i.e. aquifers) generally do not exist in the geologic formations overlying or immediately below the coal seams to be mined in the Greens Hollow Lease area (i.e. aquifers containing subsurface water are not encountered). Rather, as described below in this report, primarily because of the heterogeneous character of the bedrock framework of the Wasatch Plateau, the groundwater that is present typically occurs in fracture systems or isolated permeable strata (typically sandstone paleochannels) that are encased horizontally and vertically by relatively impermeable strata (Mayo et al., 2003). It is not uncommon for zones of unsaturated bedrock

to be present in intervening areas. Accordingly, while it may be stated generally that groundwater flow typically occurs from upland recharge areas toward downgradient discharge areas (usually following the stratal dip of the bedrock), the actual flow directions are constrained by the geometry of the sandstone members and/or fracture orientations of the bedrock. Consequently, because the generally small-scale zones of water-bearing strata are generally not in good hydraulic communication with other surrounding zones of water-bearing strata, and because there are often intervening zones of unsaturated rocks (both horizontally and vertically) between saturated zones, it is not possible (and incorrect) to construct regional maps showing potentiometric levels, groundwater flow gradients, and groundwater flow directions. Accordingly, such information is not (and cannot) be provided herein. It is noted that spring discharge locations in the Greens Hollow Lease are most commonly present along the hillsides of the major surface water drainages (i.e. Greens Hollow, Cowboy Canyon, North Fork of Quitchupah Canyon, Muddy Creek Canyon).

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The following discussion of the characteristics is based in large measure on concepts described by Maye et al. (2003). In 2003, Mayo et al. (2003) authored a peer-reviewed professional paper that presented the findings of a comprehensive, multi-year investigation of groundwater flow patterns in the mountainous terrain of Utah's Wasatch Plateau and Book Cliffs coal mining districts. This investigation describes a conceptual model of active and inactive groundwater flow regimes in the Utah coal mining districts that is directly applicable to groundwater flow regimes in the Sufco Mine and adjacent area. The Mayo investigation was based on analysis of a large volume of geologic, hydrogeologic, and hydrologic data from the study area. This included analysis of discharge data from 123 springs for which

long-term discharge data were available, 1,930 sets of major ion water sample analyses, Carbon-14 and tritium analyses from 132 sampling locations, and δ^2H and $\delta^{18}O$ analyses from 329 sampling locations. Much of the hydrologic data as well as information on historical mining practices discussed in the Mayo investigation was obtained specifically from the Sufco Mine area.

Groundwater systems in the Sufco Mine are associated with one of two fundamental types of groundwater flow regime. These two regimes are described by a fairly simple conceptual model that includes "active" and "inactive" groundwater flow regimes (Mayo et. al, 2003). The operation of these two regimes is fundamentally a consequence of the vertical and horizontal heterogeneity and discontinuity rock strata in the region. A discussion of the active- and inactive-zone groundwater regimes in the Greens Hollow Tract at the Sufco Mine is presented below.

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9.1 Active-Zone Groundwater Systems

Active zone groundwater systems are characterized as having good hydraulic communication with groundwater or surface-water recharge sources and having active groundwater flow from recharge to discharge areas. Thus, they are dependent on annual recharge events and are affected by short-term climatic variability. The elevated tritium concentrations measured at 12 of the 13 spring monitoring sites (which are indicative of groundwaters that are less than about 50 years old) and the modern radiocarbon ages of all spring waters sampled in the study area indicate these springs discharge from active-zone groundwater systems (Table 6).

Discharge hydrographs for springs in the study area are presented in Attachment A. It is apparent in the spring hydrographs of Attachment A and the discharge data presented in Table 2a that most springs exhibit seasonal variations in discharge rates and also respond to short-term climatic variability. This supports the conclusion that these springs discharge from active-zone groundwater systems, and are not related to the deep, inactive-zone groundwater systems that are encountered in the underground workings of the Sufco coal mine (discussed below).

It is noted that the discharge hydrograph for spring M-SP18 (which contained no tritium when sampled) shows pronounced responses to climatic variability, with the response to seasonal recharge being muted or non-existent (See Attachment A). Such conditions are suggestive of good hydraulic communication with active recharge sources, but perhaps longer groundwater flow paths which buffer the seasonal response. Similar conditions are observed at spring M-SP10. A relatively large storage capacity relative to the spring discharge rates in the groundwater systems that support these springs may also buffer the discharge from the springs.

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Active-zone groundwater systems exist in the Greens Hollow Tract area primarily where 1) there is adequate precipitation to facilitate groundwater recharge, 2) there is sufficient storage capacity in the near surface soils, porous rock units, and/or shallow, fractured bedrock horizons to sustain groundwater discharge for significant periods, and 3) there is a competent, impermeable perching layer present in the subsurface that prohibits the downward migration of groundwater. Downward migration of active-zone groundwaters

into deeper horizons is prevented by the presence of low permeability bedrock horizons that are widely present in the North Horn and Price River Formations in the study area, creating perched groundwater conditions. The perched groundwater systems, being constrained largely by surface topography, are usually of limited aerial extent. (i.e., groundwater discharge locations are commonly near recharge locations).

9.2 Inactive-Zone Groundwater Systems

Inactive-zone groundwater systems are characterized by old groundwater (commonly from about 2,000 to 19,000 years in the Wasatch Plateau coal mining district) and a general lack of hydraulic communication with the ground surface or active recharge sources (Mayo et. al, 2003). This condition is the result of the lack of recharge potential to deeper groundwater systems, either vertically or horizontally, because of 1) the abundance of low-permeability rocks in the rock sequence, and 2) the lenticular, discontinuous nature of the interbedded more permeable horizons that limits the extent of potential groundwater movement. Inactive-zone groundwater systems are not influenced by either annual recharge events or by short-term climatic variability. This is evidenced by the lack of seasonal or climatic discharge responses of groundwater inflows into the Sufco Mine. Discussions of lower Blackhawk Formation groundwater systems and the lack of seasonal or climatic discharge responses (including graphs of roof drip and mine water discharge rates) are provided by Mayo and Associates (1997) and Mayo et al. (2003). All groundwater inflows into the Sufco Mine have been from inactive-zone systems, as evidenced by the radiocarbon ages of the waters and the lack of tritium in in-mine groundwaters (Table 6), and the lack of seasonal or climatic response in discharge rates.

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Inactive-zone groundwaters in the Blackhawk Formation in the study area are not part of a regionally continuous aquifer. Groundwater in the inactive zone occurs primarily in isolated partitions created by the discontinuous nature of bedrock hydrostratigraphic horizons. Because these partitions are isolated both vertically and horizontally by low-permeable strata, lateral migration of groundwater in the deep Blackhawk Formation is limited. Historically, mining operations in the Sufco Mine have encountered groundwater in some portions of the mine, while other nearby locations have been dry. This condition demonstrates the limited groundwater recharge potential and the limited potential for lateral groundwater migration in the lenticular rock bodies of the Blackhawk Formation.

The groundwater flow characteristics within individual geologic formations present in the Greens Hollow Tract are summarized in the following section.

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Quaternary Alluvium

Groundwater is likely present in the Quaternary alluvial deposits that exist in the bottoms of the major surface-water drainage in the Greens Hollow Tract and adjacent areas. Where the alluvial deposits are comprised of permeable sediments (sands and gravels), the shallow alluvial groundwater is commonly in good hydraulic communication with overlying surface waters. In areas where the alluvial deposits are comprised mostly of low permeability clays and silts that are common in alluvial sediments derived from erosion of the North Horn and Price River Formations (such as that identified in the South Fork of Quitchupah Creek;

Petersen Hydrologic, 2012), surface streams are sometimes perched above the underlying low-permeability sediments.

North Horn Formation

Because of the pervasiveness of low-permeability shale horizons in the North Horn Formation, the potential for vertical migration of groundwater through the formation into deeper strata is low. Consequently, groundwater recharge through the North Horn Formation to the underlying Price River Formation is minimal.

Groundwater flow in the North Horn generally occurs as shallow flow within sandstone paleochannels in the unit. Locally, groundwater flow in the minor limestone units may also support groundwater flow to springs and seeps. Recharge to the sandstone paleochannel systems likely occurs where the up-dip ends of the sandstones are present at or near the surface in recharge areas. Groundwater then flows laterally through the sandstone channels under perched conditions until the unit intersects the land surface in down-gradient areas, forming a spring. Because of the pervasiveness of low-permeability shales in the formation that encase the sandstone members both vertically and horizontally, groundwater flow directions are largely constrained by the sinuous geometry of the sandstone paleochannels. In other words, the groundwater in the North Horn does not widely flow throughout the formation, but rather areas of appreciable groundwater flow to springs and seeps are concentrated only within the sandstone channels. The potential for groundwater flow through sandstone channels is enhanced locally by bedrock fracturing. Thus, areas of groundwater flow in the North Horn Formation are limited to perched, local, partitioned

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groundwater systems that are generally not mappable. Groundwater aquifers (i.e. zones of continuous saturation over broad lateral extents that are capable of yielding water to wells) are generally not present in the North Horn Formation.

Price River Formation

Groundwater discharge from the Price River Formation in the Greens Hollow Tract is meager (Table 2a). Baseflow discharge rates at the three springs identified in the Price River Formation in the Greens Hollow Tract are usually less than one gallon per minute at each of these springs (Table 2a). This condition is likely the result of the pervasive presence of low-permeability shales in the formation which impedes the potential for groundwater flow in the formation. Additionally, where the Price River Formation is overlain by the North Horn Formation, the potential for vertical recharge from the overlying formation to the underlying Price River Formation is low because of the poor vertical groundwater transmitting properties of the overlying North Horn Formation.

Mayo and Associates (1997) noted that boreholes penetrating the Price River Formation in the Sufco Mine lease area have not encountered water in this unit. Mayo and Associates attributed the general lack of groundwater recharge in the Price River Formation to the combined factors of low precipitation, evapotranspiration of soil-zone moisture, and the presence of near-surface clayey horizons.

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The presence of the Price River Formation at the land surface over significant portions of the Greens Hollow Tract and adjacent areas (Figure 4) limits the potential for groundwater recharge to underlying strata regionally.

In the Greens Hollow Tract and adjacent existing Sufco Mine area, groundwaters from the Price River Formation often contain higher concentrations of dissolved salts than do groundwaters from the overlying North Horn Formation (Table 5). This is likely due to the increased presence of soluble minerals in the formation.

Castlegate Sandstone

The Castlegate Sandstone is a massive, cliff-forming sandstone unit. In many locations, the intergranular spaces in the sandstone are filled with calcite or silica cement, which decreases the primary porosity and permeability of the formation. Consequently, groundwater flow in the Castlegate Sandstone in the study area occurs primarily thorough fracture and joint systems and along bedding planes. Although some of the sandstone rocks in the Castlegate are sufficiently permeable to transmit appreciable groundwater, groundwater flow through the pore spaces in the formation is limited. This is due primarily to the presence of low-permeability mudstone drapes and bounding layers that are interbedded in the formation. Near cliff exposures and in stream bottoms, the Castlegate Sandstone sometimes becomes friable due to the dissolution of the carbonate cement and the unit is more capable of supporting shallow, active groundwater systems.

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Near-vertical jointing in the Castlegate Sandstone is pervasive and readily observable where the formation is exposed at the surface in the region (notably in the Pines Tract area east of the Greens Hollow Tract). Groundwater flow commonly occurs along the joints and fractures, and also locally along bedding planes where permeable strata are sometimes underlain by the thin clay or shale perching layers that exist locally in the formation. The direction of bedding plain groundwater flow in the area is controlled by the local dip of the stratigraphic bedding horizons (which is generally toward the north-northwest in the Greens Hollow Tract). Because of the discontinuous nature of the shale layers, and the fact that individual permeable sandstone strata are not continuous over significant distances, long, regional-type flow systems generally do not develop in the Castlegate Sandstone. Rather, Castlegate Sandstone groundwater systems, where they exist, are typically local in nature with small to moderate quantities of groundwater commonly being discharged.

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Where the Price River Formation, which generally does not support vertical migration of fluids, is present above the Castlegate Sandstone, the potential for recharge to the Castlegate Sandstone is minimal. This conclusion is supported by the lack of springs in the Castlegate Sandstone in the Greens Hollow Tract. Accordingly, in surrounding areas outside the Greens Hollow Tract, appreciable groundwater recharge to the Castlegate Sandstone likely occurs only where the formation is directly exposed at the surface, or where it is covered only by a thin covering of sandy sediments (as is the case in the Pines Tract area to the east of the Greens Hollow Tract). In the Greens Hollow Tract and adjacent area, the Castlegate Sandstone is exposed along the rims of the deeply incised canyons (which include the North Fork of Quitchupah, South Fork of Quitchupah, Box, and Muddy Creek Canyons), but the

total surface area of the exposure is small (Figure 4). Thus the potential for recharge to the Castlegate Sandstone within the Greens Hollow Tract is not appreciable. The Castlegate Sandstone is underlain by the Blackhawk Formation, which acts as a basal confining layer, preventing appreciable vertical migration of groundwater from the unit into deeper strata. Consequently, it is common regionally for springs to originate near the base of the Castlegate Sandstone (Thiros and Cordy, 1991), or occasionally where thin shaley perching interbeds within the Castlegate Sandstone intersect the land surface.

This conclusion is supported by observations at Castlegate Sandstone monitoring well MW-15-5-2, which is located in the valley bottom about 280 feet horizontally from Cowboy Creek (Figure 2). It is noteworthy that MW-15-5-2 has been consistently dry (other than an initial measurement taken shortly after the well was constructed which was likely influenced by the residual presence of well drilling fluid). The absence of groundwater in the Castlegate near the creek suggests that the Price River Formation acts as an effective perching layer in that area that prevents recharge to the underlying Castlegate Sandstone from the Cowboy Creek system. It is likely that the lack of appreciable groundwater in the Castlegate Sandstone in the Greens Hollow Lease area is also a result of the presence of the Price River Formation atop the Castlegate in most locations within the Greens Hollow Tract (Figure 4).

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Blackhawk Formation

Because of the presence of interbedded low-permeability units in the Blackhawk Formation and the vertical and lateral discontinuity of sandstone horizons, the potential for vertical and horizontal movement of groundwater within the Blackhawk Formation is limited. For this reason, it is observed that groundwater flow in the formation occurs primarily through sandstone paleochannels, or occasionally through faults and fractures, while regional migration of groundwater across lithologies (either vertically or horizontally) is minimal. The direction of groundwater flow within permeable sandstone channels is largely constrained by the geometry of the sinuous sandstone paleochannel structures and also by the structural dip of the strata. Because of the lenticular nature of the permeable strata in the Blackhawk Formation (both at a micro and macro scale), and the fact that individual sandstone channels often interpenetrate and are truncated, regional type groundwater flow regimes typically do not form in the formation.

The Blackhawk Formation is known to contain swelling clays that tend to naturally heal mining-induced fractures in the formation. Well drilling reports and laboratory analysis of samples indicate that the claystone layers in the Blackhawk Formation contain swelling clays which plastically deform when fractured (Mayo and Associates, 1997). Chempet Research Corporation (1989) found that Blackhawk Formation claystone layers contain up to 58% montmorillonite.

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Effects of subsidence-related fracturing in the Blackhawk Formation

In an attempt to substantiate the conclusion that subsidence-related fracturing has not induced the downward movement of modern, overlying groundwaters into the Sufco Mine, an investigation was performed by Mayo and Associates (1997) during which a sample of groundwater which drains an old, sealed longwall gob area was collected and analyzed for ^{3}H and ^{14}C. As described by Mayo and Associates, the sample site (1L 8E seals) was specifically chosen because it underlies a region which is known to have undergone substantial ground subsidence, and the rocks at the surface contain abundant subsidence-related fractures. Mining ceased in this area in 1989, and the outflow from this area has steadily decreased since that time. If groundwaters from shallow, overlying active-zone systems (which contain abundant anthropogenic carbon and tritium) were being intercepted by subsidence fractures and flowing downward into the mine, we would expect to find some of the modern water in this sample. Mayo and Associates found that this was not the case. The groundwater had a mean ^{14}C age of 13,000 years, and contained no tritium (0.00 T.U.). The fact that the discharge from this and other abandoned longwall areas consistently decrease with time also suggests that there is not good hydraulic communication between groundwater systems immediately overlying the mine and overlying shallow groundwaters.

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Water level hydrographs for wells completed in the Blackhawk Formation at the Sufco Mine area demonstrate that water levels in these deep groundwater systems do not respond to seasonal recharge or climatic variability (Mayo and Associates, 1997; Petersen Hydrologic 2010). These conditions suggest isolation from shallow, seasonal recharge sources and are consistent with the deep Blackhawk Formation being part of the inactive-groundwater system

in the region. However, as mining occurs in areas in close proximity to the locations of deep monitoring wells, as anticipated water levels in the wells commonly respond to the mining activity. This condition is not unanticipated, as the ancient, inactive-zone groundwater that is intercepted by the mine workings is pumped from mining areas, resulting in decreased hydraulic head on the groundwater system near the wells. It is noted that the deep, inactive groundwater system monitored at monitoring well 01-8-1 (located on Big Ridge as shown on Figure 2) responded appreciably to the effects of mining in the vicinity (see Attachment C). It is noteworthy that spring discharges on Big Ridge, which are derived from shallow, active-zone groundwater systems, continued to occur after mining in the area was complete, further demonstrating the lack of hydraulic communication between the deep, inactive-zone groundwaters encountered in the underground mine workings and the shallow, active-zone systems that support springs and seeps.

In the general sense, groundwater flow in the Blackhawk Formation is in the down-dip direction, with local flow directions being largely constrained by the geometry of the sinusoidal sandstone paleochannels through which groundwater may flow. Groundwater flow may also occur along linear, relatively narrow damaged zones associated with faulting. Consequently, because of the discontinuous, isolated nature of saturated strata in the mine, and the localized perched groundwater conditions, it is not possible to create a meaningful potentiometric surface map of the Blackhawk Formation in the vicinity of the Sufco Mine.

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Star Point Sandstone

Groundwater flow in the Star Point Sandstone regionally occurs primarily through joints, fractures, and faults. Appreciable groundwater flow through unfractured Star Point Sandstone bedrock is generally not observed (Bills, 2000).

No springs associated with the Star Point Sandstone have been identified in the Greens Hollow Tract and adjacent area. However, springs discharging from the Star Point Sandstone are present in Convulsion Canyon near the Sufco Mine surface facilities, located about five miles south of the Greens Hollow Tract. Discharge from one of these springs (Sufco 047) is used for a water supply for the Sufco Mine surface facilities. Sufco 047 discharges from a fracture zone in the south-facing Star Point Sandstone cliff below the mine surface facilities. Discharge from this spring is collected in a buried collection system and stored in a storage tank for use as the mine surface facilities water supply. It is interesting to note that the average discharge temperature from Sufco 047 is 26.3° C, which is substantially elevated relative to the mean annual air temperature in the region. It is considered most likely that the elevated discharge temperature at this spring is a result of interactions with bedrock strata that have locally been heated as a result of coal burn near the outcrops. The measured carbon-14 content of Sufco 047 (25.27 pmC) indicates a mean groundwater residence time of approximately 7,300 years (Mayo and Associates, 1997). The tritium concentration at spring Sufco 047 (0.1 to 0.2 TU), which is near the lower laboratory detection limit, indicates that this spring does not have an appreciable modern recharge component (within the past approximately 50 years). This finding is consistent with the old radiocarbon mean residence time determined with the carbon-14 analysis.

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As indicated in the Sufco Mine MRP, it was noted during the drilling of four monitoring wells in the basal Blackhawk Formation/Upper Star Point Sandstone that these holes did not encounter significant quantities of groundwater. Similarly, where the Star Point Sandstone is exposed along the canyon walls in lower Muddy Creek, no appreciable discharges of groundwater have been observed.

Masuk Member of the Mancos Shale

The Masuk Member of the Mancos Shale is composed primarily of fine-grained marine sedimentary deposits (claystones and shales). Consequently, the Mancos has poor water-transmitting properties. No springs associated with the Mancos Shale have been identified in the Greens Hollow Tract and adjacent area. The Mancos Shale is continuous regionally and the shales of the formation likely form a basement in the Sufco Mine area that prevents vertical migration of groundwater into deeper strata.

The Mancos Shale is also known regionally to contain appreciable quantities of soluble minerals. Consequently, groundwater that interacts with the unit typically acquires elevated TDS concentrations through the dissolution of these minerals.

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10.0 DESCRIPTION OF SURFACE-WATER SYSTEMS

Baseline information quantifying seasonal variation in water quality and water quality in the surface-water resources in the Greens Hollow Tract and adjacent areas is presented in Table 1. Monitoring site locations are shown on Figure 2 and monitoring site details are listed on Table 1. Discharge hydrographs for streams, together with plots of temperature, pH and specific conductance are presented in Attachment B.

Surface-water drainages in the Greens Hollow Tract and adjacent areas are shown on Figure 8. All surface waters draining from the Greens Hollow Tract are tributary to the Muddy Creek drainage. Muddy Creek flows from its headwaters near the Greens Hollow Tract towards the southeast where it combines with the Freemont River to form the Dirty Devil River near the town of Hanksville, Utah. The Dirty Devil then flows southward to its confluence with the Colorado River near the upper extent of Lake Powell.

Although no land area within the Greens Hollow Tract drains to the Skutumpah Creek drainage, lands located southwest of the tract drain to Skutumpah Creek. Skutumpah Creek is a tributary to Salina Creek, which flows to the Sevier River just west of the town of Salina, Utah. The Sevier River flows into Sevier Lake in the lowest part of the Sevier Desert in Millard County, Utah. Sevier Lake has been mostly dry during recorded history with no lake outflow.

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The primary surface water sub-drainages in the Greens Hollow Tract are described below.

Muddy Creek Drainage

Surface-water drainage from most of the Greens Hollow Tract, including the central and northern portions of the tract, flows into Muddy Creek. Sub-drainages in the tract include the Cowboy Creek drainage, the Greens Hollow drainage, the South Fork of Muddy Creek drainage, and a series of unnamed drainages along the northern margin of the tract that drain directly to Muddy Creek.

The Cowboy Creek sub-drainage includes lands north of Big Ridge and south of the adjacent Greens Hollow drainage to the north. The watercourse extends from its headwaters along the northern end of White Mountain eastward for a distance of about three and a half miles across the North Horn and Price River Formations. The stream channel then flows into the Castlegate Sandstone escarpment and down the steep-walled canyon across the Blackhawk Formation to its confluence with Muddy Creek (Figure 8). Long-term monitoring of the stream has occurred since 2001 at site M-STR04 (Table 2). A summary of monitoring data collected at surface-water sites by Cirrus for the period 2001-2004 is presented in Table 4. Recent monitoring data at M-STR04 indicate that the Cowboy Creek where it enters the Castlegate Sandstone gorge has usually been dry. Discharge was observed at M-STR04 on only one occasion in the previous five years of monitoring, with a flow of 2.25 gpm on that occasion in June of 2015 (Table 2). A stream gain/loss study of the Cowboy Creek drainage was performed by Cirrus Ecological Solutions in September of 2001 (USFS, 2005). Maps and data showing the results of their study are available in the 2005 Groundwater and Surface Water Technical Report (USFS, 2005). Cirrus found that flow was present from the

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headwaters to regions about mid-way through the stream's traverse through the Price River Formation. Below that point, the stream was dry as the stream channel crossed the Castlegate Sandstone until about 300 feet above monitoring station M-STR05, where water entered the channel from beneath a rock outcrop associated with the Blackhawk Formation. Below that point, the steam lost flow, and then gained flow from M-STR05 to M-STR02 all along the Blackhawk Formation with flow disappearing below M-STR02.

The Greens Hollow sub-drainage extends from the steep slopes on the northwestern flanks of White Mountain in the North Horn Formation, and eastward for a distance of about two and a half miles, where the watercourse enters the Castlegate Sandstone gorge near monitoring site M-STR06 (Figure 2). The stream channel crosses the Castlegate Sandstone for a distance of about 0.5 miles to the confluence with Cowboy Creek in Greens Canyon. Cirrus (USFS, 2005) reports that the only inflows to Greens Hollow Creek during their 2001 survey was from springs M-SP04, M-SP05, and M-SP06. Above these locations, the stream channel was dry. These same conditions were observed by the author during quarterly monitoring site visits during 2015 and 2016. Cirrus noted in their gain/loss study that the stream continued to flow from this location to below monitoring site M-STR06. Below that point, the watercourse was dry to the confluence with Cowboy Creek in Greens Canyon. It has been noted during recent monitoring (2015 and 2016) that the stream at M-STR06 was dry on 5 of the six quarterly monitoring events during this period. The stream was flowing at a low rate (0.636 gpm) during the 26 June 2015 monitoring event (Table 2a).

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The Cirrus study showed losses for both Cowboy Creek and Greens Hollow creek in the Blackhawk Formation and Castlegate Sandstone (USFS, 2005). Greens Hollow did not flow in the Blackhawk Formation. Cowboy Creek and Greens Canyon had both gains and losses in the Blackhawk Formation. Cirrus noted that the results of their gain/loss study might not be representative of the gains and losses that may occur during other seasons or other years.

Box Canyon Creek is a tributary drainage to Muddy Creek that is situated a considerable distance east of the Greens Hollow Tract boundary. Box Canyon is mostly isolated from the Greens Hollow Tract by the upland Big Ridge area and also by the deeply incised Greens Canyon. Consequently, groundwater and surface-water systems in Box Canyon should not be influenced by proposed mining activities in the Greens Hollow Tract.

Discharge in Muddy Creek is substantial. The long-term average annual flow rate (1952-2012) at the USGS gauging station near Emery, Utah (station 09330500) is 37.5 cfs (USFS, 2005). The surface area drained by Muddy Creek at station 09330500 is 105 square miles. The headwaters of Muddy Creek are situated north of the Greens Hollow Tract in the upland area bounded by White Mountain, Heliotropoe Mountain, and Ferron Mountain. During the springtime snowmelt runoff event, discharge in Muddy Creek usually peaks in the late springtime (May or June) coincident with the peak of the springtime snowmelt runoff with discharge rates exceeding 100 cfs. During wet climatic cycles, discharge in Muddy Creek during the springtime runoff has exceeded 500 cfs. During the late summer and fall monsoon season, large discharge rates of several hundred cfs also occur occasionally. During baseflow conditions, discharges of less than 10 cfs in Muddy Creek are not uncommon. It

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should be noted that there are several water storage reservoirs in the Muddy Creek headwaters area (USFS, 2005). The timing of water releases from these reservoirs can affect the discharge rates occurring in Muddy Creek below the headwaters area.

Historic discharge rates have been measured by the USGS at station 09330500 since 1910. Field and laboratory water quality parameters have also been analyzed periodically on water samples from Muddy Creek by the USGS.

Water quantity and water quality in the South Fork of Quitchupah was monitored by Cirrus personnel at station M-STR08 from 2002-2004 (Tables 2a, 2b). Water quantity and water quality measurements have been performed on behalf of the Sufco Mine at various monitoring stations on Muddy Creek since 1997.

Petersen Hydrologic 2015 Gain/Loss Study on Muddy Creek

A gain/loss study of Muddy Creek was performed by Petersen Hydrologic during low-flow conditions on 28-29 October 2015. The results of the study, including discharge measurement locations and measurement results, are presented in Table 7 and also plotted on Figure 9. Field water quality parameters, including temperature, pH, and specific conductance, were measured at each of the stream monitoring stations. The water quality information is also provided in Table 7.

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The purpose of the study was to determine whether Muddy Creek gains or loses appreciably as the creek flows past the Greens Hollow Tract and downstream to the USGS gauging

station near Emery, Utah. Over this reach of Muddy Creek, the stream crosses the Blackhawk Formation, Star Point Sandstone, and Mancos Shale. It is acknowledged that because of the appreciable flow in Muddy Creek and the inherent margin of error associated with conventional discharge measurement techniques, small gains or losses in the stream would not be detected in this gain/loss study.

Discharge measurements were performed using the velocity-area method as described in United States Geological Survey Circular (1995). The measurements were performed using a Marsh-McBirney model 2000 electromagnetic current velocity meter. Based on our professional experience and the prevailing stream conditions we estimate that the discharge measurements are accurate to within about 5 to 10 percent of actual values. It should be noted that the gain/loss study was performed over a two day period of time. Considerable effort was taken to select a time for the performance of the test when optimal weather conditions would prevail in the drainage. The dates chosen for the performance of the study (28-29 October 2015) were selected after monitoring weather forecasts that predicated a precipitation-free window at that time that would include the two testing days as well as several precipitation-free days prior to the test. The testing dates were also selected based on predicted air temperatures in the area to ensure that air temperatures would remain above freezing to minimize the potential influence of freeze/thaw conditions in the watercourse during the test. Unfortunately, some intermittent light to moderate intensity rain fell during the period of the test, which could possibly have influenced the discharge rates in the creek. However, it is our opinion that the effects of the intermittent light to moderate precipitation likely did not excessively influence the discharge rates in the Muddy Creek drainage

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Discharge rates measured at Muddy Creek gauging Station #1 and Station #2 were 4,320 gpm and 4,580 gpm, respectively. These two discharge measurements vary by 5.7 percent, which is within the estimated margin of error for the utilized measurement technique. Accordingly, there is no statistically significant indication of a gain or loss of flow in this reach of Muddy Creek. Between Muddy Creek Station #2 and Station #3, measured inflows from side tributaries 2a, 2b, and 2c, totaling 775 gpm, entered Muddy Creek. Thus, if there was no loss or gain of flow in this reach, the total flow in Muddy Creek anticipated to arrive at Muddy Creek Station #3 is 4,580 gpm plus 775 gpm, or 5,355 gpm. The discharge measured at Muddy Creek Station #3 was 5,350 gpm, which is very close to the 5,355 gpm projected discharge at Station #3. Accordingly, there is no statistical indication of a gain or loss in the discharge in Muddy Creek in this reach of the watercourse. The measured discharge at Muddy Creek Station #4 was 4,890 gpm. The discharge measurements for Station #3 and Station #4 vary by 9.4 percent, which is within the projected statistical error of these measurements, although it is near the upper limit of the error range. It is possible that the difference in the measured discharge rates between these two stations is a reflection of the intermittent light to moderate precipitation that was occurring in the drainage at that time. The first occurrence of rain in the drainage on 29 October 2015 occurred as monitoring at Station #4 commenced. The discharge measurement performed at Station #3 occurred about four hours later in the day as the light to moderate rain in the drainage had been ongoing. It is noteworthy that, based on 20 years of monitoring flows under seasonal conditions in Muddy Creek at Station #3 (Pines 405) and Station #4 (Pines 406b), appreciable gains or

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losses of discharge in the creek as it flows between these two stations has generally not been noted.

The results of the water quality measurements performed coincident with the discharge measurements do not indicate any unanticipated changes in the water quality parameters that might be indicative of appreciable groundwater/surface water interactions (gains of water with varying water quality).

Quitchupah Creek Drainage

The southern portions of the Greens Hollow Tract and adjacent area are within the Quitchupah Creek drainage (Figure 8). Quitchupah Creek flows into Muddy Creek approximately 15 miles southeast of the Greens Hollow Tract near the Interstate 70 crossing of Muddy Creek. Most of the Greens Hollow Tract area within the Quitchupah Creek drainage is within the North Fork of Quitchupah Creek drainage. A small area in the extreme southern portion of the Greens Hollow Tract is within the South Fork of Quitchupah Creek drainage. Lands adjacent to the southern portions of the Greens Hollow Tract are also within the South Fork of Quitchupah Creek surface water drainage.

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Long-term monitoring of the North Fork of Quitchupah Creek (1979-2016) has taken place at monitoring site Sufco 007 (North Fork Lower) (Figure 2). Long term monitoring of the South Fork of Quitchupah Creek (1979-2016) has taken place at monitoring site Sufco 006. Additionally, supplemental monitoring at site Sufco 006A on the South Fork of Quitchupah

has been performed since 2010. Monitoring at station Sufco 006B occurs a short distance below the long-term Sufco 006 station.

The North Fork of Quitchupah Creek drainage extends from its headwaters area on the White Mountain within the Flagstaff Limestone eastward across entire thicknesses of the North Horn Formation and the Price River Formation to monitoring station Sufco 007 (North Fork Lower) which at the lower (eastern) margin of the Greens Hollow Tract boundary. A short distance further to the east, the stream flows into the steep-walled North Fork of Quitchupah Creek gorge.

Discharge measured at Sufco 007 (North Fork Lower) on the North Fork is a function of seasonal and climatic variability. Yearly discharge peaks are readily apparent in the discharge hydrograph for the South Fork (Attachment B). The yearly discharge peaks typically occur during the second quarter monitoring event (usually in May or June) in response to the annual snowmelt event. The minimum flow monitored during a year typically occurs during the 4th quarter monitoring event (usually in October or November) as seasonal water is gradually drained over the summer and fall months.

The peak and baseflow discharge rates in the North Fork of Quitchupah Creek increased markedly in response to significantly wet periods that occurred in the early 1980s, the late 1990s, and the mid-2000s (Attachment B). Peak and baseflow discharge rates were low in the creek during the early 1990s and early 2000s in response to regional drought conditions that prevailed during these times.

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The South Fork of Quitchupah Creek extends mostly in the area adjacent to the Greens Hollow Tract from its headwaters region in the North Horn Formation along the western flanks of White Mountain in a southeasterly direction for a distance of about 2.5 miles to monitoring site Sufco 006. Monitoring site Sufco 006 is situated a short distance above the contact between the Price River Formation and the underlying Castlegate Sandstone (Figure 4). To the east of Sufco 006 the drainage enters the deep, steep-walled South Fork of Quitchupah Canyon gorge where the stream course initially flows across the Castlegate Sandstone and then in the lower reaches of the canyon it flows across the Blackhawk Formation that is present in the bottom of the canyon (Figure 4).

Discharge rates measured in the South Fork of Quitchupah Creek at Sufco 006 are usually less than those flowing at the same time in the North Fork of Quitchupah Creek (Table 2a). Discharge in the South Fork is a function of seasonal and climatic variability. Yearly discharge peaks are readily apparent in the discharge hydrograph for the South Fork (Attachment B). The yearly discharge peaks typically occur during the second quarter monitoring event (usually in May or June) in response to the annual snowmelt event. The minimum flow monitored during a year typically occurs during the 4th quarter monitoring event (usually in October or November) as seasonal water is gradually drained over the summer and fall months.

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The peak and baseflow discharge rates in the South Fork increased markedly in response to significantly wet periods that occurred in the early 1980s, the late 1990s, and the mid-2000s (Attachment B). Peak and baseflow discharge rates were low in the creek during the early

1990s and early 2000s in response to regional drought conditions that prevailed during these times. Discharge is sometimes completely absent in the South Fork of Quitchupah Creek at monitoring site Sufco 007 during the fall and winter months. The periodic lack of substantial discharge in the creek during the fall and winter is likely due to a combination of factors including 1) diversion of the water in upstream locations at the crude stream diversion (discussed below), and 2) the influence of climatic variability (drought conditions).

It is noted that the Skutumpah Creek drainage is present to the southwest of the Greens Hollow Tract (Figure 2). No portion of the Skutumpah Creek drainage is present within the Greens Hollow Tract. However, it is noteworthy that the quantities of surface water flowing in Skutumpah Creek and the South Fork of Quitchupah Creek are influenced by a crude stream diversion. The crude undeveloped surface diversion on the South Fork of Quitchupah Creek that diverts surface water to the Skutumpah drainage is present in the south-central portion of Section 15, T21S, R4E (Figure 8). Historical information on the magnitude of water diverted from the South Fork to Skutumpah Creek at this location is not available. Additionally, a United States Forest Service diversion for stock watering use is present higher in the drainage.

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Surface waters in both the North Fork and the South Fork of Quitchupah Creek as monitored at Sufco 007 (North Fork Lower) and Sufco 006, respectively, are generally of the no-dominant cation – bicarbonate geochemical type. Sodium, Calcium, and Magnesium are all present in appreciable quantities. The variability of the TDS concentrations of surface waters

in the North Fork and South Fork is likely attributable to 1) diluting effects of seasonal low-TDS snowmelt waters, and 2) the dissolution of soluble minerals commonly known to occur in the Price River Formation (Petersen Hydrologic, 2010).

A gain/loss investigation of the South Fork of Quitchupah Creek was performed on 1 June 2012. At the time of this survey, discharge in the South Fork was essentially absent. The absence of flow was likely attributable to the combination of the effects of the prevailing drought conditions, and also to likely diversions of water at up-gradient locations. Because of the lack of water in the stream channel at that time, observations of areas potentially contributing baseflow to the stream channel could readily be observed. It was noted during that survey that a meager discharge of less than 1 gpm was present at monitoring site 006A. Discharges of less than 1 gpm were intermittently present in the reach between 006A and Sufco 006 (which was considered likely to represent the re-emergence of water originating at upstream locations as alluvial seepage into the creek where it was forced to the surface as a result of the alluvial geometry).

11.0 PROBABLE HYDROLOGIC CONSEQUENCES DETERMINATION

The following section describes the Determination of Probable Hydrologic Consequences of Coal Mining in the Greens Hollow Tract.

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728.100 Quality and quantity of surface water and groundwater under seasonal flow conditions

Information on Quantity and quality of surface-water and groundwater under seasonal flow conditions in the Greens Hollow Tract and surrounding areas is presented in Tables 2a and 2b. Additional information on groundwater and surface-water quality and quantity in and around the Greens Hollow Tract has been submitted electronically to the Utah Division of Oil, Gas and Mining through the on-line coal water quality database, which is freely accessible and located at: http://ogm.utah.gov/coal/edi/wqdb.htm.

Discharge hydrographs for springs and seeps in the Greens Hollow Tract and adjacent areas are presented in Attachment A. Discharge hydrographs for streams in the Greens Hollow Tract and adjacent areas are presented in Attachment B. Also included in Attachments A and B are plots of temperature, pH, and specific conductance in addition to a plot of the Palmer Hydrologic Drought Index.

728.200 Baseline hydrologic information

Spring and seep surveys were conducted at the Greens Hollow Tract by Cirrus Ecological Solutions, LC for the U.S. Forest Service beginning in 2001. As part of the spring and seep surveys, groundwater and surface-water discharge rates and field water- quality parameters, including water temperature, pH, specific conductivity, were measured. Spring and seep locations were determined in the field using hand-held GPS receivers.

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Baseline monitoring of selected springs and streams, including laboratory water quality analyses, were performed in the Greens Hollow Tract and surrounding areas during both high-flow and low-flow conditions from 2002 to 2004. The results of baseline monitoring at the Greens Hollow Tract and adjacent areas are listed in Tables 2a and 2b.

Additional monitoring of springs, streams, and wells was performed previously by the United States Geologic Survey (Thiros and Cordy, 1991) as part of a hydrologic reconnaissance of the Quitchupah and Pines areas. Additional baseline hydrologic data for the Greens Hollow Tract area have been submitted electronically to the Division of Oil, Gas and Mining Coal Water Quality Database, which are available on line at:

http://ogm.utah.gov/coal/edi/wqdb.htm.

728.310 Whether adverse impacts may occur to the hydrologic balance

The hydrologic balance is the sum of the flow interactions between surface waters and groundwaters and between various groundwater flow systems. This section describes the potential for adverse impacts to the hydrologic balance as a result of coal mining activities in the Greens Hollow Tract and adjacent area.

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For reasons described in previous sections of this report, the potential for the establishment of hydrodynamic communication between the shallow, active-zone groundwater systems that support spring and seep discharges in the Greens Hollow Tract and the deep, inactive-zone groundwater systems that will likely be encountered in the underground mine workings of the Sufco Mine is considered remote. Accordingly, while the deep inactive-zone

groundwaters held primarily in sandstone paleochannels immediately overlying the mined coal seam will be dewatered through mining activities, it is considered highly unlikely that surface waters or shallow groundwaters could migrate from the near surface into the underlying mine workings where the depth of cover exceeds 800 feet (which includes all proposed mining areas in the Greens Hollow Tract).

Active-zone groundwater systems in near-surface sediments and strata in the Price River and North Horn Formations, where overburden thicknesses are greater than about 800 feet should not be impacted by mining operations. This conclusion is based on the following lines of evidence:

1) The Price River and North Horn Formations are known to contain abundant, relatively thick shale and claystone layers. These low-permeability layers inhibit the vertical migration of groundwater into deeper strata. Additionally, the Mesa Verde Group shales and claystones in the region are known to contain hydrophyllic clays which are of low permeability and swell when wetted to effectively seal subsidence cracking. Clays in the North Horn and Price River Formations have been determined to contain about 24 percent smectite clay which swells when wetted effectively sealing fractures and stopping the downward flow of water (DOGM, 2005).

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2) While surface cracking in these formations (which typically extend less than about 50 feet below the land surface) can occur as a result of subsidence, the presence of uncompromised shale or claystone layers beneath the subsidence cracked zone prevents further downward migration of groundwater into

deeper formations. Additionally, unconsolidated soils and weathered shales and clays are known to be present in North Horn- and Price River-derived sediments regionally. In areas where these formations are present near the surface and where tension cracking may occur, the tension cracks would likely remain open for only short periods of time. This is because the weathered or unconsolidated clayey or shaley sediments derived from these formations are typically plastic in nature and of low-permeability. These materials, through infilling or in-place swelling, tend to rapidly heal all but the largest tension cracks, minimizing impacts to local groundwater flow regimes. That this is the case is supported by decades of previous experience in the Wasatch Plateau and Book Cliffs coal districts of Utah, where literally hundreds of springs discharging from these formations have been undermined without perceptible or quantifiable impacts occurring to groundwater and surface-water quality or quantity.

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It should be noted that, while the downward migration of shallow groundwater into deeper geologic formations is unlikely to occur, the potential exists for the moving of groundwater discharge locations at the surface. Occasionally, where near-surface tension cracking is extensive, spring discharge locations may be moved to locations a few to several tens of feet topographically lower than the original spring discharge location. For example, if a low-permeability perching layer upon which groundwater was flowing toward a spring were to be compromised as a result of extensive tension cracking, the discharge previously flowing to the spring could be rerouted through the fractured perching layer downward until a lower

uncompromised perching layer was present. Under this scenario, the post-mining discharge location for the spring would likely occur where the lower perching layer first intersected the ground surface in a down-dip location.

In considering the proposed coal mining activities in the Greens Hollow Tract, it is informative to consider the response of Castlegate Sandstone groundwater systems to previous coal mining activities in the Pines Tract at the Sufco Mine. At the Pines Tract area, the Castlegate Sandstone is exposed at or near the surface over large portions of the tract. The pre-existing joints and fractures in the brittle sandstone bedrock are apparent in the field are clearly visible in aerial imagery from the area. The thin soil that covers the Castlegate Sandstone bedrock in some locations generally consists predominantly of loose, clean sand, which is likely permeable. The potential for groundwater recharge through the exposed fractured Castlegate Sandstone bedrock is substantial. The potential for lateral perched groundwater flow through the fractured shallow sandstone is also appreciable in the gently sloping topography of the Pines Tract. Field observations of spring discharge mechanisms in the Pines area suggest that the springs discharge from fractured sandstone horizons, commonly where a thin (a few inches thick) clay-rich parting that is interbedded within the sandstone perches horizontal groundwater flow. Groundwater flows along the bedding plane/perching layer down-dip until the flowpath intersects the canyon wall forming a spring. When longwall mining occurred in the Pines Tract area beneath the springs and subsidence of the land surface occurred, discharges to the surface at some of the spring locations ceased. Based on site observations, it is apparent that discharges at these springs ceased when the existing joints dilated and/or additional fractures formed in response to

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subsidence. It is considered likely that the thin, clay-rich layers that perched the groundwater flow to the spring were also compromised with the subsidence fracturing. With the perching layer compromised, the shallow, perched groundwater that previously flowed to the spring likely migrated into deeper strata until encountering impermeable layers within the underlying Blackhawk Formation and causing the groundwater to discharge at a new or existing discharge point.

Thus, it is evident that important factors contributing to the responses of the Castlegate Sandstone springs to mining in the Pines Tract included:

- The brittle, jointed characteristics of the near-surface Castlegate Sandstone framework at the Pines Tract
- The shallow depths of groundwater flow in the Castlegate Sandstone – within the depths below the surface to which near-surface subsidence fractures typically propagate
- The fact that the thin, clayey perching layers interbedded in the brittle sandstone could be compromised by the subsidence-related near-surface ground movement.
- Recharge to the Castlegate Sandstone occurred where the sandstone was at or very near the surface under perched conditions.

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In considering the proposed mining at the Greens Hollow Tract, it is important to note that the hydrogeologic conditions described above for the Pines Tract areas are fundamentally different from those anticipated in proposed Greens Hollow Tract mining areas.

The Price River Formation and North Horn Formation are present at the surface in almost all of the proposed mining area at the Greens Hollow Tract. Groundwater flow in these formations occurs primarily in sandstone units that are interbedded with thick sequences of low-permeability shale that generally deform plastically rather than in a brittle manner in response to subsidence mining. Additionally, swelling clays have been identified in the overburden that swell when wetted (USFS, 2014). Accordingly, impacts to groundwater systems in these formations such as those that occurred in the Pines Tract are not anticipated for the Greens Hollow Tract. Rather, it is anticipated that groundwater flow conditions within the Price River Formation and North Horn Formation will generally be maintained during mining, as has been the previous experience elsewhere in mining operations at the Sufco Mine and other mining operations in the Wasatch Plateau coal mining district.

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Additionally, in order to protect hydrologic resources along perennial stream courses, the lease stipulations for the Greens Hollow Lease specify the use of non-subsidence (full-support) mining methods in areas within the lease where the Castlegate Sandstone is exposed at the surface or covered by less than 50 feet of Price River Formation or North Horn Formation sediments. Within the Greens Hollow Tract, these specified areas include portions of the lower Cowboy Creek, lower Greens Hollow, and Muddy Creek drainages.

Consequently, longwall mining and accompanying subsidence in areas where the Castlegate Sandstone is exposed at or near the surface – as was the case in portions of the Pines Tract – is not proposed for the Greens Hollow Tract.

It is noteworthy that while the discharge locations of some springs were moved as a result of subsidence of the drainage, several other springs in and around the subsided areas of the East Fork of Box Canyon were not affected by the undermining of the drainage. This observation suggests that the movement of some spring discharge locations was a likely a local-scale phenomenon and apparently not a regional change in the Castlegate Sandstone groundwater system in the drainage.

Mine workings in the Greens Hollow Tract will likely intercept primarily ancient, perched groundwater systems in sandstone channels in the mine roof. Groundwater inflows along fault zones that may be intercepted by the mine workings in the Greens Hollow Tract may also occur. Although it is never possible to predict with certainty the nature and magnitude of groundwater inflows that will be intercepted in a new coal mining area, based on the similarity of the geologic and hydrogeologic conditions at the Greens Hollow Tract to adjacent mining areas at the existing Sufco mine, it is considered likely that groundwater inflows in the Greens Hollow Tract will be short lived and of magnitudes similar to those encountered previously in the Sufco Mine. Mining operations will dewater these ancient, perched groundwater systems. However, because these systems are not in good hydraulic communication with the ground surface or shallow overlying active-zone groundwat

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systems, dewatering of the deep perched systems will likely have no impact on overlying groundwater or surface water regimes.

As discussed previously, inactive-zone groundwater systems in the Blackhawk Formation occur in isolated partitions that are not in good hydraulic communication with the land surface or shallow overlying active-zone groundwater systems that support springs and seeps. Therefore, it is likely that the groundwater that will be intercepted in the Blackhawk Formation in the Greens Hollow Tract will be groundwater being removed from storage. Because inactive-zone groundwater systems are not in hydraulic communication with the land surface or shallow, active-zone groundwater systems, groundwater being removed from the Blackhawk Formation is likely not being replenished to any appreciable extent by recharge from adjacent or overlying groundwater systems or from infiltration of surface waters.

At any coal mine, subsidence-related interruption and deformation of strata above longwall-mined areas has the potential to alter the pre-mining groundwater flow conditions. The potential for this impact to affect groundwater and surface-water resources in the Greens Hollow Tract is low. Subsidence of the land surface overlying coal mining areas is a commonly observed phenomenon in the Utah coal mining environment. Surface subsidence can occur where the rock strata overlying mined-out areas sags into the voids left by the extraction of the coal. The United States Mine Safety and Health Administration (MSHA 2009) describes zones of disturbance of geologic strata over mine workings. These zones include:

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- Floor heave – Upward thrust of the floor in the mine working area.

- Caved zone – Caving of the overburden directly over a mine void and bulking of the caved material leading to support of overlying strata generally extending to a height of 3 to 10 times the extraction thickness. Assuming an extraction thickness of 10 feet, the caved zone would extend from 30 to 100 feet above the mining interval.

- Fractured zone – A zone of vertical fracturing and bed separations. Overburden in this zone moves vertically in large blocks along existing joints and new vertical fractures. Typically this zone extends no more than 24 times the extraction thickness above the mine, but can reach 30 times the extraction thickness. Assuming an extraction thickness of 10 feet, the Fractured Zone would be anticipated to extend no more than 240 feet above the mine, possibly reaching 300 feet above the mine level.

- Main roof – This zone, which is sometimes subdivided into the Dilated Zone and the Constrained Zone, is an area of no significant increase in vertical hydraulic conductivity. This zone has been characterized as extending above the Fractured Zone up to 60 times the extraction thickness. Assuming a coal extraction thickness of 10 feet, the Main roof zone would extend for 600 feet above the mine level.

- Surface zone – Surface cracks are typically present in this zone and are generally limited to areas placed in tension by subsidence. Cracks can be created in dry clayey soil and joints can open in massive sandstones. Such cracks can extend downward to a depth of 50 feet.

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Similarly, in order to estimate the height overlying mining areas to which subsidence-induced fracturing may extend, and to project minimum overburden thickness required to protect hydrologic resources, the Society for Mining, Metallurgy, and Exploration (SME, 2011) has developed empirical relationships between the thickness of the extracted coal seam and the upward fracture propagation distances (see SME Chapter 10.6, "Mine Subsidence"). Utilizing these relationships, the Mining Engineers Handbook recommends that a minimum vertical distance between the mine and an overlying water body with the potential for causing catastrophic damage should be a minimum of 60 times the coal mining height. The same minimum vertical separation distance is recommended for protection of aquifers overlying total extraction mining areas. Based on these considerations, it is considered unlikely that impacts to groundwater aquifers, springs, seeps and streams will occur as a result of upwardly propagating fracturing in areas where the overburden exceeds 600 feet. Because mining in the Greens Hollow Tract will occur in areas where the overburden exceeds 800 feet, subsidence-related impacts to shallow groundwater systems that support springs and provide baseflow to streams are not anticipated. The presence of a thick zone of unfractured, low-permeability bedrock prevents the downward migration of active-zone groundwaters into the deeper subsurface. Sealing of subsidence cracks by clays in the Blackhawk Formation is expected to minimize long-term effects of subsidence on the hydrologic systems (DOGM, 2013).

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Previous experience at the Sufco Mine suggests that the surface tension fractures commonly extend to about 50 feet or less below the land surface. Thus, in the Greens Hollow Tract, a sequence of several hundred feet of unfractured rocks will likely exist between the bottom of

the shallow tension cracks near the surface and the top of the fractured zone above longwall mined regions. This sequence of low-permeability rock prevents the downward migration of active-zone groundwaters into the deeper subsurface. The presence of hydrophyllic clays in the fine-grained rocks of the Sufco Mine area effectively seal fractures that may form in the subsurface, preventing appreciable downward migration of groundwater.

Impacts to groundwater systems in the Star Point Sandstone, which underlie the coal seams to be mined in the Blackhawk Formation, are not anticipated. Springs discharging from the Star Point Sandstone (spring Sufco 047 and groundwater seepage areas related to Sufco 047A) are associated with fractures in the sandstone bedrock that are stratigraphically lower than the Upper Hiawatha Coal seam to be mined. As discussed previously, the Upper Hiawatha Coal seam is underlain by shaley lagoonal sediments that include the Lower Hiawatha Coal seam, which would isolate the Upper Hiawatha coal seam from the underlying Star Point Sandstone. Mayo and Associates (1997) indicate that there is no known or suspected hydrologic connection between in-mine groundwaters and groundwaters discharging from the Star Point Sandstone. We concur with this conclusion.

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In summary, based on the characterization of groundwater and surface-water systems presented above, and on the proposed mining plan, no significant impacts to the overall hydrologic balance are anticipated as a result of mining in the Greens Hollow Tract.

It is noted that discharge from a spring located on the adjacent Pines area of the Sufco Mine permit area appears to have been impacted by mining operations at the Sufco Mine. This

spring (Pines 303) discharges from a sandstone channel that overlies the mined coal seam by only 100 feet. The decreased discharge from this spring is likely attributable to the interception of the sandstone paleochannel that supports the spring by the underground Sufco Mine workings. It should be noted that the potential for this occurrence was discussed in the Pines Tract EIS (1999) prior to coal mining in the Pines Tract. Because there are no springs that discharge from sandstone channels in the Blackhawk Formation stratigraphically near the coal seams in the Greens Hollow Tract area, this potential impact to springs should not occur in the Greens Hollow Tract area.

Tension cracking of the substrate of a perennial stream has the potential to temporarily divert surface waters. The potential for loss of surface waters to deeper groundwater systems through downward migration of water through subsidence fractures in the Greens Hollow Tract area is considered minimal. This is because, as discussed previously, the thick perching layers underlying perennial streams would not likely be compromised as a result of tension fracturing. This is the case for two reasons. First, the hydraulic conductivites of underlying bedrock formations are low and permeable horizons are lenticular and discontinuous. Thus, the underlying bedrock is not capable of accepting appreciable quantities of stream leakage, and rejected recharge occurs. Second, the presence of swelling clays in the bedrock formations in the Greens Hollow Tract area causes the rapid healing of tension cracks in fine-grained bedrock lithologies. Surface cracks in stream substrates that occur in more brittle sandstones would be filled with clay-rich sediment transported from the North Horn and Price River Formations by the streams in the Greens Hollow Tract area. Because, as discussed previously, active-zone groundwater systems will likely not be

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impacted by subsidence fracturing, the potential for diminution of baseflow in perennial streams is considered remote. Thus, the overall potential for detrimental effects resulting from subsidence fracturing beneath perennial streams in the Greens Hollow Tract area is believed to be low.

728.320 Whether acid-forming or toxic-forming materials are present that could result in the contamination of surface water or groundwater supplies

Acid- and toxic-forming materials in soil and rock disturbed by mining have to potential to impact groundwater and surface water quality. Mine discharge water from the Sufco Mine is routinely monitored for indicators of increased acidity (iron, manganese, and pH) and toxic materials. Although the concentrations of iron in mine discharge water are occasionally elevated relative to springs in the region, mine discharge waters rarely exceed permitted discharge limits.

No new topsoil or waste rock piles are planned as a consequence of mining in the Greens Hollow Tract and no impact from acid- or toxic-forming materials is anticipated.

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With the exception of modest quantities of pyrite or similar sulfide minerals, no significant quantities of any acid- or toxic-forming materials are believed to be present in the Greens Hollow Tract area. Iron pyrite, marcasite, and other iron sulfide minerals are common in western coal mines. The oxidation of pyrite and marcasite, when exposed to water and oxygen, releases H^+ ions (acid) into the mine water. The acid produced from pyrite and marcasite oxidation temporarily lowers the pH of the water. However, the acid produced

from pyrite oxidation is rapidly consumed by reactions with the carbonate minerals which are pervasive in the rocks associated with the coal fields of the Wasatch Plateau. Thus, acid mine discharge does not occur. The iron released into the water from pyrite and marcasite oxidation is readily precipitated as iron-hydroxide when it contacts oxygenated water.

Thus, the potential for acid-forming or toxic-forming materials to result in contamination of surface-water or groundwater supplies is believed to be negligible.

728.331 What impact the proposed coal mining and reclamation operation will have on sediment yield from the disturbed areas

The sediment load of streams can be impacted by increased sediment yield from disturbed areas and from land that has undergone subsidence. Canyon Fuel Company has implemented a rigorous sediment control program that is designed to minimize the sediment yield from disturbed areas. This includes the use of sediment control fences, re-vegetation of previously disturbed areas, and the diversion of surface waters around disturbed areas. Runoff from disturbed areas is collected near its source and diverted into sediment control ponds for retention and settlement of suspended solids before it is discharged to natural drainages. Because the Greens Hollow Tract will be accessed through the existing Sufco Mine, the potential for additional impacts at the disturbed surface facilities resulting from coal mining in the Greens Hollow Tract is minimal.

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Where differential subsidence of the land surface occurs in stream drainages, there is the potential for the temporary increase of sediment yield in these drainages. This potential

impact is primarily the result of subsidence-induced gradient changes along areas of differential subsidence. However, this effect is generally expected to be short lived. This is because the channel substrate in areas of increased stream gradients is down-cut while sediment is being deposited in areas of decreased stream gradients and the stream gradually returns to equilibrium with its channel substrate.

728.332 What impact the proposed coal mining and reclamation operation will have on acidity, total suspended and dissolved solids and other important water quality parameters of local impact

As discussed previously, impacts to the active-zone groundwater systems that support springs and seeps and provide baseflow to streams in the Greens Hollow Tract and adjacent area are not anticipated. Thus, detrimental impacts to important water quality parameters such as acidity, total suspended solids, and total dissolved solids in creeks and springs in the Greens Hollow Tract area are generally considered unlikely.

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It should be noted that in the event that subsidence fracturing of bedrock horizons beneath a stream or near the discharge location of a spring occurs, there is a potential of a modest, temporary increase in TDS concentration. This increase could result if the bedrock horizons fractured contained pyrite or other sulfide minerals. When subsidence-fractured rock surfaces expose pyrite in an aqueous, oxygen-rich environment, sulfide mineral oxidation may occur. Under such circumstances, some solutes, primarily sulfate, bicarbonate, calcium, and magnesium, can increase. Such reactions typically do not occur in deep groundwater environments because of the lack of available oxygen in these systems. Because the pyrite is

consumed by the oxidation reaction, the reaction ceases when all the freshly exposed pyrite is oxidized.

Such an occurrence was noted in a short reach of the East Fork of Box Canyon after the stream was undermined in 2003-2004 (Petersen Hydrologic, 2004). In that instance, the TDS concentration of water increased in the creek by 66 mg/l from 325 to 374 mg/l. When the stream reach was again visited in the spring of 2005, it was apparent that the oxidation reaction in the creek had ceased. The iron hydroxide deposits that had precipitated in the stream channel as a result of pyrite oxidation had been scoured from the channel and conditions in the stream appeared normal.

Fuels, greases, and oils are stored and used in the Sufco Mine permit area. There is the potential for spillage of these substances during equipment maintenance and operations, during filling of storage tanks and vehicle tanks, and from leakage from potentially leaking storage tanks. However, because the Greens Hollow Tract will be accessed through the existing Sufco Mine, the potential for increased releases of these materials as a result of mining activities in the Greens Hollow Tract above is considered minimal.

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The Sufco Mine has previously implemented a rigorous spill prevention plan that is designed to minimize the potential for spillage of these substances and to ensure that any potential spills that may occur are promptly cleaned-up. This plan will continue to be followed during mining in the Greens Hollow Tract. Because the Greens Hollow Tract reserves will be accessed from the permitted existing surface facilities area (including equipment

maintenance and fueling areas and chemical storage areas), there should be no additional potential for spillage as a result of mining in the Greens Hollow Tract.

The discharge of Sufco Mine water to surface water drainages will have an impact on the water quality of receiving waters. The nature and magnitude of this impact is related to the relative quality of the receiving water and the mine discharge water. If the mine discharge water is of poorer quality than the receiving water, then the quality of the receiving water will be degraded proportionally. If the mine discharge water is of better quality than the receiving water, the quality of the receiving water will be improved. Historically, the discharge water from the Sufco Mine has generally been of relatively good quality and has usually met the beneficial use standards of the receiving water (DOGM, 2016).

Based on the fact that the geologic conditions at the Greens Hollow Tract are generally similar to those in the adjacent existing Sufco Mine permit area, it is anticipated that the character of groundwater inflows in terms of both quality and quantity will likely be similar to those that occur in the existing Sufco Mine. Consequently, no impacts to important water quality parameters above those that may occur at the existing Sufco Mine area are anticipated as a result of mining in the Greens Hollow Tract. The discharge of Sufco Mine water will be regulated under a UPDES permit issued from the Utah Division of Water Quality.

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728.333 What impact the proposed coal mining and reclamation operation will have on flooding or streamflow alteration

There are no known geologic features in the Greens Hollow Tract area that are substantively different than those that have been encountered elsewhere in the Sufco Mine (Personal communication, Mark Bunnell, 2017). Mining practices to be utilized in mining the Greens Hollow Tract will also be similar to those currently implemented at the Sufco Mine. Accordingly, it is anticipated that discharge rates from the Sufco Mine during mining in the Greens Hollow Tract will likely be of similar magnitude to those that are currently occurring. Thus, no significant increase to the flooding or streamflow alteration potential of Sufco Mine discharge water to Quitchupah Creek is anticipated above that currently occurring as a result of mining in the Greens Hollow Tract.

728.334 What impact the proposed coal mining and reclamation operation will have on groundwater and surface-water availability

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It has been demonstrated that the active-zone groundwater systems that support springs and seeps in the Greens Hollow Tract area are isolated from the inactive-zone groundwater systems that will be encountered during mining in the Greens Hollow Tract. As noted above, were bedrock springs or their groundwater flowpath areas in the Greens Hollow Tract to be directly undermined and subsided, there is the potential for diminished discharge from these springs. However, no Castlegate Sandstone springs are to be undermined in the proposed mining plan. Also discussed previously, the potential for impacts to springs and seeps in the

overlying Price River and North Horn Formations is considered minimal. Therefore, the availability of these groundwaters and surface waters will likely not be impacted.

Current mining operations have made available several hundreds of gallons per minute of mine discharge water that has previously been unavailable for use. It is anticipated that as mining progresses in the Greens Hollow Tract, additional groundwater inflows into the mine workings will occur and discharge of groundwater to the Quitchupah Creek surface-water drainage will likely continue. It should be noted that the discharge of mine water at current discharge rates would likely not be sustained over a long period of time. Historically, discharge rates from individual inactive-zone mine inflows decline over time. This is because the inactive-zone groundwater is being removed from storage and is not being actively recharged. Rather, the rate of discharge from the mine is best correlated with the rate at which the mine workings are advanced into new mining areas, and not to the total cumulative footprint of the mine workings (Mayo and Associates, 1997). It should not be assumed that the groundwater discharging from the mine will be a long-term source of water.

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It should be noted that discharge in spring Pines 303, which discharges from a sandstone channel only 100 feet above the mined coal seam in lower Box Canyon, was diminished coincident with mining in the Sufco Mine. This condition is likely related to the interception and draining of the sandstone channel that supports Pines 303 by the Sufco Mine workings. The potential for this occurrence was discussed in the Pines Tract EIS (1999). Because there are no springs that discharge from sandstone channels in the Blackhawk Formation

stratigraphically near the coal seams in the Greens Hollow Tract area, this potential impact to springs should not occur in the Greens Hollow Tract area.

728.350 Whether the underground coal mining and reclamation activities may result in contamination, diminution or interruption of State-appropriated water

It has been demonstrated that the active-zone groundwater systems that support springs and seeps and provide baseflow to perennial streams in the Greens Hollow Tract area are isolated from the inactive-zone groundwater systems that will be encountered during mining activities. Accordingly, the potential for contamination, diminution, or interruption of groundwater systems resulting from draining of active-zone groundwaters into deep horizons (or the mine workings) is considered remote. Inactive-zone groundwater systems that will likely be encountered during mining in the Greens Hollow Tract include primarily perched systems associated with sandstone channels in the Blackhawk Formation beneath the Greens Hollow Tract. While deep, inactive-zone Blackhawk Formation groundwater systems will be intercepted and dewatered during mining activities, there are no known uses or State appropriations of these waters.

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Potential for Trans-Basin Diversion

The deep, inactive-zone groundwater systems that will be intercepted in the Greens Hollow Tract are generally not in strong hydraulic communication with shallow active-zone groundwater systems. Consequently, while flow paths of surface-water systems and shallow, active-zone groundwater systems are usually constrained in large measure by surface

topography (i.e. drainage basins), the deep, inactive-zone groundwater systems that will likely be intercepted during mining operations in the Greens Hollow Tract (away from shallow, near-surface outcrop areas) operate independently of the surface topography. Consequently, the removal of deep, inactive-zone groundwaters intercepted in the underground mine environment likely does not result in and quantifiable diminution of waters from the overlying surface water drainage basin (i.e. trans-basin diversion). Rather, the pumping of the ancient, inactive-zone groundwaters intercepted in the mine workings to surface drainages likely makes water resources available to downstream water users that otherwise would not be available for use.

12.0 Recommended Monitoring Plan

The recommended monitoring plans for groundwater and surface-water in the Greens Hollow Tract are presented in Tables 8, 9, 10, and 11. Recommended hydrologic monitoring protocols are listed in Table 8. Groundwater and surface-water monitoring sites recommended for hydrologic monitoring are presented in Table 9. Recommended field and laboratory water quality parameters for groundwaters and surface-waters are presented for groundwaters and surface waters in Tables 10 and 11, respectively.

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These recommended monitoring plans for groundwaters and surface-waters are designed to verify that mining-related activities do not adversely impact groundwater or surface-water resources in the tract area, and to quantify impacts to water quantity and water quality in the event that impacts do occur. Additionally, the plan is designed to collect data to document

that the active-zone springs and streams at the surface in the Greens Hollow Tract area operate independently of the deep, inactive-zone groundwater systems encountered in the Sufco Mine. The proposed monitoring sites are shown in Figure 9. The monitoring plan is summarized in below.

Springs

We recommend the monitoring of 26 springs in the Greens Hollow Tract and adjacent area. This includes springs that discharge from the North Horn Formation, Price River Formation, and Castlegate Sandstone and are distributed over the area where spring discharge occurs. Of the 26 springs recommended for operational monitoring, seven are currently part of the existing Sufco Water Monitoring Plan. These springs are listed here for clarity regarding the specific springs recommended for monitoring in connection with mining activities at the Greens Hollow Tract. It is noted that Price River Formation springs M-SP87 and USP-1 are essentially the same spring. Thus, monitoring of this groundwater discharge source will be designated as M-SP87 in the hydrologic monitoring plan.

Both discharge and laboratory solute water-quality data from the springs proposed for monitoring have been collected during baseline monitoring activities from 2001 – 2004. Because the baseline discharge and water quality characteristics of these springs have been adequately characterized, we do not recommend monitoring for laboratory water quality parameters at these springs. We do recommend routine monitoring of these springs for discharge and field water-quality parameters.

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Streams

We recommend the regular monitoring of Cowboy Creek at site M-STR04. It is noted that this has previously been added to the Sufco Mine monitoring plan. M-STR04 is located on Cowboy Creek downstream of the Greens Hollow Tract. As surface waters from a large portion of the Greens Hollow Tract area drain into Cowboy Creek, monitoring of discharge rates at this site can provide useful data on potential impacts to discharge rates in the Cowboy Creek drainage above M-STR04. Similarly, potential cumulative impacts to water quality in the drainage can be evaluated at this site. Thus, we also recommend the regular monitoring of M-STR04 for field water-quality parameters.

We recommend the regular monitoring of Greens Hollow Creek at monitoring site M-STR06. This station is located on Greens Hollow Creek immediately upstream of the drainage entering the steep-walled Castlegate Sandstone canyon. We recommend the monitoring of discharge and field water quality parameters at this site.

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We recommend the monitoring of Muddy Creek at site U-Mud. U-Mud is located immediately below the confluence of the North and South Forks of Muddy Creek above proposed mining areas in the Greens Hollow Tract. We recommend the monitoring of discharge and field water quality parameters at this site. It should be noted that commonly during the second quarter monitoring event, and particularly during wet climatic cycles, the discharge rates in Muddy Creek can be high (sometimes exceeding several hundred cubic feet per second). When the stream flow is considered by the monitoring personnel to be in an

unsafe condition to wade to perform the discharge measurement, the flow may be determined using alternate methods. Typically, this may be performed by measuring the time it takes for a partially submerged object to float over a known distance and using this information to calculate an average stream velocity.

We recommend the monitoring of Muddy Creek below the Greens Hollow Tract area at monitoring site Pines 405. This is a previously established monitoring site on Muddy Creek with 20 years of monitoring data previously collected. We recommend that Pines 405 be monitored for discharge and field water quality parameters.

We recommend the monitoring of Sufco 006 (South Fork of Quitchupah Creek) and Sufco 007 (North Fork of Quitchupah Creek). These sites have been monitored by Sufco since 1979 and are currently part of Sufco's approved monitoring plan. We recommend that Sufco 006 and Sufco 007 be monitored for field and laboratory water quality parameters.

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In contemplating future mining in the Greens Hollow Tract, it is acknowledged that additional hydrologic data from surface streams will be useful in determining impacts in specific mining areas. Accordingly, we recommend that one year of quarterly monitoring at selected stream sites above and below proposed mining areas be collected prior to the commencement of longwall mining in the area. We recommend that the monitoring continue on a quarterly basis during the period of active mining and continuing for one year after the mining in the area is completed. The locations of these monitoring locations are shown on Plates 7-3 and 7-10 in the Sufco M&RP.

Wells

An in-mine monitoring well will be drilled into the Star Point Sandstone below the coal seam. The well will be drilled as close to the Greens Hollow Lease boundary as possible with the location being determined by safety and access. The location of the well will be added to Plate 7-3 of the Sufco Mine MRP once the well has been completed. The well will be monitored during the 2nd, 3rd, and 4th quarters of the year for water level.

Using the Groundwater and Surface-Water Monitoring Programs

The monitoring plans for groundwaters and surface-waters for the Greens Hollow Tract may be used to provide verification that mining-related impacts to groundwater and surface-water systems do not occur, and to determine the magnitude and character of potential impacts if they do occur. Comparisons between monitoring data (for the parameter of interest or concern) collected during baseline pre-mining conditions should be made with monitoring data (for the same parameter or interest of concern) collected during the operational and/or reclamation phase of mining to determine impacts. When changes to monitored parameters subsequent to mining in an area are observed in the monitoring data, an analysis of all data should be performed to determine the cause(s) of the change in the hydrologic condition. In utilizing the monitoring data to detect or quantify potential mining-related impacts, it is necessary to evaluate all factors relevant to the prevailing hydrologic conditions together with the monitoring data. This is because other factors, which are not related to the mining activity, may cause changes in the prevailing hydrologic conditions. In particular, climatic variability (which may result in increased or decreased groundwater and surface-water flow

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rates, changes in water levels in wells, and changes in water quality) should be carefully evaluated together with the monitoring data. Other factors that may influence coal mine hydrology include grazing practices, land use, range condition, and potential effects associated with other industrial or mining activity in the area. A convenient and useful means of evaluating regional climatic data is through the use of the Palmer Hydrologic Drought Index (PHDI). The PHDI is a monthly value that indicates the severity of wet and dry spells that is generated by the National Climatic Data Center and available on-line at http://www1.ncdc.noaa.gov/pub/data/cirs/drd964x.phdi.txt.

The use of Stiff (1951) diagrams is a useful technique that is frequently used to analyze and compare groundwater and surface-water quality characteristics from various sources. Information required to create Stiff diagrams is available from the Division of Oil, Gas and Mining Coal Water Quality Database, which is freely accessible at: http://ogm.utah.gov/coal/edi/wqdb.htm. Additional information on coal mining hydrology and potential mining-related impacts, which can be used to assist in the evaluation of monitoring data and potential mining-related impacts, is provided on the Utah Division of Oil, Gas and Mining web page at http://ogm.utah.gov/coal/water/default.htm.

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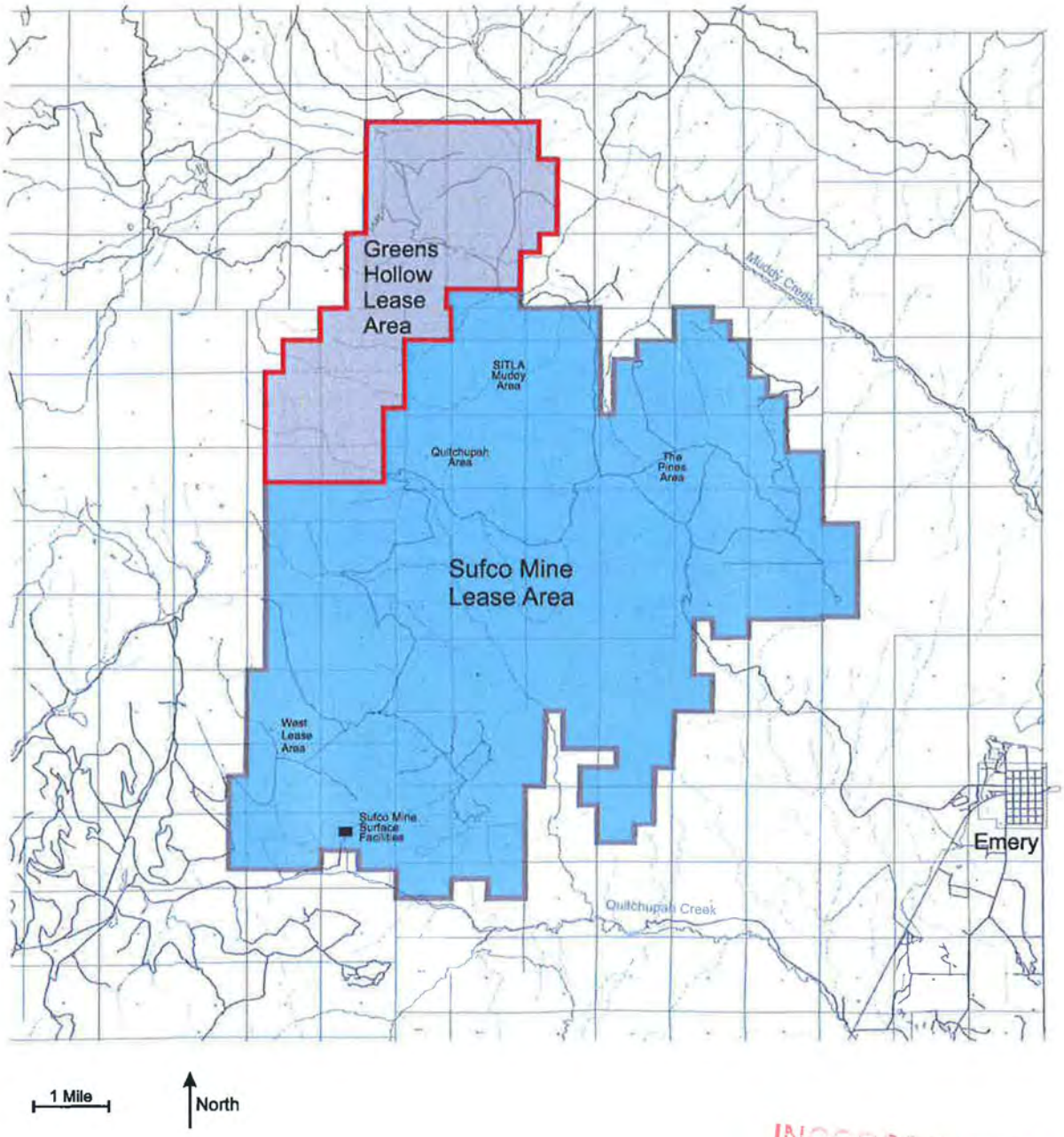

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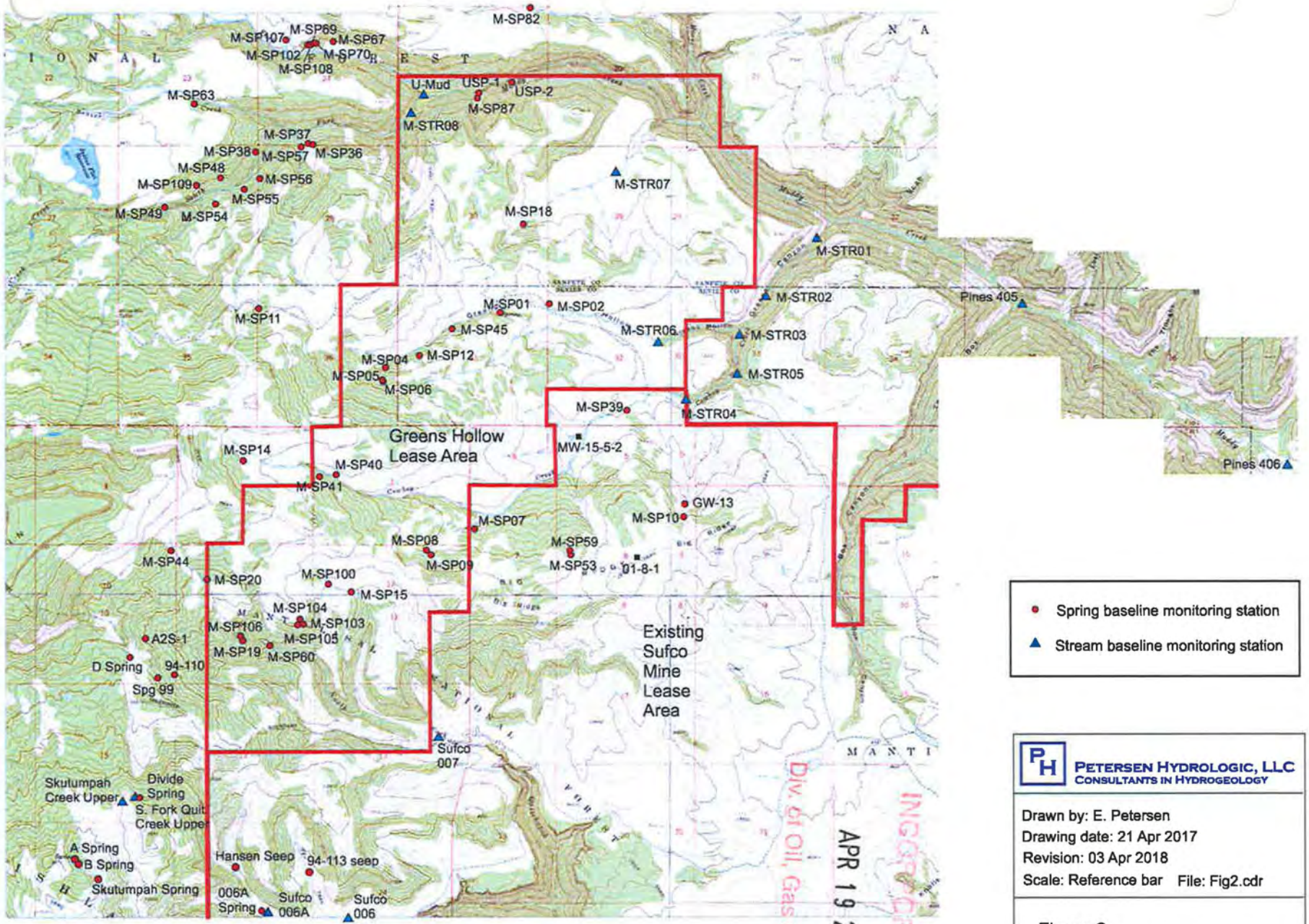
Figure 1 Location of Sufco Mine and Greens Hollow Lease area.



1927 North American Datum, UTM grid zone 12
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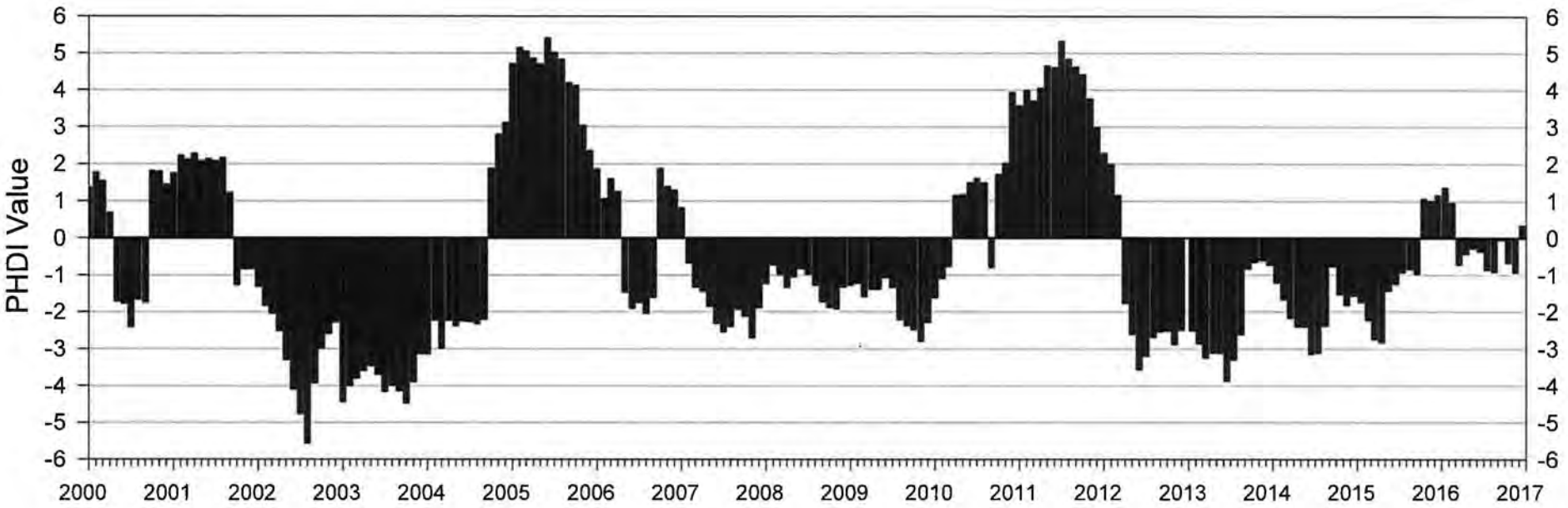
Revision: 03 Apr 2018
Scale: Reference bar File: Fig2.cdr

Figure 2
Baseline monitoring locations for the Greens Hollow Tract.



-1 to -2 Mild Drought	1 to 2 Mild Wet Spell
-2 to -3 Moderate Drought	2 to 3 Moderate Wet Spell
-3 to -4 Severe Drought	3 to 4 Severe Wet Spell
-4 to -5 Extreme Drought	4 to 5 Extreme Wet Spell

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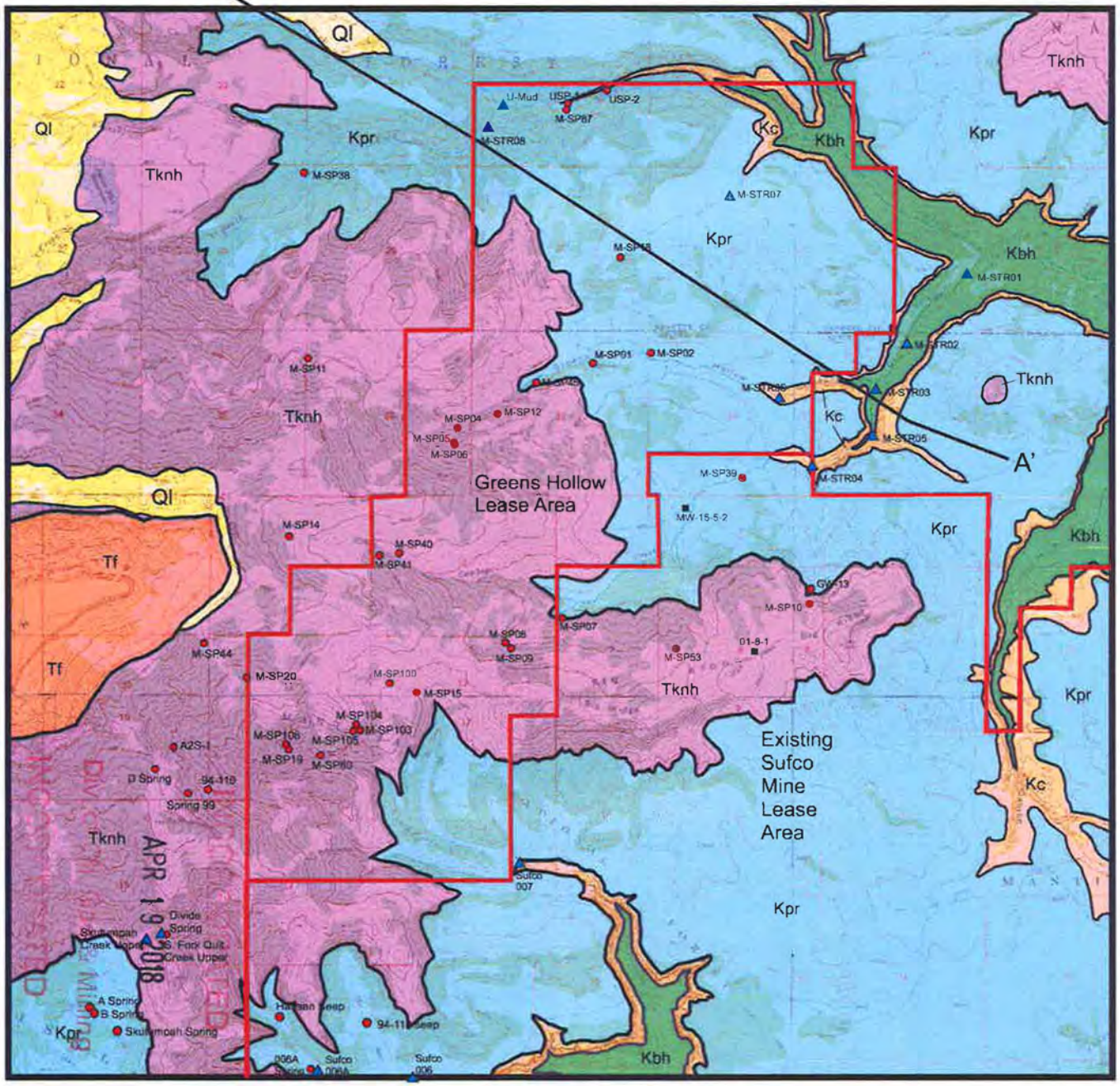
Figure 3 Plot of Palmer Hydrologic Drought Index for Utah Region 4.



Legend

Ql	Quaternary landslide dep.	Kc	Castlegate Sandstone
Tf	Flagstaff Limestone	Kbh	Blackhawk Formation
Tknh	North Horn Formation		
Kpr	Price River Formation		

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Figure 4
Geologic map of the Greens Hollow Tract.

1927 North American Datum; UTM grid zone 12
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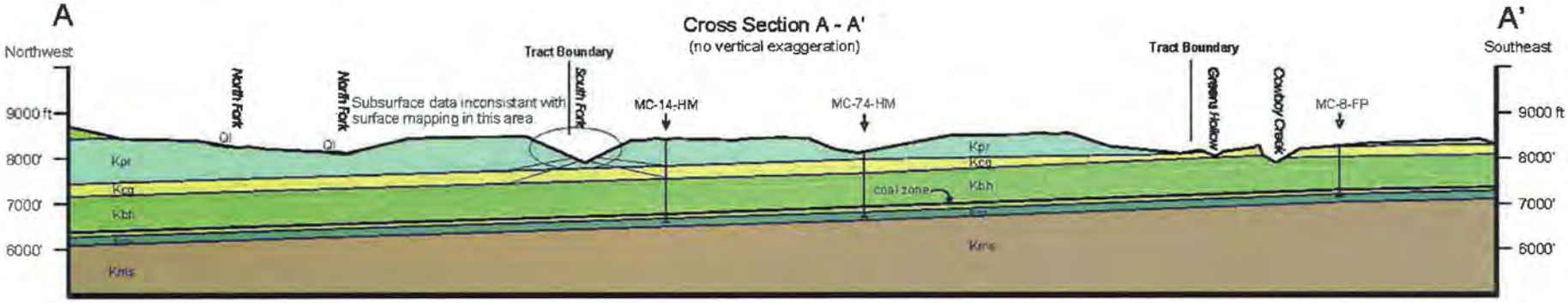
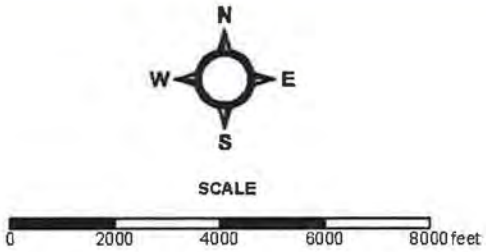
Map compiled from USGS Quads: Helicrope Mountain, UT Flagstaff Peak, UT Acoint Lakes, UT Emery West, UT

BigTopo Map





See Figure 4 for cross-section location.

Explanation

- Ql — Landslide/mass movement
- Tf — Flagstaff Limestone
- Tkn — North Horn Formation
- Kpr — Price River Formation
- Kcg — Castlegate Sandstone
- Kbh — Blackhawk Formation
- Kss — Star Point Sandstone (cross section only)
- Kmv — Mancos Shale (cross section only)

From P. Anderson, 2008; in Greens Hollow Tract SDEIS, 2014

Figure 4a Geologic cross-section through the Greens Hollow Tract area.

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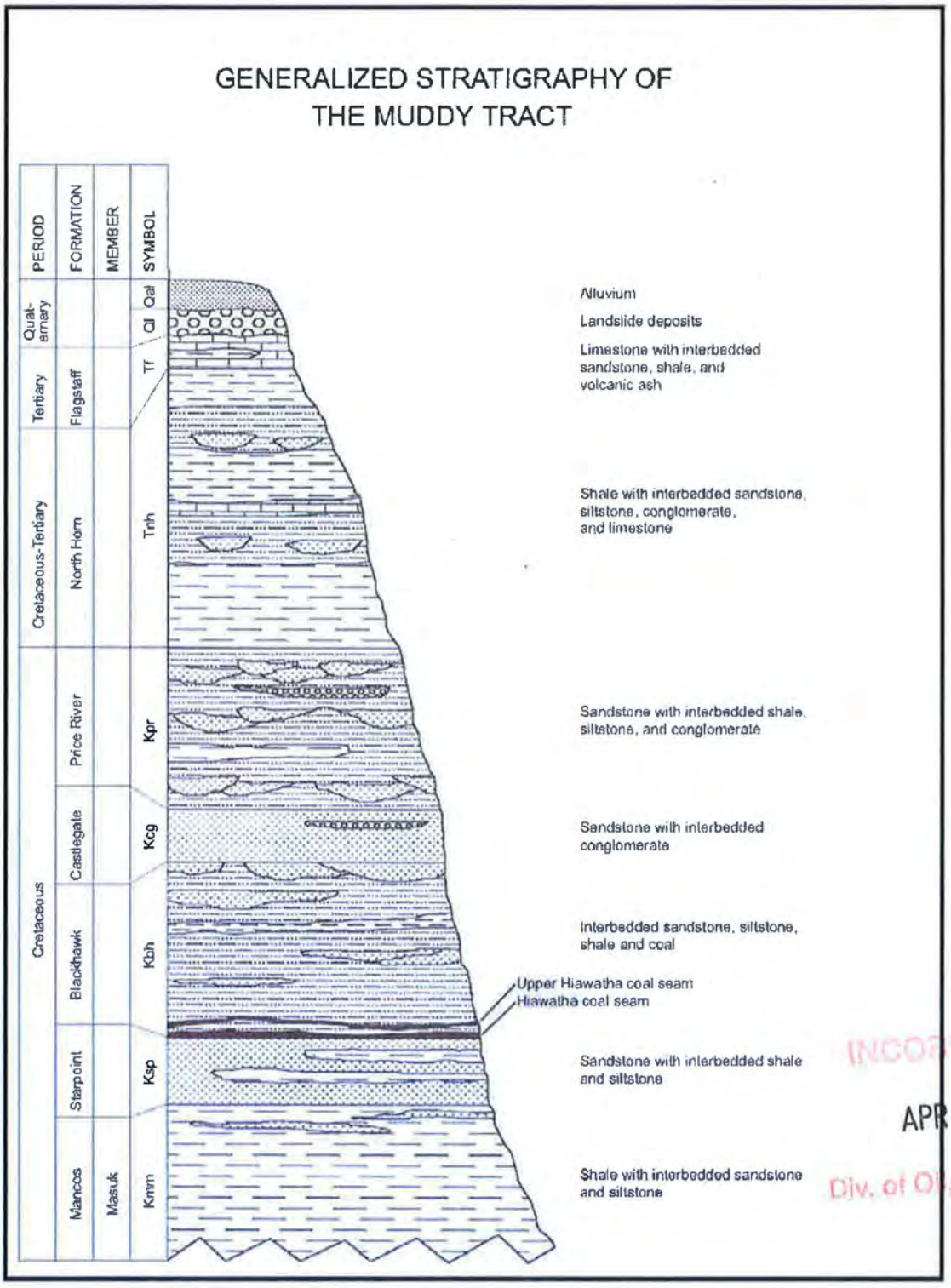

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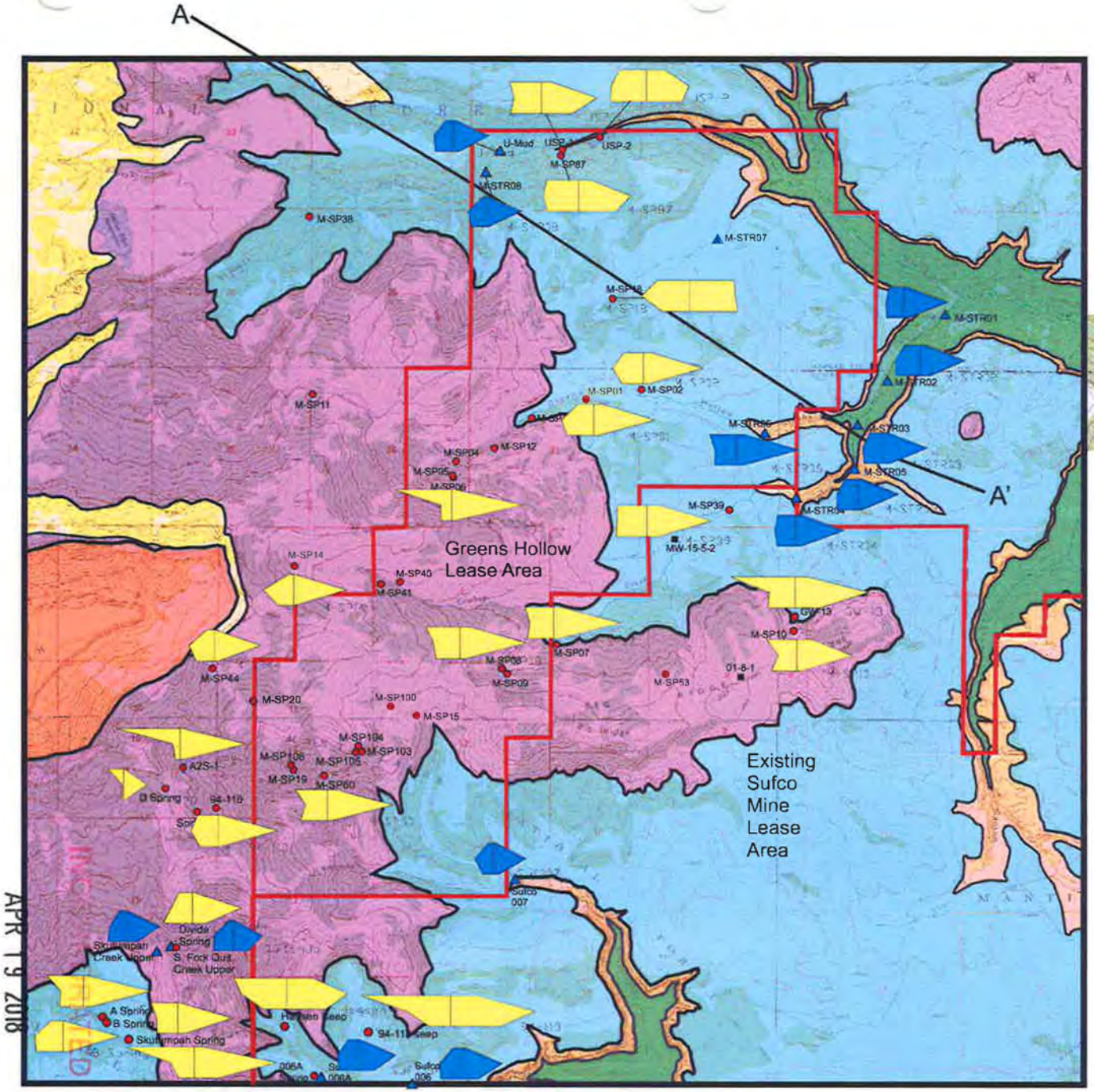
Figure 5 Generalized stratigraphy (from Anderson, 2004).



Legend

Ql	Quaternary landslide dep.	Kc	Castlegate Sandstone
Tf	Flagstaff Limestone	Kbh	Blackhawk Formation
Tknh	North Horn Formation		
Kpr	Price River Formation		

Na + K, Ca, Mg — Cl, $HCO_3 + CO_3$, SO_4

10 5 0 5 10 Meq/L

Surface water

Groundwater

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Revision: 02 Oct 2017
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Figure 6
Stiff diagrams for groundwaters and surface-waters in the Greens Hollow Tract.

1927 North American Datum: UTM grid zone 12
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Map compiled from USGS Quads: Helicopter Mountain, UT; Flagstaff Peak, UT; Acord Lakes, UT; Emery West, UT

0 ¼ ½ 1 2 Miles
1000 0 2000 4000 6000 8000 10,000 Feet
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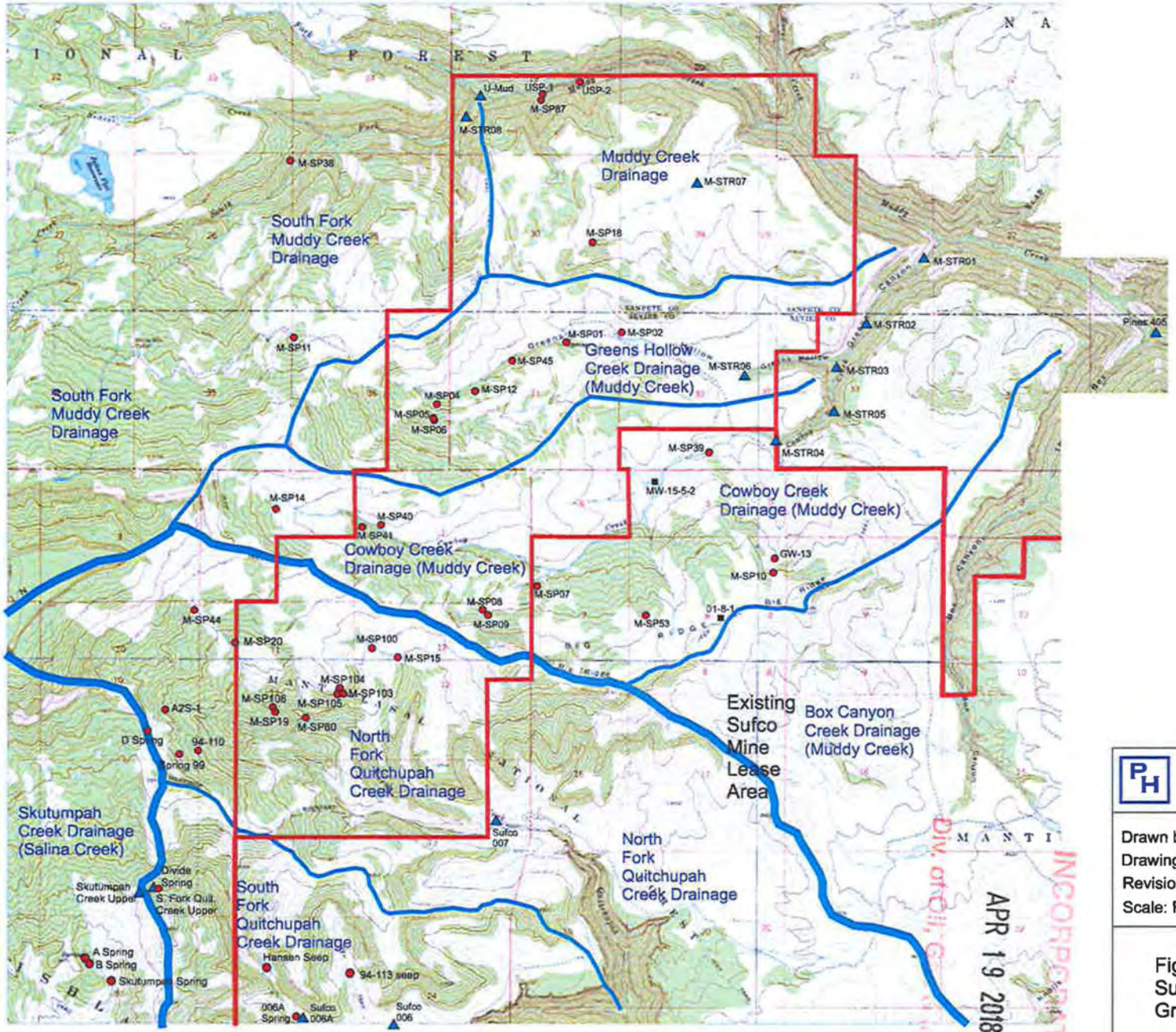

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Figure 7
Surface-water basins in the Greens Hollow Tract.

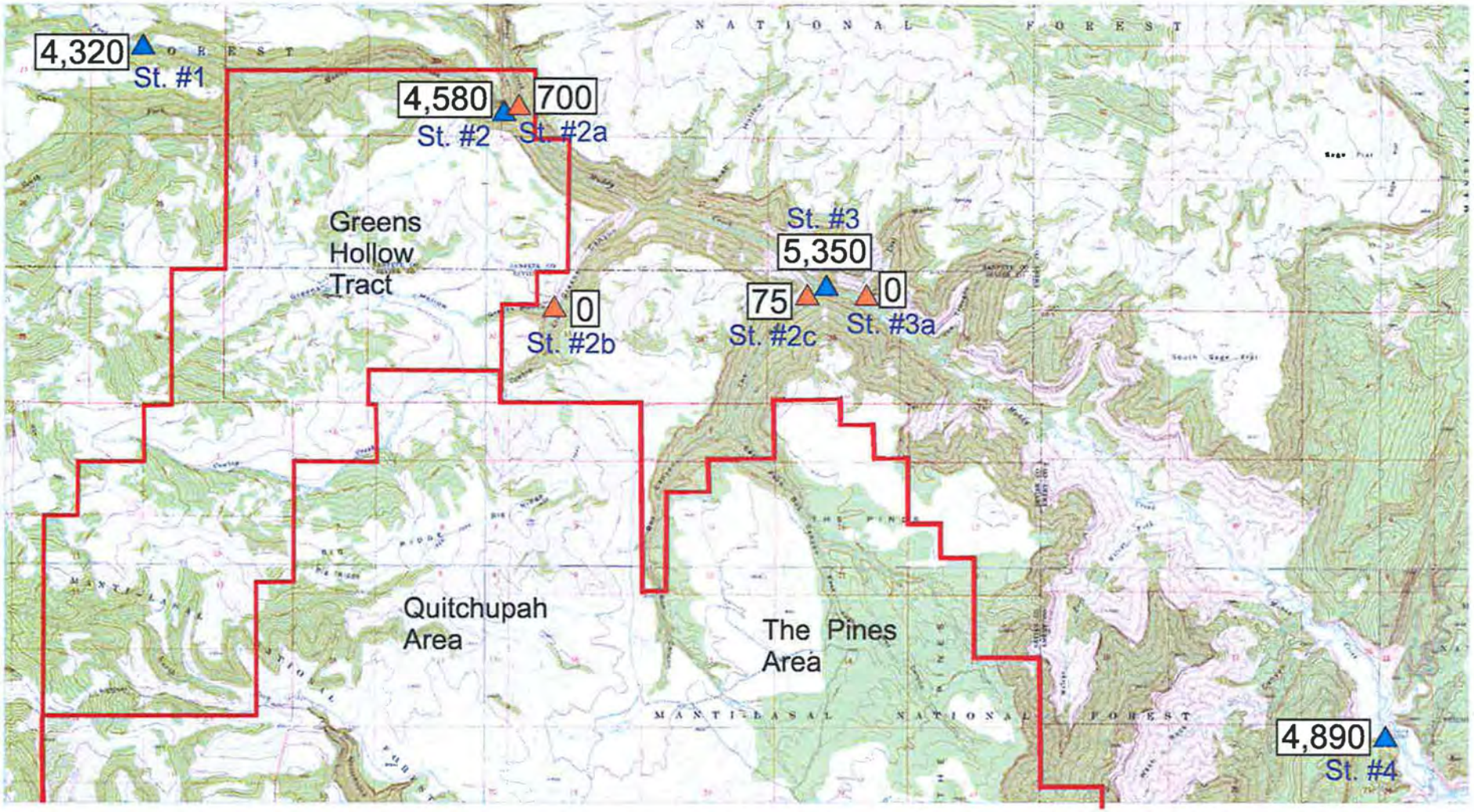

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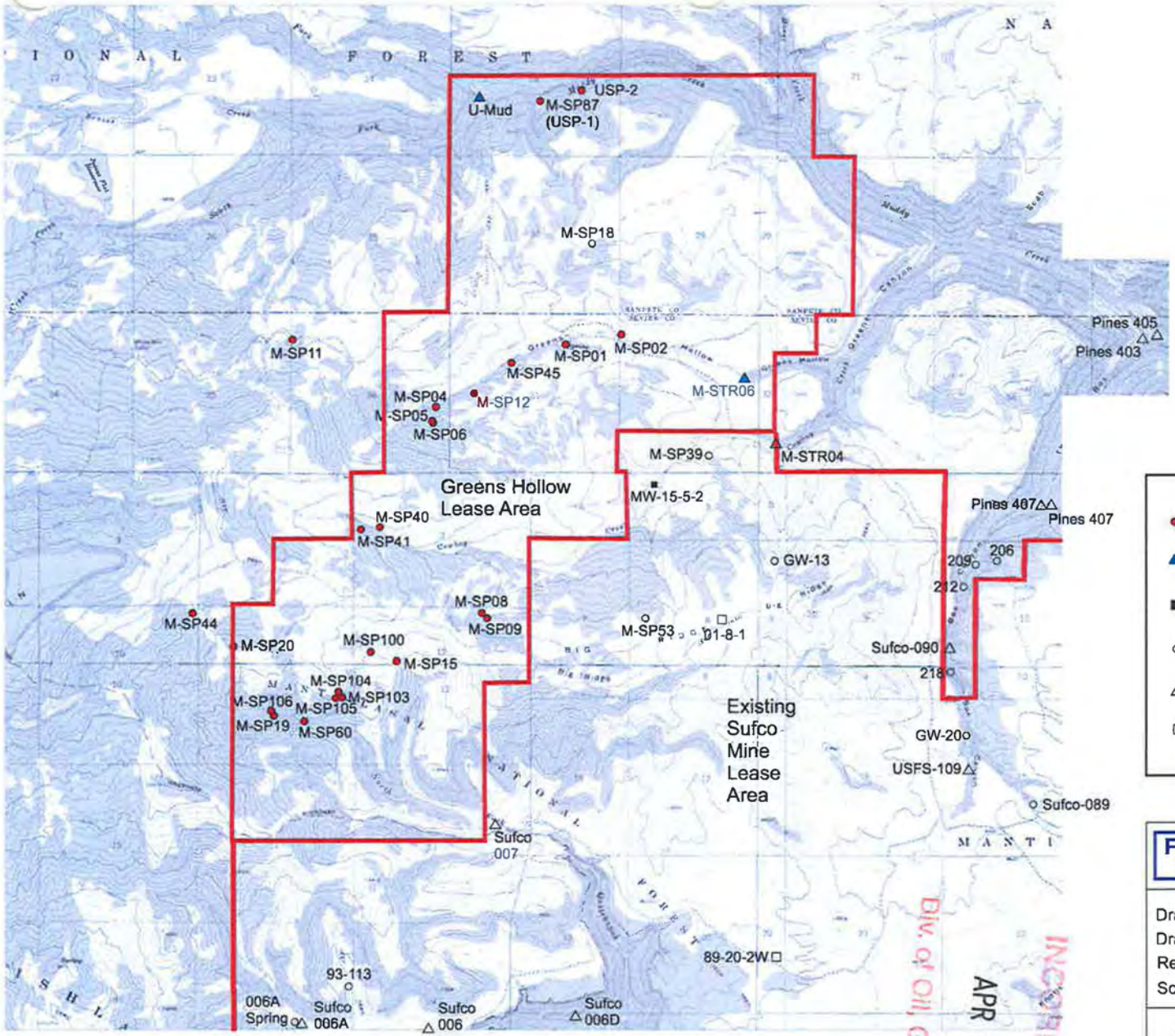
Figure 8 Discharge measurements for Muddy Creek gain/loss study 28-29 October 2015.



Legend

- Proposed spring operational monitoring station
- Proposed stream operational monitoring station
- Proposed well operational monitoring station
- Existing spring operational monitoring station
- Existing stream operational monitoring station
- Existing well operational monitoring station

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Figure 9
Proposed groundwater and surface-water monitoring sites for the Greens Hollow Tract.

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Table 1 Greens Hollow Tract baseline monitoring site details

Station ID	Location UTM NAD 27		Elev. (feet)	Geologic Fm.	Monitoring Period	Baseline Field	Baseline Lab Anal.	Lab solutes/ metals	Comments/Use
North Horn Formation springs									
M-SP04	464246	4319267	8,812	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP05	464212	4319133	8,937	North Horn Fm.	2002-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP06	464215	4319121	8,952	North Horn Fm.	2001-2004; 2014-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
M-SP07	465280	4317433	8,709	North Horn Fm.	2001-2004	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
M-SP08	464754	4317178	8,820	North Horn Fm.	2001-2004; 2006-2017	Yes	Yes	Yes	Developed spring with trough - stock/wildlife use
M-SP09	464791	4317141	8,849	North Horn Fm.	2001-2004; 2011; 2015-2017	Yes	No	No	Undeveloped spring - stock/wildlife use
M-SP10	467693	4317562	8,778	North Horn Fm.	2002-2004	Yes	Yes	Yes	Developed spring with trough - stock/wildlife use
M-SP11	462772	4319958	9,237	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring, flows into pond - stock/wildlife use
M-SP12	464583	4319397	8,739	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP14	462545	4318227	9,584	North Horn Fm.	2001-2004	Yes	Yes	Yes	Spring with springbox - stock/wildlife use
M-SP15	463884	4316685	8,811	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP19	462644	4316124	8,968	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP20	462191	4316826	9,395	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP40	463677	4318041	9,163	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP41	463475	4318025	9,223	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP44	461759	4317150	9,599	North Horn Fm.	2001-2004; 2014-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
M-SP45	465156	4319780	8,505	North Horn Fm.	2001-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP49	461704	4321192	8,552	North Horn Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use - Seep
M-SP53	466373	4317126	8,941	North Horn Fm.	2001-2004; 2006-2017	Yes	No	No	Developed spring with trough - stock/wildlife use
M-SP59	466357	4317186	8,920	North Horn Fm.	2001-2004; 2015	Yes	No	No	Undeveloped spring - stock/wildlife use
M-SP60	462887	4316092	8,801	North Horn Fm.	2002-2004; 2014-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
M-SP63	462054	4322332	8,666	North Horn Fm.	2002-2004	Yes	No	No	Undeveloped spring
M-SP100	463616	4316719	8,975	North Horn Fm.	2002-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP103	463271	4316302	8,999	North Horn Fm.	2003-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP104	463250	4316335	9,052	North Horn Fm.	2003-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP105	463233	4316280	8,971	North Horn Fm.	2003-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
M-SP106	462626	4316155	8,997	North Horn Fm.	2003-2004; 2015-2017	Yes	Yes	No	Undeveloped spring - stock/wildlife use
94-110	461800	4315754	9,224	North Horn Fm.	2013-2017	Yes	Yes	Yes	Previously developed spring, now defunct - stock/wildlife use
A2S-1	461387	4316234	9,460	North Horn Fm.	2013-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
Divide Spring	461297	4314348	8,840	North Horn Fm.	2013-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
GW-13	467720	4317723	8,600	North Horn Fm.	1995-2017	Yes	Yes	No	Developed spring with trough - stock/wildlife use
Spring 99	461609	4315684	9,352	North Horn Fm.	2014-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
D Spring	461296	4315975	9,541	North Horn Fm.	2013-2017	Yes	Yes	Yes	Undeveloped spring - no use apparent
Price River Formation springs									
M-SP01	465615	4319979	8,420	Price River Fm.	2001-2004; 2006-2017	Yes	Yes	Yes	Undeveloped spg. previously cabin water supply
M-SP02	466086	4319977	8,335	Price River Fm.	2001-2004; 2006-2017	Yes	Yes	Yes	Developed spring, flows to nearby trough - stock/wildlife use
M-SP18	465794	4320892	8,295	Price River Fm.	2001-2004; 2006-2017	Yes	Yes	Yes	Developed spring, flows to nearby trough - stock/wildlife use
M_SP36	463401	4321859	8,253	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M_SP37	463357	4321868	8,235	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M-SP38	462767	4321782	8,273	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M-SP39	466990	4318775	8,225	Price River Fm.	2001-2004; 2006-2017	Yes	Yes	Yes	Developed spring, flows to nearby trough - stock/wildlife use
M_SP48	462471	4321492	8,324	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M_SP54	462320	4321203	8,370	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M_SP55	462585	4321330	8,324	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M_SP56	462792	4321469	8,332	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use/Multiple sources form single flow
M_SP57	463278	4321845	8,184	Price River Fm.	2001-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M_SP67	463654	4323044	8,191	Price River Fm.	2002-2004	Yes	No	No	Undeveloped spring

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Station ID	Location UTM NAD 27		Elev. (feet)	Geologic Fm.	Monitoring Period	Baseline Field	Baseline Lab Anal.	Lab solutes/ metals	Comments/Use
M-SP82	465886	4323447	8,106	Price River Fm.	2002-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M-SP87	470404	4318092	7,931	Price River Fm.	2002-2004; 2009; 2014-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
M_SP109	462075	4321387	8,467	Price River Fm.	2003-2004	Yes	No	No	Undeveloped spring
USP-1	465340	4322471	7,810	Price River Fm.	2009	Yes	No	Yes	Undeveloped spring - stock/wildlife use
USP-2	465713	4322578	7,810	Price River Fm.	2009	Yes	No	Yes	Undeveloped spring - stock/wildlife use
Hansen Seep	462514	4313461	8,399	Price River Fm.	2012-2014	Yes	Yes	Yes	Undeveloped spring in stream bottom - no use apparent
006A Spring	462827	4312962	8,330	Price River Fm.	2010-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
Skutumpah Spring	460903	4313360	8,400	Price River Fm.	2010-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
94-113	469793	4305169	8,317	Price River Fm.	2010-2017	Yes	Yes	Yes	Undeveloped seep in channel bottom - no use apparent
A Spring	460639	4313578	8,520	Price River Fm.	2010-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
B Spring	460661	4313547	8,520	Price River Fm.	2010-2017	Yes	Yes	Yes	Undeveloped spring - stock/wildlife use
Price River Formation/Landslide springs									
M-SP102	463336	4322997	8,164	Price R. Fm./Landslide	2002-2004	Yes	No	No	Undeveloped spring
M-SP107	463091	4323024	8,276	Price R. Fm./Landslide	2002-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M-SP108	463359	4322999	8,174	Price R. Fm./Landslide	2003-2004	Yes	No	No	Undeveloped spring - stock/wildlife use
M-SP69	463388	4323019	8,192	Price R. Fm./Landslide	2002-2004	Yes	No	No	Undeveloped spring
M-SP70	463370	4323017	8,196	Price R. Fm./Landslide	2002-2004	Yes	No	No	Undeveloped spring
Streams									
M-STR01	469241	4320776	7,462	Blackhawk Fm.	2001-2004	Yes	Yes	Yes	Greens Canyon lower site; stock/wildlife use
M-STR02	468670	4320106	7,740	Blackhawk Fm.	2002-2004	Yes	Yes	Yes	Greens Canyon middle site - stock/wildlife use
M-STR03	468331	4319623	7,927	Blackhawk Fm.	2001-2004	Yes	Yes	Yes	Cowboy Creek above Greens Hollow - stock/wildlife use
M-STR04	467758	4318904	8,164	Castlegate S.S.	2001-2004; 2006-2017	Yes	Yes	Yes	Cowboy Creek below lease boundary - stock/wildlife use
M-STR05	468320	4319250	7,980	Blckhwk/Cstlgt cont.	2002-2004	Yes	Yes	Yes	Cowboy Creek near base of Blackhawk - stock/wildlife use
M-STR06	467424	4319577	8,170	Castlegate S.S.	2001-2004; 2015-2017	Yes	Yes	Yes	Greens Hollow Creek - stock/wildlife use
M-STR07	466926	4321557	8,015	Price River Fm.	2002-2004	(Dry)	(Dry)	(Dry)	Unnamed eph. trib to Muddy Creek in N. tract area - no use apparent
M-STR08	464513	4322181	7,930	Blackhawk Fm.	2002-2004	Yes	Yes	Yes	South Fork Muddy Creek above North Fork - stock/wildlife use
Pines 405	471581	4320035	7,190	Star Point S.S.	1997-2017	Yes	Yes	Yes	Muddy Creek below lease area - stock/wildlife use
Pines 406	474680	4318165	6,820	Qa overlaying Mancos Shale	2000	Yes	Yes	Yes	Muddy Creek below lease area - stock/wildlife use
S Fork Quitch Upr.	461329	4314316	8,840	North Horn Fm.	2013-2017	Yes	Yes	Yes	S. Fk. Quitchupah Creek just below Skut. Diversion - stock/wildlife use
Skut Creek Upr.	461235	4314290	8,840	North Horn Fm.	2013-2017	Yes	Yes	Yes	Skutumpah Creek upper - stock/wildlife use
Sufco 007	464886	4314993	8,218	Price River Fm.	1979-2017	Yes	Yes	Yes	North Fork Quitchupah below lease - stock/wildlife use
Sufco 006	463784	4312810	8,220	Price River Fm.	1979-2017	Yes	Yes	Yes	South Fork Quitchupah Creek below lease - stock/wildlife use
Sufco 006A	462900	4312941	8,320	Price River Fm.	2010-2017	Yes	Yes	Yes	South Fork Quitchupah Creek below lease - stock/wildlife use
U-Mud	464739	4322439	7,840	Blackhawk Fm.	2014-2017	Yes	Yes	Yes	Upper Muddy Creek below forks - stock/wildlife use
North Fork Upper	462185	4316005	8,990	North Horn Fm.	2017	Yes	Yes	Yes	North Fork Quitchupah - stock/wildlife use
North Fork Middle	463973	4315256	8,360	Price River Fm.	2017	Yes	Yes	Yes	North Fork Quitchupah - stock/wildlife use
SP60 Creek	462942	4316040	8,620	North Horn Fm.	2017	Yes	Yes	Yes	Tributary to North Fork Quitchupah - stock/wildlife use
CPC - Upper	463527	4316891	9,010	North Horn Fm.	2017	Yes	Yes	Yes	Tributary to North Fork Quitchupah - stock/wildlife use
CPC - Middle	463940	4315936	8,500	Price River Fm.	2017	Yes	Yes	Yes	Tributary to North Fork Quitchupah - stock/wildlife use
CPC - Lower	463978	4315264	8,360	Price River Fm.	2017	Yes	Yes	Yes	Tributary to North Fork Quitchupah - stock/wildlife use
Cowboy Top	463410	4318133	9,175	North Horn Fm.	2017	Yes	Yes	Yes	Cowboy Creek - stock/wildlife use
Cowboy Middle	463964	4315255	8,570	Price River Fm.	2017	Yes	Yes	Yes	Cowboy Creek - stock/wildlife use
Cowboy Bottom	466562	4318577	8,245	Price River Fm.	2017	Yes	Yes	Yes	Cowboy Creek - stock/wildlife use
URGH	464322	4319370	8,660	North Horn Fm.	2017	Yes	Yes	Yes	Upper Right Fork Greens Hollow - stock/wildlife use
ULGH	464277	4319327	8,715	North Horn Fm.	2017	Yes	Yes	Yes	Upper Left Fork Greens Hollow - stock/wildlife use
GH at Road	465619	4319986	8,360	Price River Fm.	2017	Yes	Yes	Yes	Greens Hollow Creek at Road- stock/wildlife use

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Station ID	Location UTM NAD 27		Elev. (feet)	Geologic Fm.	Monitoring Period	Baseline Field	Baseline Lab Anal.	Lab solutes/ metals	Comments/Use
Muddy Above Horse	467926	4322052	7,510	Blackhawk Fm.	2017	Yes	Yes	Yes	Muddy Creek - stock/wildlife use
Muddy Below Horse	467956	4322038	7,500	Blackhawk Fm.	2017	Yes	Yes	Yes	Muddy Creek - stock/wildlife use
Horse Creek	467938	4322054	7,510	Blackhawk Fm.	2017	Yes	Yes	Yes	Horse Creek - stock/wildlife use
Wells									
MW-15-5-2	466354	4318730	8,270	Castlegate Sandstone	2015-2017	—	—	—	Castlegate Sandstone well, constructed in 2015
01-8-1	467150	4317092	8,988	Blackhawk Fm.	2001-2017	—	—	—	Deep Blackhawk Formation well, In previously mined area

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Table 2A Discharge and water-quality data for springs and streams in the Greens Hollow Tract area.

Petersen Hydrologic, LLC

		Field Measurements						Major Ions							Baseline				Nutrients						Trace Metals																		Other Parameters				
	Date	Flow	T	pH	Cond.	D.O	Turb	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	TDS	TSS	T-Fe	T-Mn	NO2+	NO3	NO2	NH3	O-PO4	T-P	D-Fe	D-Mn	D-Al	T-Al	D-As	D-B	D-Cd	D-Cr	D-Cu	T-Hg	D-Hg	D-Mb	D-Ni	D-Pb	D-Se	T-Se	D-Zn	O&G	Acidity	CN	T-Alk	T-Hard
		gpm	°C	S.U.	µS/cm	mg/l	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/l	mg/l	mg/L	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/L	mg/l	mg/L	mg/L	mg/l	mg/l	mg/l	mg/l
Stream Monitoring Data																																																
U-Mud	30-Jun-14	28,274	13.0	8.78	381	8.17		42.00	22.00	4.00	0.55	224.336	15	7	1	199	16	0.12	0.006		0.68	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.20	<0.01	0.01	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004	<5	<5		199	196
U-Mud	18-Sep-14	8,707	13.2	8.72	378	8.26		40.17	22.76	6.73	0.68	227.993	5	8	1	198	<5	0.11	0.007		0.36	<0.05	0.2	<0.05	<0.05	<0.03	<0.002	<0.03	0.14	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5		192	194
U-Mud	5-Nov-14	5,205	1.6	8.7	440	9.97		98.05	53.30	105.66	3.57	427.944	29	173	60	820	11	0.38	0.018	0.05	0.05	<0.05	<0.1	<0.05	<0.05	<0.03	0.002	<0.03	0.17	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.02	<0.004	<5	<5		380	464
U-Mud	26-Jun-15	28,928	14.8	8.78	379	8.31		41.01	22.70	5.91	0.63	227.993	<5	8	1	217	13	0.05	0.009	0.33	0.36	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.09	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.009	<5	<5		187	196
U-Mud	29-Sep-15	7,315	11.4	8.72	360	8.21		37.67	24.26	7.15	0.67	231.651	<5	9	1	220	11	0.06	0.003	2.3	0.39	0.11	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.08	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5		190	194
U-Mud	28-Oct-15	4,057	3.6	8.65	412	9.86		45.16	25.04	8.43	0.74	245.062	<5	10	2	255	5	0.11	0.003	0.63	0.51	0.12	0.3	<0.05	<0.05	<0.03	<0.002	<0.03	0.12	<0.01	0.01	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	0.005	<5	<5		201	216
U-Mud	23-Jun-16	36,353	16.1	8.69	355	7.54																																									
U-Mud	28-Sep-16	8,572	10.1	8.75	388	8.88										250	24	0.17	0.008																													
U-Mud	7-Nov-16	4,313	4.6	8.79	416	9.10										216	7	<.05	< 002																													
U-Mud	26-Jun-17	43,980	12.9	8.69	368	8.20		48.04	23.79	4.69	0.77	197	<5	8		200	13	0.12	0.005	1.54	1.16	0.38	<0.1		0.11	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.02		<0.004	<5	-300		197	218
U-Mud	30-Sep-17	9,370	8.4	8.77	388	8.64		39.73	22.83	4.56	0.77	193	16	<5	1	211	<5	0.08	<0.002		0.38	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.05		<0.004		<5		209	193
U-Mud	14-Nov-17	4,161	2.5	8.70	411	10.90		45.29	26.01	8.24	0.91	215	11	11	2	204	36	0.06	<0.002		0.47	0.09	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.05		<0.004		<5		227	220
PINES 405	26-Jun-97	U	13.8	8.4	282											210		0.7	<0.1																													
PINES 405	27-Aug-97	18,625	12	8.5	365													6.5	0.1																													
PINES 405	22-Oct-97	9,874	13.8	8.4	282			39	23	10	<1	285	<5	13	4	210	437	5.4	<0.1																													
PINES 405	1-Jun-00	U	11.2	8.57	355	6.5		47	21	4	< 1	248	< 5	8	< 1	214	90	0.3	< .1											< 01		< .01												< .1			< 2		203	204
PINES 405	21-Aug-00	9,470	15.3	8.19	382	6.53		36	23	8	< 1	260	< 5	10	1	200	227	3.4	< .1	0.49						< .1	< .1			< 01		< 01				< 2						< .1			< 2		213	185
PINES 405	6-Dec-00	4,488	-0.5	8.4	387	11.38		43	24	10	< 1	278	< 5	14	2	268	42	0.4	< .1	0.65		<0.01	<0.5							< 01		< .01				< 2						< .1	< .01			4		229	206
PINES 405	1-Jun-01	> 22440	8.8	8.49	369	8.42																																									
PINES 405	7-Sep-01	6,324	9.5	8.72	391	7.92																																									
PINES 405	27-Nov-01	4,084	0.1	8.69	433	8.81																																									
PINES 405	18-May-02	27,511	9.3	8.35	369	8																																									
PINES 405	26-Sep-02	5,520	10.5	8.61	384	6.69																																									
PINES 405	18-Nov-02	5,049	0.1	8.59	385	8.78																																									
PINES 405	8-Jun-03	78,540	10.2	8.6	332	7.1																																									
PINES 405	21-Sep-03	6,777	7.9	8.34	390	7.62																																									
PINES 405	5-Dec-03	4,533	0.4	8.59	417	8.47																																									
PINES 405	13-Jun-04	49,388	11	8.72	374	6.85																																									
PINES 405	21-Sep-04	7,091	5.2	8.66	364	9.3																																									
PINES 405	21-Dec-04	3,142	0	8.43	357	7.23																																									
PINES 405	23-May-05	157,080	9.7	8.15	409	9.73																																									
PINES 405	5-Sep-05	22,440	14.5	8.68	324	7.4																																									
PINES 405	20-Dec-05	5,350	0	8.58	423	8.16																																									
PINES 405	23-Jun-06	53,856	6.7	8.65	374	8.84																																									
PINES 405	24-Sep-06	9,510	7.1	8.54	393	8.17																																									
PINES 405	8-Dec-06	6,820	0.1	8.44	427	9.1																																									
PINES 405	24-Jun-07	19,300	16.7	8.79	382	8.1																																									
PINES 405	16-Sep-07	5,840	13	8.92	399	6.22																																									
PINES 405	6-Dec-07	4,490	1.8	8.62	334	10.4																																									
PINES 405	28-Apr-08	26,900	10.4	8.58	422	8.25																																									
PINES 405	17-Sep-08	9,170	10.9	8.65	383	7.59																																									
PINES 405	3-Nov-08	5,850	4.1	8.74	399	9.29																																									
PINES 405	29-May-09	80,780	11.4	8.84	385	8.55																																									
PINES 405	14-Sep-09	8,580	10.5	8.71	384	8.8																																									
PINES 405	2-Dec-09	4,040	0.4	8.47	427	10.4																																									
PINES 405	17-May-10	17,560	11	8.73	407	7.28																																									
PINES 405	13-Sep-10	8,340	11	8.47	371	9.35																																									
PINES 405	27-Nov-10	4,480	0.9	8.25	457	9.91																																									
PINES 405	18-Jun-11	134,640	8.4	8.81	358	7.77																																									
PINES 405	19-Sep-11	22,090	11.9	8.72	388	8.62																																									
PINES 405	18-Nov-11	8,037	0.2	8.82	445	9.29																																									
PINES 405	9-Jun-12	16,400	16.2	8.93	368	7.66																																									
PINES 405	7-Sep-12	5,470	17.6	8.83	372	7.51																																									
PINES 405	16-Nov-12	5,520	0.2	8.71	419	10.43																																									
PINES 405	25-Jun-13	17,413	15.8	8.83	353	8.74																																									
PINES 405	22-Sep-13	8,078	9.7	8.88	408	8.18																																									
PINES 405	2-Dec-13	4,880	0.2	8.74	461	10.8																																									
PINES 405	27-Jun-14	28,274	14.6	8.82	367	8.46																																									
PINES 405	19-Sep-14	7,271	11.8	8.81	396	8.25																																									
PINES 405	2-Dec-14	5,386	0.3	8.77	479	10.56																																									
PINES 405	14-Jun-15	52,958	13.3	8.7	389	7.54																																									
PINES 405	20-Sep-15	8,864	10.9	8.66	383	8.27																																									
PINES 405	29-Oct-15	5,222	4.6	8.67	411	9.46																																									
PINES 405	13-Jun-16	118	10.6	8.53	365	8.51																																									
PINES 405	26-Aug-16	13,623	13.8	8.67	381	8.7																																									
PINES 405	18-Oct-16	4,416	6.8	8.76	423	9.49																																									
PINES 405	19-Jun-17	103,224	14.2	8.52	376	8.37																																									
PINES 405	25-Sep-17	11,040	5.8	8.77	405	9.48																																									
PINES 405	13-Dec-17	4,905	0.3	8.65	233	11.65		46.55	27.47	9.54	0.98	226	9	9.54	2	255	9	0.1	0.005		0.47	0.06	<0.1		<0.05	<0.03	0.004	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.07		<0.004	<5	<5		235	229
PINES 406	1-Jun-00	0	13.4	8.38	376	6.95		46	21	4	<1	232	6	9	<1	231	61	0.4	<0.1											<0.01	<0.1	<0.01												<0.1			<2		203	201
PINES 406	21-Aug-00	9514	18.2	8.48	377	6.56		34	23	8	<1	252	<5	10	1	52	221	3.4	<0.1							<0.1	<0.1																			<2				
M-STR01	6-Jun-01	50,094	13.6	8.61	567	7.53	18.4	43	35	54	2	349	7	34	24	378		0.5		<0.03		<0.03		<0.05	0.05			0.03		0.0008		<0.0005	0.0034	0.0013		2E-04		0.002	<0.005	0.0005		0.02				296	220
M-STR01	16-Aug-01	0																																														
M-STR01	30-Aug-01	0																																														
M-STR01	25-Sep-01	0																																														
M-STR01	29-Oct-01	0																																														
M-STR01	18-Apr-02	0																																														
M-STR01	1-May-02	0																																														
M-STR01	5-Jun-02	0																																														

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		Field Measurements						Major Ions								Baseline				Nutrients						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3 mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-STR01	7-Aug-02	0																																											
M-STR01	25-Sep-02	0																																											
M-STR01	12-Nov-02	0																																											
M-STR01	6-May-03	9.715	0.7	8.48		8.65	7.5	45	27	42	2.3	350	9	34	18	401	7	<0.02	<0.01	<0.03		<0.03	<0.2	<0.05	0.03	0.15	<0.01	<0.03		0.1	<0.05	<0.005	<0.005	<0.01	<0.0002		<0.01	<0.07	<0.1		<0.01				290	
M-STR01	19-Jun-03	0																																											
M-STR01	23-Aug-03	0																																											
M-STR01	6-Oct-03	0																																											
M-STR01	10-May-04	460	11.8	8.84	443	8.36	39.7	50	19	32	1.8	284	18	13	7.4	570	15	0.57	0.02				<0.2		0.05	<0.02	<0.01	<0.1		0.001	<0.05	<0.005	<0.005	<0.01		2E-04		<0.01	<0.07	0.001		<0.01		<5		250	200
M-STR01	6-Jun-04																			<0.05		<0.05		0.07																						
M-STR01	6-Jun-17	0																																											
M-STR01	19-Dec-17	NA																																											
M-STR02	7-Aug-02	0																																											
M-STR02	25-Sep-02	1.857	8.2	7.97	509	8.35	0.7	77	53	54	3.5	370	5	140	38	531	<5	<0.02	<0.01	<0.03		<0.03	<0.2	<0.05	0.04	<0.02	<0.01	0.06		0.0009	0.06	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0021		0.01		<5		297	410
M-STR02	12-Nov-02	2.925	0.6	8.19	416	11.19	0.9	72	47	47	2.8	380	<5	110	35	477	30	0.08	<0.01	0.11		<0.03	<0.2	<0.05		<0.02	<0.01	0.05		<0.1	<0.05	<0.005		<0.01				<0.07	<0.1		0.02		<5		303	370
M-STR02	6-May-03	74.148	3.3	8.58	591	9.88	9.8	51	28	41	2.4	340	<5	36	18	391	13	0.32	0.01	<0.03		<0.03	<0.2	<0.05	0.03	<0.02	<0.01	<0.03		<0.1	0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	<0.1		<0.01		<5		290	240
M-STR02	19-Jun-03	4.235	13	8.46	705	7.51	3.73					354	6	62	24	435		0.13		<0.03				<0.05	0.08			<0.03		0.001		<0.0005	<0.005	<0.01	<0.0002			<0.01	<0.001	0.0012		0.01				300	
M-STR02	4-Aug-03	1.184	14.9	8.11	722	5.84	30.9	66	36	45	4.1	350	14	72	27	457	83	1.2	0.05	<0.03		<0.03	<0.2	<0.05	0.08	<0.02	0.02	<0.03		0.0016	0.07	<0.005	<0.005	<0.01	<0.0002			<0.01	<0.07	0.0012		<0.01		<5		310	310
M-STR02	6-Oct-03	2.379	9.3	9.25	495	7.15	2.99	74	46	46	3.6	411	<5	<0.03	28	507	9	0.05	0.01	<0.03		<0.03	<0.2	<0.05	0.06	<0.02	<0.01	<0.03		0.001	0.06	<0.005	<0.005	<0.01	<0.0002			<0.01	<0.07	0.0007		<0.01		<5		337	370
M-STR02	10-May-04	460	11.8	8.84	443	8.36	39.7	48	18	28		280	<1	9.1	5.3	271	28	1.6	0.07				<0.2		0.12	<0.02	<0.01	<0.1		<0.0005	<0.05	<0.005	<0.005	<0.01	<0.0002			<0.01	<0.07	0.0006		0.01		<5		230	190
M-STR02	6-Jun-04																			<0.05		<0.05		0.08																						
M-STR02	26-Jun-17	4	16.2	8.49	712	6.65		67.37	41.74	47.46	3.63	286	<5	67	25	430	26	0.09	0.007	<0.05	<0.05	<0.05	<01		0.08	<0.03	<0.002	0.04		0.01	0.08	<0.001		<0.01				<0.01	0.05		<0.004	<5	-302		286	340
M-STR02	19-Dec-17	0																																											
M-STR03	6-Jun-01	36.62	10.4	8.54	527	7.11	22.5					344	6	24	22	364		0.4		<0.03		<0.03		<0.05	0.06			<0.03		0.001		<0.0005	0.0037	0.001		<0.0002		0.002	<0.005	0.0006		<0.01				293	
M-STR03	16-Aug-01	0.61	12.1	7.81	405	4.03	3.17					357	<5	41	28	383		<0.1	<0.05	0.31		<0.03			<0.05			0.04		0.0009		<0.0005	0.0036	0.0007		<0.0002		0.002	<0.005	0.0013		0.02				293	
M-STR03	30-Aug-01	6.052																																											
M-STR03	25-Sep-01	0.501	8.7	7.85	395	3.83	2.21					371	<5	44.2	29.4	390	10	0.1		<0.03					0.05			0.04		0.0008		<0.0005	0.001	0.0008		<0.0002		0.001	<0.005	0.0012		<0.01				304	
M-STR03	29-Oct-01	0.967	3.6	7.98	202	6.68	0			39		356	<5	45.8	27.8	414	63	<0.1		0.09					<0.05			<0.03		<0.1		<0.0005	<0.005	<0.01		<0.0002		<0.01	<0.005	0.0017		0.04				292	
M-STR03	18-Apr-02	9.451	13	7.87	311	6.29	1.21					334	<5	53	26	406		<0.1		0.08					<0.05		<0.05	0.03		0.0011		<0.0005	<0.005	<0.005		<0.002		0.003	<0.001	0.0021		<0.01				274	
M-STR03	1-May-02	7.993	3.6	8.29	409	9.7	0.67					346	<5	55	30	416		<0.1		0.11					0.08			0.05		<0.1		<0.005	<0.005	<0.01		<0.0004		<0.01	<0.07	<0.1		<0.01				284	
M-STR03	5-Jun-02	2.61	6.3	8.18	365																																								
M-STR03	7-Aug-02	0																																										
M-STR03	25-Sep-02	1.83	8.2	7.87	405	4.85	2	60	39	42	2.7	370	<1	54	30	399	7	0.42	0.02	<0.03		<0.03	<0.2	<0.05	0.03	<0.02	<0.01	0.05		0.001	0.07	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0027		<0.01		<5		293	310
M-STR03	12-Nov-02	0																																											
M-STR03	6-May-03	54.9	4	8.71	621	9.37	23.8	51	28	50	2.1	350	6	27	20	415	41	0.5	0.02	<0.03		<0.03	<0.2	<0.05	0.05	<0.02	<0.01	<0.03		0.1	0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	<0.1		<0.01		<5		290	240
M-STR03	19-Jun-03	2.499	10.9	8.1	659	5.2	2.83					356	<5	39	24	379		0.35		0.08				<0.05	0.07			<0.03		0.0011		<0.0005	<0.005	<0.01		<0.0002		0.01	<0.001	0.0014		0.01				292	
M-STR03	4-Aug-03	1.631	12	7.72	647	3.58	43.3	58	33	41	3.4	360	<1	40	24	361	113	1.7	0.05	0.03		<0.03	<0.2	<0.05	0.05	<0.02	0.01	<0.03		0.0013	0.06	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0014		0.01		6		300	280
M-STR03	6-Oct-03	1.382	7.9	8.01	398	5.56	7.29	62	36	38	2.8	373	<5	42	25	406	11	0.11	0.02	<0.03		<0.03	<0.2	<0.05	0.04	<0.02	0.02	<0.03		0.0009	0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0011		<0.01		<5		306	300
M-STR03	10-May-04	491.5	8.4	8.73	307	8.51	51.4	42	14	28	2.2	250	<1	7.4	4.5	247		1.6	0.06				<0.2		0.13	<0.02	<0.01	<0.1		<0.0005	<0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0005		0.03		<5		210	160
M-STR03	26-Jun-17	1.02	14.1	8.39	656	7.02		60.34	35.11	44.75	3.64	292	<5	36	22	405	15	0.31	0.017	<0.05	<0.05	<0.05	<0.1		0.1	<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01				<0.01	0.03		<0.004					
M-STR03	19-Dec-17	0																																											
M-STR04	7-Jun-01	71.081	19.4	8.55	386	6.84	3.08					344	17	22	23	353		< 1		< 03		< 03		< 05	< 05			0.03		0.0011		<0.0005	0.0039	0.0011		<0.0002		0.002	<0.005	0.0006		<0.01				310	
M-STR04	22-Jun-01	11.719																																											
M-STR04	16-Aug-01	0																																											
M-STR04	31-Aug-01	0																																											
M-STR04	27-Sep-01	0																																											
M-STR04	28-Oct-01	0																																											
M-STR04	17-Apr-02	13.005	8.2	8.87	470	9.19	7.49	58	41	79	2	431	11	68	47	548		0.2	< .05	< .03		11	431	<0.05	< .05			<0.07		< .0005		< .0005	< .005	< .005		<0.0002		0.002	< .001	0.0016		< .01			< .002	372	
M-STR04	3-May-02	12.245	12.1	8.87	8.69	—	0																																						
M-STR04	4-Jun-02	3.037	18	8.63	514	5.23	2.8					361	17	71	60	513		0.4		< .03					0.1			0.06		0.1		<0.005	<0.005	<0.01		<0.0004		<0.01	<0.07	<0.1		<0.01			<0.002	325	
M-STR04	8-Aug-02	0																																											
M-STR04	25-Sep-02	0																																											
M-STR04	12-Nov-02	0																																											
M-STR04	6-May-03	79.9	8	8.74	599			50	27	49	2	360	5	25	18	399	17	0.29	0.02	< .03		<0.03	< .2	<0.05	0.02	< .02	0.01	< .03		< .1	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	< .1		0.01		<5	0	300	240
M-STR04	20-Jun-03	14.231	8.4	8.65	792	8.92	4.73					410	13	35	35	429		0.18		0.05				< .05	0.01			< .03		0.0014		< .0005	< .005	< .01		<0.0002		0.01	< .001	0.0013		< .01			< .002	358	
M-STR04	6-Aug-03	0																																											
M-STR04	8-Oct-03	0																																											
M-STR04	11-May-04	717.264	11.9	8.82	445	8.12	76.3	52	18	27	1.6	280	8	9.3	5.6	280	21	0.57	0.03				< .2		0.05	< .02	0.01	< .1		0.0008	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0006		0.01		<5	< .002	240	200
M-STR04	13-May-04																			< .03	< .03			< .05																						
M-STR04	23-Jun-06	3.85	19.8	8.72	627	6.44																																								
M-STR04	28-Sep-06	1.01	10.4	8.67	705	7.92																																								
M-STR04	8-Nov-06	3.19	4.5	8.5	758	8.73																																								
M-STR04	26-Jun-07	0																																											
M-STR04	11-Sep-07	0																																											
M-STR04	8-Nov-07	0																																											
M-STR04	21-Jun-08	16.3	20.7	8.59	573	6.64																																								
M-STR04	24-Sep-08	0																																											
M-STR04	6-Nov-08	0																																											
M-STR04	27-Jun-09	0.67	21.2	8.83	684	7.12																																								
M-STR04	23-Sep-09	0																																											
M-STR04	10-Nov-09	0																																											
M-STR04	26-Jun-10	0																																											
M-STR04	23-Sep-10	0																																											
M-STR04	12-Nov-10	0																																											
M-STR04	27-Jun-11	142	14.1	8.48	573	7.82																																								
M-STR04	30-Sep-11	3.71	14.5	8.66	865	7.56																																								
M-STR04	29-Oct-11	14.6	0.3	8.75	767	10.4																																								
M-STR04	27-Jun-12	0																																											
M-STR04	25-Sep-12	0																																											
M-STR04	7-Nov-12	0																																											
M-STR04	28-Jun-13	0																																											
M-STR04	25-Sep-13	0																																											
M-STR04	26-Oct-13	0																																											
M-STR04	29-Jun-14	0																																											

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	Date	Field Measurements: Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	Major Ions: Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^- mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl^- mg/L	Baseline: TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L
M-STR04	29-Aug-14	0																	
M-STR04	31-Oct-14	0																	
M-STR04	24-Jun-15	2.25	17.7	8.86	605	7.47													
M-STR04	28-Sep-15	0																	
M-STR04	26-Oct-15	0																	
M-STR04	23-Jun-16	0																	
M-STR04	28-Sep-16	0																	
M-STR04	7-Nov-16	0																	
M-STR04	2-Jun-17	1.14	19.9	8.83	725	7.21		31.38	45.06	75.93	3.39	291	11	54	34	416	33	0.17	0.005
M-STR04	29-Sep-17	0																	
M-STR04	15-Nov-17	0																	
M-STR05	8-Aug-02	1.412	9.5	6.5	346	8.45	1.56	51	34	31		312	7	37	26	329		< .1	< .05
M-STR05	25-Sep-02	1.717	7	8.38	353	8.21	4	52	35	32	2	320	< 5	37	27	352	6	0.13	< .01
M-STR05	6-Oct-02																		
M-STR05	12-Nov-02	immeas.	0.5	8.25	329	11.18	2.32	55	36	33	2	350	<1	39	29	381	8	0.02	< .01
M-STR05	6-May-03	61.6	6.1	8.73	616	9.04	22.5	51	28	52	2.1	360	6	20	17		31	0.46	0.02
M-STR05	19-Jun-03	2.686	10.3	8.56	605	8.04	1.37	51	34	37	2.3	304	10	33	22	345		0.02	
M-STR05	5-Aug-03	2.043	10.2	8.35	610	8.5						316	6			329	400		
M-STR05	6-Aug-03							54	34	34	2.2	350	7	36	25			0.68	0.02
M-STR05	6-Oct-03	1.534	6	8.47	356	7.23	3.99	55	35	32	2	342	< 5.	34	23	366	11	0.07	0.01
M-STR05	11-May-04	598.482	10	8.82	446	8.07	17.4	52	18	27	1.7	290	<1	9.1	5.6	290	49	0.63	0.02
M-STR05	26-Jun-17	1.72	12	8.38	616	7.58		60.63	36.5	34.11	2.8	292	<5	25	20	357	30	0.42	0.03
M-STR05	19-Dec-17	0.36	0.3	8.21	720	11.35		65.18	38.18	30.62	3.17	328	<5	40	28	418	<5	0.11	0.077
M-STR06	7-Jun-01	16.85	20.10	8.48	608.00	6.54	67.50		33.00			400	14.00	35.00	40.00	457		1.10	
M-STR06	22-Jun-01	5.651																	
M-STR06	16-Aug-01	4.783	12.4	8.3	439	7.13	81.4	61		37		458	<5	47	47	515		1.7	
M-STR06	25-Sep-01	1.9	11.5	7.92	575	3.14	30	66	42	86	9	538	<5	37.9	57.9	595		0.3	
M-STR06	30-Oct-01	6.438	2.7	8.39	446	8.73	11.6		38			581.565	5	44.2	43.1	539		0.3	
M-STR06	17-Apr-02	18.165	9.6	8.77	462	7.16	9.63	56	32	85		439	8	46	40	536		0.4	<0.05
M-STR06	1-May-02	4.455	8.2	8.51	819	8.55	6.32												
M-STR06	5-Jun-02	3.020	23.3	8.52	569	5.13	40.9	45	34	90		412	7	53	53	556		0.8	
M-STR06	8-Aug-02	0																	
M-STR06	24-Sep-02	0																	
M-STR06	13-Nov-02	0																	
M-STR06	7-May-03	17.836	11.7	8.54	490	7.01	8.29	55.00	31/36	80.00	2.70	524.262	02/08	38.00	31.00	474.00	25.00	0.54	0.03
M-STR06	20-Jun-03	3.024	12.6	8.66	822	8.15	12.8	56	40			464.5/381	17	36/44	39/44	452		0.31	
M-STR06	6-Aug-03	0																	
M-STR06	8-Oct-03	0																	
M-STR06	11-May-04	27.400	15.4	8.65	723	6.59	96.3	55	25	85	2.8	512.07	13-Nov	21	21	451	42	1.4	0.04
M-STR06	13-May-04																		
M-STR06	26-Jun-15	0.636	22.3	8.64	968	5.43	NM									648	680	5.67	0.251
M-STR06	28-Sep-15	0																	
M-STR06	28-Oct-15	0																	
M-STR06	23-Jun-16	0																	
M-STR06	28-Sep-16	0																	
M-STR06	7-Nov-16	0																	
M-STR06	26-Jun-17	2.43	18	8.44	825	6.23		29.78	32.5	130	4.17	363	<5	36	36	504	76	1.37	0.031
M-STR06	30-Sep-17	0.18	10.4	8.36	1008	7.57													
M-STR06	14-Nov-17	0																	
M-STR07	25-Sep-02	0																	
M-STR07	12-Nov-02	0																	
M-STR07	7-May-03	0																	
M-STR07	8-Aug-03	0																	
M-STR07	6-Oct-03	0																	
M-STR07	13-May-04	0																	
M-STR07	26-Jun-17	0																	
M-STR07	30-Sep-17	0																	
M-STR07	14-Nov-17	0																	
M-STR08	26-Sep-02	2062	9.2	8.7	234	9.1	2.2	48	27	9.8	0.7	250	7	10	2.1	218	5	0.03	<0.01
M-STR08	13-Nov-02	967	1	8.72	65	13.66	1.5	48	25	11	0.6	280	4	12	2.6	257	8	0.02	<0.01
M-STR08	7-May-03	2447	3.5	8.69	247	10.22	5.15	54	24	12	0.6	280	2	9.3	3.1	270	14	0.14	0.01
M-STR08	5-Aug-03	7145	16.2	8.74	371	7.51		43	24	5.5	0.7	230	9	6.6	1.4	208		0.45	0.02
M-STR08	7-Oct-03	3087	5.5	8.88	232	9.27	1.99	46	25	8.1	0.6	255	8	8.4	1.6	230	10	<0.08	<0.01
M-STR08	13-May-04	15644	4.2	8.9	352	9.76	6.81	53	22	7.5	0.6	270	1	5.8	1.8	246	28	0.39	0.02
Sufco 007 (North Fork Lower)	5-Oct-79											302.5	< .01	45	18	340	1	0.02	0.014
Sufco 007	1-Nov-80											405.04	< .01	25.5	10.1	386		6	0.1
Sufco 007	9-Jun-81											197.64	9.6	27	6	218		0.63	0.02
Sufco 007	26-Aug-81											253.76	1.2	19.5	15.4	270	1	0.29	0.01
Sufco 007	27-Oct-81											340	3.6	18	9.1	335		0.65	0.021
Sufco 007	22-Jun-82	3132.624	16	8.2	654							246.6	< .01	12	6.3	128		1.2	0.14
Sufco 007	12-Aug-82	403.92	12	8.6	460							273.3	< .01	9	26	280		1.52	0.144
Sufco 007	20-Oct-82	498.168	0	9.2	690							356.2	< .01	66	19.9	425		2.22	0.135
Sufco 007	21-Jun-83	5771.568	14	8.4	446							258.6	< .01	28	12	204		10.3	0.285
Sufco 007	16-Aug-83	516.12	15	7.6	593							292.8	2.4	40	16	320		12.9	0.012
Sufco 007	12-Oct-83	269.3	12	7.7	640							339.16	< .01	46	20	377		3.39	0.21
Sufco 007	21-Jun-84	2629.968	7	7.6	525							283	< .01	28	6.1	295		0.06	0.01
Sufco 007	9-Aug-84	359.04	21	7.8	555							317.2	< .01	39	16.8	375		3.04	0.07
Sufco 007	11-Oct-84	686.664	5	7.9	621							329.4	< .01	46	17	380		2.06	0.07
Sufco 007	13-Jun-85	2217.072	7.8	7.5	409							493	< .01	475	88	904		0.66	0.14
Sufco 007	14-Aug-85	287.232	13	8	680							290.4	< .01	36	19.7	322		0.31	< .02
Sufco 007	22-Oct-85	94.248	0.5	7.6	638							353.8	< .01	47	22.8	388		1.84	0.1

	Date	Nutrients: NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	Trace Metals: D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	Other Parameters: O&G mg/L	Acidly mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-STR04	29-Aug-14																												
M-STR04	31-Oct-14																												
M-STR04	24-Jun-15																												
M-STR04	28-Sep-15																												
M-STR04	26-Oct-15																												
M-STR04	23-Jun-16																												
M-STR04	28-Sep-16																												
M-STR04	7-Nov-16																												
M-STR04	2-Jun-17	<0.05	<0.05	<0.05	<0.1		0.07	<0.03	<0.002	<0.03	<0.03	<0.01	0.09	<0.001		<0.01					<0.01	0.04		<0.004	<5	-310		302	264
M-STR04	29-Sep-17																												
M-STR04	15-Nov-17																												
M-STR05	8-Aug-02	0.16					< .05			0.04		< .002		< .001	0.0034	< .001		< .2		0.007	< .001	< .002		0.08			0	267	
M-STR05	25-Sep-02	0.17		< .03	<0.2	< .05	0.01	< .02	< .01	0.05		0.0009	0.06	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0035		0.01		< 5		267	300
M-STR05	6-Oct-02																										< .002		
M-STR05	12-Nov-02	0.27		< .03	< .2	< .05		< .02	< .01	0.03		< .1	0.05	< .005		< .01			< .02		< .07	< .1		0.01		< 5		277	290
M-STR05	6-May-03	<0.03		<0.03	< .2	<0.05	0.02	< .02	< .01	< .03		< .1	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	< .1		< .01		<5	< .002	300	240
M-STR05	19-Jun-03	0.03				< .05	0.02			<0.03		0.0009		<0.0005	<0.005	<0.01		<0.0002		0.01	< .001	0.002		0.01			< .002	265	
M-STR05	5-Aug-03	0.12		< .03		< .05																				< 5		270	
M-STR05	6-Aug-03				< .2		0.05	< .02	< .01	< .03		0.0008	0.05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0022		< .01			< .002	300	270
M-STR05	6-Oct-03	0.09		< .03	<2	< .05	0.02	< .02	< .01	< .03		0.0006	0.05	< .005	< .005	< .01	< .2		< .02	0.01	< .07	0.002		< .01		< 5.	< .002	280	280
M-STR05	11-May-04	< .03		< .03	< .2	< .05	0.05	< .02	< .01	< .1		0.0006	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0006		0.02		< 5.	< .002	232	200
M-STR05	26-Jun-17	<0.05	<0.05	<0.05	<0.1		0.11	<0.03	<0.002	<0.03		<0.01	0.06	<0.001		<0.01					<0.01	0.02		<0.004	<5	<5		292	302
M-STR05	19-Dec-17		0.34	<0.05	<0.1		<0.05	<0.03	0.067	<0.03		<0.01	0.06	<0.001		<0.01					<0.01	0.09		<0.004	<5	<5		328	320
M-STR06	7-Jun-01	<0.03		<0.03	<0.03	<0.05	<0.05			<0.03		0.00		<0.0005	0.00	0.00		<0.0002		0.00	<0.005	0.00		0.01				351.00	
M-STR06	22-Jun-01																												
M-STR06	16-Aug-01	<0.03		<0.03			0.06			0.05		0.0022		<0.0005	0.0051	<0.01		<0.0002		0.003	<0.005	0.0011		0.01				378	
M-STR06	25-Sep-01	<0.03					0.1			0.05		0.0025		<0.0005	0.006	0.0019		<0.0002		0.004	<0.005	0.0009		0.01				441	
M-STR06	30-Oct-01	0.05					0.06			<0.03		<0.1		<0.0005	<0.005	<0.01		<0.0002		<0.01	<0.005	0.0008		0.01				391	
M-STR06	17-Apr-02	<0.03					0.05			<0.07		<0.001		<0.0005	<0.005	<0.005		<0.0002		0.002	<0.001	0.0009		0.01				373	
M-STR06	1-May-02									0.07		<0.1		<0.0005	<0.005	<0.01		<0.0004		<0.01	<0.07	<0.1	0.0009	0.01					
M-STR06	5-Jun-02	0.08					0.14			0.04		<0.1		<0.0005	<0.0005	<0.01		<0.0004		<0.01	<0.07	<0.1		0.01				350	
M-STR06	8-Aug-02																												
M-STR06	24-Sep-02																												
M-STR06	13-Nov-02																												
M-STR06	7-May-03	0.04/<0.03		<0.03	<0.2	<0.05	0.03	<0.02	0.01	<0.03		<0.1	0.06	<0.0005	0.01	<0.01		<0.0002		<0.01	0.07		<0.1	<0.01		<5		360/369	260.00
M-STR06	20-Jun-03	<0.03				<0.05	0.05			<0.03		0.0015		<0.0005	<0.0005	<0.01		<0.0002		<0.01	<0.001	0.0012		<0.01				341	
M-STR06	6-Aug-03																												
M-STR06	8-Oct-03																												
M-STR06	11-May-04	<0.03		<0.03	<0.2	<0.05	0.08	<0.02	<0.01	<0.1		0.0016	0.05	<0.005	<0.005	<0.01		<0.0002		0.01	<0.07	0.0014		0.02		<5		368/370	240
M-STR06	13-May-04	<0.03		<0.03		<0.05																							
M-STR06	26-Jun-15																												
M-STR06	28-Sep-15																												
M-STR06	28-Oct-15																												
M-STR06	23-Jun-16																												
M-STR06	28-Sep-16																												
M-STR06	7-Nov-16																												
M-STR06	26-Jun-17	<0.05	<0.05	<0.05	<0.1		0.14	0.38	0.013	0.61		<0.01	0.11	<0.001		<0.01					<0.01	0.03		<0.004	<5	-390		363	298
M-STR06	30-Sep-17																												
M-STR06	14-Nov-17																												
M-STR07	25-Sep-02																												
M-STR07	12-Nov-02																												
M-STR07	7-May-03																												
M-STR07	8-Aug-03																												
M-STR07	6-Oct-03																												
M-STR07	13-May-04																												
M-STR07	26-Jun-17																												
M-STR07	30-Sep-17																												
M-STR07	14-Nov-17																												
M-STR08	26-Sep-02	0.57		<0.03	<0.2	<0.05		<0.02	<0.01	0.04		0.0009	<0.05	<0.005		<0.01					<0.07	0.0007		0.01		<5		215	230
M-STR08	13-Nov-02	0.67		<0.03	<0.2	<0.05		<0.02	<0.01	0.03		<0.1	<.05	<0.005		<0.01					<0.07	<0.1		<0.01		5		227	220
M-STR08	7-May-03	0.54		<0.03	<0.2	<0.05		<0.02	<0.01	<0.03		<0.1	<0.05	<0.005		<0.01					<0.07	<0.1		0.01		<5		230	230
M-STR08	5-Aug-03	0.68		<0.03	<0.2	<0.05		<0.02	<0.01	<0.03		0.0011	<.05	<0.005		<0.01					<0.07	0.0006		<0.01		<5		200	210
M-STR08	7-Oct-03	0.68		<0.03	<0.2	<0.05		<0.02	<0.01	<0.03		0.0011	0.05	<0.005		<0.01					<0.07	0.0008		<0.01		<5		222	220
M-STR08	13-May-04			<0.03	<0.02	<0.05		<0.02	<0.01	<0.1		0.0009	<0.05	<0.005		<0.01					<0.07	0.0006		<0.01		<5		220	220
Sufco 007 (North Fork Lower)	5-Oct-79		< .01				0.06																< 1						
Sufco 007	1-Nov-80		0.02	< .01	< .01	< .001		0.94									< 2						< 1					332	244
Sufco 007	9-Jun-81		< .01	< .01	< .01			0.08									< 2						< 1					178	168
Sufco 007	26-Aug-81		< .01			0.04																	< 1						
Sufco 007	27-Oct-81		< .01	< .01		0.1		0.095	0.018																			284.7	244
Sufco 007	22-Jun-82		0.28				0.005	0.34	0.13																			202.1	178
Sufco 007	12-Aug-82		0.11				0.01	0.335	0.13																			224	210
Sufco 007	20-Oct-82		0.12				0.44	0.04	0.045																			292	288
Sufco 007	21-Jun-83		< .02				0.92	0.08	0.003																			220	192
Sufco 007	16-Aug-83		0.08				0.03	0.11	0.01																			244	240
Sufco 007	12-Oct-83		0.02				0.05	0.12	0.01																			278	262
Sufco 007	21-Jun-84		0.06				0.06	0.01	0.01																			232	210
Sufco 007	9-Aug-84		0.08				0.18	< .01																				260	260
Sufco 007	11-Oct-84		1.39				0.49	0.03	0.03																			270	335
Sufco 007	13-Jun-85		2.03				0.18	0.04	0.13																			404	720
Sufco 007	14-Aug-85		0.09				0.09	< .01	< .02																			238	208
Sufco 007	22-Oct-85		< .01				0.03	0.03	0.03																			290	264

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		Field Measurements					Major Ions							Baseline				Nutrients						Trace Metals																		Other Parameters				
	Date	Flow gpm	T °C	pH S.U	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3 mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl^{-} mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
Sufco 007	2-Jun-86	3388.44	14	7.6	412							200		88	4.1	255		29.6	1.48		0.15				1.64	< .01	< .01																	182	216
Sufco 007	13-Aug-86	246.84	17	8.3	531							256.6	< 1	31	13.9	228		0.36	< .01		0.05				0.02	< .01	< .01																	212	200
Sufco 007	7-Jun-88	1297.032	12	8.2	468							229	< 1	20	3.5	236		0.91	0.06		0.11				< .04	< .03	< .01																	188	214
Sufco 007	9-Aug-88	71.81	19	7.4	500							244	< 1	31	33	310		0.04	< .01		0.1				< .04	< .03	< .01																	200	218
Sufco 007	5-Oct-88	94.25	8	7.3	619							317	< 1	125	16	470		0.05	0.02		0.04				< .04	< .03	0.02																	260	365
Sufco 007	13-May-92	1108.61										207	3	27	3	230		2.63	0.09		0.41				0.38	< .02	< .02																	175	213
Sufco 007	4-Aug-92	161.579										156	2	20	5.3	210		0.13	< .01		< .05	< .02			< .02	0.11	< .01																		164
Sufco 007	6-Oct-92	85.276										222	0	27	11.2	300		0.18	0.02	< .05		< .02			0.02	0.08	0.02																		208
Sufco 007	9-Jun-93	1683.12										223	2.1	20.1	3.53	234		0.85	0.04		0.2				< .1	< .04	< .02																	186	224
Sufco 007	6-Jun-95	3751.968	10.4	8.29	511							260	20	17	3	290										1	0.2																		
Sufco 007	23-Aug-95	1122	15.2	8.35	419			43	17	18		235	20	15	7	220		2.7	0.1	< .1				0.23		< .1	< .1																	220	177
Sufco 007	3-Oct-95	188.5	13.5	8.37	541							265	10	21	10	250		< .1	< .1	< .1				< .01		< .1	< .1																	235	213
Sufco 007	27-Aug-96	184.008	17.2	8.6	446							204	18	23	8	234		< .1	< .1	< .1				0.01		< .1	< .1																	197	186
Sufco 007	22-Oct-96	103.224	2.1	8.38	568							323	< 5	21	12	302		< .1	< .1	< .1				0.02		< .1	< .1																	265	233
Sufco 007	2-Jun-97		16.15	8.58	401							209	< 5	83	3	220		< .1	< .1	< .1				0.03		< .1	< .1																	171	283
Sufco 007	18-Aug-97	664.224	19.8	8.4	467		10.2					243	< 5	22	7	250		< .1	< .1	< .1				0.02		< .1	< .1																	199	196
Sufco 007	8-Oct-97	336.6	6.38	8.77	548		11.4					303	< 5	26	9	320		< .1	< .1	< .1				0.02		< .1	< .1																	248	230
Sufco 007	4-Jun-98	3265.216	7.61	8.62	473	6.37		57	18	10	< 1	215	21	36	6	265		3.1	0.1							< .1	< .1														< 2			210	216
Sufco 007	5-Aug-98	14.8	19.65	8.08	537	7.5		50	23	24	< 1	311	< 5	20	11	290		0.2								< .1	< .1														3			255	
Sufco 007	1-Oct-98	94.248	12.45	8.43	598	8.27		53	26	35	1	336	< 5	23	15	330		0.6	< .1							< .1	< .1														< 2			275	
Sufco 007	21-Jun-99	839.256	15.99	8.22	441	6.89		49	16	10	< 1	239	< 5	15	3	228		1.9	< .1							< .1	< .1														< 2			203	
Sufco 007	9-Aug-99	119.8296	22.2	8.37	505	6.39		41	21	25	< 1	252	< 5	20	8	262		1	< .1							< .1	< .1														< 2			213	
Sufco 007	4-Oct-99	94.248	12.05	8.32	604	8.25		55	24	31	1	310	9	26	12	316		0.2	< .1							< .1	< .1														< 2			269	
Sufco 007	21-Jun-00	0.18	17.97	8.29	473	6.15		49	17	15	< 1	234	< 5	21	5	252		0.1	< .1							< .1	< .1														< 2			196	192
Sufco 007	2-Aug-00	42.1872	21.25	8.52	458	5.65		39	17	21	< 1	224	< 5	19	8	231		< .1	< .1							< .1	< .1														< 2			184	167
Sufco 007	5-Oct-00	15.2592	10	8.24	577	6.48		50	21	29	1	295	< 5	23	10	275		< .1	< .1							< .1	< .1														< 2			242	211
Sufco 007	11-Jun-01	885	14.3	8.29	407	7.92		47	13	6	< 1	197	< 5	18	2	190		0.4	< .1							< .1	< .1														< 2			169	171
Sufco 007	20-Aug-01	0.215	17.4	8.68	363	7.15		37	17	18	< 1	200	6	19	5.3	242		< .1	< .05							< .1	< .05														< 2			174	162
Sufco 007	2-Oct-01	69.2	10.3	8.58	431	7.51		47	19	24	1	261	< 5	22	8.3	263		< .1	< .05							< .1	< .05														< 2			218	196
Sufco 007	8-May-02	559	9.6	8.45	488	8.42		66	21	12	< 1	262	< 5	53	3	309		0.7	0.26							< .1	< .05														< 2			215	251
Sufco 007	20-Sep-02	72.9	16.5	8.48	453	6.88		49	19	25	< 1	254	< 5	25	7	240		0.2	< .05							< .1	< .05																		
Sufco 007	8-Oct-02	88.2	11.7	8.63	477	8.01		57	20	27	1	268	7	36	9	308		0.2	< .05							< .1	< .05														< 2			231	304
Sufco 007	29-May-03	2560	12.7	8.54	358	7.62		53.7	14.4	4.84	0.743	238	7	29	1	202		9.02	0.282							0.006	< .005														< 2			206	193
Sufco 007	19-Sep-03	68.6	12.3	8.61	376	8.14		47.1	15.8	16.1	0.673	226	7	19	5	266		0.258	0.006							< .005	< .005														< 2			197	183
Sufco 007	30-Oct-03	51.7	11.4	8.65	465	7.63		55.9	18.6	22.9	1.38	243	8	23	6	311		0.128	0.01							0.009	0.009														< 2			213	216
Sufco 007	26-Jun-04	1510	11	8.66	336	7.53		45.4	12.6	6.14	0.48	158	11	16	2	180		0.08	0.003							< .03	0.002														< 2			169	165
Sufco 007	1-Sep-04	66.3	18.7	8.73	343	8.73		41.1	13.8	13	0.8	157	9	13	4	187		< .05	0.002							< .03	< .002														< 2			167	159
Sufco 007	15-Oct-04	398	7.2	8.54	439	8.17		52.4	16.2	19.4	1.28	204	14	21	5	261		0.08	0.009							< .03	0.009														< 2			217	198
Sufco 007	13-Jun-05	2180	12.7	8.59	373	6.78		55.6	16.9	8.76	0.85	228	< 5	22	2	199		1.04	0.028							< .03	< .002														< 2			192	206
Sufco 007	20-Sep-05	104	11.4	8.57	389	7.1		51.4	19.2	19.9	0.99	253	< 5	20	8	276		0.27	0.007							< .03	0.004														< 2			211	207
Sufco 007	24-Oct-05	96	7.3	8.61	470	8.03		54.9	19.6	22.9	0.74	284	< 5	23	7	281		< .05	0.005							< .03	0.004														< 2			233	218
Sufco 007	26-Jun-06	661	17.1	8.56	337	8.18		48.4	15.9	10.2	0.62	210	< 5	16	4	218		< .05	0.002							< .03	< .002														< 2			173	190
Sufco 007	13-Sep-06	62.8	15.9	8.46	375	7.1		42.47	18.2	23.17	1.06	223	10	21	7	228		0.33	0.004							< .03	0.002														< 2			198	181
Sufco 007	4-Nov-06	190	1.5	8.58	478	9.7		59.41	21.88	22.56	0.75	284	< 5	37	7	302		1.21	0.015							< .03	0.004														< 2			233	236
Sufco 007	25-Jun-07	227	22.5	8.67	304	7.05		41.1	16.8	12.7	0.64	204	< 5	20	4	216		0.17	0.004							< .03	< .002														< 2			167	172
Sufco 007	19-Sep-07	50.7	9.4	8.73	381	7.51		44.4	16.9	19.1	1.02	233	< 5	17	6	224		0.31	0.01							< .03	0.003														< 2			191	180
Sufco 007	29-Oct-07	78	5.2	8.77	436	7.63		54.67	20.57	24.53	1.15	271.885	4.8	26	8	317		0.36	0.014							< .03	0.005														< 2			230	221
Sufco 007	12-Jun-08	1550	10.9	8.63	301	7.59		52.26	14.69	5.88	0.55	197.513	3.6	24	2	233		2.88	0.074							< .03	< .002														< 5			168	191
Sufco 007	15-Sep-08	77.4	12	8.54	303	7.72		44.36	15.75	15.29	0.79	201.17	< 5	15	4	207		0.05	0.003							< .03	< .002														< 5			165	176
Sufco 007	21-Oct-08	71	4.3	8.58	442	9.82		55.01	19.03	23.67	1.65	263.35	< 5	134	26	265		0.1	0.008							< .03	0.007														< 5			216	216
Sufco 007	19-Jun-09	716	15.7	8.56	358	7.2		50.82	15.25	7.51	0.61	185.321	7.8	23	2	213		0.42	0.014							< .03	0.002														< 5			165	190
Sufco 007	17-Sep-09	79.3	13.5	8.61	362	8.26		45.4	15.6	15.45	0.99	207.267	5.4	15	4	225		0.25	0.006							< .03	< .002														< 5			179	178
Sufco 007	19-Nov-09	57	0.3	8.39	515	10.6		57.16	19.5	22.18	0.98	288.954	< 5	25	6	276		0.11	0.006							< .03	0.004														< 5			237	223
Sufco 007	28-Jun-10	612	14.5	8.59	351	7.89		50.97	13.87	6.27	0.78	188.978	7.2	21	2	226		0.56	0.018							< .03	< .002														< 5			167	184
Sufco 007	15-Sep-10	62.4	13.4	8.5	328	7.92		37.4	12.1	12.3	0.7	234.089	3	17	3	216		0.08	< .005							< .02	< .005														< 5			165	
Sufco 007	1-Nov-10	129	2.7	8.32	449	9.79		57.6	17.2	19.6	0.7	266.515	1.8	33	5	298		0.69	0.027							< .02	0.007														< 5			198	
Sufco 007	18-Jun-11	6032	9	8.79	352	7.88		52.1	12.8	4.8	0.8	253.597	1.8	25	< 1	210		15.9	0.833							< .02	< .005														< 6			176	
Sufco 007	27-Sep-11	189	11	8.7	405	8.82		39.7	16	19.7	0.8	280.419	3	18	6	212		0.05	< .005							< .02	< .005														< 5			196	
Sufco 007	29-Oct-11	133	0.8	8.46	492	10.53		52	19	24.6	0.8	309.681	3	26	8	258		0.12	0.009							< .02	0.007														6			254	
Sufco 007	1-Jun-12	327	11.9	8.76	373	7.51		46.7	15.1	12	0.7	208.486	1.98	25	4	228		0.38	0.019							< .02	< .005														< 6			171	
Sufco 007	26-Sep-12	19.7	9.7	8.54	539	8.88		46.1	22.2	38.9	1.5	304.804	4.2	32	14	188		0.13	0.006							< .02	< .005														< 5			250	
Sufco 007	1-Nov-12	48.8	3.7	8.47	480	9.46		48.4	17.6	26.4	0.9	275	6	28	8	290		0.17	0.009							< .02	< .005														9			235	
Sufco 007	27-Jun-13	261	13.9	8.58	373	8.83		46.1	12.3	7.3	0.7	246.281	1.2	35	2	252		1.56	0.066							0.02	< .005														< 5				
Sufco 007	25-Sep-13	253	7.2	8.74	398	8.62		54.1	14.9	9.1	0.9	277.981	3	28	3	224		0.12	0.009							< .02	< .005														< 6				
Sufco 007	26-Oct-13	216	2.6	8.66	420	10.92		53.3	14.7	11.5	0.7	259.693	4.2	26	3	180		0.03	0.006							< .02	< .005														< 5			213	
Sufco 007	11-Jun-14	1521	12	8.67	351	9.63		48.22	12.87	5.92	0.49	204.828	< 5	19	2	217		2.67	0.082							< .03	< .002														< 5				
Sufco 007	23-Sep-14	101	13.5	8.72	419	8.51		46.14	16.85	18.19	0.98	224.336	< 5	22	5	240		0.16	0.02							< .03	< .002														< 5				
Sufco 007	6-Nov-14	90	1.7	8.6	495	9.99		56.75	20.03	25.16	0.9	268.227	< 5	28	6	281		0.06	0.016							< .03	< .002														< 5				188
Sufco 007	24-Jun-15	1107	14.9	8.7	375	8.16		47.27	16.97	13.78	0.6	207.267	< 5	25	2	236		0.37	0.088							< .03	< .002														< 5			158	155
Sufco 007	22-Sep-15	97	11.1	8.61	328	8.31		38.43	14.26	13.35	< .14	158	<5	16	4	188	<2	<5	< 002							< .03	< .002														< 5				
Sufco 007	7-Nov-15	70	0.2	8.37	514	10.95		59.8	19.36	25.11	1.1	297.488	< 5	31	7	322	5	0.05	0.005							< .03	0.002														< 5				
Sufco 007	23-Jun-16	840	17.2	8.59	329	7.31		47.38	12.68	6.36	0.76	155	<5	17	2	172	41	0.42	0.022							< .03	0.022														< 5			155	171
Sufco 007	28-Sep-16	115	9.9	8.61	409	8.92		48.3	14.98	15.42	0.97	176	8	23	4	254	15	0.33	0.01							< .03	< .002														< 5			184	182
Sufco 007	6-Nov-16	99	4.1	8.71	449	9.43		52.69	15.92	20.3	0.75	215	10	25	5	221	9	0.07	0.008							<0.03	0.005																	225	197
Sufco 007 (North Fork Lower)	30-Jun-17	622	10	8.65	357	8.43		53.76	15.74	8.66	0.94	173	14	16	2	215	21	0.1	0.006	0.05	0.05	<0.05	<0.1	<0.05	<0.05	0.1	<0.002	<0.03		<0.01	0.02	<0.001		<0.01			<0.01			<0.004	<5	<180	187	199
Sufco 007 (North Fork Lower)	28-Sep-17	28	6.9	8.6	540	8.89																																								
Sufco 007 (North Fork Lower)	10-Nov-17	144	0.4	8.47	439	11.57																																								
Sufco 006	5-Oct-79											283.04	< .01	90	14	396	6	0.15	0.024		< .01				0.1																	< 1			372	293
Sufco 006	1-Nov-80											453.84	< .01	63	18.1	480		1.8	0.1		0.04	< .01	< .01	0.1		0.46									0.1					< 1			294	232
Sufco 006	9-Jun-81											344.04	7.2	108	24	465		0.68	0.06		< .01	< .01	< .01	0.12		0.21									< 2					< 1				
Sufco 006	26-Aug-81											265.96	12	79.5	11	390	13	3.6	0.17		0.02			0.07																			267.2	252
Sufco 006	27-Oct-81											318.6	3.8	160	7.5	530		0.71	0.04		< .01	< .01		0.7		0.24	0.026																	372.6	290
Sufco 006	22-Jun-82	143.616	12.5	7.7	423							454.6	< .01	42	33.7	486		2.88	0.03		0.21				0.014	0.01	0.005																	222	250
Sufco 006	12-Aug-82	462.264	12	8.3	510							270.5	< .01	30	20	282		2.76	0.028		0.17				0.015	0.075	0.02																	251.4	274
Sufco 006	20-Oct-82	426.36	1	8.6	545							306.7	< .01	66	10.4	355		3	0.175		0.13				0.57	0.08	0.055																			

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		Field Measurements						Major Ions								Baseline				Nutrients						Trace Metals																				Other Parameters				
	Date	Flow	T	pH	Cond.	D.O.	Turb	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{-2}	SO_4^{-2}	Cl^{-}	TDS	TSS	T-Fe	T-Mn	NO2+	NO3	NO2	NH3	O-PO4	T-P	D-Fe	D-Mn	D-Al	T-Al	D-As	D-B	D-Cd	D-Cr	D-Cu	T-Hg	D-Hg	D-Mb	D-Ni	D-Pb	D-Se	T-Sn	D-Zn	O&G	Acidity	CN	T-Alk	T-Hard
		gpm	°C	S.U.	µS/cm	mg/l	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/L	mg/l	mg/l	mg/l	mg/l
Sufco 006	21-Jun-83	933.504	16	8.4	799							400.2	< .01	74	36	424		0.81	0.065		< .02				0.2	0.03	0.042																			328	298
Sufco 006	16-Aug-83	623.832	17	7.5	726							370.88	2.4	62	4	432		5.4	0.045		< .01				0.11	0.09	0.015																			308	280
Sufco 006	12-Oct-83	260.3	10	7.7	833							390.4	< .01	87	34	490		0.25	0.08		0.06				0.1	0.044	0.07																			320	328
Sufco 006	21-Jun-84	704.667	11	8	920							416	< .01	66	38.4	490		0.07	0.04		0.01				0.1	0.01	0.03																			341	307
Sufco 006	9-Aug-84	569.976	18	7.9	688							384.3	< .01	405	29.4	850		1.3	0.09		0.02				0.14	0.07																			315	610
Sufco 006	11-Oct-84	359.04	6	7.7	824							390.4	< .01	95	34	520		0.6	0.09		0.09				0.77	0.23	0.07																			320	390
Sufco 006	13-Jun-85	704.616	14	7	712							256	< .01	75	14.2	316		24.6	0.73		0.42				1.12	0.03	< .01																			210	246
Sufco 006	14-Aug-85	287.232	13	7.9	884							348.9	< .01	85	28	460		0.06	0.03		0.03				0.28	< .01	< .02																			286	284
Sufco 006	22-Oct-85	219.912	1	7.7	729							329.4	< .01	87	24.5	484		0.58	0.09		0.05				0.02	< .01	0.05																			270	346
Sufco 006	3-Jun-86	825.792	16	8	610							279		95	20.3	386		0.62	0.07		0.06				0.03	< .01	0.02																			259	264
Sufco 006	13-Aug-86	260.304	17	8.1	662							275.7	14.4	59	17.2	340		0.57	0.05		0.03				0.02	< .01	< .01																			250	278
Sufco 006	7-Jun-88	412.9	16	7.9	715							316	< .1	73	11.3	388		0.3	0.09		0.03				0.05	< .03	0.05																			259	266
Sufco 006	9-Aug-88	112.2	17.5	7.4	648							301	< .1	83	32.5	430		0.68	0.09		0.15				0.09	< .03	0.03																			247	300
Sufco 006	5-Oct-88	70.9	15.5	7.1	782							381	< .1	174	15	577		0.75	0.15		< .02				0.12	< .03	0.08																			312	425
Sufco 006	13-May-92	17.95										399	2.3	93	26	544		1.33	0.09		1.4				0.1	< .02	< .02																			331	355
Sufco 006	4-Aug-92	94.25																1	0.04							0.13	0.01																					
Sufco 006	6-Oct-92	7										358						0.08	0.02							0.05	< .02																					
Sufco 006	9-Jun-93	45.33										468	1.7		33.1			0.04	0.05							< .04	0.029																			386	351
Sufco 006	6-Jun-95	44.88	16.1	8.07	977							420	20	95	33	570										0.1	< .1																			370	330
Sufco 006	24-Aug-95	426.4	16	8.46	578			56	32	18		235	20	73	6	320		0.3	< .1	< .1				0.03		< .1	< .1																			220	272
Sufco 006	3-Oct-95	192.98	12.5	8.2	636							275	10	66	7	380		0.2	< .1	< .1				0.01		< .1	< .1																			240	278
Sufco 006	27-Aug-96	130.152	15.9	8.35	635							260	14	72	8	378		0.1	< .1	< .1				0.02		< .1	< .1																			237	294
Sufco 006	22-Oct-96	6.5272	1.02	6.28	398							361	< 5.	81	14	450		0.3	< .1	< .1				0.03		< .1	< .1																			296	329
Sufco 006	2-Jun-97		21.53	8.3	805							385	< 5.	86	19	460		0.9	< .1	< .1				0.04		< .1	< .1																			315	310
Sufco 006	18-Aug-97	287.232	18.9	8.44	574		46.8					251	< 5.	77	5	350		0.8	< .1	< .1				0.02		< .1	< .1																			206	265
Sufco 006	8-Oct-97	184.008	5.5	8.35	529		53.2					267	< 5.	92	9	380		0.6	< .1	< .1				0.02		< .1	< .1																			235	272
Sufco 006	4-Jun-98	112.2	13.1	8.42	901	6.21		66	40	72	2	456	< 5.	95	32	269		1.1	< .1							< .1	< .1																			374	330
Sufco 006	3-Aug-98	224.4	22.75	8.08	577	6.19		55	31	17	2	135	72	70	5	359		1.4	< .01							< .01	< .01																					
Sufco 006	1-Oct-98	71.808	11.54	8.33	626	9.33		54	34	23	2	292	< 5.	70	9	380		0.5	< .1							< .1	< .1																					
Sufco 006	21-Jun-99	201.96	17.3	8.19	625	7.03		55	33	17	1	290	5	73	5	353		1.5	< .1							< .1	< .1																					
Sufco 006	9-Aug-99	394.944	22.04	8.3	592	6.54		50	31	17	1	273	6	70	5	338		4.1	0.1							< .1	< .1																					
Sufco 006	4-Oct-99	192.984	12.11	8.3	647	8.15		54	32	21	1	275	6	88	6	364		0.6	< .1							< .1	< .1																					
Sufco 006	21-Jun-00	0.8	15.32	8.13	627	7.05		53	32	18	1	258	9	94	5	374		3.7	0.1							< .1	< .1																					
Sufco 006	2-Aug-00	192.984	21.3	8.39	600	5.6		51	32	16	2	263	< 5.	89	4	364		2.9	0.2							< .1	< .1																					
Sufco 006	5-Oct-00	179.52	9	8.12	747	7.28		59	35	34	2	323	< 5.	90	13	399		0.5	< .1							< .1	< .1																					
Sufco 006	11-Jun-01	646.272	17.5	8.34	592	5		53	30	13	< 1.	237	8	96	3	330		1.2	< .1							< .1	< .1																					
Sufco 006	20-Aug-01	179.0712	16.3	8.76	512	6.76		49	31	15	1	232	9	84	3.3	354		1.5	< .05							< .1	< .05																					
Sufco 006	2-Oct-01	0																																															
Sufco 006	8-May-02	88.1	10.4	8.28	621	8.42		63	35	29	2	291	8	107	7	388		1.9	0.07							< .1	< .05																					
Sufco 006	20-Sep-02	11.5	16.8	8.47	721	6.24		63	33	37	3	301	7	107	11	402		2	< .05							< .1	< .05																					
Sufco 006	8-Oct-02	35.1	10.8	8.2	738	7.51		64	35	32	2	297	8	114	10	417		0.5	< .05							< .1	< .05																					
Sufco 006	29-May-03	0.909	20.9	8.42	962	6.02		66.1	43.2	80.1	3.77	371	< 5.	152	34	571		1.16	0.034							0.006	0.013																					
Sufco 006	19-Sep-03	26.3	13.5	8.53	631	7.91		63.4	35.5	28.9	2.25	285	10	108	9	458		0.447	0.01							0.009	0.005																					
Sufco 006	30-Oct-03	0.131	8.8	8.58	1228	7.33		94.7	56.4	110	6.47	549	< 5.	203	45	828		0.162	0.026							0.008	0.021																					
Sufco 006	26-Jun-04	420	13	8.77	493	7.06		50.9	30.4	10.9	1.01	184	16	95	3	302		1.9	0.046							< .03	0.006																					
Sufco 006	1-Sep-04	132	16.9	8.72	529	6.89		54	31.7	12.8	1.59	173	21	93	4	324		0.05	0.02							< .03	0.005																					
Sufco 006	15-Oct-04	70.3	9.6	8.47	593	7.05		56.5	31.5	20.2	1.79	218	< 5.	109	5	352		0.37	0.013							< .03	0.003																					
Sufco 006	13-Jun-05	703	15.5	8.37	523	6.37		63	34.6	15.4	2.17	282	< 5.	82	4	312		7.64	0.174							< .03	< .002																					
Sufco 006	30-Sep-05	402	12.1	8.57	542	7.67		52.2	32.6	14.5	1.35	215	16	98	3	338		0.77	0.02							< .03	0.007																					
Sufco 006	24-Oct-05	18.8	8.5	8.53	719	7.91		63.5	34	36.9	1.58	314	< 5.	93	13	425		< .05	0.012							< .03	0.006																					
Sufco 006	26-Jun-06	363	16.8	8.54	522	7.66		56.1	32.7	12.4	1.05	245.22	< 5.	77	4	335		2.93	0.059							< .03	< .002																					
Sufco 006	13-Sep-06	155	14.6	8.45	536	7.08		52.79	31.18	16.58	1.48	225	10	87	5	320		1.66	0.025							< .03	0.003																					
Sufco 006	4-Nov-06	90	3.9	8.46	591	9.09		59.61	34.32	28.01	1.2	261	< 5.	91	9	350		0.91	0.023							< .03	0.007																					
Sufco 006	25-Jun-07	160	17.6	8.62	543	8.72		55.1	33.8	14.3	0.93	244	< 5.	88	4	351		3.71	0.095							< .03	< .002																					
Sufco 006	19-Sep-07	95	12.3	8.89	515	8.69		50.2	33.7	17.1	1.72	128	79	95	4	330		0.19	0.005							< .03	0.003																					
Sufco 006	29-Oct-07	1.23	6.1	8.72	920	7.33		72.06	41.5	65.89	2.5	389	< 5.	122	25	555		0.23	0.012							< .03	0.007																					
Sufco 006	12-Jun-08	146	14.9	8.65	649	7.1		62.72	34.03	26.37	1.38	281.839	5.4	90	8	401		0.95	0.034							< .03	0.004																					
Sufco 006	15-Sep-08	104	11.9	8.63	518	7.82		56.09	33.36	14.57	1.36	224.336	< 5.	92	3	345		0.2	0.007							< .03	0.002																					
Sufco 006	21-Oct-08	1.18	7.2	8.44	882	8.34		81.24	45.53	76.47	3.87	412.095	< 5.	134	26	578		0.1	0.008							< .03	0.007																					
Sufco 006	19-Jun-09	80.4	16.5	8.46	617	6.99		65.11	35.56	25.93	1.64	273.104	9.6	95	7	391		2.33	0.066							< .03	0.007																					
Sufco 006	17-Sep-09	100	14.1	8.61	531	7.81		54.06	32.98	14.37	1.62	212.143	10.8	92	3	343		1.4	0.033							0.03	0.007																					
Sufco 006	19-Nov-09	71	0.3	8.39	612	10.6		56.79	34.34	21.27	1.83	256.035	< 5.	102	5	361		0.8	0.014							< .03	0.004																					
Sufco 006	28-Jun-10	433	18.8	8.43	576	6.68		57.6	32.99	14.8	4.21	249.939	< 5.	97	3	372		1.84	0.094							< .03	< .002																					
Sufco 006	15-Sep-10	49.9	11.2	8.42	532	7.42		55.4	31.5	20.4	2.2	297.488	4.2	98	4	372		1.26	0.034							0.03	< .005																					
Sufco 006	1-Nov-10	62.4	3.2	8.21	585	9.33		60.4	32.8	22.2	1.6	318.215	1.2	102	5	404		1.41	0.048							0.02	0.006																					
Sufco 006	17-Jun-11	1116	9.5	8.74	525	8.03		55.4	29.6	14.2	1.1	335.284	2.4	69	4	322		1.3	0.057							< .02	< .005																					
Sufco 006	21-Sep-11	205	11.6	8.62	533	7.62		53.4	31.3	14.5	1.4	295.05	2.4	86	4	336		1.1	0.037							< .02	< .005																					
Sufco 006	12-Oct-11	155	6.4	8.62	578	8.9		55.7	32.2	17.2	1.5	263.35	1.98	88	4	366		0.59	0.024							< .02	< .005																					
Sufco 006	1-Jun-12	0.208/93.35	17.5	8.43	988	8.08		64.3	43.1	84.1	3.9	432.821	< 1.	135	27	596		0.24	0.01							< .02	< .005																					
Sufco 006	12-Sep-12	45.3	11.1	8.65	557	8.35		55.2	34.9	24.4	2	254.816	4.2	105	5	338		0.1	0.009							< .02	< .005																					
Sufco 006	1-Nov-12	53.9	3.4	8.59	592	9.64		55	31.7	23.8	1.5	263	4	102	6	368		0.32	0.02							< .02	< .005																					
Sufco 006	27-Jun-13	80.4	16.1	8.56	566	7.73		48.8	32.8	17.5	2	296.269	2.4	119	4	376		0.83	0.038							< .02	< .005																					
Sufco 006	16-Sep-13	239	13.8	8.56	627	8.27		69.3	32.8	24.5	2.4	352.353	4.8	111	6	380		2.84	0.111							< .02	< .005																					
Sufco 006	23-Oct-13	116	3.7	8.72	618	10.34		61.4	32.7	20.9	1.4	285.296	6	105	5	388		0.85	0.06							< .03	< .002																					
Sufco 006	28-May-14	363	12.2	8.59	574	7.6		57.75	32.68	15.24	1.03	269.446	< 5.	90	3	373		1.1	0.072							0.09	0.003																					
Sufco 006	17-Sep-14	101	14.4	8.76	557	7.5		51.85	31.77	15.51	1.68	240.185	< 5.	97	3	372		1.04	0.034																											
Sufco 006	28-Oct-14	0																																													
Sufco 006	21-Jun-15	142	14.9	8.58	593	8.39		53.56	36.54	17.2	1.04	280.419	< 5.	95	4	374		1.57	0.145							< .03	< .002																					
Sufco 006	22-Sep-15	146	15.1	8.67	1080	7.76		51.61	34.04	17.22	1.17	230.432	< 5.	95	3	331	20	< .05	< .002							< .03	< .002																					
Sufco 006	8-Nov-15	19	0.2	8.52	753	10.21		72.77	43.97	36.62	2.44	374.299	< 5.	135	9	530	79	0.5	0.019							< .03	< .002																					
Sufco 006	18-Jun-16	8.58	17.6	8.58	543	7.02		58	34.55	15.58	1.1	202	<5	98	3	462	253	2.86	0.168	0.13	0.13	<0.05	0.2	<0.05	<0.05	< .03	< .002	5.03	<0.1	0.05	001<0.001	<0.01	<0.02	0.007	0.002	<0.01	0.02	0.02	.00475	42	< 5	202	202	287
Sufco 006	26-Sep-16	89	9.5	8.63	541	8.92		51.27	29.94	15.48	1.87	170	40	97	3	369	171	2.45	0.055							< .03	< .002																					
Sufco 006	5-Nov-16	Dry																																													
Sufco 006	28-Jun-17	249	12.6	8.64	513	8.07		57.06	33.4	11.32	1.35	208	<5	80	2	320	264	2.06	0.071							<0.03	<0.002																					
Sufco 006	28-Aug-17	115	14.5	8.68	499	7.56																																									
Sufco 006	13-Oct-17	21.7	5	8.64	626	9.62																																									

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		Field Measurements						Major Ions							Baseline				Nutrients						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{+2} mg/L	Mg^{+2} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{-2} mg/L	SO_4^{-2} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	D-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/l	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
Sufco 006A	19-Oct-09	75																																											
Sufco 006A	28-Jun-10	500	16.8	8.51	538	7.31		56.93	32.42	12.89	1.54	224.336	4.8	95	2	360		1.27	0.072							< .03	< .002															< 5				
Sufco 006A	15-Sep-10	50.8	11.7	8.44	529	7.33		48.3	29	16.1	2.6	296.269	2.4	99	4	366		0.58	0.023							0.02	0.008															< 5			206	
Sufco 006A	1-Nov-10	82.2	3.4	8.22	560	9.38		53.5	29.8	17.8	1.3	306.023	1.2	101	4	382		0.72	0.039							0.02	0.013															< 5			210	
Sufco 006A	17-Jun-11	1109	9.5	8.77	512	7.86		56.1	30.1	13.2	1	325.53	2.4	88	4	312		0.58	0.035							< .02	< .005															< 6			226	
Sufco 006A	21-Sep-11	296	11.7	8.68	624	7.53		47.5	28.8	12	1.1	249.939	4.8	86	3	348		0.78	0.031							< .02	< .005															< 5			205	
Sufco 006A	12-Oct-11	186	7.9	8.6	556	8.72		54	31.6	15.3	1.3	256.035	1.998	86	4	342		0.32	0.019							< .02	< .005															< 5			210	
Sufco 006A	1-Jun-12	0.949	14.3	8.5	1182	7.5		64.7	37	138	2.5	513.289	4.2	183	47	776	46	0.74	0.016	< .1		< .02	< .2	< .01	0.06	< .02	0.006		< .05		< .005			< .2		< .02	< .02	< 20		< 6			421	314
Sufco 006A	12-Sep-12	59.5	11.8	8.56	547	8.62		45.2	28.8	18	1.4	251.158	4.2	103	4	356	18	0.13	0.014		< .2	< .2	0.3	< .01	< .01	< .02	< .005		< .05		< .005			< .2		< .02	0.02	20		< 5			206	251
Sufco 006A	1-Nov-12	56	3.9	8.56	578	9.85		52.7	31	20.4	1.3	251	4	101	5	324	27	0.22	0.014		0.2	< .1	< .2	< .01	0.02	< .02	< .005		< .05		< .005			0.2		< .02	0.03	30		< 6			213	259
Sufco 006A	27-Jun-13	136	17.2	8.56	551	7.96																																							
Sufco 006A	16-Sep-13	210	13	8.52	609	7.88																																							
Sufco 006A	23-Oct-13	118	4	8.56	604	10.76																																							
Sufco 006A	28-May-14	576	12.4	8.56	569	7.56																																							
Sufco 006A	17-Sep-14	126	12.7	8.67	547	8.18																																							
Sufco 006A	28-Oct-14	2.86	2.4	8.61	1123	10.08																																							
Sufco 006A	23-Jun-15	168	8.7	8.7	573	7.37																																							
Sufco 006A	23-Sep-15	113	11.7	8.59	518	8.22																																							
Sufco 006A	5-Nov-15	28.6	0.2	8.37	640	10.5																																							
Sufco 006A	28-Jun-16	339	18.5	8.51	536	7.16																																							
Sufco 006A	25-Sep-16	122	9.2	8.68	536	9.24																																							
Sufco 006A	28-Jun-17	321	12.5	8.62	510	8.04										321	140	0.95	0.042																											
Sufco 006A	28-Aug-17	117	15	8.61	509	7.48																																							
Sufco 006A	2-Nov-17	13.3	6.3	8.47	660	8.96																																							
Sufco 006B*	12-Sep-12	36.8	11.5	8.66	555	8.33		48.5	31.3	22.2	1.9	247	4	104	5	390	16	0.36	0.013			<0.2	<0.2	<0.2	<0.01	0.03	<0.02	<0.005	<0.05	0.5	<0.05	<0.05	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	<0.02	0.04	0.02	<0.01	<6	<5		210	260
S. Fk. Quitchupah Upper	11-Nov-13	128	4.6	8.63	514	10										328	4	0.05	<0.005																											
S. Fk. Quitchupah Upper	1-Jul-14	731	12.5	8.61	515	8.3		52	30	9	1.16	227.993	6	88	2	322	19	0.27	0.012	NM	0.37	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.5	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004	<5	<5	193	253
S. Fk. Quitchupah Upper	25-Sep-14	151	13.6	8.72	518	8.05		50.55	31.26	11.14	1.14	213.363	<5	97	2	350	6	<0.05	0.004	0.15	0.23	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.07	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5	175	255
S. Fk. Quitchupah Upper	11-Nov-14	11.8	0.1	8.43	593	10.14		56.1	32.43	12.22	1.12	246.281	<5	102	2	372	13	0.12	0.009	0.36	0.36	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.21	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5	202	274
S. Fk. Quitchupah Upper	29-Jul-15	411	13.4	8.77	497	8.1		48.34	32.62	10.65	1.01	209.705	<5	87	2	302	24	0.16	0.01	2.28	0.31	<0.05	<0.1	<0.05	1.99	<0.03	<0.002	<0.03	0.27	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	0.005	<5	<5	172	255
S. Fk. Quitchupah Upper	9-Nov-15	70	0.3	8.42	503	10.02																																							
S. Fk. Quitchupah Upper	9-Jul-16	455	14.7	8.69	507	8.03										331	17	0.28	0.012																											
S. Fk. Quitchupah Upper	14-Nov-16	4.4	4.7	8.33	611	10.05										394	23	0.12	0.012																											
S. Fk. Quitchupah Upper	29-Jul-17	354.0	14.7	8.66	485	7.85										300	14	0.23	0.009																											
S. Fk. Quitchupah Upper	18-Oct-17															169	11	<0.05	<0.002																											
Skutumpah Creek Upper	11-Nov-13	59	4.5	8.42	547	10.04										316	11	0.13	<0.005																											
Skutumpah Creek Upper	2-Jul-14	81	16.5	8.24	549	7.3		36	27	34	2.56	257.254	22	46	8	305	39	0.53	0.014	NM	<0.05	<0.05	<0.1	<0.05	0.06	<0.03	<0.002	<0.03	1.03	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004	<5	<5	232	203
Skutumpah Creek Upper	25-Sep-14	7.8	15.5	8.48	527	8.39																																							
Skutumpah Creek Upper	11-Nov-14	129	0.9	8.56	570	10.36																																							
Skutumpah Creek Upper	9-Nov-15	67	0.3	8.45	505	10.06		49.68	33.38	10.47	1.05	223.116	<5	88	2	314	42	0.35	0.016	0.21	0.29	<0.05	<0.1	<0.05	0.05	<0.03	<0.002	<0.03	0.52	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5	183	262
Skutumpah Creek Upper	9-Jul-16	75	15.3	8.65	509	7.81										323	38	0.57	0.016																											
Skutumpah Creek Upper	14-Nov-16	101	5.8	8.57	540	9.89										357	22	0.22	0.007																											
Skutumpah Creek Upper	29-Jul-17	14	14.9	8.59	490	7.51										302	30	0.36	0.015																											
Skutumpah Creek Upper	18-Oct-17															165	20	0.07	<0.002																											
Cowboy Top	29-Jun-17	1.74	13.8	8.43	540	7.49		73.24	28.77	24.28	2.06	290	<5	4	3	306	<5	<0.05	0.008		<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01		<0.2		0.005	<0.01	0.03		<0.004	<5		290	230
Cowboy Top	29-Sep-17	0																																											
Cowboy Top	9-Nov-17	0																																											
Cowboy Middle	29-Jun-17	10.1	15.2	8.55	668	7.5		45.88	36.51	66.58	3.1	333	6	14	18	379	<5	<0.05	<0.002		<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	<0.03	<0.01	0.07	<0.001		<0.01		<0.2		0.002	<0.01	0.09		<0.004	<5		339	265
Cowboy Middle	30-Sep-17	12.1	8.5	8.58	743	8.86		48.5	34.02	68.51	3.09	376	12	16	20	420	7	0.11	0.003		<0.05	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01					<0.01	0.05		<0.004		<5	388	261
Cowboy Middle	15-Nov-17	2.23	0.6	8.55	832	9.58		58.36	39.18	77.06	3.33	431	8	19	<1	462	16	0.28	0.01		<0.05	<0.05	0.3		0.08	<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01					<0.01	0.07		<0.004		<5	440	307
Cowboy Bottom	29-Jun-17	0.51	13.6	8.8	610	7.49		26.79	35.46	67.73	3.4	160	11	27	22	345	<5	<0.05	<0.002		<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03		<0.01	0.08	<0.001		<0.01		<0.2		0.002	<0.01	0.07		<0.004	<5		171	213
Cowboy Bottom	30-Sep-17	1.41	8.9	8.75	693	7.94		34.78	34.94	68.59	5.59	312	19	36	27	469	22	0.61	0.032		<0.05	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01					<0.01	0.06		<0.004		<5	331	231
Cowboy Bottom	15-Nov-17	0.66	1.1	8.66	643	9.64		36.36	32.85	58.5	3.49	301	10	31	22	417	12	0.15	0.005		<0.05	<0.05	<0.1		0.07	<0.03	<0.002	<0.03		<0.01	0.06	<0.001		<0.01					<0.01	0.08		<0.004		<5	311	226
SP60 Creek	30-Jun-17	37.5	14.5	8.64	545	8.11		39.56	31.21	45.66	1.46	258	16	19	6	293	12	0.06	<0.002		<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03		<0.01	0.05	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5	273	227
SP60 Creek	28-Sep-17	15.7	6.9	8.67	635	8.97																																							
SP60 Creek	10-Nov-17	10.7	0.7	8.54	737	11.28										514	9	0.31	0.011																											
CPC Upper	30-Jun-17	0.103	12.9	8.58	645	8.13		43.25	43.31	50.43	2.75	307	29	14	18	373	18	0.46	0.015		307	29	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5	335	286
CPC Upper	28-Sep-17	0																																											
CPC Upper	10-Nov-17	0																																											
CPC Middle	30-Jun-17	<0.01	11.4	7.86	1136	8.1										710	685	2.37	0.351																											
CPC Middle	28-Sep-17	0.62	7.7	8.77	795	8.98										688	164	2.65	0.036																											
CPC Middle	10-Nov-17	0																																											
CPC Lower	30-Jun-17	3.13	11.2	8.3	853	7.78		67.16	31.49	96.29	8.12	326	10	106	29	536	153	2.29	0.093		<0.05	0.4	<0.1	<0.05	0.22	<0.03	<0.002	<0.03		<0.01	0.08	<0.001		<0.01		<.2			<0.01			<0.004	<5	<5	336	297
CPC Lower	28-Sep-17	3.6	7.5	8.6	884	9.13										584	246	2.73	0.075																											
CPC Lower	10-Nov-17	3.05	1.5	8.38	850	12.1										563	7	0.07	0.045																											
North Fork Upper	30-Jun-17	718	11.5	8.64	329	8.54		58.66	13.44	2.47	0.64	261	21	15	<1	183	10	<0.05	<0.002		0.09	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5	282	202
North Fork Upper	28-Sep-17	128	6	8.53	345	9.93		50.39	12.15	2.69	0.73	157	6	22	1	211	6	<0.05	<0.002		6	0.12	<0.1		<0.05	<0.03	<0.002	<0.03		0.01	0.02	<0.001		<0.01					<0.01	0.04		<0.004		<5	164	176
North Fork Upper	10-Nov-17	108	0.4	8.53	358	11.9		54.37	13.14	5.91	0.71	210	<5	22	1	206	13	0.08	0.004		0.15	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.03		<0.004		<5	214	190
North Fork Middle	30-Jun-17	581	10.3	8.66	355	8.44		54.11	15.38	7.75	0.88	170	14	16	2	200	20	0.19	0.009		0.08	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5	184	198
North Fork Middle	28-Sep-17	26	6.2	8.6	457	9.45		48.43	18.69	22.08	1.36	212	9	24	8	274	9	0.07	<0.002		<0.05	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.05		<0.004		<5	222	198
North Fork Middle	10-Nov-17	139	0.4	8.59	412	12.4		48.26	15.48	18.83	1.07	211	<5	22	4	254	5	0.05	<0.002		<0.05	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.04		<0.004		<5	214	184

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		Field Measurements						Major Ions							Baseline				Nutrients						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
ULGH	28-Jun-17	6.88	12.6	8.66	902	7.42		44.42	28.35	144.7	4.97	440	20	23	28	546	175	2.27	0.058		0.14	<0.05			<0.05	<0.03		<0.03		<0.01	0.09	<0.001	0.002	<0.01		<0.2		<0.001	<0.01	0.03		<0.004				460	228
ULGH	27-Sep-17	3.49	6	8.67	872	8.45		37.97	23.1	147.5	5.55	510	<5	21	24	526	500	5.71	0.222		0.07	<0.05	0.1		0.06	<0.03	0.035	<0.03		0.02	0.08	<0.001		<0.01					<0.01	0.07		<0.004		<5		510	190
ULGH	13-Nov-17	3.16	0.8	8.66	834	12.98		34.07	21.71	142.5	3.49	456	12	19	<1	278	82	2.72	0.156		0.07	<0.05	<0.1		1.73	<0.03	<0.002	<0.03		0.01	0.09	<0.001		<0.01					<0.01	0.06		<0.004		<5		468	174
URGH	28-Jun-17	1.01	14.5	8.48	770	6.85		45.27	27.96	107.7	4.17	370	25	15	20	473	10	0.09	0.008		<0.05	<0.05			<0.05	<0.03	0.008	<0.03		0.01	0.09	<0.001		<0.01		<0.2		0.001	<0.01	0.02		<0.004				396	227
URGH	27-Sep-17	0.19	5.1	8.51	944	7.92		39.62	20.23	161.9	6.69	489	22	17	27	612	21	0.43	0.023		<0.05	<0.05	<0.1		0.09	<0.03	0.023	<0.03		0.02	0.06	<0.001		<0.01					<0.01	0.03		<0.004		<5		510	182
URGH	13-Nov-17	0																																												
GH at Road	28-Jun-17	2.94	16.8	8.79	847	7.31		26.67	0.015	143.8	5.81	371	35	33	35	517	35	0.6	31.91	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	0.15	30.93	0.29		0.01	0.11	<0.001	0.003	<0.01		<0.2		0.001	<0.01	0.04		<0.004	<5			406	189
GH at Road	27-Sep-17	2.68	8.8	8.66	874	7.73		38.45	26.16	118.9	9.37	413	18	37	36	559	51	0.95	0.035		<0.05	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		0.01	0.08	<0.001		<0.01					<0.01	0.09		<0.004		<5		431	204
GH at Road	13-Nov-17	1.19	0.5	8.51	981	10.9		62.8	42.16	131.7	6.67	507	<5	49	<1	658	17	0.24	0.039		<0.05	<0.05	<0.1		0.12	<0.03	<0.002	<0.03		0.01	0.08	<0.001		<0.01					<0.01	0.12		<0.004		<5		511	330
Muddy Creek below Horse	27-Jun-17	107 cfs	14.9	8.76	366	7.52		46	23.74	4.61	0.7	192	<5	8	<1	77	0.33	0.57	0.013		0.33	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.04		<0.004	<5	-102		192	213
Muddy Creek below Horse	30-Sep-17	9620	8.7	8.75	399	8.93		40.47	23.46	5.24	0.77	204	12	11	1	222	55	0.31	0.002		0.41	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.06		<0.004		<5		215	198
Muddy Creek below Horse	14-Nov-17	4609	1.2	8.77	423	10.91		43.25	27.22	10.25	0.99	224	9	12	2	191	136	0.92	0.023		0.45	0.08	<0.1		0.11	<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.06		<0.004		<5		233	220
Muddy Creek above Horse	27-Jun-17	96 cfs	15.3	8.76	360	7.52		46.78	23.78	3.71	0.7	185	<5	7	<1	200	9	0.08	0.006		0.35	<0.05	<0.1		0.06	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.03		<0.004	<5	-292		185	215
Muddy Creek above Horse	30-Sep-17	9030	6.2	8.76	396	9.08		42.02	23.68	4.46	0.75	200	14	10	1	228	<5	0.06	<0.002		0.43	<0.05	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.05		<0.004		<5		214	202
Muddy Creek above Horse	14-Nov-17	3777	1	8.76	414	10.9		44.9	25.93	8.47	0.91	217	11	11	2	205	<5	0.05	<0.002		0.48	0.09	<0.1		<0.05	<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.09		<0.004		<5		227	219
Horse Creek	27-Jun-17	11 cfs	16.5	8.77	446	7.48		41.99	29.01	14.45	1.2	215	<5	19	2	256	862	6.9	0.165		0.23	<0.05	<0.1		0.06	<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.02		<0.004	<5	<5		215	224
Horse Creek	30-Sep-17	585	8.5	8.8	476	8.62		37.12	29.52	21.07	1.52	234	14	21	3	501	134	3.01	0.042		0.15	<0.05	<0.1		0.14	<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.05		<0.004		<5		248	214
Horse Creek	14-Nov-17	832	1.3	8.8	474	10.88		40.19	30.7	19.24	1.53	247	10	22	3	198	750	6.19	0.178		750	0.21	<0.1		0.97	<0.03	<0.002	<0.03		0.01	0.04	<0.001		<0.01					<0.01	0.07		<0.004		<5		257	227
Spring Monitoring Stations																																														
M-SP01	19-Jun-01	0.503	13.7	7.42	532		0.24																																						387	
M-SP01	28-Aug-01	0.373	8	7.53	497		0.6					472	< 5	26	47	502		< 1																										388	
M-SP01	1-May-02	0.45	5.1	7.27	451							473	< 5	28	44	464		< 1																											
M-SP01	25-Sep-02	0.324	7.5	7.4	851	2.17		88	44	48	1.9	490	< 1	28	43	464		< .02	< .01	< .03		< .03	< .2	< .05		< .02	< .01	0.05		0.0012	0.07	< .005		< .01			< .02		< .07	0.0044		< .01		33		385	400
M-SP01	12-Nov-02	0.408	5.1	7.33	815	2.83		80	40	43	1.7	480	< 1	27	43			< .02	< .01	< .03		< .03	< .2	< .05		< .02	< .01	0.04		0.1	0.06	< .005		< .01			< .02		< .07	< .1		< .01		35		374	360
M-SP01	21-May-03	0.517	4.3	7.26	435	3.1	9.99	81	40	45	1.9	470	< 1	26	37	473		< .02	< .01	< .03		< .03	< .2	< .05		< .02	< .01	< .03		0.0009	< .05	< .005		< .01			< .02		< .07	0.0037		0.01				380	370
M-SP01	8-Aug-03	0.539	7.9	7.1	490	2.51	0.15	82	40	45	1.7	510	< 1	27	42	454		< .02	< .01	< .03		< .03	< .2	< .05		< .02	< .01	< .03		0.0007	0.06	< .005		< .01			< .02		< .07	0.0026		< .01		24		420	370
M-SP01	7-Oct-03	0.287	7.6	7.32	500	2.03	1.82	86	42	47	1.8	484	< 5	26	38	489		0.02	< .01	< .03		< .03	< .2	< .05		< .02	< .01	< .03		0.0006	0.06	< .005		< .01			< .02		< .07	0.0027		0.13		36		397	390
M-SP01	11-May-04	0.621	4.5	7.34	489	3.29		84	42	49	1.9	492	< 5	30	44	500		< .02	< .01				< .2			< .02	< .01	< 1		0.0008	0.06	< .005		< .01			< .02		< .07	0.0024		< .01		17		403	380
M-SP01	13-May-04	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-		< .03	< .03		< .05		-	-	-		-	-	-		-			-		-	-		-		-		-	-
M-SP01	26-May-05	0.89	5	7.68	864																																									
M-SP01	28-Sep-05	0.19	7	7.46	777																																								
M-SP01	8-Nov-06	0.62	5.3	7.17	772																																								
M-SP01	26-Jun-07	0.39	10.2	7.48	797																																								
M-SP01	11-Sep-07	0.28	11.6	7.42	906																																								
M-SP01	8-Nov-07	0.47	4.7	7.76	874																																								
M-SP01	13-Jun-08	0.57	9.2	7.01	882																																								
M-SP01	24-Sep-08	0.24	9.5	7.07	807																																								
M-SP01	7-Nov-08	0.51	5.7	7.23	784																																								
M-SP01	27-Jun-09	0.478	11.4	7.46	803																																								
M-SP01	23-Sep-09	0.254	10.1	7.08	869																																								
M-SP01	10-Nov-09	0.49	5.1	7.32	748																																								
M-SP01	26-Jun-10	0.426	12.6	7.21	837																																								
M-SP01	23-Sep-10	0.16	10.1	7.86	846																																								
M-SP01	12-Nov-10	0.408	4.3	7.02	846																																								
M-SP01	27-Jun-11	1.11	5.6	7.52	819																																								
M-SP01	26-Sep-11	0.746	8.1	7.72	812																																								
M-SP01	29-Oct-11	0.68	6.2	7.49	821																																								
M-SP01	27-Jun-12	0.34	11.9	7.41	854																																								
M-SP01	6-Sep-12	0.246	9.6	7.35	842																																								
M-SP01	7-Nov-12	0.221	4.2	7.6	838																																								
M-SP01	30-Jun-13	0.292	14	7.57	846																																								
M-SP01	25-Sep-13	0.377	9.5	7.24	851																																								
M-SP01	26-Oct-13	0.505	6.6	7.28	811																																								
M-SP01	29-Jun-14	0.32	12.7	7.24	811																																								
M-SP01	29-Aug-14	0.241	11.0	7.23	841																																								
M-SP01	31-Oct-14	0.426	6.0	7.58	853																																								
M-SP01	24-Jun-15	0.339	10.1	7.37	842																																								
M-SP01	28-Sep-15	0.113	12.5	7.71	803																																								
M-SP01	28-Oct-15	0.34	7.1	7.43	816																																								
M-SP01	25-Jun-16	0.258	10.0	7.75	813																																								
M-SP01	29-Sep-16	0.14	8.2	7.46	825																																								
M-SP01	7-Nov-16	0.261	5.4	7.79	828																																								
M-SP01	28-Jun-17	0.473	9.5	7.33	788											463	<5	<0.05	<0.002																												
M-SP01	21-Sep-17	1.600	10.6	7.52	804											-	-	-	-																												
M-SP01	14-Nov-17	0.387	5.7	7.50	744											419	<5	<0.05	<0.002																												
M-SP02	19-Jun-01	9.274	10.7	7.43	497		0.08																																						370	
M-SP02	28-Aug-01	2.756	10.3	7.62	499							451	< 5	35	44	504		< 1																											385	
M-SP02	1-May-02	4.348	9.1	7.57	470							470	< 5	38	41	463		< 1																											
M-SP02	25-Sep-02	0																																												
M-SP02	12-Nov-02	0																																											
M-SP02	20-May-03	6.856	6.1	7.22	459	5.78	13.68	80	34	56	2.1	450	< 1	37	35	486		< .02	< .01	0.12		< .03	< .2	< .05		< .02	< .01	< .03		0.0012	0.19	< .005		< .01			< .02		< .07	0.0033		0.01		50		370	340
M-SP02	5-Aug-03	-	-	-	-	-	-	-	-	-	-	459	< 5	-	-	457	-	-	-	0.09		< .03	-	< .05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23		376	-
M-SP02	8-Aug-03	0.992	8.8	7.21	485	5.7	0.15	79	34	54	2	520	< 1	35	38			< .02	< .01				< .2			< .02	< .01	< .03		0.0008	0.05	< .005		< .01			< .02		< .07	0.0019		0.06				420	340
M-SP02	7-Oct-03	0																																												
M-SP02	11-May-04	2.485	6	7.37	437	4.82	0.25	79	33	60	2	462	< 5	36	37	488		0.02	< .01				< .2			< .02	< .01	< 1		0.0009	0.06	< .005		< .01			< .02		< .07	0.002		0.02		14		379	330
M-SP02	13-May-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	< .03	-	-	< .05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M-SP02	26-May-06	13.4	6.3	7.67	824																																									
M-SP02	28-Sep-06	4.19	8.2	7.24	772																																								

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		Field Measurements						Major Ions							Baseline				Nutrients					Trace Metals																		Other Parameters			
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^- mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP02	8-Nov-06	2.26	7.9	7	765																																								
M-SP02	26-Jun-07	4.16	6.7	7.49	813																																								
M-SP02	11-Sep-07	0.046	12.1	7.72	898																																								
M-SP02	8-Nov-07	0																																											
M-SP02	13-Jun-08	5.17	6.8	7.27	917																																								
M-SP02	24-Sep-08	< .1	9.1	7.47	805																																								
M-SP02	7-Nov-08	0	3.3	7.93	783																																								
M-SP02	27-Jun-09	2.01	10.8	7.01	829																																								
M-SP02	23-Sep-09	0	10.8	7.92	881																																								
M-SP02	10-Nov-09	0	4.9	8.49	676																																								
M-SP02	26-Jun-10	1.19	6.7	7.15	835																																								
M-SP02	23-Sep-10	0																																											
M-SP02	12-Nov-10	0																																											
M-SP02	27-Jun-11	6.25	5.2	7.41	799																																								
M-SP02	26-Sep-11	1.76	6.8	7.52	796																																								
M-SP02	29-Oct-11	0.35	7.6	7.55	826																																								
M-SP02	27-Jun-12	2.05	10.2	7.55	877																																								
M-SP02	6-Sep-12	0.872	11.2	7.45	841																																								
M-SP02	7-Nov-12	0	2.2	7.6	1385																																								
M-SP02	30-Jun-13	0.063	7.8	7.62	865																																								
M-SP02	25-Sep-13	< .1	10.7	7.99	842																																								
M-SP02	26-Oct-13	< .001	5.7	8.35	783																																								
M-SP02	29-Jun-14	0.005	6.8	7.36	848																																								
M-SP02	29-Aug-14	0	11.4	7.59	847																																								
M-SP02	31-Oct-14	< .005	5.9	8.2	721																																								
M-SP02	24-Jun-15	< .1	12.1	7.47	782																																								
M-SP02	28-Sep-15	0	—	—	—																																								
M-SP02	28-Oct-15	0	—	—	—																																								
M-SP02	25-Jun-16	< .001	10.6	7.42	834																																								
M-SP02	29-Sep-16	0	—	—	—																																								
M-SP02	7-Nov-16	0	—	—	—																																								
M-SP02	28-Jun-17	2.74	7.1	7.43	812																																								
M-SP02	21-Sep-17	0																																											
M-SP02	14-Nov-17	0.387	5.7	7.5	744																																								
M-SP04	19-Jun-01	2.838	5.6	8.05	499	NM	0.62																																							
M-SP04	28-Aug-01	1.832	4.7	7.73	379	NM	0.47																																							
M-SP04	3-May-02	2.043	4.5	7.61	866	NM	0.00																																							
M-SP04	26-Sep-02	0.900	5.3	7.41	844	6.21	0.91																																							
M-SP04	12-Nov-02	1.230	4.8	7.56	885	6.64	5.40																																							
M-SP04	20-May-03	3.226	4.2	7.38	929	7.59	0.00																																							
M-SP04	5-Aug-03	0.849	5.4	7.40	408	7.40	0.10																																							
M-SP04	6-Oct-03	0.747	5.4	7.50	861	7.30	1.02																																							
M-SP04	12-May-04	2.921	4.4	7.59	512	0.69	0.69																																							
M-SP04	26-Jun-15	1.81	4.9	7.68	986										590	36	0.14	0.007																												
M-SP04	30-Sep-15	0.251	6.9	7.89	872										550	152	0.48	0.044																												
M-SP04	1-Nov-15	0.638	5.6	7.72	873										517	109	0.37	0.018																												
M-SP04	25-Jun-16	0.967	5.5	7.75	924										590	36	0.14	0.007																												
M-SP04	28-Sep-16	0.192	6.9	7.90	923										581	129	1.86	0.146																												
M-SP04	31-Oct-16	0.617	5.8	7.77	898										566	83	1.1	0.047																												
M-SP04	28-Jun-17	3.92	5.2	7.58	877										540	<5	<0.05	<0.002																												
M-SP04	27-Sep-17	1.73	5.6	7.68	838										640	17	0.16	0.003																												
M-SP04	13-Nov-17	1.46	5.4	7.64	829																																								
M-SP05	26-Sep-02	0.082	7.7	7.77	780		19.00																																							
M-SP05	20-May-03	0.216	4.3	7.60	910		0.35																																							
M-SP05	25-Sep-03	0.119	7.3	7.78	533		17.70																																							
M-SP05	12-May-04	0.264	3.9	7.92	524		0.16																																							
M-SP05	26-Jun-15	0.127	7.8	7.8	934										577	34	0.41	0.027																												
M-SP05	30-Sep-15	0.085	8.9	7.91	870										561	115	0.38	0.078																												
M-SP05	1-Nov-15	0.157	9.6	7.84	888										548	93	0.83	0.073																												
M-SP05	25-Jun-16	0.096	7.3	7.86	889																																								
M-SP05	28-Sep-16	0.130	7.9	7.91	895										572	117	2.4	0.161																												
M-SP05	31-Oct-16	0.137	6.8	7.92	902										582	93	0.54	0.024																												
M-SP05	28-Jun-17	0.130	7	7.85	892										558	<5	0.11	0.002																												
M-SP05	27-Sep-17	0.134	7.7	7.89	887										304	800	1.69	0.153																												
M-SP05	13-Nov-17	0.142	5.5	7.85	877																																								
M-SP06	19-Jun-01	2.30	9.30	9	550		7.5																																							
M-SP06	4-Oct-01	1.86	6.30	8	474		13.2																																							
M-SP06	3-May-02	2.08	4.90	9	699		0.88																																							
M-SP06	26-Sep-02	1.549	5.4	7.55	695		0																																							
M-SP06	20-May-03	1.472	4.6	7.62	918		1.24																																							
M-SP06	25-Sep-03	1.665	5.3	7.59	514		0																																							
M-SP06	12-May-04	1.624	4.7	7.76	528		0.05																																							
M-SP06	30-Jun-14	1.47	5.3	7.81	916																																								
M-SP06	18-Sep-14	1.46	5.9	7.76	922			29.81	16.02	166.53	1.25	571.812	<5	15	15	559	23	0.39	0.016		0.16	<0.05	<0.1	<0.05	0.05	<0.03	<0.002	< 03	0.58	<0.01	0.05	<0.001	<0.001	<0.01	<0.2	<0.001	<0.01	<0.02	<0.02	<0.004	<5	469	137
M-SP06	31-Oct-14	1.33	5.2	7.78	934			29.06	16.47	165.67	1.3	536.455	18.6	15	15	566	16	<0.05	<0.002		0.17	<0.05		<0.05	<0.05	<0.03	<0.002	0.03	0.05	<0.01	0.02	<0.001	<0.001	<0.01	<0.2	<0.001	<0.01	<0.02	<0.02	<0.004	<5	11	472	139
M-SP06	26-Jun-15	1.45	5.5	7.82	932			25.6	17.69	165.88	1.28	571.812	<5	15	15	557	11	0.17	0.032	0.14	0.13	<0.05	<0.1	<0.05	0.07	<0.03	<0.002	<0.03	0.19	<0.01	0.06	<0.001	<0.001	<0.01	<0.2	<0.001	<0.01	<0.02	<0.02	0.01	<5	469	137
M-SP06	29-Sep-15	1.34	5.8	7.88	868			26.1	16.59	176.66	1.26	551.085	<5	15	12	559	9	<0.05	0.002	1.43	0.17	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.08	<0.01	0.06	<0.001	<0.001	<0.01	<0.2	<0.001	<0.01	<0.02	<0.02	<0.004		10	452	133
M-SP06	1-Nov-15	1.23	5.5	7.77	887			26.4	16.31	172.56	1.44	582.765	<5	15	15	542	25	0.1	0.008	0.9	0.18	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.15	<0.01	0.05	<0.001	<0.001	<0.01	<0.2	<0.001	<0.01	<0.02	<0.02	<0.004		<5	478	133
M-SP06	25-Jun-16	1.34	5.9	7.76	886																																								
M-SP06	28-Sep-16	1.32	5.9	7.78	897										566	67	0.42	0.017																												
M-SP06	31-Oct-16	1.39	5.7	7.79	906										568	12	0.15	0.007																												
M-SP06	28-Jun-17	1.62	5.8	7.76	888										552	36	0.37	0.013																												
M-SP06	27-Sep-17	1.69	5.9	7.81	884										269	<5	<0.05	<0.002																												

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		Field Measurements						Major Ions								Baseline				Nutrients					Trace Metals																		Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	Ca^{+2} mg/L	Mg^{+2} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{-2} mg/L	SO_4^{-2} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	Ol-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP06	13-Nov-17	1.60	5.5	7.85	877																																									
M-SP07	20-Jun-01	1.137	7.8	7.37	491		1.02																																							
M-SP07	29-Aug-01	0.249	7.3	7.5	541		2.25																																						459	
M-SP07	3-May-02	0.409	4.6	8.37	530		11.5					540	< 5	28	32	498		2.2																										449	
M-SP07	26-Sep-02	0.211	6.5	7.45	878	5.21	1.8	65	43	86	1.9	520	< 5	29	31	472		0.8	0.01	0.14		< .03	< .2	< .05		< .02	< .01	0.05		0.0009	0.1	< .005		< .01			< .02		< .07	0.0034		< .01		13		426	340
M-SP07	12-Nov-02	0.273	3.9	7.46	799	4.94	3.9	61	40	80	1.8	553	< 5	30	30	509		0.19	< .01	0.14		< .03	< .2	< .05		< .02	< .01	0.04		0.1	0.07	< .005		< .01			< .02		< .07	0.1		0.02		23		453	320
M-SP07	20-May-03	0.601	4.6	7.36	854	6.17	6.25	60	40	81	1.7	520	< 1	27	26	493		0.55	< .01	0.33		< .03	< .2	< .05		< .02	< .01	< .03		0.0009	0.08	< .005		< .01			< .02		< .07	0.0025		0.01		22		430	310
M-SP07	5-Aug-03	0.28	6.7	7.32	442	6.03	0.95	60	39	81	1.9	530	< 1	28	29	480		0.36	< .01	0.22		< .03	< .2	< .05		< .02	< .01	< .03		0.0006	0.07	< .005		< .01			< .02		< .07	0.002		0.02		17		440	310
M-SP07	7-Oct-03	0.283	6.3	7.62	865	7.02	0.56	63	41	85	2	516	< 5	27	27	517		2.5	0.03	0.21		< .03	< .2	< .05		0.02	0.02	< .03		0.0007	0.07	< .005		< .01			< .02		< .07	0.0024		0.02		9		423	330
M-SP07	10-May-04	0.677	4	7.38	500	6.28	0.53	64	42	87	1.8	526	< 5	37	30	531		< .02	< .01				< .2			< .02	< .01	< .1		0.0008	0.08	< .005		< .01			< .02		< .07	0.0019		< .01		32		433	330
M-SP07	13-May-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	0.14		< .03		< .05																							
M-SP08	20-Jun-01	1.03	8.4	7.78	424		7.58																																							
M-SP08	29-Aug-01	0.433	7.3	7.26	332		2.04																																						279	
M-SP08	3-May-02	0.775	6.3	8.27	600		3.5					564	< 5	33	52	545		0.8																										463	
M-SP08	26-Sep-02	0.023	11.7	7.91	901	5.8		68	38	86	2.7	517	< 5	23	43	494		0.02	< .01	0.14		< .03	< .2	< .05		< .02	< .01	0.05		0.0014	0.09	< .005		< .01			< .02		< .07	0.0034		< .01		7		424	340
M-SP08	12-Nov-02	0																																										21			
M-SP08	20-May-03	0.79	3.9	7.27	1013	2.93	0.66	89	38	110	1.9	560	< 1	34	48	590		0.03	< .01	0.13		< .03	< .2	< .05		< .02	< .01	< .03		0.0013	0.08	< .005		< .01			< .02		< .07	0.0044		0.01				460	330
M-SP08	5-Aug-03	0.096	10.1	7.25	541	2.86	21	65	36	87	2.3	550	< 1	28	40	501		1.4	0.05	0.18		< .03	< .2	< .05		< .02	0.01	< .03		0.0013	0.08	< .005		< .01			< .02		< .07	0.0028		< .01		35		450	310
M-SP08	7-Oct-03	0.08	7.7	7.33	898	2.54	2.08	67	37	90	2.1	526	< 5	24	37	238		0.94	0.03	0.07		< .03	< .2	< .05		0.07	0.02	< .03		0.0011	0.07	< .005		< .01			< .02		< .07	0.0021		0.01		15		431	320
M-SP08	10-May-04	1.189	4.8	7.4	557	5.42	-	67	37	120	2.5	564	< 5	44	60	651		0.23	0.01				< .2			< .02	< .01	< .1		0.0012	0.11	< .005		< .01			< .02		< .07	0.0033		< .01		18		462	320
M-SP08	13-May-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	0.11		< .03		< .05																							
M-SP08	23-Jun-06	0.68	7.8	7.83	931																																								
M-SP08	28-Sep-06	0.51	7.3	7.78	837																																								
M-SP08	8-Nov-06	0.78	5.5	7.49	878																																								
M-SP08	26-Jun-07	0.37	8.6	7.52	888																																								
M-SP08	11-Sep-07	0.071	13.2	7.93	864																																								
M-SP08	8-Nov-07	0.16	3.6	7.82	709																																								
M-SP08	21-Jun-08	0.46	7.8	7.35	932																																								
M-SP08	24-Sep-08	0.016	12.6	8.03	912																																								
M-SP08	6-Nov-08	0																																											
M-SP08	22-Jun-09	0.26	8.1	7.55	897																																								
M-SP08	23-Sep-09	0.011	13.2	7.94	963																																								
M-SP08	10-Nov-09	< .01	5.9	7.74	698																																								
M-SP08	26-Jun-10	0.12	12.1	7.58	930																																								
M-SP08	16-Jul-10	0.0084	27.6	7.1	951																																								
M-SP08	23-Sep-10	0																																											
M-SP08	12-Nov-10	0																																											
M-SP08	27-Jun-11	1.04	6.2	7.72	912																																								
M-SP08	27-Sep-11	0.49	7.9	7.71	930																																								
M-SP08	29-Oct-11	0.73	5.5	7.77	941																																								
M-SP08	27-Jun-12	0.138	10.1	7.99	954																																								
M-SP08	25-Sep-12	0.021	12.9	7.99	996																																								
M-SP08	7-Nov-12	0.0689	5.4	7.93	934																																								
M-SP08	28-Jun-13	0.017	23.9	7.93	1037																																								
M-SP08	25-Sep-13	0.01	9.5	7.67	715																																								
M-SP08	26-Oct-13	0.014	13.4	7.98	953																																								
M-SP08	29-Jun-14	0.015	20.8	8.34	1061																																								
M-SP08	16-Sep-14	0																																											
M-SP08	31-Oct-14	0.012	2.6	7.92	504																																								
M-SP08	25-Jun-15	0.01	36	6.38	1125																																								
M-SP08	26-Sep-15	0.094	15.2	8.05	982																																								
M-SP08	1-Nov-15	0.064	7.8	7.64	988																																								
M-SP08	26-Jun-16	0.074	20.4	7.8	1140																																								
M-SP08	27-Sep-16	0.035	17.5	8.38	972																																								
M-SP08	26-Oct-16	0.050	8.0	7.91	980																																								
M-SP08	29-Jun-17	0.205	11.7	7.68	1,152											695	<5	<0.05	<0.002																												
M-SP08	29-Sep-17	0.131	8.3	7.59	929											29	11	<0.05	<0.002																												
M-SP08	9-Nov-17	0.171	0.3	7.78	975											598	7	<0.05	<0.002																												
M-SP09	20-Jun-01	1	7.9	7.53	464		1.43																																							
M-SP09	29-Aug-01	0																																											
M-SP09	3-May-02	0.254	3.6	8.55	429		141																																						
M-SP09	26-Sep-02	0																																											
M-SP09	20-May-03	0																																											
M-SP09	7-Oct-03	0																																											
M-SP09	10-May-04	0																																											
M-SP09	27-Sep-11	1.430	5.4	7.77	794																																								
M-SP09	29-Oct-11	1.820	—	—	—																																									
M-SP09	25-Jun-15	0																																											
M-SP09	26-Sep-15	0																																											
M-SP09	1-Nov-15	0																																											
M-SP09	26-Jun-16	0	—	—	—																																									
M-SP09	27-Sep-16	0	—	—	—																																									
M-SP09	26-Oct-16	0	—	—	—																																									
M-SP09	29-Jun-17	0																																											
M-SP09	29-Sep-17	<0.05	7.8	7.99	918																																								
M-SP09	9-Nov-17	0																																											
M-SP10	20-Jun-01	0.532	14.5	7.75	610		0.16																																							
M-SP10	28-Aug-01	0.489	7.8	7.76	526							428	< 5	29	85	531		< .1																										351			
M-SP10	1-May-02	0.42	8.5	7.99	490		-					429	< 5	29	75	469		< 1																										352			
M-SP10	25-Sep-02	0.238	7.7	7.84	833	4.56		49	40	84	2.5	403	< 5	25	68	456		< .02	< .01	0.19		< .03	< .2	< .05		< .02	< .01	0.06		0.0014	0.06	< .005		< .01			< .02		< .07	0.0054		< .01		8		330	260
M-SP10	13-Nov-02	0.244	3.8	7.55	814	5.98		47	38	80	2.4	512	< 5	27	73	448		< .02	< .01	0.22		< .03	< .2	< .05		< .02	< .01	0.04		< .1	0.05	< .005		< .01			< .02		< .07	< .1		0.01		14		420	270
M-SP10	20-May-03	0.243	5.8	7.56	509	4.16	1.71	49	40	92	2.5	440	< 1	28	66	510		< .02	< .01	0.17		< .03	< .2	< .05		< .02	< .01	< .03		0.001	0.06	< .005		< .01			< .02		< .07	0.0036		0.01		18		360	290

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		Field Measurements						Major Ions								Baseline				Nutrients					Trace Metals																Other Parameters			
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/l	$NO2+$ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg µg/l	D-Hg µg/l	D-Mn mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Sn mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP10	5-Aug-03	0.224	9.9	7.7	500	5.6	-	46	38	84	2.3	430	4	27	67	420		< .02	< .01	0.16		< .03	< .2	< .05		< .02	< .01	< .03		0.0008	0.05	< 005		< .01			< .02		< .07	0.0035		0.01		22		360	270
M-SP10	7-Oct-03	0.275	6.7	7.67	846	5.55	-	49	39	86	2.5	415	< 5	24	62	484		< .02	< .01	0.21		< .03	< .2	< .05		< .02	< .01	< .03		0.0007	0.05	< 005		< .01			< .02		< .07	0.0036		0.01		10		340	280
M-SP10	10-May-04	0.271	6.1	7.52	538	4.02	0.82	51	41	98	2.4	468	< 5	30	69	473		0.11	0.02				< .2			< .02	< .01	< .1		0.001	0.06	< 005		< .01			< .02		< .07	0.0031		0.01		14		384	300
M-SP10	13-May-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	0.18		< .03		< .05																							
M-SP11	21-Jun-01	0.408	12.8	7.50	488																																										
M-SP11	4-Oct-01	0.000	---	---	---	---																																									
M-SP11	2-May-02	0.548	4.4	7.72	433																																									
M-SP11	28-Sep-02	0.000	---	---	---	---																																									
M-SP11	22-May-03	6.275	7.6	7.83	754																																									
M-SP11	25-Sep-03	0.000	---	---	---	---																																									
M-SP11	4-Jun-04	5.984	6.0	8.02	396																																									
M-SP11	26-Jun-15	0.932	9.3	7.78	866											534	46	0.27	0.063																												
M-SP11	30-Sep-15	Damp	---	---	---																																									
M-SP11	1-Nov-15	0.000	---	---	---																																									
M-SP11	25-Jun-16	<1	13.0	7.69	1,060																																									
M-SP11	28-Sep-16	0.000	---	---	---																																									
M-SP11	31-Oct-16	0.000	---	---	---																																									
M-SP11	28-Jun-17	0.190	11.1	7.77	788											503	151	0.15	0.007																												
M-SP11	27-Sep-17	<0.01	3.7	8.23	627																																									
M-SP11	13-Nov-17	0																																												
M-SP12	19-Jun-01	0.746	22.0	8.44	495																																									
M-SP12	4-Oct-01	0.749	5.4	7.55	399																																									
M-SP12	3-May-02	0.472	2.8	8.07	785																																									
M-SP12	26-Sep-02	0.422	5.5	7.71	714																																									
M-SP12	21-May-03	Immeas	3.9	7.62	779																																									
M-SP12	27-Sep-03	0.263	5.5	7.56	443																																									
M-SP12	3-Jun-04	0.937	4.4	7.71	430																																									
M-SP12	26-Jun-15	0.873	5.5	7.94	837											500	13	<0.05	0.003																												
M-SP12	30-Sep-15	0.769	6.5	7.96	784											484	44	0.09	0.006																												
M-SP12	6-Nov-15	0.847	5.3	7.75	798											506	26	0.18	0.008																												
M-SP12	25-Jun-16	0.781	5.3	7.84	804											459	8	0.28	0.009																												
M-SP12	29-Sep-16	0.785	6.1	7.82	808											496	7	0.08	<.002																												
M-SP12	31-Oct-16	0.817	5.8	7.80	814											485	36	0.31	0.01																												
M-SP12	28-Jun-17	0.811	5.3	7.87	804											590	84	0.47	0.039																												
M-SP12	27-Sep-17	0.899	6.1	7.81	801																																									
M-SP12	13-Nov-17	0.943	5.5	7.78	757																																									
M-SP14	21-Jun-01	11.229	4.8	7.35	295																																									
M-SP14	29-Aug-01	0.865	6.9	7.35	340							526	<5	6	3	358		<0.1																												
M-SP14	20-May-02	1.95	4	7.47	542							392	<5	6	3	300		<0.1																												
M-SP14	26-Sep-02	Dry	---	---	---																																									
M-SP14	20-May-03	37.2	3.9	7.42	304			79	25	17	0.7	390	<1	6.1	2.1	349		<0.02	<0.01																												
M-SP14	4-Aug-03	Dry	---	---	---																																									
M-SP14	9-Oct-03	Dry	---	---	---																																									
M-SP14	6-Jun-04	61.4	4.4	7.58	309			77	24	15	0.8	360	<5	7.6	3.3	338		<0.02	<0.01																												
M-SP15	11-Jul-01	4.822	13.5	8.26	821		69.90																																								
M-SP15	3-Oct-01	1.733	6.4	8.34	433		3.68																																								
M-SP15	2-May-02	0.548	5.4	7.70	448		0.00																																								
M-SP15	27-Sep-02	0																																												
M-SP15	21-May-03	0.433	14.9	7.65	509		14.07																																								
M-SP15	8-Oct-03	0																																												
M-SP15	5-Jun-04	0.268	15.5	8.14	930		2.52																																								
M-SP15	27-Jun-15	0.059	12.9	7.42	1073											528	31	0.29	0.046																												
M-SP15	29-Sep-15	0																																												
M-SP15	7-Nov-15	0																																												
M-SP15	23-Jun-16	<0.1	9.9	7.37	986											575	15	0.22	0.052																												
M-SP15	26-Sep-16	0.000	---	---	---																																									
M-SP15	6-Nov-16	0.000	---	---	---																																									
M-SP15	30-Jun-17	0.037	12	7.14	1050											526	60	0.12	0.006																												
M-SP15	28-Sep-17	<0.1	8.1	7.59	978											598	29	4	0.187																												
M-SP15	10-Nov-17	<0.25	Only	Pool																																										
M-SP18	22-Jun-01	0.34	6.6	6.96	728		0.36																																								
M-SP18	28-Aug-01	0.212	8.3	7.58	726		0.32					431	< 5	261	833	865		0.2																											353		
M-SP18	1-May-02	0.33	6.8	7.23	1274		0.46					346	< 5	316	70	858		0.7																											284		
M-SP18	25-Sep-02	0																																												
M-SP18	12-Nov-02	0																																												
M-SP18	20-May-03	0.147	5.5	7.35	748	4.65	9.6	130	45	96	5.2	350	< 1	260	73	879		37	0.24	0.08		< .03	< .2	< .05		0.03	0.01	< .03		0.0015	0.06	< .005		< .01			< .02		< .07	0.0044		0.01		16		290	510
M-SP18	6-Aug-03											344	< 5			830				0.07		< .03		< .05																				13		282	
M-SP18	8-Aug-03	0.344	10	7.34	748	4.74	1.3	120	41	88	5.1	350	< 1	300	78			0.07	< .01				< .2			0.04	0.01	< .03		0.001	0.08	< .005		< .01			< .02		< .07	0.003		< .01				290	470
M-SP18	6-Oct-03	0.47	6.9	7.26	1276	5.16	0.38	120	42	90	5.2	350	< 5	300	72	876		0.57	0.01	0.07		< .03	< .2	< .05		0.08	< .01	< .03		0.0007	0.08	< .005		< .01			< .02		< .07	0.0032		0.01		11		287	470
M-SP18	11-May-04	0.463	4.2	7.47	728	5.01	2.62	130	44	96	5.2	329	< 5	330	61	883		1.2	< .01	0.08		< .03	< .2	< .05		< .02	< .01	< .1		0.0029	0.07	< .005		< .01			< .02		< .07	0.0088		0.01		12		270	510
M-SP18	26-May-06	0.65	4.2	7.66	1214																																									
M-SP18	28-Sep-05	0.45	6	7.46	1174																																									
M-SP18	8-Nov-06	0.47	4.5	7.45	1165																																								
M-SP18	26-Jun-07	0.25	6	7.49	1198																																								
M-SP18	11-Sep-07	0.21	8.3	7.75	1435																																								
M-SP18	8-Nov-07	0.29	4.1	7.66	1428																																								
M-SP18	21-Jun-08	0.2	5.2	7.24	1245																																								
M-SP18	24-Sep-08	0.06	6.9	7.29	1227																																								
M-SP18	6-Nov-08	0.252	4.3	7.41	1226																																								
M-SP18	27-Jun-09	0.082	6.3	7.11	1283																																								
M-SP18	23-Sep-09	0.229	7.8	7.25	1264																																								

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		Field Measurements						Major Ions								Baseline				Nutrients						Trace Metals																				Other Parameters			
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3 mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP18	10-Nov-09	0.244	4.5	7.38	1259																																										
M-SP18	26-Jun-10	0.227	8.9	7.17	1347																																										
M-SP18	23-Sep-10	0.118	7.6	7.18	1394																																										
M-SP18	12-Nov-10	0.257	2.2	7.27	1359																																										
M-SP18	27-Jun-11	0.77	9.1	7.52	1228																																										
M-SP18	26-Sep-11	0.431	7.8	7.44	1289																																										
M-SP18	29-Oct-11	0.456	3.4	7.79	1324																																										
M-SP18	27-Jun-12	0.36	16.5	7.49	1317																																										
M-SP18	6-Sep-12	0.149	14.2	7.51	1528																																										
M-SP18	7-Nov-12	0.128	2.2	7.6	1385																																										
M-SP18	30-Jun-13	0.115	8.3	7.31	1365																																										
M-SP18	25-Sep-13	0.145	8.2	7.35	1389																																										
M-SP18	28-Oct-13	0.128	6.6	7.39	1302																																										
M-SP18	29-Jun-14	< .05	7.4	7.51	1356																																										
M-SP18	29-Aug-14	0	8.1	7.33	1364																																										
M-SP18	5-Nov-14	0.299	3.5	7.53	1380																																										
M-SP18	26-Jun-15	0.225	8.9	7.49	1352																																										
M-SP18	28-Sep-15	0.076	8.9	7.72	1298																																										
M-SP18	28-Oct-15	0.151	5.6	7.76	1323																																										
M-SP18	23-Jun-16	0.131	10.1	7.54	1314																																										
M-SP18	28-Sep-16	0.186	7.7	7.52	1336																																										
M-SP18	7-Nov-16	0.229	5.1	7.67	1,333																																										
M-SP18	29-Jun-17	0.211	7.7	7.52	1,274											908	<5	<0.05	<0.002																													
M-SP18	30-Sep-17	0.253	7.0	7.44	1,295																																										
M-SP18	14-Nov-17	0.201	3.0	7.54	1,196											911	<5	<0.05	<0.002																													
M-SP19	11-Jul-01	2.260	10.4	8.24	508		5.90																																								
M-SP19	3-Oct-01	1.976	6.1	7.83	443		0.17																																								
M-SP19	2-May-02	3.031	5.1	8.28	456		0.46																																								
M-SP19	27-Sep-02	2.114	5.8	7.94	457		0.35																																								
M-SP19	21-May-03	2.868	5.2	7.86	449		12.30																																								
M-SP19	8-Oct-03	2.555	6.1	8.21	480		0.68																																								
M-SP19	5-Jun-04	3.128	6.5	8.23	851		1.34																																								
M-SP19	27-Jun-15	2.56	5.7	7.97	873											522	40	0.36	0.044																													
M-SP19	28-Sep-15	1.73	6.3	8.04	824											523	12	0.27	0.004																													
M-SP19	7-Nov-15	1.95	6	7.98	829											519	16	0.11	0.004																													
M-SP19	23-Jun-16	2.53	6.0	8.00	835																																									
M-SP19	26-Sep-16	1.74	6.4	8.00	845											533	25	0.49	0.009																													
M-SP19	8-Nov-16	2.05	6.3	8.07	840											509	<5	<0.05	<0.002																													
M-SP19	30-Jun-17	4.49	6.1	8.05	818											514	12	0.06	<0.002																													
M-SP19	28-Sep-17	3.28	6.3	8.01	822											513	<5	<0.05	<0.002																													
M-SP19	10-Nov-17	3.11	6.2	8.01	813											504	<5	<0.05	<0.002																													
M-SP20	11-Jul-01	3.507	14.2	7.84	486		3.52																																								
M-SP20	3-Oct-01	0.909	12.1	7.85	435		5.20																																								
M-SP20	2-May-02	0.814	10.5	7.97	432		0.00																																								
M-SP20	26-Sep-02	0.706	7.4	7.79	435		20.00																																								
M-SP20	22-May-03	1.041	7.6	7.59	420		19.05																																								
M-SP20	8-Oct-03	0.781	11.0	8.31	494		18.60																																								
M-SP20	5-Jun-04	8.621	10.8	7.92	814		0.35																																								
M-SP20	25-Jun-15	5.24	8.3	7.78	624											468	13	0.15	0.016																													
M-SP20	26-Sep-15	1.04	7.5	7.38	769											505	87	0.37	0.049																													
M-SP20	1-Nov-15	1.21	6.8	7.69	763											453	23	0.85	0.042																													
M-SP20	26-Jun-16	1.90	6.6	7.41	775																																										
M-SP20	27-Sep-16	0.980	7.0	7.56	781											484	13	0.11	0.004																													
M-SP20	26-Oct-16	0.980	7.8	7.79	770											440	7	0.13	0.013																													
M-SP20	29-Jun-17	8.060	7.4	7.61	736											432	7	0.23	0.032																													
M-SP20	29-Sep-17	1.490	7	7.52	747											446	14	0.49	0.047																													
M-SP20	9-Nov-17	1.440	7.1	7.57	745											443	46	0.61	0.047																													
M-SP36	20-Jul-01	2.270	8.9	8	562		1.90																																								
M-SP36	5-Oct-01	1.497	6.2	8.07	603		0.00																																								
M-SP36	22-May-02	0.666	9.3	8.76	688		8.67																																								
M-SP36	26-Sep-02	1.559	6.4	8.02	626		0.05																																								
M-SP36	4-Jun-03	1.715	4.3	8.36	615		0.63																																								
M-SP36	23-Sep-03	1.752	6.2	8.12	619		0.32																																								
M-SP36	16-Jun-04	1.930	4.8	8.22	652		0.63																																								
M-SP37	20-Jul-01	1.528	8.2	8.46	658		2.98																																								
M-SP37	5-Oct-01	1.660	6.1	8.12	667		0.00																																								
M-SP37	22-May-02	1.827	5.9	8.58	746		3.97																																								
M-SP37	26-Sep-02	1.424	6.4	8.1	720		0.10																																								
M-SP37	4-Jun-03	2.110	5.2	8.33	714		0.41																																								
M-SP37	23-Sep-03	1.540	6.1	8.11	725		0.45																																								
M-SP37	16-Jun-04	2.327	5.4	8.26	737		0.00																																								
M-SP38	20-Jul-01	5.71	8.4	7.99	302		25.50																																								
M-SP38	29-Aug-01	5.538	8.5	7.39	303	0		38	22	49	<1	353	<5	14	3	313		<0.1																											289		
M-SP38	26-May-02	2.832	7.8	7.70	321	0.69		39	23	49	<1	332	<5	15	3	311		<0.1		0.17				0.07																					273		
M-SP38	26-Sep-02	4.956	8.7	7.59	301	0		40	24	52	1.1	327	<5	17	3	288		<0.02	<0.01	0.13	<0.03	<0.02		<0.02	<0.01	0.03	0.0021	<0.05	<0.005	<0.01	<0.07	0.0009	0.05	6	268	200
M-SP38	13-Nov-02	4.999	8.4	7.64	276	0		37	23	48	1	322	<5	16	3.3	282		<0.02	<0.01	0.13	<0.03	<0.02	<0.05	<0.02	<0.01	0.03	0.1	<0.05	<0.005	<0.01	<0.07	<0.1	0.02	9	264	190
M-SP38	20-May-03	5.111	7.7	7.65	179	10.95		40	24	50	1.2	330	<1	16	3.6	298		<0.02	<0.01	0.2	<0.03	<0.02	<0.05	<0.02	<0.01	<0.03	0.002	<0.05	<0.005	<0.01	<0.07	0.0009	0.02	11	270	200
M-SP38	4-Aug-03	5.24	8.5	7.47	267	18		40	23	48	1	329	<5	17	3.3	293		0.39	0.01	<0.03	<0.03	<0.02	<0.05	<0.02	<0.01	<0.03	0.0021	<0.05	<0.005	<0.01	<0.07	0.0006	<0.01	21	290	190
M-SP38	7-Oct-03	5.764	8.8	7.7	312	1.37		39	24	52	1.1	339	<5	16	3.2	303		<0.03	<0.03	<0.03	<0.03	<0.02	<0.05	<0.02	<0.01	<0.03	0.0023	<0.05	<0.005	<0.01	<0.07	0.0006	<0.01	<5	278	200
M-SP38	6-Jun-04	5.808	7.9	7.7	313	1.11		40	24	48	1.2	336	<5	17	3.4	319		<0.02	<0.01	0.13	<0.05	<0.02	0.1	<0.02	<0.01	<0.1	0.0026	<0.05	<0.005	<0.01	<0.07	0.0011	<0.01	<5	275	200

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		Field Measurements						Major Ions							Baseline				Nutrients						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP39	30-Aug-01	1.068	7.1	7.16	590							552	< 5.	67	63	604		0.1																											453		
M-SP39	3-May-02	4.663	5.3	7.48	603		3.25					520	< 5.	70	61	554		0.2																											427		
M-SP39	25-Sep-02	0.441	6.5	7.56	1011	5.63		78	49	88	2.2	504	< 5.	68	60	563		0.02	< .01	0.1		< .03	< .2	< .05		< .02	< .01	0.06		0.002	0.09	< .005		< .01			< .02	< .07	0.0073		0.06		15		413	400
M-SP39	13-Nov-02	0.566	5.8	7.36	986	5.04	0.15	73	48	82	2.1	510	< 1.	67	61	553		0.02	< .01	0.04		< .03	< .2	< .05		< .02	< .01	0.05		< .1	0.08	< .005		< .01			< .02	< .07	< .1		0.01		23		330	380
M-SP39	20-May-03	2.374	5.7	7.43	573	7.39	9.24	79	50	88	2.1	510	< 1.	68	57	609		< .02	< .01	0.05		< .03	< .2	< .05		< .02	< .01	< .03		0.0013	0.06	< .005		< .01			< .02	< .07	0.0051		0.01		23		426	410
M-SP39	6-Aug-03											503	< 5.			596				< .03		< .03		< .05																			13		413	
M-SP39	9-Aug-03	0.509	6.4	7.4	585	5.78	0.11	74	46	83	2	550	< 1.	75	62			< .02	< .01				< .2			< .02	< .01	< .03		0.0007	0.07	< .005		< .01			< .02	< .07	0.0032		< .01				450	370
M-SP39	7-Oct-03	0.266	6.2	7.39	1035	4.5	0.13	78	48	87	2.2	519	< 5.	65	56	595		0.09	0.01	0.03		< .03	< .2	< .05		0.06	0.01	< .03		0.0005	0.07	< .005		< .01			< .02	< .07	0.0035		0.07		16		425	390
M-SP39	12-May-04	0.446	5.7	7.54	604	4.86	0.24	80	50	89	2.1	530	< 1.	78	64	1214		< .02	< .01	0.04		< .03	< .2	< .05		< .02	< .01	< .1		0.0014	0.08	< .005		< .01			< .02	< .07	0.0044		0.02		18		430	410
M-SP39	30-Aug-01	1.068	7.1	7.16	590																																									
M-SP39	3-May-02	4.663	5.3	7.48	603																																								
M-SP39	25-Sep-02	0.441	6.5	7.56	1011	5.63																																								
M-SP39	13-Nov-02	0.566	5.8	7.36	986	5.04																																								
M-SP39	20-May-03	2.374	5.7	7.43	573	7.39																																								
M-SP39	9-Aug-03	0.509	6.4	7.40	585	5.78																																								
M-SP39	7-Oct-03	0.266	6.2	7.39	1035	4.50																																								
M-SP39	12-May-04	0.446	5.7	7.54	604	4.86																																								
M-SP39	23-Jun-06	1.84	5.4	7.59	982																																								
M-SP39	28-Sep-06	0.66	6.2	7.87	931																																								
M-SP39	8-Nov-06	0.64	5.9	7.64	960																																								
M-SP39	26-Jun-07	0.72	6.7	7.67	983																																								
M-SP39	11-Sep-07	0.94	7.8	8.31	1080																																								
M-SP39	8-Nov-07	1.38	5.9	7.74	1048																																								
M-SP39	13-Jun-08	2.04	6.1	7.39	1086																																								
M-SP39	24-Sep-08	0.89	6.1	7.72	954																																								
M-SP39	6-Nov-08	1.2	5.8	7.5	941																																								
M-SP39	27-Jun-09	2.04	6.8	7.22	975																																								
M-SP39	23-Sep-09	1.11	7.1	7.39	1058																																								
M-SP39	10-Nov-09	1.9	6.2	7.51	858																																								
M-SP39	26-Jun-10	0.24	11.2	7.29	1054																																								
M-SP39	23-Sep-10	0.753	5.8	7.65	1029																																								
M-SP39	12-Nov-10	1.12	4.6	7.29	994																																								
M-SP39	27-Jun-11	2.71	4.1	7.67	981																																								
M-SP39	26-Sep-11	0.962	4.8	7.53	782																																								
M-SP39	29-Oct-11	1.38	6.2	7.72	1007																																								
M-SP39	27-Jun-12	1.03	9.2	7.63	1024																																								
M-SP39	6-Sep-12	0.221	5.2	7.55	1013																																								
M-SP39	7-Nov-12	1.29	6.2	7.77	1007																																								
M-SP39	28-Jun-13	1.44	6.1	7.64	997																																								
M-SP39	25-Sep-13	1.06	6.8	7.53	984																																								
M-SP39	26-Oct-13	1.17	6.5	7.51	942																																								
M-SP39	29-Jun-14	0.61	6.3	7.51	982																																								
M-SP39	29-Aug-14	0.987	6.5	7.5	1002																																								
M-SP39	31-Oct-14	0.769	6.2	7.52	1021																																								
M-SP39	26-Jun-15	1.27	6.2	7.59	1026																																								
M-SP39	28-Sep-15	0.581	6.9	7.65	947																																								
M-SP39	28-Oct-15	0.67	6.7	7.58	964																																								
M-SP39	25-Jun-16	0.87	6.6	7.44	960																																								
M-SP39	29-Sep-16	0.434	7.2	7.49	969																																								
M-SP39	7-Nov-16	0.434	6.6	7.65	970																																								
M-SP39	28-Jun-17	0.735	6.7	7.58	954											556	14	0.26	0.013																												
M-SP39	21-Sep-17	0.390	12.3	8.11	1,005																																									
M-SP39	15-Nov-17	0.700	6.1	7.63	904																																									
M-SP40	26-Sep-01	0.657	7.9	7.64	497		30.40																																								
M-SP40	2-May-02	0.455	7.5	7.92	865		11.60																																								
M-SP40	28-Sep-02	0.336	8.4	7.72	483		0.70																																								
M-SP40	22-May-03	0.314	6.9	7.77	538		15.03																																								
M-SP40	9-Oct-03	0.180	8.3	7.76	900		19.00																																								
M-SP40	6-Jun-04	0.447	7.7	8.10	545		0.68																																								
M-SP40	25-Jun-15	0.102	7.4	7.82	959											584	283	3.43	0.228																												
M-SP40	26-Sep-15	0.082	9.5	7.77	905											598	337	1.13	0.253																												
M-SP40	1-Nov-15	0.093	8	7.78	925											554	218	0.87	0.076																												
M-SP40	26-Jun-16	0.107	8.0	7.74	930																																								
M-SP40	27-Sep-16	0.068	9.1	7.85	956											606	106	0.37	0.017																												
M-SP40	26-Oct-16	0.087	8.4	7.93	943											569	32	0.37	0.018																												
M-SP40	29-Jun-17	0.277	7.2	7.79	849											503	50	0.51	0.042																												
M-SP40	29-Sep-17	0.292	8.1	7.77	827											461	<5	0.07	<0.002																												
M-SP40	9-Nov-17	0.391	7.6	7.87	818											489	15	0.11	0.009																												
M-SP41	26-Sep-01	0.422	5.3	7.85	285		1.25																																								
M-SP41	2-May-02	2.253	10.2	8.53	616		28.90																																								
M-SP41	28-Sep-02	0.427	5.1	7.97	323		4.50																																								
M-SP41	22-May-03	0.472	3.9	7.99	429		24.03																																								
M-SP41	9-Oct-03	0.402	4.9	7.87	799		0.86																																								
M-SP41	6-Jun-04	0.509	6.0	8.14	452		0.48																																								
M-SP41	25-Jun-15	0.974	9.7	7.52	897											952	28	0.18	0.031																												
M-SP41	26-Sep-15	0.313	5.9	7.94	765											521	435	1.1	0.111																												
M-SP41	1-Nov-15	0.321	5	7.87	789											479	60	0.68	0.016																												
M-SP41	26-Jun-16	0.210	4.7	7.80	786																																								
M-SP41	27-Sep-16	0.193	5.4	7.97	795											503	107	1.62	0.068																												
M-SP41	26-Oct-16	0.245	5.2	7.98	796											490	37	0.47	0.015																												
M-SP41	29-Jun-17	0.354	4.5	7.86	764											472	79	0.59	0.031																												
M-SP41	29-Sep-17	0.364	5.2	7.87	786											451	103	1.3	0.093																												
M-SP41	9-Nov-17	0.282	4.8	7.94	770											487	94	1.14	0.038																												

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		Field Measurements						Major Ions							Baseline				Nutrients						Trace Metals																				Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3 mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP44	3-Oct-01	0.561	9.2	7.52	314		5.39																																								
M-SP44	2-May-02	2.016	4.6	7.66	269		0.00																																								
M-SP44	28-Sep-02	0.196	10.3	7.66	376		110.00																																								
M-SP44	22-May-03	13.029	6.1	7.85	276		11.91																																								
M-SP44	24-Sep-03	0.197	12.1	7.93	721		15.30																																								
M-SP44	5-Jun-04	4.900	5.4	7.65	542		0.00																																								
M-SP44	29-Jun-14	3.18	5.9	7.84	554			86.00	33.00	15.00	0.48	345.038	<5	19	1	313		<0.05	<0.002	0.34			<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	<0.03	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004		8		283	298
M-SP44	18-Sep-14	0.588	8.7	7.78	610			64.82	23.48	27.48	0.58	360.888	<5	25	2	340	26	0.22	0.010		0.24	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.33	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		296	259
M-SP44	31-Oct-14	0.595	8.2	7.58	611			63.52	24.9	26.29	0.89	370.641	<5	26	2	358	27	0.12	0.010	<0.05	0.06	<0.05	0.1	<0.05	<0.05	<0.03	0.002	<0.03	0.24	<0.01	<0.01	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		12		304	261
M-SP44	25-Jun-15	4.21	8	7.67	570			68.47	32.10	9.94	0.57	362.107	<5	14	1	348	37	0.34	0.046	0.14	0.16	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.46	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.004		7		297	303
M-SP44	26-Sep-15	0.493	9.2	7.54	581			63.37	26.32	30.97	<0.14	362.107	<5	18	1	367		0.12	0.006	0.29	0.06	<0.05	0.3	<0.05	<0.05	<0.03	<0.002	<0.03	0.2	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004		5		297	267
M-SP44	1-Nov-15	0.45	8.3	7.59	594			65.95	25.55	35.83	0.64	375.518	<5	26	2	365	14	0.13	0.005	0.86	0.12	<0.05	0.9	0.06	<0.05	<0.03	<0.002	<0.03	0.21	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		308	270
M-SP44	28-Jun-16	3.74	6.3	7.52	547			68.47	32.1	9.94	0.57	362	<5	14	1	348	37	0.34	0.046	0.14	0.16	<0.05	<0.1	<0.05		<0.03	<0.002	<0.03	0.48	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.004		7		297	303
M-SP44	27-Sep-16	0.530	8.9	7.55	593											372	35	0.25	0.019																													
M-SP44	26-Oct-16	0.495	8.6	7.65	597											330	41	0.61	0.022																													
M-SP44	29-Jun-17	5.350	5.3	7.55	532											295	28	0.1	0.002																													
M-SP44	29-Sep-17	0.760	8.5	7.56	569											303	30	0.59	0.017																													
M-SP44	9-Nov-17	0.550	7.9	7.63	560											332	32	0.5	0.02																													
M-SP45	4-Oct-01	2.230	5.9	7.32	508		0.60																																								
M-SP45	3-May-02	1.837	3.5	7.85	969		0.00																																								
M-SP45	25-Sep-02	1.713	6.0	7.58	977		0.00																																								
M-SP45	21-May-03	1.824	3.7	7.30	977		1.67																																								
M-SP45	27-Sep-03	1.541	5.9	7.30	545		0.29																																								
M-SP45	3-Jun-04	0.673	5.0	7.42	369		1.08																																								
M-SP45	26-Jun-15	1.26	5.1	7.47	996											594	<5	<0.05	<0.002																													
M-SP45	30-Sep-15	1.21	6.5	7.47	923											580	34	0.34	0.005																													
M-SP45	6-Nov-15	1.21	5.9	7.38	933											586	25	0.3	0.006																													
M-SP45	25-Jun-16	1.28	5.4	7.53	931																																									
M-SP45	29-Sep-16	1.29	6.5	7.38	952											532	13	1.45	0.021																													
M-SP45	31-Oct-16	1.03	6.1	7.46	940											597	55	0.26	0.004																													
M-SP45	28-Jun-17	1.53	5.3	7.5	935											566	<5	<0.05	<0.002																													
M-SP45	27-Sep-17	1.49	8.5	7.41	932											670	<5	0.32	<0.002																													
M-SP45	13-Nov-17	1.49	5.7	7.46	886																																									
M-SP48	19-Oct-01	1.213	9.7	7.96	311		0.30																																								
M-SP48	22-May-02	1.694	7.7	8.08	345		7.99																																								
M-SP48	7-Oct-02	0.959	9.6	8.03	545		3.63																																								
M-SP48	4-Jun-03	1.307	7.1	7.92	321		0.27																																								
M-SP48	23-Sep-03	1.119	9.7	8	330		0.00																																								
M-SP48	16-Jun-04	1.482	7.6	8.05	341																																								
M-SP49	19-Oct-01	0.363	9.2	8.29	303		11.30																																								
M-SP49	22-May-02	0.261	7.7	8.29	347		7.86																																								
M-SP49	8-Oct-02	0.3	7.9	7.22	538		0.37																																								
M-SP49	4-Jun-03	0.313	6.3	7.55	323		0.54																																								
M-SP49	23-Sep-03	0.211	8.6	7.55	325		4.74																																								
M-SP49	16-Jun-04	0.38	7.4	7.56	328		6.73																																								
M-SP53	24-Oct-01																																													
M-SP53	24-Oct-01	0.092	2.9	7.82	366																																									
M-SP53	2-May-02	0.109	4.5	7.81	15		0.17																																								
M-SP53	27-Sep-02	0.090	7.2	7.61	402																																									
M-SP53	21-May-03	0.101	6.7	7.66	381		0.75																																								
M-SP53	27-Sep-03	0.48	8.5	7.68	694		0.84																																								
M-SP53	6-Jun-04	0.087	6.9	7.77	417																																								
M-SP53	23-Jun-06	0.11	10.4	7.79	698																																								
M-SP53	28-Sep-06	0.104	8.5	7.93	839																																								
M-SP53	4-Nov-06	0.11	3.8	7.49	648																																								
M-SP53	25-Jun-07	0.079	10.2	7.95	697																																								
M-SP53	24-Sep-07	0.087	5	7.58	580																																								
M-SP53	29-Oct-07	0.084	5.9	7.51	592																																								
M-SP53	21-Jun-08	0.072	9.2	7.52	692																																								
M-SP53	24-Sep-08	0.27	8.7	7.63	687																																								
M-SP53	6-Nov-08	0.081	3.2	7.75	644																																								
M-SP53	19-Jun-09	0.062	8.6	7.55	683																																								
M-SP53	23-Sep-09	0.065	8.6	7.67	686																																								
M-SP53	10-Nov-09	0.064	5.5	7.46	682																																								
M-SP53	26-Jun-10	0.057	9.8	7.51	734																																								
M-SP53	16-Jul-10	0.058	14.3	7.75	698																																								
M-SP53	23-Sep-10	0.059	9.1	7.69	713																																								
M-SP53	12-Nov-10	0.058	3.1	7.52	682																																								
M-SP53	27-Jun-11	0.124	8.2	7.87	663																																								
M-SP53	26-Sep-11	0.117	12.9	7.63	728																																								
M-SP53	29-Oct-11	0.126	6.4	7.78	703																																								
M-SP53	27-Jun-12	0.11	8.3	7.85	730																																								
M-SP53	25-Sep-12	0.116	6	7.69	723																																								
M-SP53	7-Nov-12	0.113	6.3	7.79	713																																								
M-SP53	28-Jun-13	0.091	9.5	7.79	728																																								
M-SP53	25-Sep-13	0.078	9.5	7.67	715																																								
M-SP53	26-Oct-13	0.08	8.6	7.66	684																																								
M-SP53	21-Jun-14	0.07	11.6	7.75	701																																								
M-SP53	18-Sep-14	0.063	13.8	7.75	714																																								
M-SP53	31-Oct-14	0.063	9.5	7.67	722																																								
M-SP53	25-Jun-15	0.055	14.3	7.9	722																																								
M-SP53	26-Sep-15	0.056	14.5	7.76	684																																								

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		Field Measurements						Major Ions								Baseline				Nutrients						Trace Metals																		Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP53	1-Nov-15	0.05	9.6	7.67	686																																									
M-SP53	26-Jun-16	0.053	19.2	7.68	711																																									
M-SP53	27-Sep-16	0.054	14.3	7.59	708																																									
M-SP53	26-Oct-16	0.054	7.6	7.76	698																																									
M-SP53	29-Jun-17	0.068	14.2	7.80	784																																									
M-SP53	29-Sep-17	0.072	7.4	7.64	929																																									
M-SP53	9-Nov-17	0.073	4.6	7.78	694																																									
M-SP54	25-Oct-01	1.131	6.7	8.11	463		0.52																																								
M-SP54	23-May-02	1.014	4.7	8.27	481		5.50																																								
M-SP54	7-Oct-02	1.092	6.3	7.89	869		0.31																																								
M-SP54	4-Jun-03	1.282	4.2	7.92	488		0.01																																								
M-SP54	23-Sep-03	1.051	6.2	7.93	504		0.00																																								
M-SP54	16-Jun-04	1.371	4.9	7.87	517		1.06																																								
M-SP55	25-Oct-01	0.722	2.9	8.20	519		0.00																																								
M-SP55	22-May-02	0.879	3.8	8.57	607		14.10																																								
M-SP55	7-Oct-02	0.627	5.1	7.55	955		0.55																																								
M-SP55	4-Jun-03	0.853	4.5	7.43	572		0.14																																								
M-SP55	23-Sep-03	0.787	5.2	7.51	575		0.22																																								
M-SP55	16-Jun-04	0.698	4.4	7.51	598		0.46																																								
M-SP 56	25-Oct-01	3.599	3.7	8.52	598		0.09																																								
M-SP 56	22-May-02	3.910	7.7	8.66	718		18.60																																								
M-SP 56	7-Oct-02	3.305	5.5	7.84	1,147		0.00																																								
M-SP 56	4-Jun-03	1.590	5.0	7.87	650		0.00																																								
M-SP 56	23-Sep-03	2.679	5.6	7.97	662		0.00																																								
M-SP 56	16-Jun-04	3.196	5.1	8.01	682		0.00																																								
M-SP57	25-Oct-01	0.726	5.7	8.22	790		4.27																																								
M-SP57	22-May-02	1.296	6.6	8.42	889		11.70																																								
M-SP57	26-Sep-02	0.487	7.2	8.24	850		3.60																																								
M-SP57	4-Jun-03	1.768	5.7	7.98	825		0.18																																								
M-SP57	23-Sep-03	0.592	7.1	8.10	833		2.38																																								
M-SP57	16-Jun-04	1.631	5.8	7.90	862		0.38																																								
M-SP59	24-Oct-01	0.372	3.4	7.58	446		1.13																																								
M-SP59	2-May-02	0																																												
M-SP59	27-Sep-02	0.117	6.4	7.6	451		1.1																																								
M-SP59	21-May-03	0.216	8.5	8.04	478		1.53																																								
M-SP59	27-Sep-03	0.69	7.1	7.92	859		13.9																																								
M-SP59	6-Jun-04	0.173	7.4	8.08	509		0.67																																								
M-SP59	27-Jun-15	0.014	13.7	7.87	836																																								
M-SP60	2-May-02	0.888	5.7	7.64	403		5.70																																								
M-SP60	27-Sep-02	0.728	8.0	7.52	512		0.10																																								
M-SP60	21-May-03	0.761	6.5	7.63	491		14.25																																								
M-SP60	8-Oct-03	0.600	7.8	7.63	426		0.81																																								
M-SP60	4-Jun-04	0.676	9.6	7.79	943		0.76																																								
M-SP60	30-Jun-14	0.72	11.5	7.68	931			54.00	40.00	89.00	2.00	535.235	<5	27	39	513		0.08	0.007		0.18	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.14	<0.01	0.07	<0.001	<0.001	<0.01	<0.2	0.001	<0.01	<0.02	<0.02	<0.004	<5	439	299
M-SP60	23-Sep-14	0.57	8.4	7.67	935			57.42	43.29	94.13	1.69	510.651	<5	26	39	527	<5	0.05	<0.002		0.13	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	0.03	0.03	<0.01	0.07	<0.001	<0.001	<0.01	<0.2		<0.01	<0.02	<0.02	<0.004	<5	419	322
M-SP60	6-Nov-14	0.56	6.9	7.61	932			61.05	41.92	95.59	1.74	513.289	<5	26	39	507	13	<0.05	0.002	<0.05	0.13	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.05	<0.01	0.12	<0.001	<0.001	<0.01	<0.2	0.001	<0.01	<0.02	<0.02	0.009	8	421	325
M-SP60	27-Jun-15	0.545	6.9	7.61	960			52.98	43.64	92.22	1.76	507.193	<5	26	39	536		0.14	0.017	2.76	0.11	<0.05	<0.1	<0.05	<0.05	0.04	0.004	<0.03	0.23	<0.01	0.05	<0.001	0.009	<0.01	<0.2	0.002	<0.01	<0.02	<0.02	0.096	<5	416	312
M-SP60	29-Sep-15	0.348	9.5	7.8	876			53.87	41.74	98.2	1.81	518.166	<5	25	36	552	23	0.55	0.043	1.36	0.17	0.39	0.3	<0.05	<0.05	<0.03	<0.002	0.03	0.91	<0.01	0.07	<0.001	<0.001	<0.01	<0.2	<0.001	<0.01	<0.02	0.03	<0.004	<5	425	306
M-SP60	7-Nov-15	0.39	6.7	7.47	893			54.05	39.98	93.24	1.68	530.358	<5	25	38	535	93	0.58	0.039	1.41	0.3	0.32	0.1	<0.05	0.08	<0.03	<0.002	<0.03	0.89	<0.01	0.06	<0.001	<0.001	<0.01	<0.2	0.001	<0.01	<0.02	0.03	<0.004	<5	435	300
M-SP60	23-Jun-16	0.424	7.4	7.72	889																																									
M-SP60	26-Sep-16	0.330	8.3	7.51	909											549	20	0.07	0.003																												
M-SP60	6-Nov-16	0.299	7.3	7.83	896											513	6	<0.05	<0.002																												
M-SP60	30-Jun-17	0.584	7.4	7.69	858											466	<5	<0.05	<0.002																												
M-SP60	28-Sep-17	0.523	8.0	7.63	870											511	8	<0.05	<0.002																												
M-SP60	10-Nov-17	0.423	6.7	7.66	863											449	28	0.06	0.004																												
M-SP63	23-May-02	0.779	6.8	7.99	282		0.69																																								
M-SP63	28-Sep-02	0.430	6.4	7.24	515		1.10																																								
M-SP63	5-Jun-03	1.746	7.1	7.82	512		9.81																																								
M-SP63	24-Sep-03	0.949	6.2	7.54	290		0.15																																								
M-SP63	15-Jun-04	2.032	6.0	7.66	304		0.26																																								
M-SP67	24-May-02	1.331	11.0	8.20	4		0.52																																								
M-SP67	8-Oct-02	0.416	10.1	7.38	594		0.22																																								
M-SP67	3-Jun-03	1.023	7.6	7.46	396		0.12																																								
M-SP67	26-Sep-03	0.239	18.1	8.45	623		6.91																																								
M-SP67	15-Jun-04	0.923	11.8	8.51	657		23.70																																								
M-SP69	24-May-02	2.973	7.4	8.38	271		4.71																																								
M-SP69	8-Oct-02	1.627	8.9	7.40	477		0.00																																								
M-SP69	3-Jun-03	2.145	7.7	7.75	286		0.44																																								
M-SP69	26-Sep-03	1.865	12.5	8.44	374		4.26																																								
M-SP69	15-Jun-04	1.098	7.8	7.47	498		0.22																																								
M-SP 70	24-May-02	1.992	7.5	7.75	282		3.51																																								
M-SP 70	8-Oct-02	1.886	7.9	7.49	473		0.09																																								
M-SP 70	3-Jun-03	1.261	7.3	8.02	288		1.40																																								
M-SP 70	26-Sep-03	1.518	9.8	8.33	396		3.66																																								
M-SP 70	15-Jun-04	1.135	8.7	8.37	488		1.05																																								

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		Field Measurements						Major Ions								Baseline				Nutrients							Trace Metals																		Other Parameters			
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	Ca^{+2} mg/L	Mg^{+2} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{-2} mg/L	SO_4^{-2} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP82	25-May-02	2.383	6.8	7.65	667		0.00																																							
M-SP82	7-Oct-02	1.303	4.6	8.01	370		0.00																																							
M-SP82	3-Jun-03	5.384	5.1	7.70	629		16.95																																							
M-SP82	23-Sep-03	1.259	5.9	7.98	471		1.47																																							
M-SP82	4-Jun-04	3.601	5.0	7.87	491		0.00																																							
M-SP87	26-May-02	2.193	5.2	8.32	681		0.25																																							
M-SP87	29-Sep-02	2.313	5.2	8.13	627		0.05																																							
M-SP87	22-May-03	3.079	4.1	7.66	699		16.17																																							
M-SP87	7-Oct-03	2.52	6.1	8.14	770	6.6	5.020																																							
M-SP87	13-May-04	2.907	3.6	8.39	1,277		0.59																																							
M-SP87	20-Nov-09	1.65	3.3	7.10	1,203																																								
M-SP87	30-Jun-14	1.14	7.1	7.78	1,282			101.00	53.00	109.00	4.00	441.356	<5	279	59	845		0.25	0.013		0.37	0.14	<0.1	<0.05	<0.05	<0.03	0.003	<0.03	0.21	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		362	470
M-SP87	18-Sep-14	0.92	7.8	7.84	1,259			100.27	53.33	108.57	3.93	440.137	<5	261	98	851	<5	<0.05	0.004		<0.05	0.22	<0.1	<0.05	<0.05	<0.03	0.002	0.04	0.04	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	0.02	0.03	<0.004		<5		361	470
M-SP87	5-Nov-14	1.15	3.8	7.85	1,301			45.60	23.28	8.90	0.63	242.624	26	10	2	214	68	0.35	0.022	0.48	0.48	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.51	<0.01	<0.01	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		225	210
M-SP87	26-Jun-15	1.08	6.6	7.78	1,311			92.73	55.40	105.15	3.93	451.109	<5	265	60	858	<5	<0.05	0.010	2.83	<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	0.003	<0.03	0.03	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		370	460
M-SP87	29-Sep-15	0.8	7.6	7.77	1,224			98.84	54.52	114.31	4.06	440.137	<5	297	61	851	18	0.14	0.011	1.79	0.1	0.31	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.07	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	0.03	<0.004		<5		361	471
M-SP87	28-Oct-15	0.58	5.1	7.78	1,262			103.16	52.53	111.3	4.2	443.794	<5	272	55	853	22	0.27	0.016	0.33	0.08	0.25	0.2	<0.05	<0.05	<0.03	0.005	<0.03	0.16	<0.01	0.1	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	0.03	<0.004		5		364	474
M-SP87	23-Jun-16	0.980	6.6	7.75	1,254																																								
M-SP87	28-Sep-16	0.962	7.7	7.52	1,336											839	11	0.28	0.013																												
M-SP87	7-Nov-16	1.05	5.0	7.73	1,254											817	<5	0.14	0.006																												
M-SP87	26-Jun-17	0.94	6.8	7.76	1,236											-	-	0.28	0.015																												
M-SP87	30-Sep-17	1.04	6.0	7.69	1,225											800	<5	0.38	0.009																												
M-SP87	14-Nov-17	1.00	3.7	7.68	1,200											817	<5	0.15	0.006																												
M-SP100	27-Sep-02	0.774	6.8	7.25	388		0.20																																							
M-SP100	21-May-03	0.840	7.9	7.35	373		38.78																																							
M-SP100	8-Oct-03	0.794	6.7	7.38	292		0.83																																							
M-SP100	5-Jun-04	1.076	9.4	7.47	683		0.51																																							
M-SP100	27-Jun-15	0.802	6.3	7.51	695											389	12	<0.05	0.004																												
M-SP100	29-Sep-15	0.777	7	7.47	651											407	46	0.2	0.016																												
M-SP100	7-Nov-15	0.754	6.8	7.46	661											384	87	0.17	0.012																												
M-SP100	23-Jun-16	0.826	6.4	7.48	689																																								
M-SP100	26-Sep-16	0.638	7.4	7.59	677											426	13	0.16	0.01																												
M-SP100	6-Nov-16	0.872	7.1	7.53	673											375	35	0.32	0.015																												
M-SP100	30-Jun-17	1.13	6.4	7.32	684											384	52	0.13	0.007																												
M-SP100	28-Sep-17	1.13	7.1	7.55	669											371	67	0.35	0.009																												
M-SP100	10-Nov-17	0.955	7	7.53	661											379	22	0.23	0.011																												
M-SP102	8-Oct-02	0.253	8.6	7.68	498		0.68																																							
M-SP102	3-Jun-03	2.679	6.9	7.5	283		0.30																																							
M-SP102	25-Sep-03	0																																											
M-SP102	15-Jun-04	0.869	7.1	7.38	477		0.12																																							
M-SP103	21-May-03	1.193	10.3	8.28	377		35.67																																							
M-SP103	8-Oct-03	0.939	16.5	8.27	416		1.23																																							
M-SP103	5-Jun-04	1.506	9.2	7.67	706		0.12																																							
M-SP103	27-Jun-15	1.16	9.4	7.59	703											389	145	0.5	0.035																												
M-SP103	29-Sep-15	0.878	10.9	7.55	669											404	9	<0.05	<0.002																												
M-SP103	7-Nov-15	0.963	8.6	7.58	675											367	14	<0.05	0.006																												
M-SP103	23-Jun-16	1.30	9.8	7.85	682																																								
M-SP103	26-Sep-16	0.591	10.7	7.77	690											415	192	1.61	0.1																												
M-SP103	6-Nov-16	1.13	9.6	7.79	680											374	70	0.14	0.01																												
M-SP103	30-Jun-17	2.20	9.3	7.7	670											356	12	0.08	0.005																												
M-SP103	28-Sep-17	1.62	9.7	7.6	675											720	234	0.72	0.021																												
M-SP103	10-Nov-17	1.15	8.7	7.58	676											388	11	0.16	0.012																												
M-SP104	21-May-03	0.115	11.5	8.51	327																																								
M-SP104	8-Oct-03	0																																											
M-SP104	5-Jun-04	0.382	20.4	8.26	686																																								
M-SP104	27-Jun-15	0.279	12.4	7.94	678											392	39	0.06	0.011																												
M-SP104	29-Sep-15	0.279	12.9	7.88	577											326	67	0.26	0.023																												
M-SP104	7-Nov-15	0.355	5.7	7.95	685											355	239	1.03	0.274																												
M-SP104	23-Jun-16	0.421	11.4	7.89	691																																								
M-SP104	26-Sep-16	0.30800821	10.3	8.02	624											379	76	0.84	0.034																												
M-SP104	6-Nov-16	0.313	9.3	8.24	673											323	257	1.86	0.114																												
M-SP104	30-Jun-17	5.75	8.1	7.69	669											312	164	0.61	0.058																												
M-SP104	28-Sep-17	0.71	8.6	7.66	961											362	542	6.96	0.536																												
M-SP104	10-Nov-17	1.46	7.5	8.05	675											346	21	0.36	0.018																												
M-SP105	21-May-03	0.795	8.0	8.18	363		18.20																																							
M-SP105	8-Oct-03	0.617	12.8	8.09	381		0.00																																							
M-SP105	5-Jun-04	0.945	10.3	7.78	696		0.35																																							
M-SP105	27-Jun-15	0.652	9.3	7.67	700											397	64	0.09							0.011																						
M-SP105	29-Sep-15	0.475	11.1	7.98	646											382	64	0.38	0.025						0.025																						
M-SP105	7-Nov-15	0.568	8.9	7.89	665											397	18	0.09	0.009						0.009																						
M-SP105	23-Jun-16	0.682	9.6	7.88	663																																								
M-SP105	26-Sep-16	0.586	10.3	7.97	667											396	232	2.27	0.14																												
M-SP105	6-Nov-16	0.579	9.7	8.04	670											332	150	3.73	0.462																												
M-SP105	30-Jun-17	1.12	9.5	7.68	653											312	48	0.1	0.009																												
M-SP105	28-Sep-17	0.926	9.6	7.76	660											369	53	0.38	0.014																												
M-SP105	10-Nov-17	0.785	9	7.91	650											367	15	0.08	0.005																												
M-SP106	21-May-03	0.685	4.7	7.84	451		9.42																																							
M-SP106	8-Oct-03	1.095	7.3	7.68	430		6.80																																							
M-SP106	5-Jun-04	0.476	7.6	7.70	878		116																																							

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		Field Measurements						Major Ions								Baseline				Nutrients							Trace Metals																		Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl^{-} mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/l	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP106	27-Jun-15	0.345	6.1	7.67	884											539	32	0.32	0.017																												
M-SP106	29-Sep-15	0.339	7	7.65	824											519	52	0.51	0.018																												
M-SP106	7-Nov-15	0.325	5.5	7.64	834											543	229	1.92	0.089																												
M-SP106	23-Jun-16	0.377	6.2	7.74	849																																								
M-SP106	26-Sep-16	0.586	6.8	7.74	860											539	75	1.41	0.049																												
M-SP106	6-Nov-16	0.334	6.0	7.78	863											496	27	1.96	0.049																												
M-SP106	30-Jun-17	0.383	6.2	7.66	846											495	30	0.27	0.006																												
M-SP106	28-Sep-17	0.342	6.7	7.63	851											520	34	0.92	0.067																												
M-SP106	10-Nov-17	0.346	5.3	7.78	831											498	197	1.65	0.145																												
M-SP107	24-May-02	4.981	9.3	7.6	314		0.00																																						
M-SP107	3-Jun-03	40.65	6.8	7.58	305		0.05																																						
M-SP107	25-Aug-03	35.419	7.5	7.32	522		0.00																																						
M-SP107	15-Jun-04	28.302	7.8	7.69	450		0.18																																						
M-SP108	3-Jun-03	0.39	8.3	8.1	298		3.20																																						
M-SP108	25-Sep-03	0.416	10.9	8.12	454		22.90																																						
M-SP108	15-Jun-04	0.334	13.5	7.84	465		7.33																																						
M-SP109	4-Jun-03	0.809	7.1	7.82	314		1.49																																						
M-SP109	23-Sep-03	0.704	7.9	7.77	318		0.00																																						
M-SP109	16-Jun-04	2.491	8.6	7.84	364		0.21																																						
GW-13	5-Jun-95	0.52	9	7.72	1344			67	42	189	3	540	20	140	56	850										< 1	< 1																480	330
GW-13	23-Aug-95	0.41	10	7.85	1325							560	10	142	54	770										< 1	< 1																470	340
GW-13	3-Oct-95	0.45	10	7.5	1353							585	< 5	175	56	790		1.4	< 1							< 1	< 1																480	343
GW-13	26-Aug-96	0.449	12.8	8.22	1351							559	6	142	56	601										< 1	< 1																471	352
GW-13	3-Jun-97	0.6	8.45	7.95	1318																																								
GW-13	18-Aug-97	0.269	16.13	7.85	1335							581	< 5	150	57	780										< 1	< 1																476	340
GW-13	6-Oct-97	0.898	6.85	6.86	1320							585	< 5	150	56	800										< 1	< 1																479	330
GW-13	20-Jun-98	1.76	13.62	8.11	1292							576	< 5	185	57	830										< 1	< 1																472	384
GW-13	5-Aug-98	1.5	15.27	7.61	1335																																								
GW-13	3-Oct-98	0.804	7.09	7.25	1292																																								
GW-13	30-Jun-99	0.003	10.89	7.65	1334																																								
GW-13	12-Aug-99	1.795	11.17	7.69	1337																																								
GW-13	4-Oct-99	0.898	9.91	7.58	1328																																								
GW-13	22-Jun-00	0.002	7	7.61	1302																																								
GW-13	1-Aug-00	0.583	10	7.86	1333																																								
GW-13	6-Oct-00	0.583	7	7.24	1310																																								
GW-13	12-Jun-01	0.882	6	7.89	1351																																								
GW-13	22-Aug-01	0.597	11.7	7.62	135																																								
GW-13	1-Oct-01	0.316	7.5	7.86	1205																																								
GW-13	8-May-02	0.519	4.2	7.96	1187																																								
GW-13	21-Sep-02	0.361	6.9	8.25	1335																																								
GW-13	9-Oct-02	0.332	5.7	7.58	1347																																								
GW-13	6-Jun-03	0.125	8.8	8.47	1209																																								
GW-13	4-Aug-03	0.353	9.9	8.18	1243																																								
GW-13	17-Oct-03	0.359	6.8	7.73	1346																																								
GW-13	25-Jun-04	0.331	9.6	8.19	1315																																								
GW-13	12-Aug-04	1.58	10.8	8.19	1358																																								
GW-13	2-Nov-04	0.247	1.0	7.46	1253																																								
GW-13	27-Jun-05	0.439	8.8	8.16	1134																																								
GW-13	29-Sep-05	0.65	7.8	7.98	1467																																								
GW-13	27-Oct-05	0.72	4.8	8.16	1437																																								
GW-13	23-Jun-06	0.35	8.1	8.05	1227																																								
GW-13	28-Sep-06	0.38	6.1	8.03	1450																																								
GW-13	8-Nov-06	0.46	4.5	7.95	1420																																								
GW-13	26-Jun-07	0.44	7.4	8.24	1475																																								
GW-13	10-Sep-07	0.38	9.7	8.14	1493																																								
GW-13	6-Nov-07	0.45	2.1	8.21	1442																																								
GW-13	13-Jun-08	0.234	6.1	8.05	1531																																								
GW-13	24-Sep-08	0.31	6.2	8.07	1522																																								
GW-13	11-Dec-08	0.323	2.7	7.82	1258																																								
GW-13	27-Jun-09	0.289	8.8	8.03	1576																																								
GW-13	18-Sep-09	0.361	8.1	8.05	1557																																								
GW-13	26-Oct-09	0.16	2.8	8.06	1262																																								
GW-13	26-Jun-10	0.45	14.2	8	1501																																								
GW-13	23-Sep-10	0.43	8	7.89	1386																																								
GW-13	12-Nov-10	0.59	5.2	7.21	1367																																								
GW-13	27-Jun-11	0.83	5.2	7.91	1333																																								
GW-13	26-Sep-11	0.754	5.6	7.84	1409																																								
GW-13	29-Oct-11	0.9	5.5	7.72	1309																																								
GW-13	27-Jun-12	0.84	5.6	7.66	1474																																								
GW-13	25-Sep-12	0.76	6.2	7.45	1399																																								
GW-13	7-Nov-12	0.688	5.7	7.66	1413																																								
GW-13	28-Jun-13	0.84	5.8	7.84	1603																																								
GW-13	25-Sep-13	0.87	6.2	7.49	1578																																								
GW-13	25-Oct-13	0.83	6.3	7.48	1537																																								
GW-13	29-Jun-14	0.77	5.9	7.52	1564																																								
GW-13	29-Aug-14	0.755	6.4	7.48	1637																																								
GW-13	31-Oct-14	0.688	5.4	7.5	1663																																								
GW-13	24-Jun-15	0.701	5.8	7.51	1670																																								
GW-13	28-Sep-15	0.59	11.5	7.64	1621																																								
GW-13	28-Oct-15	0.62	4.6	7.71	1648																																								
GW-13	25-Jun-16	0.62	13.4	7.54	1677																																								

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		Field Measurements						Major Ions								Baseline				Nutrients						Trace Metals																				Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^{-} mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
GW-13	29-Sep-16	0.63	9.5	7.55	1687																																										
GW-13	27-Jun-17	1.3	8.4	7.61	1667																																										
GW-13	29-Sep-17	0.6	9.2	7.65	1670											1133	<5	<0.05	<0.002																													
GW-13	15-Nov-17	0.59	2.1	7.69	1568																																										
006A Spring	28-Jun-2010	0.28	5.3	7.39	1,302																																										
006A Spring	15-Sep-2010	0.19	6.5	7.29	1,255																																										
006A Spring	1-Nov-2010	0.27	5.6	7.17	1,227			63.2	24.8	205	3.4	605	<1	151	37	832		0.59	0.012							<0.02	<0.005																					
006A Spring	17-Jun-2011	0.44	4.5	7.66	1261			59.3	23.4	206	3.3	644	<1	150	38	796		0.14	<0.005							<0.02	<0.005																					
006A Spring	21-Sep-2011	0.30	6.5	7.47	1277			58.6	23.3	190	3.4	713	<1	135	36	816		0.09	<0.005							<0.02	<0.005																					
006A Spring	12-Oct-2011	0.37	6.1	7.68	1298																																										
006A Spring	1-Jun-2012	0.39	4.4	7.36	1263			62.1	24.8	207	3.4	629	<1	137	37	800		0.29	<0.005							<0.02	<0.005																					
006A Spring	12-Sep-12	0.18	7.1	7.56	1216																																										
006A Spring	1-Nov-12	0.29	6.1	7.50	1247																																										
006A Spring	27-Jun-13	0.19	6.5	7.61	1271																																										
006A Spring	26-Sep-13	0.203	7.1	7.65	1246																																										
006A Spring	23-Oct-13	0.303	4.7	7.60	1210																																										
006A Spring	28-May-14	0.495	4	7.57	1267																																										
006A Spring	23-Sep-14	0.373	6.6	7.44	1254																																										
006A Spring	28-Oct-14	0.439	5.6	7.53	1273																																										
006A Spring	23-Jun-15	0.493	8.5	7.48	1293																																										
006A Spring	21-Sep-15	0.36	6.7	7.49	1174																																										
006A Spring	8-Nov-15	0.40	5.1	7.53	1221																																										
006A Spring	28-Jun-16	0.376	6.0	7.37	1247																																										
006A Spring	25-Sep-16	0.292	6.8	7.48	1250																																										
006A Spring	11-Nov-16	0.379	5.8	7.47	1237																																										
94-110	11-Nov-13	0.115	5.2	7.59	724																																										
94-110	30-Jun-14	0.299	6.1	7.52	744			67	28	56	1.48	485.248	<5	8	10	445	NM	0.22	0.008	NM	0.32	<0.05	<0.1	<0.05	<0.05	<0.03	0.002	<0.03	0.39	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		398	282
94-110	25-Sep-14	0.205	9.2	7.6	775			70.64	27.85	59.09	1.22	481.59	<5	8	11	468	15	<0.05	<0.002	1.47	0.24	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.13	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	15		395	291
94-110	11-Nov-14	0.181	4.4	7.54	777			67.26	27.66	60.22	1.28	497.44	<5	8	11	427	91	0.31	0.019	0.27	0.27	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.8	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	11		408	282
94-110	29-Jul-15	0.253	7.1	7.47	756			70.31	30.18	59.92	1.2	475.494	<5	9	11	411	10	0.13	0.005	0.37	0.29	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.34	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	0.012	<5	15		390	300
94-110	9-Nov-15	0.179	5.9	7.50	758			73.21	28.33	63.93	1.47	412	<5	8	11	444	17	0.19	0.007	3.08	0.31	<0.05	0.2	<0.05	<0.05	0.09	0.007	0.24	0.45	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		0.001<0.01		<0.02	<0.02	0.011		5		412	269
94-110	9-Jul-16	0.192	7.3	7.48	748											439	18	0.13	<0.002																													
94-110	14-Nov-16	0.126	5.9	7.62	771											482	14	<0.05	<0.002																													
94-110	29-Jul-17	0.335	7.1	7.46	726											465	6	0.13	<0.002																													
94-110	18-Oct-17	0.229	6.2	7.54	745											?	?	0.08	<0.002																													
94-113	1-Jun-12	0																																												
94-113	27-Jun-13	0																																												
94-113	26-Sep-13	<.01	7.1	7.99	1808			114	33	263	4.2	665	<1	305	122	1120	1040	4.75	0.043		<0.1	<0.1	<0.2	0.02	1.9	0.02	0.043	<0.05	8.8	<0.05	0.13	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	0.02	0.02	0.02	<0.01		<5		545	421
94-113	23-Oct-13	<0.01	5.3	7.69	1,830																																									
94-113	28-May-14	<0.05	11.2	7.74	1,761																																									
94-113	23-Sep-14	0																																												
94-113	28-Oct-14	0.000																																												
94-113	21-Jun-15	0.000																																												
94-113	21-Sep-15	0.000																																												
94-113	8-Nov-15	Damp																																												
94-113	28-Jun-16	0																																												
94-113	25-Sep-16	0.000																																												
94-113	11-Nov-16	0.000																																												
A Spring	8-Nov-13	1.47	6.7	7.47	882																																										
A Spring	31-Jul-14	1.76	6.4	7.5	946																																										
A Spring	21-Nov-14	1.42	6.2	7.54	944			58.45	35.53	100.35	1.61	556.4	<5	47	15	576	<5	0.07	0.005	3.16	0.06	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.06	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	10		456	292
A Spring	31-Jul-15	1.60	6.7	7.52	904			58.42	38.63	110.45	1.55	553.524	<5	48	15	595	NM	<0.05	<0.002	0.13	0.09	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.11	<0.01	0.09	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.02	0.007	NM	<5		454	305
A Spring	14-Nov-15	0.83	6.8	7.45	997			60.27	37.69	112.84	2.07	472	<5	50	15	595	8	<0.05	<0.002	3.5	0.11	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	0.09	<0.03	<0.01	0.08	<0.001	<0.001	<0.01		<0.2		<0.001<0.01		<0.02	<0.02	<0.004		5		472	302
A Spring	23-Jul-16	1.01	7.0	7.58	953											563	69	0.98	0.019																													
A Spring	15-Nov-16	1.06	7.0	7.51	947											575	10	0.23	0.009																													
A Spring	28-Jul-17	2.21	6.9	7.57	911											520	<5	0.12	<0.002																													
A Spring	12-Dec-17	1.50	6.2	7.57	914											567	12	0.35	0.012																													
B Spring	8-Nov-13	4.31	6.4	7.5	717																																										
B Spring	31-Jul-14	5.37	6.0	7.54	793																																										
B Spring	21-Nov-14	0.773	5.3	7.59	782			71.69	40.52	34.61	1.28	466.959	<5	32	5	441	8	0.09	<0.002	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.14	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		383	346
B Spring	31-Jul-15	8.020	6.1	7.52	738			72.84	44.01	33.12	1.41	462.082	<5	31	3	436	NM	<0.05	<0.002	0.13	<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.05	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	<0.004	NM	<5		379	363
B Spring	14-Nov-15	0.340	6.2	7.48	717			73.41	41.84	35.53	1.63	385	<5	32	4	422	38	0.38	0.007	1.12	<0.05	<0.05	<0.1	<0.05	0.07	<0.03	<0.002	0.63	0.63	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001<0.01		<0.02	0.03	<0.004		<5		385	345
B Spring	23-Jul-16	3.04	6.5	7.59	733											416	19	<0.05	<0.002																													
B Spring	15-Nov-16	0	---	---	---											408	<5	0.06	<0.002																													
B Spring	28-Jul-17	4.46	6.4	7.58	713																																									
B Spring	12-Dec-17	0.42	5.8	7.59	744											452	38	0.61	0.014																													
D Spring	11-Nov-13	0.545	7.7	9.44	235			3.4	2.3	43.3	2.8	171	7	3	2	133	848	26.6	1.48	0.3			<0.2	0.45	2.2	3.25	0.014	7.3	61.7	<0.05	0.09	<0.005	0.006	<0.005		<0.2	<0.01	<0.005	<0.02	<0.02	0.39	0.02		<5		151	18
D Spring	30-Jun-14	0																																												
D Spring	25-Sep-14	0																																												
D Spring	29-Jul-15	0																																												
D Spring	9-Nov-15	0																																												
A2S-1	11-Nov-13	0																																												
A2S-1	30-Jun-14	0.106	9.5	7.98	832			18	8	174	1.78	499.878	<5	16	14	511	NM	0.86	0.031	NM	0.18	<0.05	<0.1	<0.05	0.08	<0.03	<0.002	<0.03	2.13	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		410	77
A2S-1	25-Sep-14	0.028	12.9	7.97	882			17.85	7.44	161	1.24	534.016	<5	19	14	584	137	0.66	0.156	1.02	0.24	<0.05	<0.1	<0.05	0.17	0.11	0.003	0.26	1.16	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		438	75
A2S-1	11-Nov-14	0.063	5.9	7.97	909			17.92	6.96	205.84	1.34	535.235	20	19	14	480	357	2.03	0.074	0.31	0.31	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	4.17	<0.01	0.06	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		459	73
A2S-1	29-Jul-15	0.062	12.1	7.37	832			18.83	8.22	185.06	1.43	513.289	<5	46	3	540	158	2.03	0.094	3.37	<0.05	<0.05	0.2	<0.05	0.13	<0.03	<0.002	<0.03	3.93	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.014	NM	<5		421	81
A2S-1	9-Nov-15	0.045	7.2	8.03	902			18.02	7.3	93,792.16		484	<5	19	15	660	372	2.54	0.246	3.37	0.35	0.13	0.6	<0.05	5.69	0.28	0.246	4.24	4.24	<0.01	0.07	001<0.001		<0.01		<0.2		0.001	<0.01	<0.02	<0.02	0.009		<5		487	75
A2S-1	9-Jul-16	0.100	11.9	7.99	819											518	59	0.63	0.019																													
A2S-1	14-Nov-16	0.054	8.3	8.24	878											558	78	3.07	0.082																													

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		Field Measurements						Major Ions							Baseline				Nutrients						Trace Metals																		Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	HCO_3^- mg/L	CO_3^{2-} mg/L	SO_4^{2-} mg/L	Cl mg/L	TDS mg/L	TSS mg/L	T-Fe mg/L	T-Mn mg/L	NO2+ mg/L	NO3 mg/L	NO2 mg/L	NH3 mg/L	O-PO4 mg/L	T-P mg/L	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As ug/l	D-B mg/l	D-Cd ug/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
A2S-1	29-Jul-17	0.097	12.7	8.01	782											544	142	0.8	0.04																												
A2S-1	18-Oct-17	0.076	9.2	8.07	829											294	221	9.61	0.519																												
Divide Spring	1-Jul-14	1.63	7.4	7.59	743			55	43	43	1.33	402.341	<5	81	8	429	NM	<0.05	<0.002	NM	0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.04	<0.01	0.06	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004	NM	11		330	312
Divide Spring	25-Sep-14	DAMP																																												
Divide Spring	11-Nov-14	0																																												
Divide Spring	29-Jul-15	0.268	7.9	7.78	703			54.48	47.41	35.97	1.23	365.764	<5	79	7	419	<5	<0.05	0.002	<0.05	<0.05	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	0.06	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	<0.004	NM	8		300	331
Divide Spring	9-Nov-15	0.000	---	---	---																																									
Divide Spring	14-Nov-15	0	--	--	--																																									
Divide Spring	9-Jul-16	2.36	10.7	7.52	720											460	300	0.07	<0.002																												
Divide Spring	14-Nov-16	0.000	---	---	---											374	12	0.31	0.017																												
Divide Spring	29-Jul-17	0.564	8.4	7.51	679																																								
Divide Spring	18-Oct-17	0																																												
Hansen Seep	23-Apr-12	0.356	11.3	7.63	1489			127	38.4	158	2.9	501	<1	228	118	974	82	1.06	0.278		<0.1	<0.1	<0.2	0.02	0.08	0.46	0.279	0.4	1.7	<0.05	0.11	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	<0.02	0.02	0.02	<0.01		<5		411	475
Hansen Seep	27-Jun-13	<0.1	14.9	7.41	1461																																									
Hansen Seep	26-Sep-13	0.284	8.4	7.85	1452			114	36.5	150	2.8	467	<1	254	127	904	8	0.14	0.06		<0.1	<0.1	<0.2	0.04	0.05	<0.02	0.041	<0.05		<0.05	0.09	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	<0.02	<0.02		<0.01				383	455
Hansen Seep	23-Oct-13	0.242	5.0	7.57	1,418																																									
Hansen Seep	28-May-14	0.266	8.8	7.66	1,431																																									
Hansen Seep	17-Sep-14	0.196	10.9	7.64	4,590			114.06								915	49	0.92	0.389																												
Hansen Seep	28-Oct-14	0.226	6.1	7.44	1,473			113.03	35.82	151.39	2.66	466.959	<5	247	114	928	50	0.37	0.228	NM	<0.05	<0.05	<0.1	<0.05	0.08	<0.03	0.081	<0.03	0.33	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.01	NM	17		383	430
Skulumpah Spring	8-Nov-13	12.2	7.0	7.53	785																																									
Skulumpah Spring	31-Jul-14	14.9	8.6	7.59	805																																									
Skulumpah Spring	21-Nov-14	13.4	6.8	7.63	819			55.62	30.42	75.36	1.2	452.329	<5	49	11	503	12	0.08	0.002	<0.05	0.08	<0.05	<0.1	<0.05	0.1	<0.03	<0.002	<0.03	0.12	<0.01	0.05	<0.001	<0.001	<0.01		<0.02		<0.001	<0.01	<0.02	<0.02	<0.004	NM	7		371	264
Skulumpah Spring	31-Jul-15	14.0	6.7	7.39	786			53.45	33.52	81.39	1.23	454.767	<5	49	11	472		<0.05	<0.002	0.22	0.06	<0.05	<0.1	<0.05	<0.05	<0.03	<0.002	<0.03	<0.03	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	6		373	271
Skulumpah Spring	14-Nov-15	13.2	17.0	7.50	777			53.76	32.85	79.38	1.23	371	<5	50	11	445	12	<0.05	<0.002	3.65	1.13	<0.05	<0.01	<0.05	<0.05	<0.03	<0.002	<0.03	0.07	<0.01	0.06	<0.001	<0.001	<0.01		<0.02		<0.001	<0.01	<0.02	0.03	0.00453.76		6		371	270
Skulumpah Spring	23-Jul-16	13.3	7.0	7.59	785											470	11	<0.05	<0.002																												
Skulumpah Spring	15-Nov-16	12.0	7.2	7.58	793											500	<5	<0.05	<0.002																												
Skulumpah Spring	28-Jul-17	14.1	7.0	7.63	786											436	8	<0.05	<0.002																												
Skulumpah Spring	12-Dec-17	11.8	7.1	7.61	782											491	<5	<0.05	0.002																												
USP-1	20-Nov-09	0.18	4.2	7.59	1,146			70.98	47.73	90.64	4.79	434	<1	191	44.2																																
USP-2	20-Nov-09	0.43	5.5	7.46	1,287			90.47	55.85	75.61	4.5	335	<1	222	63.9																																
USP-2	30-Sep-17	0.35	7.7	7.74	1,321											885	103	0.93	0.007																												
USP-2	14-Nov-17	0.37	6.4	7.65	1,277											873	201	1.38	0.005																												
Spring 99	11-Nov-14	0.200	5.0	7.61	660																																								
Spring 99	29-Jul-15	0.337	8.3	7.38	584																																								
Spring 99	9-Nov-15	0.229	5.5	7.51	620																																								
Spring 99	9-Jul-16	0.265	8.2	7.74	560											310	44	1.01	0.075																												
Spring 99	14-Nov-16	0.130	5.5	7.79	637											370	30	0.2	0.013																												
Spring 99	29-Jul-17	0.465	8.5	7.56	615											384	<5	0.07	<0.002																												
Spring 99	18-Oct-17	0.185	6.2	7.68	627											183	14	0.41	0.028																												

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Groundwater Monitoring Well Data

	Date	W.L. (feet toc)
MW 15-5-2	28-Sep-15	301.37
MW 15-5-2	1-Nov-15	Dry
MW 15-5-2	23-Jun-16	Dry
MW 15-5-2	28-Sep-16	Dry
MW 15-5-2	7-Nov-16	Dry
MW 15-5-2	28-Jun-17	Dry
MW 15-5-2	27-Sep-17	Dry
MW 15-5-2	13-Nov-17	Dry
01-8-1	1-Oct-01	1464.8
01-8-1	30-Oct-02	1491.5
01-8-1	29-May-03	1487.2
01-8-1	19-Sep-03	1493.81
01-8-1	27-Oct-03	1496.65
01-8-1	24-Jun-04	1498.72
01-8-1	1-Sep-04	1497.11
01-8-1	15-Oct-04	1496.86
01-8-1	13-Jun-05	1500.33
01-8-1	29-Sep-05	1501.88
01-8-1	24-Oct-05	1501.99
01-8-1	23-Jun-06	1525.33
01-8-1	3-Aug-06	1535.44
01-8-1	4-Nov-06	1551.81
01-8-1	25-Jun-07	1599.11
01-8-1	24-Sep-07	1641.62
01-8-1	29-Oct-07	1652.24
01-8-1	21-Jun-08	1776.87
01-8-1	24-Sep-08	1781.18
01-8-1	6-Nov-08	1778.44
01-8-1	19-Jun-09	1779.15
01-8-1	23-Sep-09	1785.54
01-8-1	10-Nov-09	1786.22
01-8-1	26-Jun-10	1788.99
01-8-1	23-Sep-10	1790.07
01-8-1	12-Nov-10	1790.4
01-8-1	27-Jun-11	1791.07
01-8-1	27-Sep-11	1799.36
01-8-1	29-Oct-11	1798.94
01-8-1	27-Jun-12	1799.21
01-8-1	25-Sep-12	1798.95
01-8-1	7-Nov-12	1798.44
01-8-1	28-Jun-13	1797.75
01-8-1	25-Sep-13	1774.51
01-8-1	26-Oct-13	1765.13
01-8-1	29-Jun-14	1724.31
01-8-1	18-Sep-14	1728.61
01-8-1	5-Nov-14	1728.99
01-8-1	24-Jun-15	1732.41
01-8-1	26-Sep-15	1735.67
01-8-1	1-Nov-15	1735.56
01-8-1	26-Jun-16	1739.45

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01-8-1	27-Sep-16	1740.31
01-8-1	29-Jun-17	1740.94
01-8-1	29-Sep-17	1736.75
01-8-1	9-Nov-17	1738.06

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Table 2B Discharge and water-quality data for springs and streams in the Greens Hollow Tract area.

Petersen Hydrologic, LLC

		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
Stream Monitoring Data																												
U-Mud	30-Jun-14	28,274	13.0	8.78	381	8.17		<0.03	<0.002	<0.03	0.20	<0.01	0.01	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004	<5	<5		199	196
U-Mud	18-Sep-14	8,707	13.2	8.72	378	8.26		<0.03	<0.002	<0.03	0.14	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5		192	194
U-Mud	5-Nov-14	5,206	1.6	8.7	440	9.97		<0.03	0.002	<0.03	0.17	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.02	<0.004	<5	<5		380	464
U-Mud	26-Jun-15	26,928	14.8	8.78	379	8.31		<0.03	<0.002	<0.03	0.09	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.009	<5	<5		187	196
U-Mud	29-Sep-15	7,315	11.4	8.72	360	8.21		<0.03	<0.002	<0.03	0.08	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5		190	194
U-Mud	28-Oct-15	4,057	3.6	8.65	412	9.86		<0.03	<0.002	<0.03	0.12	<0.01	0.01	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	0.005	<5	<5		201	216
U-Mud	23-Jun-16	36,353	16.1	8.69	355	7.54																						
U-Mud	28-Sep-16	8,572	10.1	8.75	388	8.88																						
U-Mud	7-Nov-16	4,313	4.6	8.79	416	9.10																						
U-Mud	26-Jun-17	43,980	12.9	8.69	368	8.20		<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.02		<0.004	<5	-300		197	218
U-Mud	30-Sep-17	9,370	8.4	8.77	388	8.64		<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.05		<0.004		<5		209	193
U-Mud	14-Nov-17	4,161	2.5	8.70	411	10.90		<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.05		<0.004		<5		227	220
PINES 405	26-Jun-97	U	13.8	8.4	282																							
PINES 405	27-Aug-97	18,625	12	8.5	365																							
PINES 405	22-Oct-97	9,874	13.6	8.4	282																							
PINES 405	1-Jun-00	U	11.2	8.57	355	6.5						< .01		< .01							< .1				< 2			203	204
PINES 405	21-Aug-00	9,470	15.3	8.19	382	6.53		< .1	< .1			< .01		< .01				< .2			< .1				< 2			213	185
PINES 405	6-Dec-00	4,488	-0.5	8.4	387	11.38						< .01		< .01				< .2			< .1	< .01			4			229	208
PINES 405	1-Jun-01	> 22440	8.8	8.49	369	8.42																						
PINES 405	7-Sep-01	6,324	9.5	8.72	391	7.92																						
PINES 405	27-Nov-01	4,064	0.1	8.69	433	8.81																						
PINES 405	18-May-02	27,511	9.3	8.38	369	8																						
PINES 405	26-Sep-02	5,520	10.5	8.61	384	6.69																						
PINES 405	18-Nov-02	5,049	0.1	8.59	385	8.78		1018																				
PINES 405	8-Jun-03	78,540	10.2	8.6	332	7.1																						
PINES 405	21-Sep-03	6,777	7.9	8.34	390	7.62																						
PINES 405	5-Dec-03	4,533	0.4	8.59	417	8.47																						
PINES 405	13-Jun-04	49,368	11	8.72	374	6.85																						
PINES 405	21-Sep-04	7,091	5.2	8.66	364	9.3																						
PINES 405	21-Dec-04	3,142	0	8.43	357	7.23																						
PINES 405	23-May-05	157,080	9.7	8.15	409	9.73																						
PINES 405	5-Sep-05	22,440	14.5	8.68	324	7.4																						
PINES 405	20-Dec-05	5,350	0	8.56	423	8.16																						
PINES 405	23-Jun-06	53,856	6.7	8.65	374	8.84																						
PINES 405	24-Sep-06	9,510	7.1	8.54	393	8.17																						
PINES 405	8-Dec-06	6,820	0.1	8.44	427	9.1																						
PINES 405	24-Jun-07	19,300	16.7	8.79	382	8.1																						
PINES 405	16-Sep-07	5,840	13	8.92	399	8.22																						
PINES 405	6-Dec-07	4,490	1.8	8.62	334	10.4																						
PINES 405	28-Apr-08	26,900	10.4	8.58	422	8.25																						
PINES 405	17-Sep-08	9,170	10.9	8.65	383	7.89																						
PINES 405	3-Nov-08	5,850	4.1	8.74	399	9.29																						
PINES 405	29-May-09	80,780	11.4	8.64	385	8.55																						
PINES 405	14-Sep-09	8,580	10.5	8.71	384	8.8																						
PINES 405	2-Dec-09	4,040	0.4	8.47	427	10.4																						
PINES 405	17-May-10	17,560	11	8.73	407	7.28																						
PINES 405	13-Sep-10	8,340	11	8.47	371	9.35																						
PINES 405	17-Nov-10	4,480	0.9	8.25	457	9.91																						
PINES 405	8-Jun-11	134,640	6.4	8.81	358	7.77																						
PINES 405	9-Sep-11	22,090	11.9	8.72	388	8.62																						
PINES 405	18-Nov-11	8,037	0.2	8.82	445	9.29																						
PINES 405	9-Jun-12	16,400	16.2	8.93	368	7.66																						
PINES 405	7-Sep-12	5,470	17.8	8.83	372	7.51																						
PINES 405	16-Nov-12	5,520	0.2	8.71	419	10.43																						
PINES 405	25-Jun-13	17,413	15.8	8.83	353	8.74																						
PINES 405	22-Sep-13	6,078	9.7	8.88	408	8.18																						
PINES 405	2-Dec-13	4,880	0.2	8.74	461	10.8																						
PINES 405	27-Jun-14	28,274	14.6	8.82	367	8.46																						

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
PINES 405	19-Sep-14	7,271	11.8	8.81	396	8.25																						
PINES 405	2-Dec-14	5,386	0.3	8.77	479	10.56																						
PINES 405	14-Jun-15	52,958	13.3	8.7	389	7.54																						
PINES 405	20-Sep-15	8,864	10.9	8.66	383	8.27																						
PINES 405	29-Oct-15	5,222	4.6	8.67	411	9.46																						
PINES 405	13-Jun-16	118	10.6	8.53	365	8.51																						
PINES 405	26-Aug-16	13,823	13.8	8.67	381	8.7																						
PINES 405	18-Oct-16	4,416	6.8	8.76	423	9.49																						
PINES 405	19-Jun-17	103,224	14.2	8.52	376	8.37																						
PINES 405	13-Dec-17	4,905	0.3	8.65	233	11.65		<0.03	0.004	0.03		0.01	0.02	<0.001		<0.01					<0.01	0.07		<0.004	<5	<5		235	229
M-STR01	6-Jun-01	50.094	13.6	8.61	567	7.53	18.4			0.03		0.0008		<0.0005	0.0034	0.001		2E-04		0.002	<0.005	0.0005		0.02				298	220
M-STR01	16-Aug-01	0																											
M-STR01	30-Aug-01	0																											
M-STR01	25-Sep-01	0																											
M-STR01	29-Oct-01	0																											
M-STR01	18-Apr-02	0																											
M-STR01	1-May-02	0																											
M-STR01	5-Jun-02	0																											
M-STR01	7-Aug-02	0																											
M-STR01	25-Sep-02	0																											
M-STR01	12-Nov-02	0																											
M-STR01	6-May-03	9.715	0.7	8.48		8.65	7.5	0.15	<0.01	<0.03		0.1	<0.05	<0.005	<0.005	<0.01	<0.0002			<0.01	<0.07	<0.1		<0.01				290	
M-STR01	19-Jun-03	0																											
M-STR01	23-Aug-03	0																											
M-STR01	6-Oct-03	0																											
M-STR01	10-May-04	460	11.8	8.84	443	8.36	39.7	<0.02	<0.01	<0.1		0.001	<0.05	<0.005	<0.005	<0.01		2E-04		<0.01	<0.07	0.001		<0.01		<5		250	200
M-STR01	6-Jun-04	-	-	-	-	-	-																						
M-STR01	6-Jun-17	0																											
M-STR02	7-Aug-02	0																											
M-STR02	25-Sep-02	1,857	8.2	7.97	509	8.35	0.7	<0.02	<0.01	0.06		0.0009	0.06	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0021		0.01		<5		297	410
M-STR02	12-Nov-02	2,925	0.8	8.19	416	11.19	0.9	<0.02	<0.01	0.05		<0.1	<0.05	<0.005		<0.01					<0.07	<0.1	<0.1	0.02		<5		303	370
M-STR02	6-May-03	74,148	3.3	8.58	591	9.88	9.8	<0.02	<0.01	<0.03		<0.1	0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	<0.1		<0.01		<5		290	240
M-STR02	19-Jun-03	4,235	13	8.46	705	7.51	3.73			<0.03		0.001		<0.0005	<0.005	<0.01	<0.0002			<0.01	<0.001	0.0012		0.01				300	
M-STR02	4-Aug-03	1,184	14.9	8.11	722	5.84	39.9	<0.02	0.02	<0.03		0.0016	0.07	<0.005	<0.005	<0.01	<0.0002			<0.01	<0.07	0.0012		<0.01		<5		310	310
M-STR02	6-Oct-03	2,379	9.3	9.25	495	7.15	2.99	<0.02	<0.01	<0.03		0.001	0.06	<0.005	<0.005	<0.01	<0.0002			<0.01	<0.07	0.0007		<0.01		<5		337	370
M-STR02	10-May-04	460	11.8	8.84	443	8.36	39.7	<0.02	<0.01	<0.1		<0.0005	<0.05	<0.005	<0.005	<0.01	<0.0002			<0.01	<0.07	0.0006		0.01		<5		230	190
M-STR02	6-Jun-04	-	-	-	-	-	-																						
M-STR02	26-Jun-17	4	16.2	8.49	712	8.65		<0.03	<0.002	0.04		0.01	0.08	<0.001		<0.01					<0.01	0.05		<0.004	<5	-302		286	340
M-STR03	6-Jun-01	36.62	10.4	8.54	527	7.11	22.5			<0.03		0.001		<0.0005	0.0037	0.001		<0.0002		0.002	<0.005	0.0006		<0.01				293	
M-STR03	16-Aug-01	0.61	12.1	7.81	405	4.03	3.17			0.04		0.0009		<0.0005	0.0036	7E-04		<0.0002		0.002	<0.005	0.0013		0.02				293	
M-STR03	30-Aug-01	6.052																											
M-STR03	25-Sep-01	0.501	8.7	7.85	395	3.83	2.21			0.04		0.0008		<0.0005	0.001	8E-04		<0.0002		0.001	<0.005	0.0012		<0.01				304	
M-STR03	29-Oct-01	0.967	3.6	7.98	202	6.68	0			<0.03		<0.1		<0.0005	<0.005	<0.01		<0.0002		<0.01	<0.005	0.0017		0.04				292	
M-STR03	18-Apr-02	9.451	13	7.87	311	6.29	1.21		<0.05	0.03		0.0011		<0.0005	<0.005	<0.005		<0.002		0.003	<0.001	0.0021		<0.01				274	
M-STR03	1-May-02	7.993	3.6	8.29	409	9.7	0.67																						
M-STR03	5-Jun-02	2.61	6.3	8.18	365					0.05		<0.1		<0.005	<0.005	<0.01		<0.0004		<0.01	<0.07	<0.1		<0.01				284	
M-STR03	7-Aug-02	0																											
M-STR03	25-Sep-02	1.83	8.2	7.87	405	4.85	2	<0.02	<0.01	0.05		0.001	0.07	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0027		<0.01		<5		293	310
M-STR03	12-Nov-02	0																											
M-STR03	6-May-03	54.9	4	8.71	621	9.37	23.8	<0.02	<0.01	<0.03		0.1	0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	<0.1		<0.01		<5		290	240
M-STR03	19-Jun-03	2.499	10.9	8.1	659	5.2	2.83			<0.03		0.0011		<0.0005	<0.005	<0.01		<0.0002		0.01	<0.001	0.0014		0.01				292	
M-STR03	4-Aug-03	1.631	12	7.72	647	3.58	43.3	<0.02	0.01	<0.03		0.0013	0.06	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0014		0.01		6		300	280
M-STR03	6-Oct-03	1.382	7.9	8.01	398	5.56	7.29	<0.02	0.02	<0.03		0.0009	0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0011		<0.01		<5		306	300
M-STR03	10-May-04	491.5	8.4	8.73	307	8.51	51.4	<0.02	<0.01	<0.1		<0.0005	<0.05	<0.005	<0.005	<0.01		<0.0002		<0.01	<0.07	0.0005		0.03		<5		210	160
M-STR03	26-Jun-17	1.02	14.1	8.39	656	7.02		<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01					<0.01	0.03		<0.004					
M-STR04	7-Jun-01	71.081	19.4	8.55	386	6.84	3.08			0.03		0.0011		<0.0005	0.0039	0.001		<0.0002		0.002	<0.005	0.0006		<0.01				310	
M-STR04	22-Jun-01	11.719																											
M-STR04	16-Aug-01	0																											
M-STR04	31-Aug-01	0																											

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-STR04	27-Sep-01	0																									
M-STR04	26-Oct-01	0																									
M-STR04	17-Apr-02	13.005	6.2	8.87	470	9.19	7.49			<0.07		< .0005		< .0005	< .005	< .005		<0.0002		0.002	< .001	0.0016		< .01			< .002	372	
M-STR04	3-May-02	12.245	12.1	8.87	8.69	—	0																						
M-STR04	4-Jun-02	3.037	18	8.83	514	5.23	2.8			0.06		0.1		<0.005	<0.005	<0.01		<0.0004		<0.01	<0.07	<0.1		<0.01			<0.002	325	
M-STR04	8-Aug-02	0																											
M-STR04	25-Sep-02	0																											
M-STR04	12-Nov-02	0																											
M-STR04	6-May-03	79.9	8	8.74	599			< .02	0.01	< .03		< .1	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	< .1		0.01		<5	0	300	240
M-STR04	20-Jun-03	14.231	8.4	8.65	792	8.92	4.73			< .03		0.0014		< .0005	< .005	< .01		<0.0002		0.01	< .001	0.0013		< .01			< .002	358	
M-STR04	6-Aug-03	0																											
M-STR04	8-Oct-03	0																											
M-STR04	11-May-04	717.264	11.9	8.82	445	8.12	76.3	< .02	0.01	< .1		0.0008	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0006		0.01		<5	< .002	240	200
M-STR04	13-May-04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M-STR04	23-Jun-06	3.85	19.8	8.72	627	6.44																							
M-STR04	28-Sep-06	1.01	10.4	8.67	705	7.92																							
M-STR04	8-Nov-06	3.19	4.5	8.5	758	8.73																							
M-STR04	26-Jun-07	0																											
M-STR04	11-Sep-07	0																											
M-STR04	8-Nov-07	0																											
M-STR04	21-Jun-08	16.3	20.7	8.59	573	8.64																							
M-STR04	24-Sep-08	0																											
M-STR04	6-Nov-08	0																											
M-STR04	27-Jun-09	0.67	21.2	8.83	684	7.12																							
M-STR04	23-Sep-09	0																											
M-STR04	10-Nov-09	0																											
M-STR04	26-Jun-10	0																											
M-STR04	23-Sep-10	0																											
M-STR04	12-Nov-10	0																											
M-STR04	27-Jun-11	142	14.1	8.48	573	7.82																							
M-STR04	30-Sep-11	3.71	14.5	8.66	865	7.56																							
M-STR04	29-Oct-11	14.6	0.3	8.75	767	10.4																							
M-STR04	27-Jun-12	0																											
M-STR04	25-Sep-12	0																											
M-STR04	7-Nov-12	0																											
M-STR04	26-Jun-13	0																											
M-STR04	25-Sep-13	0																											
M-STR04	26-Oct-13	0																											
M-STR04	29-Jun-14	0																											
M-STR04	29-Aug-14	0																											
M-STR04	31-Oct-14	0																											
M-STR04	24-Jun-15	2.25	17.7	8.86	605	7.47																							
M-STR04	28-Sep-15	0																											
M-STR04	28-Oct-15	0																											
M-STR04	23-Jun-16	0																											
M-STR04	28-Sep-16	0																											
M-STR04	7-Nov-16	0																											
M-STR04	2-Jun-17	1.14	19.9	8.83	725	7.21		<0.03	<0.002	<0.03	<0.03	<0.01	0.09	<0.001		<0.01					<0.01	0.04		<0.004	<5	-310		302	264
M-STR05	8-Aug-02	1.412	9.5	6.5	346	8.45	1.56			0.04		< .002		< .001	0.0034	< .001		< .2		0.007	< .001	< .002		0.08			0	267	
M-STR05	25-Sep-02	1.717	7	8.38	353	8.21	4	< .02	< .01	0.05		0.0009	0.06	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0035		0.01		< 5		267	300
M-STR05	6-Oct-02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	< .002	.	.
M-STR05	12-Nov-02	immeas	0.5	8.25	329	11.16	2.32	< .02	< .01	0.03		< .1	0.05	< .005		< .01			< .02		< .07	< .1		0.01		< 5		277	290
M-STR05	6-May-03	61.8	6.1	8.73	616	9.04	22.5	< .02	< .01	< .03		< .1	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	< .1		< .01		<5	< .002	300	240
M-STR05	19-Jun-03	2.686	10.3	8.56	605	8.04	1.37			<0.03		0.0009		<0.0005	<0.005	<0.01		<0.0002		0.01	< .001	0.002		0.01			< .002	265	
M-STR05	6-Aug-03	2.043	10.2	8.35	610	8.5																				< 5		270	
M-STR05	8-Aug-03	.	.	.	.	.	.	< .02	< .01	< .03		0.0008	0.05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0022		< .01			< .002	300	270
M-STR05	6-Oct-03	1.534	6	8.47	356	7.23	3.99	< .02	< .01	< .03		0.0006	0.05	< .005	< .005	< .01	< .2		< .02	0.01	< .07	0.002		< .01		< 5	< .002	280	280
M-STR05	11-May-04	598.482	10	8.82	446	8.07	17.4	< .02	< .01	< .1		0.0008	< .05	< .005	< .005	< .01		< .2	< .02	< .01	< .07	0.0006		0.02		< 5	< .002	232	200
M-STR05	26-Jun-17	1.752	12	8.38	616	7.58		<0.03	<0.002	<0.03		<0.01	0.06	<0.001		<0.01					<0.01	0.02		<0.004	<5	-304		292	302
M-STR05	19-Dec-17	0.36	0.3	8.21	720	11.35		<0.03	0.067	<0.03		<0.01	0.06	<0.001		<0.01					<0.01	0.09		<0.004	<5	<5		328	320
M-STR06	7-Jun-01	16.85	20.10	8.48	808.00	6.54	67.50			<0.03		0.00		<0.0005	0.00	0.00		<0.0002		0.00	<0.005	0.00		0.01				351.00	

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-STR06	22-Jun-01	5,651	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M-STR06	16-Aug-01	4.783	12.4	8.3	439	7.13	81.4			0.05		0.0022		<0.0005	0.0051	<0.01		<0.0002		0.003	<0.005	0.0011		0.01				378	
M-STR06	25-Sep-01	1.9	11.5	7.92	575	3.14	30			0.05		0.0025		<0.0005	0.006	0.002		<0.0002		0.004	<0.005	0.0009		0.01				441	
M-STR06	30-Oct-01	6.438	2.7	8.39	446	8.73	11.6			<0.03		<0.1		<0.0005	<0.005	<0.01		<0.0002		<0.01	<0.005	0.0008		0.01				391	
M-STR06	17-Apr-02	18.165	9.6	8.77	462	7.16	9.63			<0.07		<0.001		<0.0005	<0.005	<0.005		<0.0002		0.002	<0.001	0.0009		0.01				373	
M-STR06	1-May-02	4.455	8.2	8.51	619	8.55	8.32			0.07		<0.1		<0.0005	<0.005	<0.01		<0.0004		<0.01	<0.07	<0.1	0.0009	0.01					
M-STR06	5-Jun-02	3.020	23.3	8.52	569	5.13	40.9			0.04		<0.1		<0.0005	<0.0005	<0.01		<0.0004		<0.01	<0.07	<0.1		0.01				350	
M-STR06	6-Aug-02	0																											
M-STR06	24-Sep-02	0																											
M-STR06	13-Nov-02	0																											
M-STR06	7-May-03	17.636	11.7	8.54	490	7.01	8.29	<0.02	0.01	<0.03		<0.1	0.06	<0.0005	0.01	<0.01		<0.0002		<0.01	0.07		<0.1	<0.01		<5		360/369	260.00
M-STR06	20-Jun-03	3.024	12.6	8.66	822	8.15	12.8			<0.03		0.0015		<0.0005	<0.0005	<0.01		<0.0002		<0.01	<0.001	0.0012		<0.01				341	
M-STR06	6-Aug-03	0																											
M-STR06	8-Oct-03	0																											
M-STR06	11-May-04	27.400	15.4	8.65	723	6.59	96.3	<0.02	<0.01	<0.1		0.0016	0.05	<0.005	<0.005	<0.01		<0.0002		0.01	<0.07	0.0014		0.02		<5		368/370	248
M-STR06	13-May-04																												
M-STR06	26-Jun-15	0.636	22.3	8.64	968	5.43	NM																						
M-STR06	28-Sep-15	0																											
M-STR06	28-Oct-15	0																											
M-STR06	23-Jun-16	0																											
M-STR06	28-Sep-16	0																											
M-STR06	7-Nov-16	0																											
M-STR06	26-Jun-17	2.43	18	8.44	825	6.23		0.38	0.013	0.61		<0.01	0.11	<0.001		<0.01					<0.01	0.03		<0.004	<5	<5		363	208
M-STR06	30-Sep-17	0.18	10.4	8.36	1008	7.57		<0.03	<0.002	<0.03		<0.01	0.09	<0.001		<0.01					<0.01	0.05		<0.004		<5		452	266
M-STR06	14-Nov-17	0																											
M-STR07	25-Sep-02	0																											
M-STR07	12-Nov-02	0																											
M-STR07	7-May-03	0																											
M-STR07	8-Aug-03	0																											
M-STR07	6-Oct-03	0																											
M-STR07	13-May-04	0																											
M-STR07	26-Jun-17	0																											
M-STR08	26-Sep-02	2062	9.2	8.7	234	9.1	2.2	<0.02	<0.01	0.04		0.0009	<0.05	<0.005		<0.01					<0.07	0.0007		0.01		<5		215	230
M-STR08	13-Nov-02	967	1	8.72	65	13.66	1.5	<0.02	<0.01	0.03		<0.1	05<0.005			<0.01					<0.07	<0.1		<0.01		5		227	220
M-STR08	7-May-03	2447	3.5	8.69	247	10.22	5.15	<0.02	<0.01	<0.03		<0.1	<0.05	<0.005		<0.01					<0.07	<0.1		0.01		<5		230	230
M-STR08	5-Aug-03	7145	16.2	8.74	371	7.51		<0.02	<0.01	<0.03		0.0011	05<0.005			<0.01					<0.07	0.0006		<0.01		<5		200	210
M-STR08	7-Oct-03	3087	5.5	8.88	232	9.27	1.99	<0.02	<0.01	<0.03		0.0011	0.05	<0.005		<0.01					<0.07	0.0008		<0.01		<5		222	220
M-STR08	13-May-04	15644	4.2	8.9	352	9.76	6.81	<0.02	<0.01	<0.1		0.0009	<0.05	<0.005		<0.01					<0.07	0.0006		<0.01		<5		220	220
Sufco 007	5-Oct-79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 1	-	-	-	-	-	-
Sufco 007	1-Nov-80	-	-	-	-	-	-	0.94	-	-	-	-	-	-	-	-	< 2	-	-	-	-	-	< 1	-	-	-	-	332	244
Sufco 007	9-Jun-81	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	-	< 2	-	-	-	-	-	< 1	-	-	-	-	178	168
Sufco 007	26-Aug-81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 1	-	-	-	-	-	-
Sufco 007	27-Oct-81	-	-	-	-	-	-	0.095	0.018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	284.7	244
Sufco 007	22-Jun-82	3132.624	16	8.2	654			0.34	0.13																			202.1	178
Sufco 007	12-Aug-82	403.92	12	8.6	460			0.335	0.13																			224	210
Sufco 007	20-Oct-82	498.168	0	9.2	690			0.04	0.045																			292	288
Sufco 007	21-Jun-83	5771.568	14	8.4	446			0.08	0.003																			220	192
Sufco 007	16-Aug-83	516.12	15	7.8	593			0.11	0.01																			244	240
Sufco 007	12-Oct-83	269.3	12	7.7	640			0.12	0.01																			278	262
Sufco 007	21-Jun-84	2629.968	7	7.6	525			0.01	0.01																			232	210
Sufco 007	9-Aug-84	359.04	21	7.8	555			< .01																				260	260
Sufco 007	11-Oct-84	686.664	5	7.9	621			0.03	0.03																			270	335
Sufco 007	13-Jun-85	2217.072	7.8	7.5	409			0.04	0.13																			404	720
Sufco 007	14-Aug-85	287.232	13	8	680			< .01	< .02																			238	208
Sufco 007	22-Oct-85	94.248	0.5	7.6	638			0.03	0.03																			290	264
Sufco 007	2-Jun-86	3388.44	14	7.6	412			< .01	< .01																			182	216
Sufco 007	13-Aug-86	246.84	17	8.3	531			< .01	< .01																			212	200
Sufco 007	7-Jun-88	1297.032	12	8.2	468			< .03	< .01																			188	214
Sufco 007	9-Aug-88	71.81	19	7.4	500			< .03	< .01																			200	218
Sufco 007	5-Oct-88	94.25	8	7.3	619			< .03	0.02																			260	365

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		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
Sufco 007	13-May-92	1108.61	-	-	-	-	-	< .02	< .02																		175	213
Sufco 007	4-Aug-92	161.579	-	-	-	-	-	0.11	< .01																			164
Sufco 007	6-Oct-92	85.278	-	-	-	-	-	0.08	0.02																			208
Sufco 007	9-Jun-93	1683.12	-	-	-	-	-	< .04	< .02																		186	224
Sufco 007	6-Jun-95	3751.968	10.4	8.29	511			1	0.2																		240	270
Sufco 007	23-Aug-95	1122	15.2	8.35	419			< .1	< .1																		220	177
Sufco 007	3-Oct-95	188.5	13.5	8.37	541			< .1	< .1																		235	213
Sufco 007	27-Aug-96	184.008	17.2	8.6	446			< .1	< .1																		197	186
Sufco 007	22-Oct-96	103.224	2.1	8.38	568			< .1	< .1																		265	233
Sufco 007	2-Jun-97		16.15	8.58	401			< .1	< .1																		171	283
Sufco 007	18-Aug-97	664.224	19.8	8.4	467		10.2	< .1	< .1																		199	196
Sufco 007	8-Oct-97	336.6	6.38	8.77	548		11.4	< .1	< .1																		248	230
Sufco 007	4-Jun-98	3285.216	7.61	8.62	473	6.37		< .1	< .1																		210	216
Sufco 007	5-Aug-98	14.8	19.65	8.08	537	7.5		< .1	< .1																3		255	
Sufco 007	1-Oct-98	94.248	12.45	8.43	598	8.27		< .1	< .1																< 2.		275	
Sufco 007	21-Jun-99	839.256	15.99	8.22	441	6.89		< .1	< .1																< 2.		203	
Sufco 007	9-Aug-99	119.8296	22.2	8.37	505	6.39		< .1	< .1																< 2.		213	
Sufco 007	4-Oct-99	94.248	12.05	8.32	604	8.25		< .1	< .1																< 2.		269	
Sufco 007	21-Jun-00	0.18	17.97	8.29	473	6.15		< .1	< .1																< 2.		196	192
Sufco 007	2-Aug-00	42.1872	21.25	8.52	458	5.65		< .1	< .1																< 2.		184	167
Sufco 007	5-Oct-00	15.2592	10	8.24	577	6.48		< .1	< .1																< 2.		242	211
Sufco 007	11-Jun-01	885	14.3	8.29	407	7.92		< .1	< .1																< 2.		169	171
Sufco 007	20-Aug-01	0.215	17.4	8.68	363	7.15		< .1	< .05																< 2.		174	162
Sufco 007	2-Oct-01	69.2	10.3	8.56	431	7.51		< .1	< .05																< 2.		218	196
Sufco 007	8-May-02	559	9.6	8.45	488	8.42		< .1	< .05																< 2.		215	251
Sufco 007	20-Sep-02	72.9	16.5	8.48	453	6.88		< .1	< .05																			
Sufco 007	8-Oct-02	88.2	11.7	8.63	477	8.01		< .1	< .05																< 2.		231	304
Sufco 007	29-May-03	2560	12.7	8.54	358	7.62		0.008	< .005																< 2.		206	193
Sufco 007	19-Sep-03	68.6	12.3	8.61	376	8.14		< .005	< .005																< 2.		197	183
Sufco 007	30-Oct-03	61.7	11.4	8.65	465	7.63		0.009	0.009																< 2.		213	216
Sufco 007	26-Jun-04	1510	11	8.66	336	7.63		< .03	0.002																< 2.		169	165
Sufco 007	1-Sep-04	66.3	18.7	8.73	343	8.73		< .03	< .002																< 2.		167	159
Sufco 007	15-Oct-04	398	7.2	8.54	439	8.17		< .03	0.009																< 2.		217	198
Sufco 007	13-Jun-05	2180	12.7	8.59	373	6.78		< .03	< .002																< 2.		192	208
Sufco 007	30-Sep-05	104	11.4	8.57	389	7.1		< .03	0.004																< 2.		211	207
Sufco 007	24-Oct-05	98	7.3	8.61	470	8.03		< .03	0.004																< 2.		233	218
Sufco 007	26-Jun-06	661	17.1	8.56	337	8.18		< .03	< .002																< 2.		173	190
Sufco 007	13-Sep-06	62.8	15.9	8.48	375	7.1		< .03	0.002																< 2.		198	181
Sufco 007	4-Nov-06	190	1.5	8.58	478	9.7		< .03	0.004																< 2.		233	238
Sufco 007	25-Jun-07	227	22.5	8.67	304	7.05		< .03	< .002																< 2.		167	172
Sufco 007	19-Sep-07	50.7	9.4	8.73	381	7.51		< .03	0.003																< 2.		191	180
Sufco 007	29-Oct-07	78	5.2	8.77	436	7.63		< .03	0.005																< 2.		230	221
Sufco 007	12-Jun-08	1550	10.9	8.63	301	7.59		< .03	< .002																< 5.		168	191
Sufco 007	15-Sep-08	77.4	12	8.54	303	7.72		< .03	< .002																< 5.		165	176
Sufco 007	21-Oct-08	71	4.3	8.58	442	9.82		< .03	0.007																< 5.		216	216
Sufco 007	19-Jun-09	716	15.7	8.56	358	7.2		< .03	0.002																< 5.		165	190
Sufco 007	17-Sep-09	79.3	13.5	8.61	362	8.26		< .03	< .002																< 5.		179	178
Sufco 007	19-Nov-09	57	0.3	8.39	515	10.8		< .03	0.004																< 5.		237	223
Sufco 007	28-Jun-10	612	14.5	8.59	351	7.89		< .03	< .002																< 5.		167	184
Sufco 007	15-Sep-10	62.4	13.4	8.5	328	7.92		< .02	< .005																< 5.		165	
Sufco 007	1-Nov-10	129	2.7	8.32	449	9.79		< .02	0.007																< 5.		198	
Sufco 007	18-Jun-11	6032	9	8.79	352	7.88		< .02	< .005																< 5.		176	
Sufco 007	27-Sep-11	189	11	8.7	405	8.82		< .02	< .005																< 5.		196	
Sufco 007	29-Oct-11	133	0.8	8.46	492	10.53		< .02	0.007																8		254	
Sufco 007	1-Jun-12	327	11.9	8.76	373	7.51		< .02	< .005																< 5.		171	
Sufco 007	26-Sep-12	19.7	9.7	8.54	539	6.88		< .02	< .005																< 5.		250	
Sufco 007	1-Nov-12	48.8	3.7	8.47	480	9.46		< .02	< .005																9		235	
Sufco 007	27-Jun-13	261	13.9	8.58	373	8.83		0.02	< .005																< 5.			
Sufco 007	25-Sep-13	253	7.2	8.74	398	8.82		< .02	< .005																< 5.			
Sufco 007	26-Oct-13	216	2.6	8.66	420	10.92		< .02	< .005																< 5.		213	
Sufco 007	11-Jun-14	1521	12	8.67	351	9.63		< .03	< .002																< 5.			
Sufco 007	23-Sep-14	101	13.5	8.72	419	8.51		< .03	< .002																< 5.			
Sufco 007	6-Nov-14	90	1.7	8.6	495	9.99		< .03	0.002																< 5.			

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
Sufco 007	24-Jun-15	1107	14.9	8.7	375	8.16		< .03	< .002															< 5.				188
Sufco 007	22-Sep-15	97	11.1	8.61	328	8.31		< .03	< .002															< 5.			158	155
Sufco 007	7-Nov-15	70	0.2	8.37	514	10.95		< .03	0.002															< 5.				
Sufco 007	23-Jun-16	840	17.2	8.59	329	7.31		< .03	0.022															< 5.			155	171
Sufco 007	28-Sep-16	115	9.9	8.61	409	8.92		< .03	< .002															< 5.			184	182
Sufco 007	6-Nov-16	99	4.1	8.71	449	9.43		<0.03	0.005																		225	197
Sufco 007	30-Jun-17	622	10	8.65	357	8.43		0.1	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01			<0.004	<5	-180		187	199
Sufco 006	5-Oct-79	.	.	.	.	.	.																1						
Sufco 006	1-Nov-80	.	.	.	.	.	.	0.46									0.1						< 1.				372	293
Sufco 006	9-Jun-81	.	.	.	.	.	.	0.21									< 2						< 1.				294	232
Sufco 006	26-Aug-81	.	.	.	.	.	.																< 1.					
Sufco 006	27-Oct-81	.	.	.	.	.	.	0.24	0.028																		267.2	252
Sufco 006	22-Jun-82	143.616	12.5	7.7	423			0.01	0.005																		372.6	290
Sufco 006	12-Aug-82	462.264	12	8.3	510			0.075	0.02																		222	250
Sufco 006	20-Oct-82	426.36	1	8.6	545			0.08	0.055																		251.4	274
Sufco 006	21-Jun-83	933.504	16	8.4	799			0.03	0.042																		328	298
Sufco 006	16-Aug-83	623.832	17	7.5	726			0.09	0.015																		308	280
Sufco 006	12-Oct-83	260.3	10	7.7	833			0.044	0.07																		320	328
Sufco 006	21-Jun-84	704.667	11	8	920			0.01	0.03																		341	307
Sufco 006	9-Aug-84	569.976	18	7.9	668			0.07																			315	610
Sufco 006	11-Oct-84	359.04	6	7.7	824			0.23	0.07																		320	390
Sufco 006	13-Jun-85	704.616	14	7	712			0.03	< .01																		210	246
Sufco 006	14-Aug-85	287.232	13	7.9	884			< .01	< .02																		286	284
Sufco 006	22-Oct-85	219.912	1	7.7	729			< .01	0.05																		270	346
Sufco 006	3-Jun-86	825.792	16	8	610			< .01	0.02																		259	264
Sufco 006	13-Aug-86	260.304	17	8.1	662			< .01	< .01																		250	278
Sufco 006	7-Jun-88	412.9	16	7.9	715			< .03	0.05																		259	286
Sufco 006	9-Aug-88	112.2	17.5	7.4	648			< .03	0.03																		247	300
Sufco 006	5-Oct-88	70.9	15.5	7.1	782			< .03	0.08																		312	425
Sufco 006	13-May-92	17.95	.	.	.	.	.	< .02	< .02																		331	355
Sufco 006	4-Aug-92	94.25	.	.	.	.	.	0.13	0.01																			
Sufco 006	6-Oct-92	7	.	.	.	.	.	0.05	< .02																			
Sufco 006	9-Jun-93	45.33	.	.	.	.	.	< .04	0.029																		386	351
Sufco 006	6-Jun-95	44.88	16.1	8.07	977			0.1	< .1																		370	330
Sufco 006	24-Aug-95	426.4	16	8.46	578			< .1	< .1																		220	272
Sufco 006	3-Oct-95	192.98	12.5	8.2	636			< .1	< .1																		240	278
Sufco 006	27-Aug-96	130.152	15.9	8.35	635			< .1	< .1																		237	294
Sufco 006	22-Oct-96	8.5272	1.02	8.28	398			< .1	< .1																		296	329
Sufco 006	2-Jun-97	.	21.53	8.3	805			< .1	< .1																		315	310
Sufco 006	18-Aug-97	287.232	18.9	8.44	574		46.8	< .1	< .1																		206	265
Sufco 006	8-Oct-97	184.008	5.5	8.35	629		53.2	< .1	< .1																		235	272
Sufco 006	4-Jun-98	112.2	13.1	8.42	901	6.21		< .1	< .1																< 2.		374	330
Sufco 006	3-Aug-98	224.4	22.75	8.08	577	6.19		< .01	< .01																< 2.		231	
Sufco 006	1-Oct-98	71.808	11.54	8.33	626	9.33		< .1	< .1																< 2.		240	
Sufco 006	21-Jun-99	201.96	17.3	8.19	625	7.03		< .1	< .1																< 2.		247	
Sufco 006	9-Aug-99	394.944	22.04	8.3	592	6.54		< .1	< .1																< 2.		234	
Sufco 006	4-Oct-99	192.984	12.11	8.3	647	8.15		< .1	< .1																< 2.		236	
Sufco 006	21-Jun-00	0.8	15.32	8.13	627	7.05		< .1	< .1																< 2.		226	264
Sufco 006	2-Aug-00	192.984	21.3	8.39	600	5.6		< .1	< .1																< 2.		217	259
Sufco 006	5-Oct-00	179.52	9	8.12	747	7.28		< .1	< .1																< 2.			
Sufco 006	11-Jun-01	646.272	17.5	8.34	592	.5		< .1	< .1																< 2.		207	256
Sufco 006	20-Aug-01	179.0712	16.3	8.76	512	6.76		< .1	< .05																< 2.		204	250
Sufco 006	2-Oct-01	0																										
Sufco 006	8-May-02	88.1	10.4	8.28	621	8.42		< .1	< .05																< 2.		252	301
Sufco 006	20-Sep-02	11.5	16.8	8.47	721	6.24		< .1	< .05																			
Sufco 006	8-Oct-02	35.1	10.8	8.2	738	7.51		< .1	< .05																< 2.		257	227
Sufco 006	29-May-03	0.909	20.9	8.42	962	6.02		0.006	0.013																< 2.		310	343
Sufco 006	19-Sep-03	26.3	13.5	8.53	631	7.91		0.009	0.005																< 2.		250	304
Sufco 006	30-Oct-03	0.131	8.8	8.58	1228	7.33		0.008	0.021																< 2.		450	469
Sufco 006	26-Jun-04	420	13	8.77	493	7.06		< .03	0.006																< 2.		200	252
Sufco 006	1-Sep-04	132	16.9	8.72	529	6.89		< .03	0.005																< 2.		194	265
Sufco 006	15-Oct-04	70.3	9.6	8.47	593	7.05		< .03	0.003																< 2.		220	271

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	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
Sufco 006	13-Jun-05	703	15.5	8.37	523	8.37		< .03	< .002																< 2			231	301
Sufco 006	30-Sep-05	402	12.1	8.57	542	7.67		< .03	0.007																< 2			202	265
Sufco 006	24-Oct-05	18.8	8.5	8.53	719	7.91		< .03	0.006																< 2			257	299
Sufco 006	26-Jun-06	363	16.8	8.54	522	7.66		< .03	< .002																< 2			203	275
Sufco 006	13-Sep-06	155	14.6	8.45	536	7.08		< .03	0.003																< 2			201	260
Sufco 006	4-Nov-06	90	3.9	8.48	591	9.09		< .03	0.007																< 2			230	290
Sufco 006	25-Jun-07	160	17.6	8.62	543	8.72		< .03	< .002																< 2			200	277
Sufco 006	19-Sep-07	95	12.3	8.89	515	8.69		< .03	0.003																< 2			237	264
Sufco 006	29-Oct-07	1.23	6.1	8.72	920	7.33		< .03	0.007																< 2			319	351
Sufco 006	12-Jun-08	146	14.9	8.65	649	7.1		< .03	0.004																< 5			240	297
Sufco 006	15-Sep-08	104	11.9	8.63	518	7.82		< .03	0.002																< 5			184	277
Sufco 006	21-Oct-08	1.18	7.2	8.44	882	8.34		< .03	0.007																< 5			338	390
Sufco 006	19-Jun-09	80.4	16.5	8.46	617	6.99		< .03	0.007																< 5			240	309
Sufco 006	17-Sep-09	100	14.1	8.61	531	7.81		0.03	0.007																< 5			193	271
Sufco 006	19-Nov-09	71	0.3	8.39	612	10.6		< .03	0.004																< 5			210	283
Sufco 006	28-Jun-10	433	18.8	8.43	576	6.68		< .03	< .002																< 5			205	280
Sufco 006	15-Sep-10	49.9	11.2	8.42	532	7.42		0.03	< .005																< 5			211	
Sufco 006	1-Nov-10	62.4	3.2	8.21	585	9.33		0.02	0.006																< 5			217	
Sufco 006	17-Jun-11	1116	9.5	8.74	525	8.03		< .02	< .005																< 5			232	
Sufco 006	21-Sep-11	205	11.6	8.62	533	7.62		< .02	< .005																< 6			205	
Sufco 006	12-Oct-11	155	6.4	8.62	578	8.9		< .02	< .005																< 6			216	
Sufco 006	1-Jun-12	0.208/93.35	17.5	8.43	968	8.08		< .02	< .005																< 6			355	
Sufco 006	12-Sep-12	45.3	11.1	8.65	557	8.35		< .02	< .005																< 6			209	
Sufco 006	1-Nov-12	53.9	3.4	8.59	592	9.64		< .02	< .005																6			223	
Sufco 006	27-Jun-13	80.4	16.1	8.56	566	7.73		< .02	< .005																< 5				
Sufco 006	16-Sep-13	239	13.8	8.56	627	8.27		< .02	< .005																< 5				
Sufco 006	23-Oct-13	116	3.7	8.72	618	10.34		< .02	< .005																< 5			234	
Sufco 006	28-May-14	363	12.2	8.59	574	7.6		< .03	< .002																< 5				
Sufco 006	17-Sep-14	101	14.4	8.76	557	7.5		0.09	0.003																< 5			197	260
Sufco 006	28-Oct-14	0																											
Sufco 006	21-Jun-15	142	14.9	8.58	593	8.39		< .03	< .002																< 5				284
Sufco 006	22-Sep-15	146	15.1	8.67	1080	7.76		< .03	< .002																< 5				
Sufco 006	8-Nov-15	19	0.2	8.52	753	10.21		< .03	< .002																< 5				
Sufco 006	18-Jun-16	8.58	17.6	8.58	543	7.02		< .03	< .002		5.03	<0.1	0.05	.001<0.001		<0.01		<0.02	0.007	0.002	<0.01	0.02	0.02	).00475.4	< 5	202		202	287
Sufco 006	26-Sep-16	89	9.5	8.63	541	8.92		< .03	< .002																< 5				
Sufco 006	5-Nov-16	Dry																											
Sufco 006	28-Jun-17	249	12.6	8.64	513	8.07		<0.03	<0.002																<5			208	280
Sufco 006A	19-Oct-09	75																											
Sufco 006A	28-Jun-10	500	16.8	8.51	538	7.31		< .03	< .002																< 5				
Sufco 006A	15-Sep-10	50.8	11.7	8.44	529	7.33		0.02	0.008																< 5			206	
Sufco 006A	1-Nov-10	82.2	3.4	8.22	560	9.38		0.02	0.013																< 5			210	
Sufco 006A	17-Jun-11	1109	9.5	8.77	512	7.86		< .02	< .005																< 6			226	
Sufco 006A	21-Sep-11	296	11.7	8.68	624	7.53		< .02	< .005																< 5			205	
Sufco 006A	12-Oct-11	186	7.9	8.6	558	8.72		< .02	< .005																< 5			210	
Sufco 006A	1-Jun-12	0.949	14.3	8.5	1182	7.5		< .02	0.006			< .05		< .005				< .2			< .02	< .02	< 20		< 6			421	314
Sufco 006A	12-Sep-12	59.5	11.8	8.56	547	8.62		< .02	< .005			< .05		< .005				< .2			< .02	0.02	20		< 5			206	251
Sufco 006A	1-Nov-12	56	3.9	8.56	578	9.85		< .02	< .005			< .05		< .005				0.2			< .02	0.03	30		< 6			213	259
Sufco 006A	27-Jun-13	136	17.2	8.56	551	7.96																							
Sufco 006A	16-Sep-13	210	13	8.52	609	7.88																							
Sufco 006A	23-Oct-13	118	4	8.56	604	10.78																							
Sufco 006A	28-May-14	576	12.4	8.56	569	7.56																							
Sufco 006A	17-Sep-14	126	12.7	8.67	547	8.18																							
Sufco 006A	28-Oct-14	2.86	2.4	8.61	1123	10.08																							
Sufco 006A	23-Jun-15	168	8.7	8.7	573	7.37																							
Sufco 006A	23-Sep-15	113	11.7	8.59	518	8.22																							
Sufco 006A	8-Nov-15	28.6	0.2	8.37	640	10.5																							
Sufco 006A	28-Jun-16	339	18.5	8.51	536	7.16																							
Sufco 006A	25-Sep-16	122	9.2	8.68	536	9.24																							
Sufco 006B	12-Sep-12	36.8	11.5	8.66	555	8.33		<0.02	<0.005	<0.05	0.5	<0.05	<0.05	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	<0.02	0.04	0.02	<0.01	<6	<5		210	260
S. Fk. Quitchupah Upper	11-Nov-13	128	4.6	8.63	514	10																							

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		Field Measurements						Trace Metals														Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
S. Fk. Quitchupah Upper	1-Jul-14	731	12.5	8.61	515	8.3		<0.03	<0.002	<0.03	0.5	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004	<5	<5		193	253
S. Fk. Quitchupah Upper	25-Sep-14	151	13.6	8.72	518	8.05		<0.03	<0.002	<0.03	0.07	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5		175	255
S. Fk. Quitchupah Upper	11-Nov-14	11.8	0.1	8.43	593	10.14		<0.03	<0.002	<0.03	0.21	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	<5		202	274
S. Fk. Quitchupah Upper	29-Jul-15	411	13.4	8.77	497	8.1		<0.03	<0.002	<0.03	0.27	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	0.005	<5	<5		172	255
S. Fk. Quitchupah Upper	9-Nov-15	70	0.3	8.42	503	10.02																							
S. Fk. Quitchupah Upper	9-Jul-16	455	14.7	8.69	507	8.03																							
S. Fk. Quitchupah Upper	14-Nov-16	4.4	4.7	8.33	611	10.05																							
S. Fk. Quitchupah Upper	29-Jul-17	354.0	14.7	8.66	485	7.85																							
Skutumpah Creek Upper	11-Nov-13	59	4.5	8.42	547	10.04																							
Skutumpah Creek Upper	2-Jul-14	81	16.5	8.24	549	7.3		<0.03	<0.002	<0.03	1.03	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004	<5	<5		232	203
Skutumpah Creek Upper	25-Sep-14	7.8	15.5	8.48	527	8.39																							
Skutumpah Creek Upper	11-Nov-14	129	0.9	8.56	570	10.36																							
Skutumpah Creek Upper	29-Jul-15	27	13.4	8.52	505	7.76		<0.03	<0.002	<0.03	0.52	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		183	262
Skutumpah Creek Upper	9-Nov-15	67	0.3	8.45	505	10.06																							
Skutumpah Creek Upper	9-Jul-16	75	15.3	8.65	509	7.81																							
Skutumpah Creek Upper	14-Nov-16	101	5.8	8.57	540	9.89																							
Skutumpah Creek Upper	29-Jul-17	14	14.9	8.59	490	7.51																							
Cowboy Top	29-Jun-17	1.74	13.8	8.43	540	7.49		<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01		<0.2		0.005	<0.01	0.03		<0.004	<5			290	230
Cowboy Top	29-Sep-17	0																											
Cowboy Top	9-Nov-17	0																											
Cowboy Middle	29-Jun-17	10.1	15.2	8.55	666	7.5		<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01		<0.2		0.002	<0.01	0.09		<0.004	<5			339	265
Cowboy Middle	30-Sep-17	12.1	8.5	8.58	743	8.86		<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01					<0.01	0.05		<0.004				388	261
Cowboy Middle	15-Nov-17	2.23	0.6	8.55	832	9.58		<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01					<0.01	0.07		<0.004		<5		440	307
Cowboy Bottom	29-Jun-17	0.51	13.6	8.8	610	7.49		<0.03	<0.002	<0.03		<0.01	0.08	<0.001		<0.01		<0.2		0.002	<0.01	0.07		<0.004	<5			171	213
Cowboy Bottom	30-Sep-17	1.41	8.9	8.75	693	7.94		<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01					<0.01	0.06		<0.004		<5		331	231
Cowboy Bottom	15-Nov-17	0.88	1.1	8.66	643	9.64		<0.03	<0.002	<0.03		<0.01	0.06	<0.001		<0.01					<0.01	0.08		<0.004		<5		311	226
SP60 Creek	30-Jun-17	37.5	14.5	8.64	545	8.11		0.06	<0.002	<0.03		<0.1	0.05	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5		273	227
SP60 Creek	28-Sep-17	15.7	6.9	8.67	635	8.97																							
SP60 Creek	10-Nov-17	10.7	0.7	8.54	737	11.28																							
CPC Upper	30-Jun-17	0.103	12.9	8.58	645	8.13		<0.03	<0.002	<0.03		<0.01	0.07	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5		335	286
CPC Upper	28-Sep-17	0																											
CPC Upper	10-Nov-17	0																											
CPC Middle	30-Jun-17	<0.01	11.4	7.86	1136	8.1																							
CPC Middle	28-Sep-17	0.62	7.7	8.77	795	8.98																							
CPC Middle	10-Nov-17	0																											
CPC Lower	30-Jun-17	3.13	11.2	8.3	853	7.78		<0.03	<0.002	<0.03		<0.01	0.08	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5		336	297
CPC Lower	28-Sep-17	3.0	7.5	8.6	884	9.13																							
CPC Lower	10-Nov-17	3.05	1.5	8.38	850	12.1																							
North Fork Upper	30-Jun-17	718	11.5	8.64	329	8.54		<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5		282	202
North Fork Upper	28-Sep-17	128	6	8.53	345	8.93		<0.03	<0.002	<0.03		0.01	0.02	<0.001		<0.01					<0.01			<0.004		<5		164	176
North Fork Upper	10-Nov-17	106	0.4	8.53	358	11.9		<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.03		<0.004		<5		214	190
North Fork Middle	30-Jun-17	581	10.3	8.66	355	8.44		<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01		<0.2			<0.01			<0.004	<5	<5		184	198
North Fork Middle	28-Sep-17	26	6.2	8.6	457	9.45		<0.03	<0.002	<0.03		<0.01	0.03	<0.001		<0.01					<0.01	0.05		0.05		<5		222	198
North Fork Middle	10-Nov-17	139	0.4	8.59	412	12.4		<0.03	<0.002	<0.03		<0.01	0.02	<0.001		<0.01					<0.01	0.04		<0.004		<5		214	184
ULGH	28-Jun-17	6.88	12.6	8.66	902	7.42		<0.03	0.058	<0.03		<0.01	0.09	<0.001	0.002	<0.01				<0.001	<0.01	0.03		<0.004				460	228
ULGH	27-Sep-17	3.49	6	8.67	872	8.45		<0.03	0.035	<0.03		0.02	0.08	<0.001		<0.01					<0.01	0.07		<0.004		<5		510	190
ULGH	13-Nov-17	3.16	0.8	8.66	834	12.98		<0.03	<0.002	<0.03		0.01	0.09	<0.001		<0.01					<0.01	0.08		<0.004		<5		468	174
URGH	28-Jun-17	1.01	14.5	8.48	770	6.85		<0.03	0.08	<0.03		0.02	0.06	<0.001	0.002	<0.01				0.001	<0.01	0.02		<0.004		<5		396	227
URGH	27-Sep-17	0.19	5.1	8.51	944	7.92		<0.03	<0.002	<0.03		0.02	0.06	<0.001		<0.01					<0.01	0.03		<0.004		<5		510	182
URGH	13-Nov-17	0																											

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
GH at Road	28-Jun-17	2.94	18.8	8.79	847	7.31	-	0.15	30.93	0.29		0.01	0.11	<0.001	0.003	<0.01		<0.2		0.001	<0.01	0.04		<0.004	<5			406	189
GH at Road	27-Sep-17	2.68	8.8	8.66	874	7.73	-	<0.03	<0.002	<0.03	-	0.01	0.08	<0.001	-	<0.01					<0.01	0.09		<0.004		<5		431	204
GH at Road	13-Nov-17	1.19	0.5	8.51	981	10.9	-	<0.03	<0.002	<0.03	-	<0.01	0.11	<0.001	-	<0.01					<0.01	0.12		<0.004		<5		511	330
Muddy Creek below Horse	27-Jun-17	107 cfs	14.9	8.76	366	7.52	-	<0.03	<0.002	<0.03	-	<0.01	0.02	<0.001	-	<0.01					<0.01	0.03		<0.004	<5	-292		185	215
Muddy Creek below Horse	30-Sep-17	9620	6.7	8.75	399	8.93	-	<0.03	<0.002	<0.03	-	<0.01	0.02	<0.001	-	<0.01					<0.01	0.06		<0.004		<5		215	198
Muddy Creek below Horse	14-Nov-17	4609	1.2	8.77	423	10.91	-	<0.03	<0.002	<0.03	-	<0.01	0.03	<0.001	-	<0.01					<0.01	0.06		<0.004		<5		233	220
Muddy Creek above Horse	27-Jun-17	96 cfs	15.3	8.76	360	7.52	-	<0.03	<0.002	<0.03	-	<0.01	0.03	<0.001	-	<0.01					<0.01	0.06		<0.004		<5		233	220
Muddy Creek above Horse	30-Sep-17	9030	6.2	8.76	398	9.08	-	<0.03	<0.002	<0.03	-	<0.01	0.02	<0.001	-	<0.01					<0.01	0.05		<0.004		<5		214	202
Muddy Creek above Horse	14-Nov-17	3777	1	8.76	414	10.9	-	<0.03	<0.002	<0.03	-	<0.01	0.03	<0.001	-	<0.01					<0.01	0.09		<0.004		<5		227	219
Horse Creek	27-Jun-17	11 cfs	16.5	8.77	446	7.48	-	<0.03	<0.002	<0.03	-	<0.01	0.03	<0.001	-	<0.01					<0.01	0.02		<0.004	<5	-298		215	224
Horse Creek	30-Sep-17	585	8.5	8.8	476	8.62	-	<0.03	<0.002	<0.03	-	<0.01	0.03	<0.001	-	<0.01					<0.01	0.05		<0.004		<5		248	214
Horse Creek	14-Nov-17	832	1.3	8.8	474	10.88	-	<0.03	<0.002	<0.03	-	0.01	0.04	<0.001	-	<0.01					<0.01	0.07		<0.004		<5		257	227
Spring Monitoring Stations																													
M-SP01	19-Jun-01	0.503	13.7	7.42	532		0.24																						
M-SP01	28-Aug-01	0.373	8	7.53	497		0.6																					387	
M-SP01	1-May-02	0.45	5.1	7.27	451		-																					388	
M-SP01	25-Sep-02	0.324	7.5	7.4	851	2.17	-	< .02	< .01	0.05		0.0012	0.07	< .005		< .01			< .02		< .07	0.0044		< .01		33		385	400
M-SP01	12-Nov-02	0.408	5.1	7.33	815	2.83	-	< .02	< .01	0.04		0.1	0.06	< .005		< .01			< .02		< .07	< .1		< .01		35		374	360
M-SP01	21-May-03	0.517	4.3	7.26	435	3.1	9.99	< .02	< .01	< .03		0.0009	< .05	< .005		< .01			< .02		< .07	0.0037		0.01				380	370
M-SP01	6-Aug-03	0.539	7.9	7.1	490	2.51	0.15	< .02	< .01	< .03		0.0007	0.06	< .005		< .01			< .02		< .07	0.0026		< .01		24		420	370
M-SP01	7-Oct-03	0.287	7.6	7.32	500	2.03	1.82	< .02	< .01	< .03		0.0006	0.06	< .005		< .01			< .02		< .07	0.0027		0.13		36		397	390
M-SP01	11-May-04	0.621	4.5	7.34	489	3.29	-	< .02	< .01	< .1		0.0008	0.06	< .005		< .01			< .02		< .07	0.0024		< .01		17		403	380
M-SP01	13-May-04	-	-	-	-																								
M-SP01	26-May-06	0.89	5	7.68	864																								
M-SP01	28-Sep-06	0.19	7	7.46	777																								
M-SP01	8-Nov-06	0.62	5.3	7.17	772																								
M-SP01	26-Jun-07	0.39	10.2	7.48	797																								
M-SP01	11-Sep-07	0.28	11.6	7.42	906																								
M-SP01	8-Nov-07	0.47	4.7	7.76	874																								
M-SP01	13-Jun-08	0.57	9.2	7.01	882																								
M-SP01	24-Sep-08	0.24	9.5	7.07	807																								
M-SP01	7-Nov-08	0.51	5.7	7.23	784																								
M-SP01	27-Jun-09	0.478	11.4	7.46	803																								
M-SP01	23-Sep-09	0.254	10.1	7.06	869																								
M-SP01	10-Nov-09	0.49	5.1	7.32	748																								
M-SP01	26-Jun-10	0.426	12.6	7.21	837																								
M-SP01	23-Sep-10	0.16	10.1	7.86	846																								
M-SP01	12-Nov-10	0.408	4.3	7.02	846																								
M-SP01	27-Jun-11	1.11	5.6	7.52	819																								
M-SP01	26-Sep-11	0.746	6.1	7.72	812																								
M-SP01	29-Oct-11	0.68	6.2	7.49	821																								
M-SP01	27-Jun-12	0.34	11.9	7.41	854																								
M-SP01	6-Sep-12	0.246	9.6	7.35	842																								
M-SP01	7-Nov-12	0.221	4.2	7.6	838																								
M-SP01	30-Jun-13	0.292	14	7.57	848																								
M-SP01	25-Sep-13	0.377	9.5	7.24	851																								
M-SP01	26-Oct-13	0.505	6.6	7.28	811																								
M-SP01	29-Jun-14	0.32	12.7	7.24	811																								
M-SP01	29-Aug-14	0.241	11.0	7.23	841																								
M-SP01	31-Oct-14	0.426	6.0	7.58	853																								
M-SP01	24-Jun-15	0.339	10.1	7.37	842																								
M-SP01	28-Sep-15	0.113	12.5	7.71	803																								
M-SP01	28-Oct-15	0.34	7.1	7.43	816																								
M-SP01	25-Jun-16	0.258	10.0	7.75	813																								
M-SP01	29-Sep-16	0.14	8.2	7.46	825																								
M-SP01	7-Nov-16	0.261	5.4	7.79	828																								
M-SP01	28-Jun-17	0.473	9.5	7.33	788																								

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		Field Measurements						Trace Metals														Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP02	19-Jun-01	9.274	10.7	7.43	497		0.08																					
M-SP02	28-Aug-01	2.756	10.3	7.62	499		-																				370	
M-SP02	1-May-02	4.348	9.1	7.57	470		-																				385	
M-SP02	25-Sep-02	0																										
M-SP02	12-Nov-02	0																										
M-SP02	20-May-03	6.856	6.1	7.22	469	5.78	13.68	< .02	< .01	< .03		0.0012	0.19	< .005		< .01			< .02		< .07	0.0033		0.01		56		370	340
M-SP02	5-Aug-03	-	-	-	-	-	-																			23		376	
M-SP02	8-Aug-03	0.992	8.8	7.21	485	5.7	0.15	< .02	< .01	< .03		0.0008	0.05	< .005		< .01			< .02		< .07	0.0019		0.06				420	340
M-SP02	7-Oct-03	0																										
M-SP02	11-May-04	2.485	6	7.37	437	4.82	0.25	< .02	< .01	< .1		0.0009	0.06	< .005		< .01			< .02		< .07	0.002		0.02		14		379	330
M-SP02	13-May-04	-	-	-	-	-	-																					
M-SP02	26-May-05	13.4	6.3	7.67	824																							
M-SP02	28-Sep-06	4.19	8.2	7.24	772																							
M-SP02	8-Nov-06	2.26	7.8	7	765																							
M-SP02	26-Jun-07	4.16	6.7	7.49	813																							
M-SP02	11-Sep-07	0.046	12.1	7.72	898																							
M-SP02	8-Nov-07	0																										
M-SP02	13-Jun-08	5.17	6.8	7.27	917																							
M-SP02	24-Sep-08	< .1	9.1	7.47	805																							
M-SP02	7-Nov-08	0	3.3	7.93	783																							
M-SP02	27-Jun-09	2.01	10.8	7.01	829																							
M-SP02	23-Sep-09	0	10.8	7.92	881																							
M-SP02	10-Nov-09	0	4.9	8.49	676																							
M-SP02	26-Jun-10	1.19	6.7	7.15	835																							
M-SP02	23-Sep-10	0																										
M-SP02	12-Nov-10	0																										
M-SP02	27-Jun-11	6.25	5.2	7.41	799																							
M-SP02	26-Sep-11	1.76	6.8	7.52	796																							
M-SP02	29-Oct-11	0.35	7.8	7.55	826																							
M-SP02	27-Jun-12	2.05	10.2	7.55	877																							
M-SP02	6-Sep-12	0.872	11.2	7.45	841																							
M-SP02	7-Nov-12	0	2.2	7.6	1385																							
M-SP02	30-Jun-13	0.063	7.8	7.62	865																							
M-SP02	25-Sep-13	< .1	10.7	7.99	842																							
M-SP02	26-Oct-13	< .001	5.7	8.35	783																							
M-SP02	29-Jun-14	0.005	6.8	7.36	848																							
M-SP02	29-Aug-14	0	11.4	7.59	847																							
M-SP02	31-Oct-14	< .005	5.9	8.2	721																							
M-SP02	24-Jun-15	< .1	12.1	7.47	782																							
M-SP02	28-Sep-15	0	—	—	—																							
M-SP02	28-Oct-15	0	—	—	—																							
M-SP02	25-Jun-16	< .001	10.6	7.42	834																							
M-SP02	29-Sep-16	0	—	—	—																							
M-SP02	7-Nov-16	0	—	—	—																							
M-SP02	28-Jun-17	2.74	7.1	7.43	812																							
M-SP04	19-Jun-01	2.838	5.6	8.05	499	NM	0.62																					
M-SP04	28-Aug-01	1.832	4.7	7.73	379	NM	0.47																					
M-SP04	3-May-02	2.043	4.5	7.61	866	NM	0.00																					
M-SP04	26-Sep-02	0.900	5.3	7.41	844	6.21	0.91																					
M-SP04	12-Nov-02	1.230	4.8	7.56	885	6.64	5.40																					
M-SP04	20-May-03	3.226	4.2	7.38	929	7.69	0.00																					
M-SP04	5-Aug-03	0.849	5.4	7.40	408	7.40	0.10																					
M-SP04	6-Oct-03	0.747	5.4	7.50	861	7.30	1.02																					
M-SP04	12-May-04	2.921	4.4	7.59	512	0.69	0.69																					
M-SP04	26-Jun-15	1.81	4.9	7.68	986																							
M-SP04	30-Sep-15	0.251	6.9	7.89	872																							
M-SP04	1-Nov-15	0.638	5.6	7.72	873																							
M-SP04	25-Jun-16	0.987	5.5	7.75	924																							
M-SP04	28-Sep-16	0.192	6.9	7.90	923																							
M-SP04	31-Oct-16	0.617	5.8	7.77	898																							
M-SP04	28-Jun-17	3.92	5.2	7.58	877																							

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		Field Measurements						Trace Metals																	Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP05	26-Sep-02	0.082	7.7	7.77	780		19.00																						
M-SP05	20-May-03	0.216	4.3	7.60	910		0.35																						
M-SP05	25-Sep-03	0.119	7.3	7.78	533		17.70																						
M-SP05	12-May-04	0.264	3.9	7.92	524		0.16																						
M-SP05	26-Jun-15	0.127	7.8	7.8	934																								
M-SP05	30-Sep-15	0.085	8.9	7.91	870																								
M-SP05	1-Nov-15	0.157	6.6	7.84	888																								
M-SP05	25-Jun-16	0.096	7.3	7.86	889																								
M-SP05	28-Sep-16	0.130	7.9	7.91	895																								
M-SP05	31-Oct-16	0.137	6.8	7.92	902																								
M-SP05	28-Jun-17	0.130	7	7.85	892																								
M-SP06	19-Jun-01	2.30	9.30	9	550		7.5																						
M-SP06	4-Oct-01	1.86	6.30	8	474		13.2																						
M-SP06	3-May-02	2.06	4.90	9	899		0.88																						
M-SP06	26-Sep-02	1.549	5.4	7.55	895		0																						
M-SP06	20-May-03	1.472	4.6	7.62	918		1.24																						
M-SP06	25-Sep-03	1.665	5.3	7.59	514		0																						
M-SP06	12-May-04	1.624	4.7	7.78	528		0.05																						
M-SP06	30-Jun-14	1.47	5.3	7.81	916																								
M-SP06	18-Sep-14	1.46	5.9	7.76	922			<0.03	<0.002	<.03	0.58	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		469	137
M-SP06	31-Oct-14	1.33	5.2	7.76	934			<0.03	<0.002	0.03	0.05	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	<5	11		472	139
M-SP06	26-Jun-15	1.45	5.5	7.82	932			<0.03	<0.002	<0.03	0.19	<0.01	0.06	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.01		<5		469	137
M-SP06	29-Sep-15	1.34	5.8	7.88	868			<0.03	<0.002	<0.03	0.08	<0.01	0.06	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		10		452	133
M-SP06	1-Nov-15	1.23	5.5	7.77	887			<0.03	<0.002	<0.03	0.15	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		478	133
M-SP06	25-Jun-16	1.34	5.9	7.76	886																								
M-SP06	28-Sep-16	1.32	5.9	7.78	897																								
M-SP06	31-Oct-16	1.39	5.7	7.79	906																								
M-SP06	28-Jun-17	1.62	5.8	7.76	888																								
M-SP07	20-Jun-01	1.137	7.8	7.37	491		1.02																						
M-SP07	29-Aug-01	0.249	7.3	7.5	541		2.25																					459	
M-SP07	3-May-02	0.409	4.6	8.37	530		11.5																					449	
M-SP07	26-Sep-02	0.211	6.5	7.45	878	5.21	1.8	< .02	< .01	0.05		0.0009	0.1	< .005		< .01			< .02		< .07	0.0034		< .01		13		426	340
M-SP07	12-Nov-02	0.273	3.9	7.46	799	4.94	3.9	< .02	< .01	0.04		0.1	0.07	< .005		< .01			< .02		< .07	0.1		0.02		23		453	320
M-SP07	20-May-03	0.601	4.6	7.36	854	6.17	6.25	< .02	< .01	< .03		0.0009	0.08	< .005		< .01			< .02		< .07	0.0025		0.01		22		430	310
M-SP07	5-Aug-03	0.28	8.7	7.32	442	6.03	0.95	< .02	< .01	< .03		0.0006	0.07	< .005		< .01			< .02		< .07	0.002		0.02		17		440	310
M-SP07	7-Oct-03	0.283	8.3	7.62	865	7.02	0.56	0.02	0.02	< .03		0.0007	0.07	< .005		< .01			< .02		< .07	0.0024		0.02		9		423	330
M-SP07	10-May-04	0.677	4	7.38	500	6.28	0.53	< .02	< .01	< .1		0.0008	0.08	< .005		< .01			< .02		< .07	0.0019		< .01		32		433	330
M-SP08	20-Jun-01	1.03	8.4	7.78	424		7.58																						
M-SP08	29-Aug-01	0.433	7.3	7.26	332		2.04																					279	
M-SP08	3-May-02	0.775	6.3	8.27	600		3.5																					463	
M-SP08	26-Sep-02	0.023	11.7	7.91	901	5.8		< .02	< .01	0.05		0.0014	0.09	< .005		< .01			< .02		< .07	0.0034		< .01		7		424	340
M-SP08	12-Nov-02	0																								21			
M-SP08	20-May-03	0.79	3.9	7.27	1013	2.93	0.66	< .02	< .01	< .03		0.0013	0.08	< .005		< .01			< .02		< .07	0.0044		0.01				460	330
M-SP08	5-Aug-03	0.096	10.1	7.25	541	2.86	21	< .02	0.01	< .03		0.0013	0.08	< .005		< .01			< .02		< .07	0.0028		< .01		35		450	310
M-SP08	7-Oct-03	0.08	7.7	7.33	896	2.54	2.08	0.07	0.02	< .03		0.0011	0.07	< .005		< .01			< .02		< .07	0.0021		0.01		15		431	320
M-SP08	10-May-04	1.189	4.8	7.4	557	5.42		< .02	< .01	< .1		0.0012	0.11	< .005		< .01			< .02		< .07	0.0033		< .01		18		462	320
M-SP08	13-May-04	-	-	-	-																								
M-SP08	23-Jun-06	0.65	7.8	7.83	931																								
M-SP08	28-Sep-06	0.51	7.3	7.78	837																								
M-SP08	8-Nov-06	0.78	5.5	7.49	878																								
M-SP08	26-Jun-07	0.37	8.6	7.52	888																								
M-SP08	11-Sep-07	0.071	13.2	7.93	864																								
M-SP08	8-Nov-07	0.16	3.6	7.82	709																								
M-SP08	21-Jun-08	0.46	7.8	7.35	932																								
M-SP08	24-Sep-08	0.016	12.6	8.03	912																								
M-SP08	6-Nov-08	0																											
M-SP08	22-Jun-09	0.26	8.1	7.55	897																								
M-SP08	23-Sep-09	0.011	13.2	7.94	963																								
M-SP08	10-Nov-09	< .01	5.9	7.74	698																								

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP08	26-Jun-10	0.12	12.1	7.58	930																							
M-SP08	16-Jul-10	0.0084	27.6	7.1	951																							
M-SP08	23-Sep-10	0																										
M-SP08	12-Nov-10	0																										
M-SP08	27-Jun-11	1.04	6.2	7.72	912																							
M-SP08	27-Sep-11	0.49	7.9	7.71	930																							
M-SP08	29-Oct-11	0.73	5.5	7.77	941																							
M-SP08	27-Jun-12	0.138	10.1	7.99	954																							
M-SP08	25-Sep-12	0.021	12.9	7.99	996																							
M-SP08	7-Nov-12	0.0689	5.4	7.93	934																							
M-SP08	28-Jun-13	0.017	23.9	7.93	1037																							
M-SP08	25-Sep-13	0.01	9.5	7.67	715																							
M-SP08	26-Oct-13	0.014	13.4	7.98	953																							
M-SP08	29-Jun-14	0.015	20.8	8.34	1061																							
M-SP08	18-Sep-14	0																										
M-SP08	31-Oct-14	0.012	2.6	7.92	504																							
M-SP08	25-Jun-15	0.01	36	8.38	1125																							
M-SP08	26-Sep-15	0.094	15.2	8.05	982																							
M-SP08	1-Nov-15	0.064	7.8	7.64	988																							
M-SP08	26-Jun-16	0.074	20.4	7.8	1140																							
M-SP08	27-Sep-16	0.035	17.5	8.38	972																							
M-SP08	26-Oct-16	0.050	8.0	7.91	980																							
M-SP08	29-Jun-17	0.205	11.7	7.68	1,152																							
M-SP09	20-Jun-01	1	7.9	7.53	464		1.43																					
M-SP09	29-Aug-01	0																										
M-SP09	3-May-02	0.254	3.6	8.56	429		141																					
M-SP09	26-Sep-02	0																										
M-SP09	20-May-03	0																										
M-SP09	7-Oct-03	0																										
M-SP09	10-May-04	0																										
M-SP09	27-Sep-11	1.430	5.4	7.77	794																							
M-SP09	29-Oct-11	1.820	—	—	—																							
M-SP09	25-Jun-15	0																										
M-SP09	26-Sep-15	0																										
M-SP09	1-Nov-15	0																										
M-SP09	26-Jun-16	0.000	—	—	—																							
M-SP09	27-Sep-16	0.000	—	—	—																							
M-SP09	26-Oct-16	0.000	—	—	—																							
M-SP10	20-Jun-01	0.532	14.5	7.75	610		0.16																					
M-SP10	28-Aug-01	0.489	7.8	7.76	526																						351	
M-SP10	1-May-02	0.42	8.5	7.99	490																						352	
M-SP10	25-Sep-02	0.238	7.7	7.84	833	4.56		< .02	< .01	0.06		0.0014	0.06	< .005		< .01			< .02		< .07	0.0054	< .01		8		330	290
M-SP10	13-Nov-02	0.244	3.8	7.55	814	5.98		< .02	< .01	0.04		< .1	0.05	< .005		< .01			< .02		< .07	< .1	0.01		14		420	270
M-SP10	20-May-03	0.243	5.8	7.56	509	4.16	1.71	< .02	< .01	< .03		0.001	0.06	< .005		< .01			< .02		< .07	0.0036	0.01		18		360	290
M-SP10	5-Aug-03	0.224	9.9	7.7	500	5.6		< .02	< .01	< .03		0.0008	0.05	< .005		< .01			< .02		< .07	0.0035	0.01		22		360	270
M-SP10	7-Oct-03	0.275	6.7	7.67	846	5.55		< .02	< .01	< .03		0.0007	0.05	< .005		< .01			< .02		< .07	0.0036	0.01		10		340	280
M-SP10	10-May-04	0.271	6.1	7.52	538	4.02	0.82	< .02	< .01	< .1		0.001	0.06	< .005		< .01			< .02		< .07	0.0031	0.01		14		384	300
M-SP10	13-May-04	-	-	-	-	-	-																					
M-SP11	21-Jun-01	0.408	12.8	7.50	488																							
M-SP11	4-Oct-01	0.000	—	—	—	—																						
M-SP11	2-May-02	0.548	4.4	7.72	433																							
M-SP11	25-Sep-02	0.000	—	—	—	—																						
M-SP11	22-May-03	6.275	7.6	7.83	754																							
M-SP11	25-Sep-03	0.000	—	—	—	—																						
M-SP11	4-Jun-04	5.984	6.0	8.02	396																							
M-SP11	26-Jun-15	0.932	9.3	7.76	866																							
M-SP11	30-Sep-15	Damp	—	—	—																							
M-SP11	1-Nov-15	0.000	—	—	—																							
M-SP11	25-Jun-16	<1	13.0	7.69	1,060																							
M-SP11	28-Sep-16	0.000	—	—	—																							

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		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP11	31-Oct-16	0.000	—	—	—																							
M-SP11	28-Jun-17	0.190	11.1	7.77	788																							
M-SP12	19-Jun-01	0.746	22.0	8.44	495																							
M-SP12	4-Oct-01	0.749	5.4	7.55	399																							
M-SP12	3-May-02	0.472	2.8	8.07	785																							
M-SP12	26-Sep-02	0.422	5.5	7.71	714																							
M-SP12	21-May-03	Immeas.	3.9	7.62	779																							
M-SP12	27-Sep-03	0.263	5.5	7.58	443																							
M-SP12	3-Jun-04	0.937	4.4	7.71	430																							
M-SP12	26-Jun-15	0.873	5.5	7.94	837																							
M-SP12	30-Sep-15	0.769	6.5	7.96	784																							
M-SP12	6-Nov-15	0.847	5.3	7.75	798																							
M-SP12	25-Jun-16	0.781	5.3	7.84	804																							
M-SP12	29-Sep-16	0.785	6.1	7.82	808																							
M-SP12	31-Oct-16	0.817	5.8	7.80	814																							
M-SP12	28-Jun-17	0.811	5.3	7.87	804																							
M-SP14	21-Jun-01	11.229	4.8	7.35	295																							
M-SP14	29-Aug-01	0.665	6.9	7.35	340																							
M-SP14	20-May-02	1.95	4	7.47	542																							
M-SP14	26-Sep-02	Dry	—	—	—																							
M-SP14	20-May-03	37.2	3.9	7.42	304																							
M-SP14	4-Aug-03	Dry	—	—	—																							
M-SP14	9-Oct-03	Dry	—	—	—																							
M-SP14	6-Jun-04	61.4	4.4	7.58	309																							
M-SP15	11-Jul-01	4.822	13.5	8.26	621		69.90																					
M-SP15	3-Oct-01	1.733	6.4	8.34	433		3.68																					
M-SP15	2-May-02	0.548	5.4	7.70	448		0.00																					
M-SP15	27-Sep-02	0																										
M-SP15	21-May-03	0.433	14.9	7.65	509		14.07																					
M-SP15	8-Oct-03	0																										
M-SP15	5-Jun-04	0.268	15.5	8.14	930		2.52																					
M-SP15	27-Jun-15	0.059	12.9	7.42	1073																							
M-SP15	29-Sep-15	0																										
M-SP15	7-Nov-15	0																										
M-SP15	23-Jun-16	<0.1	9.9	7.37	986																							
M-SP15	26-Sep-16	0.000	—	—	—																							
M-SP15	6-Nov-16	0.000	—	—	—																							
M-SP15	30-Jun-17	0.037	12	7.14	1050																							
M-SP18	22-Jun-01	0.34	6.6	6.96	728		0.36																					
M-SP18	28-Aug-01	0.212	8.3	7.58	726		0.32																				353	
M-SP18	1-May-02	0.33	6.8	7.23	1274		0.46																				284	
M-SP18	25-Sep-02	0																										
M-SP18	12-Nov-02	0																										
M-SP18	20-May-03	0.147	5.5	7.35	748	4.65	9.6	0.03	0.01	< .03		0.0015	0.06	< .005		< .01			< .02		< .07	0.0044		0.01		16		290	510
M-SP18	6-Aug-03																									13		282	
M-SP18	8-Aug-03	0.344	10	7.34	748	4.74	1.3	0.04	0.01	< .03		0.001	0.08	< .005		< .01			< .02		< .07	0.003		< .01				290	470
M-SP18	6-Oct-03	0.47	8.9	7.26	1276	5.16	0.38	0.08	< .01	< .03		0.0007	0.08	< .005		< .01			< .02		< .07	0.0032		0.01		11		287	470
M-SP18	11-May-04	0.463	4.2	7.47	728	5.01	2.62	< .02	< .01	< .1		0.0029	0.07	< .005		< .01			< .02		< .07	0.0086		0.01		12		270	510
M-SP18	26-May-06	0.65	4.2	7.66	1214																							
M-SP18	28-Sep-06	0.45	6	7.46	1174																							
M-SP18	8-Nov-06	0.47	4.5	7.45	1185																							
M-SP18	26-Jun-07	0.25	6	7.49	1198																							
M-SP18	11-Sep-07	0.21	8.3	7.75	1435																							
M-SP18	8-Nov-07	0.29	4.1	7.66	1428																							
M-SP18	21-Jun-08	0.2	5.2	7.24	1245																							
M-SP18	24-Sep-08	0.06	6.9	7.29	1227																							
M-SP18	6-Nov-08	0.252	4.3	7.41	1226																							
M-SP18	27-Jun-09	0.082	6.3	7.11	1283																							
M-SP18	23-Sep-09	0.229	7.8	7.25	1264																							

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		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP18	10-Nov-09	0.244	4.5	7.38	1259																							
M-SP18	26-Jun-10	0.227	6.9	7.17	1347																							
M-SP18	23-Sep-10	0.118	7.6	7.18	1394																							
M-SP18	12-Nov-10	0.257	2.2	7.27	1359																							
M-SP18	27-Jun-11	0.77	9.1	7.52	1228																							
M-SP18	26-Sep-11	0.431	7.8	7.44	1289																							
M-SP18	29-Oct-11	0.456	3.4	7.79	1324																							
M-SP18	27-Jun-12	0.36	16.5	7.49	1317																							
M-SP18	6-Sep-12	0.149	14.2	7.51	1528																							
M-SP18	7-Nov-12	0.128	2.2	7.6	1385																							
M-SP18	30-Jun-13	0.115	8.3	7.31	1365																							
M-SP18	25-Sep-13	0.145	8.2	7.35	1389																							
M-SP18	26-Oct-13	0.128	6.6	7.39	1302																							
M-SP18	29-Jun-14	< .05	7.4	7.51	1356																							
M-SP18	29-Aug-14	0	8.1	7.33	1364																							
M-SP18	5-Nov-14	0.299	3.6	7.53	1380																							
M-SP18	26-Jun-15	0.225	8.9	7.49	1352																							
M-SP18	28-Sep-15	0.078	8.9	7.72	1298																							
M-SP18	28-Oct-15	0.151	5.6	7.76	1323																							
M-SP18	23-Jun-16	0.131	10.1	7.54	1314																							
M-SP18	28-Sep-16	0.186	7.7	7.52	1336																							
M-SP18	7-Nov-16	0.229	5.1	7.67	1,333																							
M-SP18	29-Jun-17	0.211	7.7	7.52	1,274																							
M-SP19	11-Jul-01	2.260	10.4	8.24	508		5.90																					
M-SP19	3-Oct-01	1.976	6.1	7.83	443		0.17																					
M-SP19	2-May-02	3.031	5.1	8.28	456		0.46																					
M-SP19	27-Sep-02	2.114	5.8	7.94	457		0.35																					
M-SP19	21-May-03	2.866	5.2	7.86	449		12.30																					
M-SP19	8-Oct-03	2.555	6.1	8.21	480		0.68																					
M-SP19	5-Jun-04	3.128	6.5	8.23	851		1.34																					
M-SP19	27-Jun-15	2.56	5.7	7.97	873																							
M-SP19	29-Sep-15	1.73	6.3	8.04	824																							
M-SP19	7-Nov-15	1.95	6	7.98	829																							
M-SP19	23-Jun-16	2.53	6.0	8.00	835																							
M-SP19	26-Sep-16	1.74	6.4	8.00	845																							
M-SP19	6-Nov-16	2.05	6.3	8.07	840																							
M-SP19	30-Jun-17	4.49	6.1	8.05	818																							
M-SP20	11-Jul-01	3.507	14.2	7.84	486		3.52																					
M-SP20	3-Oct-01	0.909	12.1	7.85	435		5.20																					
M-SP20	2-May-02	0.814	10.5	7.97	432		0.00																					
M-SP20	28-Sep-02	0.706	7.4	7.79	435		20.00																					
M-SP20	22-May-03	1.041	7.6	7.59	420		19.05																					
M-SP20	8-Oct-03	0.781	11.0	8.31	494		18.60																					
M-SP20	5-Jun-04	8.621	10.8	7.92	814		0.35																					
M-SP20	25-Jun-15	5.24	8.3	7.78	824																							
M-SP20	26-Sep-15	1.04	7.5	7.38	769																							
M-SP20	1-Nov-15	1.21	6.8	7.69	763																							
M-SP20	26-Jun-16	1.90	6.6	7.41	775																							
M-SP20	27-Sep-16	0.980	7.0	7.56	781																							
M-SP20	26-Oct-16	0.980	7.8	7.79	770																							
M-SP20	29-Jun-17	8.060	7.4	7.61	736																							
M-SP36	20-Jul-01	2.270	8.9	8	562		1.90																					
M-SP36	5-Oct-01	1.497	6.2	8.07	603		0.00																					
M-SP36	22-May-02	0.866	9.3	8.75	688		8.67																					
M-SP36	26-Sep-02	1.559	6.4	8.02	626		0.05																					
M-SP36	4-Jun-03	1.715	4.3	8.36	615		0.63																					
M-SP36	23-Sep-03	1.752	6.2	8.12	619		0.32																					
M-SP36	16-Jun-04	1.930	4.8	8.22	652		0.63																					
M-SP37	20-Jul-01	1,525	9.2	8.46	658		2.98																					

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		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP37	5-Oct-01	1.660	6.1	8.12	667		0.00																					
M-SP37	22-May-02	1.827	5.9	8.58	746		3.97																					
M-SP37	26-Sep-02	1.424	6.4	8.1	720		0.10																					
M-SP37	4-Jun-03	2.110	5.2	8.33	714		0.41																					
M-SP37	23-Sep-03	1.540	6.1	8.11	725		0.45																					
M-SP37	16-Jun-04	2.327	5.4	8.26	737		0.00																					
M-SP38	20-Jul-01	5.71	8.4	7.99	302		25.50																					
M-SP38	29-Aug-01	5.538	8.5	7.39	303		0																				289	
M-SP38	28-May-02	2.832	7.8	7.70	321		0.69																				273	
M-SP38	26-Sep-02	4.956	8.7	7.59	301		0	<0.02	<0.01	0.03		0.0021	<0.05	<0.005		<0.01					<0.07	0.0009		0.05	6		268	200
M-SP38	13-Nov-02	4.999	8.4	7.64	276		0	<0.02	<0.01	0.03		0.1	<0.05	<0.005		<0.01					<0.07	<0.1		0.02	9		264	190
M-SP38	20-May-03	5.111	7.7	7.65	179		10.95	<0.02	<0.01	<0.03		0.002	<0.05	<0.005		<0.01					<0.07	0.0009		0.02	11		270	200
M-SP38	4-Aug-03	5.24	8.5	7.47	267		18	<0.02	<0.01	<0.03		0.0021	<0.05	<0.005		<0.01					<0.07	0.0006		<0.01	21		290	190
M-SP38	7-Oct-03	5.764	8.8	7.7	312		1.37	<0.02	<0.01	<0.03		0.0023	<0.05	<0.005		<0.01					<0.07	0.0006		<0.01	<5		278	200
M-SP38	6-Jun-04	5.808	7.9	7.7	313		1.11	<0.02	<0.01	<0.1		0.0026	<0.05	<0.005		<0.01					<0.07	0.0011		<0.01	<5		275	200
M-SP39	30-Aug-01	1.068	7.1	7.16	590																						453	
M-SP39	3-May-02	4.663	5.3	7.48	603		3.25																				427	
M-SP39	25-Sep-02	0.441	6.5	7.56	1011	5.63		< .02	< .01	0.06		0.002	0.09	< .005		< .01			< .02		< .07	0.0073		0.06	15		413	400
M-SP39	13-Nov-02	0.566	5.8	7.36	986	5.04	0.15	< .02	< .01	0.05		< .1	0.08	< .005		< .01			< .02		< .07	< .1		0.01	23		330	380
M-SP39	20-May-03	2.374	5.7	7.43	573	7.39	9.24	< .02	< .01	< .03		0.0013	0.06	< .005		< .01			< .02		< .07	0.0051		0.01	25		420	410
M-SP39	6-Aug-03	-	-	-	-	-	-	-	-	-		-	-	-		-			-		-	-		-	13		413	
M-SP39	9-Aug-03	0.509	6.4	7.4	585	5.78	0.11	< .02	< .01	< .03		0.0007	0.07	< .005		< .01			< .02		< .07	0.0032		< .01			450	370
M-SP39	7-Oct-03	0.268	6.2	7.39	1035	4.5	0.13	0.06	0.01	< .03		0.0005	0.07	< .005		< .01			< .02		< .07	0.0035		0.07	16		425	390
M-SP39	12-May-04	0.446	5.7	7.54	604	4.86	0.24	< .02	< .01	< .1		0.0014	0.08	< .005		< .01			< .02		< .07	0.0044		0.02	18		430	410
M-SP39	30-Aug-01	1.068	7.1	7.16	590																							
M-SP39	3-May-02	4.663	5.3	7.48	603																							
M-SP39	25-Sep-02	0.441	6.5	7.56	1011	5.63																						
M-SP39	13-Nov-02	0.566	5.8	7.36	986	5.04																						
M-SP39	20-May-03	2.374	5.7	7.43	573	7.39																						
M-SP39	9-Aug-03	0.509	6.4	7.40	585	5.78																						
M-SP39	7-Oct-03	0.268	6.2	7.39	1035	4.50																						
M-SP39	12-May-04	0.446	5.7	7.54	604	4.86																						
M-SP39	23-Jun-06	1.84	5.4	7.59	982																							
M-SP39	28-Sep-06	0.66	6.2	7.87	931																							
M-SP39	8-Nov-06	0.64	5.9	7.64	960																							
M-SP39	26-Jun-07	0.72	6.7	7.67	983																							
M-SP39	11-Sep-07	0.94	7.8	8.31	1080																							
M-SP39	8-Nov-07	1.38	5.9	7.74	1048																							
M-SP39	13-Jun-08	2.04	6.1	7.39	1086																							
M-SP39	24-Sep-08	0.89	6.1	7.72	954																							
M-SP39	6-Nov-08	1.2	5.8	7.5	941																							
M-SP39	27-Jun-09	2.04	6.8	7.22	975																							
M-SP39	23-Sep-09	1.11	7.1	7.39	1058																							
M-SP39	10-Nov-09	1.9	6.2	7.51	858																							
M-SP39	26-Jun-10	0.24	11.2	7.29	1054																							
M-SP39	23-Sep-10	0.753	5.8	7.65	1029																							
M-SP39	12-Nov-10	1.12	4.6	7.29	994																							
M-SP39	27-Jun-11	2.71	4.1	7.67	981																							
M-SP39	26-Sep-11	0.962	4.8	7.53	782																							
M-SP39	29-Oct-11	1.38	6.2	7.72	1007																							
M-SP39	27-Jun-12	1.03	9.2	7.63	1024																							
M-SP39	6-Sep-12	0.221	5.2	7.55	1013																							
M-SP39	7-Nov-12	1.29	6.2	7.77	1007																							
M-SP39	28-Jun-13	1.44	6.1	7.64	997																							
M-SP39	25-Sep-13	1.06	6.8	7.53	984																							
M-SP39	26-Oct-13	1.17	6.5	7.51	942																							
M-SP39	29-Jun-14	0.61	6.3	7.51	982																							
M-SP39	29-Aug-14	0.987	6.5	7.5	1002																							
M-SP39	31-Oct-14	0.769	6.2	7.52	1021																							
M-SP39	26-Jun-15	1.27	6.2	7.59	1026																							
M-SP39	28-Sep-15	0.581	6.9	7.65	947																							

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP39	28-Oct-15	0.67	6.7	7.58	964																						
M-SP39	25-Jun-16	0.87	6.6	7.44	960																						
M-SP39	29-Sep-16	0.434	7.2	7.49	969																						
M-SP39	7-Nov-16	0.434	6.6	7.65	970																						
M-SP39	28-Jun-17	0.735	6.7	7.58	954																						
M-SP40	26-Sep-01	0.657	7.9	7.64	497		30.40																				
M-SP40	2-May-02	0.455	7.5	7.92	865		11.60																				
M-SP40	28-Sep-02	0.336	8.4	7.72	483		0.70																				
M-SP40	22-May-03	0.314	6.9	7.77	538		15.03																				
M-SP40	9-Oct-03	0.180	8.3	7.76	900		19.00																				
M-SP40	6-Jun-04	0.447	7.7	8.10	545		0.68																				
M-SP40	25-Jun-15	0.102	7.4	7.82	959																						
M-SP40	26-Sep-15	0.082	9.5	7.77	905																						
M-SP40	1-Nov-15	0.093	8	7.78	925																						
M-SP40	26-Jun-16	0.107	8.0	7.74	930																						
M-SP40	27-Sep-16	0.068	9.1	7.85	956																						
M-SP40	26-Oct-16	0.087	8.4	7.93	943																						
M-SP40	29-Jun-17	0.277	7.2	7.79	849																						
M-SP41	26-Sep-01	0.422	5.3	7.85	286		1.25																				
M-SP41	2-May-02	2.253	10.2	8.53	616		28.90																				
M-SP41	28-Sep-02	0.427	5.1	7.97	323		4.50																				
M-SP41	22-May-03	0.472	3.9	7.99	429		24.03																				
M-SP41	9-Oct-03	0.402	4.9	7.67	799		0.86																				
M-SP41	6-Jun-04	0.509	6.0	8.14	452		0.48																				
M-SP41	25-Jun-15	0.974	9.7	7.52	897																						
M-SP41	26-Sep-15	0.313	5.9	7.94	765																						
M-SP41	1-Nov-15	0.321	5	7.87	759																						
M-SP41	26-Jun-16	0.210	4.7	7.80	786																						
M-SP41	27-Sep-16	0.193	5.4	7.97	795																						
M-SP41	26-Oct-16	0.245	5.2	7.98	796																						
M-SP41	29-Jun-17	0.354	4.5	7.86	764																						
M-SP44	3-Oct-01	0.561	9.2	7.52	314		5.39																				
M-SP44	2-May-02	2.018	4.8	7.66	269		0.00																				
M-SP44	28-Sep-02	0.196	10.3	7.66	376		110.00																				
M-SP44	22-May-03	13.029	6.1	7.65	276		11.91																				
M-SP44	24-Sep-03	0.197	12.1	7.93	721		15.30																				
M-SP44	5-Jun-04	4.900	5.4	7.65	542		0.00																				
M-SP44	29-Jun-14	3.18	5.9	7.64	554			<0.03	<0.002	<0.03	<0.03	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004		8		283	298
M-SP44	18-Sep-14	0.588	8.7	7.78	610			<0.03	<0.002	<0.03	0.33	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		296	259
M-SP44	31-Oct-14	0.595	8.2	7.58	611			<0.03	0.002	<0.03	0.24	<0.01	<0.01	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		12		304	261
M-SP44	25-Jun-15	4.21	6	7.67	570			<0.03	<0.002	<0.03	0.48	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.004		7		297	303
M-SP44	26-Sep-15	0.493	9.2	7.54	581			<0.03	<0.002	<0.03	0.2	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	<0.004		5		297	267
M-SP44	1-Nov-15	0.45	8.3	7.59	594			<0.03	<0.002	<0.03	0.21	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		308	270
M-SP44	26-Jun-16	3.74	6.3	7.52	547			<0.03	<0.002	<0.03	0.48	<0.01	0.02	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.004		7		297	303
M-SP44	27-Sep-16	0.530	8.9	7.55	593																						
M-SP44	26-Oct-16	0.495	8.6	7.65	597																						
M-SP44	29-Jun-17	5.350	6.3	7.55	532																						
M-SP45	4-Oct-01	2.230	5.9	7.32	508		0.60																				
M-SP45	3-May-02	1.837	3.5	7.85	969		0.00																				
M-SP45	25-Sep-02	1.713	6.0	7.58	977		0.00																				
M-SP45	21-May-03	1.824	3.7	7.30	977		1.67																				
M-SP45	27-Sep-03	1.541	5.9	7.30	545		0.29																				
M-SP45	3-Jun-04	0.673	5.0	7.42	369		1.08																				
M-SP45	26-Jun-15	1.26	5.1	7.47	996																						
M-SP45	30-Sep-15	1.21	6.5	7.47	923																						
M-SP45	5-Nov-15	1.21	5.9	7.38	933																						
M-SP45	25-Jun-16	1.28	5.4	7.53	931																						
M-SP45	29-Sep-16	1.29	6.5	7.38	952																						
M-SP45	31-Oct-16	1.03	6.1	7.46	940																						

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		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP45	28-Jun-17	1.53	5.3	7.5	935																							
M-SP48	19-Oct-01	1.213	9.7	7.96	311		0.30																					
M-SP48	22-May-02	1.694	7.7	8.08	345		7.99																					
M-SP48	7-Oct-02	0.959	9.6	8.03	545		3.63																					
M-SP48	4-Jun-03	1.307	7.1	7.92	321		0.27																					
M-SP48	23-Sep-03	1.119	9.7	8	330		0.00																					
M-SP48	16-Jun-04	1.482	7.6	8.05	341																							
M-SP49	19-Oct-01	0.363	9.2	8.29	303		11.30																					
M-SP49	22-May-02	0.261	7.7	8.29	347		7.86																					
M-SP49	8-Oct-02	0.3	7.9	7.22	538		0.37																					
M-SP49	4-Jun-03	0.313	6.3	7.55	323		0.54																					
M-SP49	23-Sep-03	0.211	8.6	7.55	325		4.74																					
M-SP49	16-Jun-04	0.38	7.4	7.58	328		6.73																					
M-SP53	24-Oct-01																											
M-SP53	24-Oct-01	0.092	2.9	7.82	368																							
M-SP53	2-May-02	0.109	4.5	7.81	15		0.17																					
M-SP53	27-Sep-02	0.090	7.2	7.61	402																							
M-SP53	21-May-03	0.101	6.7	7.66	381		0.75																					
M-SP53	27-Sep-03	0.48	8.5	7.68	694		0.84																					
M-SP53	6-Jun-04	0.087	6.9	7.77	417																							
M-SP53	23-Jun-06	0.11	10.4	7.79	696																							
M-SP53	28-Sep-06	0.104	8.5	7.93	639																							
M-SP53	4-Nov-06	0.11	3.8	7.49	648																							
M-SP53	25-Jun-07	0.079	10.2	7.95	697																							
M-SP53	24-Sep-07	0.087	5	7.58	580																							
M-SP53	29-Oct-07	0.084	5.9	7.51	592																							
M-SP53	21-Jun-08	0.072	9.2	7.52	692																							
M-SP53	24-Sep-08	0.27	8.7	7.63	667																							
M-SP53	6-Nov-08	0.081	3.2	7.75	644																							
M-SP53	19-Jun-09	0.062	8.6	7.55	683																							
M-SP53	23-Sep-09	0.065	8.6	7.67	686																							
M-SP53	10-Nov-09	0.064	5.5	7.46	682																							
M-SP53	26-Jun-10	0.057	9.8	7.51	734																							
M-SP53	16-Jul-10	0.058	14.3	7.75	698																							
M-SP53	23-Sep-10	0.059	9.1	7.69	713																							
M-SP53	12-Nov-10	0.058	3.1	7.52	682																							
M-SP53	27-Jun-11	0.124	6.2	7.87	663																							
M-SP53	26-Sep-11	0.117	12.9	7.63	728																							
M-SP53	29-Oct-11	0.126	6.4	7.78	703																							
M-SP53	27-Jun-12	0.11	8.3	7.85	730																							
M-SP53	25-Sep-12	0.116	6	7.69	723																							
M-SP53	7-Nov-12	0.113	6.3	7.79	713																							
M-SP53	28-Jun-13	0.091	9.5	7.79	728																							
M-SP53	25-Sep-13	0.078	9.5	7.67	715																							
M-SP53	26-Oct-13	0.08	8.6	7.66	684																							
M-SP53	21-Jun-14	0.07	11.6	7.75	701																							
M-SP53	18-Sep-14	0.063	13.8	7.75	714																							
M-SP53	31-Oct-14	0.063	9.5	7.67	722																							
M-SP53	25-Jun-15	0.055	14.3	7.9	722																							
M-SP53	26-Sep-15	0.056	14.5	7.76	684																							
M-SP53	1-Nov-15	0.06	9.6	7.67	686																							
M-SP53	26-Jun-16	0.053	19.2	7.68	711																							
M-SP53	27-Sep-16	0.054	14.3	7.59	708																							
M-SP53	26-Oct-16	0.054	7.6	7.76	699																							
M-SP54	25-Oct-01	1.131	6.7	8.11	463		0.52																					
M-SP54	23-May-02	1.014	4.7	8.27	481		5.50																					
M-SP54	7-Oct-02	1.092	8.3	7.69	869		0.31																					
M-SP54	4-Jun-03	1.282	4.2	7.92	488		0.01																					
M-SP54	23-Sep-03	1.051	6.2	7.93	504		0.00																					

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		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP54	16-Jun-04	1.371	4.9	7.87	517		1.06																					
M-SP55	25-Oct-01	0.722	2.9	8.20	519		0.00																					
M-SP55	22-May-02	0.879	3.8	8.57	607		14.10																					
M-SP55	7-Oct-02	0.627	5.1	7.55	955		0.55																					
M-SP55	4-Jun-03	0.853	4.5	7.43	572		0.14																					
M-SP55	23-Sep-03	0.787	5.2	7.51	575		0.22																					
M-SP55	16-Jun-04	0.898	4.4	7.51	598		0.46																					
M-SP 56	25-Oct-01	3.599	3.7	8.52	598		0.09																					
M-SP 56	22-May-02	3.910	7.7	8.66	718		18.60																					
M-SP 56	7-Oct-02	3.305	5.5	7.84	1,147		0.00																					
M-SP 56	4-Jun-03	1.590	5.0	7.87	650		0.00																					
M-SP 56	23-Sep-03	2.679	5.6	7.97	662		0.00																					
M-SP 56	16-Jun-04	3.196	5.1	8.01	682		0.00																					
M-SP57	25-Oct-01	0.726	5.7	8.22	790		4.27																					
M-SP57	22-May-02	1.296	6.6	8.42	889		11.70																					
M-SP57	26-Sep-02	0.487	7.2	8.24	850		3.60																					
M-SP57	4-Jun-03	1.768	5.7	7.98	825		0.18																					
M-SP57	23-Sep-03	0.592	7.1	8.10	833		2.38																					
M-SP57	16-Jun-04	1.631	5.8	7.90	862		0.38																					
M-SP59	24-Oct-01	0.372	3.4	7.58	446		1.13																					
M-SP59	2-May-02	0																										
M-SP59	27-Sep-02	0.117	6.4	7.6	451		1.1																					
M-SP59	21-May-03	0.216	8.5	8.04	478		1.53																					
M-SP59	27-Sep-03	0.69	7.1	7.92	859		13.9																					
M-SP59	6-Jun-04	0.173	7.4	8.08	509		0.67																					
M-SP59	27-Jun-15	0.014	13.7	7.87	836																							
M-SP60	2-May-02	0.888	5.7	7.64	403		5.70																					
M-SP60	27-Sep-02	0.728	8.0	7.52	512		0.10																					
M-SP60	21-May-03	0.761	6.5	7.63	491		14.25																					
M-SP60	8-Oct-03	0.600	7.8	7.63	428		0.81																					
M-SP60	4-Jun-04	0.676	9.6	7.79	943		0.76																					
M-SP60	30-Jun-14	0.72	11.5	7.88	931			<0.03	<0.002	<0.03	0.14	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004		<5		439	299
M-SP60	23-Sep-14	0.57	8.4	7.67	935			<0.03	<0.002	0.03	0.03	<0.01	0.07	<0.001	<0.001	<0.01		<0.2			<0.01	<0.02	<0.02	<0.004		<5		419	322
M-SP60	6-Nov-14	0.56	6.9	7.61	932			<0.03	<0.002	<0.03	0.05	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	0.009		8		421	325
M-SP60	27-Jun-15	0.545	6.9	7.61	960			0.04	0.004	<0.03	0.23	<0.01	0.05	<0.001	0.009	<0.01		<0.2		0.002	<0.01	<0.02	<0.02	0.096		<5		416	312
M-SP60	29-Sep-15	0.346	8.5	7.8	876			<0.03	<0.002	0.03	0.91	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	<0.004		<5		425	306
M-SP60	7-Nov-15	0.39	6.7	7.47	893			<0.03	<0.002	<0.03	0.89	<0.01	0.06	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	0.03	<0.004		<5		435	300
M-SP60	23-Jun-16	0.424	7.4	7.72	889																							
M-SP60	26-Sep-16	0.330	8.3	7.51	909																							
M-SP60	6-Nov-16	0.299	7.3	7.83	896																							
M-SP60	30-Jun-17	584.000	7.4	7.69	858																							
M-SP63	23-May-02	0.779	6.8	7.99	282		0.69																					
M-SP63	28-Sep-02	0.430	6.4	7.24	515		1.10																					
M-SP63	5-Jun-03	1.746	7.1	7.82	512		9.81																					
M-SP63	24-Sep-03	0.949	6.2	7.54	290		0.15																					
M-SP63	15-Jun-04	2.032	6.0	7.66	304		0.26																					
M-SP67	24-May-02	1.331	11.0	8.20	4		0.52																					
M-SP67	8-Oct-02	0.416	10.1	7.38	594		0.22																					
M-SP67	3-Jun-03	1.023	7.6	7.46	396		0.12																					
M-SP67	26-Sep-03	0.239	18.1	8.45	623		6.91																					
M-SP67	15-Jun-04	0.923	11.8	8.51	657		23.70																					
M-SP69	24-May-02	2.973	7.4	8.38	271		4.71																					
M-SP69	8-Oct-02	1.627	8.9	7.40	477		0.00																					
M-SP69	3-Jun-03	2.145	7.7	7.75	266		0.44																					
M-SP69	26-Sep-03	1.865	12.5	8.44	374		4.26																					

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		Field Measurements						Trace Metals																	Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP69	15-Jun-04	1.098	7.8	7.47	498		0.22																					
M-SP 70	24-May-02	1.992	7.5	7.75	282		3.51																					
M-SP 70	8-Oct-02	1.886	7.9	7.49	473		0.09																					
M-SP 70	3-Jun-03	1.261	7.3	8.02	288		1.40																					
M-SP 70	26-Sep-03	1.518	9.8	8.33	396		3.66																					
M-SP 70	15-Jun-04	1.135	8.7	8.37	488		1.05																					
M-SP82	25-May-02	2.383	6.8	7.65	667		0.00																					
M-SP82	7-Oct-02	1.303	4.6	8.01	370		0.00																					
M-SP82	3-Jun-03	5.384	5.1	7.70	629		16.95																					
M-SP82	23-Sep-03	1.259	5.9	7.98	471		1.47																					
M-SP82	4-Jun-04	3.601	5.0	7.87	491		0.00																					
M-SP87	26-May-02	2.193	5.2	8.32	681		0.25																					
M-SP87	29-Sep-02	2.313	5.2	8.13	627		0.05																					
M-SP87	22-May-03	3.079	4.1	7.86	699		16.17																					
M-SP87	7-Oct-03	2.52	6.1	8.14	770	6.6	5.020																					
M-SP87	13-May-04	2.907	3.6	8.39	1,277		0.59																					
M-SP87	20-Nov-09	1.65	3.3	7.10	1,203																							
M-SP87	30-Jun-14	1.14	7.1	7.78	1,282			<0.03	0.003	<0.03	0.21	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		362	470
M-SP87	18-Sep-14	0.92	7.6	7.84	1,259			<0.03	0.002	0.04	0.04	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	0.02	0.03	<0.004		<5		361	470
M-SP87	5-Nov-14	1.15	3.8	7.85	1,301			<0.03	<0.002	<0.03	0.51	<0.01	<0.01	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		225	210
M-SP87	26-Jun-15	1.08	6.6	7.78	1,311			<0.03	0.003	<0.03	0.03	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004		<5		370	460
M-SP87	29-Sep-15	0.8	7.6	7.77	1,224			<0.03	<0.002	<0.03	0.07	<0.01	0.12	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	0.03	<0.004		<5		361	471
M-SP87	28-Oct-15	0.58	5.1	7.78	1,262			<0.03	0.005	<0.03	0.16	<0.01	0.1	<0.001	<0.001	<0.01		<0.2		0.002	<0.01	<0.02	0.03	<0.004		5		364	474
M-SP87	23-Jun-16	0.960	6.6	7.75	1,254																							
M-SP87	28-Sep-16	0.962	7.7	7.52	1,336																							
M-SP87	7-Nov-16	1.05	5.0	7.73	1,254																							
M-SP87	26-Jun-17	0.94	6.6	7.76	1,236																							
M-SP100	27-Sep-02	0.774	6.8	7.25	388		0.20																					
M-SP100	21-May-03	0.840	7.9	7.35	373		38.78																					
M-SP100	8-Oct-03	0.794	6.7	7.38	292		0.83																					
M-SP100	5-Jun-04	1.076	9.4	7.47	683		0.51																					
M-SP100	27-Jun-15	0.802	6.3	7.51	695																							
M-SP100	29-Sep-15	0.777	7	7.47	651																							
M-SP100	7-Nov-15	0.754	6.8	7.46	661																							
M-SP100	23-Jun-16	0.826	6.4	7.48	689																							
M-SP100	28-Sep-16	0.838	7.4	7.59	677																							
M-SP100	6-Nov-16	0.872	7.1	7.53	673																							
M-SP100	30-Jun-17	1.13	6.4	7.32	684																							
M-SP102	8-Oct-02	0.253	8.6	7.68	498		0.68																					
M-SP102	3-Jun-03	2.679	6.9	7.5	283		0.30																					
M-SP102	25-Sep-03	0																										
M-SP102	15-Jun-04	0.869	7.1	7.38	477		0.12																					
M-SP103	21-May-03	1.193	10.3	8.28	377		35.67																					
M-SP103	8-Oct-03	0.939	16.5	8.27	416		1.23																					
M-SP103	5-Jun-04	1.506	9.2	7.67	706		0.12																					
M-SP103	27-Jun-15	1.16	9.4	7.59	703																							
M-SP103	29-Sep-15	0.878	10.9	7.55	669																							
M-SP103	7-Nov-15	0.963	8.6	7.58	675																							
M-SP103	23-Jun-16	1.30	9.8	7.85	682																							
M-SP103	26-Sep-16	0.591	10.7	7.77	690																							
M-SP103	6-Nov-16	1.13	9.6	7.79	680																							
M-SP103	30-Jun-17	2.20	9.3	7.7	670																							
M-SP104	21-May-03	0.115	11.5	8.51	327																							
M-SP104	8-Oct-03	0																										
M-SP104	5-Jun-04	0.382	20.4	8.26	686																							
M-SP104	27-Jun-15	0.279	12.4	7.94	678																							

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		Field Measurements						Trace Metals															Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mb mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	Q&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
M-SP104	29-Sep-15	0.279	12.9	7.88	577																							
M-SP104	7-Nov-15	0.355	5.7	7.95	665																							
M-SP104	23-Jun-16	0.421	11.4	7.89	691																							
M-SP104	26-Sep-16	0.3080082	10.3	8.02	624																							
M-SP104	6-Nov-16	0.313	9.3	8.24	673																							
M-SP104	30-Jun-17	5.75	8.1	7.69	669																							
M-SP105	21-May-03	0.795	8.0	8.18	363		18.20																					
M-SP105	8-Oct-03	0.617	12.8	8.09	381		0.00																					
M-SP105	5-Jun-04	0.945	10.3	7.78	696		0.35																					
M-SP105	27-Jun-15	0.652	9.3	7.87	700			0.011																				
M-SP105	29-Sep-15	0.475	11.1	7.98	646			0.025																				
M-SP105	7-Nov-15	0.568	8.9	7.89	665			0.009																				
M-SP105	23-Jun-16	0.682	9.6	7.88	663																							
M-SP105	26-Sep-16	0.586	10.3	7.97	667																							
M-SP105	6-Nov-16	0.579	9.7	8.04	670																							
M-SP105	30-Jun-17	1.12	9.5	7.68	653																							
M-SP106	21-May-03	0.685	4.7	7.84	451		9.42																					
M-SP106	8-Oct-03	1.095	7.3	7.68	430		6.80																					
M-SP106	5-Jun-04	0.476	7.6	7.70	878		116																					
M-SP106	27-Jun-15	0.345	6.1	7.67	884																							
M-SP106	29-Sep-15	0.339	7	7.65	824																							
M-SP106	7-Nov-15	0.325	5.5	7.64	834																							
M-SP106	23-Jun-16	0.377	6.2	7.74	849																							
M-SP106	26-Sep-16	0.586	6.6	7.74	860																							
M-SP106	6-Nov-16	0.334	6.0	7.78	863																							
M-SP106	30-Jun-17	0.383	6.2	7.66	846																							
M-SP107	24-May-02	4.981	9.3	7.6	314		0.00																					
M-SP107	3-Jun-03	40.65	6.8	7.58	305		0.05																					
M-SP107	25-Aug-03	35.419	7.5	7.32	522		0.00																					
M-SP107	15-Jun-04	28.302	7.8	7.69	450		0.18																					
M-SP108	3-Jun-03	0.39	8.3	8.1	298		3.20																					
M-SP108	25-Sep-03	0.418	10.9	8.12	454		22.90																					
M-SP108	15-Jun-04	0.334	13.5	7.84	465		7.33																					
M-SP109	4-Jun-03	0.809	7.1	7.82	314		1.49																					
M-SP109	23-Sep-03	0.704	7.9	7.77	318		0.00																					
M-SP109	16-Jun-04	2.491	6.6	7.84	384		0.21																					
GW-13	5-Jun-95	0.52	9	7.72	1344			<.1	<.1																		480	330
GW-13	23-Aug-95	0.41	10	7.85	1325			<.1	<.1																		470	340
GW-13	3-Oct-95	0.45	10	7.5	1353			<.1	<.1																		480	343
GW-13	26-Aug-96	0.449	12.8	8.22	1351			<.1	<.1																		471	352
GW-13	3-Jun-97	0.6	8.45	7.95	1318																							
GW-13	18-Aug-97	0.269	16.13	7.85	1335			<.1	<.1																		476	340
GW-13	8-Oct-97	0.898	6.65	6.86	1320			<.1	<.1																		479	330
GW-13	20-Jun-98	1.76	13.62	8.11	1292			<.1	<.1																		472	384
GW-13	5-Aug-98	1.5	15.27	7.61	1335																							
GW-13	3-Oct-98	0.804	7.09	7.25	1292																							
GW-13	30-Jun-99	0.003	10.89	7.65	1334																							
GW-13	12-Aug-99	1.795	11.17	7.69	1337																							
GW-13	4-Oct-99	0.898	9.91	7.58	1328																							
GW-13	22-Jun-00	0.002	7	7.61	1302																							
GW-13	1-Aug-00	0.583	10	7.86	1333																							
GW-13	6-Oct-00	0.583	7	7.24	1310																							
GW-13	12-Jun-01	0.882	6	7.89	1351																							
GW-13	22-Aug-01	0.597	11.7	7.62	135																							
GW-13	1-Oct-01	0.316	7.6	7.86	1205																							
GW-13	8-May-02	0.519	4.2	7.96	1187																							
GW-13	21-Sep-02	0.361	6.9	8.25	1335																							

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		Field Measurements						Trace Metals																Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
GW-13	9-Oct-02	0.332	5.7	7.58	1347																							
GW-13	5-Jun-03	0.125	8.8	8.47	1209																							
GW-13	4-Aug-03	0.353	9.9	8.18	1243																							
GW-13	17-Oct-03	0.359	6.8	7.73	1346																							
GW-13	25-Jun-04	0.331	9.6	8.19	1315																							
GW-13	12-Aug-04	1.58	10.8	8.19	1358																							
GW-13	2-Nov-04	0.247	1.0	7.46	1253																							
GW-13	27-Jun-05	0.439	8.6	8.16	1134																							
GW-13	29-Sep-05	0.65	7.8	7.98	1467																							
GW-13	27-Oct-05	0.72	4.8	8.16	1437																							
GW-13	23-Jun-06	0.35	8.1	8.05	1227																							
GW-13	28-Sep-06	0.38	6.1	8.03	1450																							
GW-13	8-Nov-06	0.46	4.5	7.95	1420																							
GW-13	26-Jun-07	0.44	7.4	8.24	1475																							
GW-13	10-Sep-07	0.38	9.7	8.14	1493																							
GW-13	6-Nov-07	0.45	2.1	8.21	1442																							
GW-13	13-Jun-08	0.234	6.1	8.06	1531																							
GW-13	24-Sep-08	0.31	6.2	8.07	1522																							
GW-13	11-Dec-08	0.323	2.7	7.82	1258																							
GW-13	27-Jun-09	0.289	8.8	8.03	1576																							
GW-13	18-Sep-09	0.361	8.1	8.05	1557																							
GW-13	26-Oct-09	0.16	2.8	8.06	1262																							
GW-13	26-Jun-10	0.45	14.2	8	1501																							
GW-13	23-Sep-10	0.43	8	7.89	1386																							
GW-13	12-Nov-10	0.59	5.2	7.21	1367																							
GW-13	27-Jun-11	0.83	5.2	7.91	1333																							
GW-13	26-Sep-11	0.754	5.6	7.84	1409																							
GW-13	29-Oct-11	0.9	5.5	7.72	1309																							
GW-13	27-Jun-12	0.84	5.6	7.66	1474																							
GW-13	25-Sep-12	0.76	6.2	7.45	1399																							
GW-13	7-Nov-12	0.688	5.7	7.66	1413																							
GW-13	28-Jun-13	0.84	5.8	7.64	1603																							
GW-13	25-Sep-13	0.87	6.2	7.49	1578																							
GW-13	26-Oct-13	0.83	6.3	7.48	1537																							
GW-13	29-Jun-14	0.77	5.9	7.52	1584																							
GW-13	29-Aug-14	0.755	6.4	7.48	1637																							
GW-13	31-Oct-14	0.688	5.4	7.5	1663																							
GW-13	24-Jun-15	0.701	5.8	7.51	1670																							
GW-13	28-Sep-15	0.59	11.5	7.64	1621																							
GW-13	28-Oct-15	0.62	4.6	7.71	1648																							
GW-13	25-Jun-16	0.62	13.4	7.54	1677																							
GW-13	29-Sep-16	0.63	9.5	7.55	1687																							
006A Spring	28-Jun-2010	0.28	5.3	7.39	1,302																							
006A Spring	15-Sep-2010	0.19	6.5	7.29	1,255																							
006A Spring	1-Nov-2010	0.27	5.6	7.17	1,227			<0.02	<0.005																			
006A Spring	17-Jun-2011	0.44	4.5	7.66	1261			<0.02	<0.005																			
006A Spring	21-Sep-2011	0.30	6.5	7.47	1277			<0.02	<0.005																			
006A Spring	12-Oct-2011	0.37	6.1	7.68	1298																							
006A Spring	1-Jun-2012	0.39	4.4	7.36	1263			<0.02	<0.005																			
006A Spring	12-Sep-12	0.18	7.1	7.56	1216																							
006A Spring	1-Nov-12	0.29	6.1	7.50	1247																							
006A Spring	27-Jun-13	0.19	6.5	7.61	1271																							
006A Spring	26-Sep-13	0.203	7.1	7.65	1246																							
006A Spring	23-Oct-13	0.303	4.7	7.60	1210																							
006A Spring	28-May-14	0.495	4	7.57	1267																							
006A Spring	23-Sep-14	0.373	6.6	7.44	1254																							
006A Spring	28-Oct-14	0.439	5.6	7.53	1273																							
006A Spring	23-Jun-15	0.493	8.5	7.48	1293																							
006A Spring	21-Sep-15	0.36	6.7	7.49	1174																							
006A Spring	5-Nov-15	0.40	5.1	7.53	1221																							
006A Spring	28-Jun-16	0.376	6.0	7.37	1247																							
006A Spring	25-Sep-16	0.292	6.8	7.48	1250																							

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		Field Measurements						Trace Metals													Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidty mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
006A Spring	11-Nov-16	0.379	5.8	7.47	1237																							
94-110	11-Nov-13	0.115	5.2	7.59	724																							
94-110	30-Jun-14	0.299	6.1	7.52	744			<0.03	0.002	<0.03	0.39	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		398	282
94-110	25-Sep-14	0.205	9.2	7.6	775			<0.03	<0.002	<0.03	0.13	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	15		395	291
94-110	11-Nov-14	0.161	4.4	7.54	777			<0.03	<0.002	<0.03	0.8	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	11		408	282
94-110	29-Jul-15	0.253	7.1	7.47	756			<0.03	<0.002	<0.03	0.34	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	0.012	<5	15		390	300
94-110	9-Nov-15	0.179	5.9	7.50	758			0.09	0.007	0.24	0.45	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		0.001<0.01		<0.02	<0.02	0.011		5		412	289
94-110	9-Jul-16	0.192	7.3	7.48	748																							
94-110	14-Nov-16	0.126	5.9	7.62	771																							
94-110	29-Jul-17	0.335	7.1	7.46	726																							
94-113	1-Jun-12	0																										
94-113	27-Jun-13	0																										
94-113	26-Sep-13	<.01	7.1	7.99	1808			0.02	0.043	<0.05	8.8	<0.05	0.13	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	0.02	0.02	0.02	<0.01		<5		545	421
94-113	23-Oct-13	<0.01	5.3	7.69	1,830																							
94-113	28-May-14	<0.05	11.2	7.74	1,761																							
94-113	23-Sep-14	0																										
94-113	28-Oct-14	0.000																										
94-113	21-Jun-15	0.000																										
94-113	21-Sep-15	0.000																										
94-113	8-Nov-15	Damp																										
94-113	28-Jun-16	0																										
94-113	25-Sep-16	0.000																										
94-113	11-Nov-16	0.000																										
A Spring	8-Nov-13	1.47	6.7	7.47	882																							
A Spring	31-Jul-14	1.76	6.4	7.5	946																							
A Spring	21-Nov-14	1.42	6.2	7.54	944			<0.03	<0.002	<0.03	0.06	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	10		458	292
A Spring	31-Jul-15	1.60	6.7	7.52	904			<0.03	<0.002	<0.03	0.11	<0.01	0.09	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.02	0.007	NM	<5		454	305
A Spring	14-Nov-15	0.83	6.8	7.45	997			<0.03	<0.002	0.09	<0.03	<0.01	0.08	<0.001	<0.001	<0.01		<0.2		<0.001<0.01		<0.02	<0.02	<0.004		5		472	302
A Spring	23-Jul-16	1.01	7.0	7.58	953																							
A Spring	15-Nov-16	1.08	7.0	7.51	947																							
A Spring	28-Jul-17	2.21	6.9	7.57	911																							
B Spring	6-Nov-13	4.31	6.4	7.5	717																							
B Spring	31-Jul-14	5.37	6.0	7.54	753																							
B Spring	21-Nov-14	0.773	5.3	7.59	782			<0.03	<0.002	<0.03	0.14	<0.01	0.03	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		383	346
B Spring	31-Jul-15	6.020	6.1	7.52	738			<0.03	<0.002	<0.03	0.05	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	<0.004	NM	<5		379	363
B Spring	14-Nov-15	0.340	6.2	7.48	717			<0.03	<0.002	0.63	0.63	<0.01	0.04	<0.001	<0.001	<0.01		<0.2		<0.001<0.01		<0.02	0.03	<0.004		<5		385	345
B Spring	23-Jul-16	3.04	6.5	7.59	733																							
B Spring	15-Nov-16	0	—	—	—																							
B Spring	28-Jul-17	4.460	6.4	7.58	713																							
D Spring	11-Nov-13	0.545	7.7	9.44	235			3.25	0.014	7.3	61.7	<0.05	0.09	<0.005	0.006	<0.005		<0.2	<0.01	<0.005	<0.02	<0.02	0.39	0.02		<5		151	18
D Spring	30-Jun-14	0																										
D Spring	25-Sep-14	0																										
D Spring	29-Jul-15	0																										
D Spring	9-Nov-15	0																										
A2S-1	11-Nov-13	0																										
A2S-1	30-Jun-14	0.106	9.5	7.98	832			<0.03	<0.002	<0.03	2.13	<0.01	0.05	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		410	77
A2S-1	25-Sep-14	0.028	12.9	7.97	882			0.11	0.003	0.26	1.16	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		438	75
A2S-1	11-Nov-14	0.063	5.9	7.97	909			<0.03	<0.002	<0.03	4.17	<0.01	0.06	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	<5		459	73
A2S-1	29-Jul-15	0.062	12.1	7.37	832			<0.03	<0.002	<0.03	3.93	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.014	NM	<5		421	81
A2S-1	9-Nov-15	0.045	7.2	8.03	902			0.28	0.246	4.24	4.24	<0.01	0.07	.001<0.001		<0.01		<0.2		0.001	<0.01	<0.02	<0.02	0.009		<5		487	75
A2S-1	9-Jul-16	0.100	11.9	7.99	819																							
A2S-1	14-Nov-16	0.054	8.3	8.24	878																							
A2S-1	29-Jul-17	0.097	12.7	8.01	782																							
Divide Spring	1-Jul-14	1.63	7.4	7.59	743			<0.03	<0.002	<0.03	0.04	<0.01	0.06	<0.001	<0.001	<0.01		<0.2		0.001	<0.01	<0.02	<0.02	<0.004	NM	11		330	312
Divide Spring	25-Sep-14	DAMP																										
Divide Spring	11-Nov-14	0																										

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		Field Measurements						Trace Metals														Other Parameters				
	Date	Flow gpm	T °C	pH S.U.	Cond. µS/cm	D.O. mg/l	Turb NTU	D-Fe mg/l	D-Mn mg/l	D-Al mg/l	T-Al mg/L	D-As mg/l	D-B mg/l	D-Cd mg/l	D-Cr mg/l	D-Cu mg/l	T-Hg ug/l	D-Hg ug/l	D-Mo mg/l	D-Ni mg/l	D-Pb mg/l	D-Se mg/l	T-Se mg/L	D-Zn mg/l	O&G mg/L	Acidity mg/l	CN mg/l	T-Alk mg/l	T-Hard mg/l
Divide Spring	29-Jul-15	0.268	7.9	7.78	703			<0.03	<0.002	<0.03	0.06	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	0.03	<0.004	NM	8		300	331
Divide Spring	9-Nov-15	0.000	—	—	—																							
Divide Spring	14-Nov-15	0	–	–	–																							
Divide Spring	9-Jul-16	2.36	10.7	7.52	720																							
Divide Spring	14-Nov-16	0.000	—	—	—																							
Divide Spring	29-Jul-17	0.564	8.4	7.51	679																							
Hansen Seep	23-Apr-12	0.356	11.3	7.63	1489			0.48	0.279	0.4	1.7	<0.05	0.11	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	<0.02	0.02	0.02	<0.01		<5		411	475
Hansen Seep	27-Jun-13	<0.1	14.9	7.41	1461																							
Hansen Seep	26-Sep-13	0.284	8.4	7.85	1452			<0.02	0.041	<0.05		<0.05	0.09	<0.005	<0.005	<0.005		<0.2	<0.01	<0.005	<0.02	<0.02		<0.01				383	435
Hansen Seep	23-Oct-13	0.242	5.0	7.57	1,418																							
Hansen Seep	28-May-14	0.266	6.8	7.68	1,431																							
Hansen Seep	17-Sep-14	0.196	10.9	7.64	4,590																							
Hansen Seep	28-Oct-14	0.226	6.1	7.44	1,473			<0.03	0.081	<0.03	0.33	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	0.01	NM	17		383	430
Skutumpah Spring	8-Nov-13	12.2	7.0	7.53	785																							
Skutumpah Spring	31-Jul-14	14.9	6.6	7.59	805																							
Skutumpah Spring	21-Nov-14	13.4	6.8	7.63	819			<0.03	<0.002	<0.03	0.12	<0.01	0.05	<0.001	<0.001	<0.01		<0.02		<0.001	<0.01	<0.02	<0.02	<0.004	NM	7		371	264
Skutumpah Spring	31-Jul-15	14.0	6.7	7.39	786			<0.03	<0.002	<0.03	<0.03	<0.01	0.07	<0.001	<0.001	<0.01		<0.2		<0.001	<0.01	<0.02	<0.02	<0.004	NM	6		373	271
Skutumpah Spring	14-Nov-15	13.2	17.0	7.50	777			<0.03	<0.002	<0.03	0.07	<0.01	0.06	<0.001	<0.001	<0.01		<0.02		<0.001<0.01		<0.02	0.03	1,00453.76		6		371	270
Skutumpah Spring	23-Jul-16	13.3	7.0	7.59	765																							
Skutumpah Spring	15-Nov-16	12.0	7.2	7.58	793																							
Skutumpah Spring	28-Jul-17	14.1	7.0	7.63	786																							
USP-1	20-Nov-09	0.18	4.2	7.59	1,146																							
USP-2	20-Nov-09	0.43	5.5	7.46	1,287																							
Spring 99	11-Nov-14	0.200	5.0	7.61	660																							
Spring 99	29-Jul-15	0.337	8.3	7.36	584																							
Spring 99	9-Nov-15	0.229	5.5	7.51	620																							
Spring 99	9-Jul-16	0.265	8.2	7.74	560																							
Spring 99	14-Nov-16	0.130	5.5	7.79	637																							
Spring 99	29-Jul-17	0.465	8.5	7.56	615																							

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Table 3 Precipitation data from the Salina 24E Weather Station.

	Monthly total precipitation (inches)												
YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	TOTAL
1984-85	2.87	0.00	0.90	0.69	0.59	2.07	2.13	0.99	0.99	2.74	0.05	0.99	**15.01**
1985-86	1.00	1.69	1.40	0.61	1.80	0.96	2.27	1.94	0.31	1.86	1.80	1.47	**17.11**
1986-87	1.05	1.34	0.18	0.99	0.82	1.52	0.45	2.45	0.60	2.21	1.38	0.65	**13.64**
1987-88	1.95	1.86	1.41	1.58	0.10	1.12	1.98	0.73	0.50	1.78	2.31	1.24	**16.56**
1988-89	1.05	0.91	1.35	0.84	0.81	1.38	0.29	1.11	0.40	1.35	1.82	0.89	**12.20**
1989-90	0.20	0.06	0.70	0.41	0.83	0.90	1.23	0.08	0.87	0.59	1.08	2.20	**9.15**
1990-91	1.36	0.32	0.87	0.88	0.41	1.78	1.47	1.14	0.48	1.76	3.02	2.17	**15.66**
1991-92	0.60	1.08	0.94	0.15	1.04	2.27	0.70	2.86	0.65	0.56	1.16	1.16	**13.17**
1992-93	1.01	1.77	1.04	2.13	2.61	1.80	0.07	1.79	1.03	0.23	1.29	0.23	**15.00**
1993-94	2.44	1.48	0.52	0.53	0.98	0.31	1.57	0.15	0.09	0.41	1.43	1.17	**11.08**
1994-95	1.56	2.17	0.37	1.08	0.44	2.33	1.52	3.28	1.27	0.54	1.92	0.58	**17.06**
1995-96	0.14	0.67	1.59	2.22	1.31	1.12	0.30	0.66	0.42	0.85	0.80	1.68	**11.76**
1996-97	1.24	1.74	1.52	1.95	1.34	0.27	2.10	1.33	0.95	1.64	3.16	4.79	**22.03**
1997-98	0.76	0.51	0.33	1.07	2.62	0.98	0.45	0.79	1.76	1.89	2.34	4.47	**17.97**
1998-99	3.08	0.74	0.17	0.95	0.76	0.14	2.23	1.32	1.55	1.75	1.89	1.40	**15.98**
1999-00	0.14	0.06	0.47	0.99	1.32	0.77	0.02	1.22	0.86	0.84	2.28	0.98	**9.95**
2000-01	2.94	0.25	0.47	1.45	1.49	0.67	0.39	1.24	1.32	0.74	1.31	0.16	**12.43**
2001-02	0.32	1.77	0.40	0.60	0.57	0.51	0.04	0.05	0.40	1.16	0.21	3.47	**9.50**
2002-03	1.52	1.64	0.52	0.23	0.79	0.77	0.34	0.92	0.14	0.90	2.86	0.51	**11.14**
2003-04	0.53	0.95	1.34	0.43	1.69	0.08	2.03	0.18	0.47	1.14	0.80	0.47	**10.11**
2004-05	2.09	1.98	0.75	1.69	0.81	0.66	0.47	1.45	4.05	0.28	1.87	0.95	**17.05**
2005-06	0.85	0.75	0.72	1.21	0.45	1.92	1.22	0.13	0.00	1.21	1.60	1.64	**11.70**
2006-07	4.44	0.52	0.75	0.08	0.54	0.60	0.45	0.34	0.20	0.60	0.95	1.12	**10.59**
2007-08	0.66	0.04	2.02	1.58	1.55	0.57	0.18	0.70	0.37	0.10	0.84	0.32	**8.93**
2008-09	0.82	0.64	0.86	0.84	0.62	0.88	1.17	2.16	1.47	0.64	0.22	0.76	**11.08**
2009-10	0.43	0.31	1.51	1.03	1.08	1.07	1.56	0.92	0.76	1.96	1.38	0.00	**12.01**
2010-11	4.39	1.22	3.28	0.32	1.05	1.11	2.16	2.68	0.78	2.82	1.45	1.04	**22.30**
2011-12	1.13	0.39	0.64	0.86	0.80	0.82	0.59	0.00	0.00	2.75	1.04	0.62	**9.64**
2012-13	1.14	0.20	1.54	0.69	0.28	0.83	0.72	1.25	0.00	0.53	2.50	5.17	**14.85**
2013-14	1.16	1.79	0.51	0.49	1.35	0.41	0.31	1.00	0.24	1.67	3.08	2.49	**14.50**
2014-15	0.26	0.69	3.50	1.02	0.46	0.52	1.11	2.52	1.24	2.05	1.65	0.84	**15.86**
2015-16	1.66	0.38	1.36	1.33	0.30	0.38	1.32	1.11	0.09	0.74	1.42	2.72	**12.81**

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Field monitoring summary for Greens Hollow tract surface water monitoring stations.										
Station ID	**M_STR 1**	**M_STR 2**	**M_STR 3**	**M_STR 4**	**M_STR 5**	**M_STR 6**	**M_STR7**	**M_STR8**	**Sufco 006 M_STR9**	**Sufco 007 M_STR10**
Location	Greens Canyon	Greens Canyon	Lower Cowboy Creek	Upper Cowboy Creek	Cowboy Creek	Greens Hollow	Unnamed Drainage	South Fork Muddy Ck.	S. Fork of N. Fork Quitchupah Ck.	Upper N. Fork Quitchupah Ck.
Start	6/6/01	8/7/02	6/6/01	6/7/01	8/8/02	6/7/01	9/25/02	9/26/02	10/5/79	10/5/79
End	5/10/04	5/10/04	5/10/04	9/25/12	5/11/04	5/11/04	5/13/04	5/13/04	9/12/12	9/26/12
# Visits	16	8	16	37	8	16	6	6	94	98
Flow (GPM)										
# NOF	13	1	2	21	1	5	6	0	1	0
# Samples	3	7	14	16	7	11	0	6	90	91
Maximum	672	460	491	717	598	27	0	15,644	1,116	6,032
Minimum	9.7	1.2	0.5	0.7	1.4	1.9	0.0	967.7	0.1	0.2
Median	50.1	2.9	2.6	12.6	2.0	5.7	0.0	2,767.0	112.2	188.5
Average	243.9	78.1	44.2	69.2	95.6	10.0	0.0	5,225.5	196.5	715.9
pH - Criteria: 6.5-9.0										
# Samples	3	7	13	15	7	10	0	6	90	91
Maximum	8.92	8.84	8.73	8.87	8.82	8.77	0.00	8.90	8.89	9.20
Minimum	8.48	7.97	7.72	8.48	6.50	7.92	0.00	8.69	7.10	7.30
Median	8.61	8.25	8.01	8.72	8.47	8.52	0.00	8.73	8.34	8.40
Average	8.7	8.3	8.1	8.7	8.3	8.5	0.00	8.8	8.3	8.3
Dissolved Oxygen (mg/l) - Criteria >4 (or >8 when early life stages are present)										
# Samples	3	7	13	14	7	10	0	6	43	44
Maximum	8.65	11.19	9.70	10.40	9.04	8.73	0.00	13.66	10.60	10.60
Minimum	7.53	5.84	3.58	5.23	7.23	3.14	0.00	7.51	5.00	5.65
Median	8.6	8.4	5.6	7.9	8.2	7.1	0.0	9.5	7.4	7.7
Average	8.3	8.3	6.1	7.8	8.2	6.8	0.0	9.9	7.5	7.8
Water Temperature (Degree C) - Criteria: <20										
# Samples	3	7	13	15	7	10	0	6	90	91
Maximum	13.6	14.9	13.0	21.2	10.3	23.3	0.0	16.2	22.8	22.5
Minimum	0.7	0.8	3.6	0.3	6.0	2.7	0.0	1.0	0.3	0.0
Median	9.9	9.3	8.4	12.1	9.5	12.1	0.0	4.9	14.7	12.5
Average	8.1	8.8	8.4	12.6	8.4	12.8	0.0	6.6	13.5	12.5
Specific Conductivity (uS/cm)										
# Samples	2	7	13	7	7	10	0	6	58	63
Maximum	567	722	659	869	616	822	0	371	1,300	1,384
Minimum	448	416	202	386	346	439	0	65	398	294
Median	507.7	509.0	404.7	514.0	445.8	572.0	0.0	240.4	710.0	490.0
Average	507.7	554.5	434.6	582.1	475.9	615.3	0.0	250.0	729.6	500.8

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Table 4 Summary of stream monitoring data from the Greens Hollow Tract collected by Cirrus for 2001-2004 (USFS, 2005).

Table 5 Average discharge rates, chemical compositions, and mineral saturation indices of groundwaters and surface-waters.

	Field measurements					Major ions								Solids and total metals				Mineral saturation indices				
	Flow	T	pH	Sp. Cond.	D.O.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	TDS	TSS	T-Fe	T-Mn	SI	SI	SI	SI	Ratio
	gpm	°C	S.U.	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Calcite	Dolomite	Gypsum	Halite	Cl:Na
Groundwater																						
North Horn Formation Springs																						
M-SP04	1.41	5.3	7.66	777	---	---	---	---	---	---	---	---	---	566	91	0.68	0.04	---	---	---	---	---
M-SP05	0.14	6.9	7.83	813	---	---	---	---	---	---	---	---	---	568	90	0.91	0.07	---	---	---	---	---
M-SP06	1.55	5.7	7.88	808	---	27.4	16.6	169.5	1.3	563	<5	15.0	14.4	560	23	0.18	0.01	0.27	0.36	-2.77	-7.15	0.06
M-SP07	0.46	5.7	7.54	656	---	62.2	40.8	83.3	1.9	530	<5	29.1	30.0	508	---	0.86	0.01	0.25	0.35	-2.18	-7.15	0.23
M-SP08	0.25	11.0	7.77	863	---	67.2	37.2	98.6	2.3	523	<5	29.8	47.0	513	---	---	---	0.58	1.04	-2.17	-6.90	0.31
M-SP09	0.30	5.6	7.95	562	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
M-SP10	0.33	7.9	7.70	630	---	48.5	39.3	87.3	2.4	436	<5	27.3	70.6	471	---	0.01	0.00	0.26	0.50	-2.31	-6.76	0.52
M-SP11	1.09	8.9	7.76	666	---	---	---	---	---	---	---	---	---	534	46	0.27	0.06	---	---	---	---	---
M-SP12	0.65	6.5	7.83	684	---	---	---	---	---	---	---	---	---	489	19	0.12	0.00	---	---	---	---	---
M-SP14	16.1	4.8	7.43	358	---	78.0	24.5	16.0	0.8	417	<5	6.4	2.9	336	---	0.00	0.00	0.16	-0.18	-2.68	-8.87	0.12
M-SP15	0.71	11.2	7.84	714	---	---	---	---	---	---	---	---	---	552	23	0.26	0.05	---	---	---	---	---
M-SP19	2.35	6.3	8.05	668	---	---	---	---	---	---	---	---	---	521	19	0.25	0.01	---	---	---	---	---
M-SP20	2.13	9.0	7.76	631	---	---	---	---	---	---	---	---	---	470	29	0.32	0.02	---	---	---	---	---
M-SP40	0.24	8.1	7.82	787	---	---	---	---	---	---	---	---	---	582	195	1.23	0.12	---	---	---	---	---
M-SP41	0.56	5.9	7.94	644	---	---	---	---	---	---	---	---	---	589	133	0.81	0.05	---	---	---	---	---
M-SP44	2.35	7.9	7.64	517	---	65.8	28.2	22.2	0.5	363	<5	20.3	1.4	349	31	0.24	0.02	0.28	0.27	-2.26	-9.04	0.04
M-SP45	1.43	5.5	7.46	835	---	---	---	---	---	---	---	---	---	578	25	0.47	0.01	---	---	---	---	---
M-SP53	0.10	8.7	7.70	644	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
M-SP59	0.26	6.6	7.84	549	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
M-SP60	0.56	7.8	7.65	786	---	55.6	41.8	93.7	1.8	519	<5	25.8	38.3	529	26	0.18	0.01	0.33	0.62	-2.29	-7.00	0.27
M-SP100	0.84	7.2	7.45	578	---	---	---	---	---	---	---	---	---	396	39	0.17	0.01	---	---	---	---	---
M-SP103	1.07	10.6	7.82	622	---	---	---	---	---	---	---	---	---	394	86	0.45	0.03	---	---	---	---	---
M-SP104	0.27	11.7	8.09	615	---	---	---	---	---	---	---	---	---	355	136	0.81	0.09	---	---	---	---	---
M-SP105	0.66	10.0	7.94	606	---	---	---	---	---	---	---	---	---	381	106	1.31	0.16	---	---	---	---	---
M-SP106	0.51	6.4	7.72	764	---	---	---	---	---	---	---	---	---	527	83	1.22	0.04	---	---	---	---	---
Spring 94-110	0.19	6.4	7.54	757	---	69.7	28.4	59.8	1.3	470	<5	8.2	10.8	445	28	0.14	0.01	0.28	0.22	-2.65	-7.73	0.12
A2S-1	0.06	9.7	7.94	865	---	18.1	7.6	188	1.4	513	<5	23.8	12.0	550	194	1.69	0.10	0.18	0.10	-2.75	-7.19	0.04
Divide Spring	0.53	8.7	7.63	722	---	54.7	45.2	39.5	1.3	384	<5	80.0	7.5	436	150	0.02	0.00	0.19	0.40	-1.80	-8.08	0.12
GW-13	0.60	7.7	7.80	1,385	---	67.0	42.0	189	3.0	569	5	155	56.0	803	---	1.40	0.00	0.54	0.97	-1.51	-6.54	0.19
Spg 99	0.23	6.5	7.61	612	---	---	---	---	---	---	---	---	---	340	37	0.61	0.04	---	---	---	---	---
D Spring	0.11	7.7	9.44	235	---	3.4	2.3	43.3	2.8	171	7	3.0	2.0	133	848	26.60	1.48	0.43	0.81	-4.25	-8.57	0.03
North Horn Fm. Avg.	***1.23***	***7.67***	***7.81***	***689***		***51.5***	***29.5***	***90.9***	***1.73***	***455***	***<5***	***35.3***	***24.4***	***481***	***107***	***1.53***	***0.09***	***0.31***	***0.45***	***-2.47***	***-7.58***	***0.17***
Price River Formation Springs																						

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	Field measurements					Major ions								Solids and total metals				Mineral saturation indices				
	Flow	T	pH	Sp. Cond.	D.O.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	TDS	TSS	T-Fe	T-Mn	SI	SI	SI	SI	Ratio
	gpm	°C	S.U.	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Calcite	Dolomite	Gypsum	Halite	Cl:Na
M-SP01	0.41	8.1	7.40	771	—	83.5	41.3	46.2	1.8	479	<5	27.1	42.1	474	—	0.00	0.00	0.23	0.24	-2.10	-7.26	0.59
M-SP02	1.57	8.1	7.56	772	—	79.3	33.7	56.7	2.0	467	<5	36.2	39.0	480	—	0.00	0.00	0.36	0.43	-1.99	-7.21	0.45
M-SP18	0.25	6.9	7.44	1,241	—	125.0	43.0	92.5	5.2	356	<5	295	201	867	—	6.62	0.06	0.20	0.02	-1.02	-6.30	1.41
M-SP38	5.11	8.3	7.65	286	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
M-SP39	1.14	6.3	7.53	908	—	77.0	48.5	86.2	2.1	509	<5	69.3	60.4	661	—	0.05	0.00	0.30	0.45	-1.75	-6.84	0.45
M-SP82	2.79	5.5	7.84	525	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hansen Seep	0.22	9.3	7.60	1,902	—	117.0	36.9	153	2.8	478	<5	243	120	930	47	0.62	0.24	0.50	0.63	-1.13	-6.32	0.51
Sufco 006A Spring	0.33	6.0	7.49	1,252	—	61.1	24.1	202	3.4	648	<5	143	37.0	811	—	0.28	0.00	0.22	0.10	-1.56	-6.69	0.12
Skutumpah Spring	13.3	8.3	7.54	793	—	54.3	32.3	78.7	1.2	426	<5	49.3	11.0	478	9	0.02	0.00	0.15	0.16	-1.99	-7.61	0.09
Spring 94-113	0.00	7.9	7.81	1,800	—	114.0	33.0	263	4.2	665	<5	306	122	1,120	1,040	4.75	0.04	0.78	1.13	-1.08	-6.08	0.30
A Spring	1.31	6.7	7.51	939	—	59.0	37.3	108	1.7	528	<5	48.3	15.0	581	22	0.26	0.01	0.20	0.26	-1.99	-7.34	0.09
B Spring	2.84	6.1	7.54	740	—	72.6	42.1	34.4	1.4	438	<5	31.7	4.0	429	22	0.12	0.00	0.25	0.31	-2.06	-8.40	0.08
M-SP87	1.55	5.6	7.85	1,116	—	90.3	48.7	92.9	3.5	410	<5	230.7	56.0	766	17	0.18	0.01	0.53	0.85	-1.21	-6.85	0.39
USP-1	0.18	4.2	7.59	1,146	—	71.0	47.7	90.6	4.8	434	<5	191.0	44.2	—	—	—	—	0.19	0.23	-1.36	-6.95	0.32
USP-2	0.43	5.5	7.46	1,287	—	90.5	55.9	75.6	4.5	335	<5	222.0	83.9	—	—	—	—	0.06	-0.03	-1.23	-6.76	0.72
Price River Fm. Avg.	***2.09***	***6.85***	***7.59***	***1032***		***84.2***	***40.3***	***106***	***2.97***	***475***	***<5***	***146***	***64.3***	***691***	***193***	***1.17***	***0.03***	***0.31***	***0.37***	***-1.58***	***-6.97***	***0.42***
Surface Water																						
Cowboy Creek																						
M-STR03	39	8.4	8.13	435	6.2	54.6	30.0	39.7	2.6	347	<5	39	24.4	382	41	0.43	0.03	0.66	1.15	-2.07	-7.56	0.40
M-STR04	22	13.0	8.70	624	7.7	53.3	28.7	51.7	1.9	364	12	38	31.4	420	19	0.27	0.02	1.28	2.48	-2.13	-7.34	0.39
M-STR05	96	7.5	8.26	458	8.6	52.6	31.8	34.8	2.0	327	<5	31	21.8	342	84	0.25	0.01	0.73	1.32	-2.18	-7.66	0.41
Greens Hollow Creek																						
M-STR06	5.0	13.6	8.49	647	6.7	56.9	34.9	77.2	4.8	483	7	40	41.6	522	249	1.25	0.08	1.21	2.40	-2.12	-7.06	0.35
Greens Hollow Creek in Greens Canyon																						
M-STR01	32	8.7	8.64	505	8.2	46.0	27.0	42.7	2.0	328	11	27	16.5	450	11	0.36	0.01	1.08	2.03	-2.30	-7.69	0.25
M-STR02	68	8.8	8.49	554	8.3	64.7	38.0	43.5	3.3	355	<5	61	25.0	438	28	0.48	0.02	1.06	2.00	-1.84	-7.51	0.37
Unnamed ephemeral tributary to Muddy Creek																						
M-STR07	0.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Muddy Creek (Main Fork)																						
U-Mud	14,414	9.8	8.73	390	8.7	50.7	28.3	23.0	1.1	264	8	36	11.0	297	11	0.12	0.01	1.13	2.13	-2.14	-8.14	0.31
PINES 405	20,615	8.2	8.62	386	8.5	41.3	22.8	8.0	<1	268	<5	11	1.8	220	199	2.78	0.02	0.93	1.70	-2.67	-9.38	0.14
Muddy Creek (South Fork)																						

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	Field measurements					Major ions								Solids and total metals				Mineral saturation indices				
	Flow	T	pH	Sp. Cond.	D.O.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	TDS	TSS	T-Fe	T-Mn	SI	SI	SI	SI	Ratio
	gpm	°C	S.U.	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Calcite	Dolomite	Gypsum	Halite	Cl:Na
M-STR08	5,225	6.6	8.77	250	9.9	48.7	24.5	9.0	0.6	261	5	9	2.1	238	13	0.17	0.01	1.11	1.98	-2.71	-9.25	0.15
Quitchupah Creek (South Fork)																						
S. Fk. Quitch. Up.	245	8.0	8.58	532	9.1	51.7	31.6	10.8	1.1	224	<5	94	2.0	343	15	0.14	0.01	0.86	1.61	-1.71	-9.20	0.12
Sufco 006A	207	10.1	8.56	622	8.5	53.2	30.9	29.3	1.6	297	<5	102	8.6	394	30	0.59	0.03	0.99	1.88	-1.69	-8.15	0.19
Sufco 006	211	12.7	8.34	656	7.7	58.4	34.3	26.7	1.9	302	6	97	12.5	410	80	1.53	0.06	0.88	1.72	-1.69	-8.03	0.30
Quitchupah Creek (South Fork)																						
Sufco 007	712	11.4	8.42	456	8.1	49.5	17.2	17.3	0.7	254	<5	34	8.8	269	10	1.58	0.06	0.83	1.36	-2.13	-8.35	0.33
Skutumpah Creek																						
Skutumpah Ck. Up.	68	9.0	8.49	532	9.0	42.8	30.2	22.2	1.8	240	11	67	5.0	323	30	0.36	0.01	0.79	1.55	-1.93	-8.49	0.15

Note: For laboratory results where a "less then" value was reported, a zero value was used in the average calculations.

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Table 6 Isotopic compositions of groundwaters and surface waters.

		δ^2H (‰)	$\delta^{18}O$ (‰)	Tritium (TU)	$\delta^{13}C$ (‰)	^{14}C (pmC)	Groundwater "age" radiocarbon years
Springs, Muddy Tract Area							
M-SP07	9/26/2001	-123	-16.4	12.7	-10.8	93.31	modern
M-SP08	9/26/2001	-120	-16.4	13.3	-11.2	95.69	modern
M-SP10	10/4/2001	-125	-17.1	11.6	-12.2	91.15	modern
M-SP39	10/4/2001	-123	-16.6	7.7	-10.5	88.34	modern
M-SP01	10/4/2001	-120	-16.1	5	-11.9	96.27	modern
M-SP02	10/4/2001	-120	-16.1	14.6	-12.6	98.15	modern
M-SP04	10/4/2001	-124	-16.3	7.7	-11.1	84.4	modern
M-SP14	9/26/2001	-117	-15.7	8	-14.1	107.73	modern
M-SP18	10/4/2001	-129	-17.4	-0.7	-12.4	78.89	modern
M-SP38	10/5/2001	-127	-17.2	9.6	-12.5	62.11	modern
USP-1	11/20/2009	---	---	2.8	-10.98	63.02	modern
USP-2	11/20/2009	---	---	4.2	-11.48	67.67	modern
GW-13	10/3/1995	---	---	8.57	---	---	modern
GW-13	6/10/1996	---	---	5.63	---	---	modern
Streams, Muddy Tract Area							
Sufco 007 (North Fork Quit)	10/3/1995	---	---	15.6	---	---	modern
Sufco Mine underground							
Greens Hollow Area							
XC51 2 South Bleeder	5/6/2015	---	---	<0.5	-10.3	28.31	5,000
3 Right 2 South Bleeder	5/6/2015	---	---	<0.5	-9.0	12.15	12,200
5 West #4 Entry R.D.	5/6/2015	---	---	<0.5	-9.0	9.00	13,300
XC51 2 South Bleeder	9/1/2015	---	---	0.03	-9.9	28.39	4,600
3R 2S Bleeder Gob Drain	9/1/2015	---	---	0.05	-4.8	24.2	---
5 West #4 Entry R.D.	9/1/2015	---	---	0.00	-8.9	9.87	12,500
Big Ridge Area							
5 Left XC57 Roof Drip	1/25/2010	---	---	0.1	-10.37	28.45	5,000
6 Left XC16 Roof Drip	1/25/2010	---	---	0.1	-10.39	22.36	7,000
Box Canyon Area							
14 Left Setup Room	9/20/2000	---	---	0.07	-9.9	31.42	4,000
14 Left E2 XC101	9/20/2000	---	---	0.01	-10.2	24.45	6,000
Quitchupah Area							
12L 4E E3 C74 1/2	9/18/1997	-120.06	-16.22	-0.07	-11.2	21.07	7,500
12L 4E fault	9/18/1997	-118.55	-16.12	-0.02	-7.1	20.38	7,500
13L 4E E2 C53	12/7/1998	---	---	-0.02	-7.2	6.28	15,000
2 Right 2 South Fracture	12/16/2011	---	---	-0.01	---	---	---
2 South Bleeder 16	12/16/2011	---	---	0.09	---	---	---
1RT 2STH E1XC45 Fault	2/23/2012	---	---	0.00	---	---	---

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Table 7 Results of gain/loss study of Muddy Creek, 28-29 October 2015.

Station	Site	Date/Time	Discharge (cfs)	Discharge (gpm)	T (°C)	pH (S.U.)	Sp. Cond. (µS/cm)
1	Upper Muddy Creek (U-Mud)	10/28/2015 12:30	9.63	4,320	3.6	8.65	412
2	Muddy Creek above Horse Creek	10/28/2015 16:00	10.20	4,580	3.8	8.68	407
2a	Horse Creek tributary to Muddy Creek	10/28/2015 15:00	1.56	700	4.8	8.7	488
2b	Cowboy Creek and Greens Hollow Creek tributaries to Muddy Creek	10/28/2015 18:30	0.00	0.00	---	---	---
2c	Box Canyon Creek tributary to Muddy Creek (Pines 403)	10/29/2015 11:20	0.17	75	5.1	8.42	951
3	Muddy Creek below Box Canyon Creek (Pines 405)	10/29/2015 12:00	11.92	5,350	4.6	8.67	411
3a	Last Water Canyon tributary to Muddy Creek (Pines 302)	10/29/2015 13:30	0.00	0.04	7.2	8.85	446
4	Muddy Creek at USGS gauging station 09330500 (Pines 406b)	10/29/2015 8:00	10.90	4,890	4.5	8.57	422

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Table 8 Recommended hydrologic monitoring protocols.

Discharge and water level measurements

Protocol	Applies to	Parameter	Frequency
D	Springs	Discharge	Quarterly when reasonably accessible
C	Streams	Discharge	Quarterly when reasonably accessible

Water quality

Protocol	Applies to	Parameters	Table	Frequency
1	Stream	Quarterly surface-water quality field measurements only	11	Quarterly when reasonably accessible
2	Stream	Quarterly surface water quality operational laboratory measurements	11	Quarterly when reasonably accessible
3	Spring	Quarterly groundwater quality field measurements only	10	Quarterly when reasonably accessible
4	Spring	Quarterly groundwater quality operational laboratory measurements	10	Quarterly when reasonably accessible
8	Stream	Quarterly surface water quality field measurements and analysis for total dissolved solids, total suspended solids, total iron, total manganese	Field Measure ments on 11	Quarterly when reasonably accessible
9	Spring	Quarterly groundwater water quality field measurements and analysis for total dissolved solids, total iron, total manganese	Field Measure ments on 10	Quarterly when reasonably accessible

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Table 9 Recommended discharge, water level, and water quality plan for springs, streams and wells (Greens Hollow).

Site	Protocols	Comments
Springs		
M-SP01	D, 3	Price River spring in Greens Hollow Canyon, previously cabin supply (currently in Sufco mon. plan)
M-SP02	D, 3	Price River spring in Greens Hollow Canyon, developed with trough (currently in Sufco mon. plan)
M-SP04	D, 9	North Horn spring in Greens Hollow Canyon
M-SP05	D, 9	North Horn spring in Greens Hollow Canyon
M-SP06	D, 9	North Horn spring in Greens Hollow Canyon
M-SP08	D, 3	North Horn spring on Big Ridge (currently in Sufco mon. plan)
M-SP09	D, 9	North Horn spring on Big Ridge
M-SP11	D, 9	North Horn spring on flanks of White Mountain
M-SP12	D, 9	North Horn spring in Greens Hollow Canyon
M-SP15	D, 9	North Horn spring in Greens Hollow Canyon
M-SP18	D, 3	Price River spring in the Muddy Creek drainage (currently in Sufco mon. plan)
M-SP19	D, 9	North Horn spring in N. Fork of Quitchupah drainage
M-SP20	D, 9	North Horn spring in N. Fork of Quitchupah drainage
M-SP39	D, 3	Price River spring at base of Big Ridge (currently in Sufco mon. plan)
M-SP40	D, 9	North Horn spring in Cowboy Creek drainage
M-SP41	D, 9	North Horn spring in Cowboy Creek drainage
M-SP44	D, 9	North Horn spring in N. Fork of Quitchupah drainage
M-SP45	D, 9	North Horn spring
M-SP53	D, 3	North Horn spring on Big Ridge (currently in Sufco mon plan)
M-SP60	D, 9	North Horn spring in N. Fork of Quitchupah Creek
M-SP87	D, 9	Castlegate spring in Muddy Crk Cyn

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Site	Protocols	Comments
M-SP100	D, 9	North Horn spring
M-SP103	D, 9	North Horn spring in N. Fork Quitchupah Canyon
M-SP104	D, 9	North Horn spring in N. Fork Quitchupah Canyon
M-SP105	D, 9	North Horn spring in N. Fork Quitchupah Canyon
M-SP106	D, 9	North Horn spring in Greens Hollow Canyon
GW-13	D, 3	North Horn spring on Big Ridge
Proposed In-Mine Well		Refer to Table 7-2 in M&RP
USP-2	D, 9	Price River Spring
Streams		
M-STR01	C, 1	Cowboy Creek
M-STR04	C, 1	Cowboy Creek (currently in Sufco mon. plan)
M-STR06	C, 8	Top Greens Canyon
Muddy ABF	C, 8	Lower Muddy Creek
U-Mud	C, 8	Confluence N&S Forks Muddy Creek
Pines 405	C, ~~1~~ 2	Cowboy Creek (currently in Sufco mon. plan)
Pines 406	C, 1	Lower Muddy Creek
Pines 406B	C, 1	Lower Muddy Creek (Currently in Sufco mon. plan)
Sufco 006	C, 2	South Fork of Quitchupah Creek (currently in Sufco mon. plan)
Sufco 007	C, 2	North Fork of Quitchupah Creek (currently in Sufco mon. plan)
Cowboy Top Cowboy Middle Cowboy Bottom	C, 2	
SP-60 Creek North Fork Upper	C, 2	
CPC Upper	C, 2	
CPC Middle	C, 2	
CPC Lower North Fork Middle North Fork Lower (007) ULGH	C, 2	
URGH GH at Road	C, 2	
Muddy Creek below Horse Muddy Creek above Horse Horse Creek	C, 2	

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Table 10 Recommended field and laboratory operational water quality monitoring parameters for Groundwater (Greens Hollow).

FIELD MEASUREMENTS	REPORTED AS
Flow or Water Level	gpm or feet
pH	pH units
Specific Conductivity	µS/cm @ 25°C
Temperature	°C
LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg/L
Bicarbonate (as $CaCO_3$)	mg/L
Carbonate(as $CaCO_3$)	mg/L
Calcium (dissolved)	mg/L
Chloride	mg/L
Iron (total)	mg/L
Iron (dissolved)	mg/L
Magnesium (dissolved)	mg/L
Manganese (total)	mg/L
Manganese (dissolved)	mg/L
Potassium (dissolved)	mg/L
Sodium (dissolved)	mg/L
Sulfate	mg/L
Cations	meq/l
Anions	meq/l

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Table 11 Recommended field and laboratory operational water quality monitoring parameters for Surface Water (Greens Hollow).

FIELD MEASUREMENTS	REPORTED AS
Flow	gpm
pH	pH units
Specific Conductance	µS/cm @ 25°C
Temperature	°C
Dissolved Oxygen	mg/L
LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg/L
Total Suspended Solids	mg/L
Bicarbonate (as $CaCO_3$)	mg/L
Carbonate(as $CaCO_3$)	mg/L
Calcium (dissolved)	mg/L
Chloride	mg/L
Iron (total)	mg/L
Iron (dissolved)	mg/L
Magnesium (dissolved)	mg/L
Manganese (total)	mg/L
Manganese (dissolved)	mg/L
Potassium (dissolved)	mg/L
Sodium (dissolved)	mg/L
Sulfate	mg/L
Oil and Grease	mg/L
Cations	meq/l
Anions	meq/l

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Attachment A

Discharge hydrographs for selected springs

Plots of temperature, pH, specific conductance,

and Palmer Hydrologic Drought Index.

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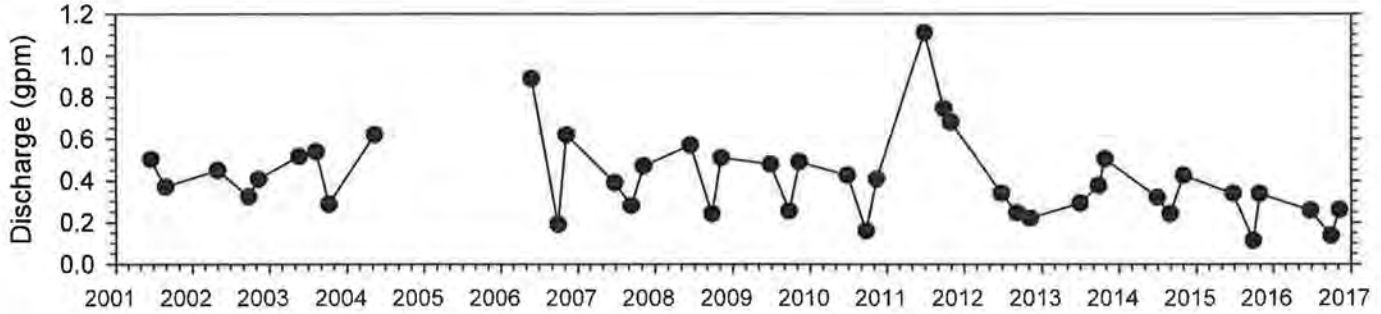
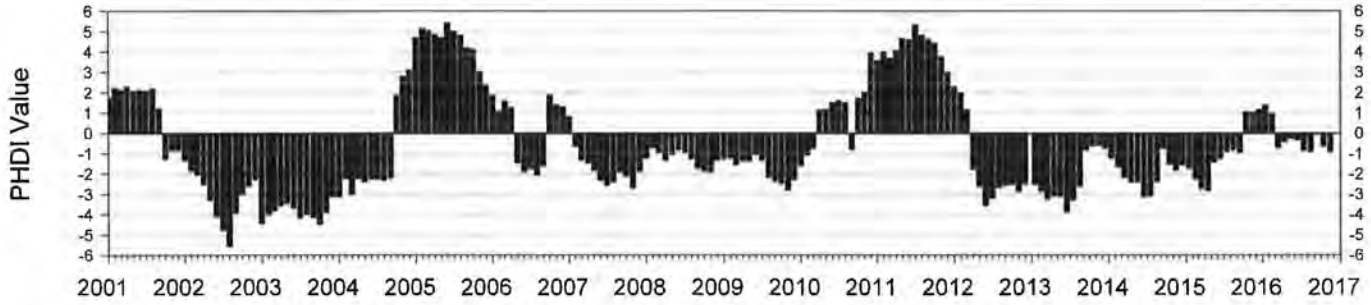
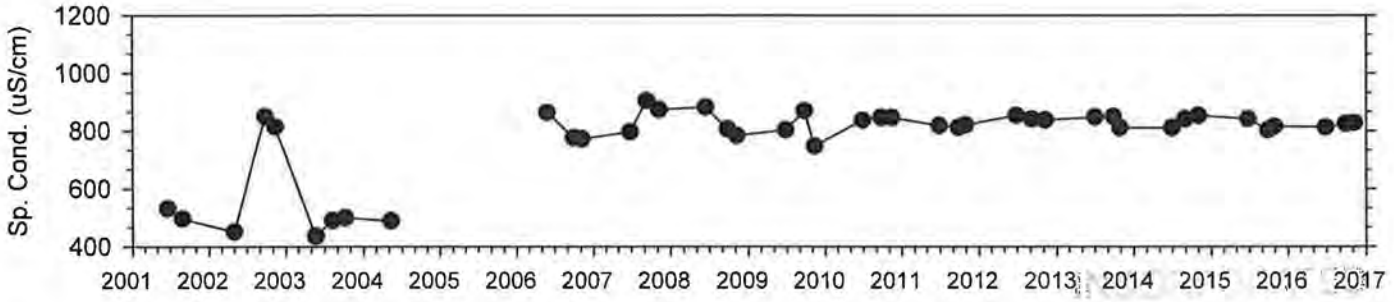
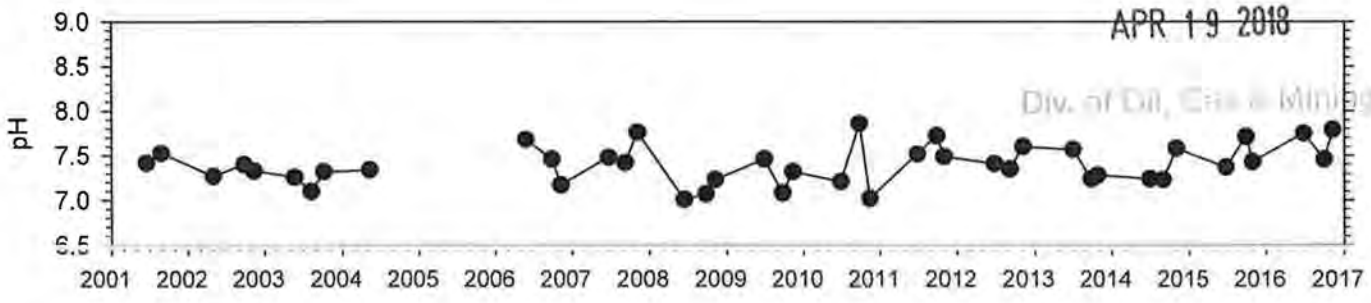
Spring M-SP01









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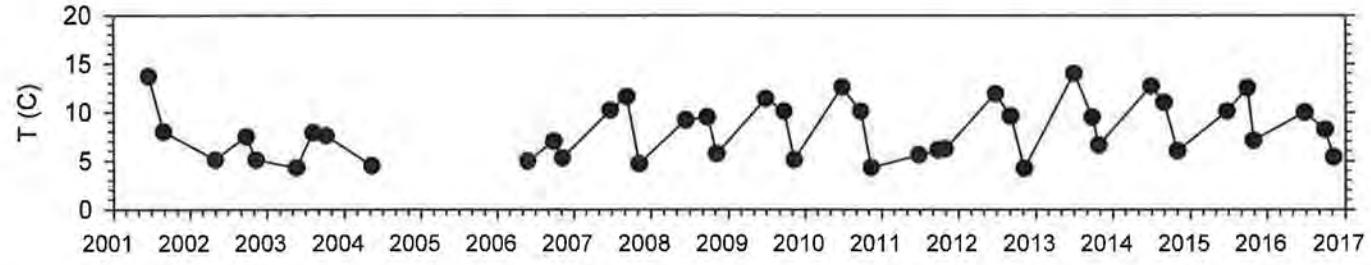
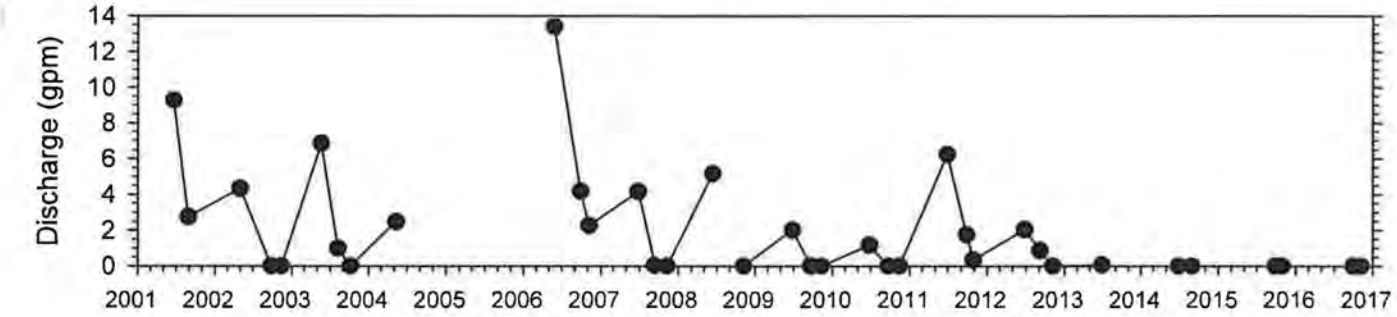
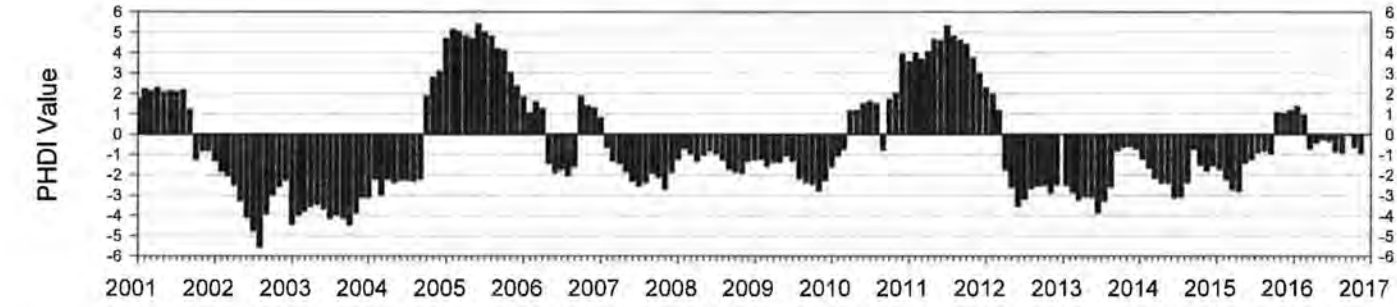
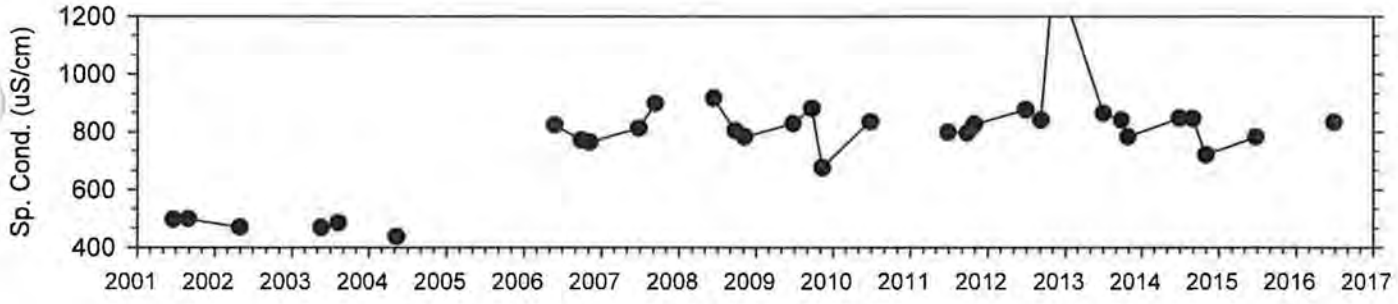
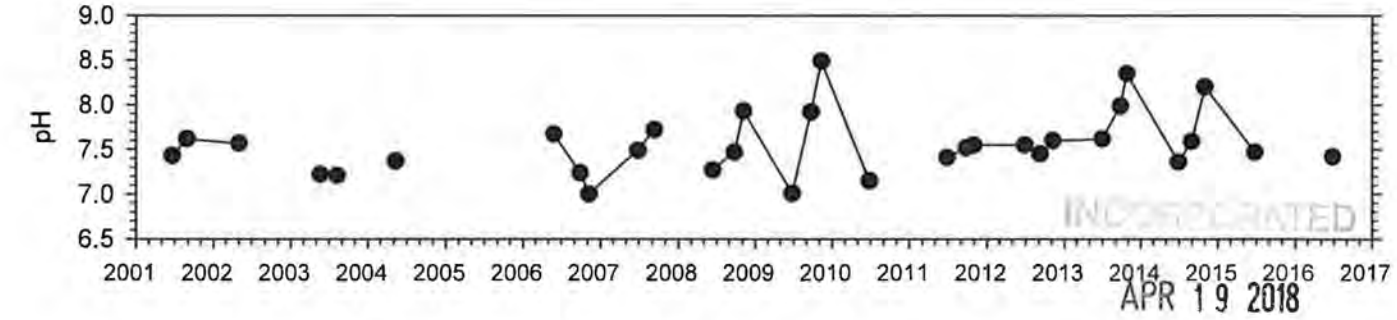


Spring M-SP02









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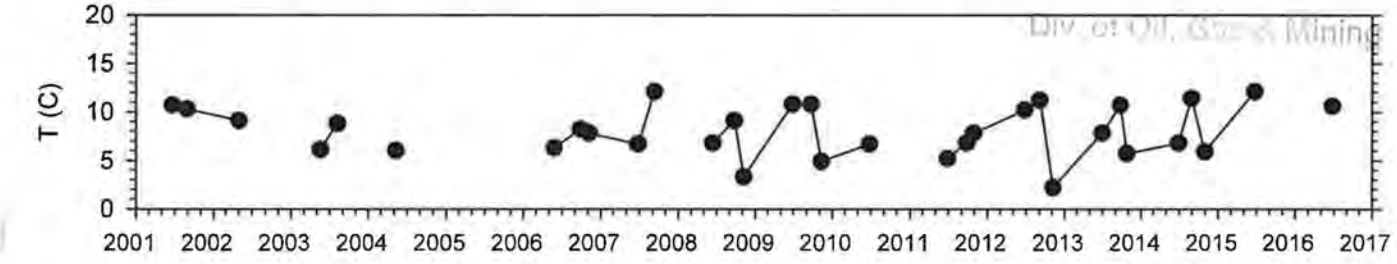
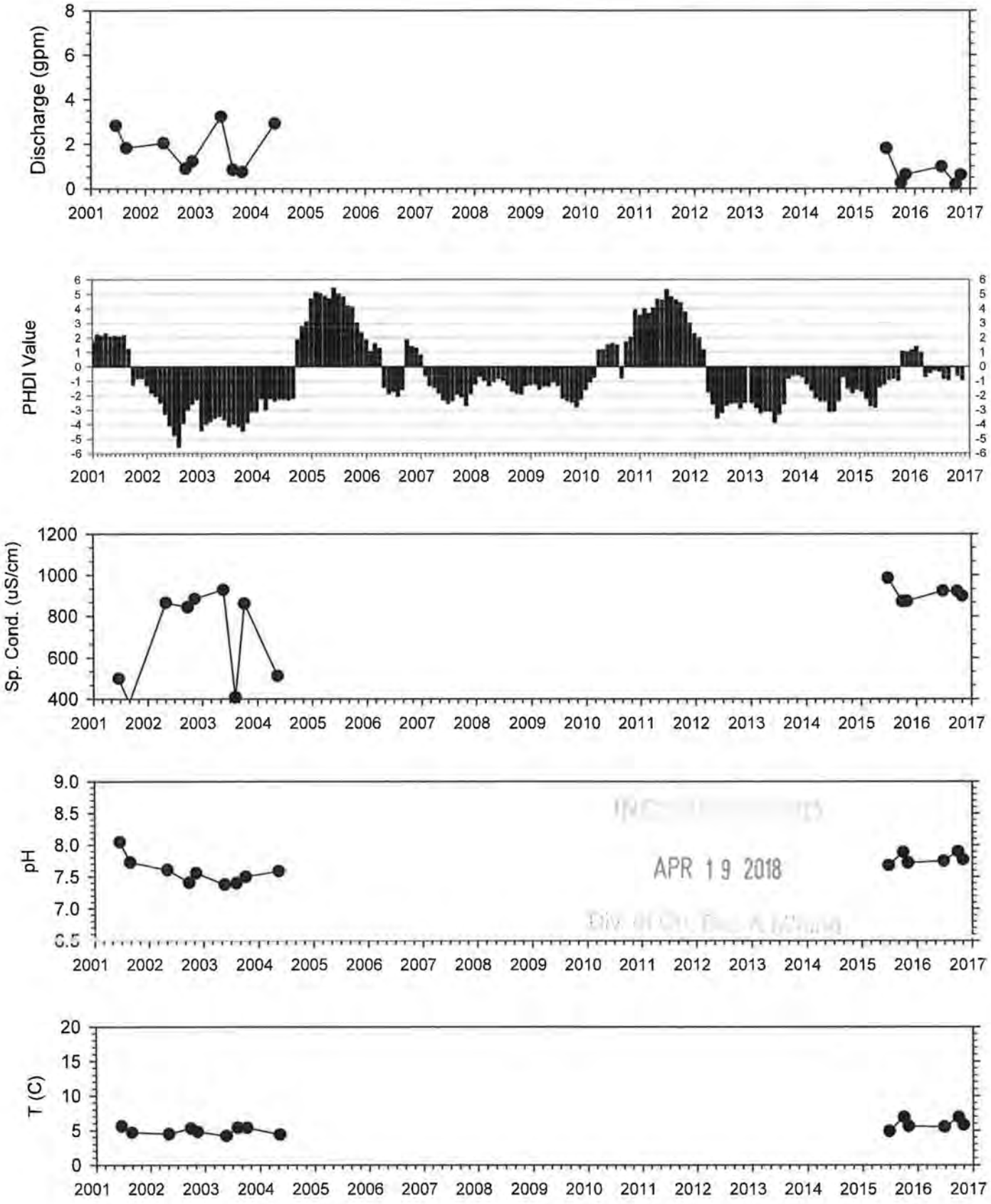


Spring M-SP04



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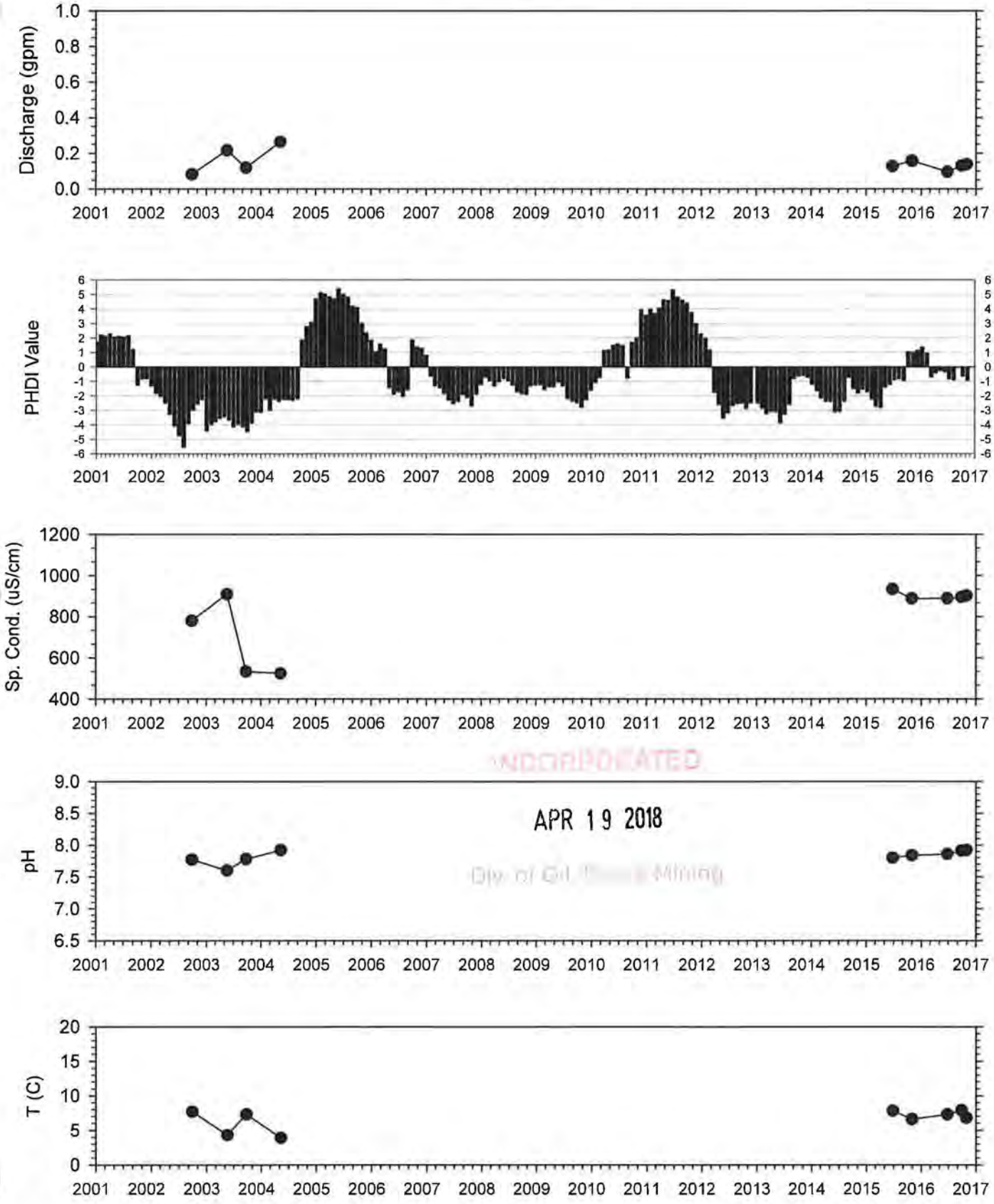
Spring M-SP05



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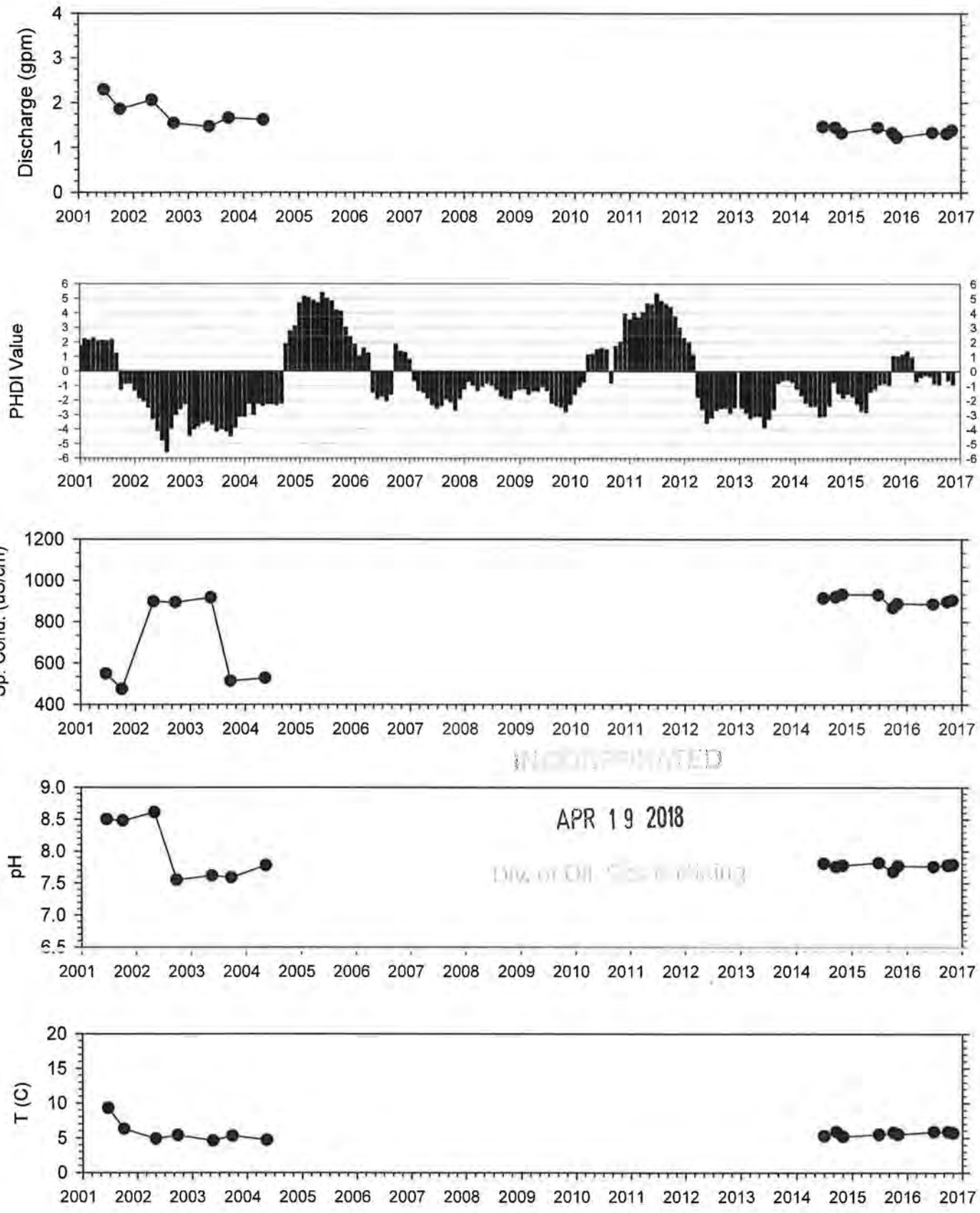
Spring M-SP06



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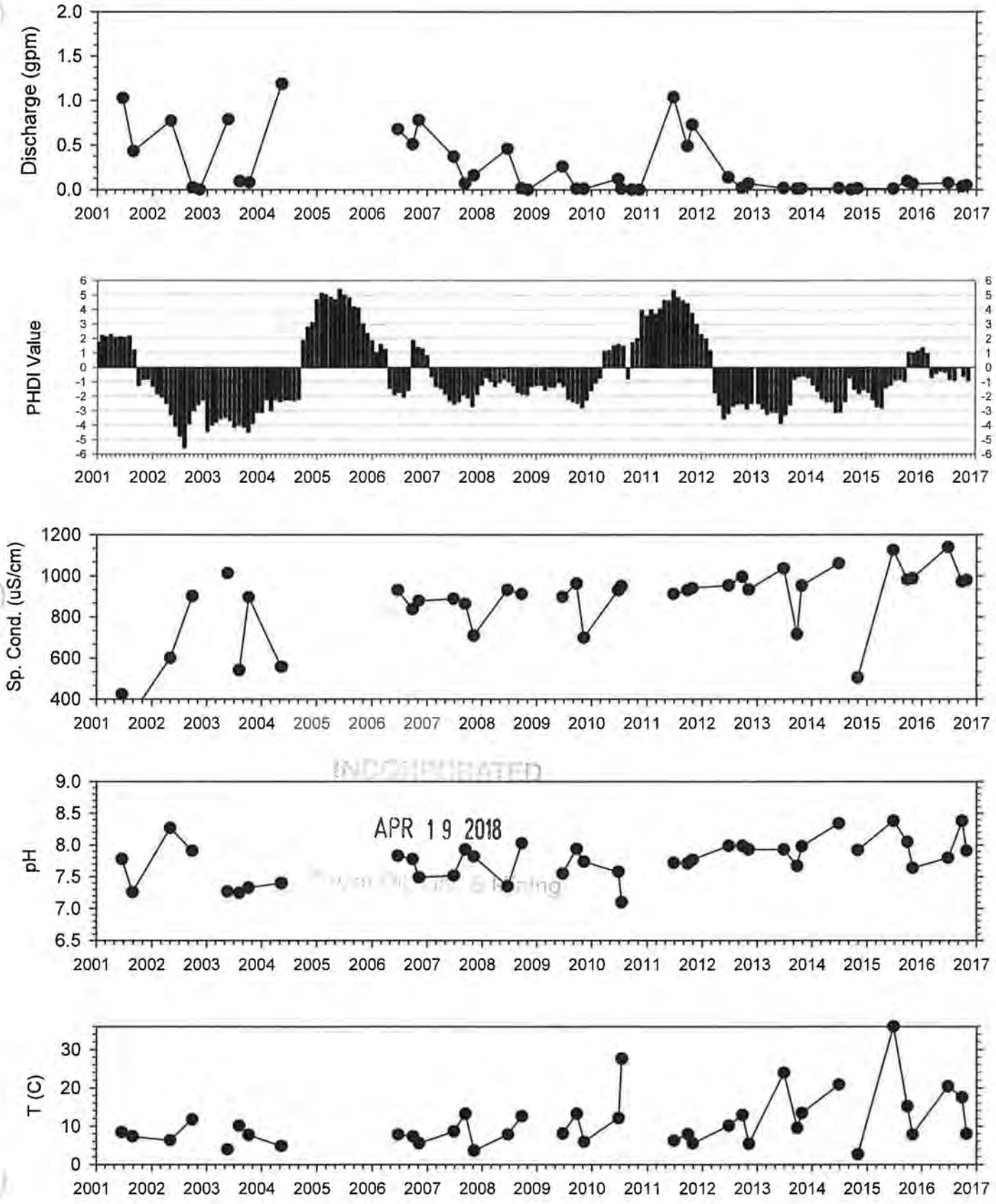
Spring M-SP08



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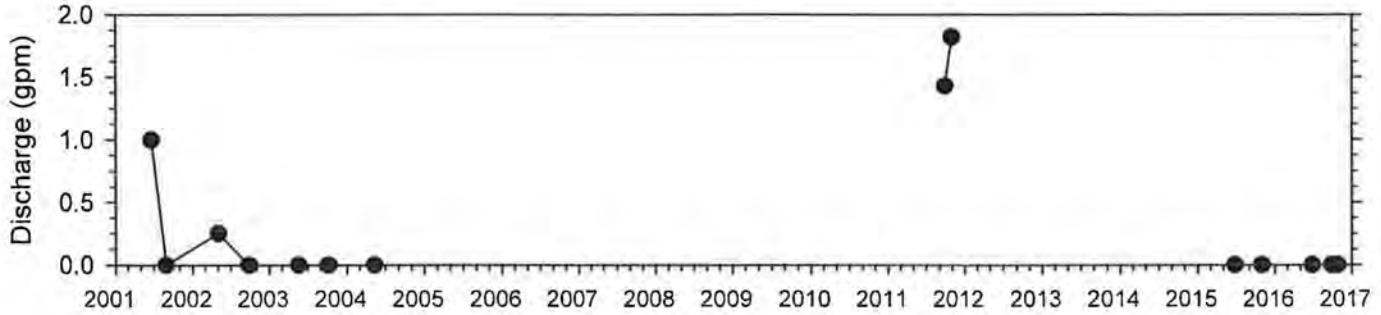
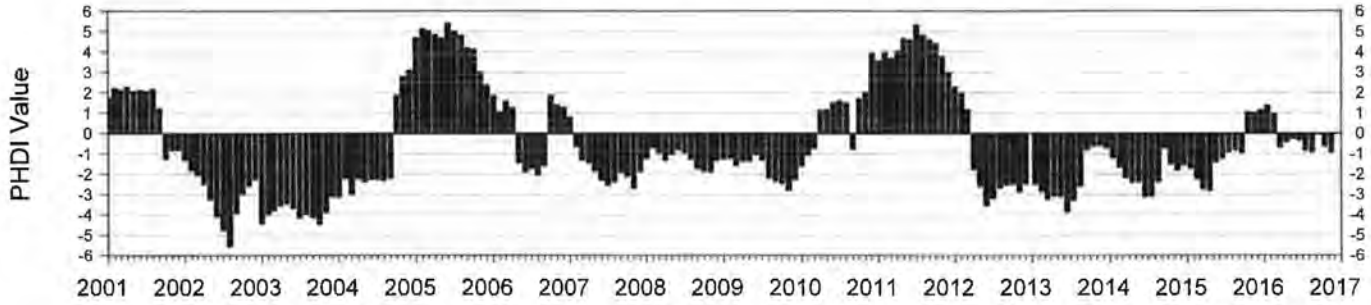
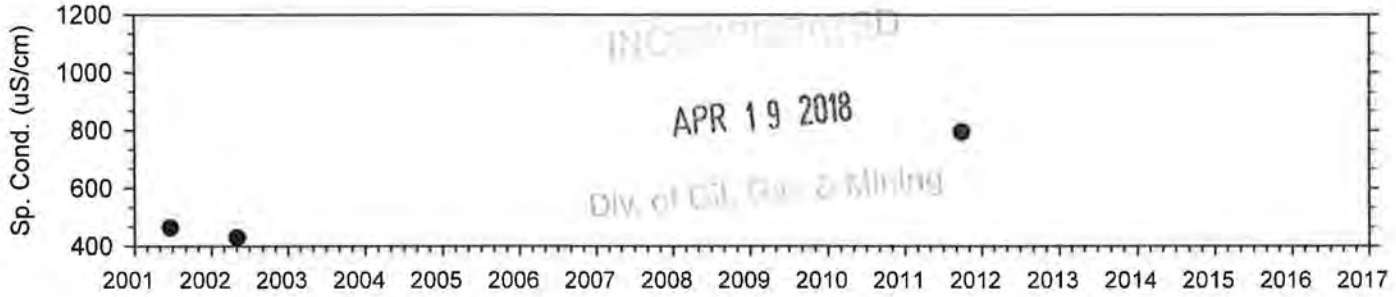
Spring M-SP09







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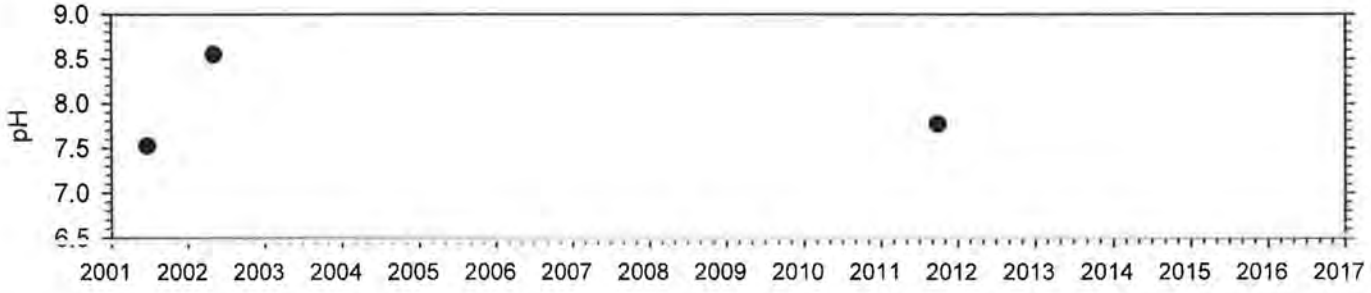
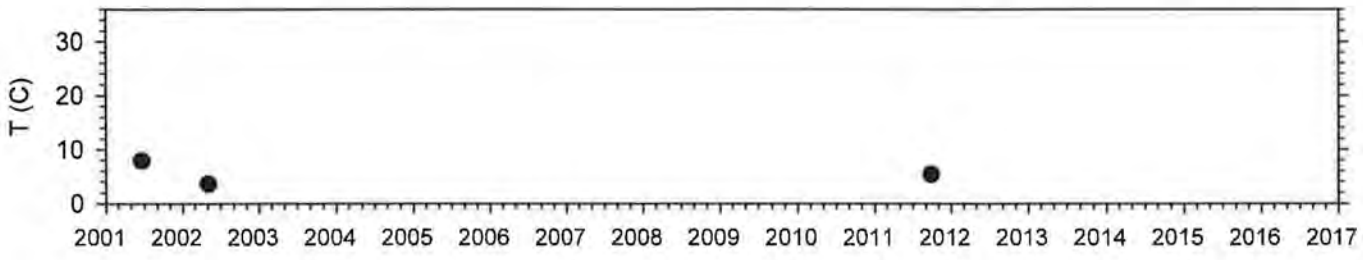
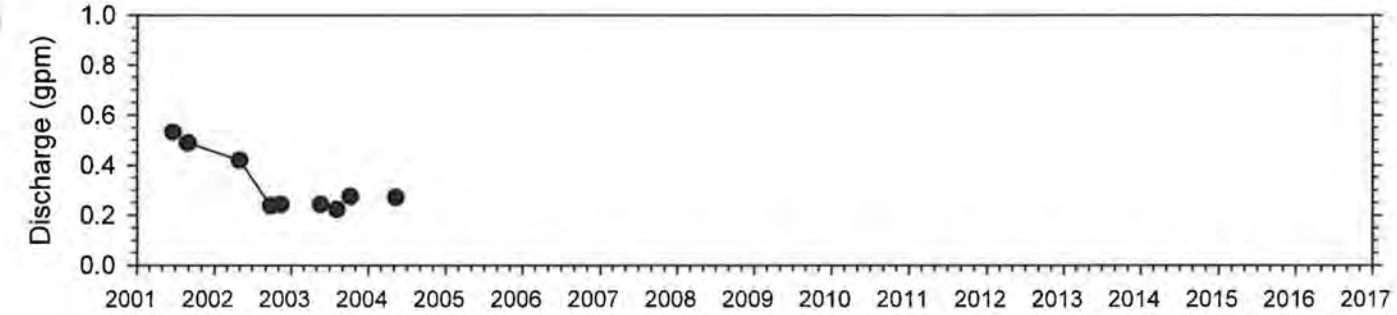
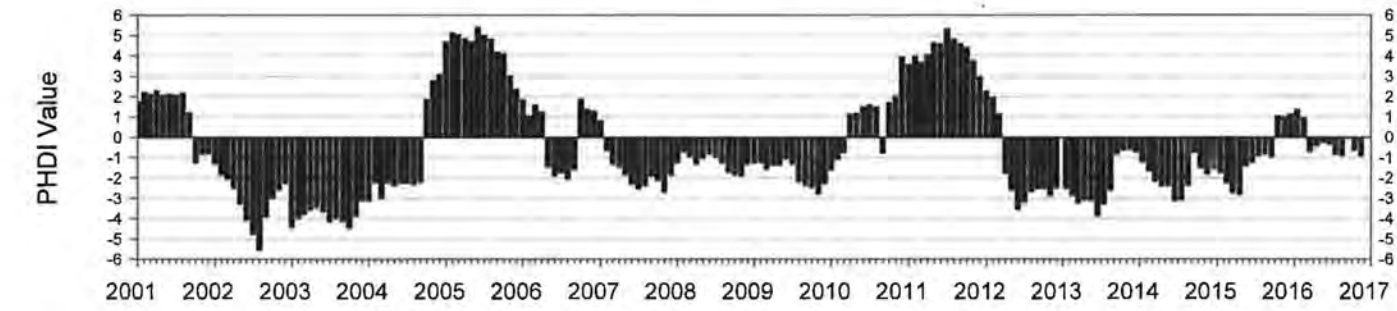
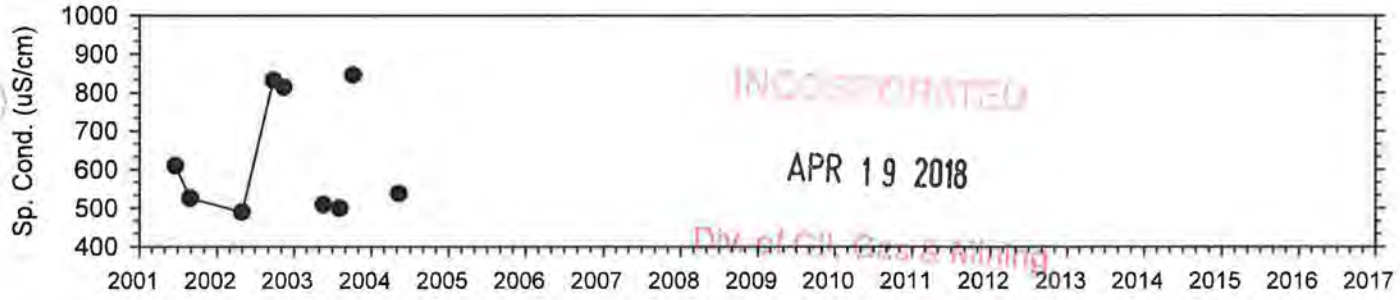




Spring M-SP10







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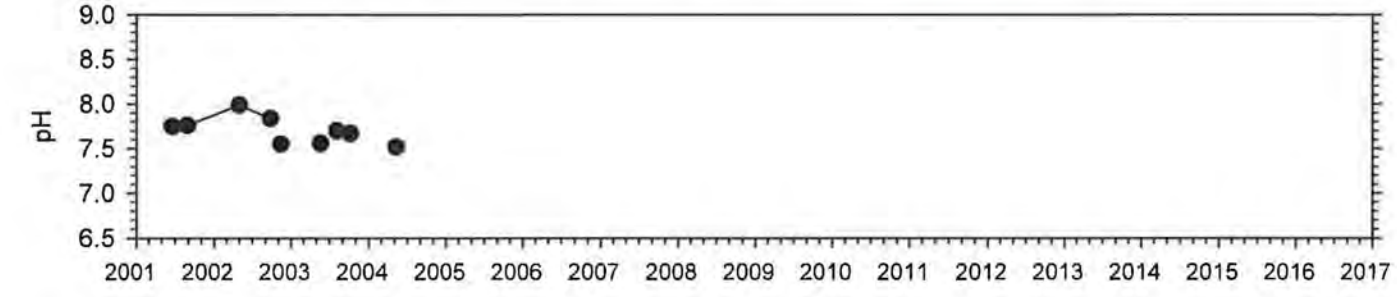
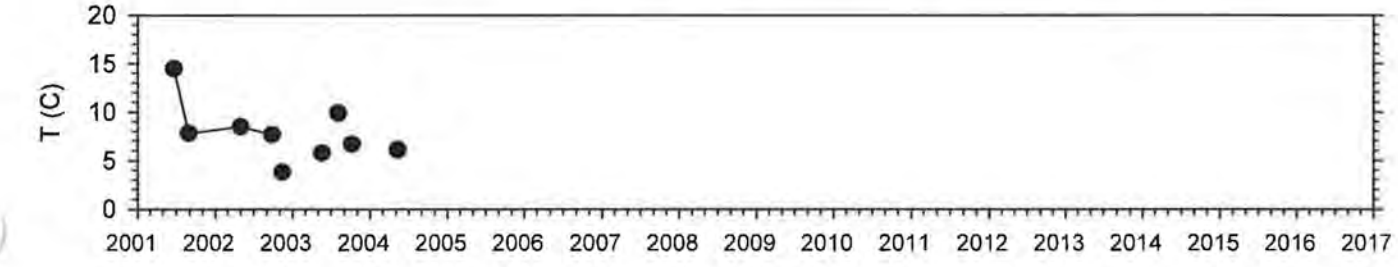
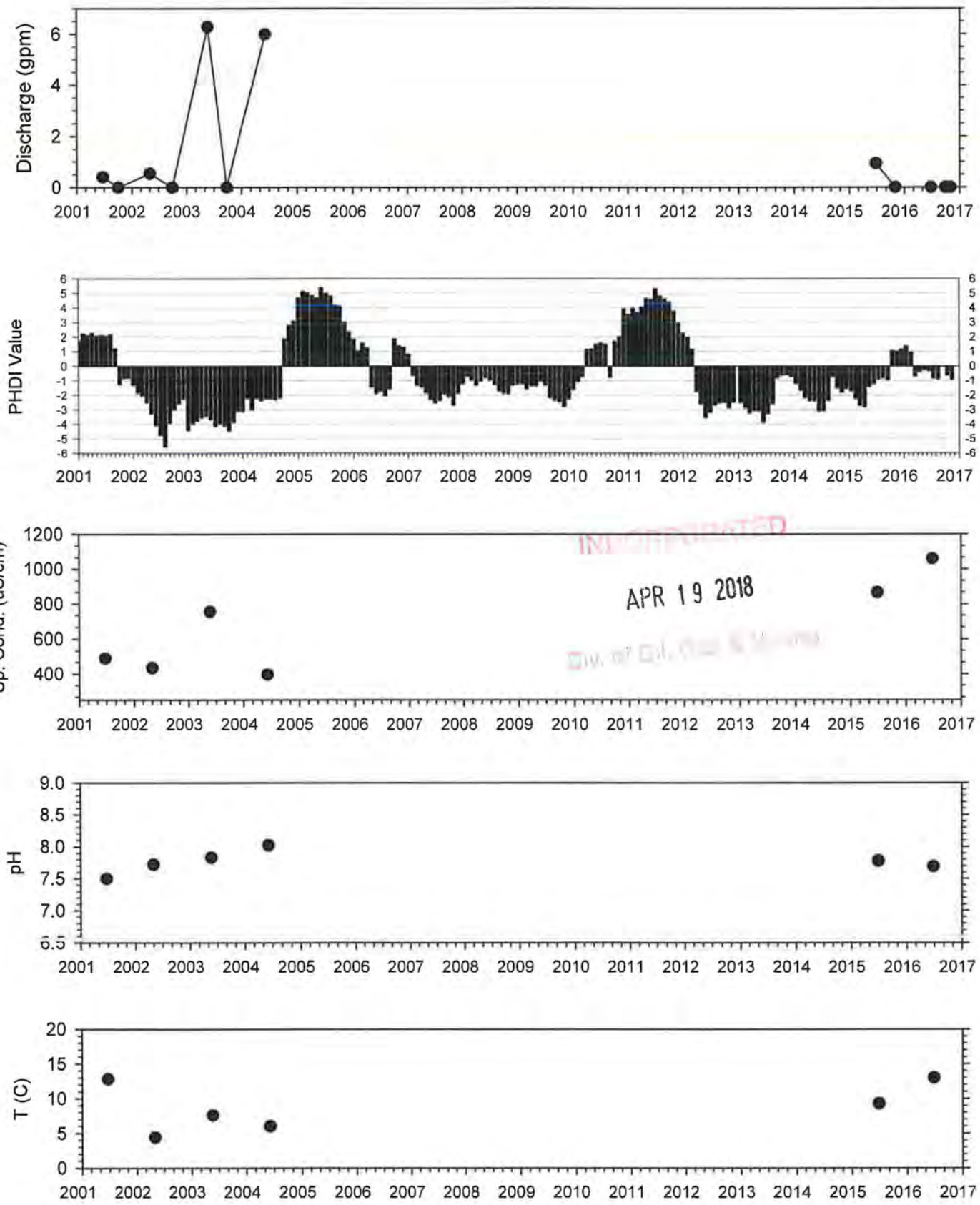




Spring M-SP11



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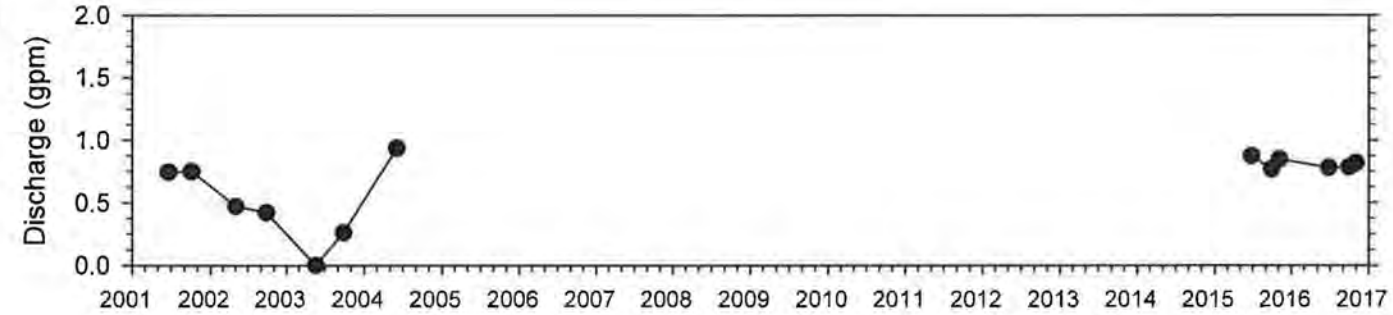
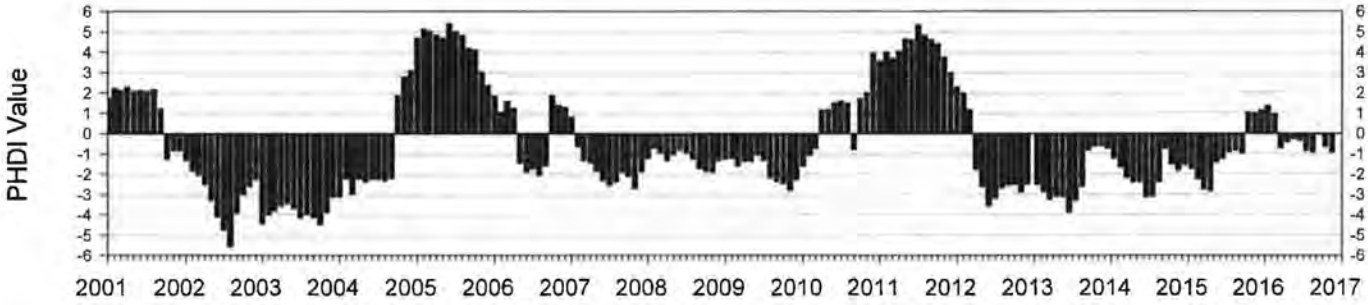
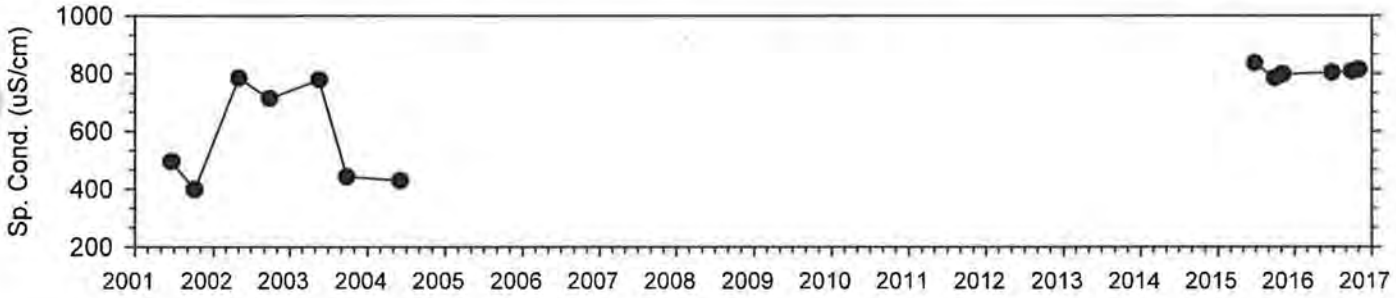
Spring M-SP12







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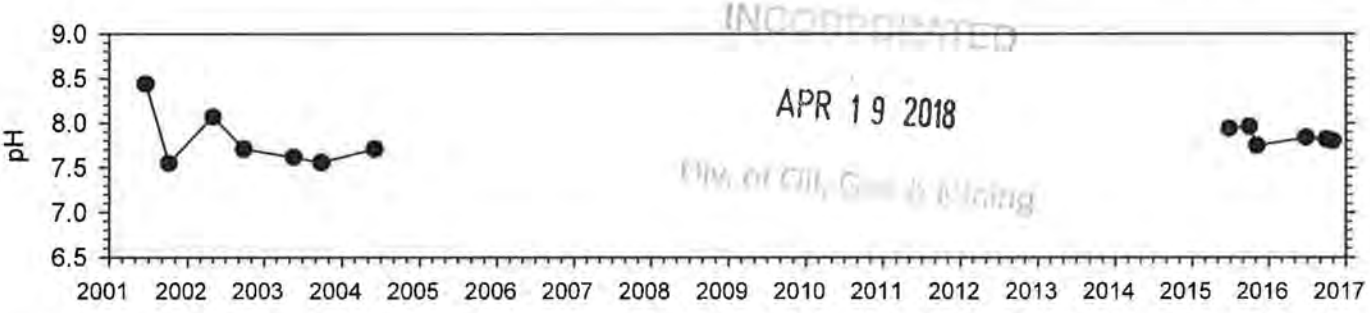
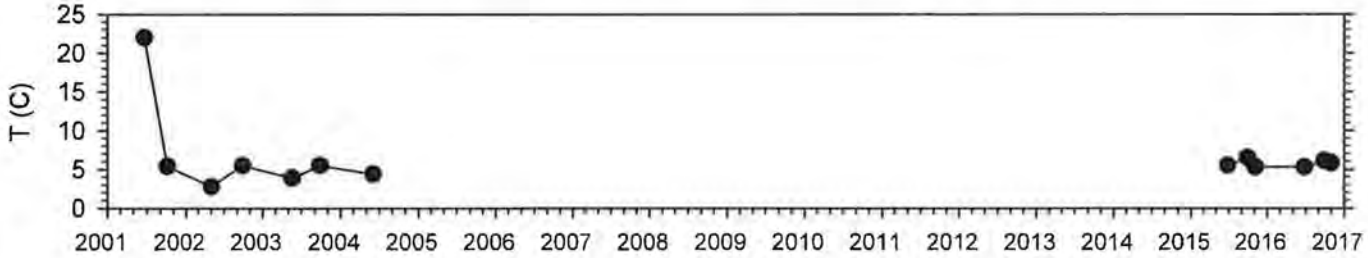
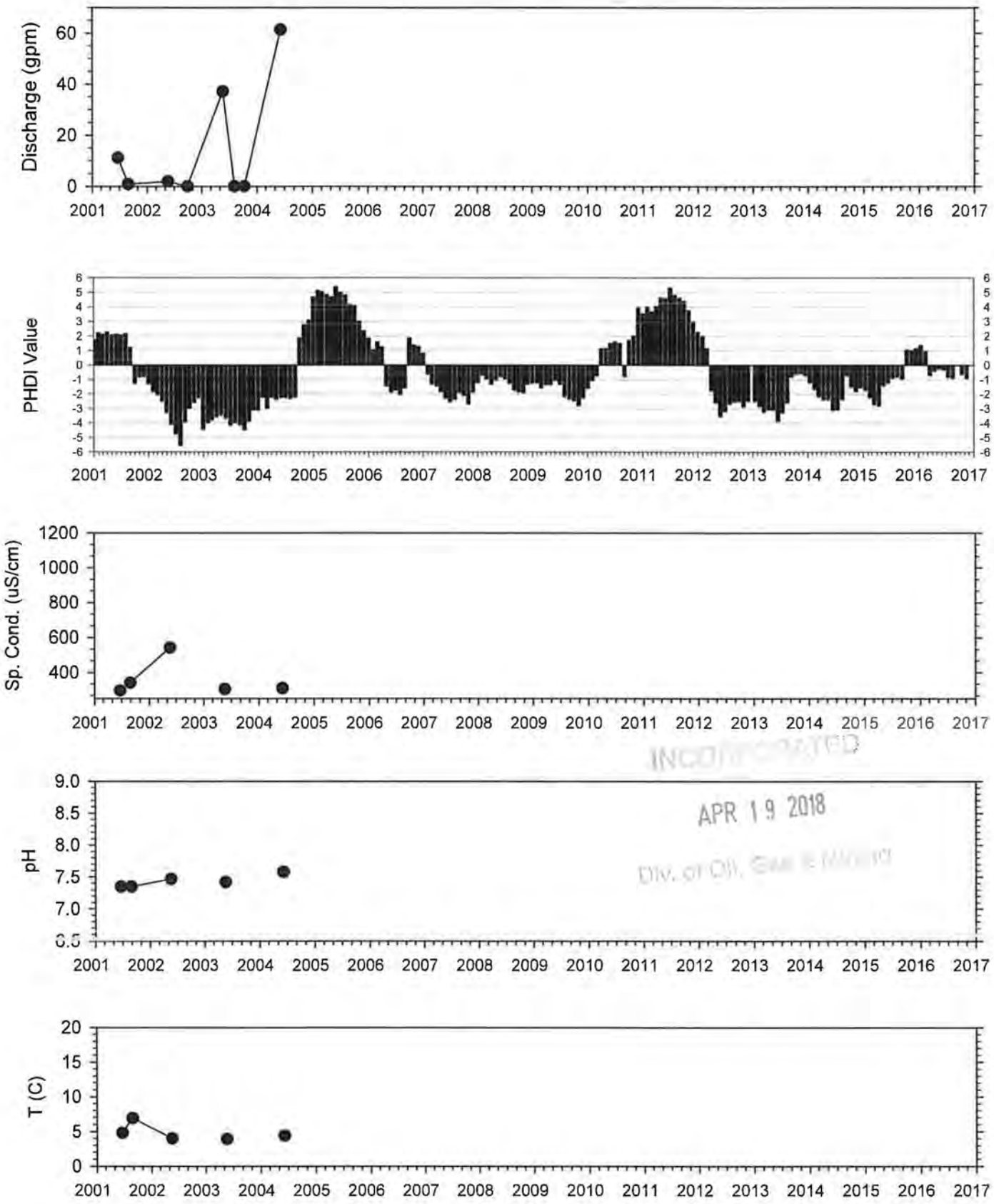




Spring M-SP14



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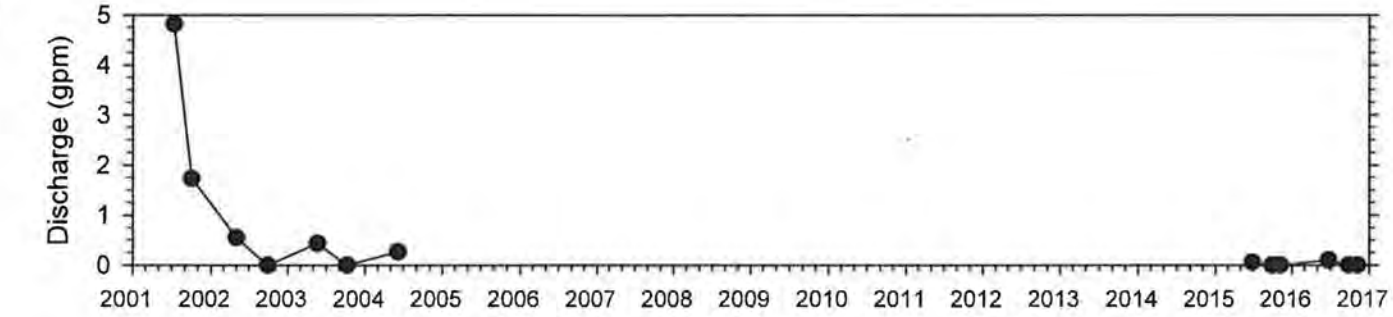
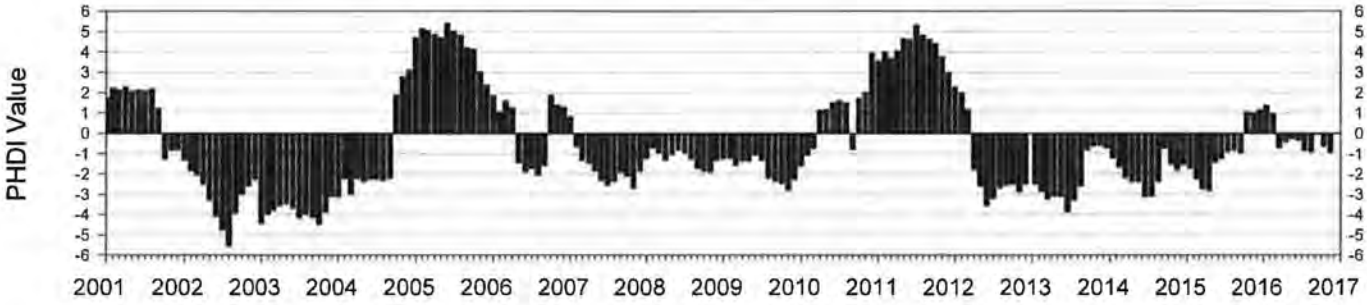
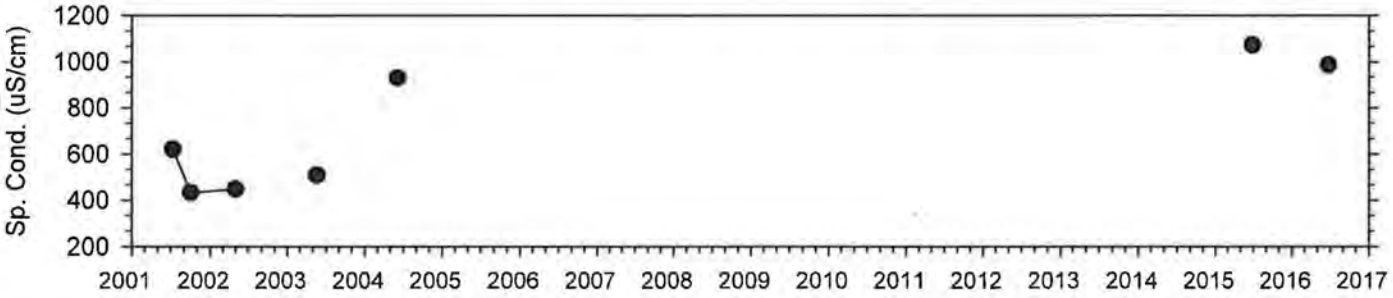
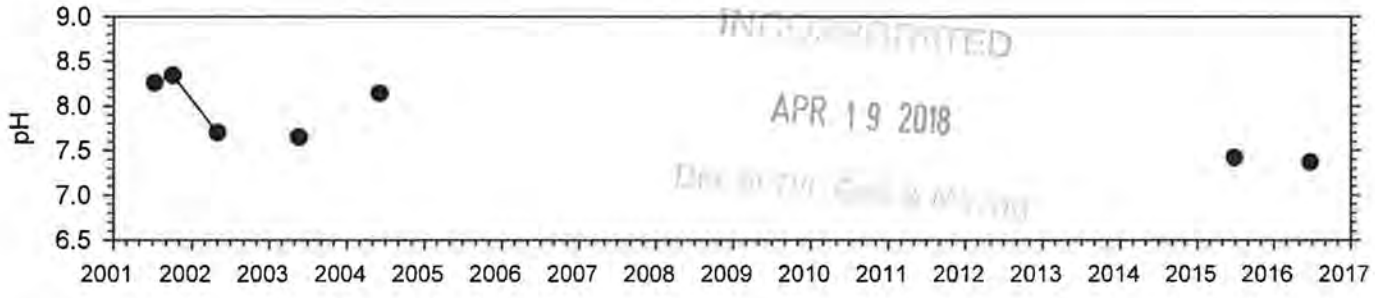
Spring M-SP15









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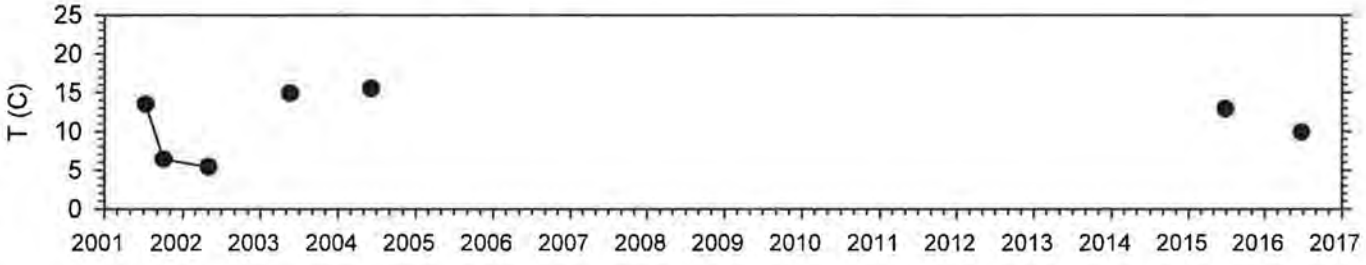
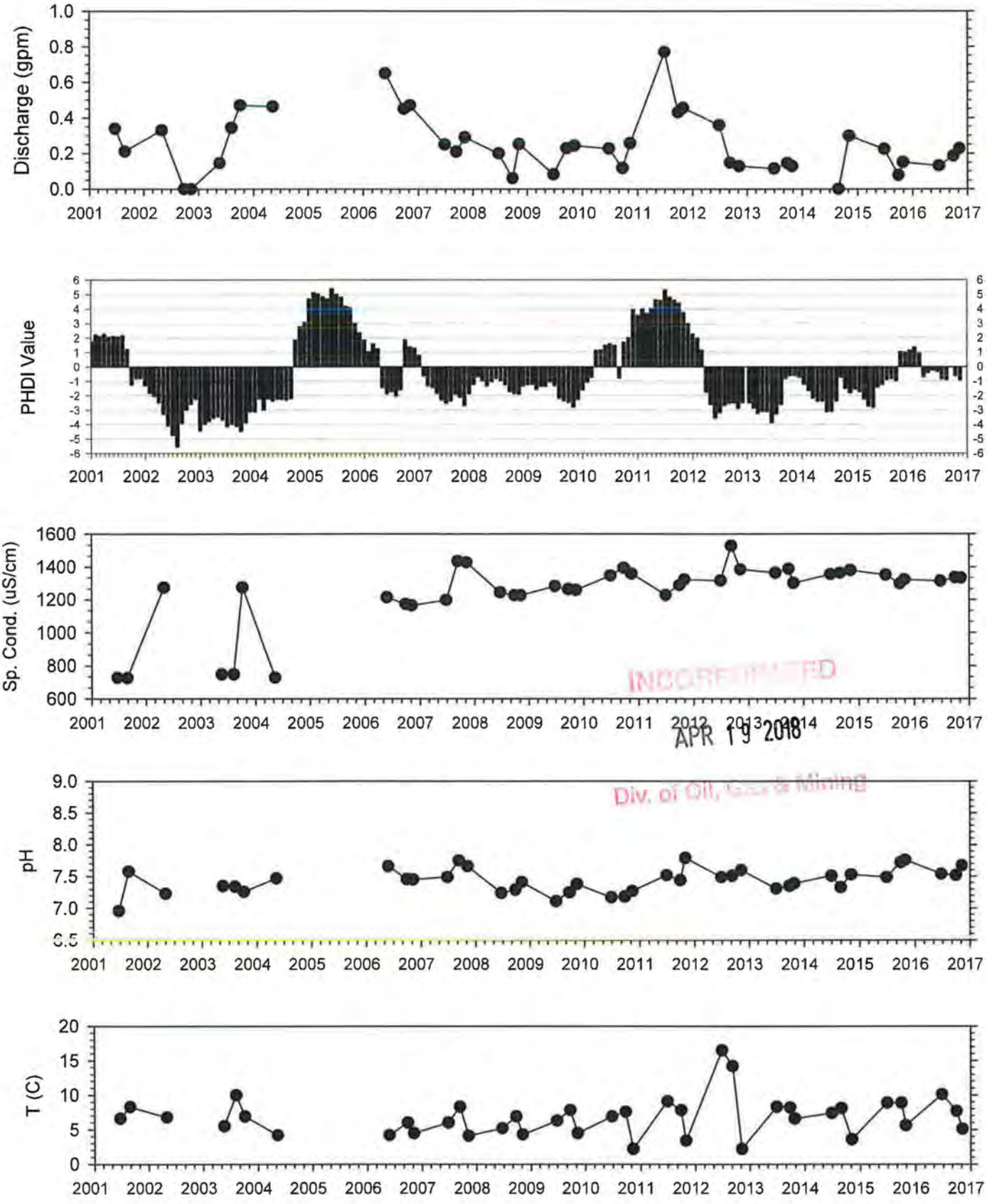


Spring M-SP18



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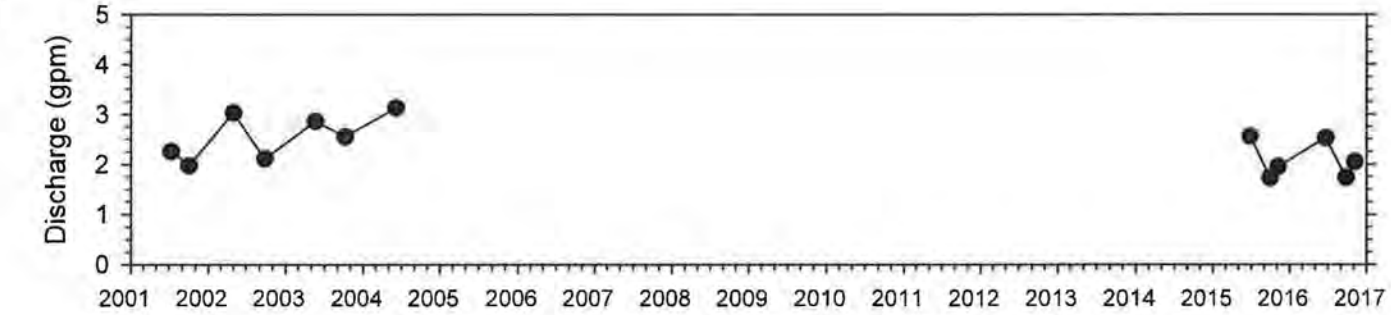
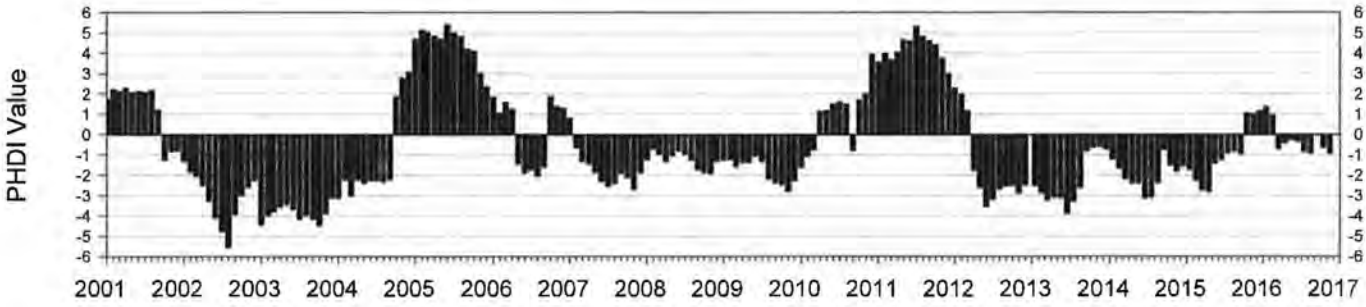
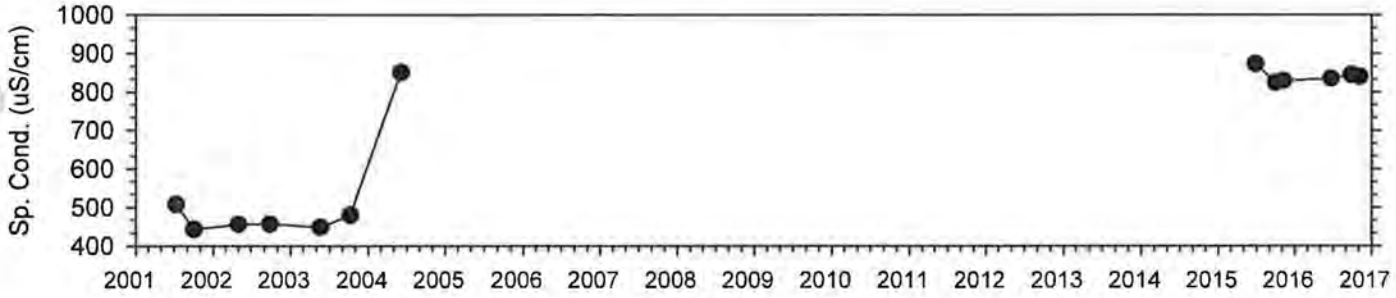
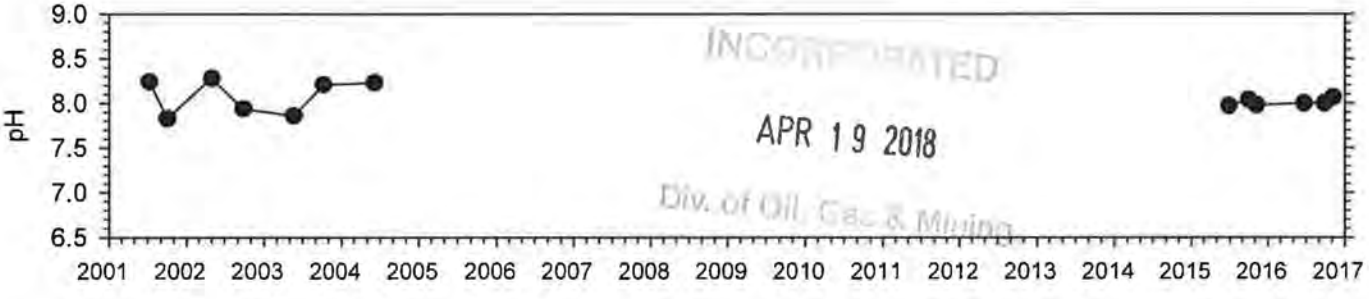
Spring M-SP19









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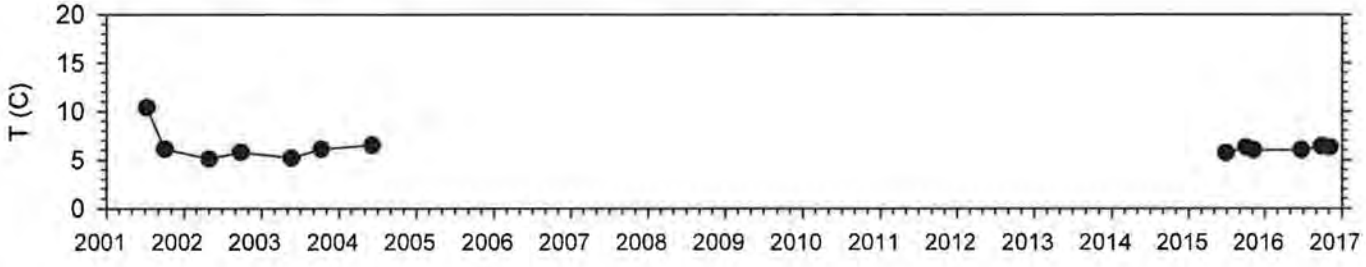
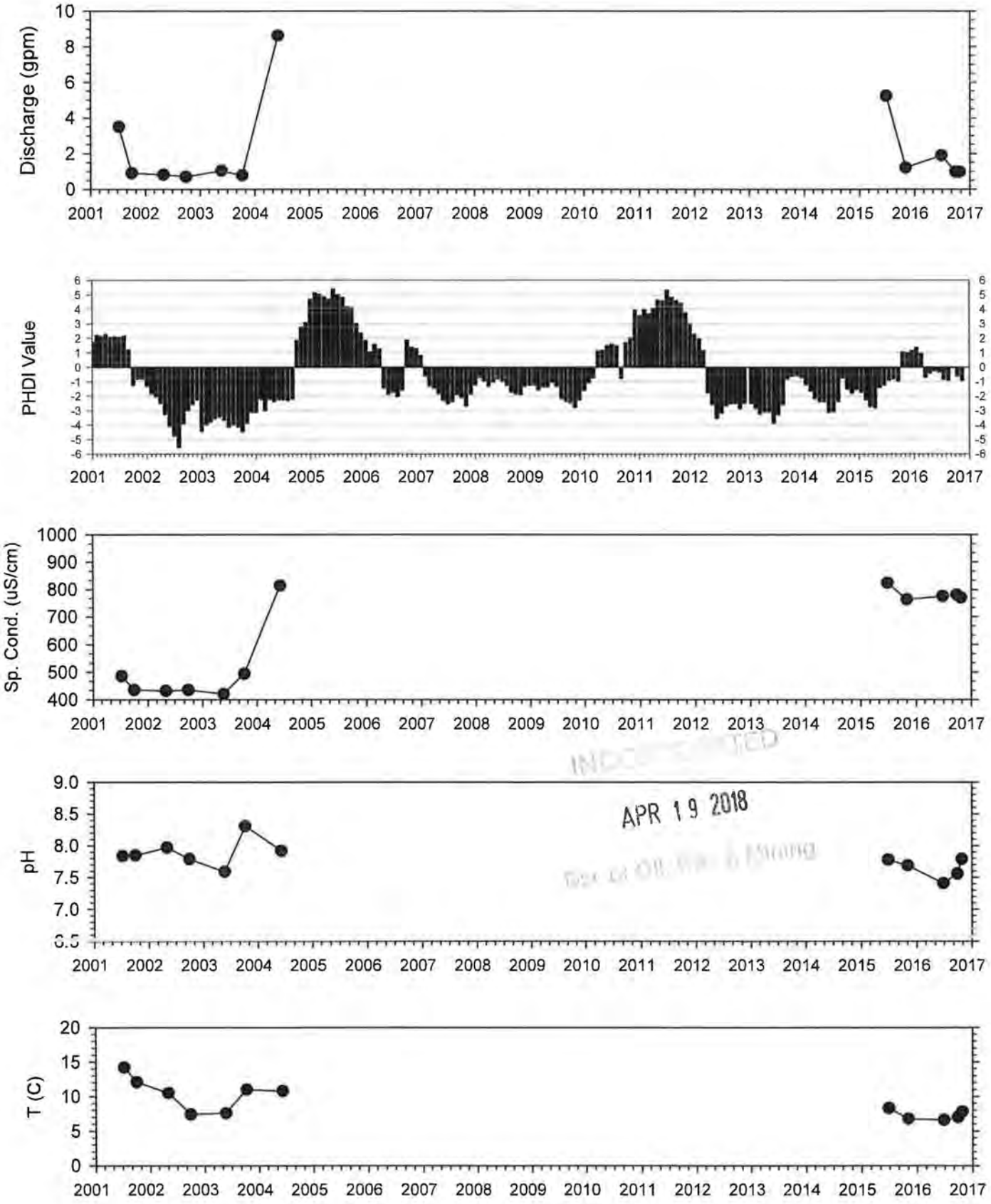


Spring M-SP20



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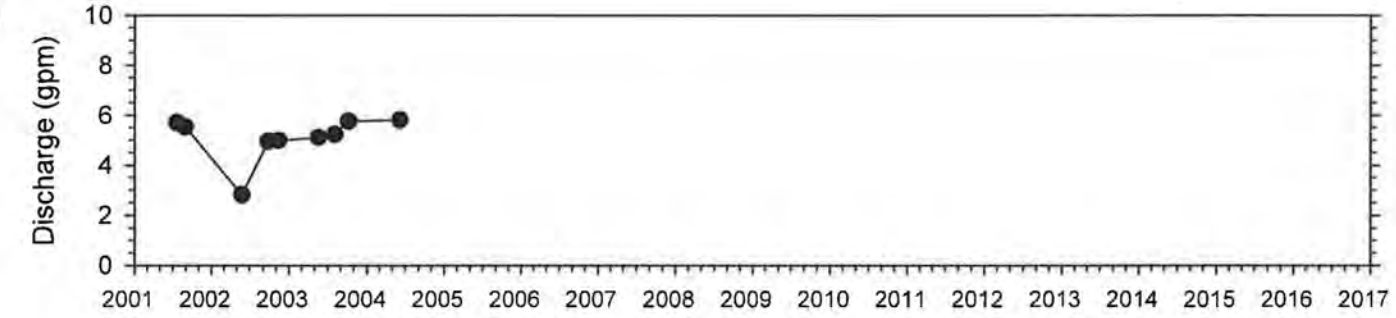
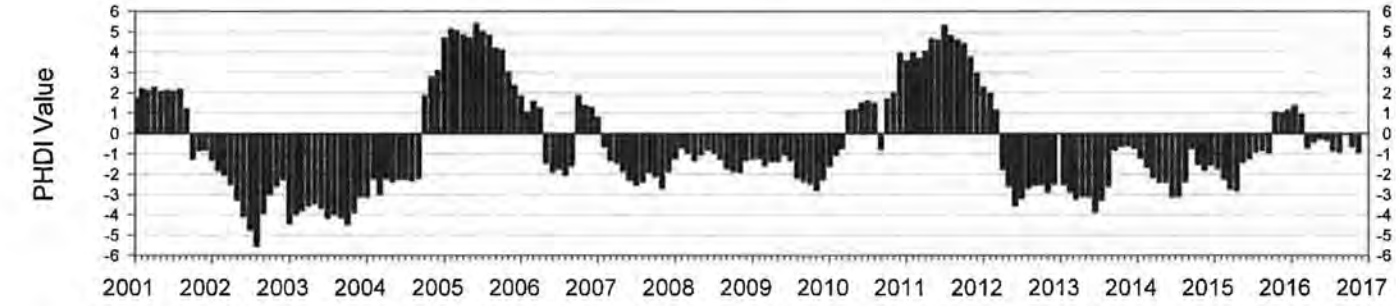
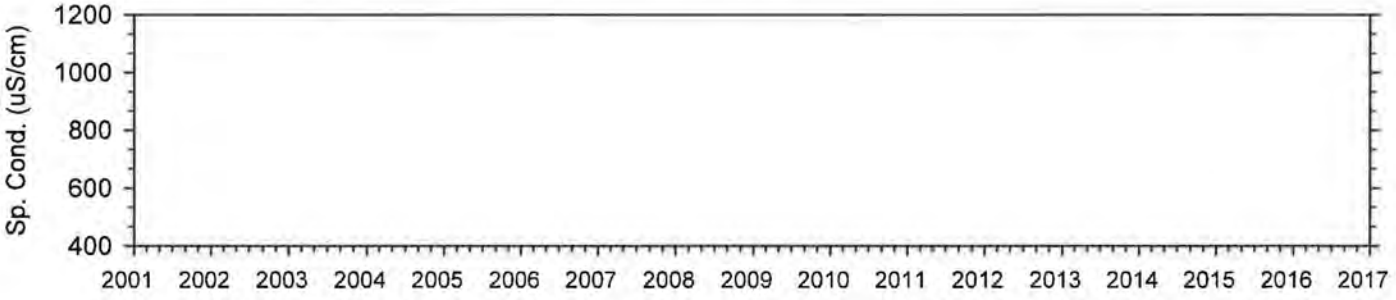
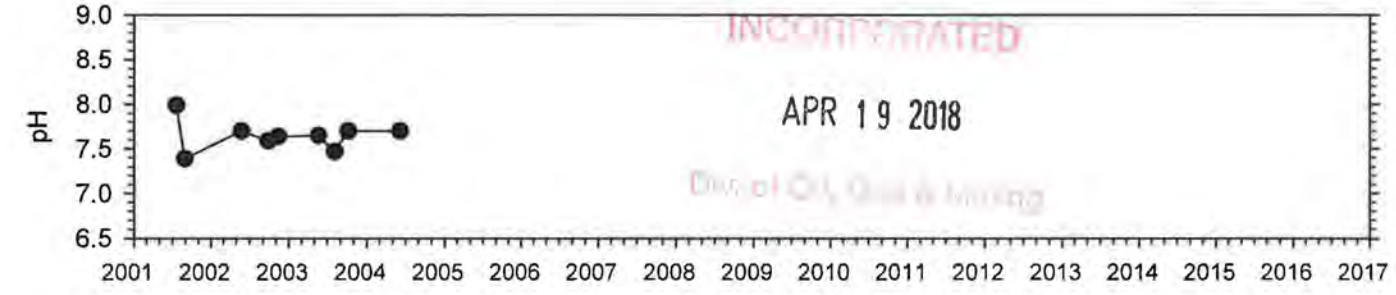
Spring M-SP38









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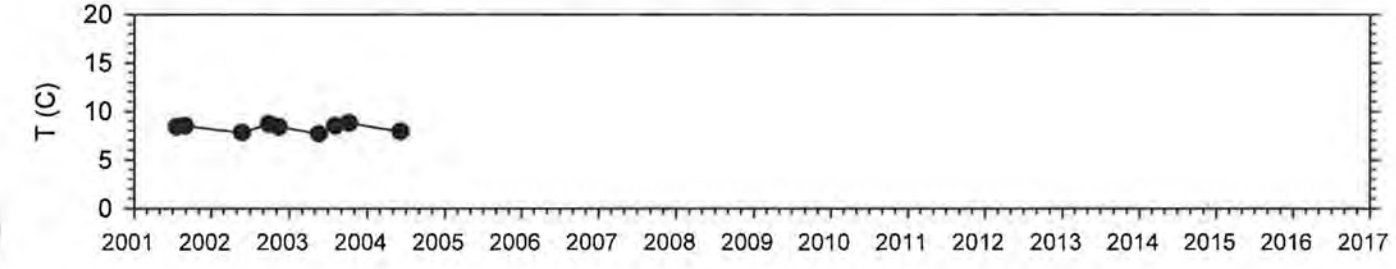
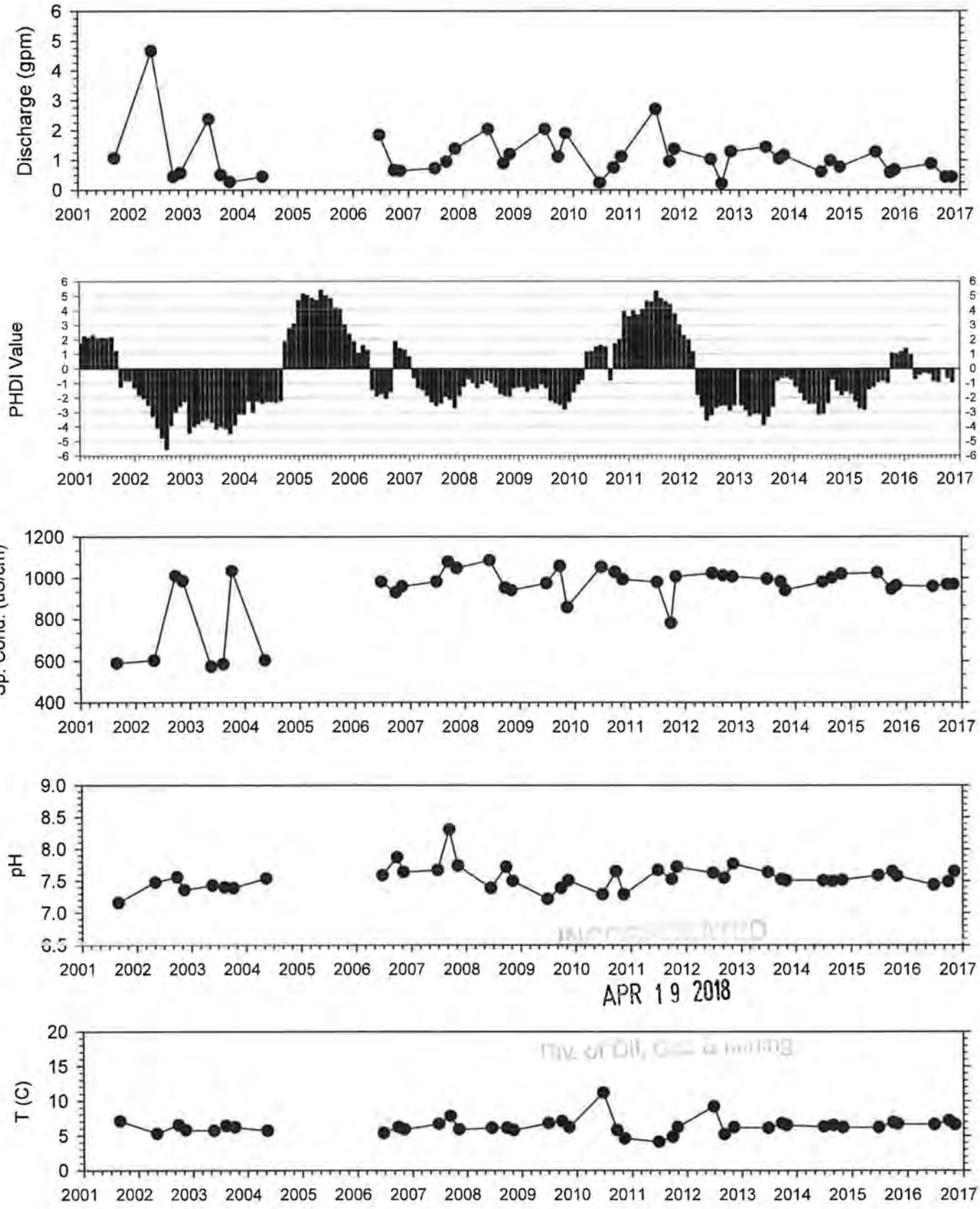


Spring M-SP39



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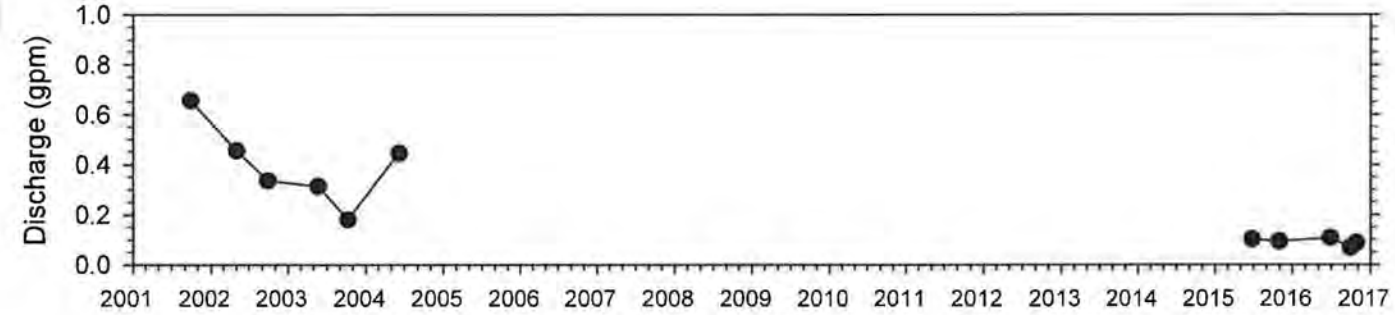
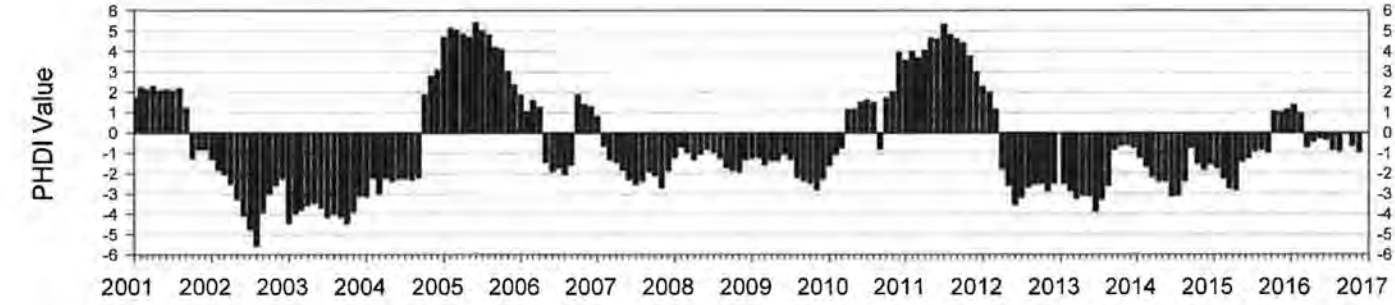
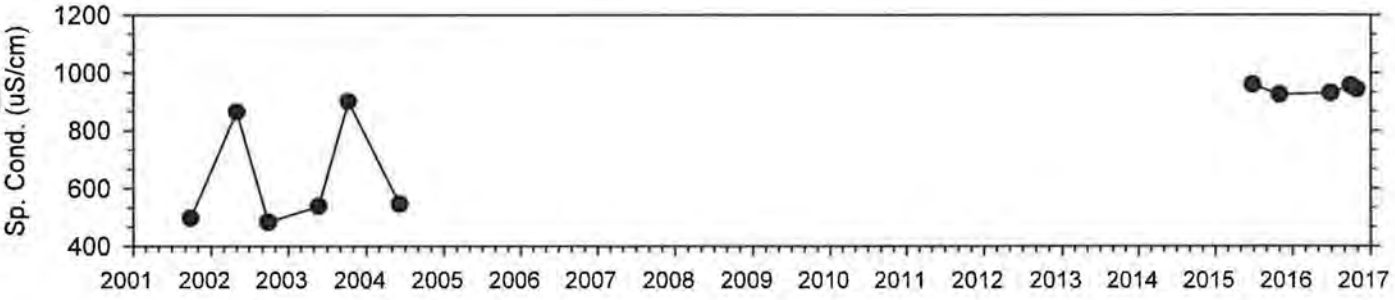
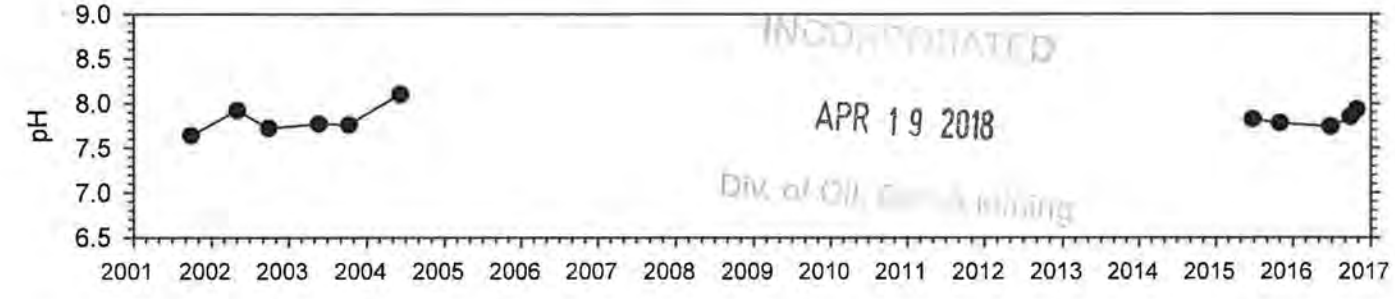
Spring M-SP40









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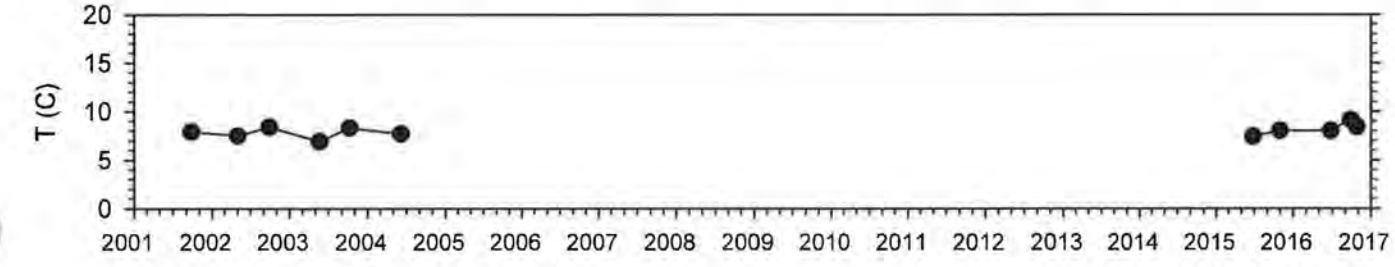
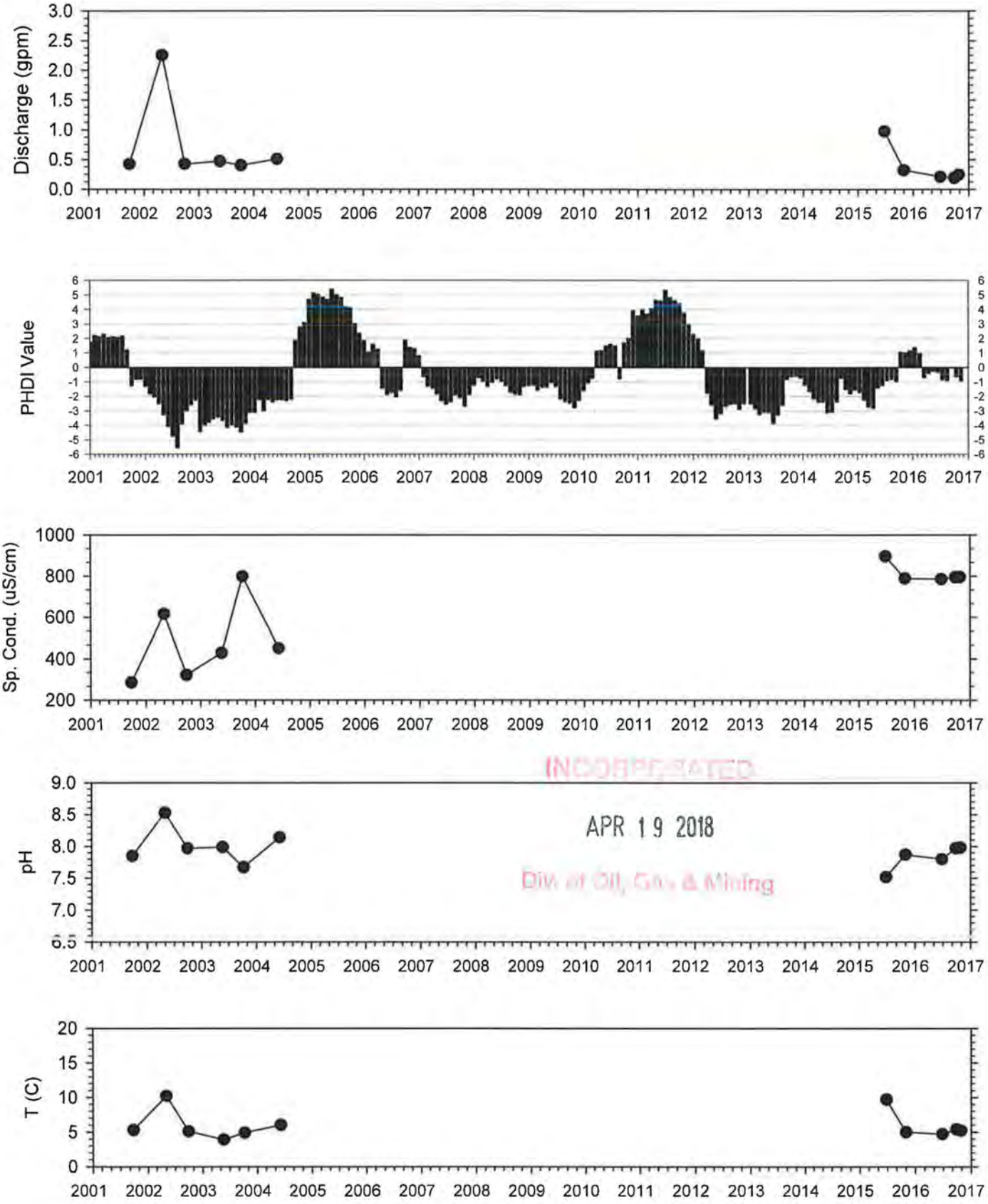


Spring M-SP41



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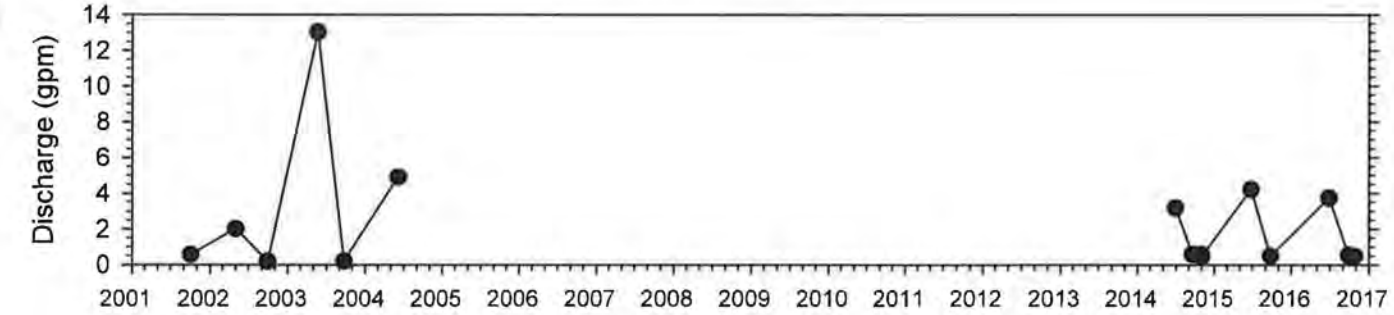
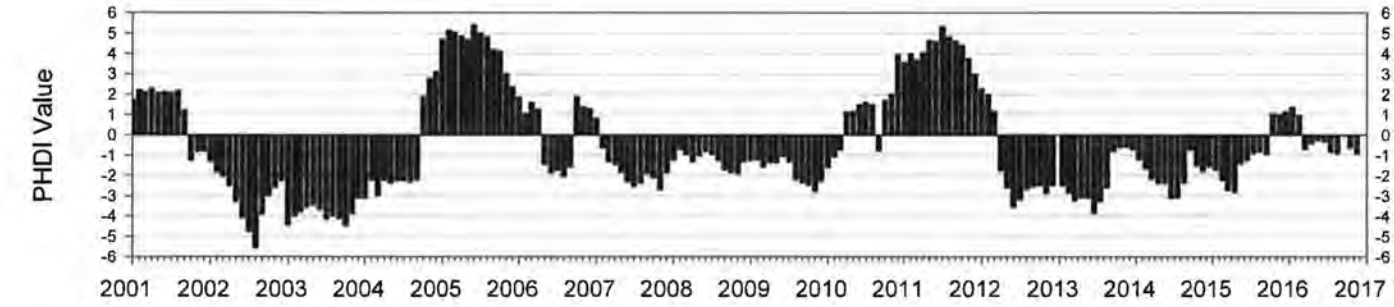
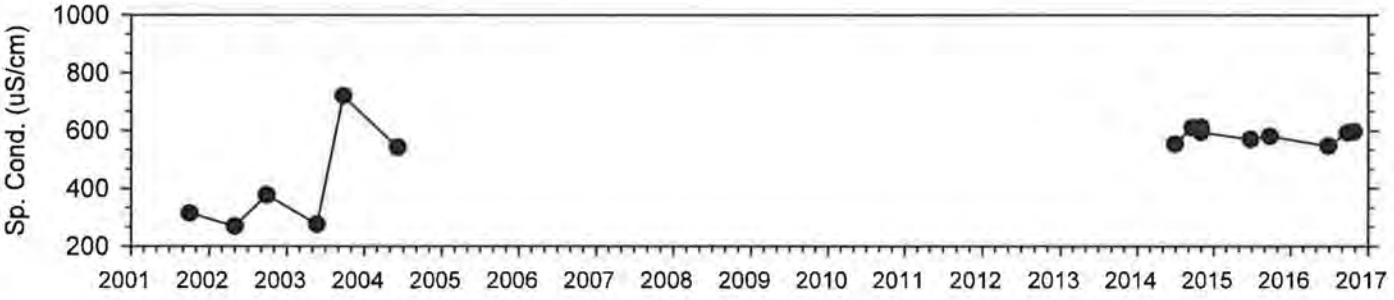
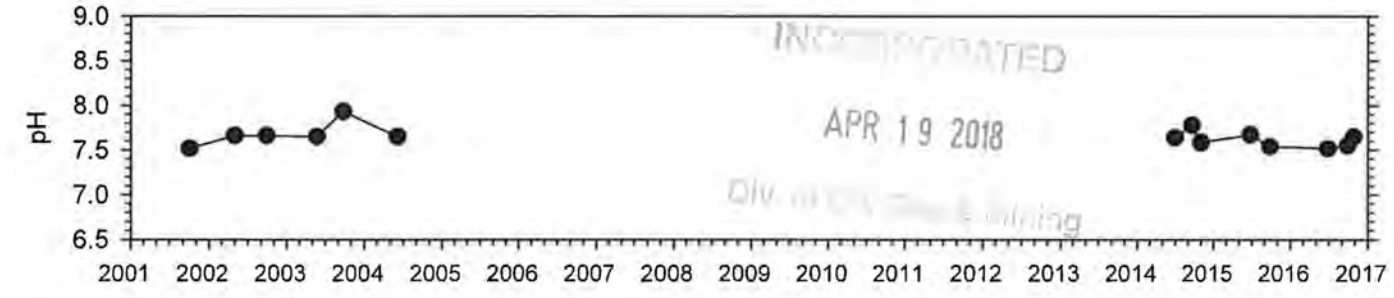
Spring M-SP44









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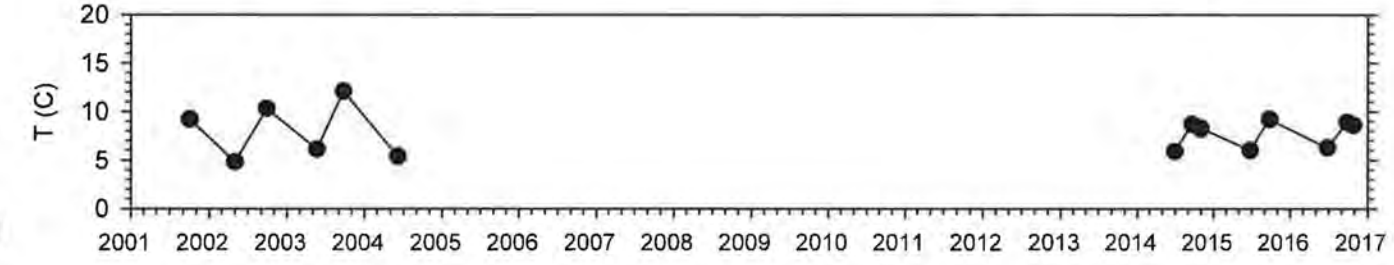
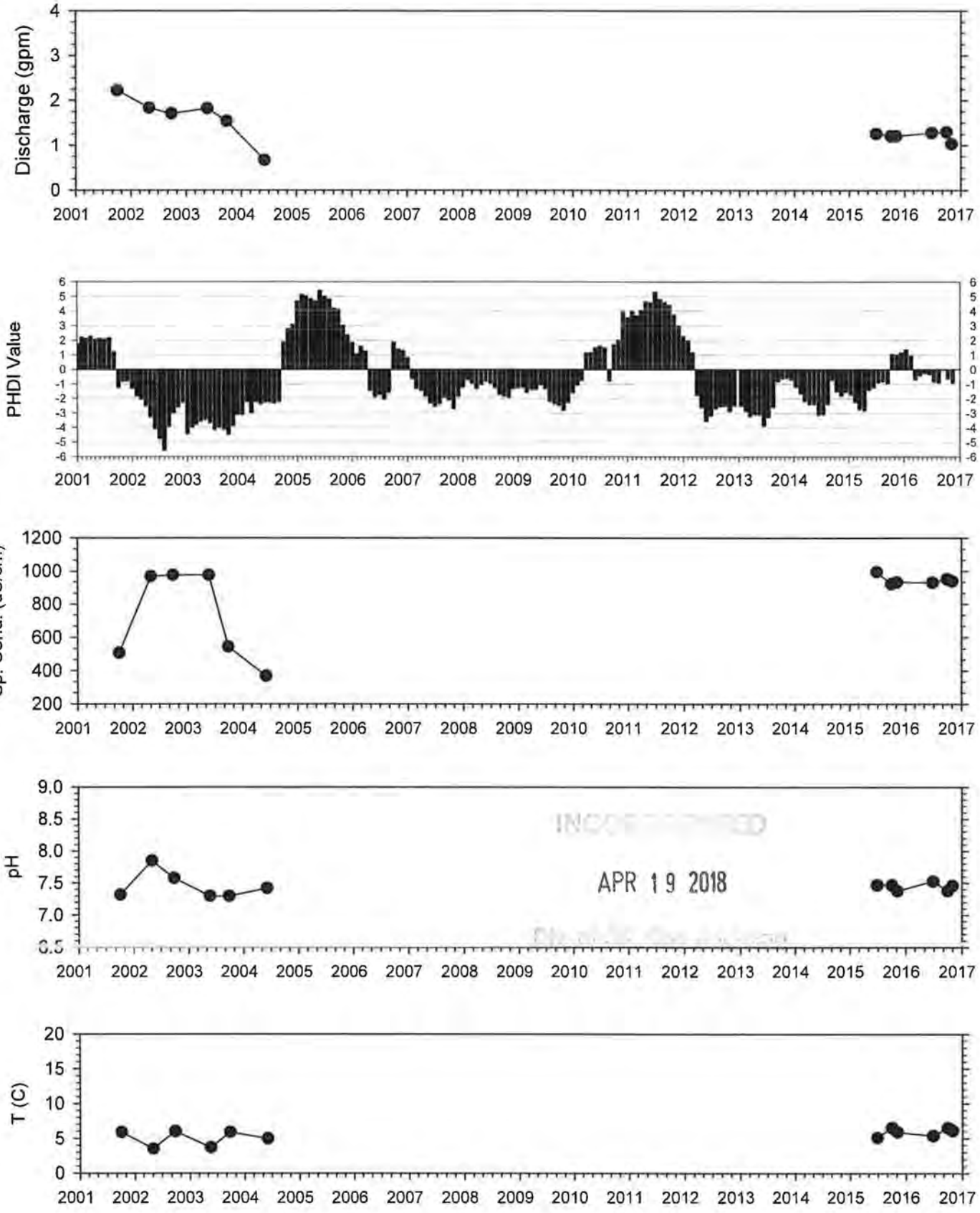


Spring M-SP45



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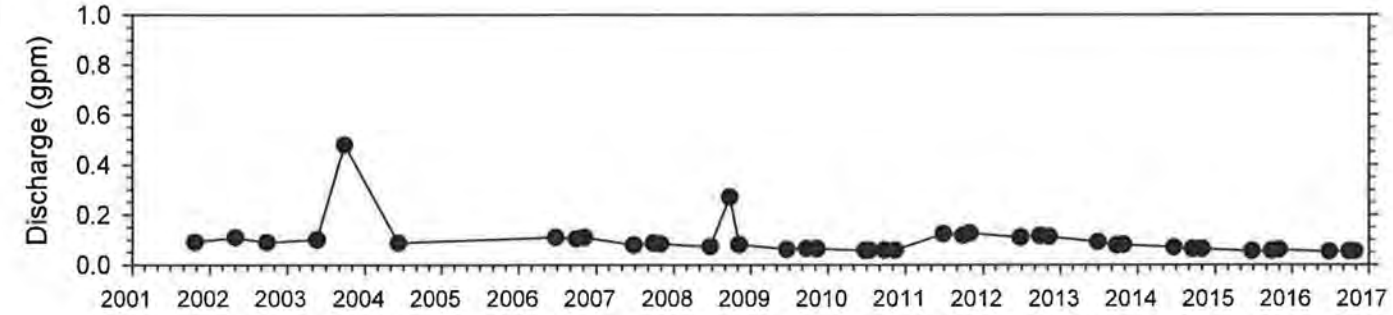
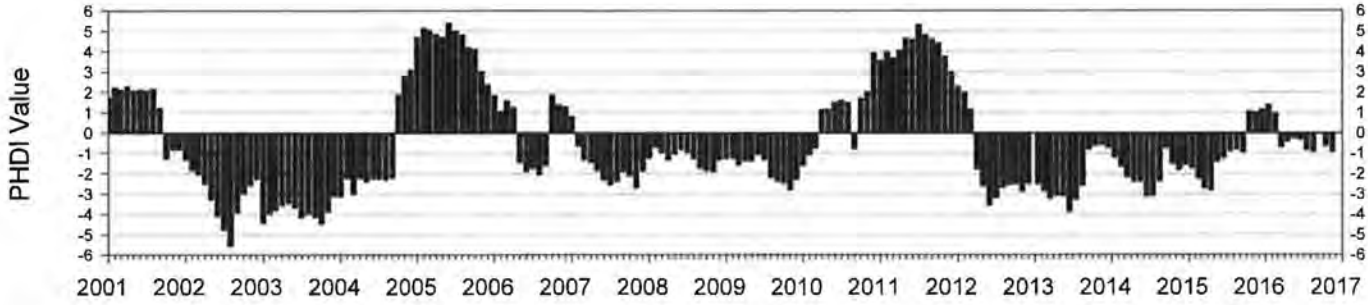
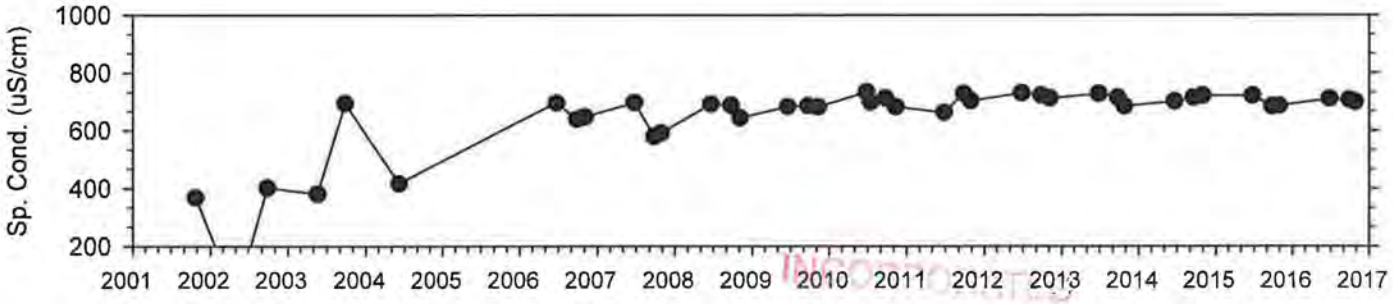
Spring M-SP53







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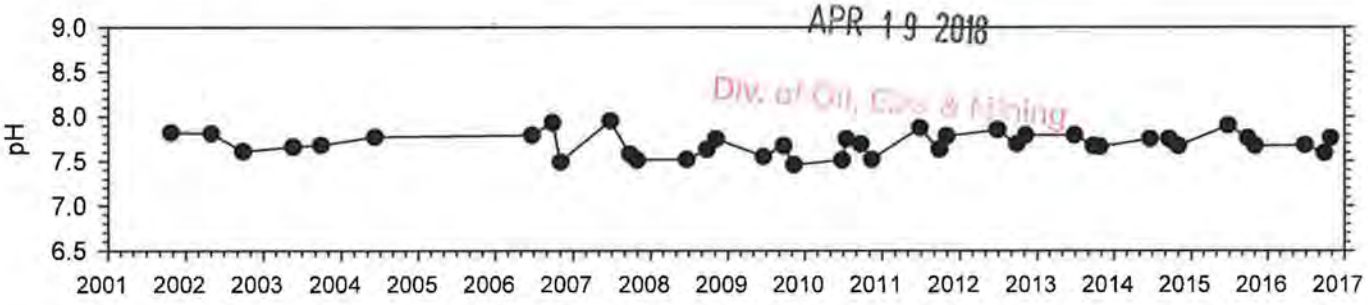
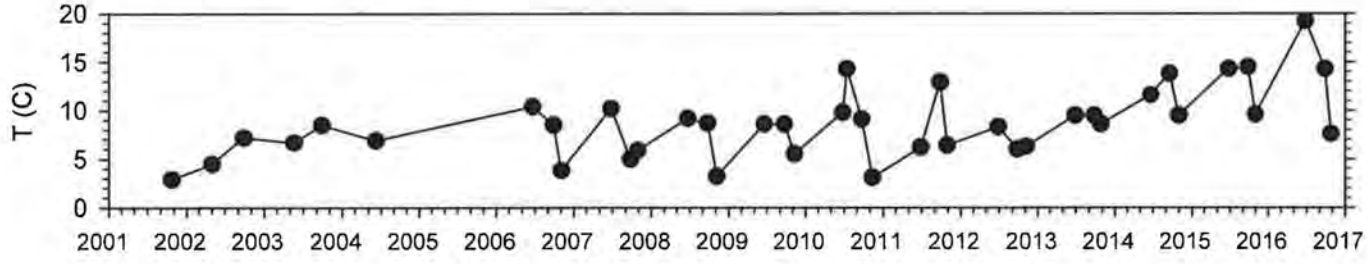
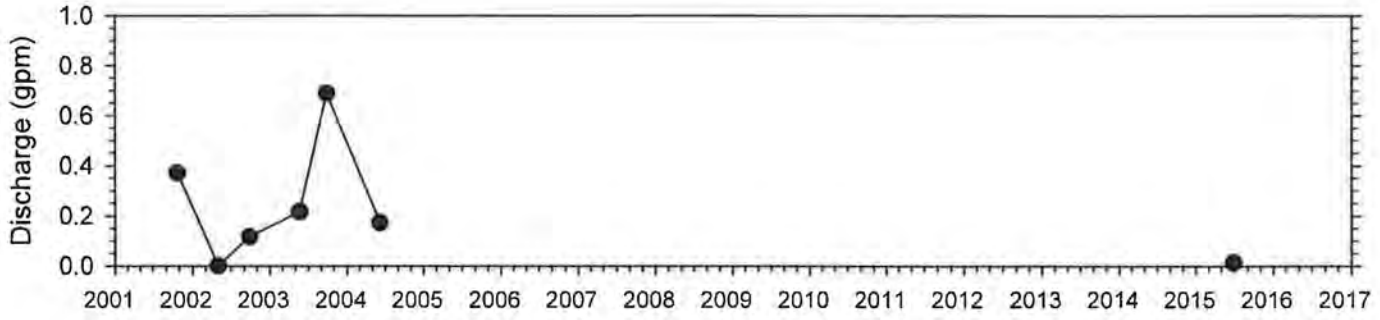
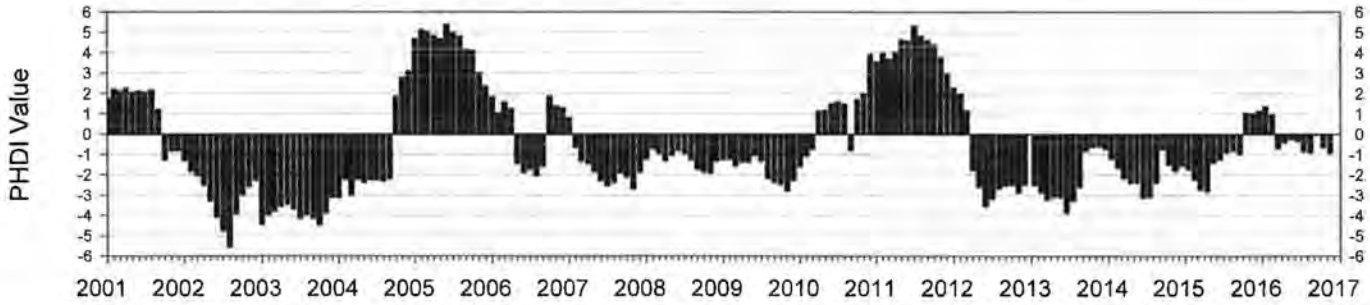
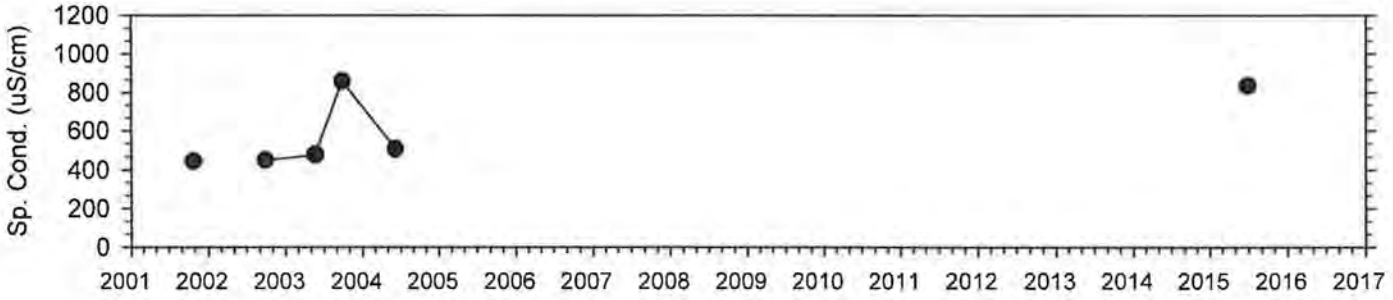


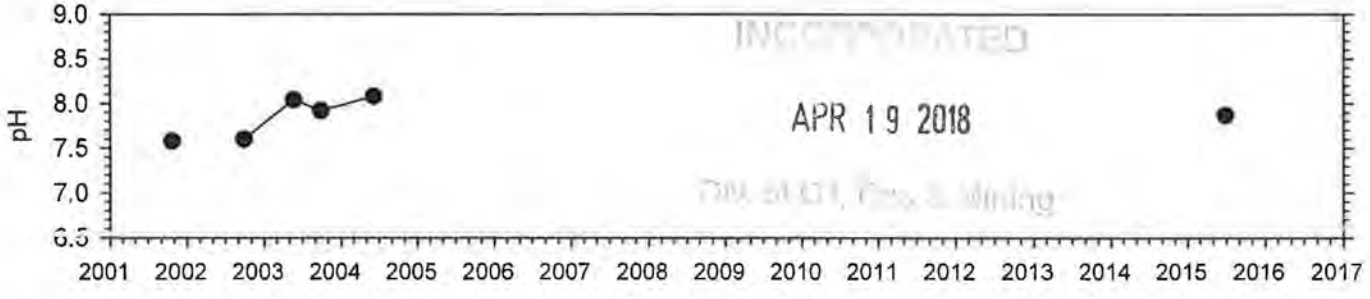


Spring M-SP59









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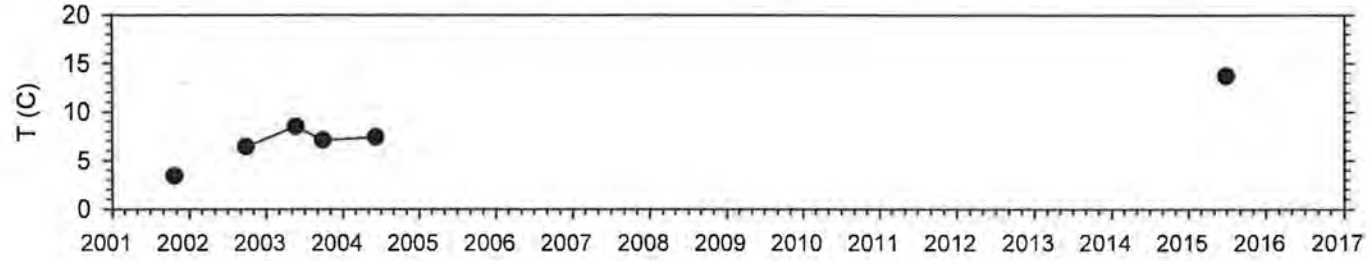
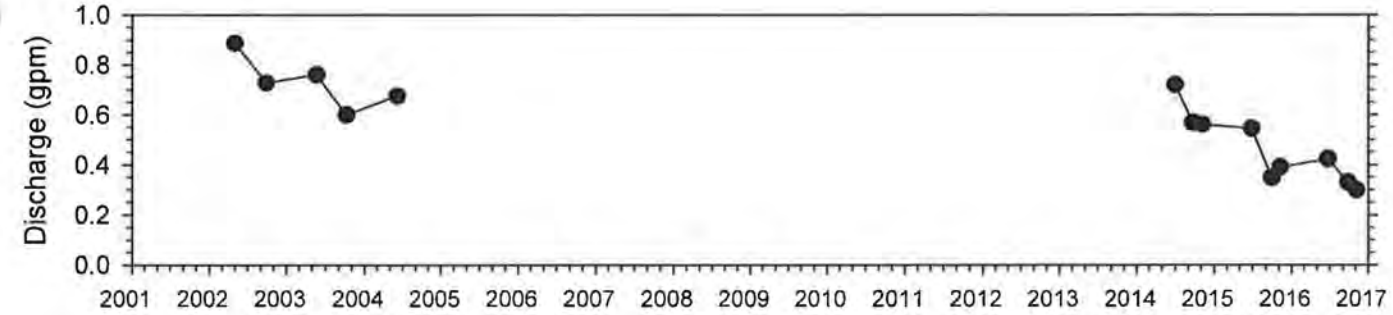
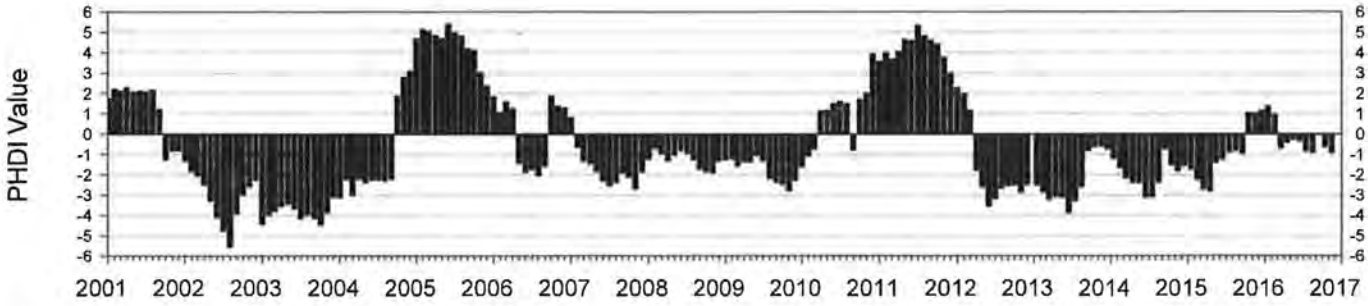
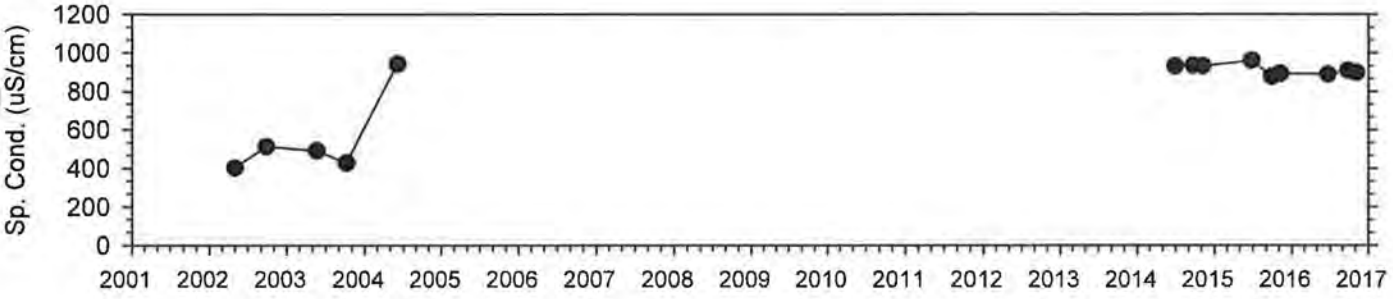
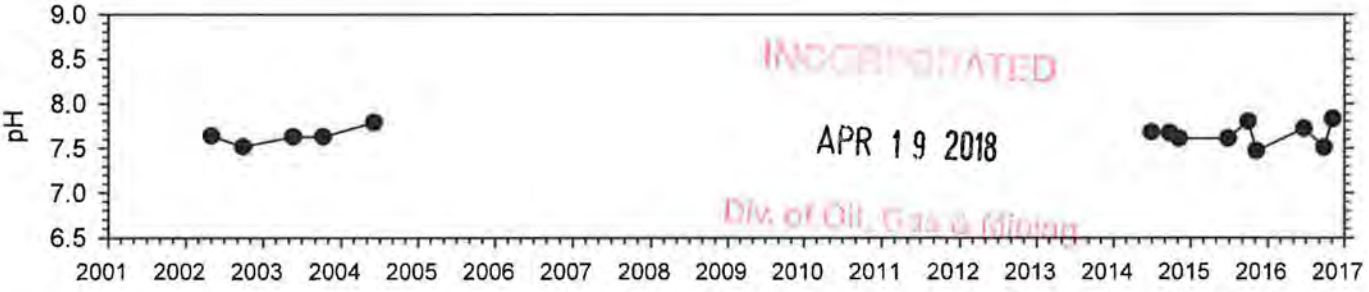


Spring M-SP60









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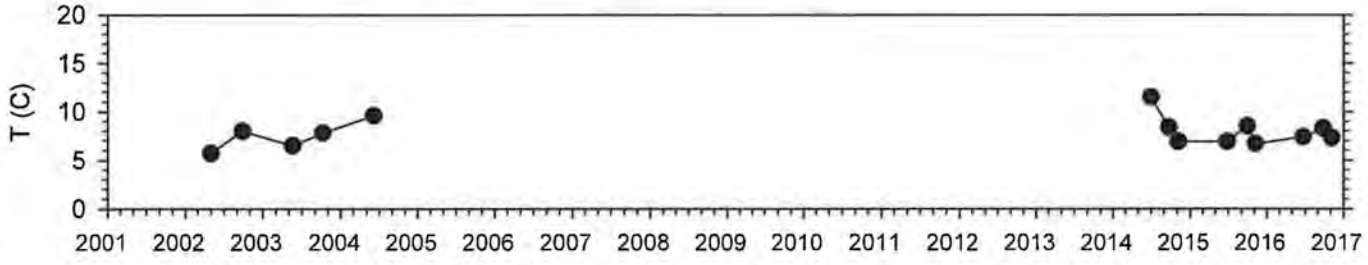

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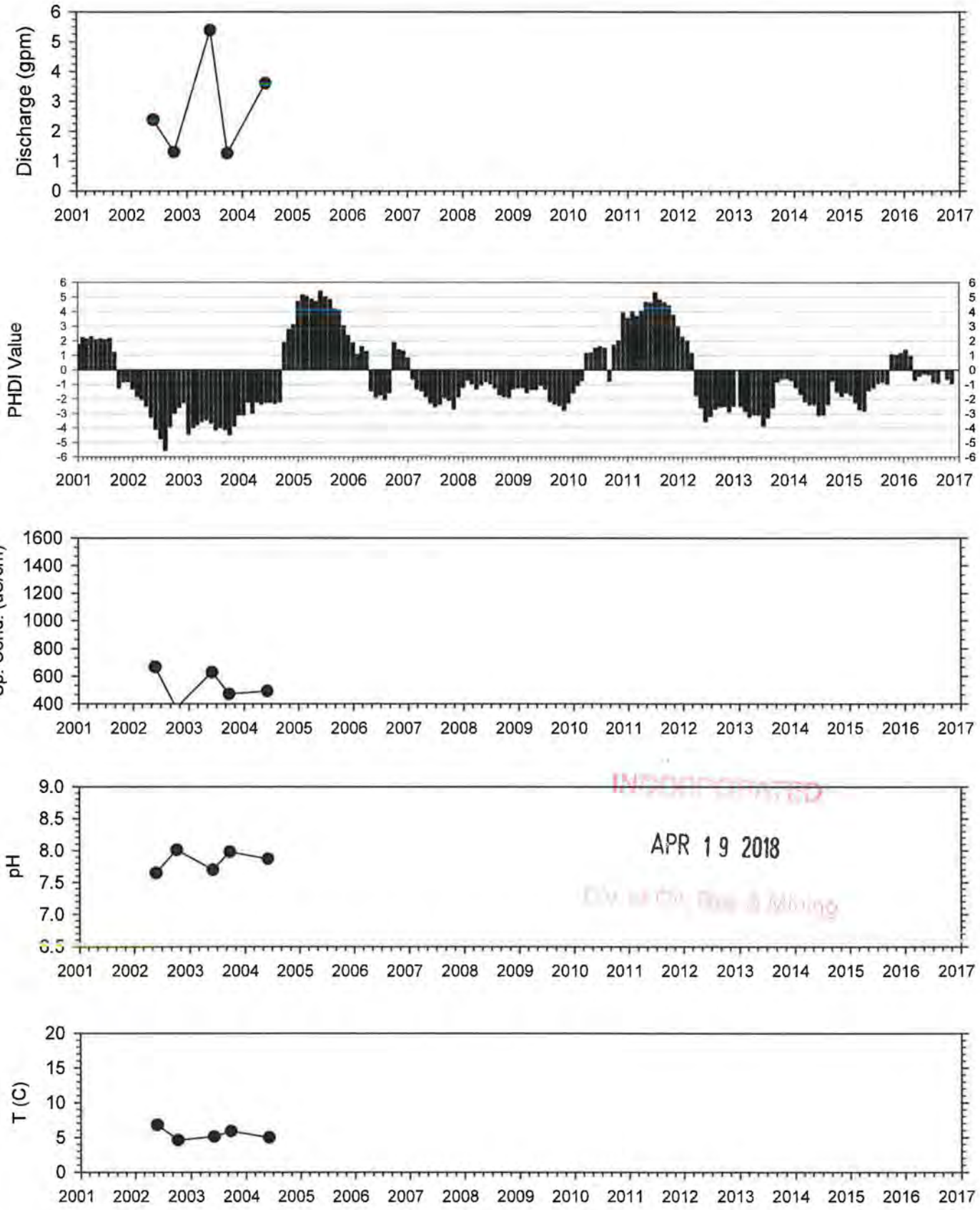

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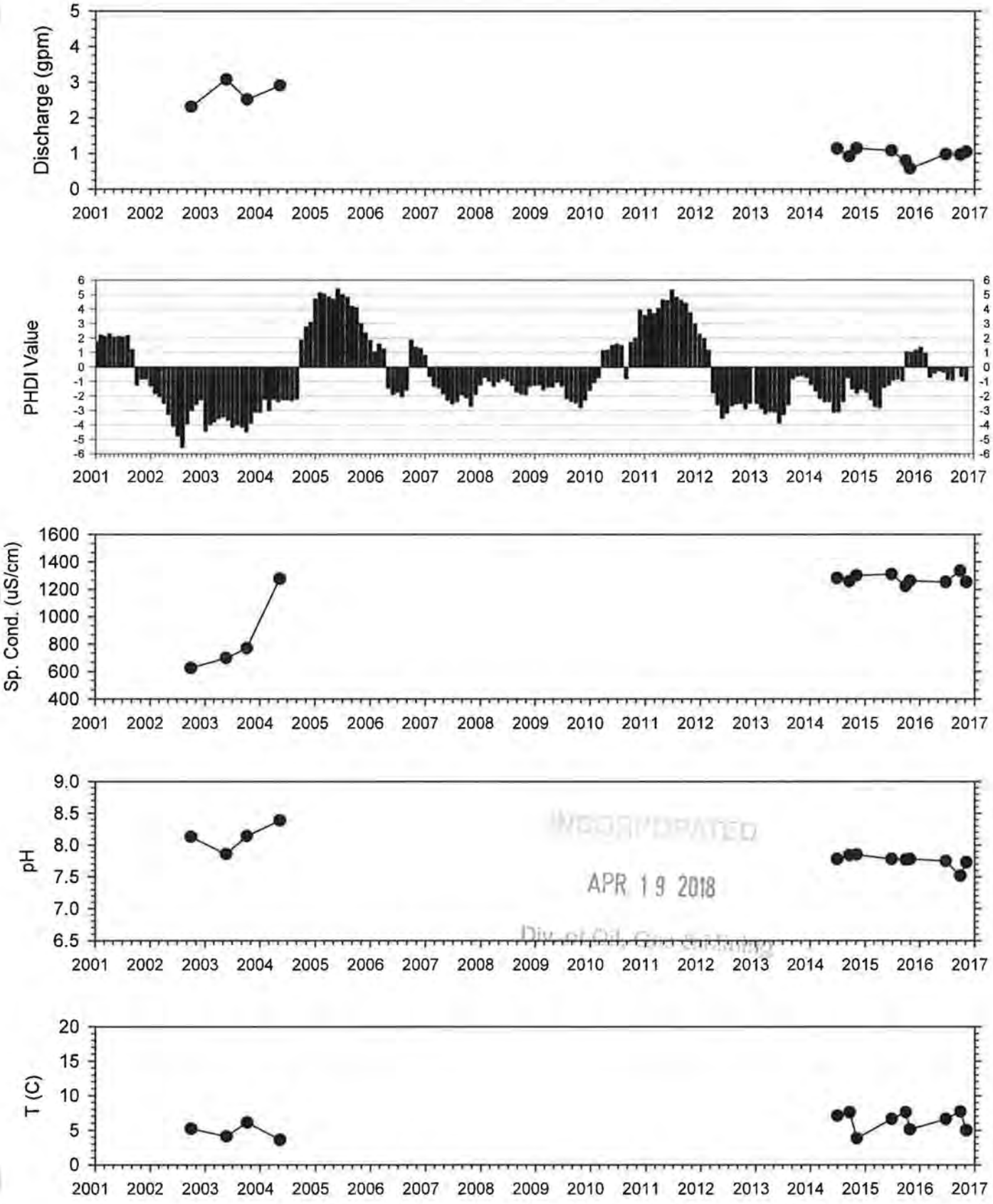
Spring M-SP87



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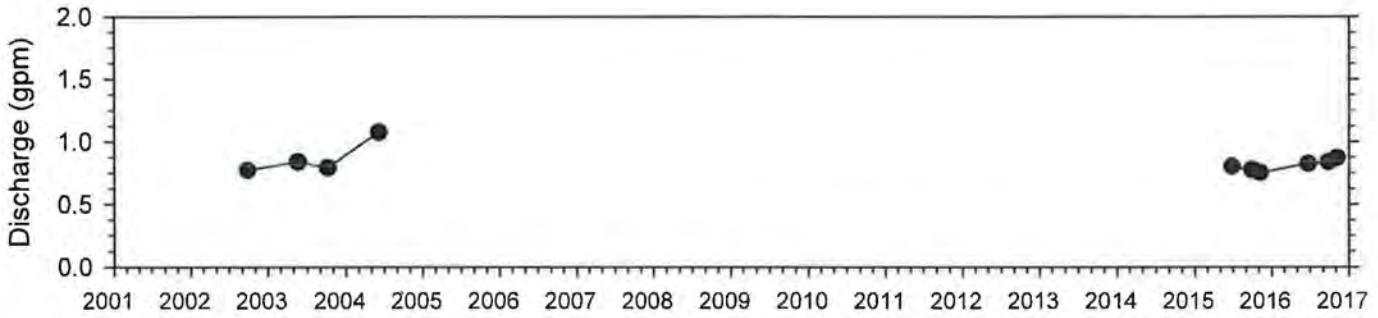
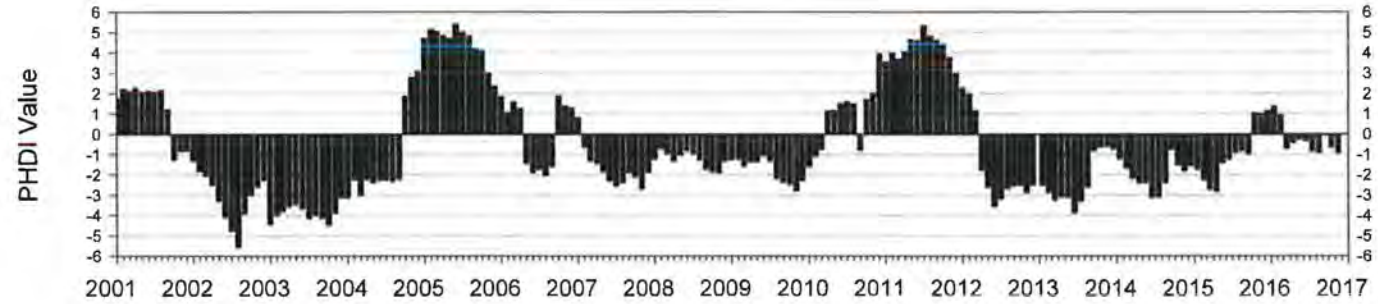
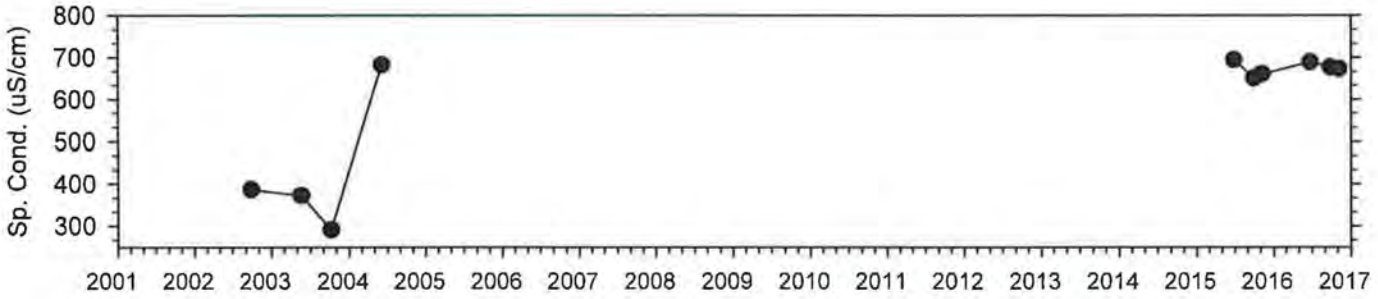
Spring M-SP100







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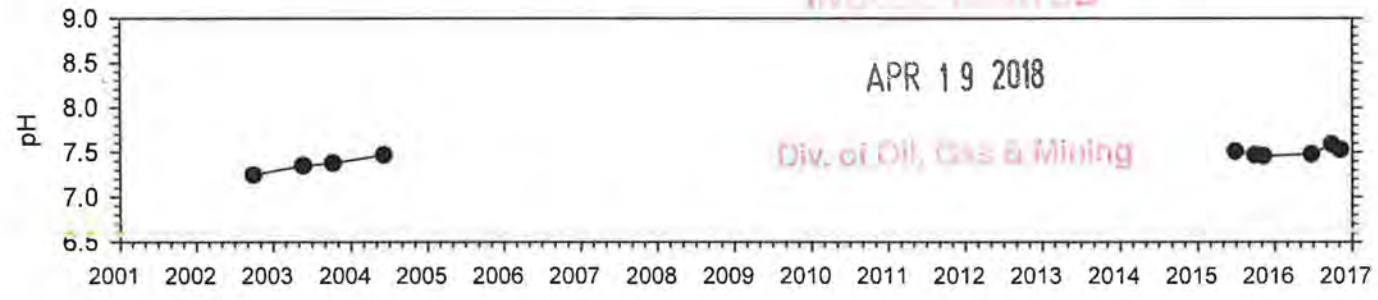

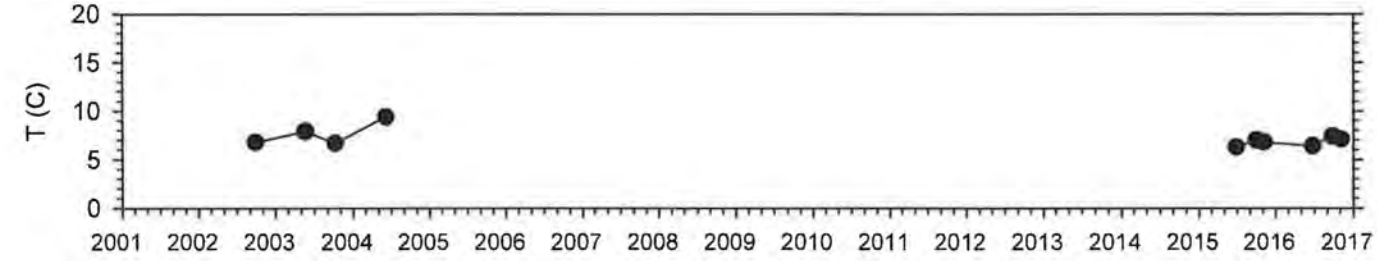

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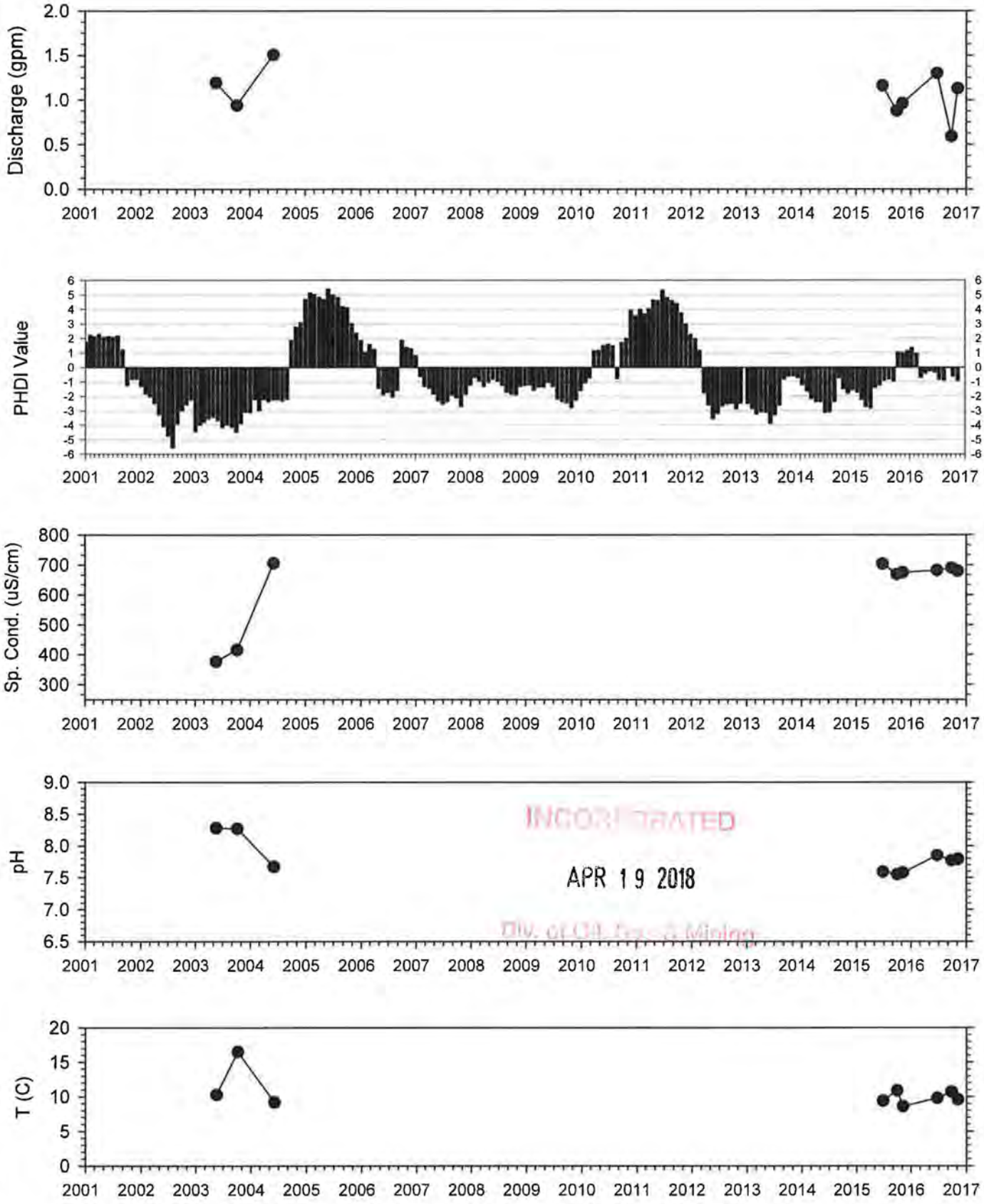

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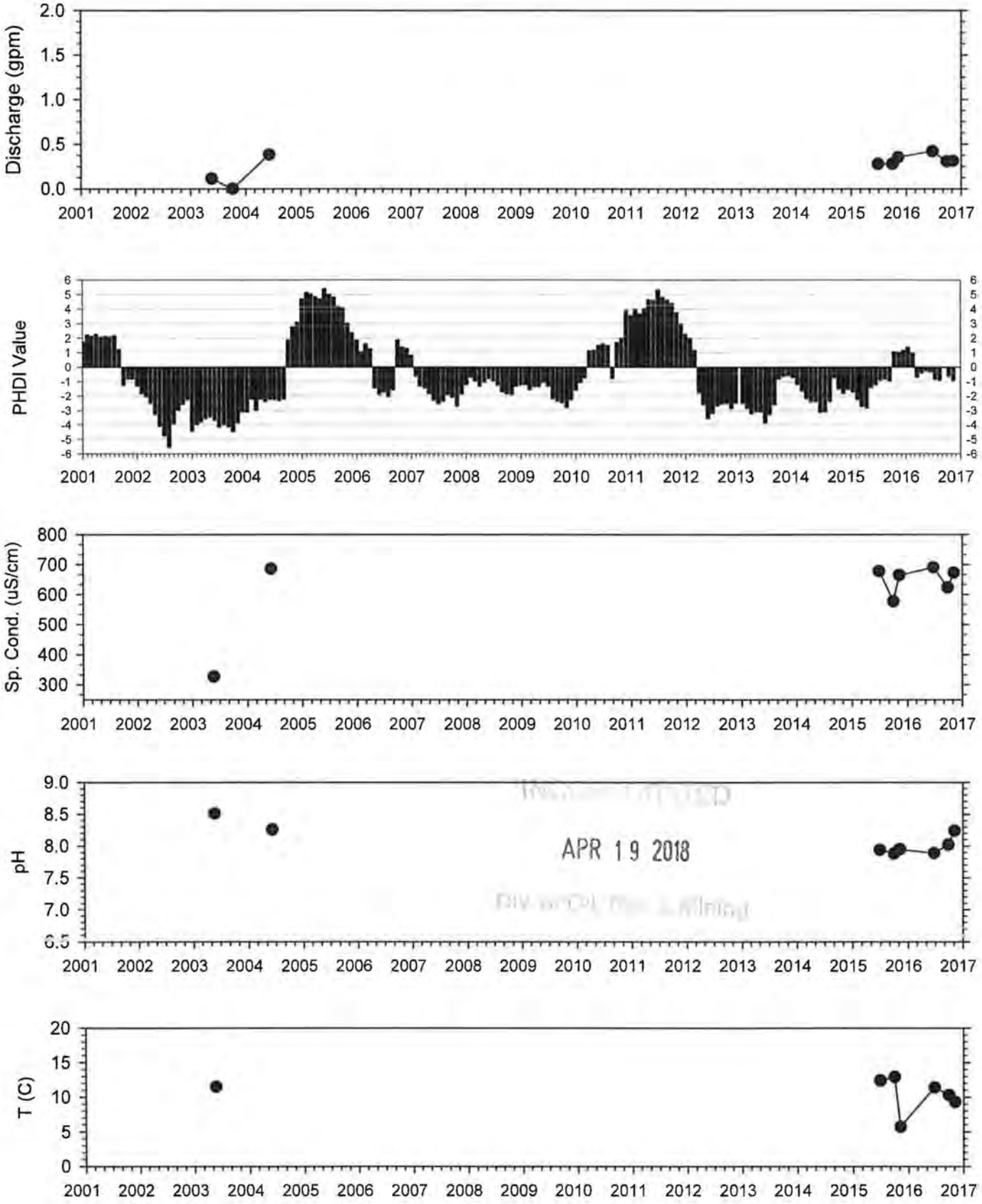
Spring M-SP104



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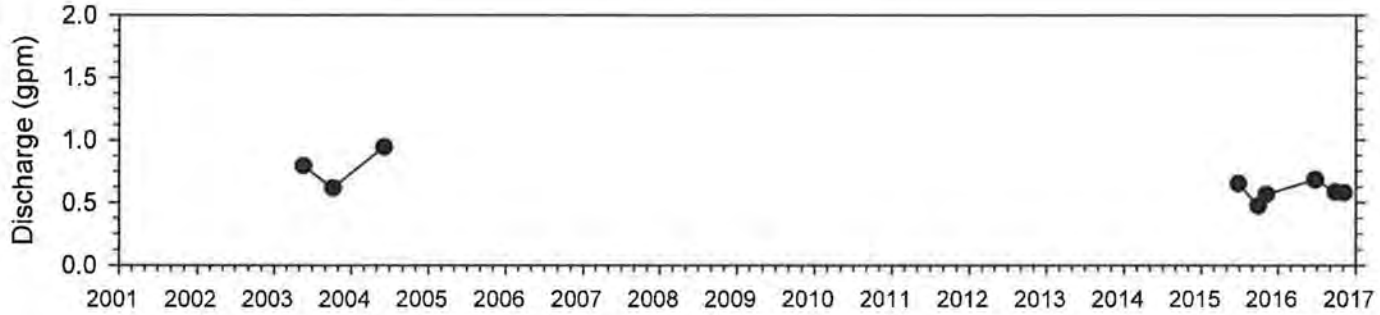
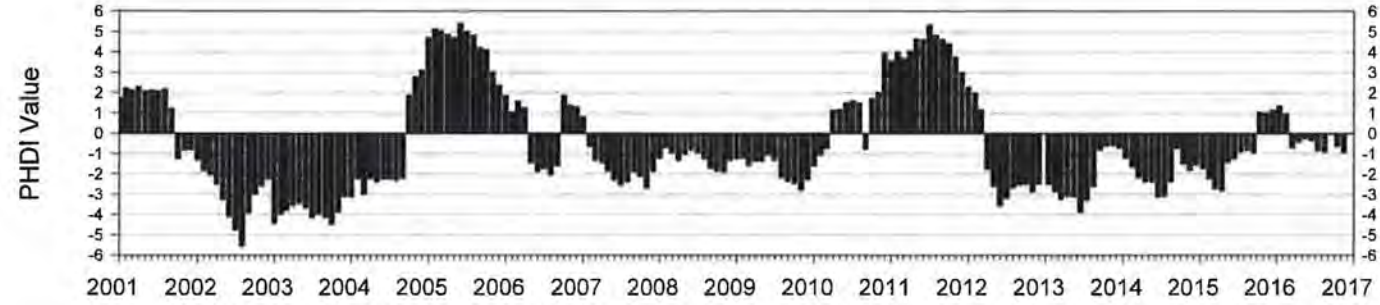
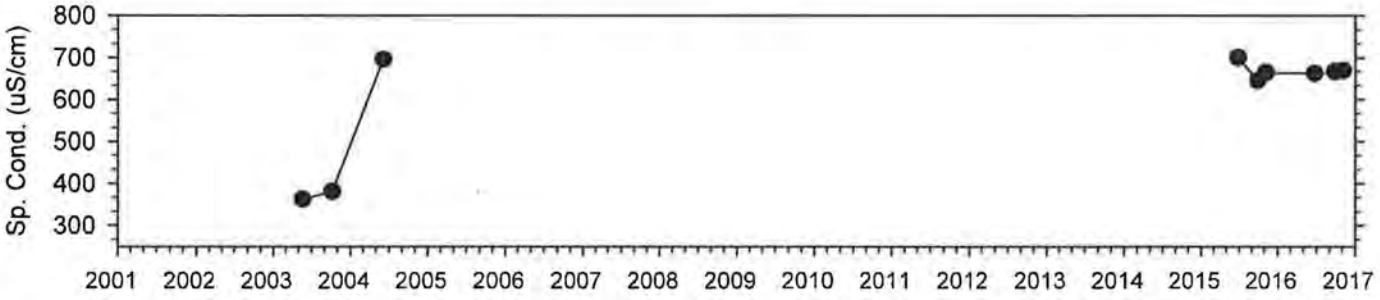
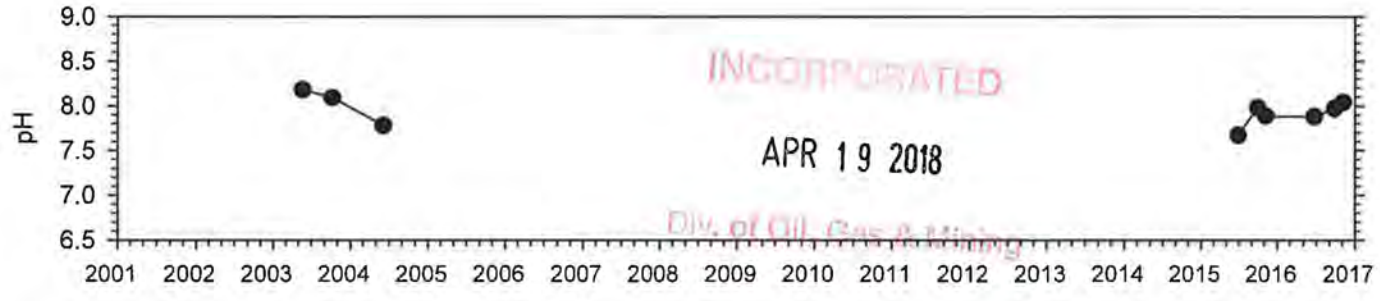
Spring M-SP105









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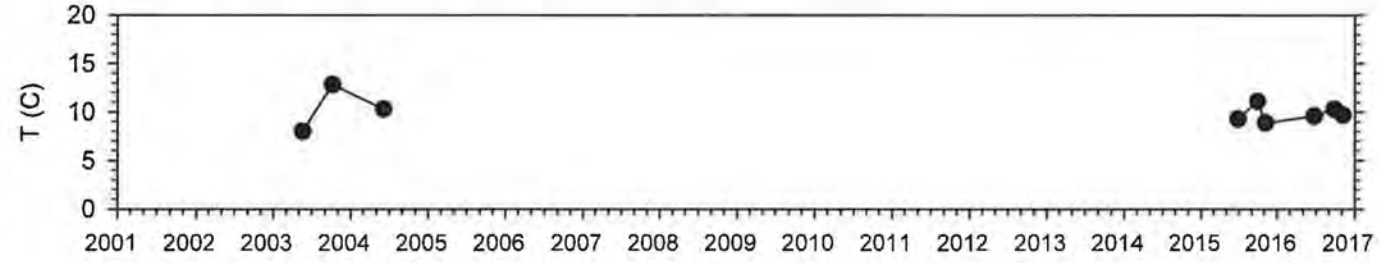

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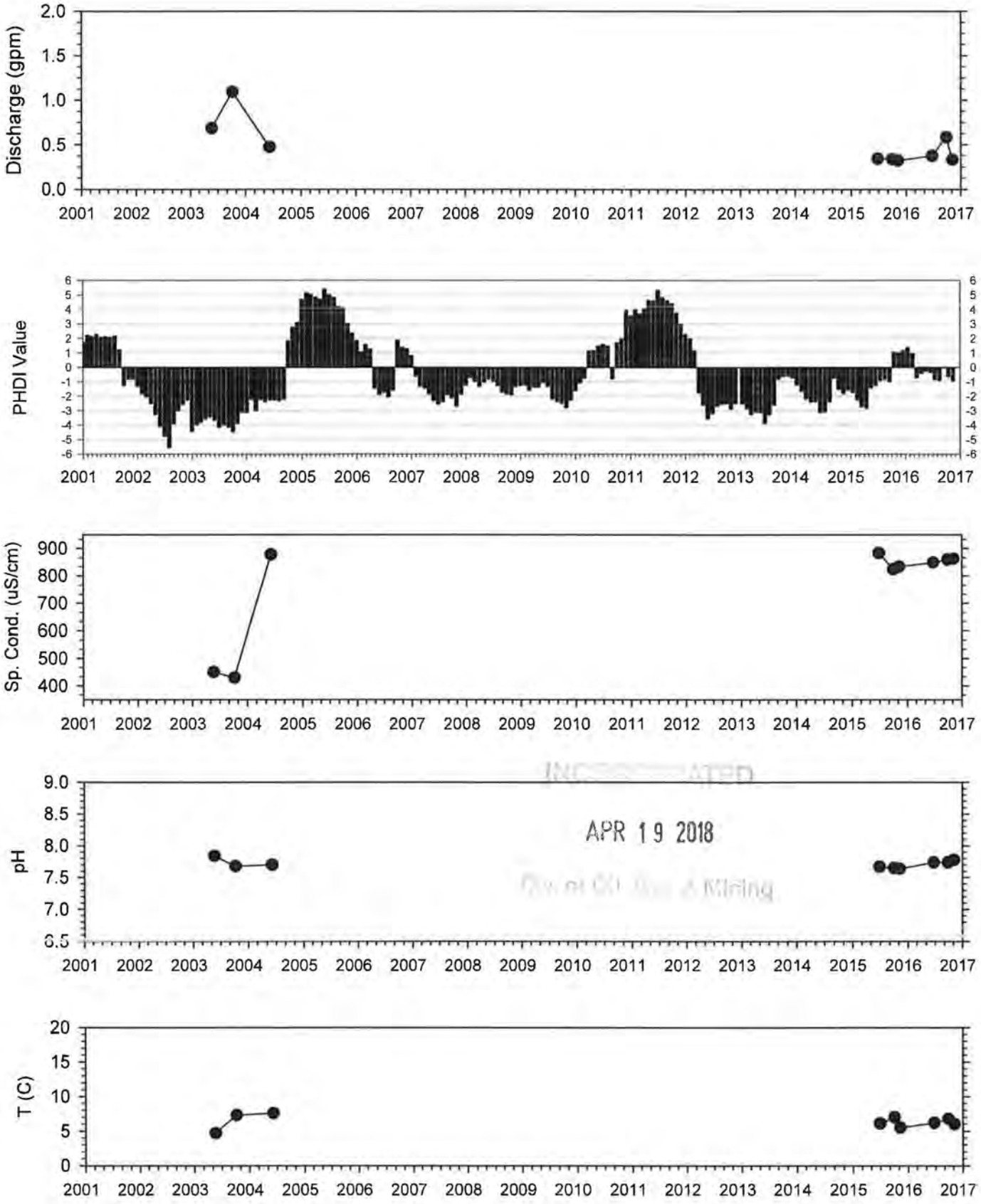

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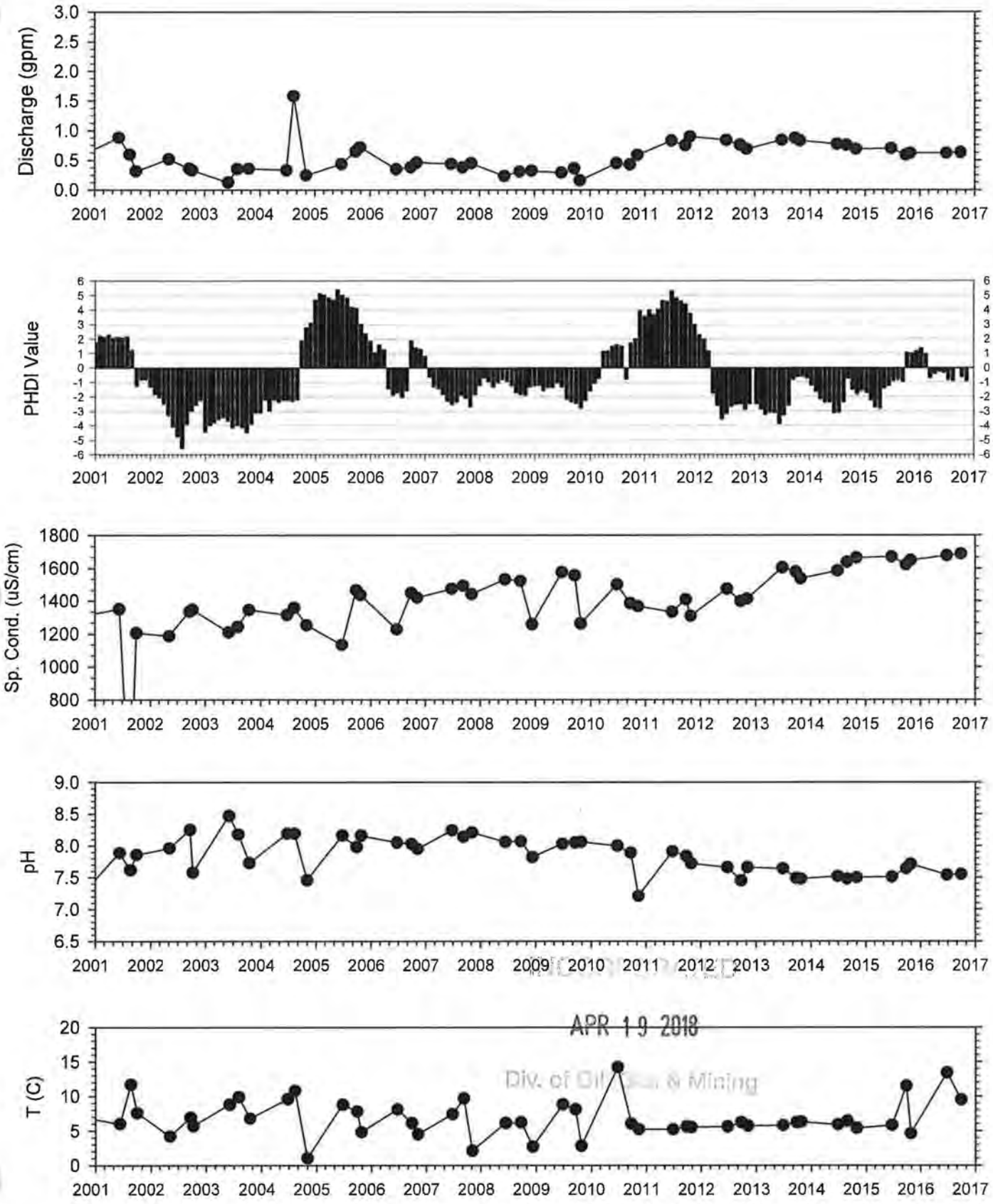
Spring GW-13



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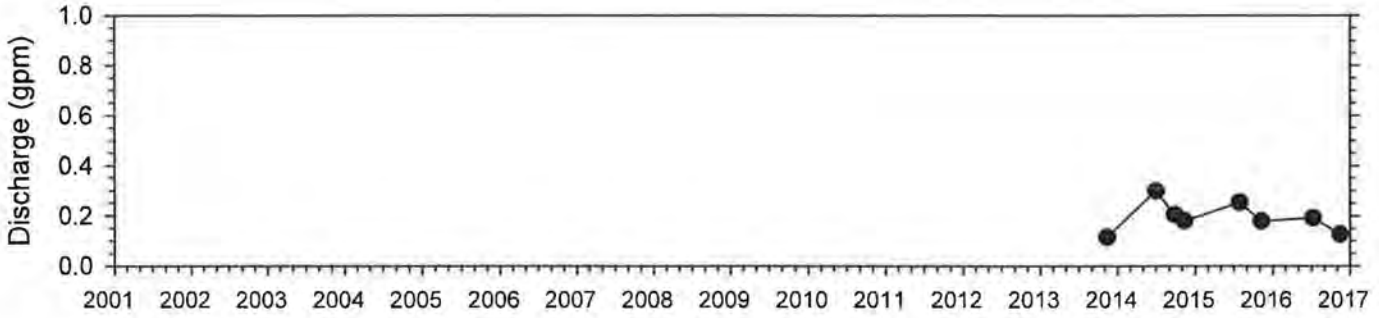
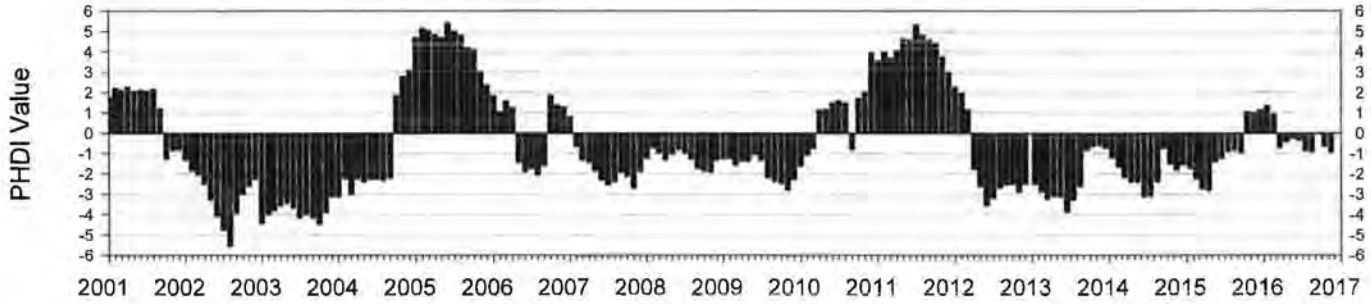
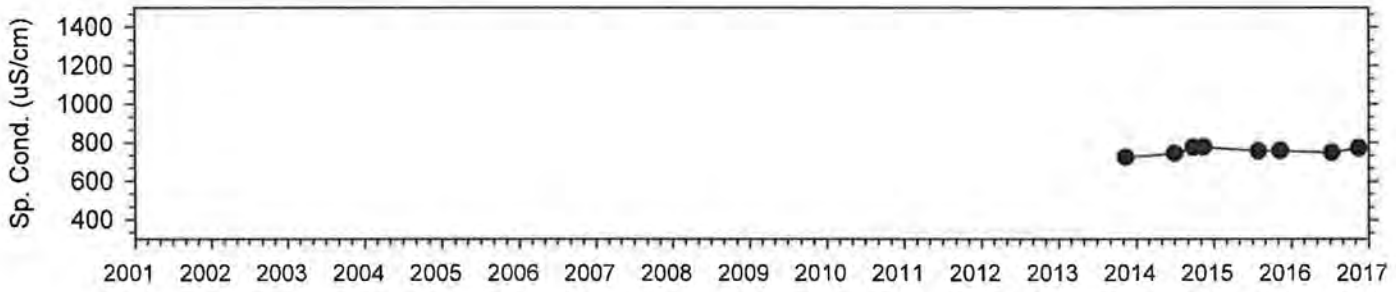
Spring Sufco 006A







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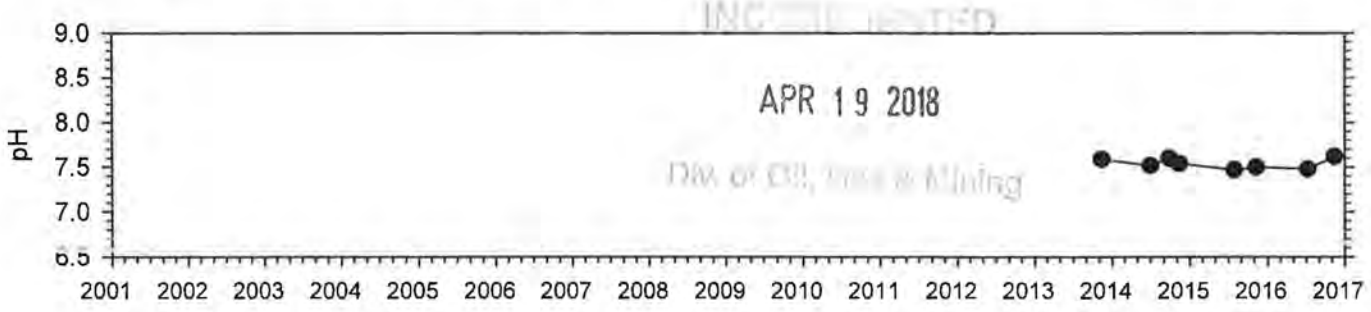
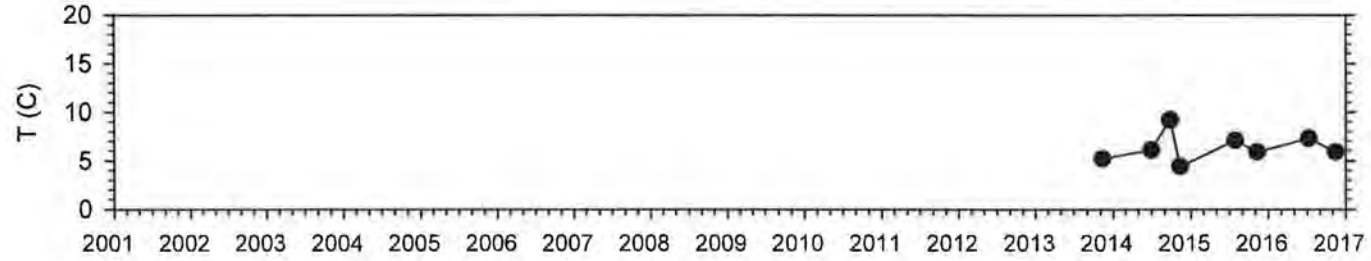
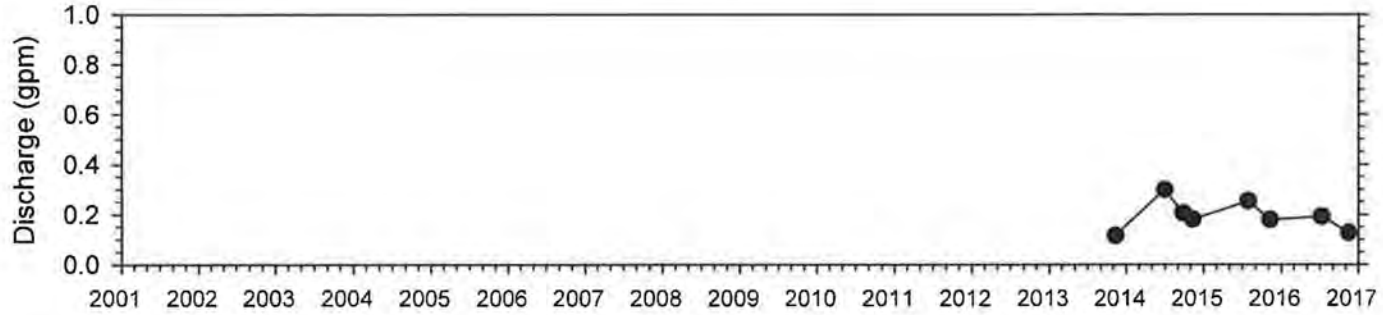
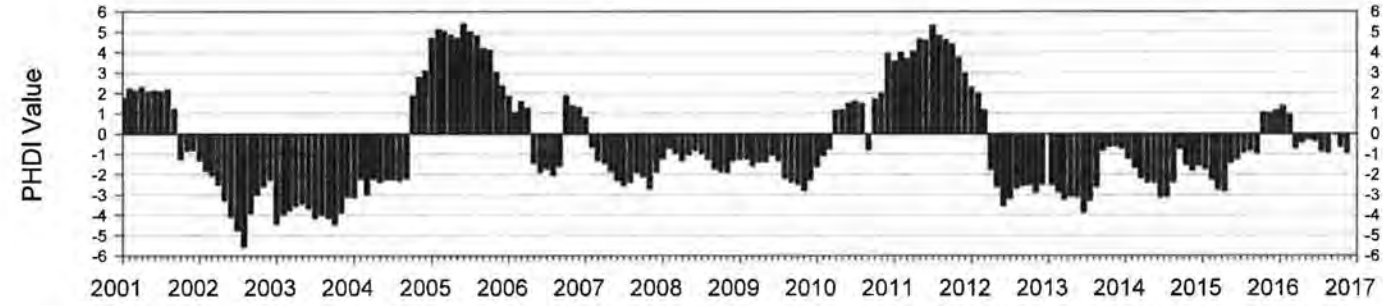
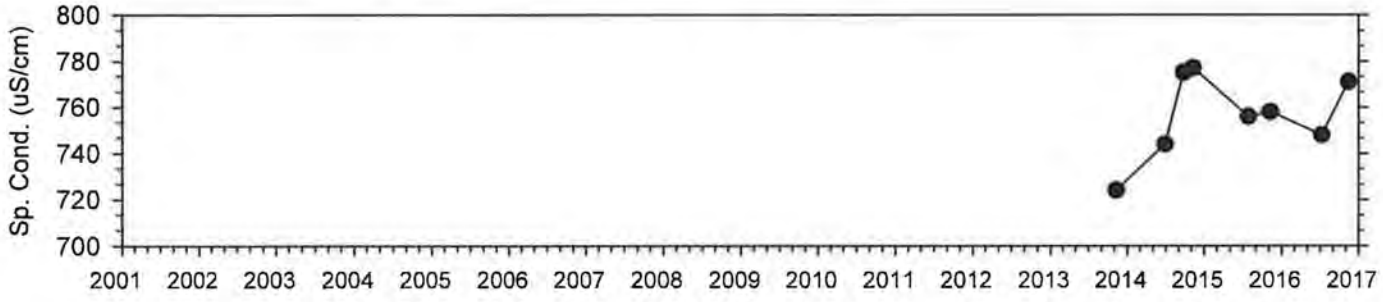


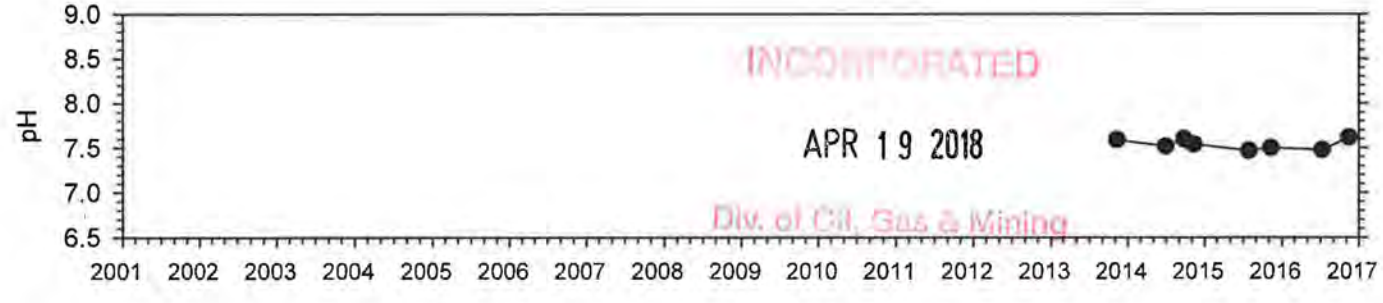


Spring 94-110









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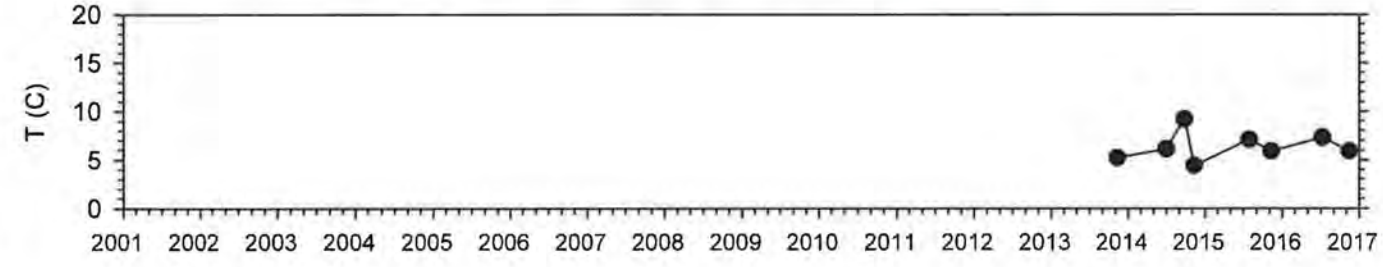
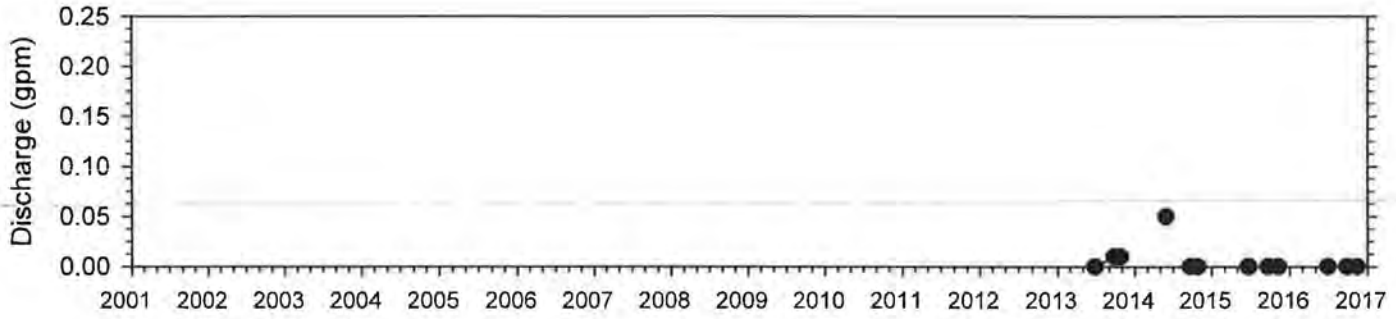
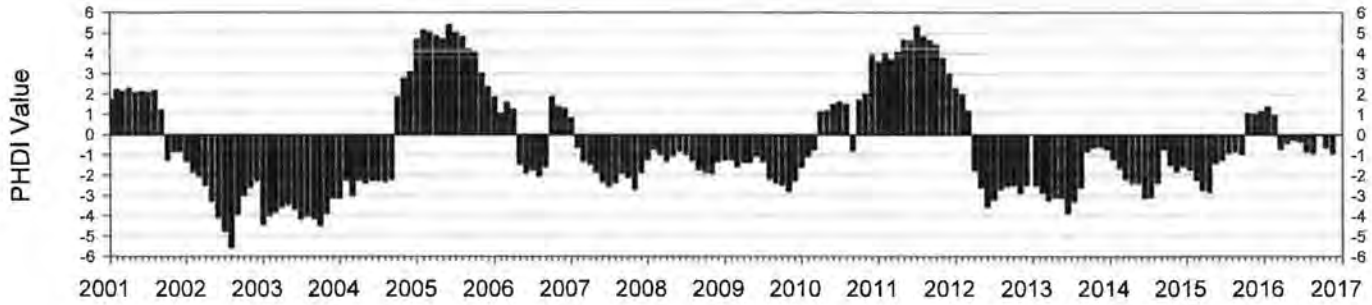
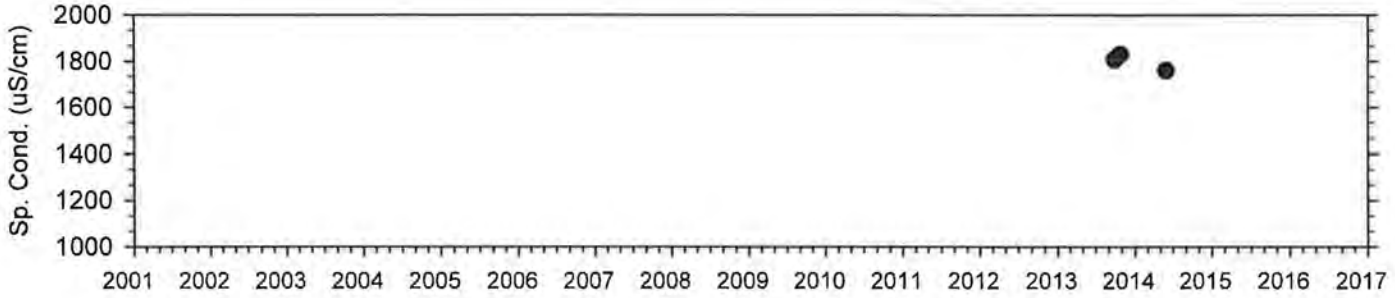
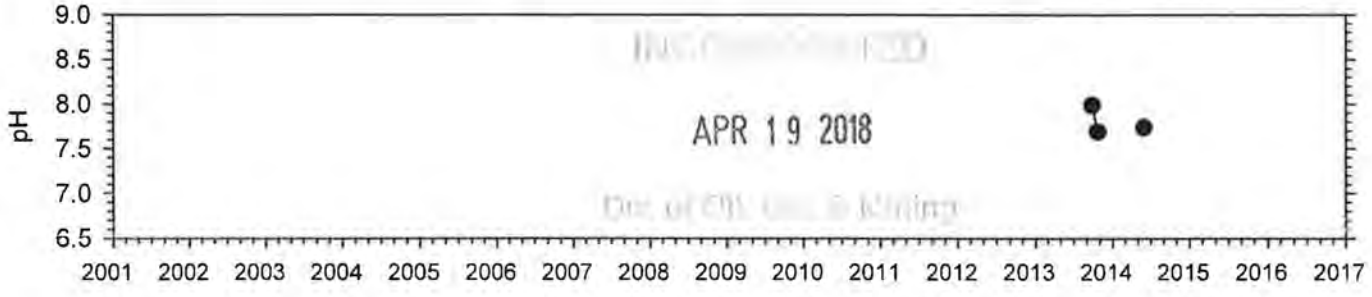


Spring 94-113









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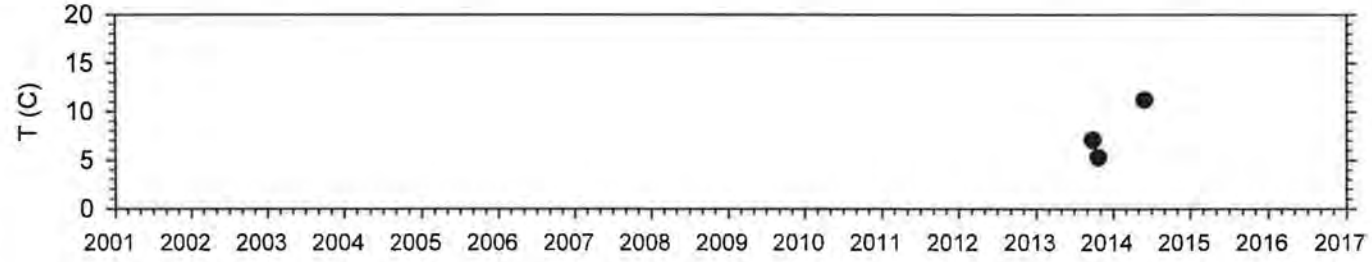
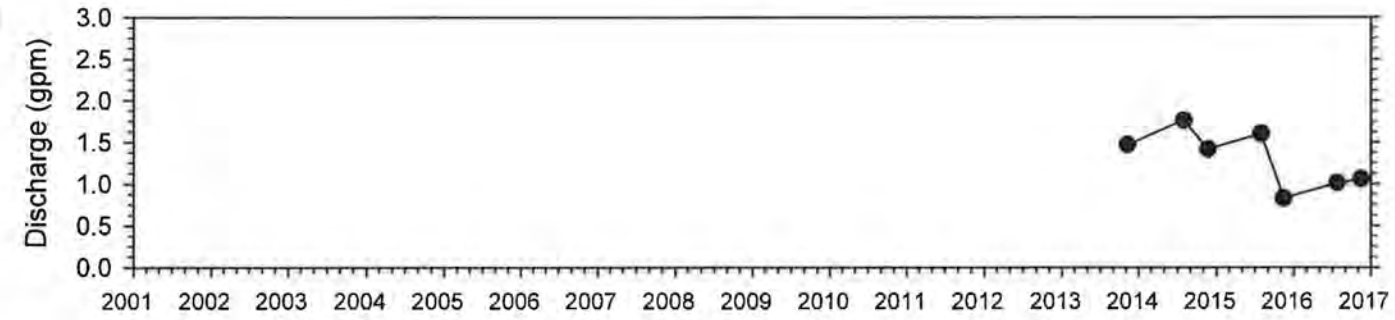
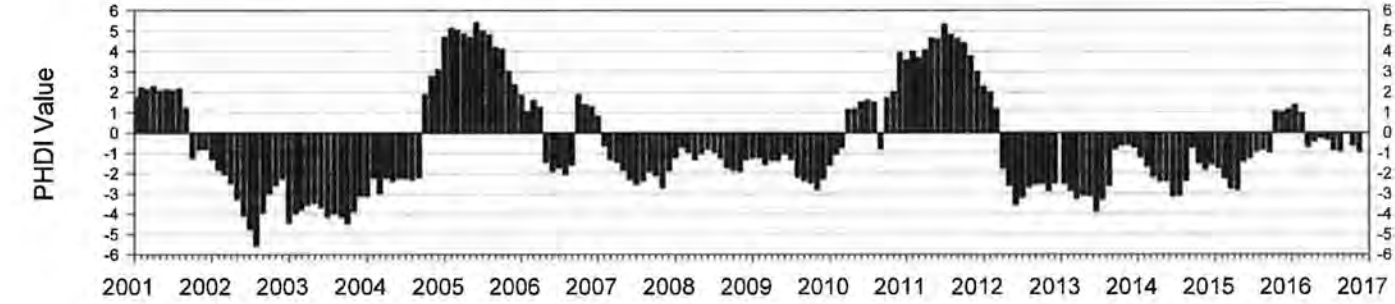
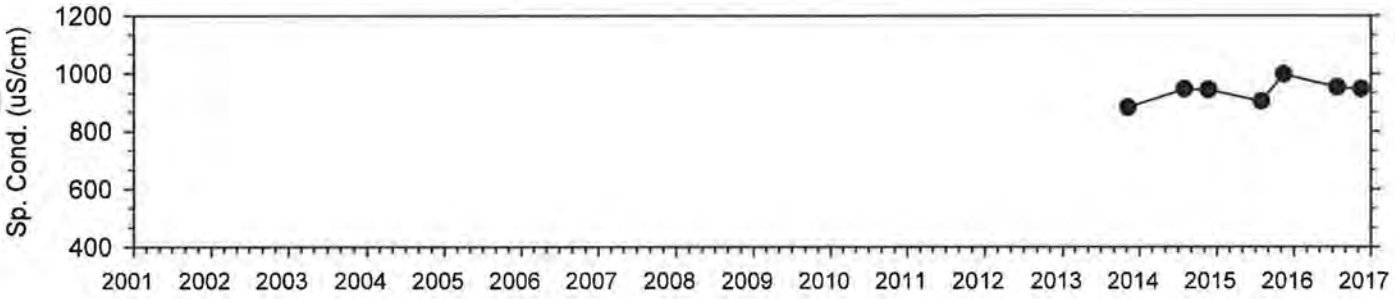
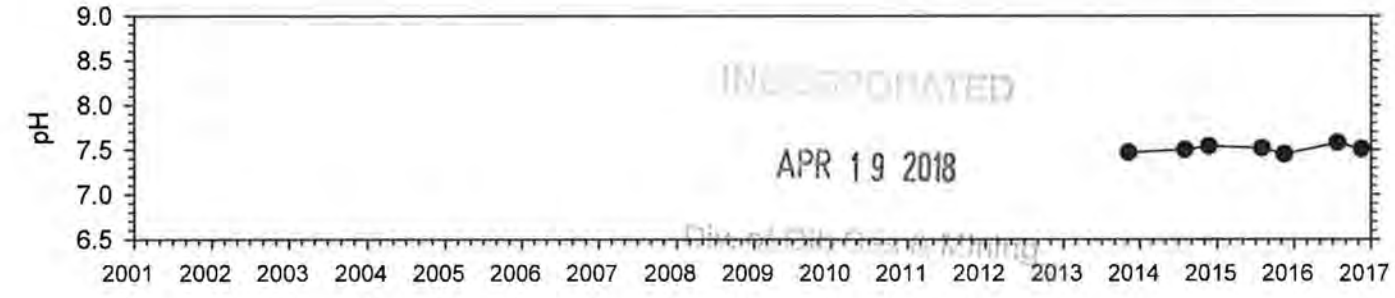


Spring A









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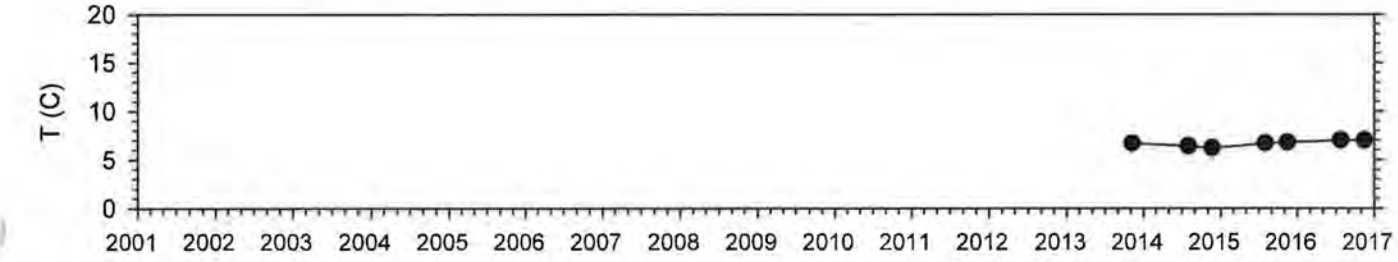
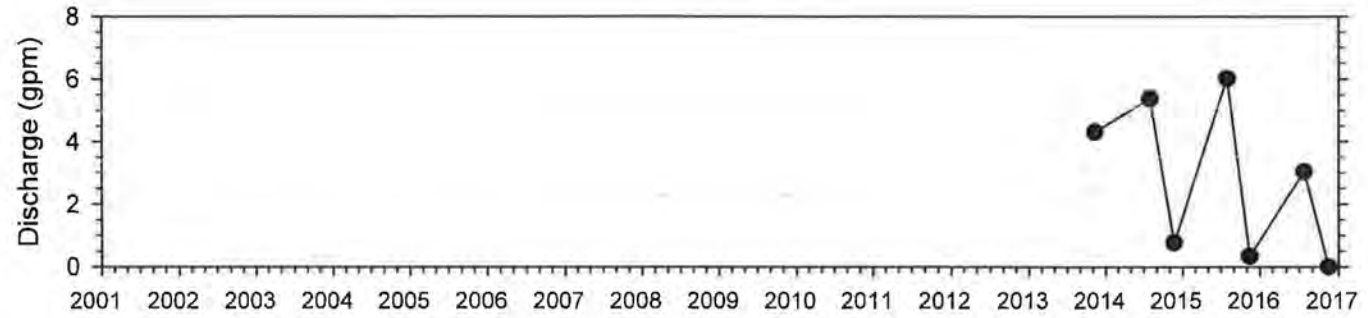
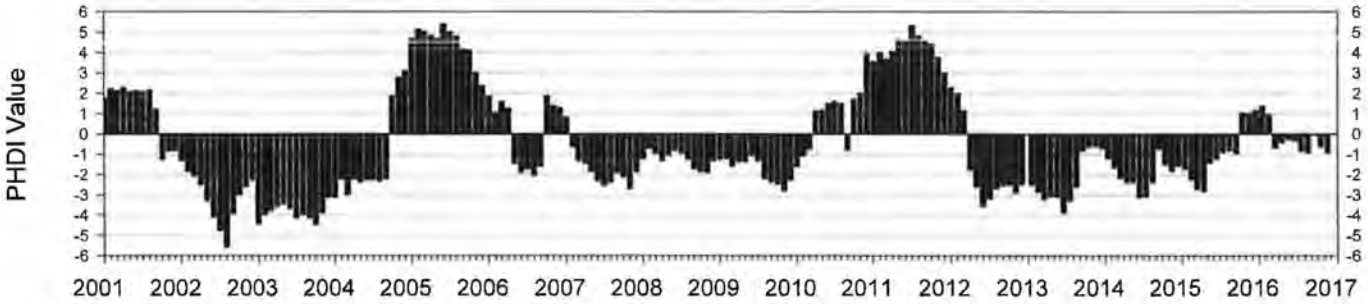
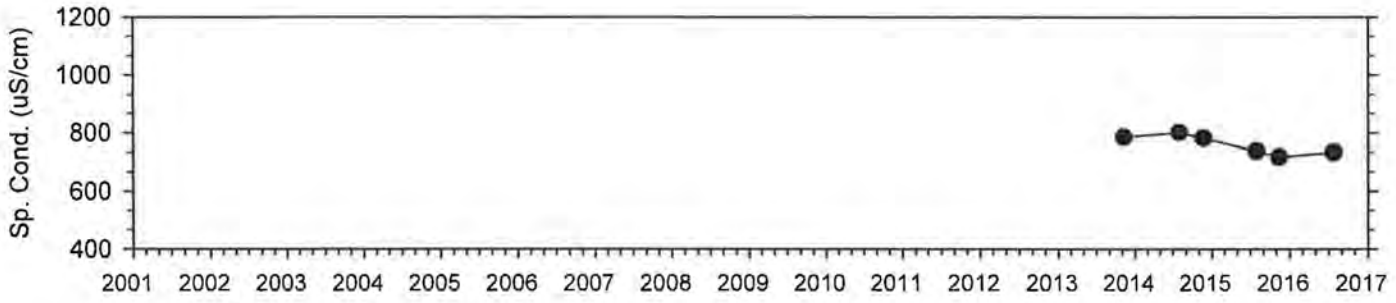
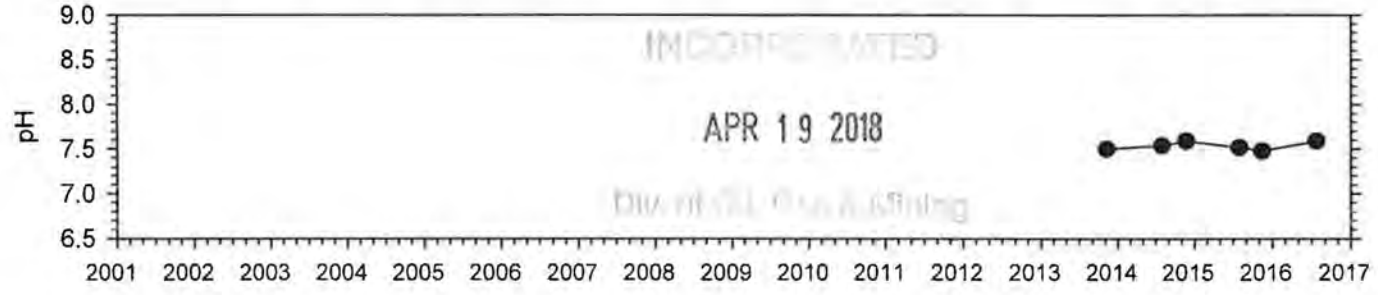


Spring B









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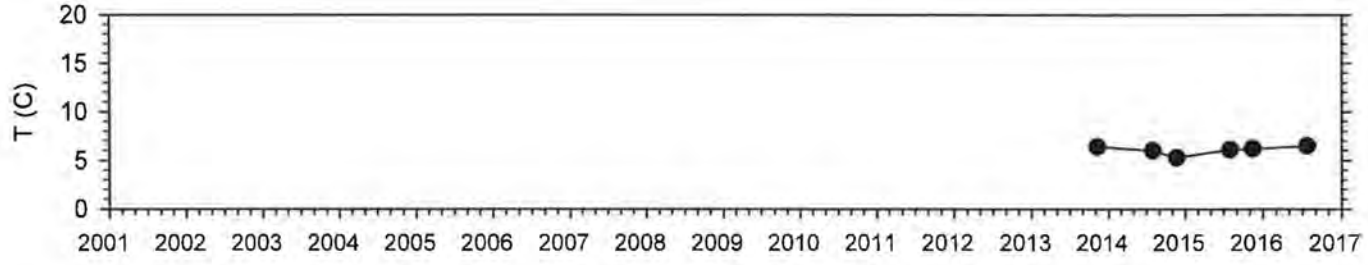
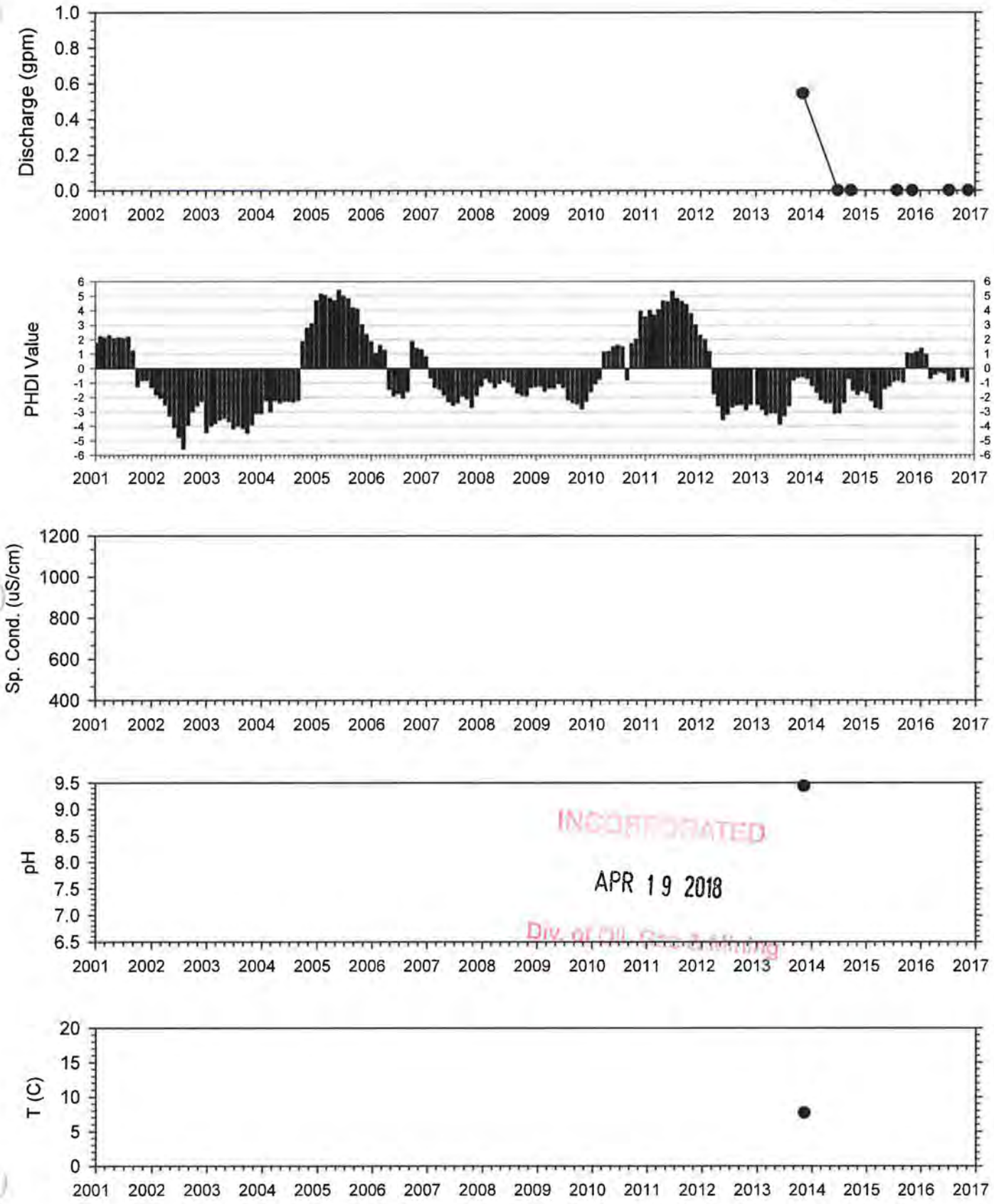


Spring D



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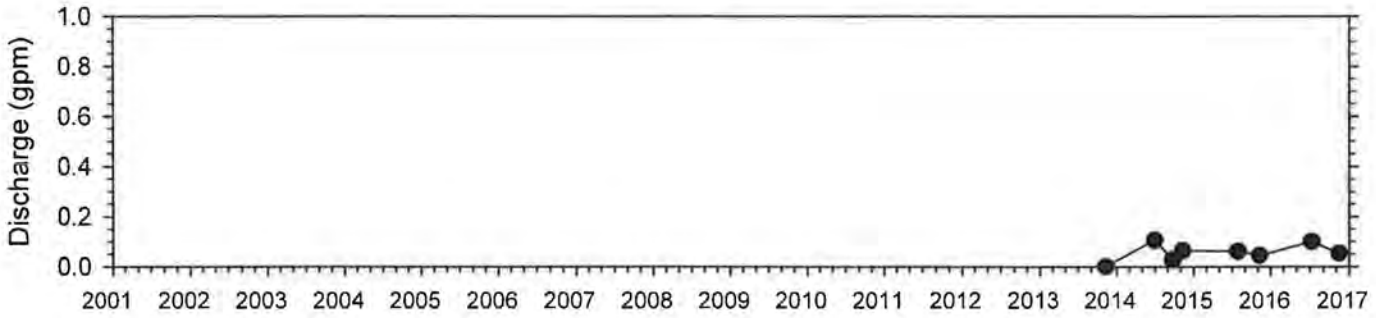
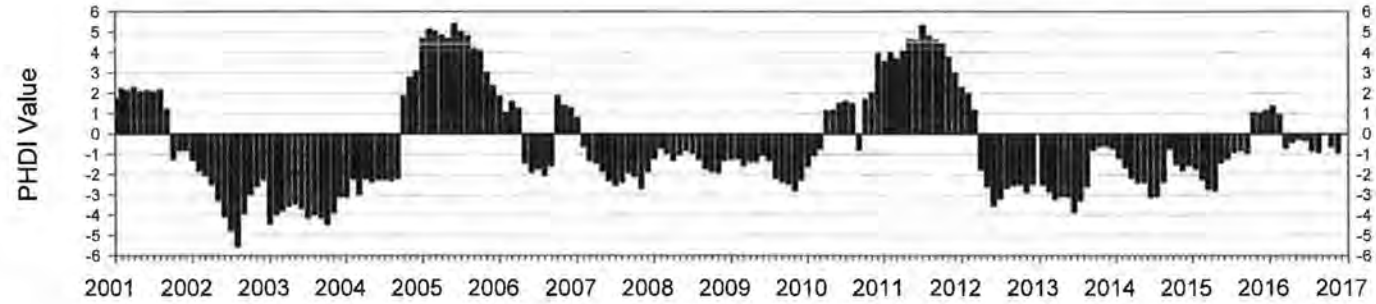
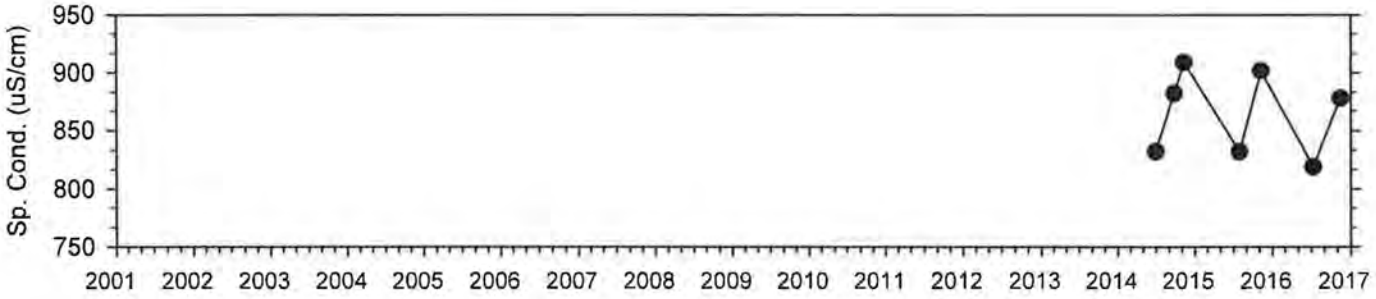
Spring A2S-1







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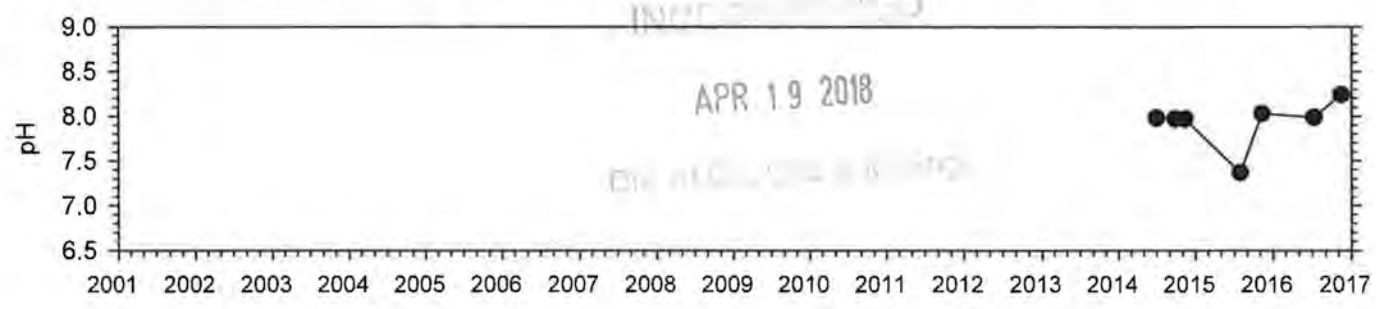
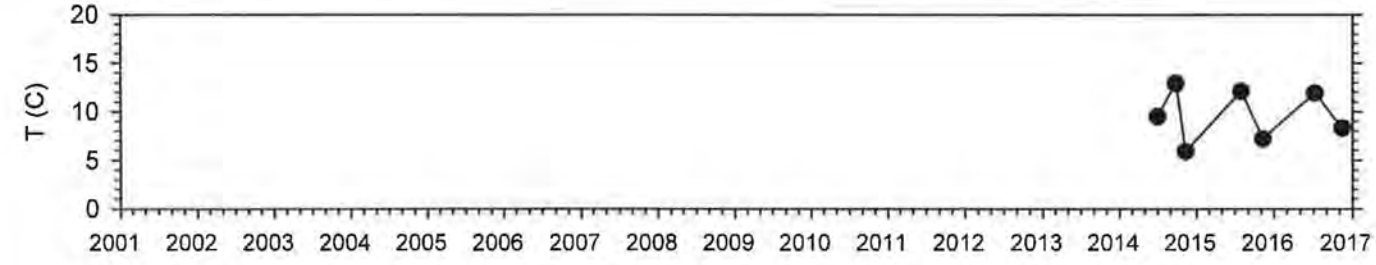
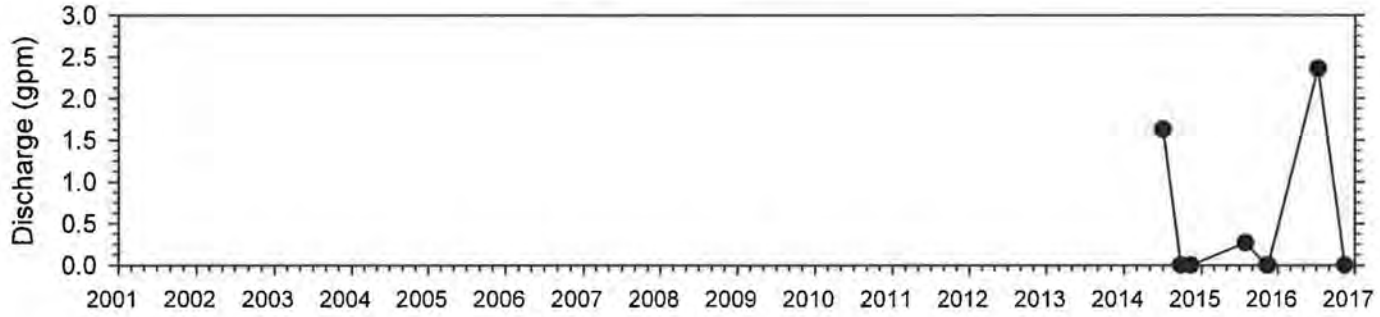
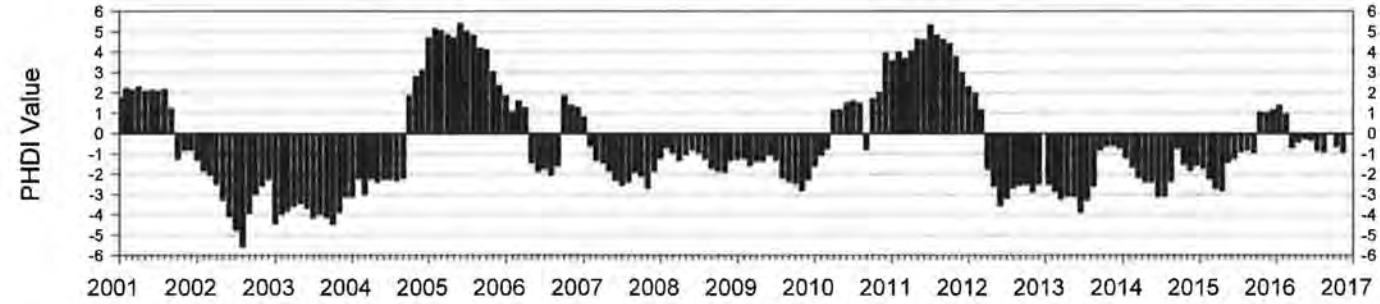
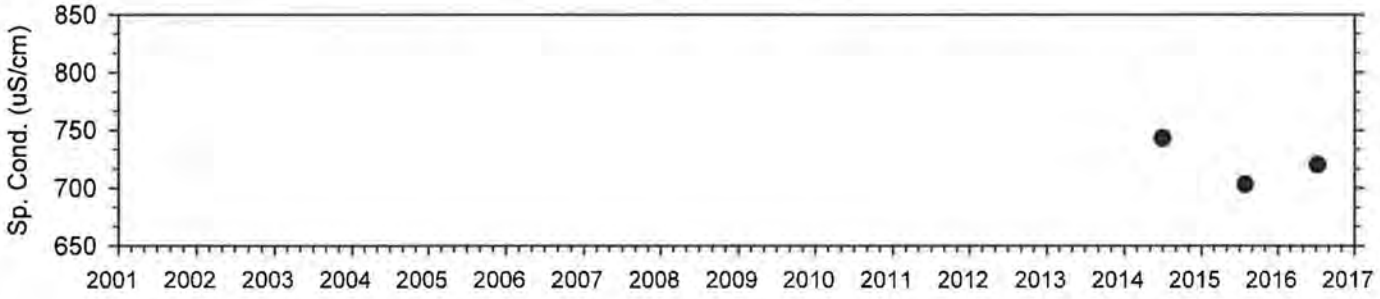


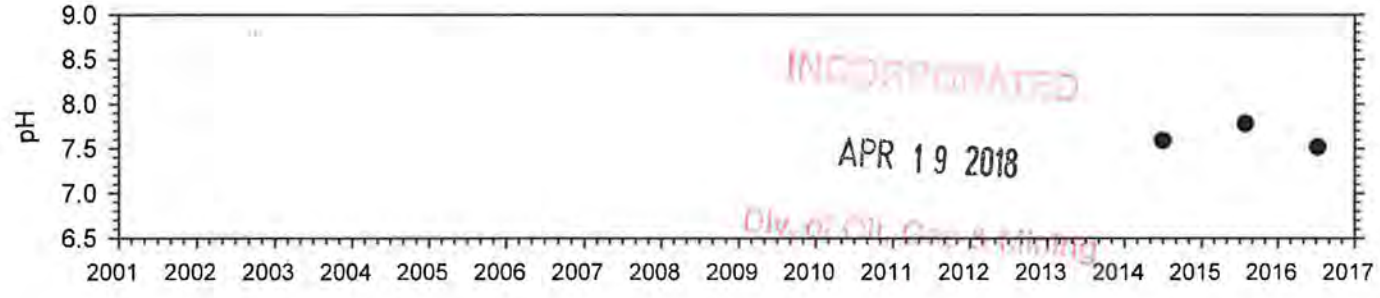


Divide Spring









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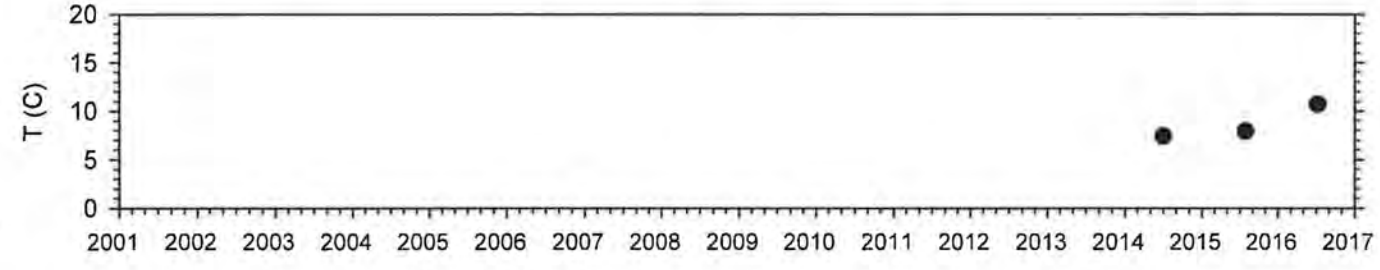
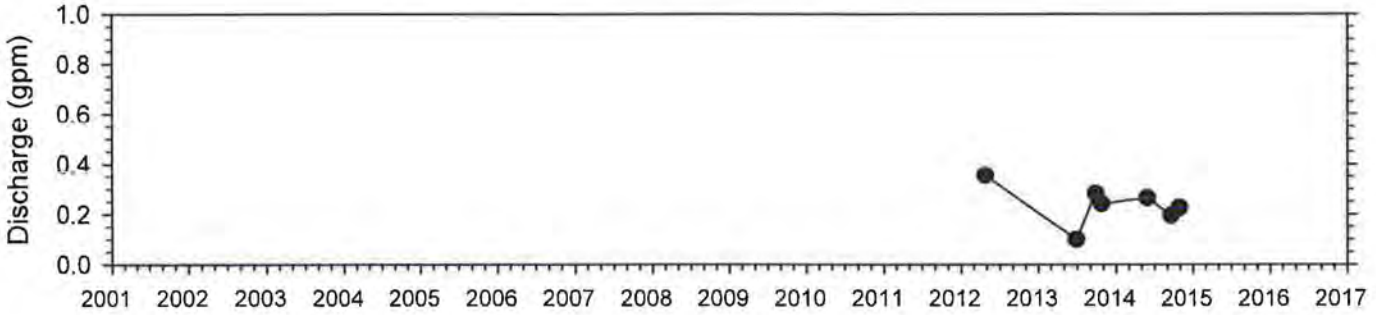
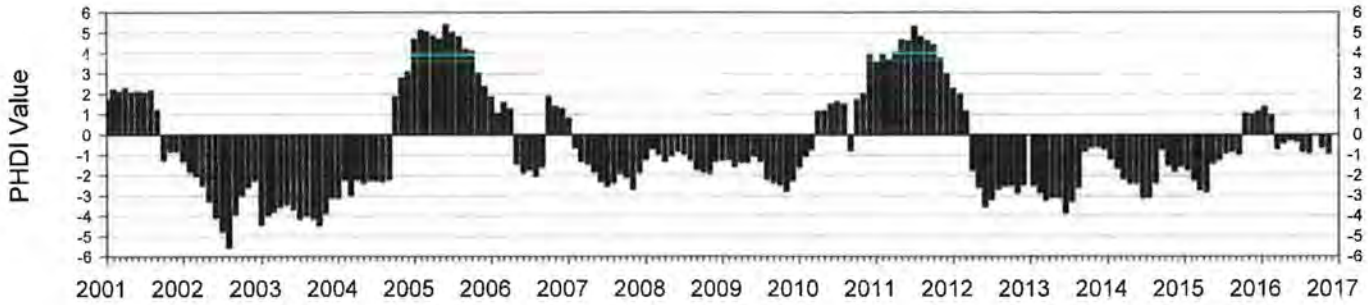
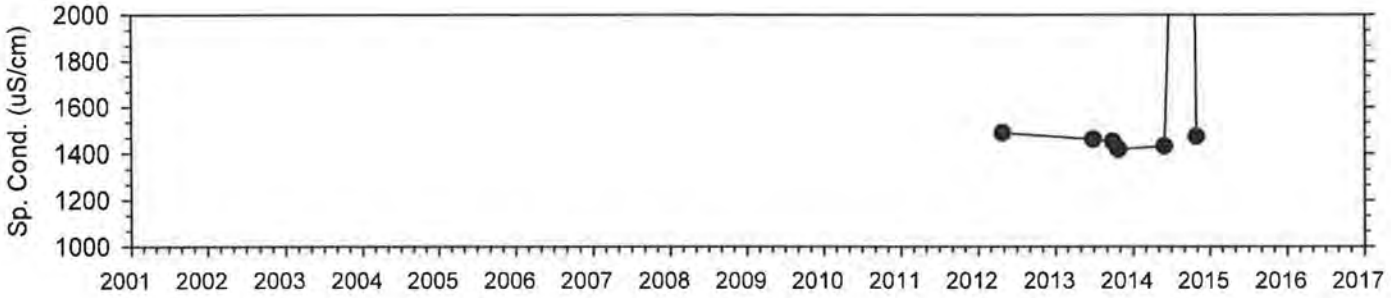


Hansen Seep







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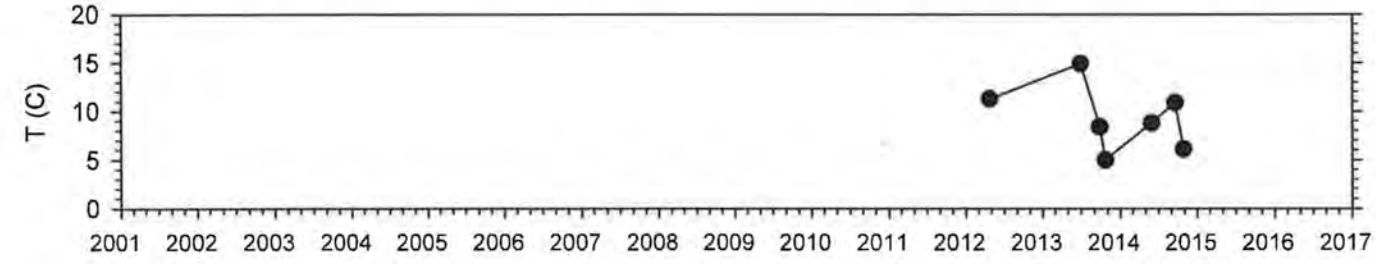
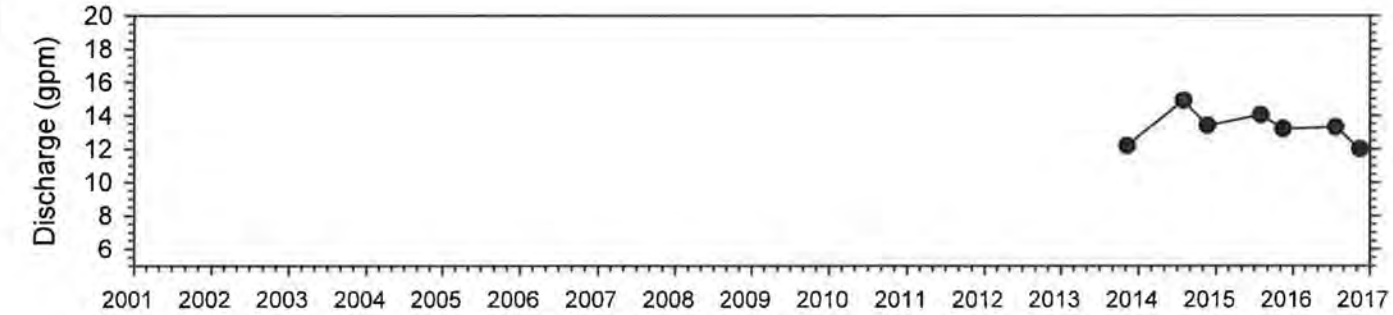
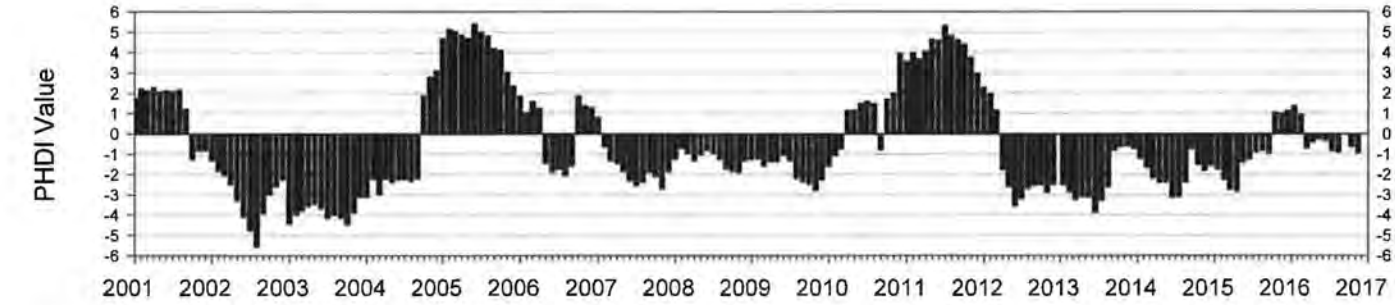
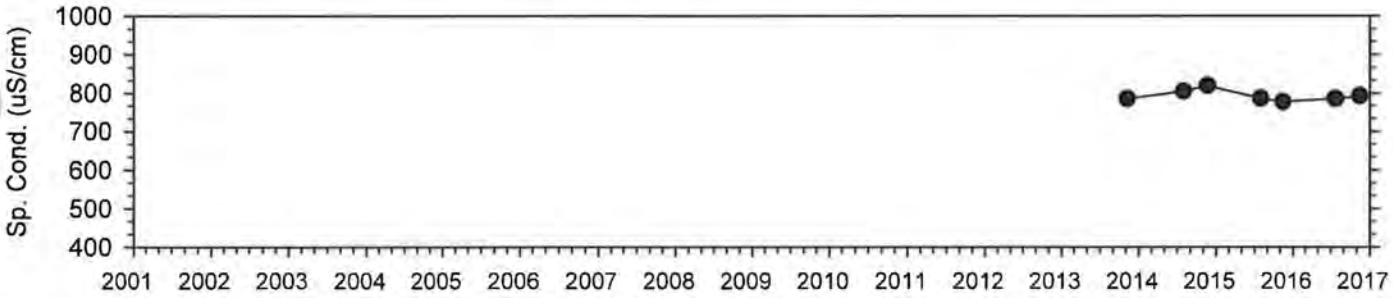
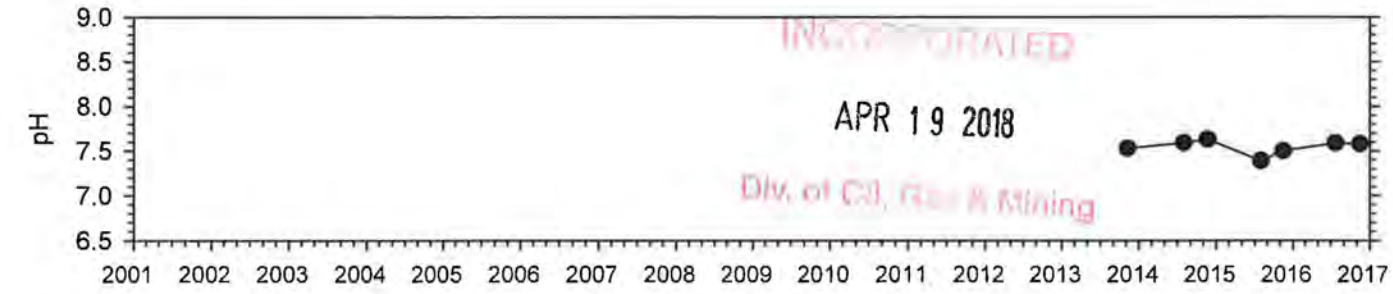


Spring Skutumpah Spring









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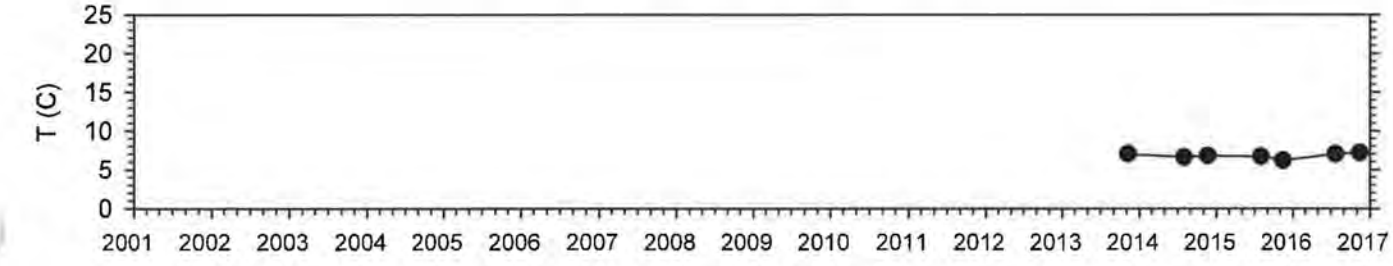
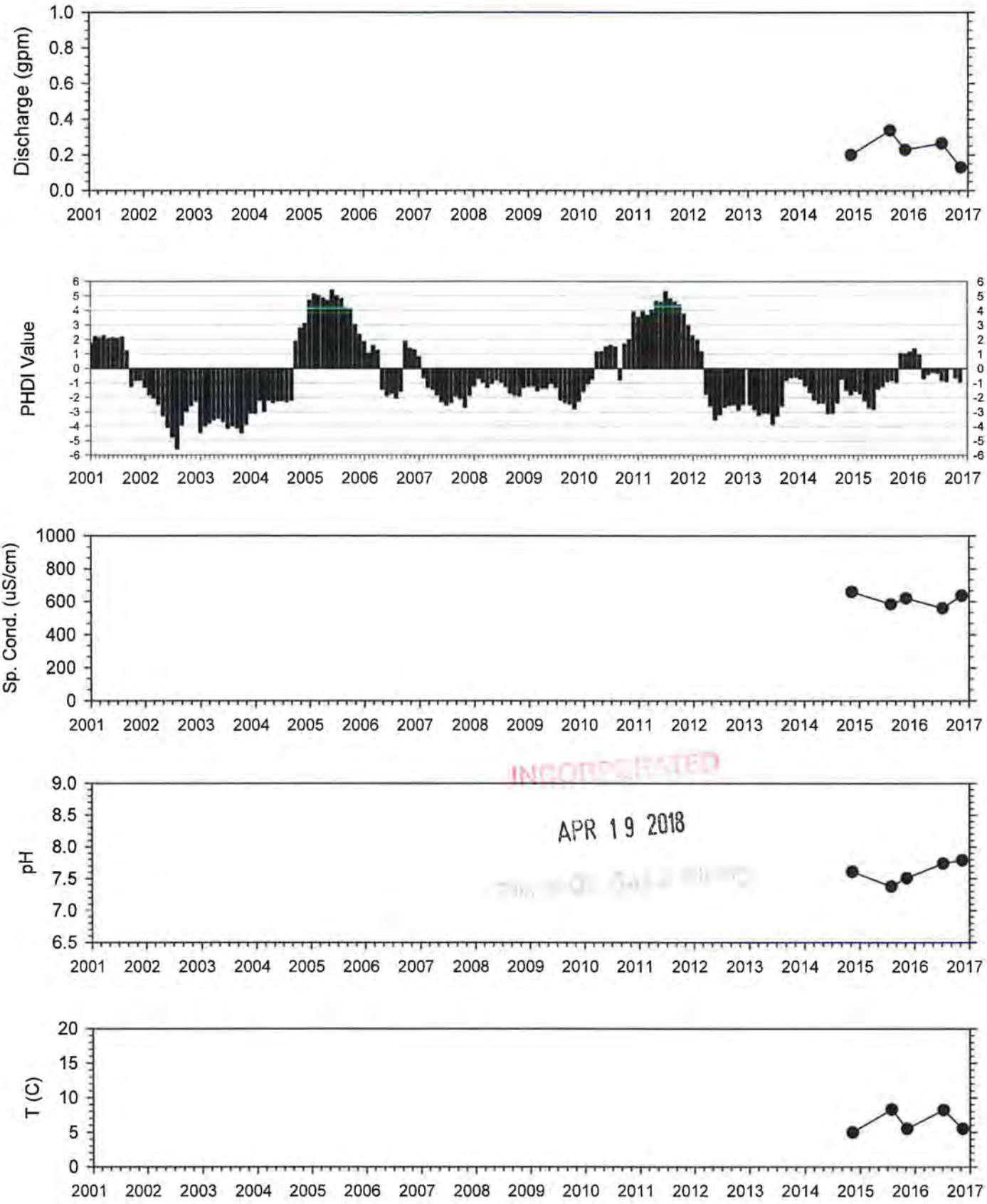


Spring Spg 99



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Attachment B

Discharge hydrographs for selected streams

Plots of temperature, pH, specific conductance,

and Palmer Hydrologic Drought Index.

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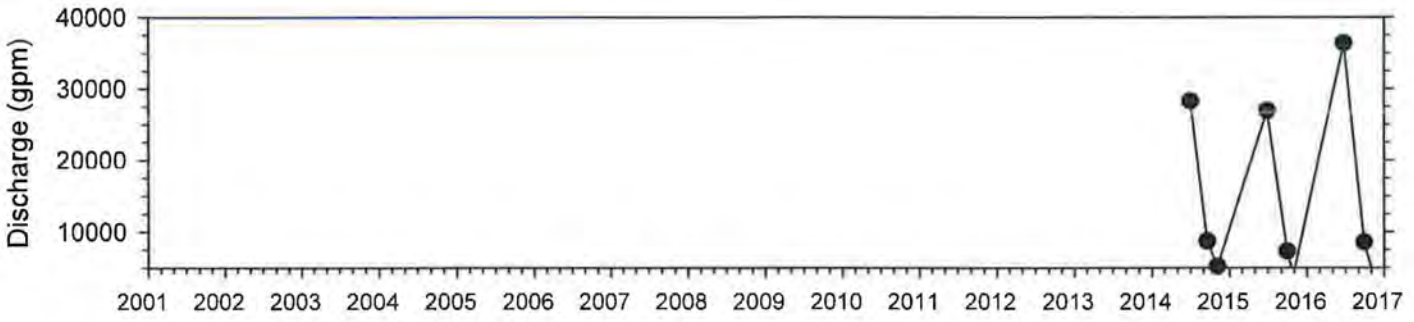
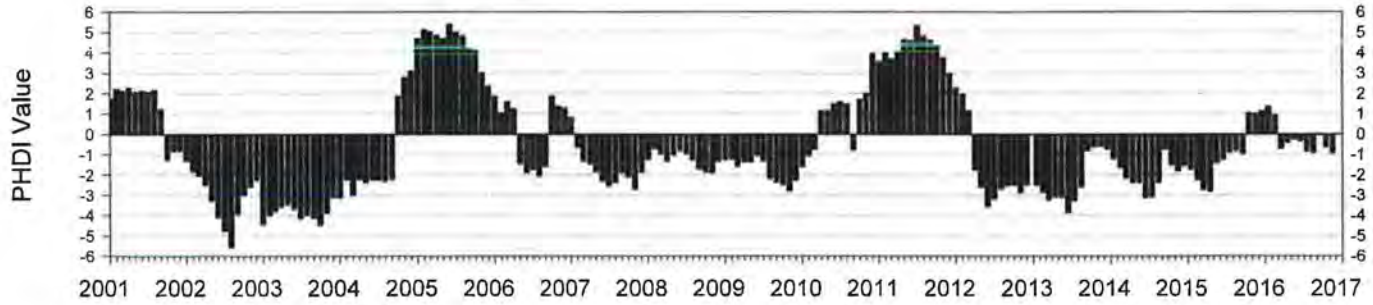
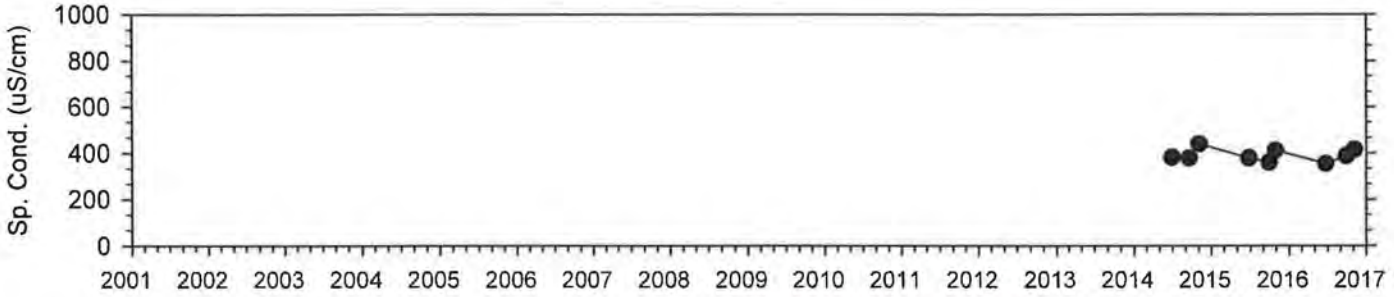
Stream U-Mud







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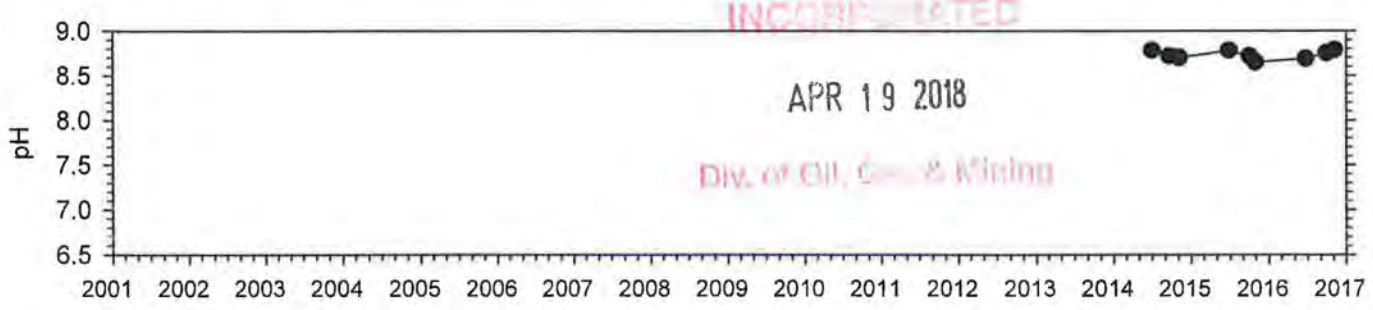
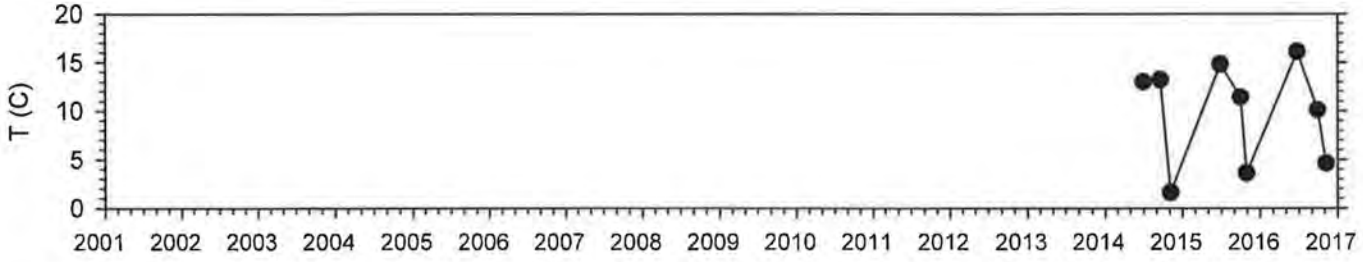
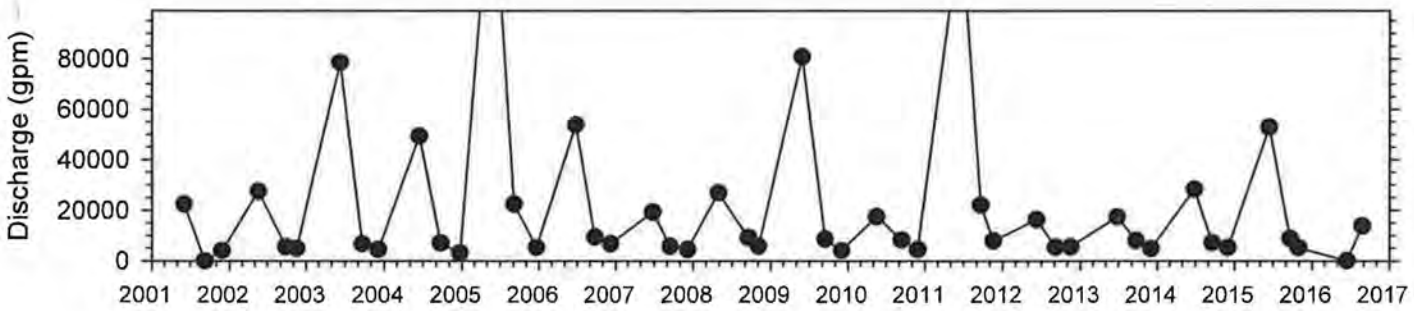
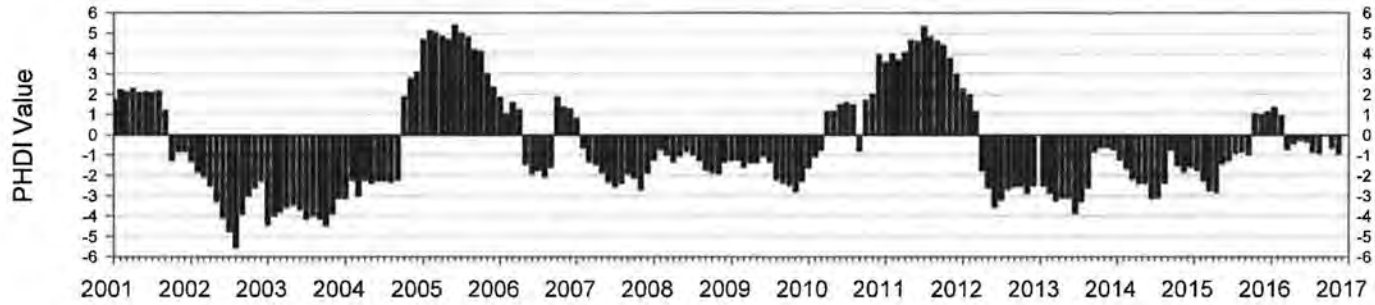
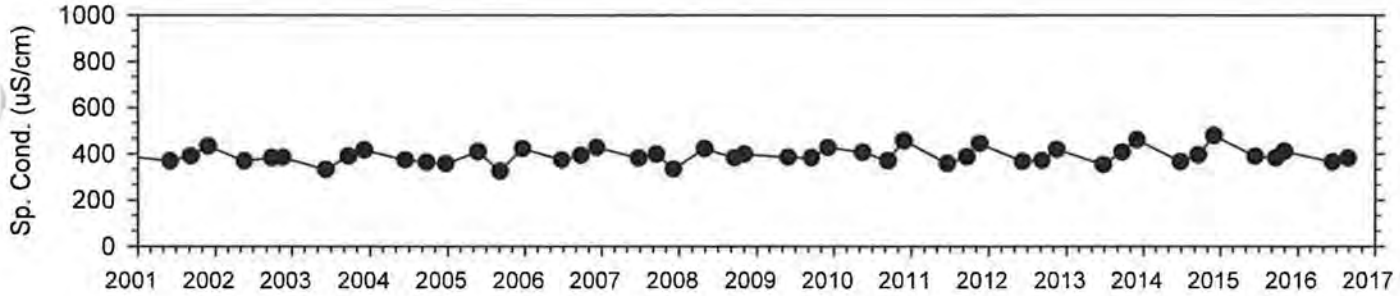


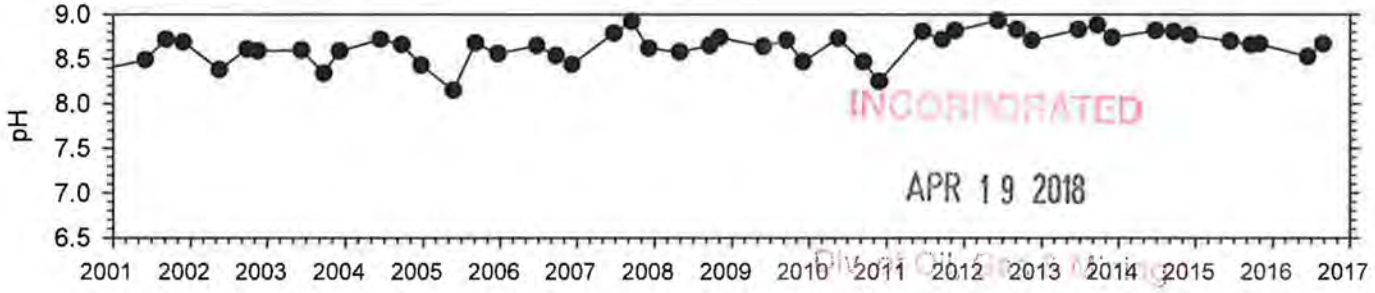


Stream Pines 405









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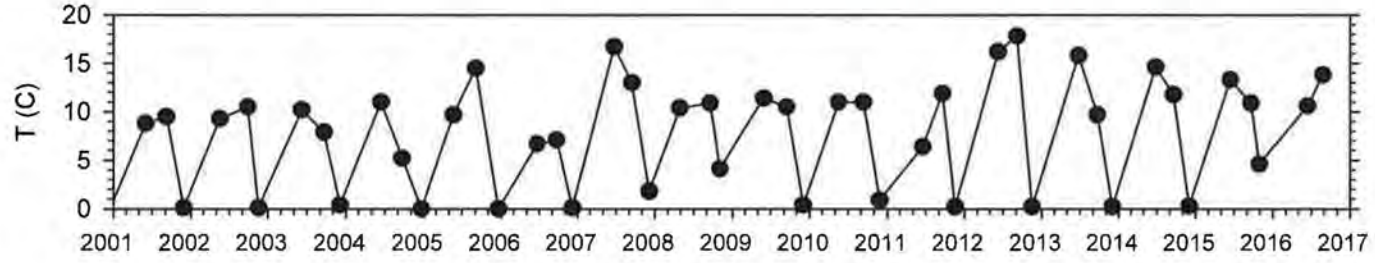

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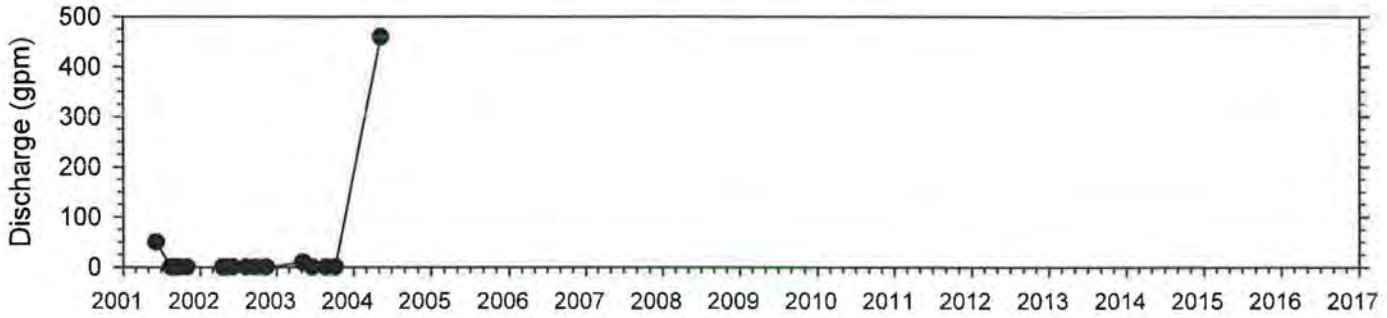

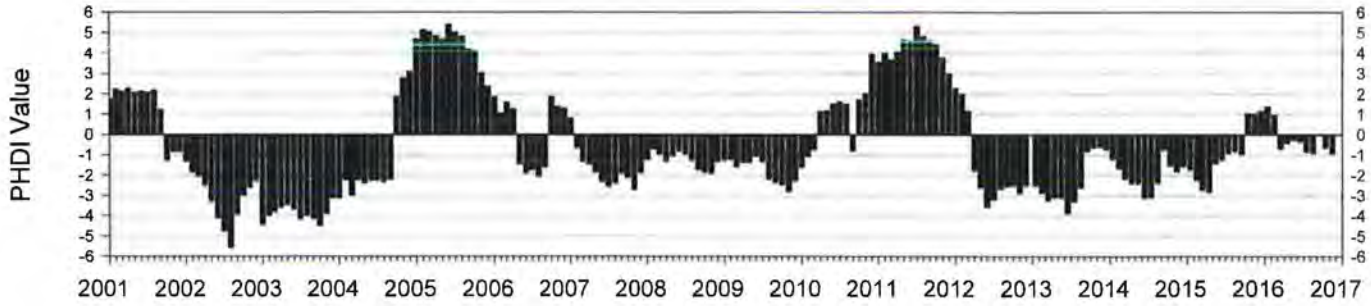

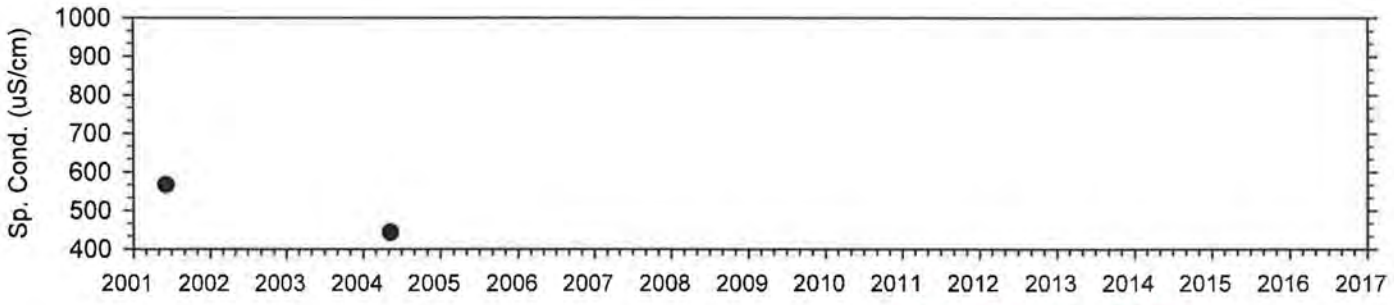

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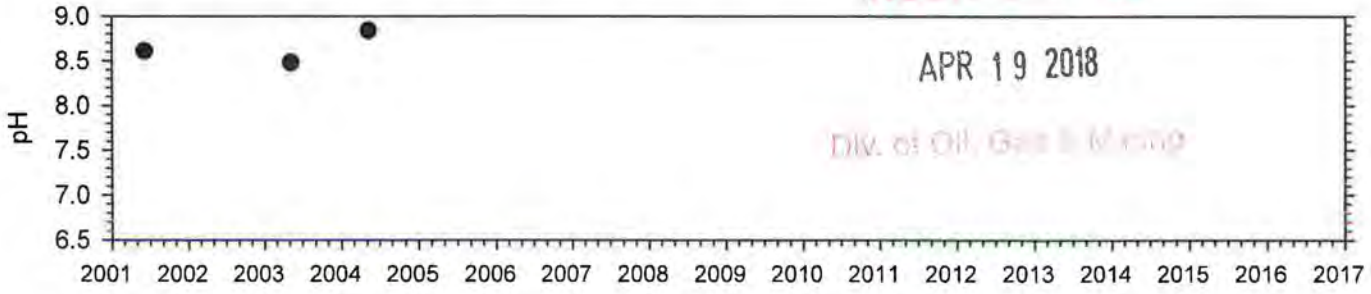
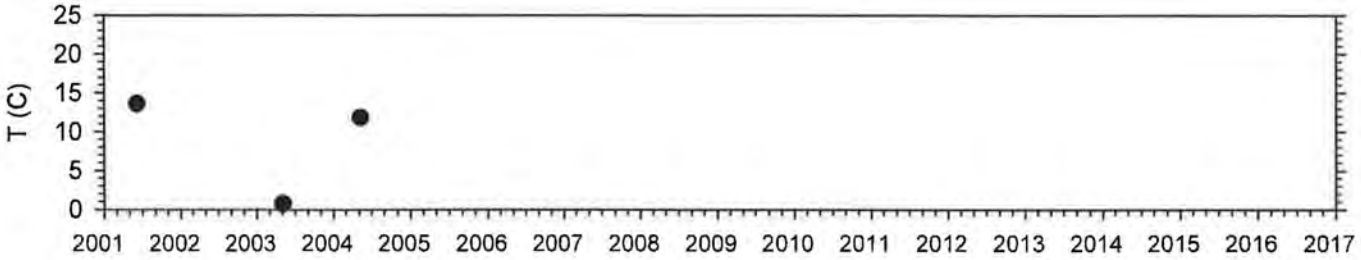
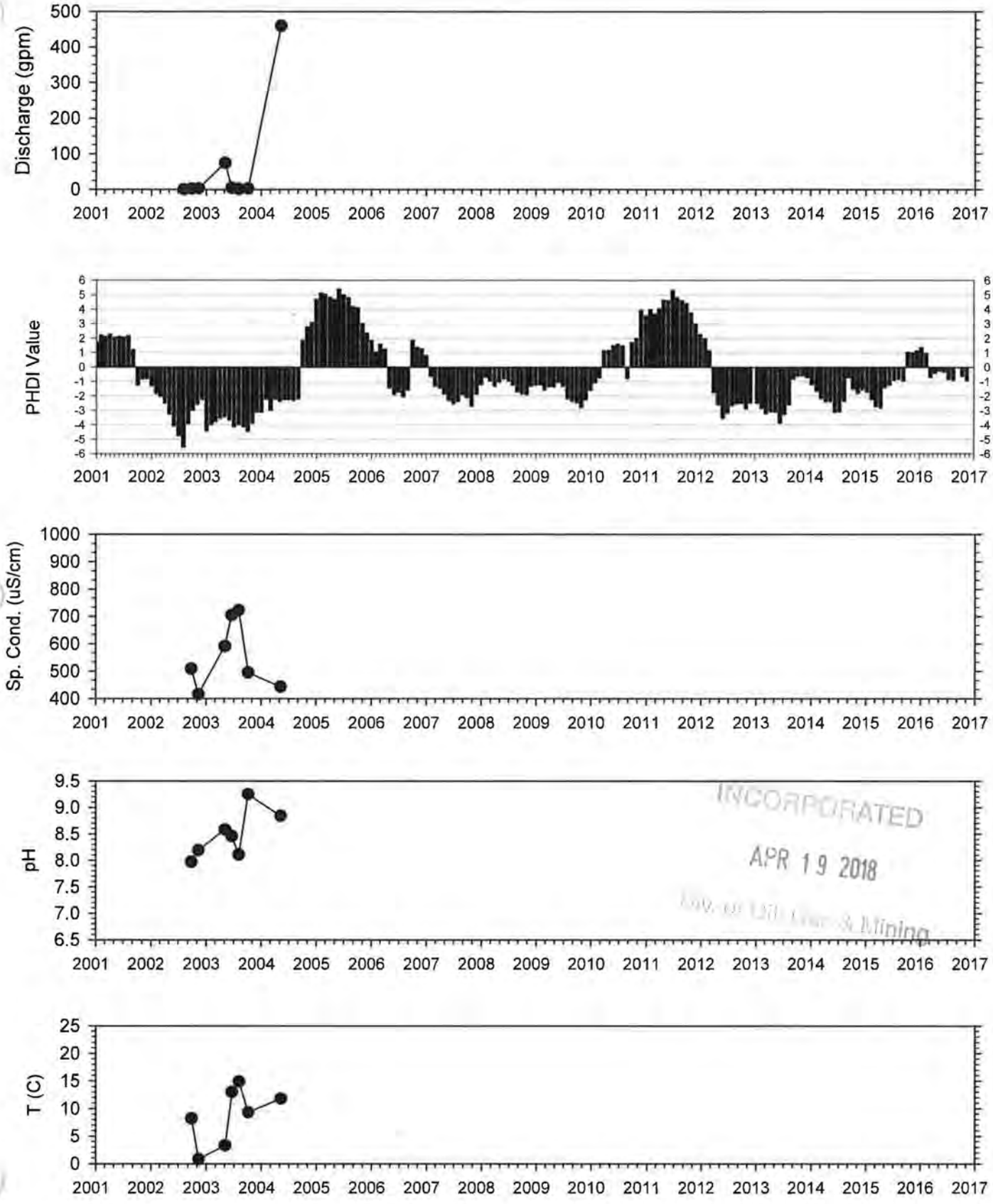




Spring M-STR02



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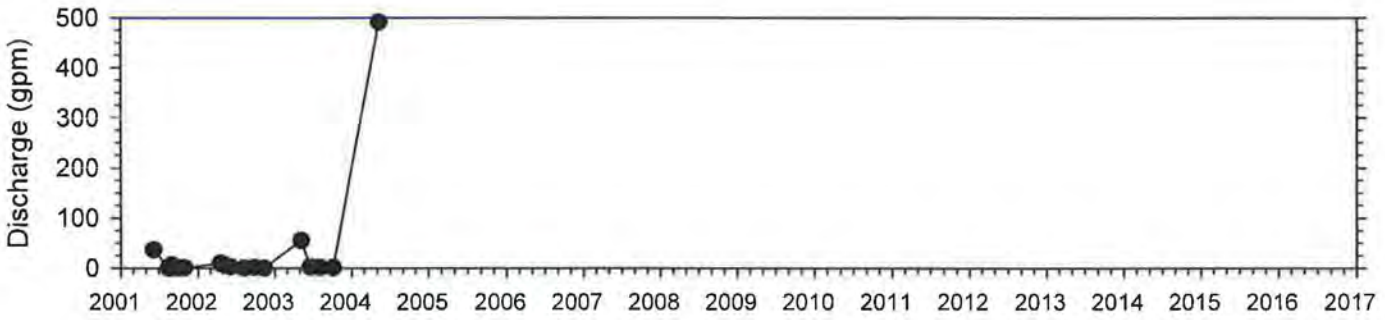

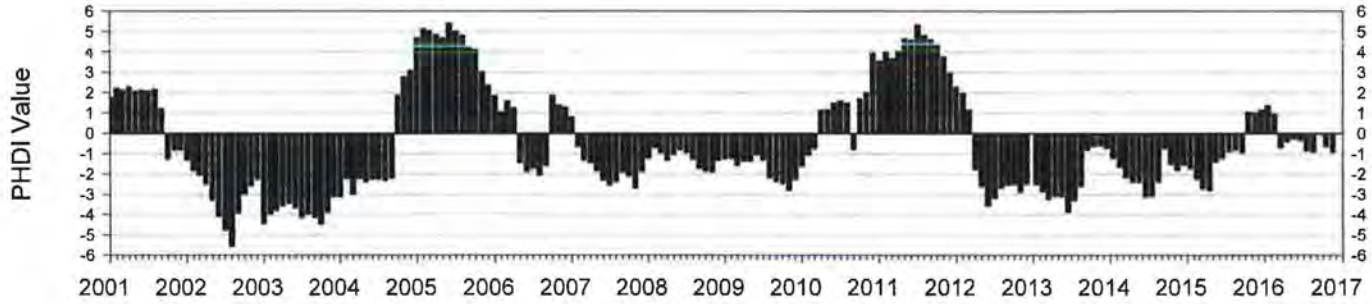

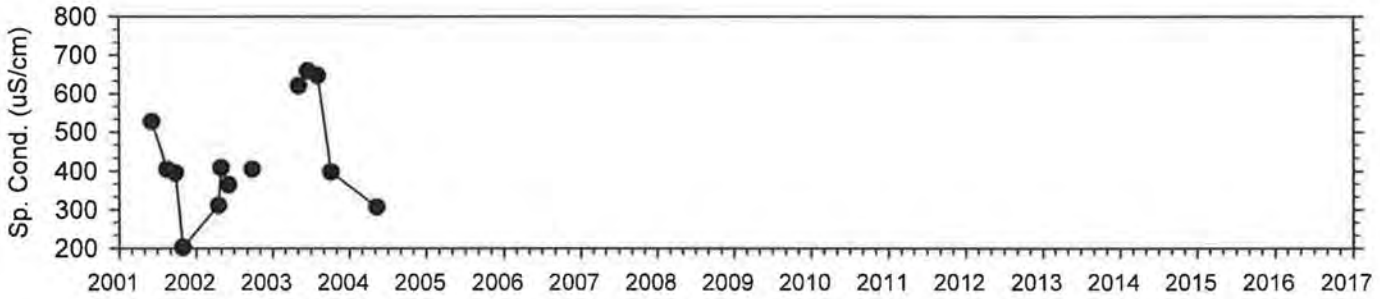

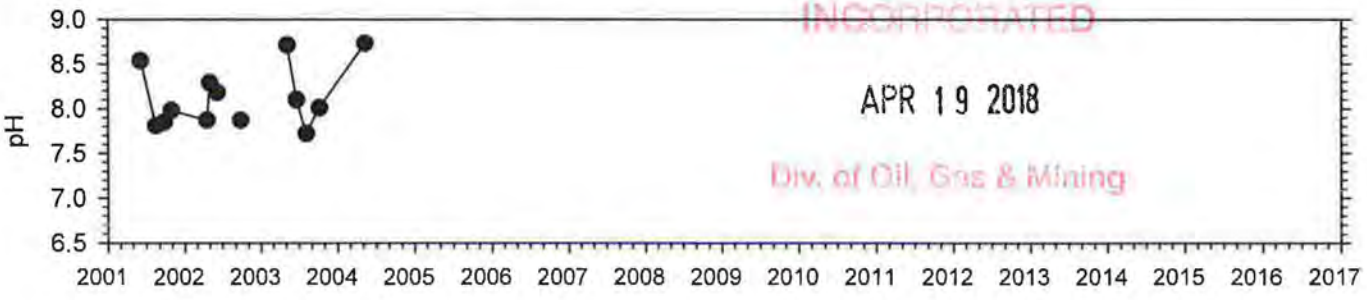

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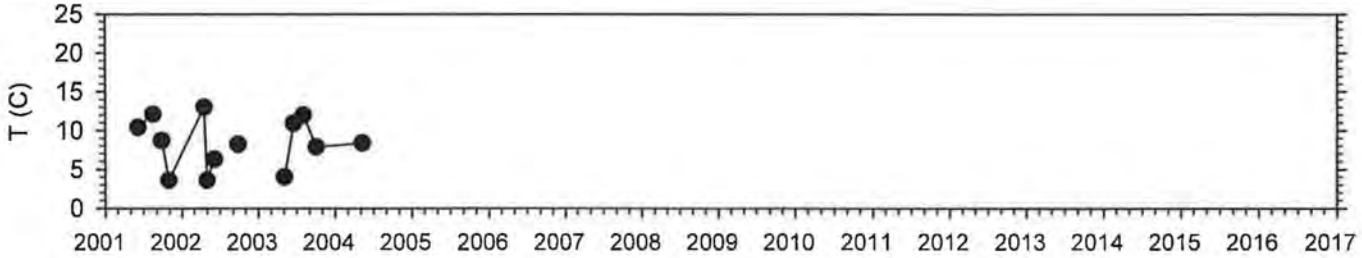
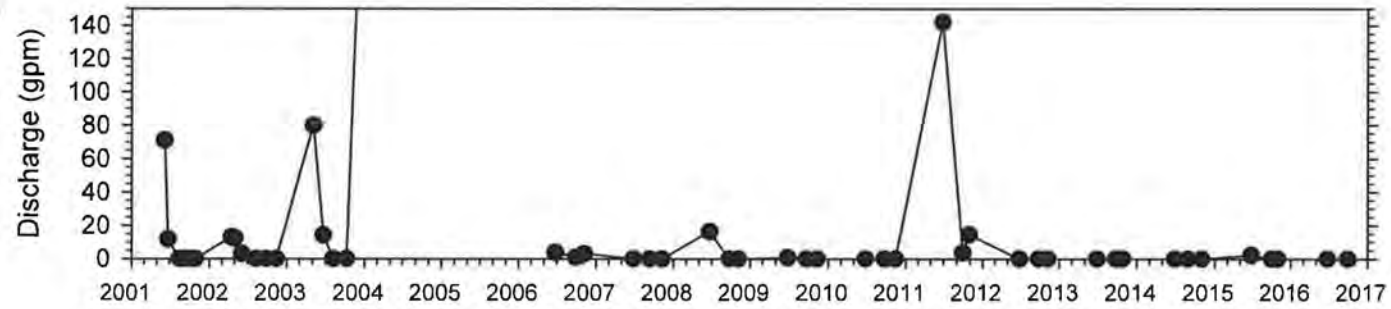
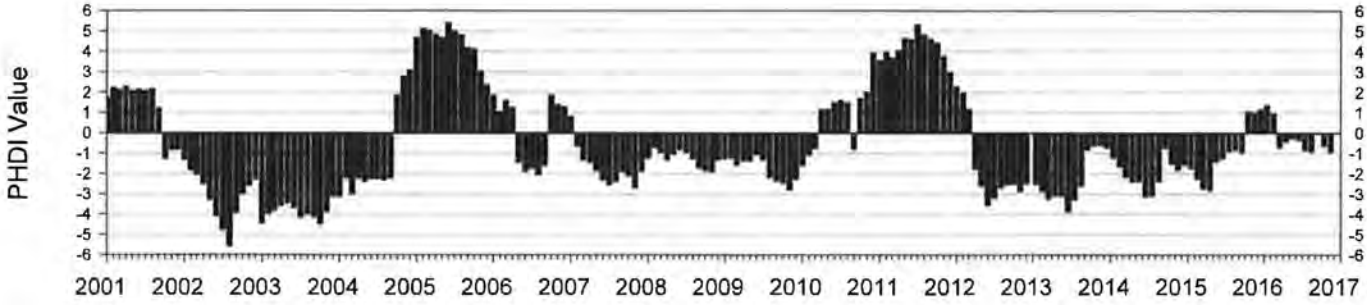
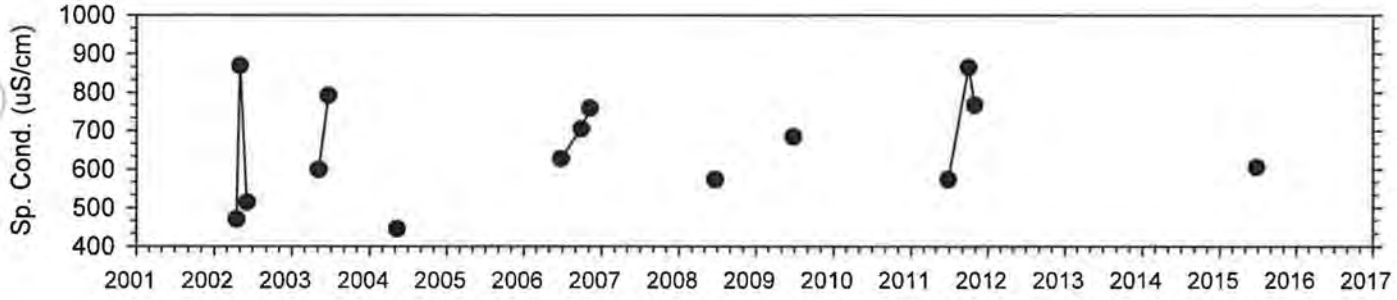
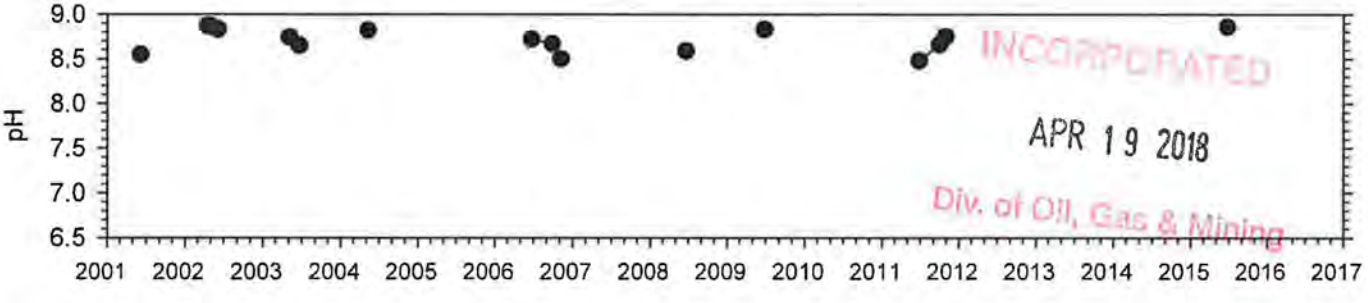


Stream M-STR04









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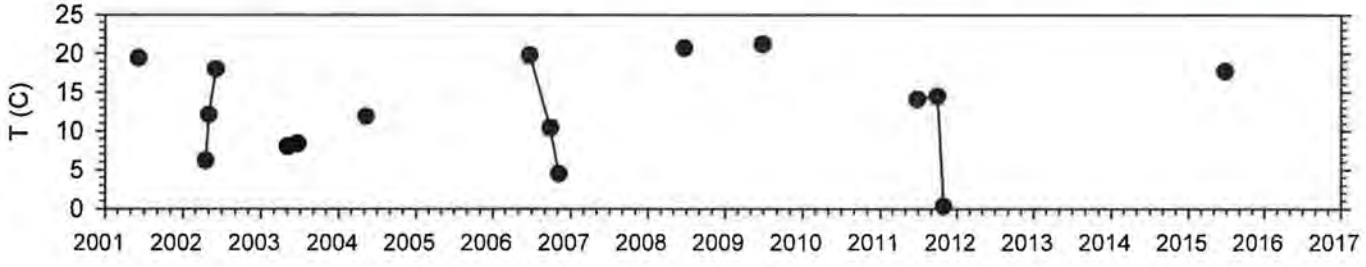

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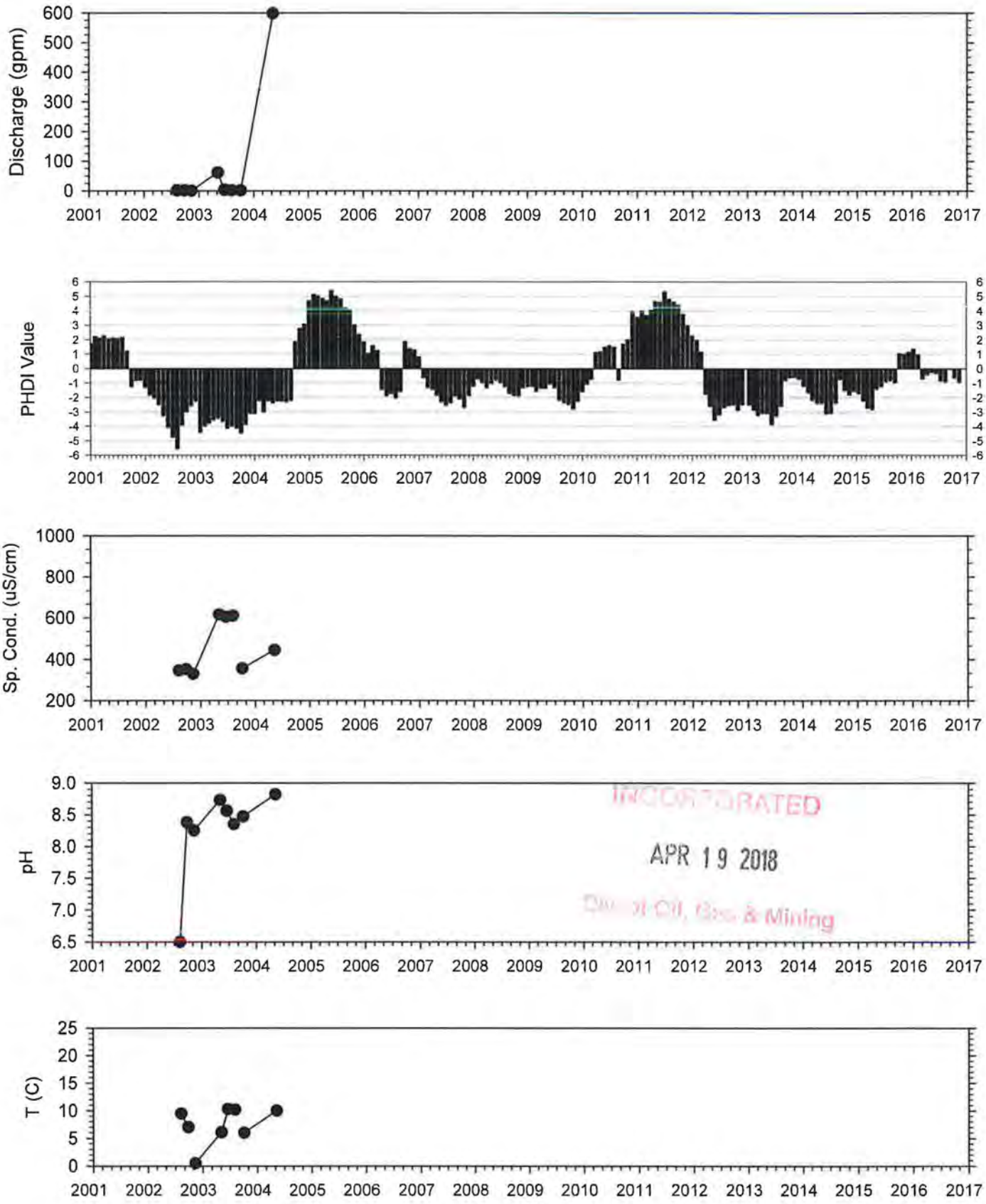

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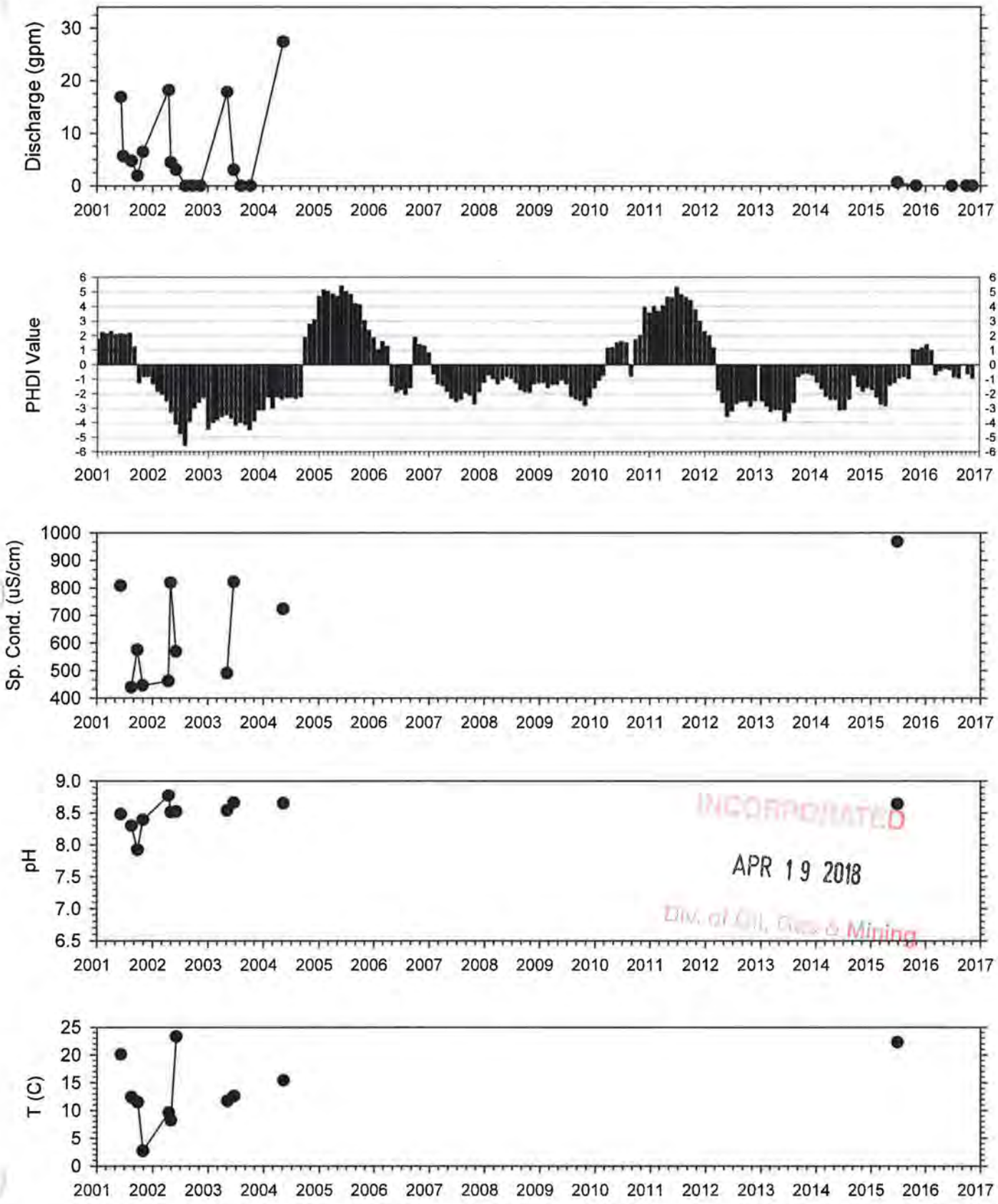
Stream M-STR06



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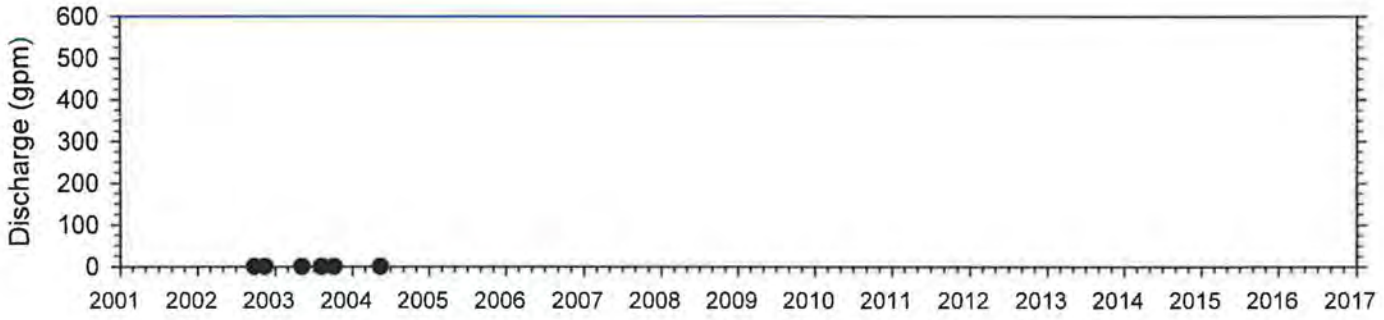
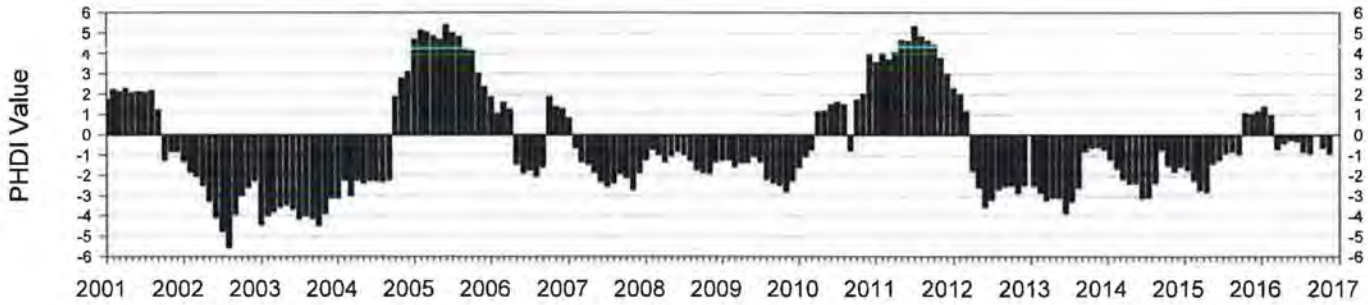
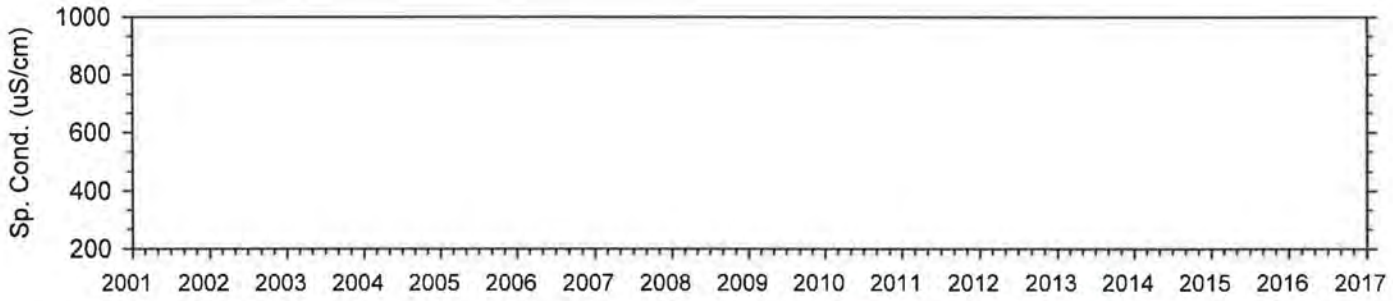
Spring M-STR07







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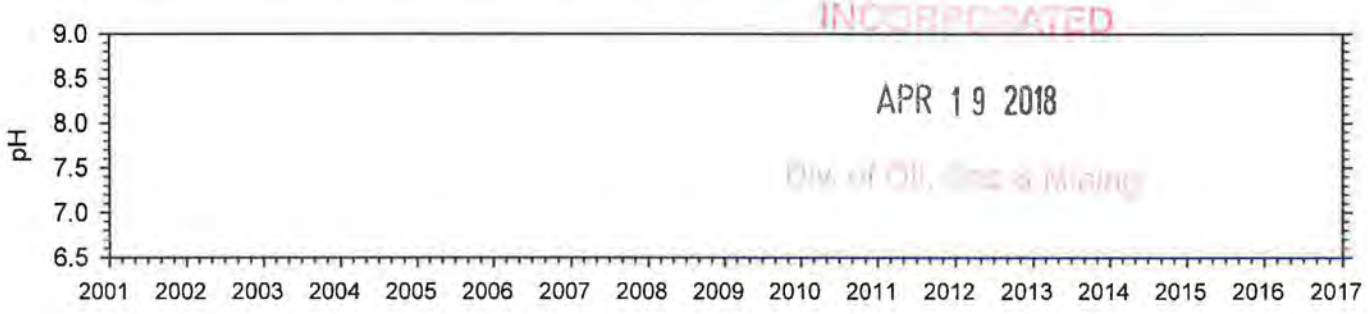
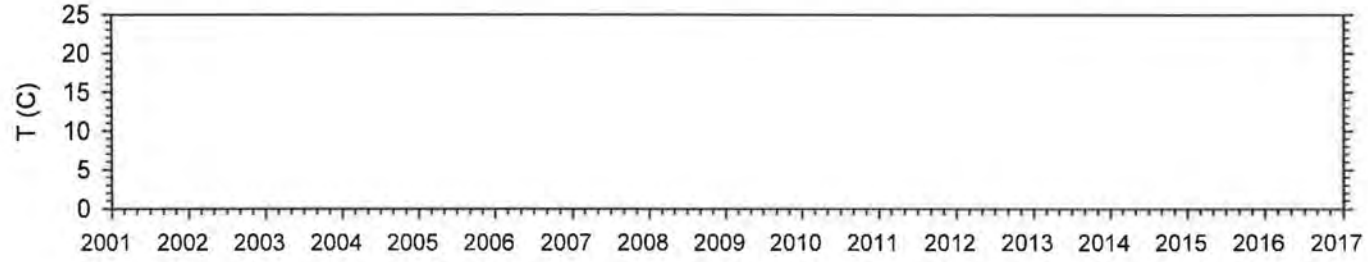
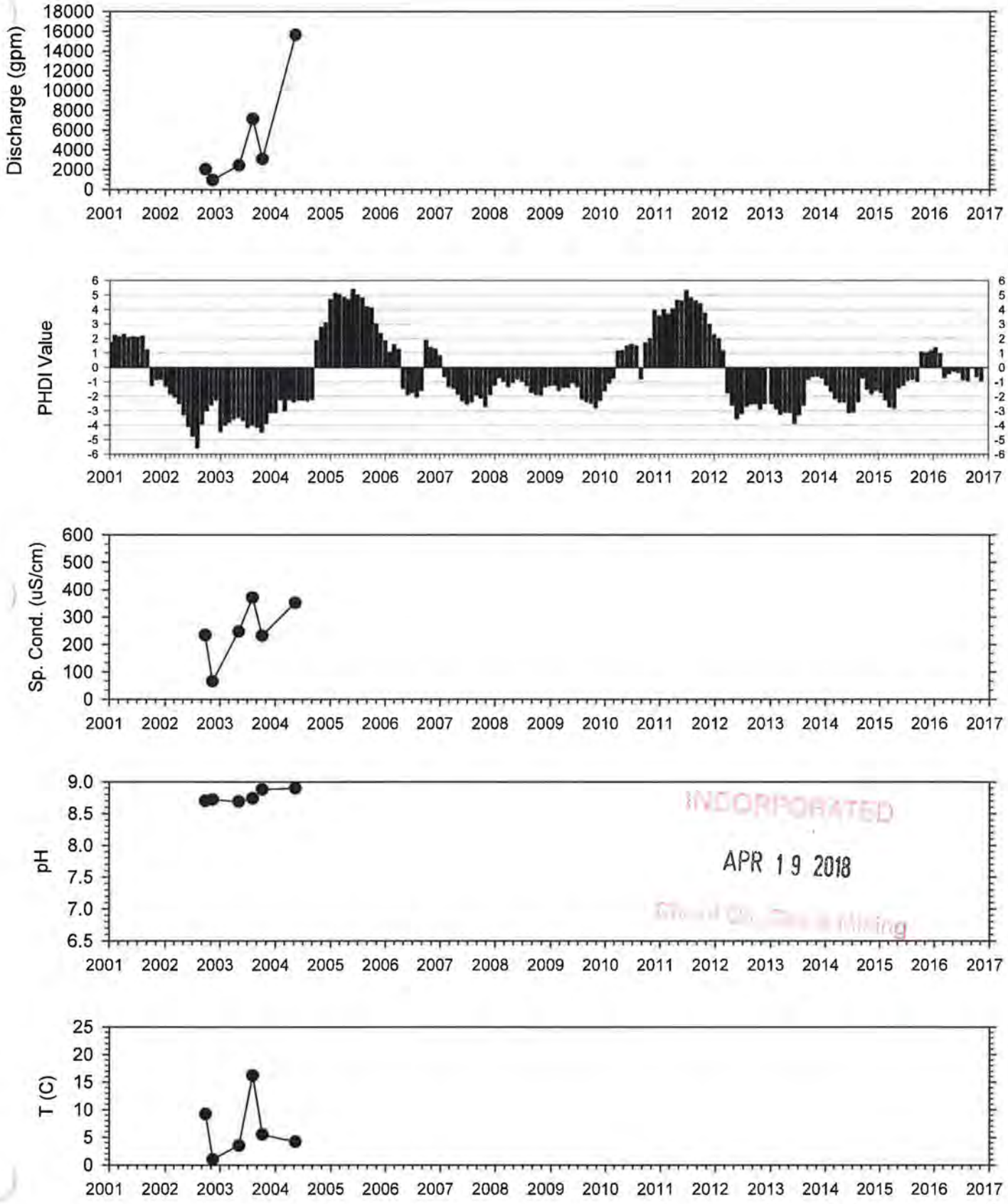




Stream M-STR08



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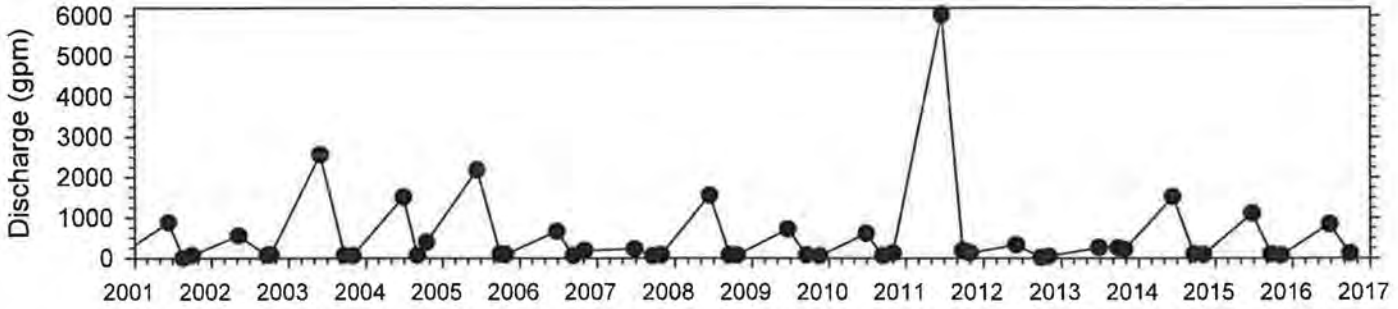
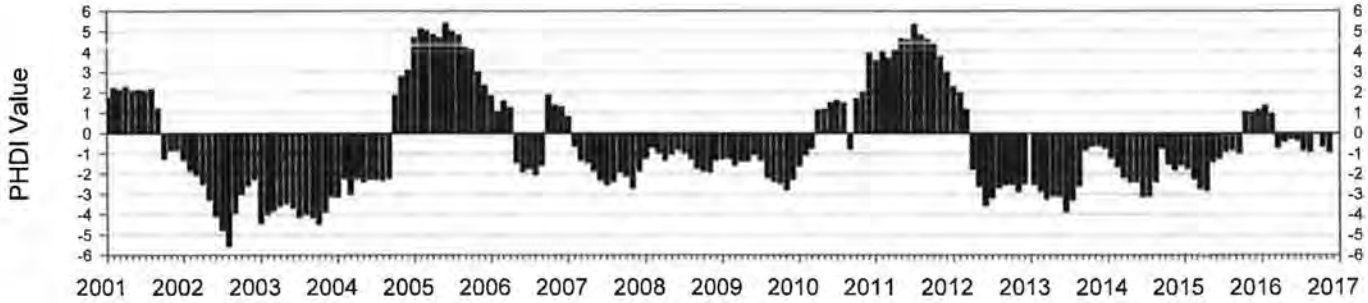
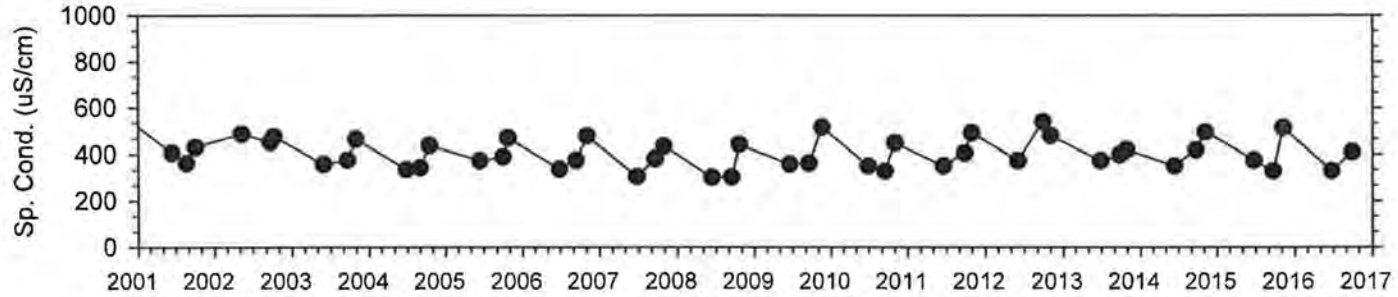
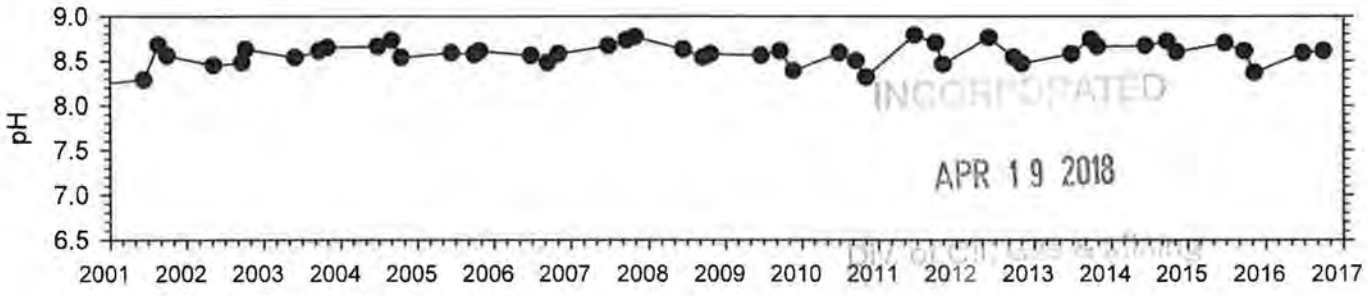
Mining

Stream Sufco 007









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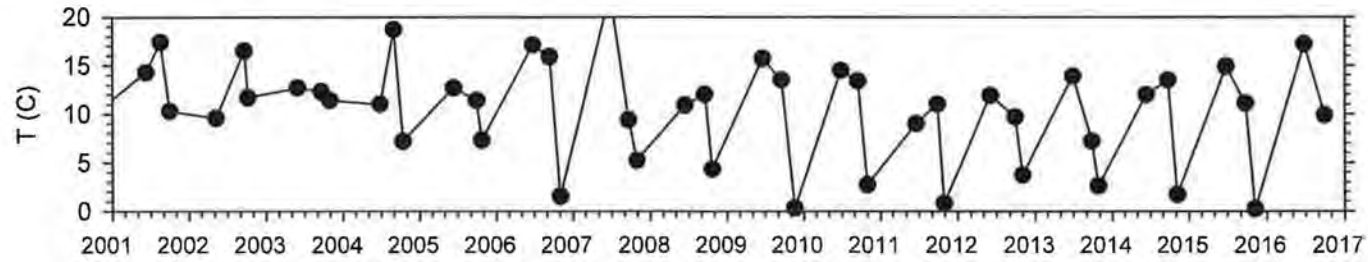
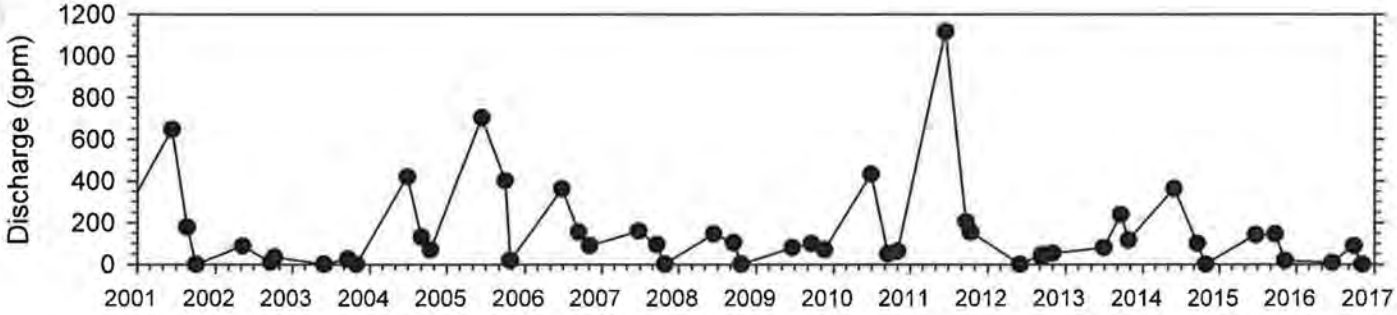
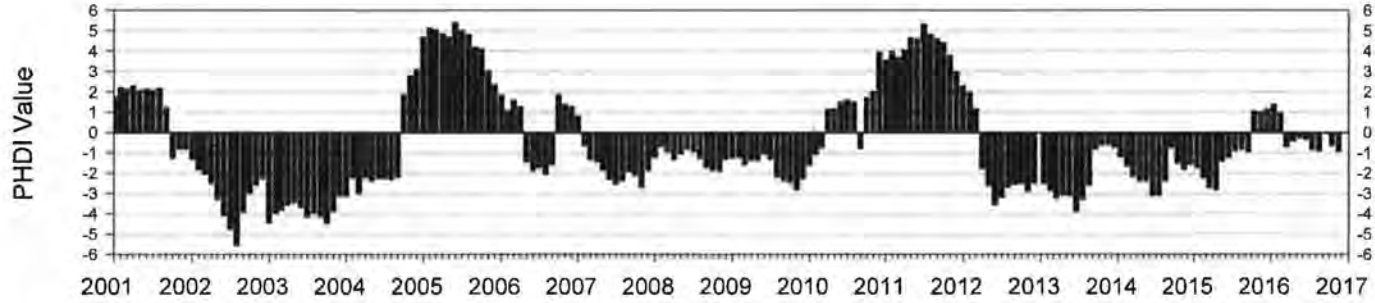
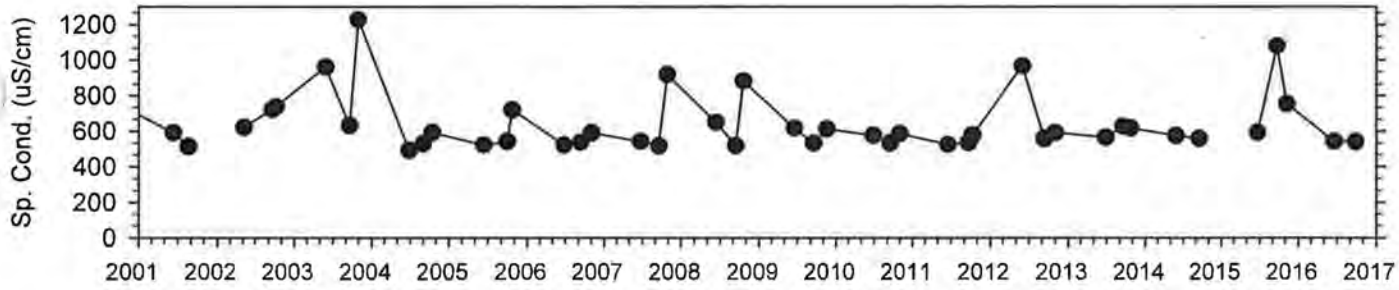
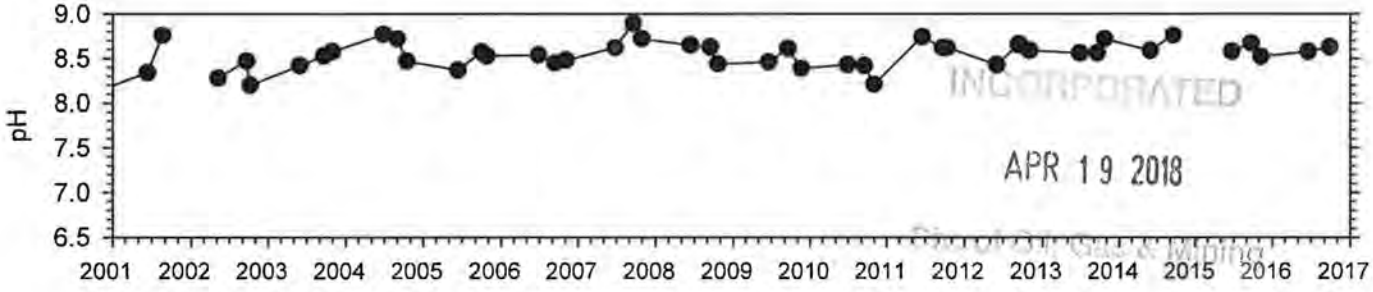


Stream Sufco 006









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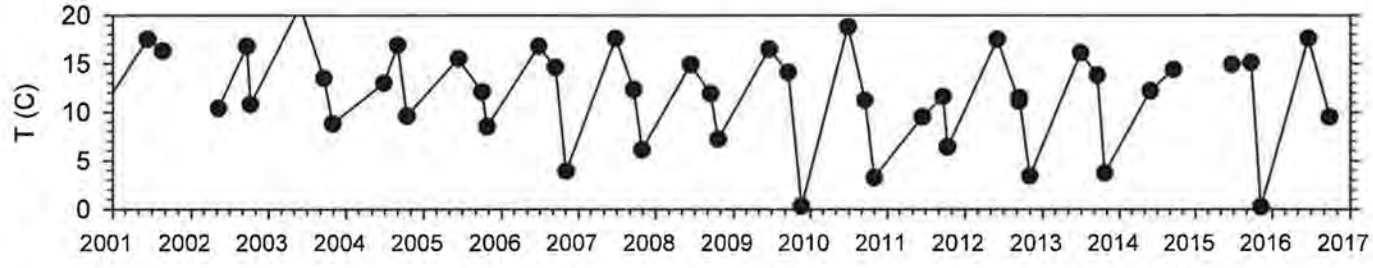
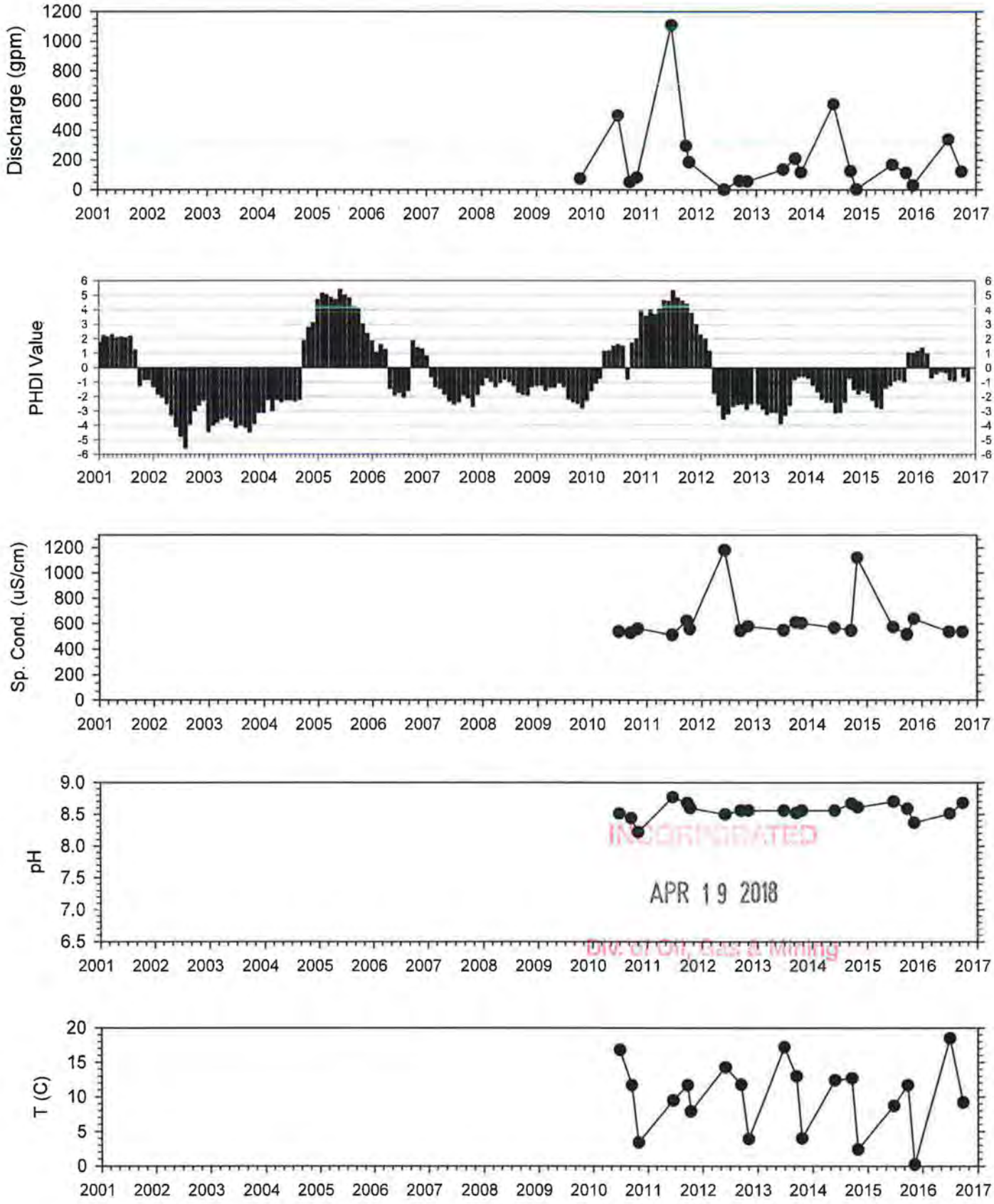


Stream Sufco 006A



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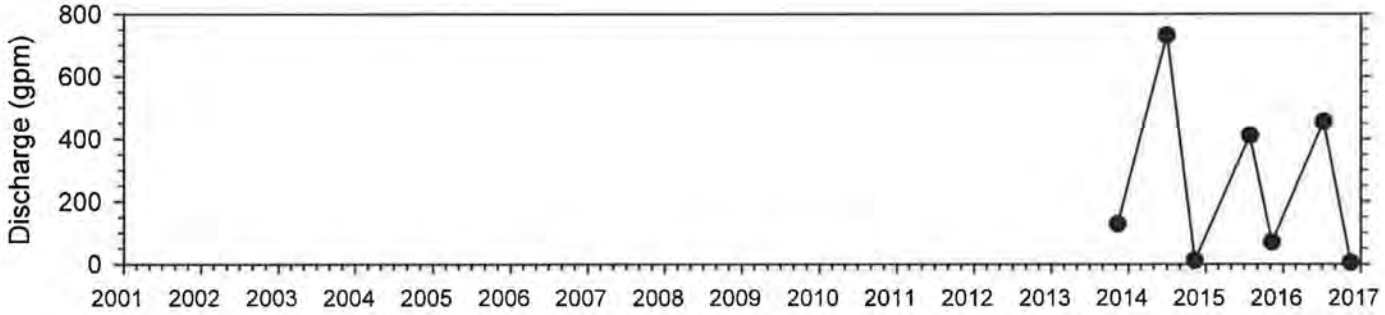
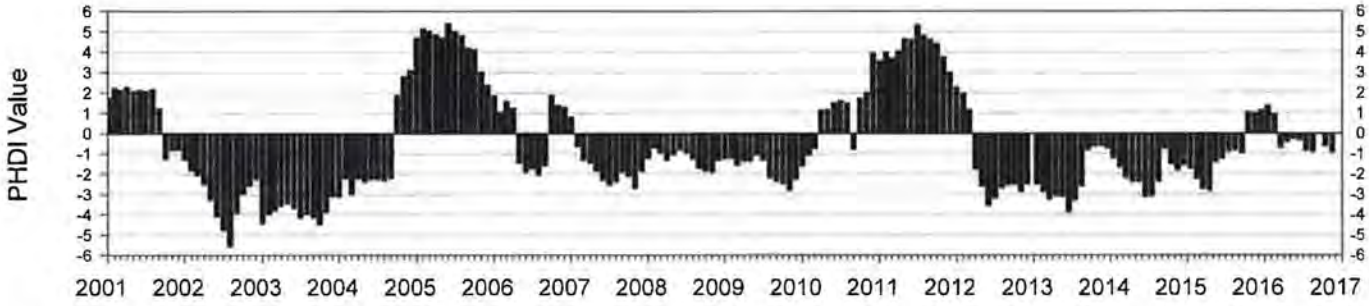
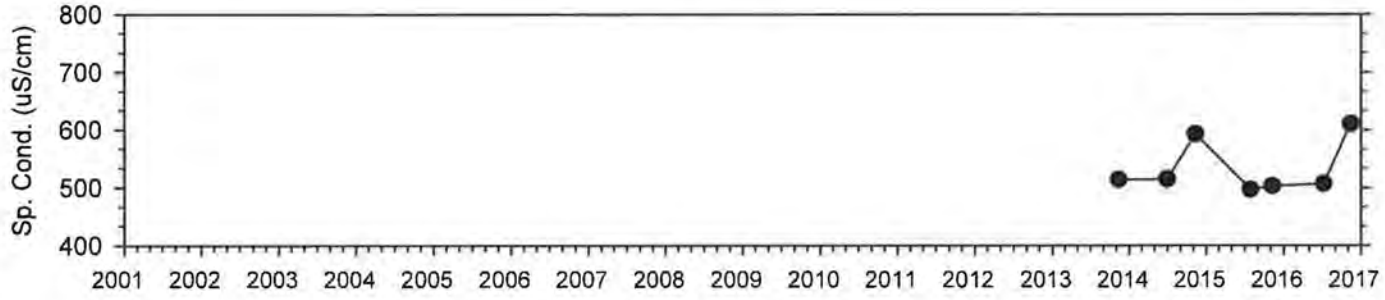
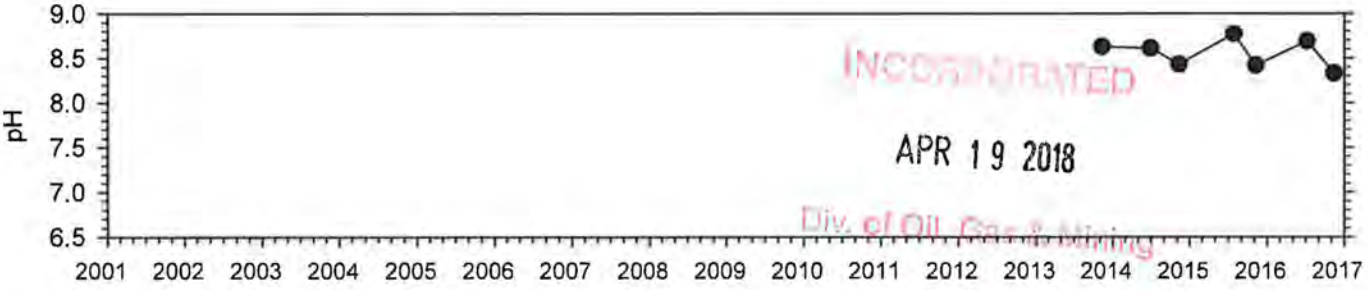
Stream South Fork Quitch. Upper









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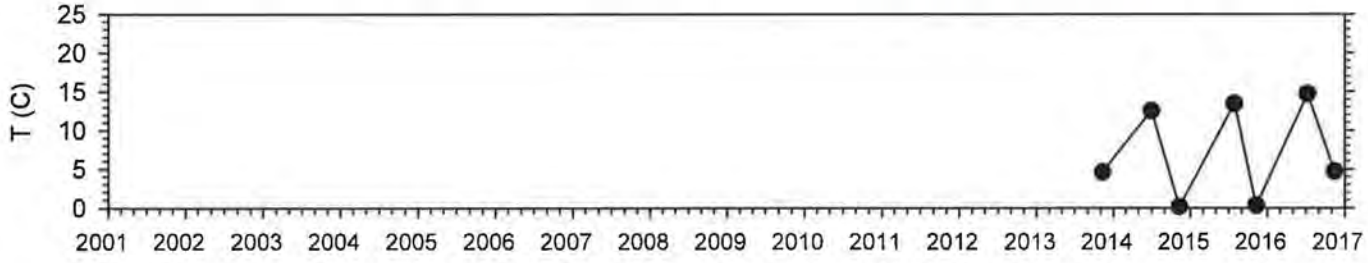
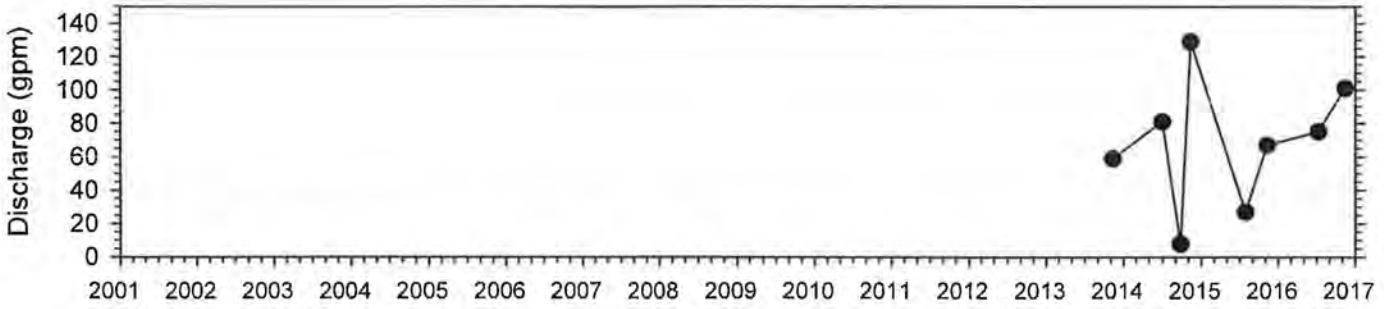
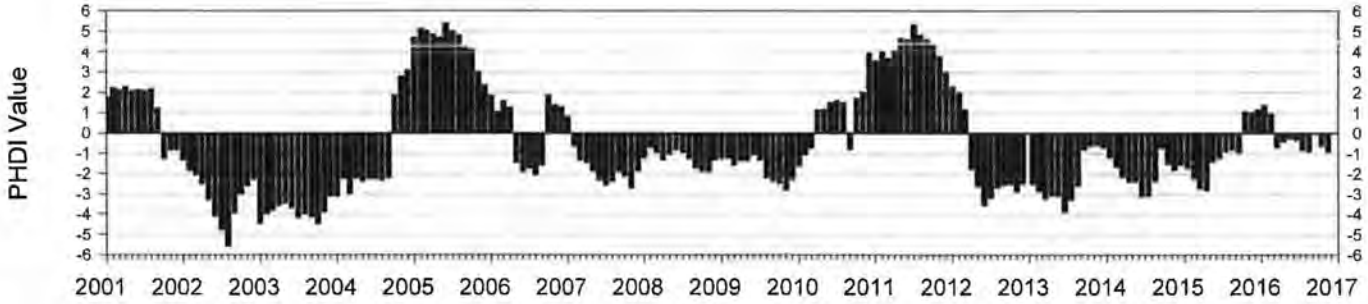
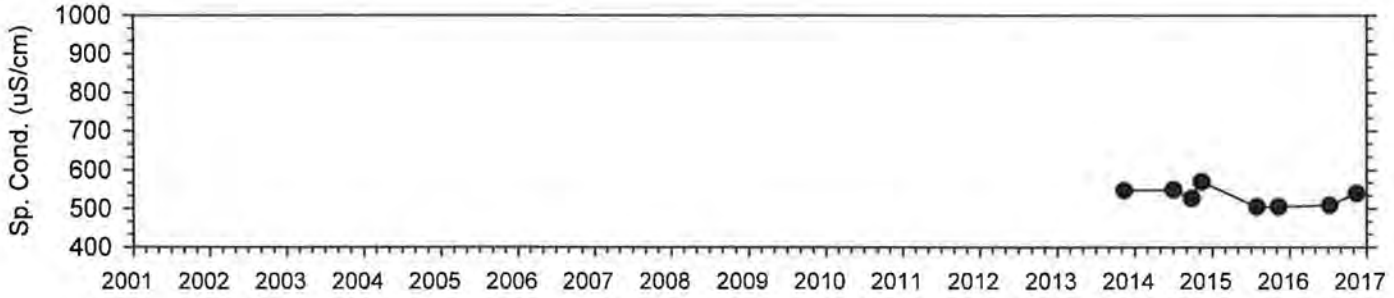


Stream Skutumpah Creek Upper







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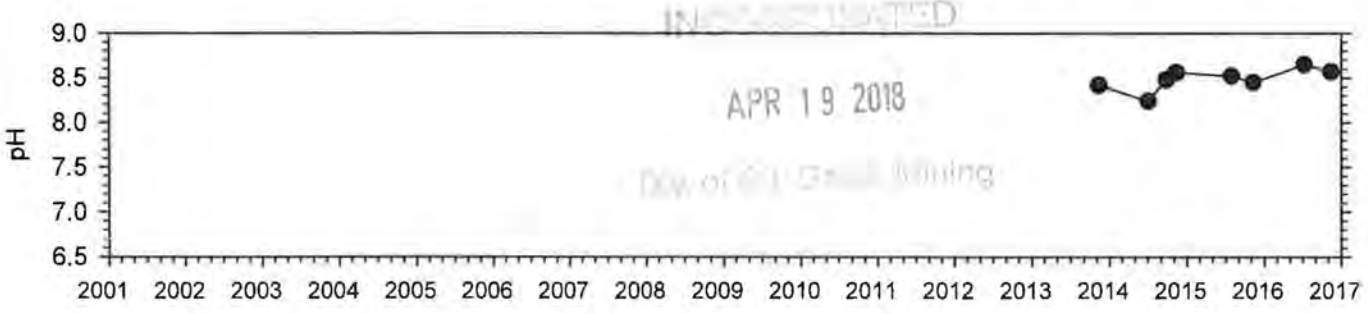

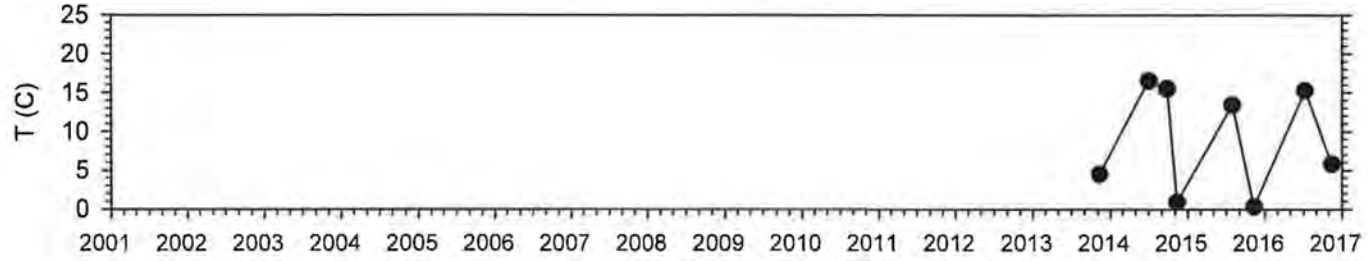

Attachment C

Water-Level hydrographs for selected monitoring wells

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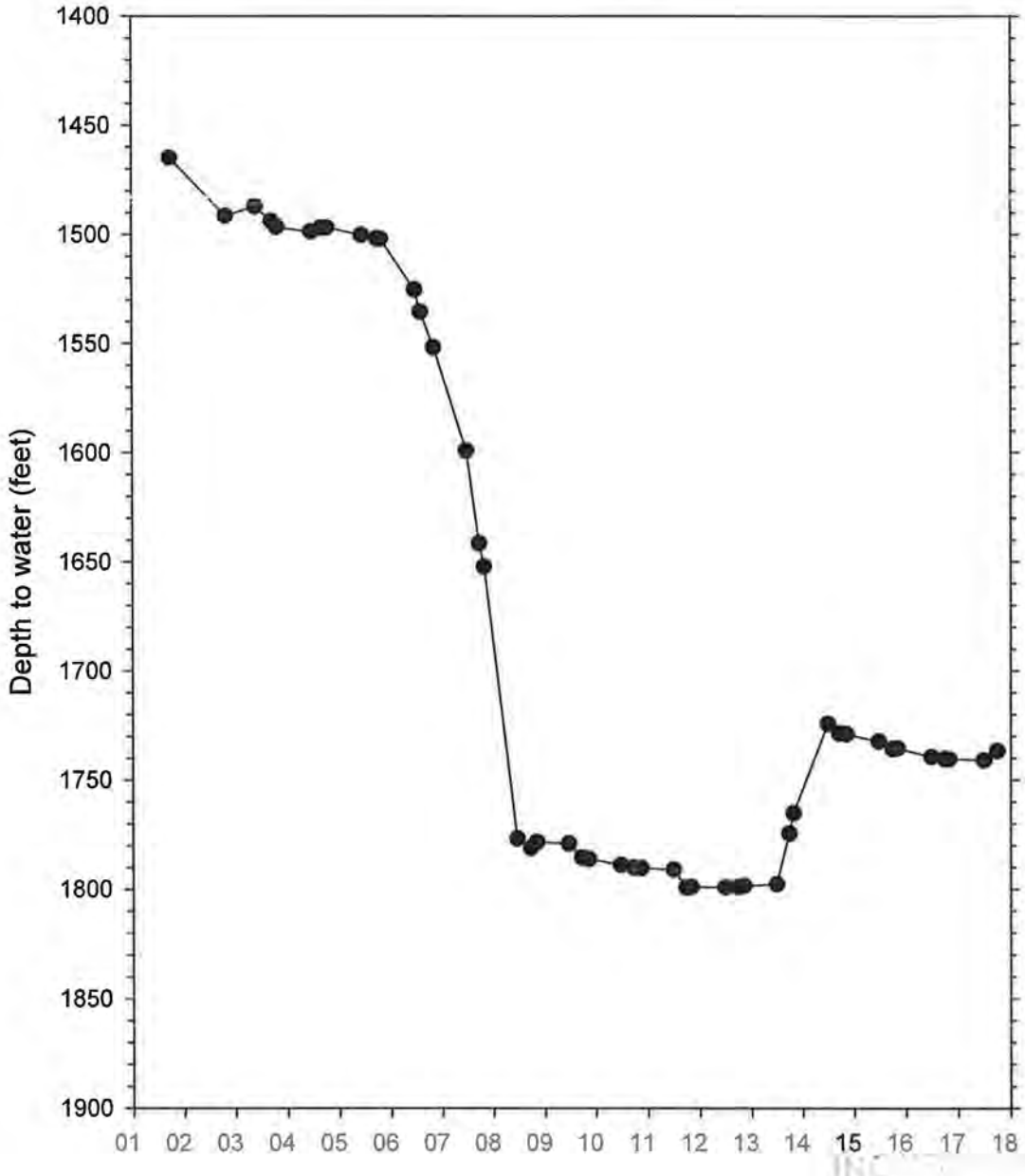
Blackhawk Formation
Monitoring well 01-8-1



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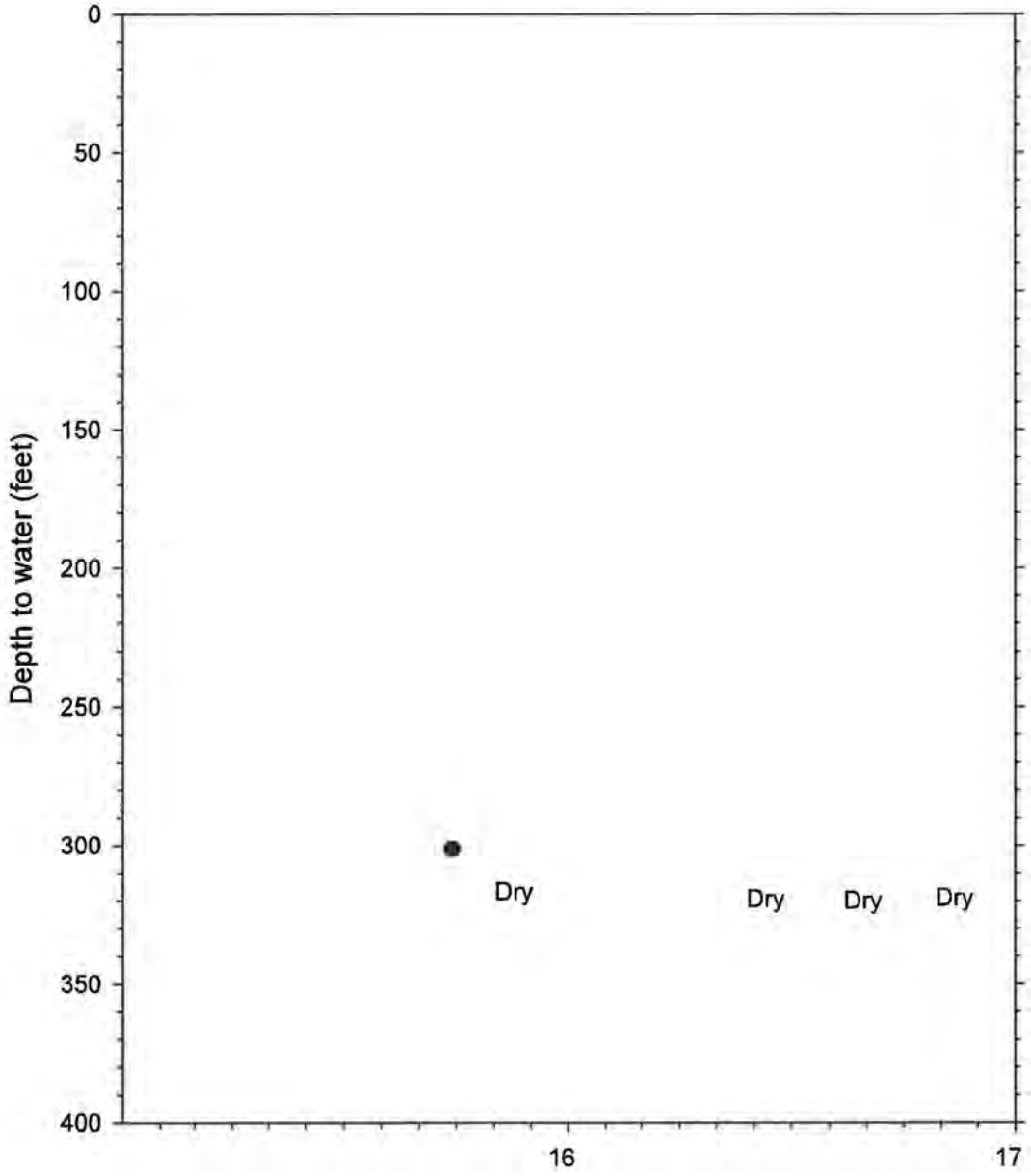
Castlegate Sandstone
Monitoring well MW 15-5-2



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CHAPTER 8

BONDING AND INSURANCE

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8.30 Determination of Bond Amount 8-3
8.40 General Terms and Conditions of the Bond 8-4
8.50 Bonding Requirements for Underground Coal Mining and Reclamation Activities and Associated Coal-Related Surface Facilities and Structures 8-5
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8.80 Requirements to Release Performance Bonds 8-8
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8-1 Certificates of Insurance (Historic)

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8.60 Forms of Bonds

The surety bond for the applicant has been executed per the documentation within the reclamation agreement. The surety bond will be noncancellable during its term except with the prior consent of the Division of Oil, Gas and Mining (UDOGM).

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS) . The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text.

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8.90 Terms and Conditions for Liability Insurance

Certificates of Insurance issued to Canyon Fuel Company LLC, SUFCO Mine are submitted to the Division upon renewal. The policy provides for personal injury and property damage protection concurrent with the amounts designated in R645-301-890.100. Said Certificates of Insurance are applicable to coal mining and reclamation operations as proposed in the SUFCO Mine M&RP.

The insurance policy will be maintained in full force during the life of the permit including the liability period necessary to complete all reclamation operations. The policy will include a rider stating that the UDOGM be notified of any changes in the policy including termination or failure to renew.

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CHAPTER 9

ALLUVIAL VALLEY FLOOR

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3.2.1.2 Studies Performed During Investigation 9-1
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LIST OF PLATES

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9-1 Alluvial Valley Floor Characteristics Determination

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9-1 Environmental Assessment for Quitchupah Lease

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CHAPTER 9
ALLUVIAL VALLEY FLOORS

3.20 Alluvial Valley Floors

All coal mining operations must provide to the UDOGM a determination that the regulations of R645-302-320 do not apply.

3.2.1 Alluvial Valley Floor Determination

This Alluvial Valley Floor (AVF) determination includes field investigations of geologic, hydrologic, land use, soils, and vegetation for all areas where the mine permit or adjacent areas have a valley holding a stream.

3.2.1.2 Studies Performed During Investigation

The studies for AVF determination may include:

- Mapping of unconsolidated stream-laid deposits of areas holding streams, including but not limited to geologic maps of unconsolidated deposits and stream-laid deposits, maps of streams, delineation of surface watersheds and directions of shallow groundwater, topography showing local and regional terrace levels, and topography of terraces, flood plains, and channels showing surface drainage patterns;
- Mapping of all lands included in the permit and adjacent area subject to agricultural activities, showing the areas of different types of agricultural lands, such as flood irrigated lands, pasture lands, and undeveloped rangelands. Also, the productivity measurements for each vegetative type should be included;
- Mapping of all lands that currently are or were historically flood irrigated, showing the location of each diversion structure, ditch, dam, and related reservoir, irrigated land, and topography of those lands;
- Identification of areas which are or are not subirrigated, based on groundwater monitoring data, representative water quality, soil moisture measurements, and measurements of rooting depth, soil mottling, and water requirements of vegetation;

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- Identification of areas which are or are not flood irrigable, based on stream flow, water quality, water yield, soils measurements, and topographic characteristics; and
- Analysis of a series of aerial photographs, including color infrared imagery flown at a time of year to show any late summer and fall differences between upland and valley floor vegetative growth.

Greens Hollow Lease

Much of the information presented for the permitting of the Greens Hollow Lease (GHL) was prepared with a conceptual mine plan assuming full extraction mining, associated subsidence and represents maximum impacts in the Bureau of Land Management's Environmental Impact Statement (FSEIS) . The information in the text represents the permittees accepted obligations and commitments, the information provided in appendices from the (FSEIS) unless reference specifically is provided as background or baseline for the obligations and commitments within the text.

3.2.1.3 Determination of Alluvial Valley Floor Existence

Based on these studies, the UDOGM will determine that an AVF exists if it finds that:

- Unconsolidated stream laid deposits holding streams are present; and,

- There is sufficient water to support agricultural activities as evidenced by:
  - The existence of flood irrigation in the area in question or its historical use;
  - The capability of an area to be flood irrigated, based on stream flow water yield, soils, water quality, and topography; or,
  - Subirrigation of the lands in question, derived from the groundwater system of the valley floor.

As shown on Plate 9-1, the mine permit area consists of plateaus and deep canyons. Evaluation of the mine permit area and UDOGM rules for AVF's show:

1. Unconsolidated stream laid deposits holding streams are present in the following drainages:

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Mine Permit Area, Mine Plan Area and Affected Area (see Plate 9-1)

A. North Fork Quitchupah Creek. This drainage is deep and very steep and is narrow at the bottom. Stream laid deposits are present only in small, discontinuous narrow patches. Bedrock is exposed in much of the canyon bottom and the stream cascades over exposed bedrock outcrops.

B. East Spring Canyon. Characteristics of unconsolidated alluvium are the same as in North Fork Quitchupah Canyon.

C. Duncan Draw. This drainage within the permit boundary is narrow and steep with a few small (less than 1 acre) patches of alluvium present. Bedrock is exposed in much of the drainage.

D. Unnamed tributary to Duncan Draw. (T21S, R5E, Section 31E1½). This drainage is steep, but contains narrow patches of unconsolidated alluvium. This drainage has not been investigated in detail, but areas underlain by unconsolidated alluvium are estimated to aggregate a few acres in size.

E. Unnamed tributaries to East Spring Canyon. These small drainages are east of Section 1, R4E, T22S, and are tributaries to East Spring Canyon (Plate 9-1). These drainages are narrow and steep, but have a few scattered patches of unconsolidated alluvium. No detailed investigation of these drainages has been made, but areas underlain by unconsolidated alluvium are estimated to aggregate only a few acres in size.

F. North Fork Quitchupah Creek downstream from mine permit area. While the canyon is steep and narrow, there are unconsolidated alluvial deposits toward the lower end. Similarly, in the adjacent area at the upper end of North Fork

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Quitchupah Canyon and its South Fork tributary are small narrow areas underlain by consolidated alluvium. None of these deposits have been mapped in detail.

G. Duncan Draw and Mud Springs Hollow. The segments of Duncan Draw and Mud Spring Hollow in the adjacent area contain some small areas underlain by unconsolidated alluvium. Both these canyons are narrow and steep, and probably there are no areas in the canyon where unconsolidated alluvium underlies more than 10 acres.

H. Convulsion Canyon and Quitchupah Creek. These drainages contain narrow deposits of unconsolidated alluvium. The canyon bottoms are narrow, but alluvium may be as much as 75 feet thick. Streams are deeply incised into the alluvium creating steep banks with a narrow stream channel in the bottoms. These unconsolidated deposits have not been mapped in detail.

I. Muddy Creek Canyon. The portion of the Muddy Creek Canyon that is within and adjacent to the Pines Tract is relatively narrow with unconsolidated alluvium. Alluvium in the bottom of the narrow canyon varies in depth from 0 to more than 50 feet thick. Side drainages are deeply incised into the alluvium creating steep banks with narrow stream channel bottoms. These unconsolidated deposits have not been mapped in detail. A few miles downstream of the Pines Tract the alluvial deposits have been irrigated and cultivated in the past.

J. Box Canyon. The drainages associated with Box Canyon have a relatively steep gradient and contain limited very narrow deposits of unconsolidated alluvium. The canyon bottoms are narrow and alluvium is typically less than 15 feet thick. Much of the floor of the channel rests directly on bedrock. These unconsolidated deposits have not been mapped in detail.

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K. Canyons of Greens Hollow Tract. The drainages have a relatively steep gradient and contain limited very narrow deposits of unconsolidated alluvium. The canyon bottoms are narrow and alluvium is shallow. Much of the floor of the channel rests directly on bedrock. These unconsolidated deposits have not been mapped in detail. Refer to the Geologic Fence Diagram in Appendix 6-4.

2. There is no flood irrigation in the mine plan area or the adjacent area and no evidence of historical use of flood irrigation.

3. Flood irrigation may be possible on a few small patches of alluvium in drainages in the mine permit area. Mud Springs Hollow, Duncan Draw, and the uppermost segment of East Spring Canyon all have small areas underlain by alluvium that could be flood irrigated. Due to small size, steepness, water availability, land ownership, and short growing season, these areas are not practical for flood irrigation. In this region, flood irrigation is not practiced in such high mountain drainages.

4. In the adjacent area, flood irrigation may be possible in a few locations. This includes:

A. North Fork Quitchupah Creek and Quitchupah Creek. In the lower segments of these drainages are narrow alluvial deposits. Due to their small size, steepness, deeply incised streams and rough terrain, flood irrigation is not feasible. Regionally, relatively flat, wide drainage bottoms are flood irrigated. Alluvium in drainages with characteristics similar to Quitchupah Creek and its North Fork, however, are not flood irrigated.

B. Duncan Draw, Mud Spring Hollow and small tributaries of the upper segment of North Fork Quitchupah Creek and its South Fork. These drainages may have small areas capable of flood irrigation. Due to small size, steepness, land ownership, and short growing season, these areas are not practical for flood irrigation. In this region, flood irrigation is not practiced in such high mountain drainages.

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C. Muddy Creek Canyon. This drainage may have small areas capable of flood irrigation. These areas are located at least 1 mile downstream of the Pines Tract. Due to the limited areal extent, limited access, steepness, land ownership, short growing season, and difficulty in maintaining a diversion, these areas would not be practical for flood irrigation.

5. Subirrigated lands are present in both the mine permit and adjacent areas where agriculturally useful vegetation is dependent on moisture supplied by groundwater or frequent flood flows. In the mine permit area, small areas (less than 2 acres) are present along Duncan Draw and the uppermost end of East Spring Canyon. Limited subirrigated lands are also present in Box Canyon and its tributaries. There are small, narrow areas where riparian vegetation is present along stream banks that are subirrigated.

In the adjacent area, small areas of subirrigated rangeland are present. The upper segmentof Duncan Draw, Mud Spring Hollow, Convulsion Canyon, and North Fork Quitchupah Creek and its South Fork, and portions of Muddy Creek contain small subirrigated areas. Narrow strips of riparian vegetation present along stream banks are subirrigated.

General Area

A potential AVF exists along portions of Quitchupah Creek from the adjacent area boundary downstream to the general area boundary. This area has not been investigated in detail; however, flood irrigation is practiced on approximately 110 acres and an additional 25 acres may have been irrigated in the past (Plate 9-1). Quitchupah Creek in this segment is deeply incised into the alluvium creating steep banks with a narrow stream channel. Thickness of the alluvium is unknown, but probably is greater than 50 feet.

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3.2.2 Operations Affecting Designated Alluvial Valley Floor

Based on hydrology and geology of the mine permit area and the adjacent area, there appear to be no alluvial valley floors in these areas. A possible AVF exists in the general area along Quitchupah Creek downstream of the adjacent area boundary. Approximately 110 acres are being irrigated at this location (Plate 9-1). There appear to be no other potential alluvial valley floors in the general area.

All of the surface on the Quitchupah Lease is owned by the United States. The surface management agencies (USFS and BLM) have determined that no alluvial valley floors exist on the lease. Their finding is documented on page 6 in the Environmental Assessment for the Quitchupah Lease Tract included as Appendix 9-1.

All of the surface on the Pines Tract Lease is owned by the United States. Based on the above discussions, the Natural Resources Conservation Service Determination on the Pines Tract (located in Appendix 2-1), and the information provided in Chapters 2, 3, 6, and 7, alluvial valley floors are not present within the Pines Tract.

All of the surface on the SITLA Muddy Tract Lease is owned by the United States. Based on the above discussions, and the information provided in Chapters 2, 3, 6, and 7, alluvial valley floors are not present within the SITLA Muddy Tract.

The Greens Hollow Tract Lease is owned by the United States. Based on the above discussions, and the information provided in Chapters 2, 3, 6, and 7, alluvial valley floors are not present within the Tract.

INFORMATION

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EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- MC 100000 MINE COORDINATES
- 2020000 SPC STATE PLANE COORDINATES

SOIL TYPES

7	SHUPERT–WINETTI FAMILIES
20	STRYCH–PATHEAD–WIGGLER FAMILIES
20A	ANDOK–STRYCH–WIGGLER FAMILIES
20X	ANDOK–WELRING FAMILIES
24	RABBITEX–REPP FAMILIES
24A	WHETROCK–DETRA FAMILIES
26	MARA–RABBITEX FAMILIES
35	DETRA FAMILY
57	FALCON FAMILY
107	BUNDO–SCOUT–UINTA FAMILIES
107A	CIRCLEVILLE–SCOUT–PANGUITCH FAMILIES
110	CASTINO–ELWOOD FAMILIES
600	FAIM–CLAYBURN–CASTINO FAMILIES
640	KILDOR FAMILY
715A	CROYDON–MORTENSON FAMILIES
570	LUCKY STAR–PRITCHETT FAMILIES

SOURCE:
COAL TRACT EVALUATIONS ON THE MANTI–LA SAL NATIONAL FOREST
MUDDY TRACT SOILS MAP
MARCH 2004
CIRRUS ECOLOGICAL SOLUTIONS, LC
965 SOUTH 100 WEST, SUITE 200
LOGAN, UTAH 84321
NATIONAL FORESTS SOIL SURVEY DATA
UTM NAD 83 ZONE 12N METERS 2013–2014

PROFESSIONAL ENGINEER No. 9073281 JACOB D. SMITH STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

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REVISIONS

NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	05/08/2007	M.L.D.	B.D.H.	
2	03/02/2015	V.M.	T.R.B.	ADDED 70 ACRE R.O.W. AREA FOR 5 WEST
3	04/26/2016	V.M.	J.G.C.	ADD GREENS HOLLOW & SOUTH FORK LEASE BOUNDARIES
4	12/14/2016	V.M.	J.G.C.	REMOVED SOUTH FORK LEASE BOUNDARY
5	04/12/2017	V.M.	B.R.	GREENS HOLLOW

_TStndrd-SUFENP1.ctb

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

SOIL TYPES
SITLA MUDDY & GREENS HOLLOW TRACT

PEN TBL:		SCALE: 1" = 2000'	DATE: 8/15/2017	DRAWN BY: B.D.H.	ENGINEER:	CHECKED BY: M.L.D.	SHEET NO.
SHT SET: ####	PROJECT NUMBER: ####	FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 2-3.dwg					PLATE 2-3

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

PINES LEASE

QUITCHUPAH LEASE

SURFACE FACILITIES
(NOT A REFERENCE SITE)

QUITCHUPAH LEASE PLANT COMMUNITIES

SOURCE:
SOUTHERN UTAH FUEL COMPANY
CONVULSION CANYON AND QUITCHUPAH TRACTS
VEGETATION MAP
EPS, INC. 129 NORTH 1000 EAST
OREM, UTAH 84057
1 OCTOBER 1991

1. SAGEBRUSH–GRASS
2. GRASS–BLACK SAGEBRUSH
3. MOUNTAIN BRUSH (OAK–SERVICEBERRY MOUNTAIN MAHOGANY, ETC.)
4. ASPEN
5. ASPEN–OAK
6. ASPEN–DOUGLAS FIR–LIMBER PINE
7. MOUNTAIN MAHOGANY–OAK–PONDEROSA PINE
8. DOUGLAS FIR–SPRUCE–LIMBER PINE
9. PINYON–JUNIPER–MOUNTAIN MAHOGANY
10. LIMBER PINE
11. PONDEROSA PINE–MOUNTAIN MAHOGANY–MANZANITA
12. PINYON–JUNIPER–DOUGLAS FIR
13. WIREGRASS–FOXTAIL–HAPLOPAPPUS
14. DOUGLAS FIR–SPRUCE–LIMBER PINE–ASPEN
15. LIMBER PINE–MOUNTAIN MAHOGANY–SERVICEBERRY
16. MOUNTAIN MAHOGANY
17. PINYON–JUNIPER
18. DOUGLAS FIR & OTHER
19. RIPARIAN
20. PONDEROSA PINE–DOUGLAS FIR–ASPEN–SERVICEBERRY

LEASE PLAN COMMUNITIES

SOURCE:
FISHLAKE NATIONAL FOREST VEGETATION GROUPS
MANTI–LA SAL NATIONAL FOREST
FES FIGURE 3–10 VEGETATION TYPES
JANUARY 1999
MANTI–LA SAL NATIONAL FOREST
FEIS, FIGURE 4–6 DECEMBER 2011

21. GRASSLAND PERENNIAL FORBS
22. SAGEBRUSH
23. MOUNTAIN BRUSH – SHRUBS
24. CONIFER TIMBER
25. MIXED CONIFER
26. BARREN GROUND
27. ASPEN – DECIDOUS FOREST
28. ASPEN – MIXED CONIFER
29. COTTONWOOD – BRUSH
30. PINYON – JUNIPER
31. GAMBEL OAK – OAK BRUSH
32. MOUNTAIN MAHOGANY
33. JUNIPER – MAHOGANY – WOODLAND
34. PONDEROSA PINE
35. ASPEN
36. FIR FOREST
37. PINE FOREST
38. HIGH MOUNTAIN BRUSH
39. RIPARIAN – WETLANDS – MEADOW
40. MANZANITA
41. PERENNIAL FORB LAND (ELEVATION MID–LOW)
42. PERENNIAL GRASSLAND (LOW ELEVATION)
43. PERENNIAL GRASSLAND (MID ELEVATION)
44. INTERMITTENT WET – DRY MEADOW
45. WILLOW – DOMINATED RIPARIAN

SITLA MUDDY LEASE PLANT COMMUNITIES

SOURCE:
MT NEBO SCIENTIFIC, INC.
RESEARCH & CONSULTING
330 EAST 400 SOUTH, SUITE 6
SPRINGVILLE, UTAH 84663
PATRICK D. COLLINS Ph.D. JANUARY 30, 2008

60. SAGEBRUSH/GRASS
61. MOUNTAIN BRUSH
62. MOUNTAIN HERBLANDS
63. OAK BRUSH
64. PINYON–JUNIPER
65. ASPEN
66. CONIFER

EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- 100000 MC — MINE COORDINATES
- 2020000 SPC — STATE PLANE COORDINATES
- VEGETATION SAMPLE SITE
- 22 — SOIL SAMPLE SITE
- (12) — VEGETATION SAMPLE NUMBER
- RIPARIAN AREAS
- * — SINK HOLE REFERENCE AREA

2000 0 2000

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Div. of Oil, Gas & Mining

PROFESSIONAL ENGINEER
No. 9073281
JACOB D. SMITH
STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
9	03/02/2015	V.M.	T.R.B.	ADDED 70 ACRE R.O.W. AREA FOR 5 WEST
10	07/13/2016	V.M.	J.G.C.	ADD GREENS HOLLOW & SOUTH FORK LEASE BOUNDARIES
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12	04/12/2017	V.M.	B.R.	GREENS HOLLOW

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286–4880 Phone
(435) 286–4499 Fax

PLANT COMMUNITIES AND SAMPLING AREA

PEN TBL:					
_Slsdvl-SUFEXPLot.ctb					
SHT SET:	PROJECT NUMBER:	SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
####	####	1" = 2,000'	12/14/2017	B.D.H.		M.L.D.	PLATE 3–1

FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 3–1.dwg

C - E - SU

H - E - W

GREENS HOLLOW LEASE

C - E - SU

H - E - WT

C - E - WT

H - E - WT

C - E - SU

C - E - SU

SITLA MUDDY LEASE

C - E - WT

C - E - WT

PINES LEASE

H - E - WT

C - E - CA

H - E - SU

I - E - WT

C - E - WT

H - E - SU
6/1 - 8/15

C - E - CA
5/1 - 7/1

QUITCHUPAH LEASE

C - E - CA
5/1 - 7/1

I - E - WT

H - E - SU
6/1 - 8/15

H - E - WT

C - E - CA
5/1 - 7/1

C - E - CA
5/1 - 7/1

I - E - WT

I - E - WT

H - E - WT

H - E - WT

EXPLANATION

	SUFCO EXTERIOR LEASE BOUNDARY
	SUFCO INTERIOR LEASE BOUNDARY
100000 MC	MINE COORDINATES
2020000 SPC	STATE PLANE COORDINATES
C - E - CA	CRITICAL ELK CALVING AREA
C - E - SU	CRITICAL ELK SUMMER RANGE
C - E - WT	CRITICAL ELK WINTER RANGE
H - E - SU	HIGH PRIORITY ELK SUMMER RANGE
H - E - WT	HIGH PRIORITY ELK WINTER RANGE
I - E - WT	LIMITED USE ELK WINTER RANGE
	CRITICAL ELK CALVING AREA BOUNDARY (WEST OF BOUNDARY LINE)
	HIGH PRIORITY SUMMER RANGE BOUNDARY
	HIGH PRIORITY WINTER RANGE BOUNDARY
5/1 – 7/1	PERIOD OF HEAVIEST RANGE USE
X	GUZZLER

SOURCES:

1. QUITCHUPAH TRACT
   DIVISION OF WILDLIFE RESOURCES
   CEDAR CITY, UTAH
   PAMELA HILL, NOV. 12, 1991
2. PINES TRACT
   DIVISION OF WILDLIFE RESOURCES
   PRICE, UTAH
   PINES TRACT CRITICAL/HIGH VALUE ELK RANGES MAP
   CHRIS COLT, FEB. 27, 1999
3. SITLA MUDDY TRACT
   COAL TRACT EVALUATIONS ON THE MANTI–LA SAL NATIONAL FOREST
   MUDDY TRACT ELK RANGE
   MARCH 2004
   CIRRUS ECOLOGICAL SOLUTIONS, LC
   965 SOUTH 100 WEST, SUITE 200
   LOGAN, UTAH 84321

PROFESSIONAL ENGINEER
No. 6073281
JACOB D. SMITH
STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

2000 0 2000

INCORPORATED
APR 19 2018
Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
7	03/02/15	V.M	T.R.B	ADDED 7 ACRE R.O.W AREA FOR S WEST BOUNDARY
8	07/25/16	V.M.	T.R.B	ADD GREEN HOLLOW AND SOUTH FORK LEASE
9	12/14/16	V.M.	T.L.M	REMOVE SOUTH FORK LEASE BOUNDARY
10	04/12/2017	V.M.	B.R.	GREENS HOLLOW

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286–4880 Phone
(435) 286–4499 Fax

ELK RANGE

PEN TBL:	SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
JShadrd-SUFDP1.ctb	1" = 2,000'	12/14/2017	A.D.D.		M.L.D.	PLATE 3–2
SHT SET: ####	PROJECT NUMBER: ####	FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 3–2.dwg				

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

PINES LEASE

QUITCHUPAH LEASE

DISTURBED AREA BOUNDARY

SITLA MUDDY TRACT

FOREST MANAGEMENT UNITS

EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- 100000 MC — MINE COORDINATES
- 2020000 SPC — STATE PLANE COORDINATES

	FOREST MANAGEMENT UNIT BOUNDARY
GWR	GENERAL BIG GAME WINTER RANGE
TBR	LIMITED TIMBERING, INCLUDES GRAZING
RNG	RANGELAND/GRAZING
MMA	LEASABLE MINERAL DEVELOPMENT
ILM	INTERMEDIATE LOGGING MANAGEMENT
MMA	LEASABLE MINERAL DEVELOPMENT

SOURCE:
SOUTHERN UTAH FUEL COMPANY
CONVULSION CANYON AND QUITCHUPAH TRACTS
FOREST MANAGEMENT UNITS MAP
EPS, INC. 129 NORTH 1000 EAST
OREM, UTAH 84057
1 OCTOBER 1991

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

PROFESSIONAL ENGINEER — No. 9073281 — JACOB D. SMITH — STATE OF UTAH

1000 0 1000

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APR 19 2018
Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
6	06/11/10	M.L.D.	K.B.B.	
7	07/14/16	V.M.	J.G.C	ADD GREEN HPLLOW & SOUTH FORK LEASE BOUNDARY
8	12/15/16	V.M.	T.L.M.	REMOVE SOUTH FORK LEASE BOUNDARY
9	04/12/2017	V.M.	B.R.	GREENS HOLLOW

PEN TBL: ~~Slate~~ SUFDP1.ctb
SHT SET: ####
PROJECT NUMBER: ####

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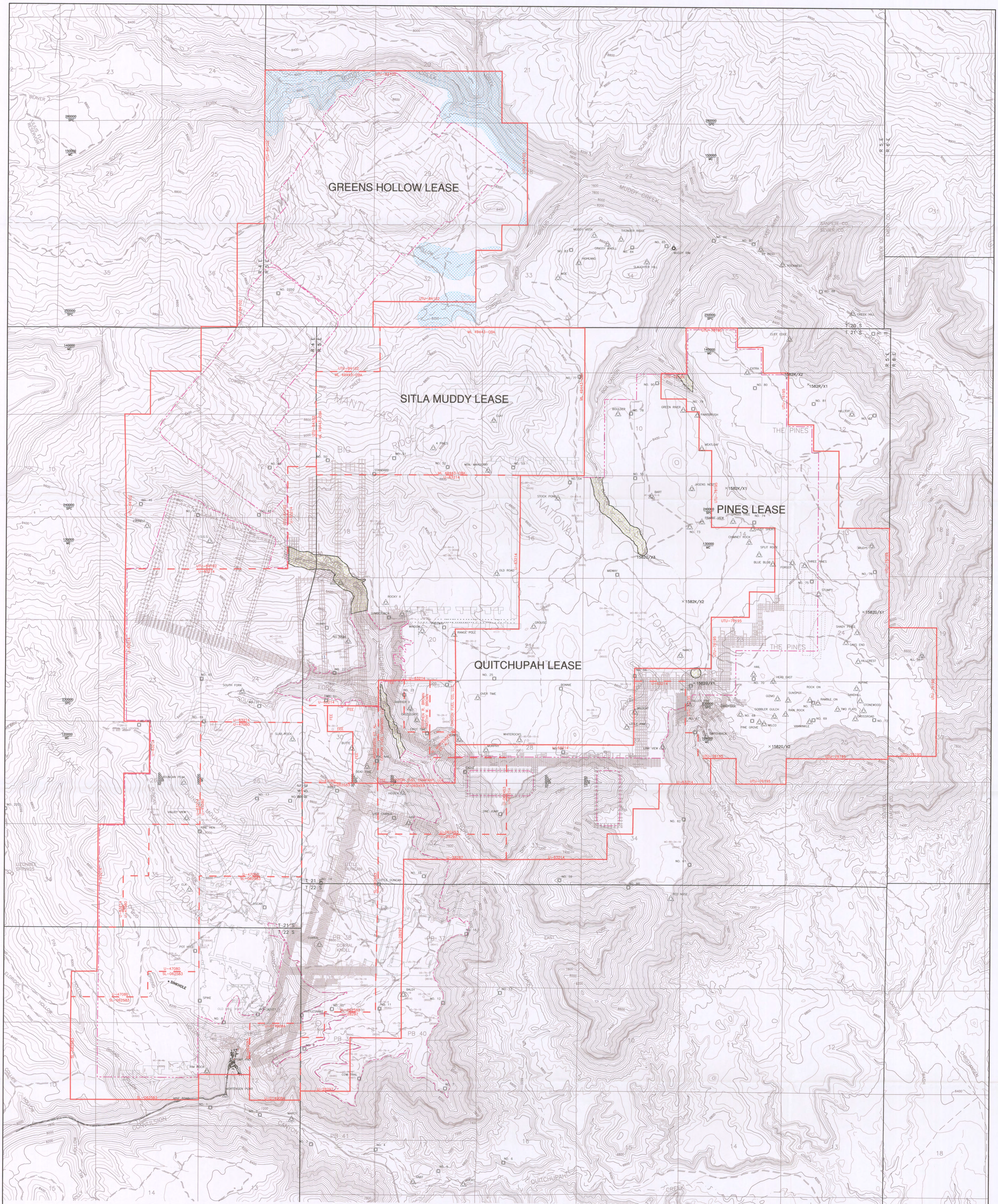
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

LAND USES – SITLA MUDDY AND GREENS HOLLOW TRACT

SCALE: 1" = 1,500' | DATE: 12/14/2017 | DRAWN BY: A.D.D. | ENGINEER: | CHECKED BY: J.D.B.
FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 4-1C.dwg
SHEET NO.: PLATE 4-1C

Plotdate: 12/14/2017 10:53 AM



EXPLANATION

SUFCO EXTERIOR LEASE BOUNDARY
SUFCO INTERIOR LEASE BOUNDARY
100000 / MC — MINE COORDINATES
2020000 / SPC — STATE PLANE COORDINATES
CONTROL POINT
AERIAL TARGET
LIMIT OF POTENTIAL SUBSIDENCE
UNDERGROUND PERENNIAL STREAM AND PROTECTED CULTURAL SITE BUFFER CORRIDOR
SUBSIDENCE EXCLUSION AREA

PROFESSIONAL ENGINEER
No. 9073281
JACOB D. SMITH
STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

1000 0 1000

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APR 19 2018
Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	08/13/09	MLD	KBB	
2	07/13/2016	V.M.	J.G.C.	ADD GREENS HOLLOW & SOUTH FORK LEASE
				BOUNDARIES
3	4/18/2017	V.M.	B.R.	GREENS HOLLOW
4	12/08/2017	V.M.	B.R.	Add 3R4E and 4R4E Panel
5	3/19/18	V.M.	B.R.	Greens Hollow Technical Analysis

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

POTENTIAL SUBSIDENCE LIMITS SITLA MUDDY & GREENS HOLLOW TRACT

SCALE:	DATE:	DRAWN BY:	ENGINEER:	SHEET NO.
1" = 1000'	08/13/09	JMB		PLATE 5–10 GH
CHECKED BY: WKS	FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 5–10 GH.dwg			

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

QUITCHUPAH LEASE

PINES LEASE

EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- 1000000 MC — MINE COORDINATES
- 2000000 SPC — STATE PLANE COORDINATES

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

PROFESSIONAL ENGINEER
No. 9073281
JACOB D. SMITH
STATE OF UTAH

2000 0 2000

INCORPORATED
APR 19 2018
Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
6	12/15/2016	V.M.	T.L.M.	REMOVE SOUTH FORK LEASE BOUNDARY
7	4/18/2017	V.M.	B.R.	GREENS HOOLOW
8	10/18/2017	B.B.	B.R.	Add 4R4E Panel
9	3/27/2018	V.M.	B.R.	GREENS HOLLOW TECHNICAL ANALYSIS

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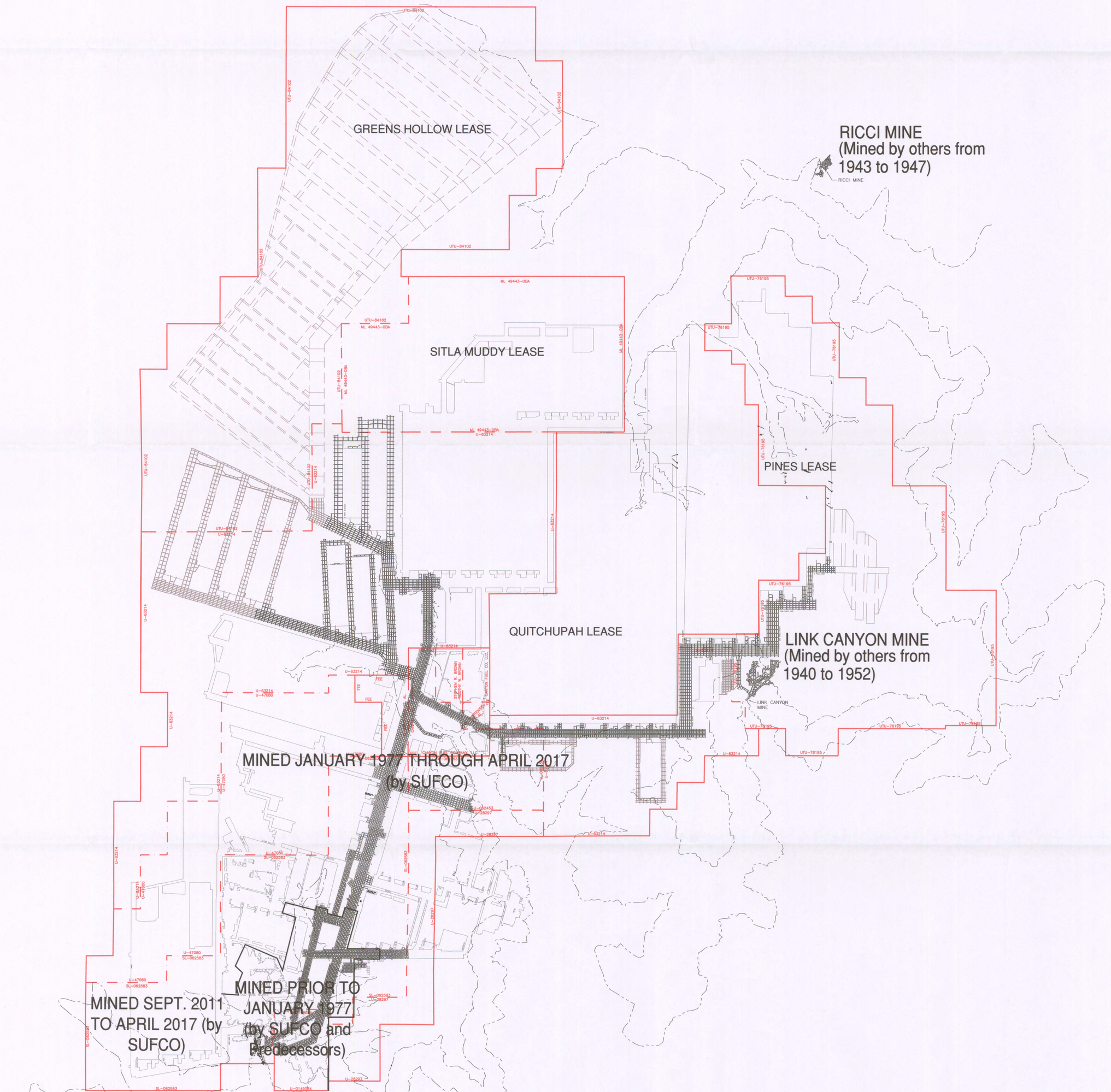
597 South SR 24 ~ Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

OVERBURDEN ISOPACH MAP

PEN TBL:	SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
_ISIndd-SUFDNP1.ctb	1" = 2,000'	01/20/2005	BDH/TRB	JDB	VM	PLATE 5-11 GH
SHT SET: ### / PROJECT NUMBER: ###	FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. - 1-1-18\PLATE 5-11 GH.dwg					



EXPLANATION

- MINED AREA BOUNDARY
- OUTCROP
- ESCARPMENT
- EXTERIROR LEASE BOUNDARY
- INTERIOR LEASE BOUNDARY

PROFESSIONAL ENGINEER
No. 9073281
JACOB D. SMITH
STATE OF UTAH

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2000 0 2000

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APR 19 2018
Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	06/18/1999	M.L.D.	B.D.H.	
2	01/20/2005	M.L.D.	B.D.H.	
3	05/08/2007	M.L.D.	K.B.B.	
4	06/11/2010	M.L.D.	K.B.B.	
5	03/02/2015	V.M.	T.R.B.	ADDED 70 ACRE R.O.W. AREA FOR 5 WEST
6	4/12/2017	V.M.	B.R.	GREENS HOLLOW
7	3/27/18	V.M.	B.R	GREENS HOLLOW TECHNICAL ANALYSIS

PEN TBL: \Stnd-SUFCMP1.ctb
SHT SET: ####
PROJECT NUMBER: ####

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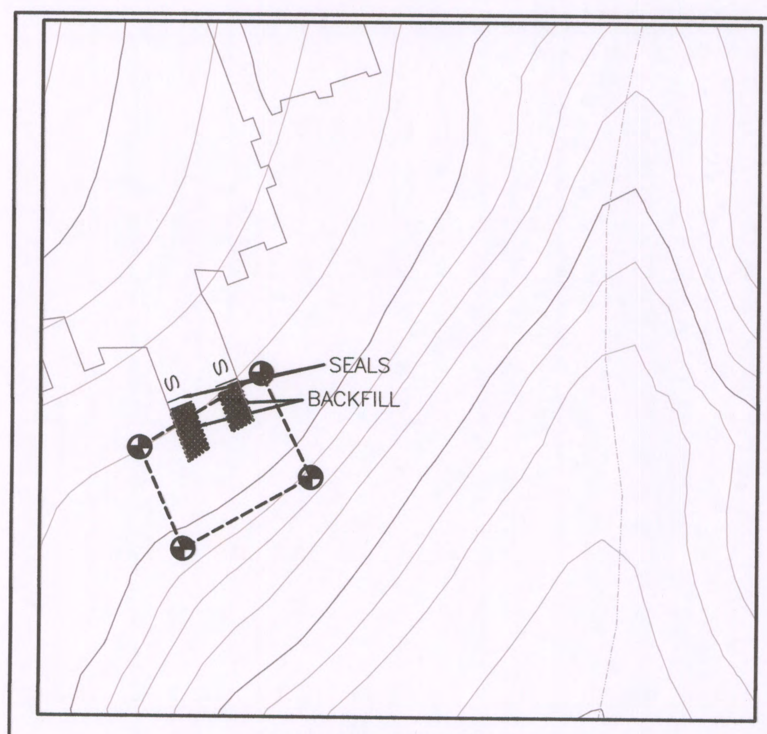
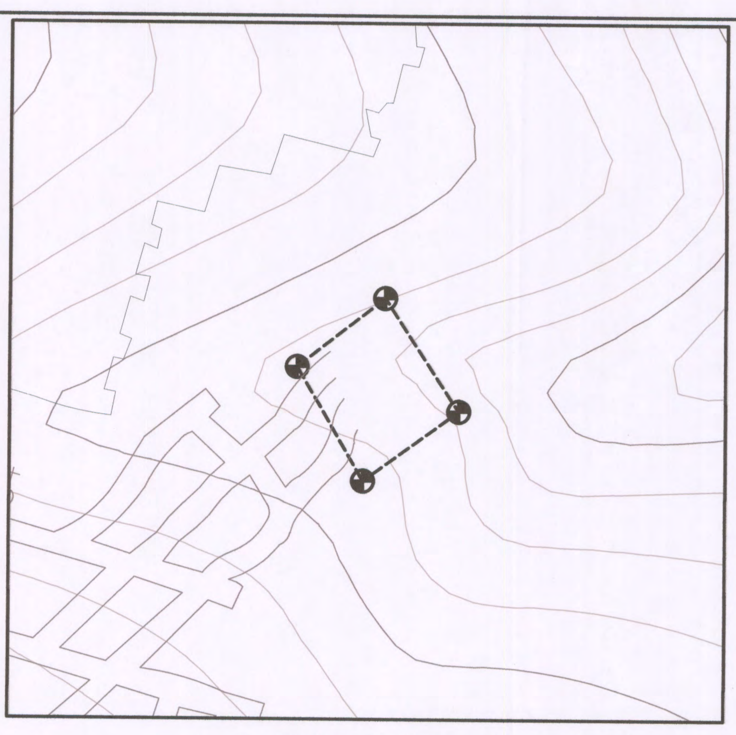
PREVIOUSLY MINED AREAS

SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
1" = 2,000'	3/27/2018	A.D.D.		M.L.D.	PLATE 5-1 GH

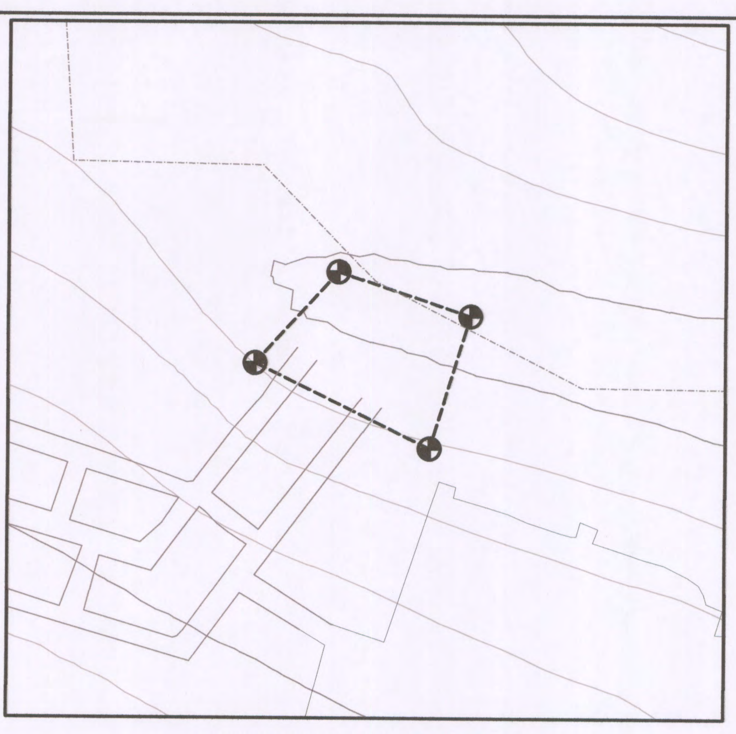
FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. – 1-1-18\PLATE 5-1 GH.dwg



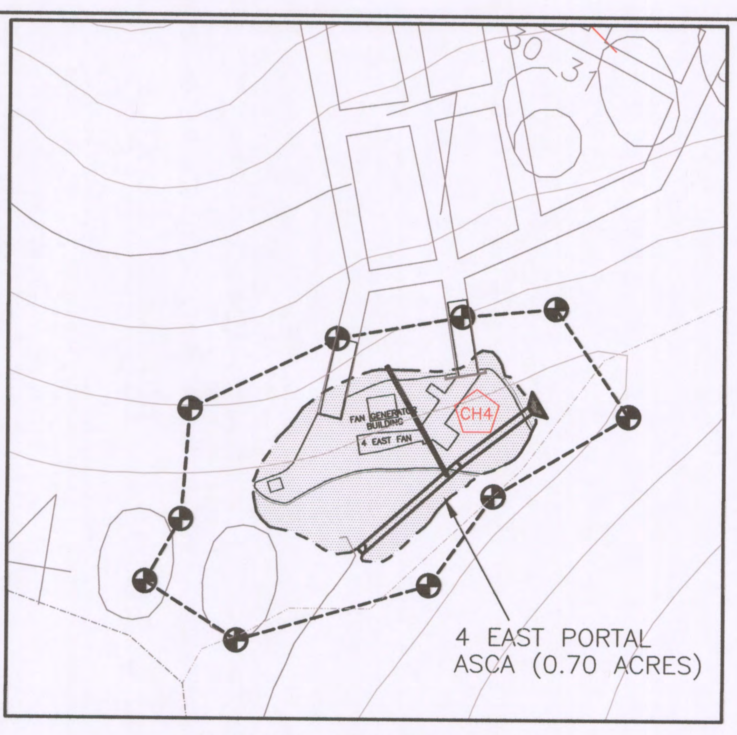
SOUTH PORTALS
SCALE: 1" = 100'



3 EAST PORTALS
SCALE: 1" = 100'

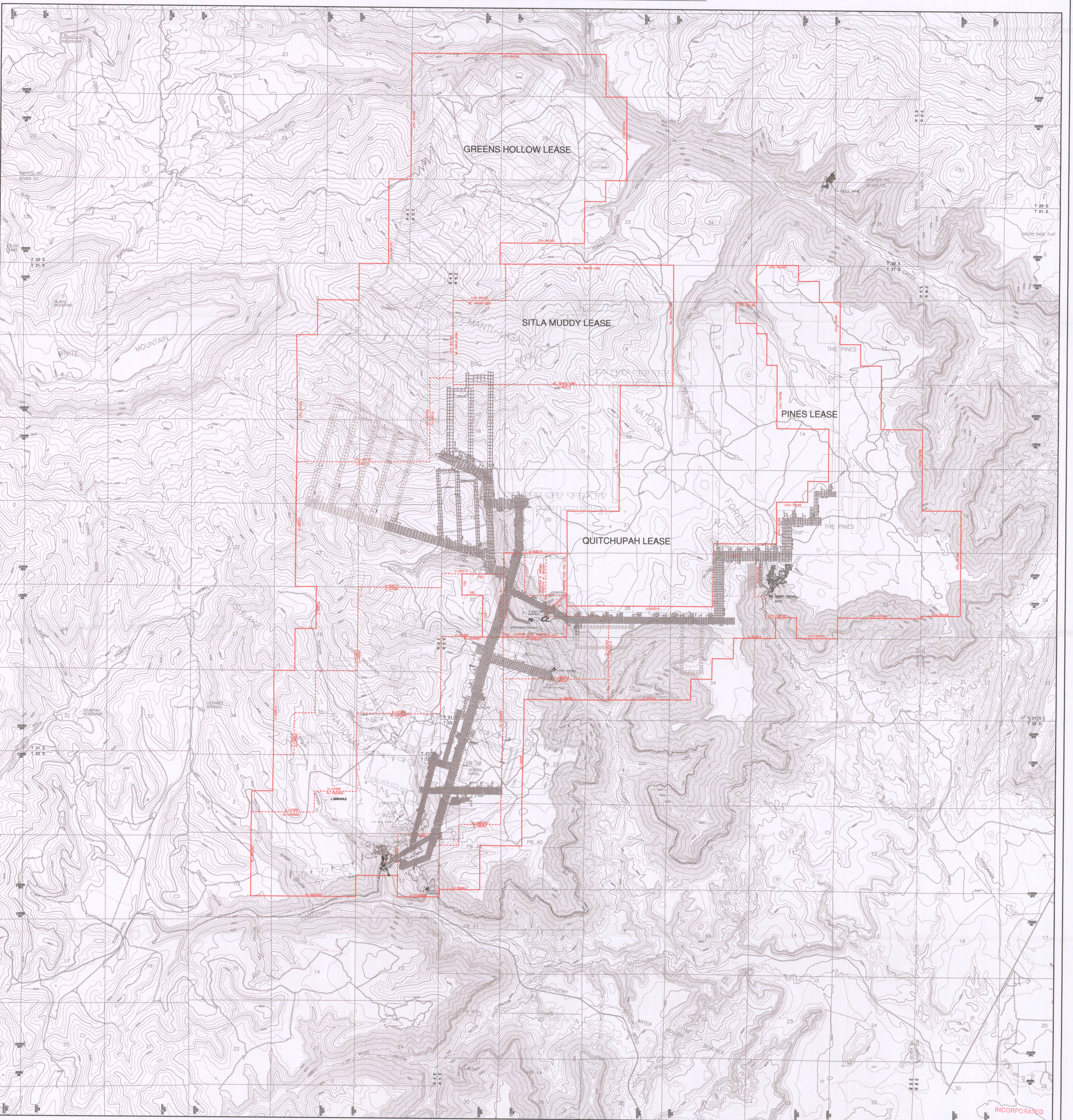


QUITCHUPAH PORTALS
SCALE: 1" = 100'



4 EAST FAN PORTALS
SCALE: 1" = 100'

SURFACE PORTAL FACILITIES – PRE MINING AND POST MINING TOPOGRAPHY



EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- MINE COORDINATES (100000 MC)
- STATE PLANE COORDINATES (2020000 SPC)
- STREAM
- ESCARPEMENT
- OUTCROP
- PERENNIAL STREAM
- DISTURBED AREA BOUNDARY
- DISTURBED AREA BOUNDARY MARKER
- DRAIN LINE
- ALTERNATE SEDIMENT CONTROL AREA (ASCA)

PROFESSIONAL ENGINEER No. 9073281 JACOB D. SMITH STATE OF UTAH

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2000 0 2000

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
10	03/02/15	V.M	T.R.B.	ADDED 70 ACRE R.O.W AREA FOR 5 WEST
11	07/13/16	V.M.	J.G.C.	ADDED GREENS HOLLW & SOUTH FORK LEASE BOUNDARY
12	12/15/16	V.M.	T.L.M.	REMOVED SOUTH FORK LEASE BOUNDRAY
13	4/13/2017	V.M.	B.R.	GREENS HOLLOW
14	10/18/2017	B.B	B.R.	Add 4R4E Panel
15	3/27/2018	V.M.	B.R	GREENS HOLLOW TECHNICAL ANALYSIS

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

DETAIL OF PORTAL SURFACE FACILITIES

PEN TBL: _1Stndrd-SUFENP1.ctb
SHT SET: ####
PROJECT NUMBER: ####
SCALE: 1" = 2,000'
DATE: 03/01/2000
DRAWN BY: B.D.H.
ENGINEER:
CHECKED BY: M.L.D.
FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 5-8.dwg
SHEET NO. PLATE 5-2C

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

PINES LEASE

QUITCHUPAH LEASE

SEE PLATE 5-2A FOR SURFACE FACILITIES AND SEDIMENT POND DETAILS.

WASTE ROCK FACILITY APPROX. 5.3 MILES

EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- MINE COORDINATES
- STATE PLANE COORDINATES
- RUNOFF POND
- NATURAL POND
- STOCK WATERING TROUGH
- TRAIL
- UNIMPROVED ROAD
- IMPROVED ROAD
- FENCE

INCORPORATED
APR 19 2018
Div. of Oil, Gas & Mining

PROFESSIONAL ENGINEER
No. 9073291
JACOB D. SMITH
STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

2000 0 2000

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
6	03/02/15	V.M.	T.R.B.	ADDED 70 ACRE R.O.W. AREA FOR 5 WEST BOUNDARY
7	07/13/16	V.M.	J.G.C.	ADD GREENS HOLLOW & SOUTH FORK LEASE
8	12/15/16	V.M.	T.L.M.	REMOVE SOUTH FORK LEASE BOUNDARY
9	4/13/2017	V.M.	B.R.	GREENS HOLLOW

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 - Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

EXISTING SURFACE AND SUBSURFACE FACILITIES AND FEATURES

PEN TBL:	SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
_10subd-SUFENP1.ctb	1" = 2,000'	1/9/2018	A.D.D.		J.D.B.	PLATE 5-5
SHT SET: ####	PROJECT NUMBER: ####	FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 5-5.dwg				

Wednesday, 1/9/2018 11:31 AM

GREENS HOLLOW LEASE

UNITED STATES

SITLA MUDDY LEASE

QUITCHUPAH LEASE

PINES LEASE

NORTHWATER MITIGATION AREA

QUITCHUPAH PORTALS

CANYON FUEL COMPANY, LLC

4 EAST PORTALS

3 EAST PORTALS

LINK CANYON PORTAL

LINK CANYON SUBSTATION NO. 2

LINK CANYON SUBSTATION NO. 1

WATER TANK

MINE SITE

SOUTH PORTALS PUMP HOUSE

SPRING COLLECTION FIELD

DRAIN FIELD

SPECIAL USE AREAS

WASTE ROCK DISPOSAL SITE

U-47080 SL-062583 ● SINKHOLE

NOTES:

1. "LEASE AREA" INCLUDES ALL FEDERAL COAL LEASES, STATE COAL LEASES, FEE LANDS AND U.S.F.S. SPECIAL USE PERMIT (SUP) AREAS SHOWN ON THIS MAP.
2. SEE VOLUME 3 REGARDING OWNERSHIP AT WASTE ROCK DISPOSAL SITE.
3. SEE PLATE 5-2A REGARDING MINESITE AREA DETAIL.
4. SEE PLATE 5-2B REGARDING U.S.F.S. SPECIAL USE AREA DETAIL.
5. SEE PLATE 5-2C REGARDING PORTAL AREA DETAIL.
6. SEE PLATE 5-2D REGARDING LINK CANYON SUBSTATION NO. 1 AREA DETAIL.
7. SEE PLATE 5-2E REGARDING LINK CANYON SUBSTATION NO. 2 AREA DETAIL.
8. SEE PLATE 5-2F REGARDING LINK CANYON PORTAL AREA DETAIL.

LAND AND MINERAL OWNERSHIP

LAND	MINERAL
UNITED STATES	STATE OF UTAH
UNITED STATES	UNITED STATES
VARIOUS OWNERS (AS SHOWN)	CANYON FUEL COMPANY, LLC
STATE OF UTAH	UNITED STATES
U.S.F.S. SPECIAL USE AREA	UNITED STATES

EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- DISTURBED BOUNDARY
- SPECIAL USE PERMIT BOUNDARY
- 100000 MC — MINE COORDINATES
- 2020000 SPC — STATE PLANE COORDINATES
- BONDED MITIGATION AREA

LEASE AREA

16,954.56 ACRES FEDERAL COAL LEASES
2,294.19 ACRES UTAH STATE COAL LEASES
640.00 ACRES FEE COAL LEASES
240.00 ACRES WASTE ROCK DISPOSAL SITE
28.50 ACRES U.S.F.S. SPECIAL USE PERMITS
70.00 ACRES B.L.M. RIGHT-OF-WAY
20,227.25 ACRES TOTAL LEASE AREA

ADJACENT AREA

1. BIOLOGY ADJACENT AREA IS A 0.5 MILE BUFFER AROUND ALL SURFACE DISTURBANCES.
2. SEE CHIA FOR HYDROLOGIC ADJACENT AREA BOUNDARY.

PROFESSIONAL ENGINEER No. 9073281 JACOB D. SMITH STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

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INCORPORATED
APR 19 2018
Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
20	03/02/15	T.R.B.	J.G.C.	ADDED 70 ACRE R.O.W AREA FOR 5 WEST
21	07/14/16	V.M	J.G.C	ADD GREENS HOLLOW & SOUTH FROK LEASE BOUNDARY
22	12/14/16	V.M	T.L.M.	REMOVE SOUTH FORK LEASE BOUNDARY
23	02/28/17	V.M.	B.R.	UPATED WASTE ROCK PERMIT BOUNDARY
24	04/13/2017	V.M.	B.R.	GREENS HOLLOW
25	3/27/2018	V.M.	B.R.	GREENS HOLLOW TECHNICAL ANALYSIS

PEN TBL: JSmith-SUFDNP1.ctb
SHT SET: ####
PROJECT NUMBER: ####

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

LAND OWNERSHIP, LEASE, AND PERMIT AREA MAP

SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
1" = 2,000'	5/1/2018	JMB/TRB	J.S	VM	PLATE 5-6 GH

FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. – 1-1-18\PLATE 5-6 GH.dwg

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

PINES LEASE

QUITCHUPAH LEASE

RICCI MINE

LINK CANYON MINE

FUTURE LOWER HIAWATHA POINT OF ACCESS FROM UPPER HIAWATHA

UTU-84102

UTU-76195

U-63214

U-47080

U-062453

U-28297

U-0149084

SL-062583

ML 49443-OBA

U-62214

FEE

PB 38

PB 37

PB 40

PB 39

PB 41

PB 42

N 10346[illegible]

E 10[illegible]

EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- ESCARPEMENT
- OUTCROP

MINING LEGEND

1ST QUARTER 2018	2019
2ND QUARTER 2018	2020
3RD QUARTER 2018	2021
4TH QUARTER 2018	2022

PROFESSIONAL ENGINEER
No. 9073281
JACOB D. SMITH
STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

1500 0 1500

INCORPORATED
APR 19 2018
Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
12	4/13/2017	V.M.	B.R.	GREENS HOLLOW
13	12/19/2017	B.B.	B.R.	Add 4R4E Panel
14	3/27/2018	V.M.	B.R.	GREENS HOLLOW TECHNICAL ANALYSIS

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

SUFCO MINE PLAN
5 YEAR PROJECTION

PEN TBL:	SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
15mdrd-SUFDMP1.ctb	1" = 1,500'	03/01/2000	J.G.C.	JDB	VM	PLATE 5-7
SHT SET: ####	PROJECT NUMBER: ####	FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. – 1-1-18\PLATE 5-7 GH 2.dwg				

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

PINES LEASE

QUITCHUPAH LEASE

FUTURE LOWER HIAWATHA POINT OF ACCESS FROM UPPER HIAWATHA

UTU-84102

ML 49443-OBA

U-63214

UTU-76195

SL-062583

U-062453

U-28297

U-0149084

FEE

U-47080

U-63214 U-47080

U-062453 U-63214

SL-062583 U-28297

EXPLANATION

U-63214 — SUFCO EXTERIOR LEASE BOUNDARY

SUFCO INTERIOR LEASE BOUNDARY

STREAM

ESCARPEMENT

OUTCROP

MINING LEGEND

1ST QUARTER 2018 (NO PLANNED MINING)

2ND QUARTER 2018 (NO PLANNED MINING)

3RD QUARTER 2018 (NO PLANNED MINING)

4TH QUARTER 2018 (NO PLANNED MINING)

2019

2020

2021

2022

PROFESSIONAL ENGINEER No. 9073281 JACOB D. SMITH STATE OF UTAH

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1500 0 1500

INCORPORATED APR 19 2018 Div. of Oil, Gas & Mining

REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	05/08/2007	M.L.D.	B.D.H.	
2	08/13/2009	M.L.D.	B.D.H.	
3	03/02/2015	V.M.	T.R.B.	ADDED 70 ACRE R.O.W. AREA FOR 5 WEST
4	07/14/2016	V.M.	J.G.C.	ADD GREENS HOLLOW & SOUTH FORK LEASE BOUNDARIES
5.	4/18/2017	V.M.	B.R.	GREENS HOLLOW
6.	12/19/2017	V.M.	B.R.	ADDED 4R4E
7	3/27/2018	V.M.	B.R.	GREENS HOLLOW TECHNICAL ANALYSIS

PEN TBL: JSmith-SUFCNP1.ctb

SHT SET: ####

PROJECT NUMBER: ####

Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 – Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

LOWER HIAWATHA MINE PLAN 5 YEAR PROJECTION

SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
1" = 1,500'	3/27/2018	BDH/TRB	JDB	VM	PLATE 5-8

FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. – 1-1-18\PLATE 5-8 GH 2.dwg

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

QUITCHUPAH LEASE

PINES LEASE

NOTE:
1. CONTACTS HAVE NOT BEEN FIELD CHECKED.
2. FAULTS PROJECTED TO SURFACE FROM MINE

EXPLANATION

- UPPER HIAWATHA COAL SEAM OUTCROP
- EXTERIOR LEASE BOUNDARY
- INTERIOR LEASE BOUNDARY
- 100000 MC — MINE BASE COORDINATES
- 2000000 SPC — STATE PLANE COORDINATES
- US-79-2 (8497) — DRILLHOLE LOCATION AND NUMBER; DRILLHOLE SURFACE ELEVATION
- FORMATION OR MEMBER CONTACT
- FAULTS WITH GREATER THAN 2' DISPLACEMENT MAPPED IN MINE
- A'——A — CROSS-SECTION (SEE PLATE 6-2, 6-3, 6-4 AND 6-5)
- PROPOSED NEWLY BUILT ACCESS ROUTES
- PROPOSED ACCESS ROUTES USING EXISTING WHEEL TRACKS OR EXISTING SURFACE

GEOLOGIC KEY

AGE	SYMBOL	NAME
QUATERNARY	Qa	ALLUVIUM, HILL WASH, SLUMPS UNDIFFERENTIATED
TERT–CRET	T–Knh	NORTH HORN FORMATION
CRETACEOUS	Kpr	PRICE RIVER FORMATION
"	Kc	CASTLEGATE SANDSTONE FORMATION
"	Kbh	BLACKHAWK FORMATION–UPPER MEMBER
"	Ksp	BLACKHAWK FORMATION–STARPOINT SANDSTONE MEMBER
"	Kmm	MANCOS SHALE–MASUK MEMBER

1.5 / N 42 E — CALCULATED STRIKE AND DIP TOP UPPER HIAWATHA COAL SEAM

COAL BURN

SOURCES:

1. QUITCHUPAH LEASE ADDITION, VOLUME 10, MAPS 5.2, 5.3, 6.1, 1989 HYDROMETRICS INC. SOUTHERN UTAH FUEL COMPANY'S HYDROLOGICAL RESPONSE TO OSM'S APPARENT COMPLETENESS REVIEW

2. MANTI–LA SAL NATIONAL FOREST–PINES TRACT PROJECT FINAL ENVIRONMENTAL IMPACT STATEMENT (FEIS) FIGURE 3–1 GEOLOGY MAP JANUARY 1999 USDA FOREST SERVICE, REGION FOUR MANTI–LA SAL NATIONAL FOREST EMERY AND SEVIER COUNTIES, UTAH

3. COAL TRACT EVALUATIONS ON THE MANTI–LASAL NATIONAL FOREST MUDDY CREEK AND NORTH HORN SURFACE AND GROUND WATER TECHNICAL REPORTS FIGURE 2 GEOLOGY MAP WITH SPRING LOCATIONS. MUDDY COAL TRACT EIS, EMERY CO. UTAH OCTOBER 2004

PROFESSIONAL ENGINEER — No. 9073281 JACOB D. SMITH — STATE OF UTAH

I CERTIFY THE ITEMS SHOWN ON THIS DRAWING ARE ACCURATE TO THE BEST OF MY KNOWLEDGE

INCORPORATED
APR 19 2018
Div. of Oil, Gas & Mining

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REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
8	03/02/2015	V.M.	T.R.B.	ADDED70 ACRE R.O.W. AREA FOR 5 WEST
9	07/14/2016	V.M.	J.G.C.	ADD GREEN HOLLOW & SOUTH FORK LEASE BOUNDARIES
10	12/15/2016	V.M.	T.L.M.	REMOVE SOUTH FORK BOUNDARY
11	4/18/2017	V.M.	B.R.	GREENS HOLLOW
12	10/3/2017	V.M.	B.R.	Castle Gate Sandstone

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GEOLOGY & DRILL HOLE LOCATION MAP

PEN TBL:	SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
15ndnd-SUFDMP.ctb	1" = 2,000'	1/17/2018	KJW/TRB	JDB	VM	PLATE 6–1
SHT SET: ####	PROJECT NUMBER: ####	FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 6-1.dwg				

JobDetails: 1/17/2018 11:23 AM

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

QUITCHUPAH LEASE

PINES LEASE

EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- 100000 MC — MINE COORDINATES
- 2020000 SPC — STATE PLANE COORDINATES
- WATER RIGHT SPRING
- RUNOFF CATCHMENT POND W/ WATER RIGHT
- RUNOFF CATCHMENT POND W/O WATER RIGHT
- SURFACE WATER RIGHT POINT TO POINT
- SURFACE WATER RIGHT

NOTES:

1. SEE APPENDIX 7-1 FOR DETAILED LISTING OF WATER RIGHTS

QUITCHUPAH TRACT

CATCHMENT PONDS WITH WATER RIGHTS NUMBER	NAME	CURRENT COMMON NAME USED BY USFS, CATTLEMEN AND OTHERS	OTHER HISTORICAL NAMES USED FOR CATCHMENT PONDS
94-115	NORTH DUNCAN RES.		
94-116	NORTH DUNCAN FLAT RES.		
94-117	UPPER DUNCAN DRAW RES.		
94-119	EAST SPRING RES.		
94-120	LOWER DUNCAN RES.		
94-122	MIDDLE MUD SPRING RES.		
94-123	SHORT HOLLOW RES.		
94-127	LOWER MUD SPRING RES.		
94-128	PIN HOLLOW RES.		
94-129	ELDRIDGE HOLLOW RES. #1		
94-130	ELDRIDGE HOLLOW RES. #2		
94-131	LITTLE DUNCAN RES.		
94-134	COLLIER RES.		
94-137	JOLLY MILL POINT RES.		
94-430	UNNAMED RES.	LINK CANYON #1	
94-431	UNNAMED RES.	BOX POND	TRIANGLE, THREE CORNER
94-434	UNNAMED RES.	SOUTH DRAW BIG RIDGE	
94-435	UNNAMED RES.	EAST DRAW BIG RIDGE	
94-436	UNNAMED RES.		
94-439	UNNAMED RES.		

QUITCHUPAH TRACT

CATCHMENT PONDS WITH WATER RIGHTS NUMBER	NAME	CURRENT COMMON NAME USED BY USFS, CATTLEMEN AND OTHERS	OTHER HISTORICAL NAMES USED FOR CATCHMENT PONDS
94-444	UNNAMED RES.		
94-583	DRY POINT RES.		
94-584	SEEPS RES.	SEEPS POND	
94-585	WHITE KNOLL RES.	ROCK POND	
94-586	BOX CANYON RES.	JENSEN	
94-587	MILL RES.	MILL POND	
94-588	DWEYS RES.	DEWYS POND	
94-589	SAGE CREEK RES.	JOHNSON POND	JENSEN, SAGE GROUSE POND
94-590	KENS RES.		
94-592	BIG RIDGE RES.		
94-730	QUITCHUMPAH RES. #1	QUITCHUPAH RES. #1	
94-1386	BOUNDARY RES.		
94-1394	MIDDLE RES.		
94-1395	UPPER MUD SPRINGS RES.		
94-1401	MIDDLE DUNCAN RES.		
94-1580	JOLLY MILL GUZZLER RES.		
	OTHER CATCHMENT PONDS WITHOUT WATER RIGHTS		
		WEST BOX	
		DRY POINT	
		HANSON'S POND	JOHNSON, HANS

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No. 9073281 JACOB D. SMITH — PROFESSIONAL ENGINEER — STATE OF UTAH

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REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	7/13/2016	V.M.	J.G.C.	ADD GREENS HOLLOW & SOUTH FORK LEASE BOUNDARIES; COMBINE 7-2A,B,C DRAWINGS
2	4/18/2017	V.M.	B.R.	GREENS HOLLOW
3	10/18/2017	B.B.	B.R.	Add 4R4E Panel
4	3/27/2018	V.M.	B.R.	GREENS HOLLOW TECHNICAL ANALYSIS

PEN TBL: JSlodd-SUFENP1.ctb
SHT SET: ####
PROJECT NUMBER: ####

Canyon Fuel Company, LLC
SUFCO Mine
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(435) 286-4499 Fax

SURFACE AND GROUNDWATER RIGHTS-QUITCHUPAH TRACT

SCALE:	DATE:	DRAWN BY:	ENGINEER:	CHECKED BY:	SHEET NO.
1" = 1,500'	07/13/2016	J.G.C	V.M.	V.M.	PLATE 7-2 GH

FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. – 1-1-18\PLATE 7-2 GH.dwg

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

QUITCHUPAH LEASE

PINES LEASE

NOTES:

1. HISTORIC STREAM, SPRING AND WELL MONITORING SITES ARE OLD BASELINE MONITORING SITES OR SITES THAT HAVE BEEN DISCONTINUED OR MINED THROUGH THAT ARE NOT CURRENTLY BEING MONITORED.

EXPLANATION

- SUFCO MINE EXTERIOR LEASE BOUNDARY
- SUFCO MINE INTERIOR LEASE BOUNDARY
- 100000 MC — MINE COORDINATES
- 2020000 SPC — STATE PLANE COORDINATES
- HISTORIC STREAM
- STREAM MONITORING
- HISTORIC MONITORING WELL
- MONITORING WELL SITE
- HISTORIC SPRING MONITORING SITE
- SPRING MONITORING
- UPDES MONITORING POINT
- IN MINE MONITORING SITE
- (7600) — ELEVATION OF SITE
- PERENNIAL FLOW LOCATION MONITORING POINT
- PERENNIAL FLOWS
- SPRING NOT MONITORED

PROFESSIONAL ENGINEER No. 9073281 JACOB D. SMITH STATE OF UTAH

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REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
24	12/08/2017	V.M.	B.R.	Add 4R4E Panel
25	12/18/2017	V.M.	J.G.C.	Above and below
26	3/27/2018	V.M.	B.R.	GREENS HOLLOW TECHNICAL ANALYSIS

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HYDROLOGIC MONITORING STATIONS

PEN TBL:						
SHT SET: ####	PROJECT NUMBER: ####	SCALE: 1" = 1,000'	DATE: 10/26/2006	DRAWN BY: JMB/TRB	ENGINEER: J.D.B.	CHECKED BY: V.M.
FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. – 1-1-18\PLATE 7-3 GH.dwg						SHEET NO. PLATE 7-3 GH

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

PINES LEASE

QUITCHUPAH LEASE

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EXPLANATION

- SUFCO EXTERIOR LEASE BOUNDARY
- SUFCO INTERIOR LEASE BOUNDARY
- MINE COORDINATES
- STATE PLANE COORDINATES
- EPHEMERAL OR INTERMITTANT FLOWS
- PERENNIAL FLOWS
- IRRIGATION DITCH
- POTENTIALLY FLOOD IRRIGATED
- FLOOD IRRIGATED

SOURCES:

1. QUITCHUPAH TRACT
   HYDROMETRICS, INC.
   SOUTHERN UTAH FUEL COMPANY'S
   HYDROLOGICAL RESPONSE TO OSM'S APPARENT
   COMPLETENESS REVIEW, NOV. 1, 1980

2. PINES TRACT
   MANTI–LA SAL NATIONAL FOREST–PINES TRACT PROJECT
   FINAL ENVIRONMENTAL IMPACT STATEMENT (FEIS)
   FIGURE 3–11 SPRINGS, SEEPS, AND RIPARIAN AREAS
   JANUARY 1999
   USDA FOREST SERVICE, REGION FOUR
   MANTI–LA SAL NATIONAL FOREST
   EMERY AND SEVIER COUNTIES, UTAH

PROFESSIONAL ENGINEER
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REVISIONS

NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	2/18/1999	M.L.D.	A.D.D.	
2	03/01/2000	W.K.S.	A.D.D.	
3	5/8/2007	M.L.D.	A.D.D.	
4	03/02/2015	V.M.	T.R.B.	ADDED 70 ACRE R.O.W. AREA FOR 5 WEST BOUNDARIES
5	07/13/2016	V.M.	J.G.C.	ADD GREENS HOLLOW & SOUTH FORK LEASE
6	12/15/2016	V.M.	T.L.M.	REMOVED SOUTH FORK BOUNDARY
7	04/12/2017	V.M.	J.G.C.	GREENS HOLLOW

PEN TBL: _5Inkd-SUFSP1.ctb
SHT SET: ####
PROJECT NUMBER: ####

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ALLUVIAL VALLEY FLOOR CHARACTERISTICS DETERMINATION

SCALE: 1" = 2,000' | DATE: 12/20/2017 | DRAWN BY: ADD/TRB | ENGINEER: JDB | CHECKED BY: VM | SHEET NO.: PLATE 9–1

FILE NAME: H:\DRAWINGS\MRP\PLATES\PLATE 9-1.dwg

GREENS HOLLOW LEASE

SITLA MUDDY LEASE

PINES LEASE

QUITCHUPAH LEASE

M-SP87(USP-1) (7922)
USP-2
U-MUD
Horse Creek
Muddy Creek below Horse
Muddy Creek above Horse
M-SP18 (8295)
M-STR1 (7462)
M-SP11 (9237)
GH at Road
M-SP01A (8420)
M-SP02 (8335)
M-SP45 (8505)
M-STR6 (8170)
URGH
M-SP12 (8739)
UL04
M-SP04 (8813)
M-SP05 (8937)
M-SP06 (8932)
M-STR4 (8164)
M-SP30 (8225)
Cowboy Bottom
MW-15-5-26
Pines 407
Pines 408 (7685)
Pines 405 (7260)
Pines 403 (7270)
Pines 300 (7140)
Pines 301 (7540)
RICCI MINE
Cowboy Top
M-SP41 (9223)
M-SP40 (9163)
Cowboy Mid
GW-13 (8600)
M-SP08 (8820)
M-SP09 (8849)
M-SP53 (8941)
01-8-1 (8988)
PINES 206(8180)
Pines 209(8080)
Pines 212(8140)
Pines 214(8160)
FP-2
Pines 106 (8200)
Pines 105 (8260)
SUFCO 090 (8320)
Pines 218 (8190)
Pines 311(8410)
Pines 310(8420)
M-SP44 (9598)
M-SP20 (9395)
CPC Upper
M-SP100 (8975)
M-SP15 (8811)
North Fork Upper
M-SP104 (9052)
M-SP103 (8999)
M-SP105 (8971)
M-SP106 (8997)
M-SP50 (8801)
M-SP19 (8968)
SP-50 CREEK
CPC Middle
CPC Lower
North Fork Middle
Sufco 007 (North Fork Lower) (8240)
GW-20 (8260)
USFS-109 (8280)
SUFCO-089 (8360)
FP-1
89-20-2W (8358)
Pines 100 (8480)
GW-21 (8460)
LINK 001 (7780)
LINK POOL - WEST (7883)
LINK - NORTHEAST (7883)
MINE
LINK 002 (7300)
SUFCO-006 (8227)
US-81-4 (8388)
057A (8720)
US-81-3 (9027)
GW-9 (8180)
GW-8 (8195)
UTZONEH SPRINGS
MUD SPRING (8287)
US-80-4 (8380)
US-80-2 (8378)
001 (8080)
US-79-3 (8826)
BROAD HOLLOW (8157)
SINKHOLE
UPDES-002 (7560)
047A (7160)
046 047 (7400) (7160)
042 (6350)
041 (6400)
Muddy-ABF
406B (6870)
406

T 20 S
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T 22 S

NOTES:

1. HISTORIC STREAM, SPRING AND WELL MONITORING SITES ARE OLD BASELINE MONITORING SITES OR SITES THAT HAVE BEEN DISCONTINUED OR MINED THROUGH THAT ARE NOT CURRENTLY BEING MONITORED.

EXPLANATION

- SUFCO MINE EXTERIOR LEASE BOUNDARY
- SUFCO MINE INTERIOR LEASE BOUNDARY
- 100000 MC — MINE COORDINATES
- 2020000 SPC — STATE PLANE COORDINATES
- UPDES MONITORING POINT
- STREAM MONITORING
- (7600) — ELEVATION OF SITE
- MONITORING WELL SITE
- PERENNIAL FLOWS
- SPRING MONITORING

PROFESSIONAL ENGINEER
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REVISIONS				
NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	9/20/2017		B.R.	ADDED PINES NOTATION
2	12/18/2017		B.T.N.	REMOVED SPRINGS
3	3/14/2018	V.M.	B.R.	Updating Monitoring points
4	3/27/2018	V.M.	B.T.N.	Greens Hollow Technical Analysis

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OPERATIONAL HYDROLOGIC MONITORING STATIONS (GREENS HOLLOW)

PEN TBL: _Slvdrd-SUFENP1.ctb
SHT SET: ####
PROJECT NUMBER: ####
SCALE: 1" = 1,000'
DATE: 8/15/2017
DRAWN BY: B.T.N.
ENGINEER: J.D.B.
CHECKED BY: V.M.
FILE NAME: H:\DRAWINGS\MRP\PLATES_PLATES_G.H. – 1-1-18\PLATE 7-10 GH.dwg

SHEET NO. PLATE 7-10 GH