Canyon Fuel Company, LLC
A Subsidiary of Wolverine Fuels, LLC

Skyline Mine
Gregg A. Galecki, Sr. Environmental Engineer
HC35, Box 380
Helper, Utah 84526
(435) 448-2636
Fax (435) 448-2632

May 6, 2020

Steve Christensen
Coal Program Supervisor
Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
Salt Lake City, Utah 84114-5801

RE: Modified Oufall Riprap Apron Design, Winter Quarters Sedimentation Pond, Canyon Fuel Company, LLC, Skyline Mine, C/007/005,

Dear Mr. Christensen:

Attached is information to construct a larger riprap apron for the Winter Quarters Sediment Pond Outfall to accommodate mine-water discharge in addition to the designed storm events. As mentioned to Justin Eatchel and Kendra Hinton, the design has changed slightly from our discussions on April 30, to run the mine-water discharge through the over-designed sediment pond decant pipe/outfall. The follow is a narrative citing items from our meeting and how they are addressed in the application:

1) Plates and drawings: Plate 3.2.4-3A_rev.2 and Plate 3.2.4-3E_rev.2 have been updated
2) Engineering Narrative: Section 3.2 page 3-23(a) describes a narrative of project, a brief description of the design parameters, and citation to the reports. An April 2020 riprap design report is included.
3) Bond: Midterm bond deficiencies have been resolved and $2,000 added for pipe demolition
4) Biological Monitoring: yet to be deterimined. Mr. Miller is conferring with DWR personnel
5) Hydrology: Section 2.5, page 2-51g and 2-51g1 provide narrative on the need to discharge and addresses impacts to groundwater and surface- water, citing the 2010 geomorphic report, two existing maps, and other narratives in the PHC.
6) Diversion Tables: the Skyline M&RP is not set up with diversion tables specifically. Diversion capacities are addressed in the narrative and supporting engineering calculation reports.

Also supplemental information is supplied for review purposes but not incorporation into the M&RP which include a DWRi Special Use permit, select design calculations from the original WQ hydrology design report, and the stream morphology report.

Skyline appreciates the DOGM Staff willingness to expedite the processing of this amendment.

Attached to this cover letter are completed C1 and C2 forms, and .pdf files of the information to be incorporated into the M&RP. The information is being submitted electronically. Two (2) hard copies will be sent upon Division approval.

If you have any questions, please call me at (435) 448-2636.

Sincerely,

Gregg A. Galecki
Sr. Environmental Engineer, Skyline Mine
Canyon Fuel Company, LLC

APPLICATION FOR COAL PERMIT PROCESSING

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

Permittee: Canyon Fuel Company, LLC
Mine: Skyline Mine **Permit Number:** C/007/005
Title: Winter Quarters Pond Outfall Increase
Description, Include reason for application and timing required to implement:
Increase in the size of the Sediment Pond Outfall Structure

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

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: 3.0 ☐ increase ☒ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☒ Yes ☐ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: ____________
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☒ Yes ☐ No 15. Does the application require or include soil removal, storage or placement?
☐ Yes ☒ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☒ Yes ☐ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☒ Yes ☐ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☒ Yes ☐ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes ☒ No 20. Does the application require or include subsidence control or monitoring?
☒ Yes ☐ No 21. Have reclamation costs for bonding been provided?
☒ Yes ☐ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☒ Yes ☐ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach four (4) review copies of the application. If the mine is on or adjacent to Forest Service land please submit five (5) copies, thank you. (These numbers include a copy for the Price Field Office)

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.

DEWEY TANNER
Print Name

[signature] GM 5/4/2020
Sign Name, Position, Date

Subscribed and sworn to before me this 4 day of May, 2020

[signature]
Notary Public

My commission Expires: 03-19, 2023
Attest: State of Utah } ss:
County of Carbon

MELISSA S. WILLDEN
NOTARY PUBLIC • STATE OF UTAH
COMMISSION# 705119
COMM. EXP. 03-19-2023

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining

Form DOGM- C1 (Revised March 12, 2002)

APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

Permittee: Canyon Fuel Company, LLC
Mine: Skyline Mine **Permit Number:** C/007/005
Title: Winter Quarters Outfall Increase

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, Appendix 118A, StreamAlterationEmergencyActionAuthorization, six (6) Water Rights user letters
☐ Add	☒ Replace	☐ Remove	Chapter 2, Section 2.3, pages 2.35c, 2-36, 2-36b
☐ Add	☒ Replace	☐ Remove	Chapter 2, Section 2.4, page 2.45
☐ Add	☒ Replace	☐ Remove	Chapter 2, Section 2.5, page 2-51g
☒ Add	☐ Replace	☐ Remove	Chapter 2, Section 2.5 page 2-51g1
☐ Add	☒ Replace	☐ Remove	Chapter 2, Section 2.8 pages 2-71a, page 2-72a (Table 2.8-1a)
☐ Add	☒ Replace	☐ Remove	Chapter 3, Section 3.2, page 3-23(a)
☐ Add	☒ Replace	☐ Remove	Chapter 3, Plates 3.2.4-3A_Rev4_5-5-20, 3.2.4-3D-Rev1_5-5-20, 3.2.4-3E_Rev2_5-1-20
☒ Add	☐ Replace	☐ Remove	Appendix A-1, Evaluation of Geomorphic Conditions in Winter Quarters Canyon Near Skyline Mine Ventilation Portal, April 2017
☒ Add	☐ Replace	☐ Remove	Appendix A-1, Winter Quarters Surface Irrigation memo
☐ Add	☐ Replace	☐ Remove	Appendix A-5, Section 25, Winter Quarters Energy Dissipator Design
☐ Add	☒ Replace	☐ Remove	Chapter 4, Section 4.3, Winter Quarters Demolition page
☐ Add	☐ Replace	☐ Remove	Chapter 4, Section 4.4, page 4-28
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Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.	**Received by Oil, Gas & Mining**
Submitted electronically. Hard copies will be shipped for incorporation following approval.	

Gregg Galecki

From: Daren Rasmussen <darenrasmussen@utah.gov>
Sent: Friday, May 1, 2020 10:54 AM
To: Gregg Galecki
Cc: Chris Hansen; Taylon Earl; Marc Stilson; Daren Rasmussen; DNR Wrt General Correspondence
Subject: Re: Construction Activity near a Stream

** STOP. THINK EXTERNAL EMAIL **

A request for modification of a riprap apron for increased outfall flows on or near Winters Quarters stream has been received by the Division of Water Rights ("Division") on 5/1/2020 at/near Skyline Mine addressing the threat to the safety and continued operation of the mine. **State of Utah DNR Stream Alteration Emergency Action is authorized.**

It is recognized that when there is a threat of injury or damage to persons or property due to flooding, there may not be time to complete typical administrative procedures. Subsection (2) of Utah Code 73-3-29 allows for proceeding with stream alterations prior to completion of administrative procedures. Subsection (2) requires that those conducting emergency work attempt to contact the State Engineer's Office immediately for authorization. If unable to contact the State Engineer's Office immediately, then notification can be given on the next working day. Emergency procedures may be undertaken prior to this as is necessary. A written application outlining the action taken and/or proposed actions shall be submitted within two working days following notification of the action. In contacting this office, guidance may be offered to help alleviate post emergency work remediation. It is typical that after emergency measures are completed, corrections to the emergency work or a more appropriate solution is offered and/or required through the permitting process.

If you have any questions or require further information, please contact me at 801-538-7377 or darenrasmussen@utah.gov .

-Daren Rasmussen, State Engineer's Office, State of Utah Dam Safety & Stream Alterations
Division of Water Rights - Department of Natural Resources
www.WaterRights.Utah.gov / 801-538-7377 office / 801-244-1748 mobile / DarenRasmussen@Utah.gov

On Fri, May 1, 2020 at 9:09 AM Gregg Galecki <ggalecki@wolverinefuels.com> wrote:

> Daren,
>
> I was forwarded correspondence from Steve Christensen concerning your correspondence with Priscilla Burton on our project. I unfortunately was not provided with the attachments she provide you so the following will hopefully outline the project in better detail.
>
> Skyline Mine needs to increase the size of a discharge structure as soon as possible. I don't believe it will require a Stream Alteration Permit, but I thought I would check with you to confirm. Attached are both a draft design done by a professional engineer and a photo illustrating the location relative to the stream. The photo illustrates the approximate location of the riprap apron outlined in red. The two green lines illustrate approximately 25-ft lengths that are well above the bank-full locations of the creek (leaving approximately 15-ft of vegetation between the apron and the creek).

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Gregg A. Galecki, Sr. Environmental Engineer
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Helper, Utah 84526
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Fax (435) 448-2632

May 13, 2020

Dale Barney Cornaby and Cheri F. Cornaby
5167 South 3200 West
Spanish Fork UT 84660

Re: Irrigation Water Right – Winter Quarters Creek

Dear Dale Barney Cornaby and Cheri F. Cornaby,

I am writing to inform you that Skyline Mine will begin discharging approximately 1,000 gpm of mine-water to upper Winter Quarters Creek on approximately May 15, 2020. The additional water is being added approximately 1.2 to 1.6 miles upstream of your diversion. The mine-water will meet water quality standards as required by the Utah Division of Environmental Quality ensuring only good quality water is added to the creek. The Utah Division of Oil Gas & Mining has also required Skyline Mine to conduct in-stream monitoring to monitor the integrity of the stream channel.

Although a future increase in discharge volume is not anticipated, Skyline Mine is currently permitted to discharge up to 4,000 gpm into the creek. No Impacts to your diversion or interruptions to use of your water right are anticipated.

If you have any questions regarding this information, please give me a call at (435) 448-2636 or Taylon Earl at (435) 448-2667.

Sincerely:

Gregg A. Galecki
Canyon Fuel Company, LLC.
Sr. Environmental Engineer – Skyline Mines

cc: Utah Division of

Canyon Fuel Company, LLC
A Subsidiary of Wolverine Fuels, LLC

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Gregg A. Galecki, Sr. Environmental Engineer
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Helper, Utah 84526
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May 13, 2020

Fred and Shelia Jensen
P.O. Box 113
Goshen UT 84633

Re: Irrigation Water Right – Winter Quarters Creek

Dear Fred and Shelia Jensen,

I am writing to inform you that Skyline Mine will begin discharging approximately 1,000 gpm of mine-water to upper Winter Quarters Creek on approximately May 15, 2020. The additional water is being added approximately 1.2 to 1.6 miles upstream of your diversion. The mine-water will meet water quality standards as required by the Utah Division of Environmental Quality ensuring only good quality water is added to the creek. The Utah Division of Oil Gas & Mining has also required Skyline Mine to conduct in-stream monitoring to monitor the integrity of the stream channel.

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Sincerely:

Gregg A. Galecki
Canyon Fuel Company, LLC.
Sr. Environmental Engineer – Skyline Mines

cc: Utah Division of

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Helper, Utah 84526
(435) 448-2636
Fax (435) 448-2632

May 13, 2020

Pioneer Canal Company No. 1
PO Box 1055
Wellington UT 84542

Re: Irrigation Water Right – Winter Quarters Creek

Dear Pioneer Canal Company No. 1,

I am writing to inform you that Skyline Mine will begin discharging approximately 1,000 gpm of mine-water to upper Winter Quarters Creek on approximately May 15, 2020. The additional water is being added approximately 1.2 to 1.6 miles upstream of your diversion. The mine-water will meet water quality standards as required by the Utah Division of Environmental Quality ensuring only good quality water is added to the creek. The Utah Division of Oil Gas & Mining has also required Skyline Mine to conduct in-stream monitoring to monitor the integrity of the stream channel.

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Sincerely:

Gregg A. Galecki
Canyon Fuel Company, LLC.
Sr. Environmental Engineer – Skyline Mines

cc: Utah Division of

Canyon Fuel Company, LLC
A Subsidiary of Wolverine Fuels, LLC

Skyline Mine
Gregg A. Galecki, Sr. Environmental Engineer
HC35, Box 380
Helper, Utah 84526
(435) 448-2636
Fax (435) 448-2632

May 13, 2020

Radakovich Ranch, LLC
1016 Hill Ave
Grand Junction, CO 81501

Re: Irrigation Water Right – Winter Quarters Creek

Dear Radakovich Ranch, LLC,

I am writing to inform you that Skyline Mine will begin discharging approximately 1,000 gpm of mine-water to upper Winter Quarters Creek on approximately May 15, 2020. The additional water is being added approximately 1.2 to 1.6 miles upstream of your diversion. The mine-water will meet water quality standards as required by the Utah Division of Environmental Quality ensuring only good quality water is added to the creek. The Utah Division of Oil Gas & Mining has also required Skyline Mine to conduct in-stream monitoring to monitor the integrity of the stream channel.

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Sincerely:

Gregg A. Galecki
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Sr. Environmental Engineer – Skyline Mines

cc: Utah Division of

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Skyline Mine
Gregg A. Galecki, Sr. Environmental Engineer
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May 13, 2020

Ellen R. Radakovich Marital and Family Trust
Robert Radakovich trustee
340 North 6th East
Price UT 84501

Re: Irrigation Water Right – Winter Quarters Creek

Dear Ellen R. Radakovich Marital and Family Trust,

I am writing to inform you that Skyline Mine will begin discharging approximately 1,000 gpm of mine-water to upper Winter Quarters Creek on approximately May 15, 2020. The additional water is being added approximately 1.2 to 1.6 miles upstream of your diversion. The mine-water will meet water quality standards as required by the Utah Division of Environmental Quality ensuring only good quality water is added to the creek. The Utah Division of Oil Gas & Mining has also required Skyline Mine to conduct in-stream monitoring to monitor the integrity of the stream channel.

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Sincerely:

Gregg A. Galecki
Canyon Fuel Company, LLC.
Sr. Environmental Engineer – Skyline Mines

cc: Utah Division of

Canyon Fuel Company, LLC
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Skyline Mine
Gregg A. Galecki, Sr. Environmental Engineer
HC35, Box 380
Helper, Utah 84526
(435) 448-2636
Fax (435) 448-2632

May 13, 2020

Carbon Water Conservancy District
P O Box 509
Helper UT 84526

Re: Irrigation Water Right – Winter Quarters Creek

Dear Carbon Water Conservancy District,

I am writing to inform you that Skyline Mine will begin discharging approximately 1,000 gpm of mine-water to upper Winter Quarters Creek on approximately May 15, 2020. The additional water is being added approximately 1.2 to 1.6 miles upstream of your diversion. The mine-water will meet water quality standards as required by the Utah Division of Environmental Quality ensuring only good quality water is added to the creek. The Utah Division of Oil Gas & Mining has also required Skyline Mine to conduct in-stream monitoring to monitor the integrity of the stream channel.

Although a future increase in discharge volume is not anticipated, Skyline Mine is currently permitted to discharge up to 4,000 gpm into the creek. No Impacts to your diversion or interruptions to use of your water right are anticipated.

If you have any questions regarding this information, please give me a call at (435) 448-2636 or Taylon Earl at (435) 448-2667.

Sincerely:

Gregg A. Galecki
Canyon Fuel Company, LLC.
Sr. Environmental Engineer – Skyline Mines

cc: Utah Division of

Ch. 2, Sec. 2.3

should be accessible for the next several years. The results of the analyses will be monitored for changes in ages that may indicate changes in the source of the mine water inflows. These samples will be obtained as outlined in Table 2.3.7-1.

Samples of water discharging from springs 8-253 (Flat Canyon area), 2-413 (James Canyon), S24-1 (Sulfur Spring in Huntington Canyon), and S15-3 (Upper Huntington Creek) will be collected during the 2nd Quarter(April - June) and 4th Quarter(October - December) monitoring period and analyzed for tritium content. Additional tritium samples will be obtained from EL-1 (inflow to Electric Lake above JC-1 and JC-3 discharge) and EL-2 (outflow from Electric Lake) during the 2nd, 3rd, and 4th Quarter water monitoring periods. These samples will be collected for a period of three years beginning in the spring of 2004. The purpose of collecting these tritium samples, along with the tritium samples from JC-1, is to monitor the change in tritium content, if any, in the local aquifers and Electric Lake during spring, summer, and fall and over the three year period.

Surface-water will be monitored in the vicinity of the Winter Quarters Ventilation Facility (WQFV) by two (2) stream sites located both up- and downstream of the site, CS-20 and CS-24, respectively. The stream sites will monitor the surface- water ensuring neither the shaft or slope is compromising the surface water system. Groundwater Well 08-1-5 screened from 297-317 feet below the surface and will monitor the water elevation below the coal seam. No springs exist on the south facing slope where the WQVF pad is located. Spring WQ1-1 is located on the north-facing slope, is approximately 1/4-mile east of the WQVF pad and monitors near surface groundwater south and east of the WQVF site.

Skyline began discharging mine-water from UPDES-004, the outfall of the WQVF pond in 2020, per the Utah State Water Quality permit. While discharging mine-water, CS-20 and CS-24 will be monitored monthly documenting flow, field parameters, and limited solute analysis as outlined on Table 2.3.7-1 in addition to quarterly monitoring. Data will be uploaded to the DOGM database in the month following date of collection.

Both surface-water and groundwater monitoring sites were added in Woods Canyon as mining was extended to the east in Section 36, T12S, R6E. CS-25 will monitor stream flow downstream of all mining activity. Shallow ground water along Woods Canyon Creek will be monitored by piezometers WC-1, WC-3, WC-5, WC-7 and WC-9. The shallow ground water wells were discontinued after the 2016 field season as mining was completed in 2015 (See Plate 2.3.6-1a for historic WC- locations). Spring WQ36-1 will monitor groundwater within the Blackhawk formation above active mining areas.

Mines #4 and #5 Flat Canyon Area Monitoring

The monitoring site selection criteria has remained relatively consistent throughout the years with representative sites being selected from the baseline data. With the addition of the Flat Canyon lease, initial seep and spring data was collected beginning in 1997 in preparation of the Flat Canyon EIS. Baseline sampling in the Mine #4 and #5- Flat Canyon lease area resumed in 2006 and continued through 2016. The number of sites were refined based on proposed mining by adding some stream sites upstream of mining and selecting spring sites representative of the geologic units in areas proposed for undermining.

In the Mine #4 and #5 - Flat Canyon lease area the groundwater monitoring will include the addition of nine (9) springs in the near-surface active zone. Spring SW32-277 is located in the Price River formation, SW33-268, SW4-429, and SW5-590 are in the Castlegate Sandstone, and SW21-104, SW28-110, SW28-111, SW4-169, SW4-174 are in the Blackhawk Formation,

Table 2.3.7-1
Comprehensive Water Quality Analytical Schedule
(Surface and Ground Water Stations)

Sample Site	1st Quarter							2nd[2] / 3rd[3] / 4th Quarters															
	Lab Analysis*[a]	Field parameters only*[1]	Monthly Flow	Dissolved Oxygen	TDS,TSS, T-P	TDS,TSS	O & G	Lab Analysis*[a]	Qtrly Field parameters* only[1]	Quarterly Flow	Monthly Flow	Flow Monitoring (HCWMP)[4, 5]	Water Level Monitoring (HCWMP)	Monthly Seasonal Flow	Manual Quarterly Water Level	Dissolved Oxygen	TDS,TSS, T-P	TDS,TSS	O & G	Carbon 14	Tritium	Deuterium	Oxygen 18
Streams																							
CS-3								X											X				
CS-6**	X			X			X	X								X			X				
CS-7 (F-5)									X			X											
CS-8									X			X											
CS-9								X															
CS-10 (C-1)									X			X											
CS-11								X											X				
CS-12	X							X															
CS-13	X							X															
CS-14***	X							X															
CS-16 (C-3)								X				X							X				
CS-17 (C-2)								X				X											
CS-18 (C-4)								X															
CS-19								X															
CS-20****								X			X							X	X				
CS-21								X															
CS-22										X													
CS-23										X													
CS-24****								X			X					X		X	X				
CS-25								X															
CS-26								X															
CS-27								X															
CS-28																		X	X				
CS-29 (C-6)								X															
CS-30 (C-8)								X															
CS-31								X				X											
CS-32										X													
CS-33										X													
CS-34										X													
CS-35										X													
MD-1			X	X		X					X							X					
SRD-1			X								X												
F-10									X			X											
UP&L-10								X															
VC-6	X			X			X	X								X			X				
VC-9	X			X			X	X								X			X				
VC-10		X							X														
VC-11										X													
VC-12										X													

Table 2.3.7-1
Comprehensive Water Quality Analytical Schedule
(Surface and Ground Water Stations) (continued)

	1st Quarter							2nd[2] / 3rd[3] / 4th Quarters															
Sample Site	Lab Analysis*a	Field parameters only*1	Monthly Flow	Dissolved Oxygen	TDS,TSS, T-P		O & G	Lab Analysis*a	Qtrly Field parameters* only1	Quarterly Flow	Monthly Flow	Flow Monitoring (HCWMP)4,5	Water Level Monitoring (HCWMP)	Monthly Seasonal Flow	Manual Quarterly Water Level	Dissolved Oxygen	TDS,TSS, T-P	TDS,TSS	O & G	Carbon 14	Tritium	Deuterium	Oxygen 18
Wells																							
JC-1 (S)			X						X		X						X			X	X	X	X
JC-2 (S)													X		X								
JC-3 (S)			X						X		X						X						
ELD-1			X								X												
W79-26-1 (B)															X								
W2-1(98-2-1)(S)													X		X								
W99-4-1 (S)													X		X								
W20-28-1 (S)													X		X								
92-91-03								X															
08-1-5 (S)															X								
15-21-2 (S)													X		X								
16-24-1 (S)															X								
17-21-1 (B)													X		X								
17-34-1B													X		X								
17-34-1S													X		X								
18-28-1B													X		X								
18-32-1B													X		X								
18-32-1S													X		X								
18-5-1S													X		X								
19-5-1B													X		X								
P17-4-1 (E&W)															X								
P17-33-1 (E&W)															X								
P17-34-1 (N&S)															X								
Sustained in-mine flow >200 GPM for 60 days								X													X		

* Field Measurements and Laborotory Analyses are defined in Table 2.3.7-2

aField parameters will be taken in conjunction with samples collected for Lab Analyses

1Sites with at least two (2) years of laboratory analysis data will be sampled once every five (5) years for the currently approved laboratory parameters in Table 2.3.7-2 beginning in 2010. If field parameter monitoring indicates any trending changes, regular laboratory analysis may be resumed until trend is adequately characterized.

22nd Quarter sampling may extend to July 15 in years when spring snow conditions do not allow access before June.

3 Baseline Lab Analysis will be conducted every five (5) years beginning in 2010 in the 3rd quarter. (ie. Years 2010, 2015, 2020, etc.) (JC-1 and In-mine shall include Microscopic Particulate Analysis (MPA))

(HCWMP)4 - Sites are incorporated as part of the Huntington Canyon Water Monitoring Program (HCWMP)
(HCWMP)5 - Stream transducers may be pulled during winter months due to ice.

** Flow measurements discontinued at CS-6 in 12/2009, lower Eccles flow documented with VC-9
*** CS-14 represents mine in-flows and discharges from Mines #1, #2, and #4 (the SW districts of the Mine.
**** CS-24 and CS-20 will be sampled monthly for TDS, TSS, and Flow only when UPDES 004 is discharging

Ch. 2, Sec. 2.4

Stations will be located both above and below the rock waste disposal site in each of the drainages. (See Drawing 2.3.6-1.)

2. When flow is present, these stations will be monitored, when accessible, at the same frequency and for the same constituents as the stations in Eccles Creek. The data will be tabulated and reported in the same manner as the Skyline water quality data.

3. The data from these stations will be evaluated for non-point source contribution from ground water aquifers. This procedure offers the best potential for detection of ground water contamination.

The Upper O'Connor seam required a breakout to improve ventilation. The breakout is on a south facing slope in a side canyon of the South Fork of Eccles Creek (see map no. 3.2.11-1). A new road was built across this canyon to gain access to the breakout area. The conyon flows water in all but the driest of years. During construction, the creek was sampled above and below the site of a daily basis. The samples were tested for total suspended solids and settleable solids as n aid to regulating construction activities and in implementing control measures. Construction related solids fluctuations were encountered throughout this phase of the project.

In 2020 Skyline began discharging mine-water through the WQVF pond as permitted under the UPDES permit. In addition to two (2) Earthfax reports (March 2010 and Evaluation of Geomorphic Conditions…April,2017 both in Appendix A-1) documenting the well-armored nature of the stream, Skyline was required to photo-document sites WQ-1 through WQ-4 monthly while mine-water is discharging to document any potential erosional features. Photos, with any added text observations, will be submitted electronically in the month following the documentation.

The volume of water discharged from the mine increased significantly in August 2002 after large volumes of ground water were encountered within the mine. The mine was concerned about what effects the increased flows might have on Eccles and Mud Creeks. EarthFax Engineering, Inc. was contracted to perform a stream bank stability analysis on the streams using flows ranging between 5,000 and 30,000 gpm. The initial results of the report indicated that the stream banks would be stable at flows up to 30,000 gpm for short periods of time, but would compromise culverts at road crossings. Further study was requested by the Division and EarthFax was again contracted to continue the study of the effects on Mud and Eccles Creeks of sustained increased discharges from the Skyline Mine. The

Ch. 2, Sec. 2.5

Very little ground water was encountered while mining in the northern portion of the existing permit area prior to the addition of the North Lease. The same geologic and hydrogeologic conditions are anticipated to occur in the North Lease as occurred in the northern portion of the existing permit area (Mine 3). From 2005 through 2009 no significant water has been encountered in the North Lease. Therefore, no significant inflows of ground water are anticipated as mining progresses into the North Lease area. Selected surface discharges of ground water and stream flows in the areas that could be impacted by mining activities have beenwill be monitored. Mining related surface impacts include subsidence and the ventilation facility in Winter Quarters Canyon (WQVF)is the only surface impact anticipated since no new surface facilities are currently planned for the in the North Lease area. The WQVF will be permitted to encompass approximately 7.93 acres with the disturbance being treated with a sedimentation pond. The sole purpose of the facility will be to provide ventilation to the mine. If impacts to the waters within the permit area are determined to have occurred, mitigation will be implemented immediately using BTCA as described previously.

In 2020, approximately two years following mining in Mine #3, a need to utilize the mine-water outfall location in Winter Quarters was necessary. The last mining in Mine #3 (Federal Lease UTU-67939) was completed in April 2018. Following the completion of mining in this area, the districts of 1-Left through 6-Left, 7-Left, and 8-Left through 15-Left were subsequently sealed. As each district was sealed, inflowing ground water was no longer discharged from the area and the district was used as a sump for mine-water from active mining areas. Calculating the combination of active-mine water management and ancillary inflows from the district suggested the 7-Left and 8- through 15-Left would fill in early 2021, allowing ample time to remove all mining equipment and structure from the area prior to completely sealing Mine #3.

Outlining in-mine water management, the 1- through 6-Left district was completed in 2013 with water reporting to the bulkheads in 5-Left in September 2014, allowing time to extract any necessary equipment. Discharge records for CS-12 (Mine #3 discharge) reflect the time periods when inactive districts were being utilized as sumps for active mining areas as no discharges are recorded during those periods. Similarly, CS-12 did not discharge from March 2018 through August 2019 while allowing other inactive areas to become inundated. In April 2020, the 8- through 15-Left district, which dips predominantly northwest at 2-4 degrees, filled 6-8 months earlier than anticipated. All equipment will be extracted from the remaining areas of Mine #3 by late 2020, and the use of the Winter Quarters outfall should no longer be necessary.

Inundating of inactive workings is a common occurrence at the Skyline Mine. As discussed earlier in this section and illustrated on Plate 2.5.2-2, mining induces some communication between the underlying Star Point Sandstone and the unsaturated Blackhawk formation. The potentiometric surface, as outlined on Plate 2.4.2-2, illustrates that it is anticipated that the regional gradient will equalize based on the nature of the regional geology and final pool Mine-pool elevations. As anticipated, there have been no discernable impacts of flooding the mine on surface or ground water discharge except at the permitted discharge locations.

No negative impacts to Winter Quarters Creek due to mine-water discharge are anticipated. Upstream of Outfall 004 has been monitored at CS-20 since 2002. Stream monitoring site CS-24 was established downstream of Outfall 004 in 2009 prior to the construction of the Winter Quarters Ventilation Facility. No impacts associated with mining have been noted at either site.

Recorded stream flows downstream of Outfall 004 average 2,121 gpm, with a high-flow recorded at 22,411 gpm, and a low-flow of approximately 107 gpm. Based on the wide seasonal variation in flows and the well-armored nature of the stream channel, additional flows of 1,000 gpm and greater will be easily accommodated. In anticipation of mine-water discharge, two (2) stream geomorphology studies were submitted in March 2010 and April 2017 by Earthfax Engineering (Appendix A-1). Both studies indicate Winter Quarters Creek can easily handle 1,000 gpm and up to 6,200 gpm of mine-water discharge. Independent of these two engineering studies, Skyline is required to conduct monthly monitoring while discharging mine-water as outlined in Sections 2.3 and 2.4 of this M&RP.

North of Winter Quarters Canyon, north of the Winter Quarters graben(NOG), the longwall panels were rotated 90 degrees to maximize coal recovery. This rotation accommodates coal recovery approximately ½-mile further to the east. A study conducted by Agapito Associates indicates mining can be safely conducted in areas with as little as 475 feet overburden without seeing adverse effects related to subsidence. A lease modification to the North Lease in 2013 extended mining slightly into the Fish Creek drainage. Approximately 690 acres of the 770 acre lease modification are being undermined in the Fish Creek drainage with overburden ranging from approximately 900-1300. Surface water drainages include Wife Creek, and two forks of Andrew Dairy Creek. All three (3) surface drainages are similar in that they are ephemeral in the reaches proposed for mining. An additional similarity they share for the majority of their entire length is springs in or very near the stream channel. These springs will flow a short distance in the stream channel prior to disappearing in the alluvium. The first such spring in Wife Canyon (S26-2) begins approximately 0.35 miles downstream of the area impacted by mining and runs approximately 50-100 feet before going subsurface. This spring is separated from the proposed mining by almost 800 feet of overburden above the coal seam. Only Wife Creek (CS-26) has demonstrated perennial flow as it enters Fish Creek, with such minimal flow (0.45 gpm) that there is only a minimal persistent groundwater-derived base flow component. Based on the elevation of the coal seam, both Wife and Andrew Dairy Creeks are above the coal seam their entire length. Water rights 91-3917 (Spring S26-1) and 91-1039 (Spring S25-32) are located within the proposed expansion area with overburden ranging from approximately 1,270 feet to 880 feet, respectively. Preliminary water quantity information for Spring S26-1 and S25-32 indicate flows of approximately 0.33 to 2.8 gpm and 3.5 to 12 gpm, respectively. Preliminary water quantity information for Stream CS-26 indicates flows from 0.45 to 40.4 gpm. Based on the amount of overburden separating the proposed mining from the surface hydrology, and the same Blackhawk formation containing shallow recharge sources that has been mined and monitored for over 30 years, there is minimal probability that the quantity of water within the Wife and Andrew Dairy drainages will be impacted by mining. Other sites identified during baseline water monitoring collected in 2012 and 2013 are located in PHC Addendum Appendix L.

The water quality in the same drainages has minimal probability of being adversely impacted due to the slightly alkaline nature of the Blackhawk formation, combining with the groundwaters that are generally near neutral to slightly alkaline which limits the solubility of metals such as total iron and total manganese into the groundwater system. Similarly, surface water quality is highly dependent on the overwhelming influence of the annual springtime snowmelt event on the surface-water discharge rates. A supplemental report located in Appendix A-1 by Petersen

Hydrologic summarizes the similarities between the groundwater and surface water systems in the Fish Creek drainage with surrounding hydrologic systems that have been

Ch. 2, Sec. 2.8

Boulger, Swens, and Little Swens Canyon Creeks

As indicated in the 2002 Flat Canyon Environmental Impact Statement (EIS) prepared by the US Forest Service (USFS) and the Bureau of Land Management (BLM) all three (3) creeks are considered third order streams providing varying contributions to the aquatic habitat. Both Swens and Little Swens provide little habitat for fish due to the shallow pools and predominance of riffles in the reaches potentially affected by undermining. Based on the combination of minimal habitat and minimal reaches being undermined, only Boulger Creek will be monitored for fish. A fish monitoring program for Boulger Creek will be implemented prior to undermining the lower portion of the creek. The electro fish survey will estimate the fish populations in the stream for one year and every third year thereafter. The fish survey will begin one year prior to undermining any portion of the creek. Unless otherwise noted, sampling methods will be consistent with surveys conducted previously on James, Burnout, Eccles, Woods, and Winter Quarters creeks.

Boulger Reservoir is an artificial, man-made fishery that is restocked with fish on a regular basis throughout the fishing season. In the event Boulger Reservoir is undermined additional permitting will outline the mitigation of possibly draining the reservoir. All necessary regulatory agencies concerns will be addressed prior to undermining.

Winter Quarters Canyon and Woods Canyon Creeks

From Fall of 2002 through early Summer of 2004 fish and baseline macroinvertebrate data for the perennial reaches within Winter Quarters Canyon and Woods Canyon Creeks in the North Lease area were gathered. Copies of the reports are included in Appendix Volume A-3, Volume 2.

A macroinvertebrate survey of portions of Winter Quarters Canyon and Woods Canyon Creeks was performed twice a year for two consecutive years and then every third year thereafter or for a period determined by Canyon Fuel Company, LLC, DOGM, USFS, and the DWR, to be long enough to provide data to establish population trends. This survey was performed in the fall and spring of each year on or about the same date and completed in 2011.

Based on adequate data being collected, and the completion of longwall mining in Winter Quarters Canyon, macroinvertebrate surveys were terminated in both Winter Quarters and Woods Canyon creeks in concurrence with the various regulatory agencies in 2015. No impacts to the macroinvertebrate community based on mining were observed. Information supporting the ending of the surveys is available in Appendix A-3 (Skyline memo) and the individual macroivertebrate reports located in the Annual Reports. Monitoring in either creek could be re-established should conditions related to mining change.

In 2010 the Winter Quarters Ventilation Facility (WQVF) was added to the permit area approximately 2 mile downstream of the existing macroinvertebrate monitoring stations. Consultation with Dr. Shiozawa who directs the Skyline marcoinvertebrate monitoring program, indicated the portion of stream in the vicinity of the WQVF pad is not conducive to a macroinvertebrate study due to low gradient and inundation of fine sediment. He recommended a electro-fishing monitoring program which is outlined later in this section.

Skyline initiated mine-water discharge from the WQVF in 2020. Assuming conditions downstream are conducive to a macroivertebrate study, monitoring stations will be set up with a study initiated in low-flow conditions in 2020. Mine-water discharge is anticipated to only last into late 2020. In the event the discharges persist, an additional study will be conducted in 2021, then follow the schedule outlined in Table 2.8.1a. At the completion of adding mine-water, attempts will be made to reduce flows gradually if possible. This is not possible with the original pumping system.

As mining progressed north of Winter Quarters Canyon, the longwall panel orientation was rotated 90 degrees to maximize coal recovery. The rotation expanded mining approximately ½ mile to the east. To accommodate the modification, an additional macroinvertebrate station and fish monitoring station were set up in Woods Canyon to insure

Table 2.8-1a

Fish

Sample Site	End Date	2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Burnout	F, 2007		C		C						C						RC								
Eccles	ND				C						C						C						C		
James	F, 2007		C		C						C						RC								
Winter							C																C		
Woods	RC						C																C		
		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
Eccles	ND				X						X						X						X		
Winter	RC - 2013				RC																				
Woods	RC - 2013				RC																				
Boulger																	X						X		
		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
Eccles	ND				X						X						X								
Boulger					X						X						X								

Macroinvertebrate

Sample Site	End Date	2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
Burnout			C	C	C	C	C	C	C	C							RC	RC							
Eccles	ND				C	C	C	C	C	C	C						C	C						C	C
James			C	C	C	C	C	C	C	C							RC	RC							
Winter	2yr ptm						C	C	C	C							C	C						RC	RC
Woods	2yr ptm						C	C	C	C							C	C						RC	RC*
		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
Eccles	ND								X		X						X		X						X
Boulger																	X		X						X
Winter																			X		ID				ID
		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
Eccles	ND		X						X		X						X		X						
Boulger			X						X		X						X		X						
Winter			ID						ID		ID						ID		ID						

Key: C = completed, X = scheduled, ND = no end date, F = Fall, RC = requirements completed *
ID= if discharging * (will re-initiate monitoring if conditions change significantly)
Reports located in the Annual Submitted to the Division of Oil, Gas, and Mining.

Revised: 5/13/2020

Ch. 3, Sec. 3.2

The emergency spillway will not normally discharge during the design runoff events. However, assuming the primary spillway was not functioning and the pond was assumed full to the emergency spillway crest (8075.55 ft) prior to the occurrence of a 25-year, 6-hour storm event, the emergency spillway is calculated to discharge 2.06 cfs with a velocity of 4.69 fps at the crest. This velocity is considered non-erosive.

The required volume for annual sediment storage has been estimated at 1,108 cubic feet. The 60 percent sediment volume is at an elevation of 8071.7 feet. The 100 percent sediment 'clean-out' marker is at an elevation of 8072.1 feet which corresponds to the elevation of the 6-inch diameter decant pipe.

The sediment pond is also permitted as a Utah Pollution Discharge Elimination System (UPDES) Outfall location (UPDES-004). The UPDES outfall is permitted for both stormwater and mine-water discharge. The outfall had not discharged since being installed until 2020 when mine-water needed to be discharged from the location. The designed storm event for the Sediment Pond is calculated to discharge water at a rate of 1.09 cubic-feet/second (cfs), the riprap apron for the outfall needed to be upgraded to accommodate the mine-water discharge. A dedicated HDPE discharge pipe was extended from the Winter Quarters pad to the decant pipe of the Sedimentation Pond. The Primary Outlet Culvert (POC) has a discharge capability of 8.43 cu-ft/sec., while the designed storm event requires only 1.09 cu-ft/sec. for stormwater discharge. This provides approximately 7.34 cu-ft.sec (3,294 gallons) of mine-water discharge capacity. The riprap apron has been upgraded to adequately accommodate approximately 8.9 cubic-feet/second (4,000 gpm) of total discharge while remaining below the non-erosive threshold velocity of 5 feet/second. Calculations for both the POC and the apron design are located in Appendix A-5, Section 25, (Winter Quarters Ventilation Shaft Pad Runoff and Sediment Control Design Report, June 2010; and Winter Quarters Canyon Discharge Energy Dissipator Design, April 2020, respectively). The April 2020 report outlines two dissipator designs. The design without the cement box was the design installed. Updates are illustrated on Plates 3.2.4-3A and 3.2.4-3E, respectively. Topsoil generated from the riprap apron, approximately 6 cu-yds, will be added to the topsoil pile and reseeded (Section 4.7, Table 4.7-9A). Any necessary reseeding of the riparian area will be reseeded as outlined in Section 4.7, Table 4.7-9B. Skyline will not discharge in excess of 1,200 gpm. Additional permitting and consultation will be conducted prior to exceeding 1,200 gpm.

Swens Canyon Ventilation Facility Cuttings Pond

The cuttings pond was not built as a Raised-bore drilling technique was used for drilling the shaft which did not require a cuttings pond.

3.2.2 Overburden and Topsoil Handling

A comprehensive discussion pertaining to this operational component of the mine plan is presented in Section 4.6 - TOPSOIL AND SUBSOIL HANDLING PLAN.

3.2.3 Coal Processing

Maps 3.2.3-1 and 3.2.3-1A are flow diagrams of the entire coal handling system. Designated capacities represent maximum design capabilities necessary to handle surges in the system. The average throughput, a substantially lower figure, is reflected in the annual production schedule.

Run of Mine (R.O.M.) coal is brought out of the mines by conveyor belts and it is temporarily stored in an 8,000 ton capacity concrete silo or the open coal storage area. As the coal is needed, it is transported by conveyor belts to a crushing system and then to the overland conveyor that transports it to the railroad loadout facility. Coal transported to the railroad loadout facility may go directly into the storage silos or may be placed in the RLO open coal storage area. Some coal is still shipped by truck direct from the truck loadout area. In the event of an emergency situation coal can be transported from the truck loadout area to the railroad loadout facility.

Stoker Coal

A stoker coal circuit is located on the coal storage silos at the train loadout area. A stoker loadout storage tank is located on

Ch. 4 Sec. 4.3

Ref.	Description Winter Quarters Ventilation Facility 42	Materials	Means Reference Number	Unit Cost	O&P	Unit	Length	Width	Height	Diameter	Area	Volume	Weight	Density	Time	Number	Unit	Swell Factor	Quantity	Unit	Cost
	Steel																				
	Substation/Transformers 42																				
	Structure's Demolition Cost	Steel Bld. Large	02 41 16 13 0020	0.27	0.39	/CF													1000	CF	390
					0																
	Escape Shaft				0																
	Structure's Demolition Cost	Steel Bld. Large	02 41 16 13 0020	0.27	0.39	/CF													88	CF	34.32
					0																
	Fencing	Fencing barbed wire 3 strand	02 41 13 60 1600	1.36	2.1	LF													1000	LF	2100
	Topsoil Pile	chain link remove 8'-10'	02 41 13 60 1700	2.98	4.22	LF													2900	LF	12238
	Ventilation Pad	chain link remove 8'-10'	02 41 13 60 1700	2.98	4.22	LF													9000	LF	37980
	Reinforced Earth Retaining Wall				0																
					0																
	Ventilation Fan	Steel Bld. Large	02 41 16 13 0020	0.27	0.36	/CF													150	CF	54
	Structure's Demolition Cost				0																
					0																
	Mobile Field Office				0																
	Structure's Demo cost	mixed materials	02 41 16 13 0100	0.3	0.36	/CF													1000	CF	360
	Structure's Demolition Cost generator	Steel Bld. Large	02 41 16 13 0020	0.27	0.36	/CF													1000	CF	360
	Subtotal				0																53516.32
					0																
	Concrete				0																
	Substation				0																
	Escape Shaft Pad	Nielson Concrete <15"	Nielson Quote	13.75	13.75	CY													60	CY	825
	Shaft Collar and Fan Pad, temp	Nielson Concrete <15"	Nielson Quote	13.75	13.75	CY													35	CY	481.25
	Mobile Field Office Pad	Nielson Concrete <15"	Nielson Quote	13.75	13.75	CY													463	CY	6366.25
	Slope Collar	Nielson Concrete <15"	Nielson Quote	13.75	13.75	CY													15	CY	206.25
	Misc	Nielson Concrete <15"	Nielson Quote	13.75	13.75	CY													30	CY	412.5
	Concrete's Vol. Demolished	Nielson Concrete <15"	Nielson Quote	13.75	13.75	CY													25	CY	343.75
	Loading Cost				0													1.3	816	CY	
	Disposal Costs	Front end Loader 3 CY	31 23 16 42 1300	1.67	2.05	/CY													816	CY	1672.8
	Loading Cost	On site disposal	02 41 16 17 4200	8.65	11.1	/CY													816	CY	9057.6
	Subtotal																				19365.4
	Concrete Demolition	Remove RipRap Pond Discharge Apron																			1700
	Demolition Cost	Place 6 cu-yd riprap apron into pond reclaim																			300
	Concrete's Vol. Demolished																				
	Loading Cost																				
	Transportation Cost																				
	Disposal Costs																				
	Subtotal																				
	Total																				74881.72

Ch. 4, Sec. 4.4

4.4.2 Grading and Final Contour

All highwalls and cutslopes will be reclaimed using geotechnically stable fill slopes with surfaces that have been sufficiently roughened with deep gouging. The operational bench slopes will be graded back to the approximate original contour at a two horizontal to one vertical slope (2h:1v) or shallower upon abandonment, utilizing a bulldozer working along the slopes. A geotechnical analysis will be made of this slope at the time of reclamation and design adjustment made as necessary to insure slope stability. The sediment pond at the portal area will be removed during the initial reclamation phase.

The reclamation plan is shown on in maps 4.4.2-1A, 4.4.2-1AA. 4.4.2-1B. 4.4.2-1BA, 4.4.2-1B1 and 4.4.2-1AC. Costs and mass balance data associated with reclamation may be found in the Engineering Calculations, Volume 5.

Grading operations will be possible at the railroad load-out site which will be returned to the approximate original contour and shown on Maps 4.4.2-1C and 4.4.2-1D. Water Tank final reclamation contours are shown on Maps 4.4.2-1E and 4.4.2-1F. The waste rock disposal site final reclamation contours are shown on Map 4.16.1-1B.

The Winter Quarters Ventilation Facility grading and final contour plan will be similar to the sites listed above. Once excess material has been used in sealing the slope and shaft as outlined in Sections 4.1.2 and 4.9, any retaining walls, highwalls or cutslopes will be reclaimed using geotechnically stable fill slopes with the final surface being roughened with deep gouging. The pad will be graded back to the approximate original contour, unless the post-mining land use changes. The sedimentation pond will be removed once sufficient re-contouring of the pad has taken place. See Plates 4.4.2-3A and 4.4.2-3B for the reclaimed site configuration. Riprap from the outfall apron will be placed in the bottom of the pond prior to pond slopes being regraded.

The Swens Canyon Ventilation Facility will continue with the grading and contour plans listed above, using geotechnically stable fill slopes. Material generated during construction of the shafts and stored in the cuttings pond area, will be used as backfill for the shafts following the backfill designs located in Section 4.9 and Figure 4.9-B. The pad will be graded back to the approximate original contour. The small section of the USFS road that was rerouted for access to the pad will be re-established in its former location. Plates 4.4.2-4A and 4.4.2-4B illustrate the proposed final reclamation designs.

PLAN VIEW
SCALE: 1"=50'

0 50 100
FEET

INDEX OF DRAWINGS

DRAWING NAME	DWG NUMBER	SHEET NUMBER
FACILITIES PLAN	3.2.4–3A	1 OF 9
ACCESS ROAD–PLAN AND PROFILE	3.2.4–3B	2 OF 9
OPERATIONAL SURFACE CROSS SECTIONS	3.2.4–3C	3 OF 9
SEDIMENTATION POND PLAN, SECTIONS AND DETAILS	3.2.4–3D	4 OF 9
ROAD AND DRAINAGE DETAILS	3.2.4–3E	5 OF 9
DRAINAGE AND RETAINING WALL DETAILS	3.2.4–3F	6 OF 9
OPERATIONAL WATERSHEDS	3.2.4–3G	7 OF 9
PROPOSED RECLAMATION PLAN	4.4.2–3A	8 OF 9
RECLAMATION SURFACE CROSS SECTIONS	4.4.2–3B	9 OF 9

LEGEND

- PERMIT AREA BOUNDARY
- 8140 EXISTING GROUND MAJOR CONTOUR (10 FOOT)
- EXISTING GROUND MINOR CONTOUR (2 FOOT)
- A A' CROSS–SECTION (SEE PLATE 3.2.4–3C)
- BERM, AS SPECIFIED
- Culvert
- EXISTING DIRT ROAD
- EXISTING STREAM
- FENCE/GATE
- 4' WIDE ASCA DITCH. SEE DETAIL 1, SHEET 5
- 2' WIDE ASCA DITCH. SEE DETAIL 1, SHEET 5
- PAD SWALE. SEE DETAIL 2, SHEET 5
- ASCA 39 (ALTERNATIVE SEDIMENT CONTROL AREA)
- Riprap

AREA	CUT (CY)	FILL (CY)
ACCESS ROAD AND PAD	13,192	7,314
SEDIMENTATION POND EMBANKMENT	522	90
TOPSOIL SEDIMENT TRAP	0	25
1.6 FEET OF TOPSOIL REMOVED (73,667SF AREA)	0	5,200
TOTAL	13,714	12,629

GENERAL NOTES:

SEAL:

DATE	No.	REVISIONS	Drw	Chk
10–4–11	1	Added Temporary Powder and Cap magazines and temporary construction buildings		
12–21–11	2	Provided As–built modifications		
1–19–16	3	Removed temporary contruction buildings and powder and cap Magazines; added finished fan structure, refuge building, propane tank, generator, transformer, and bore holes.	JCA	GAG
5–1–20	4	Added mine water discharge pipe and discharge structure	TWE	GAG

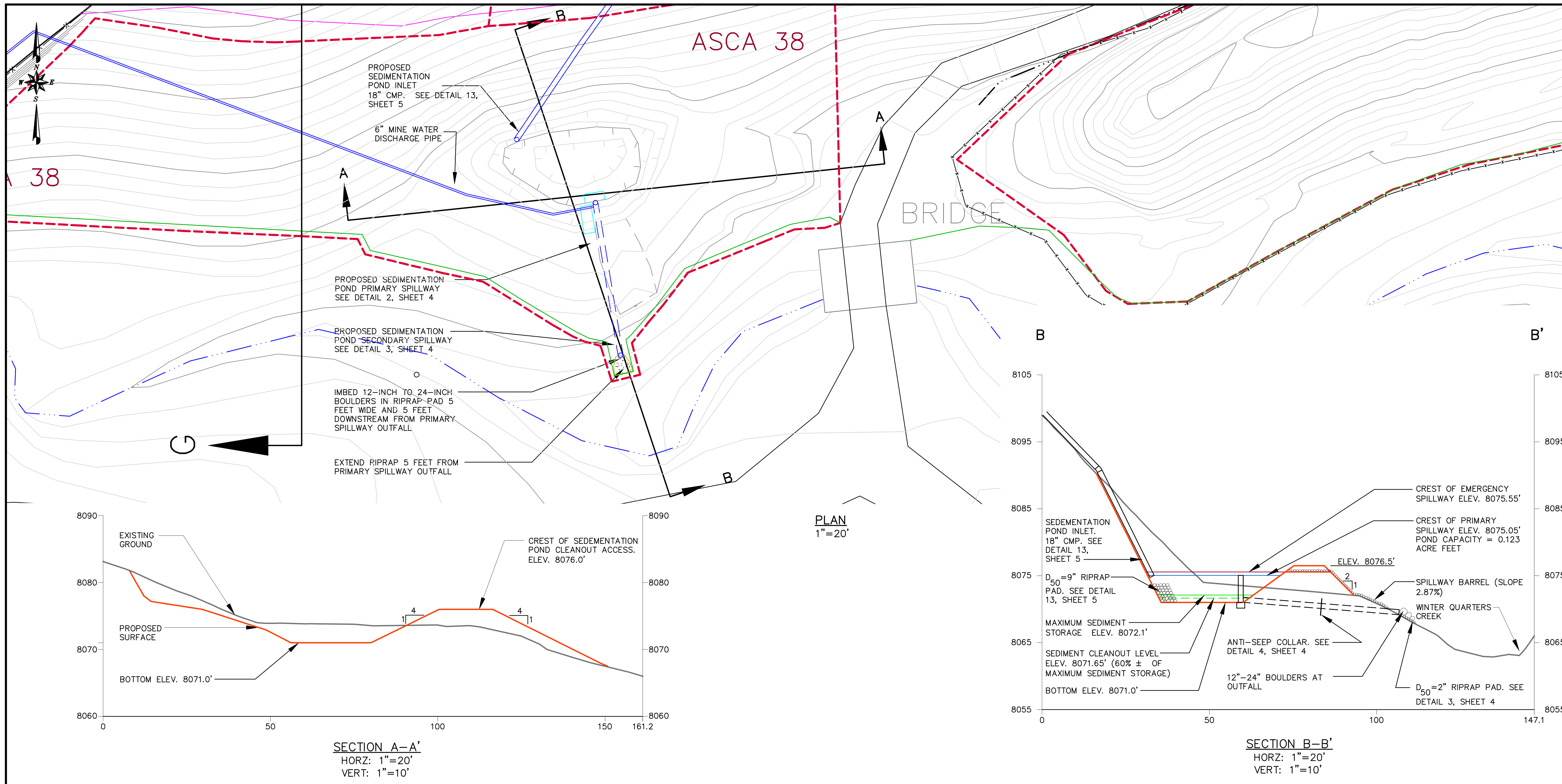
WINTER QUARTERS VENTILATION PAD FACILITIES AS–BUILT

Canyon Fuel Company, LLC
Skyline Mines

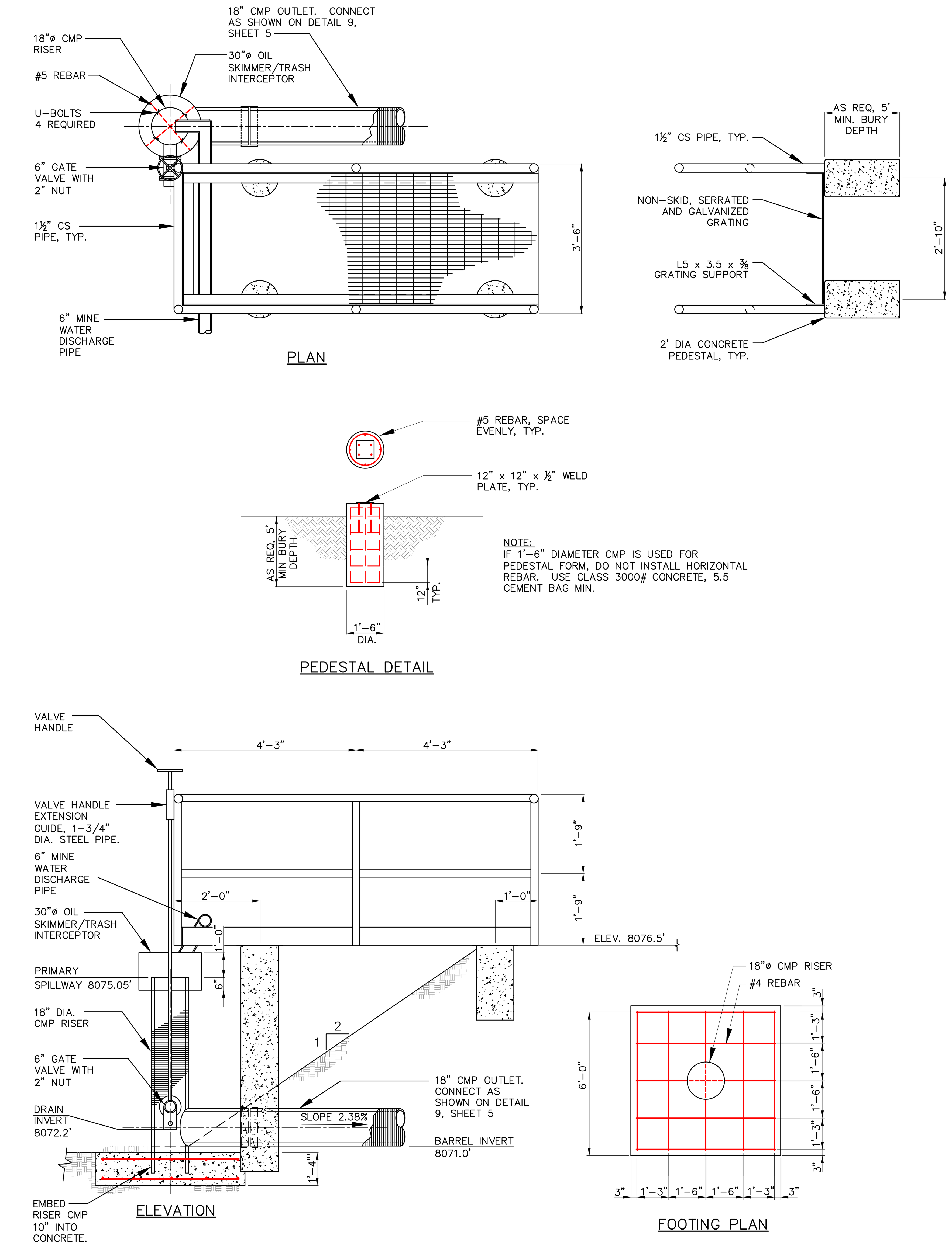
P.O. BOX 719 HELPER, UTAH 84526
801–637–7925

CAD FILE: EF–G:\UC794–18\3.2.4–3A

DATE: 12/21/11	CK.BY: CWB	REVISION: 4
SCALE: AS SHOWN	DR.BY: TWE	5/11/2020
DWG. NO.: 3.2.4–3A	SHEET 1 OF 9	

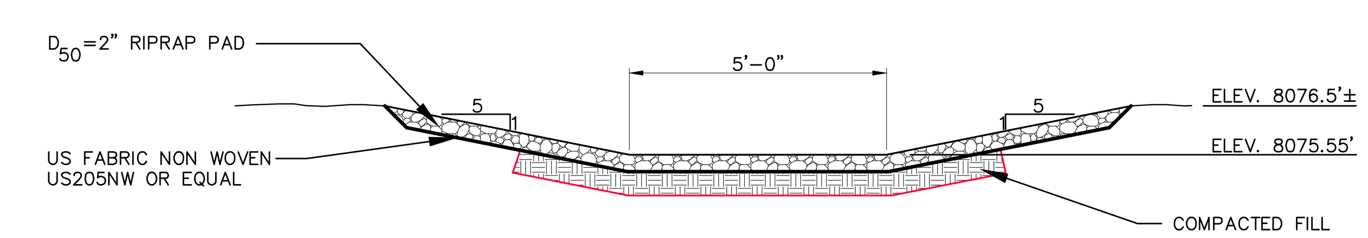


PROPOSED SEDIMENTATION POND 1/4



SEDIMENTATION POND PRIMARY SPILLWAY 2/4

NO SCALE

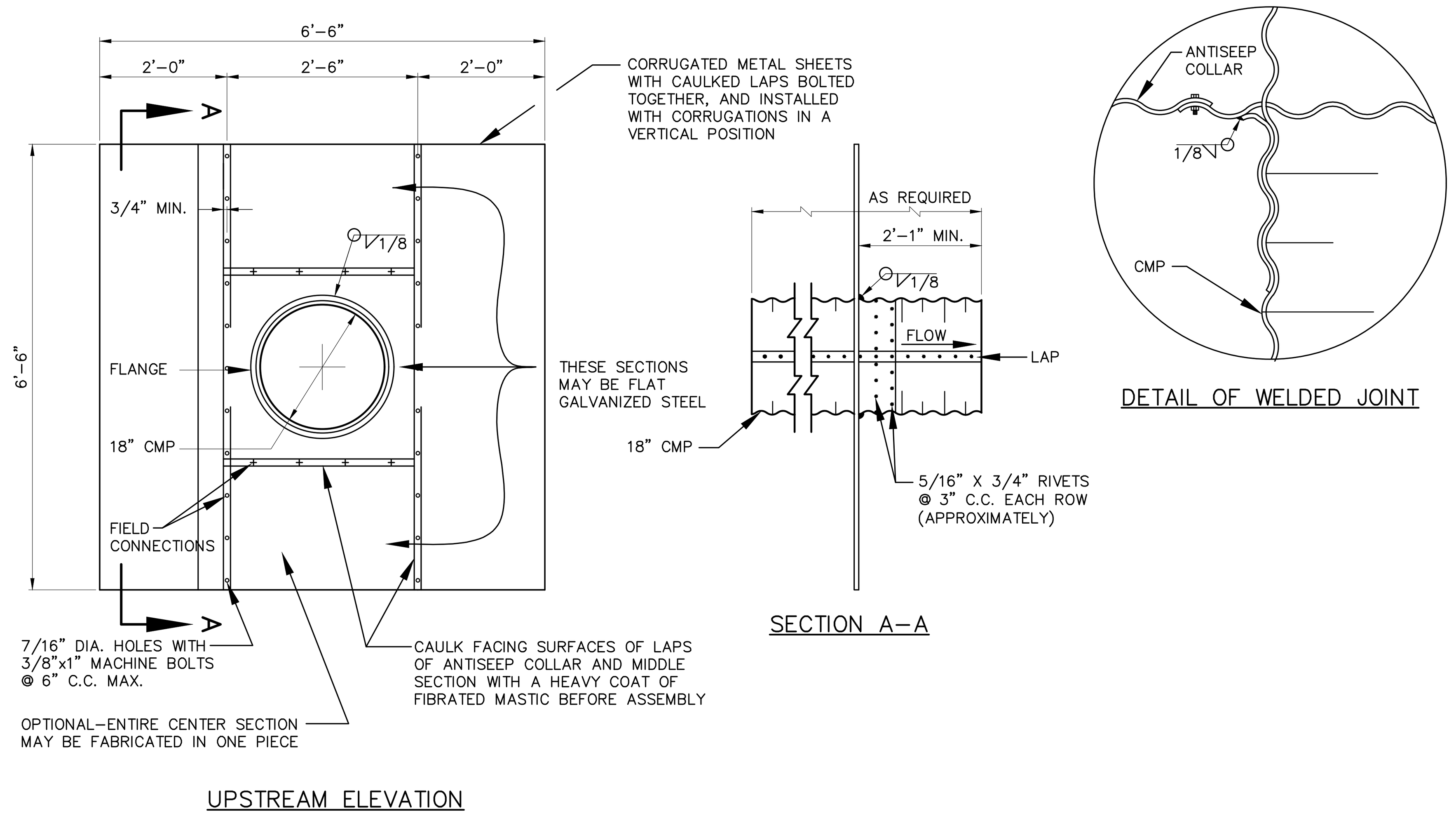


SEDIMENTATION POND SECONDARY SPILLWAY 3/4

SCALE" 1' = 3'-0"

NOTES:

1. ANTI-SEEP COLLARS SHALL BE LOCATED WITHIN 20' OF THE PRIMARY SPILLWAY INLET AND OUTLET.
2. UNASSEMBLED ANTI-SEEP COLLARS SHALL BE MARKED BY PAINTING OR TAGGING TO IDENTIFY MATCHING PAIRS.
3. THE MIDDLE SECTION OF THE ANTISEEP COLLAR SHALL BE SHOP FABRICATED.
4. FLAT SHEETS OF EQUIVALENT THICKNESS AND/OR GAGE AND COATING MAY BE SUBSTITUTED FOR THE CORRUGATED METAL SHEETS.
5. IRON OR STEEL COLLAR THICKNESS SHALL BE 0.064", (16 GAGE), OR ALUMINUM ALLOY SHALL BE 0.060".



ANTI-SEEP COLLAR DETAIL 4/4

NO SCALE

EarthFax Engineering, Inc.
Engineers/Scientists

AS SHOWN

SEAL:

DATE	No.	REVISIONS
5/20	1	Added Mine water discharge pipe

WINTER QUARTERS VENTILATION SHAFT PAD SEDIMENTATION POND PLAN, SECTIONS AND DETAILS

Canyon Fuel Company, LLC
Skyline Mines

P.O. BOX 719 HELPER, UTAH 84526 801-637-7925

CAD FILE: EF-C:\UC794-18\3.2.4-3D

DATE: 06-01-10	CK.BY: rbw	REVISION: 1
SCALE: AS SHOWN	DR.BY: st	
DWG. NO.: 3.2.4-3D	SHEET 4 OF 9	5/5/2020

SEAL:

DATE	No.	REVISIONS
12/11	1	Modified detail 7 from berm to jersey barrier
5/20	2	Added Detail for Mine Discharge Outfall

WINTER QUARTERS VENTILATION PAD
ROAD AND DRAINAGE DETAILS

Canyon Fuel Company, LLC
Skyline Mines

P.O. BOX 719 HELPER, UTAH 84526 801-637-7925
CAD FILE: CF-G:\UC794-18\3.2.4-3E

DATE: 12-12-11	CK.BY: CWW	REVISION:
SCALE: AS SHOWN	DR.BY: TWE	2
DWG. NO.: 3.2.4-3E	SHEET 5 OF 9	5-1-20

Evaluation of Geomorphic Conditions in Winter Quarters Canyon Near the Skyline Mine Ventilation Portal

Canyon Fuel Company
Skyline Mine
Scofield, Utah

April 2017

REGISTERED PROFESSIONAL ENGINEER
No. 168246
RICHARD B. WHITE
21 Apr 2017
STATE OF UTAH

EarthFax EarthFax Engineering Group, LLC

Engineers / Scientists
www.earthfax.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EVALUATION OF GEOMORPHIC CONDITIONS IN WINTER QUARTERS CANYON NEAR THE SKYLINE MINE VENTILATION PORTAL

CHAPTER 1

INTRODUCTION

Canyon Fuel Company operates the Skyline Mine in Carbon County, Utah. The primary portal for this mine is located in Eccles Canyon, approximately 3.7 miles southwest of Scofield, Utah. A ventilation portal for the mine exists in Winter Quarters Canyon, approximately 2.2 miles west of Scofield.

Canyon Fuel requested that EarthFax Engineering Group, LLC evaluate geomorphic conditions in Winter Quarters Creek upstream and downstream from the ventilation portal to aid in evaluating the long-term impacts of portal operations on the stream. This project included surveying the longitudinal profile and cross section of the stream in four locations, collection and analysis of soil and streambed samples from those four locations, and evaluation of the resulting data.

Field work for this project was conducted on September 27, 2016. This report presents the methods used to collect the data and the results of our investigation.

CHAPTER 2

FIELD DATA COLLECTION METHODS

Reference sites were established on Winter Quarters Creek at the locations shown on Figure 1. All reference sites were established in general conformance to the recommendations of Harrelson et al. (1994). The work at each site involved the following:

- Establish benchmarks - Benchmarks were installed at locations WQ-1, WQ-3, and WQ-4 using a portable power auger by drilling an 8-inch diameter hole to a depth of at least 36-inches (unless restricted by cobbles). Each hole was filled with concrete and the monument was identified with a brass marker stamped with the site number. An exception to this method of benchmark installation occurred at WQ-2, where a buried steel rail existed at a location convenient to the reference reach and was used as the benchmark. Photographs were taken and the benchmarks were surveyed using a Topcon Tesla GPS unit. Table 1 presents the coordinates of the benchmarks in both latitude/longitude and State Plane coordinate systems.

- Establish cross sections - One cross section was established in each reach by installing 4-foot long, ½ -inch diameter steel reinforcing bars that were driven approximately 3.5 feet into the ground. The bars were painted orange and marked with survey flagging.

- Survey each channel cross section - Each cross section was surveyed using the Topcon Tesla GPS unit. Elevations and locations were shot at each important feature or change in grade (e.g., slope breaks, channel banks, bankfull stages, etc.). The survey was closed by re-shooting the station benchmark.

- Survey each reference reach longitudinal profile - Reference reaches were established that extended approximately 20 times the channel width (half upstream and half downstream from the cross section location). Data were collected to indicate the elevation of the channel bottom and the water surface at each point. Data were collected using the Topcon Tesla GPS unit.

- Photograph each channel reach and cross section - Photographs were taken of each channel reach and cross section location during the field investigation.

Samples of the bed and bank materials were collected at each channel reach to evaluate geomorphic and stability relationships at those locations. Grab samples were analyzed for gradation, soil moisture, and Atterberg Limit testing.

CHAPTER 3

RESULTS SUMMARY

3.1 REFERENCE SITE CHARACTERIZATION

Data collected from the channel cross sections and profiles are presented in Figures 2 through 5. These figures also provide photographs of each reference reach and cross section. Table 2 presents a summary of the hydraulic gradient at each reference reach based on the water-surface survey collected during the site survey. Average hydraulic gradients range from a high of 0.048 ft/ft in reach WQ-2 to a low of 0.011 ft/ft in reach WQ-4. Maximum hydraulic gradients range from a high of 0.135 ft/ft in reach WQ-2 to a low of 0.030 ft/ft in reach WQ-4. Minimum hydraulic gradients range from a high of 0.005 ft/ft in reaches WQ-3 and WQ-4 to 0.002 in reach WQ-1.

General descriptions of each reference reach follows:

- WQ-1: This reach is located immediately upstream of the ventilation portal. The upper portion of this reach flows to the north-northeast, while the middle and lower portions flow to the east-northeast. The south bank of this reach is well vegetated with grasses. The upper and lower portions of the north bank of this reach are similarly vegetated, while the middle section of the north bank is a steep, south-facing natural slope that is much drier. No areas of substantial channel instability were apparent at the time of our field survey.

- WQ-2: This reach is located near the point where the ventilation portal access road leaves the Winter Quarters Canyon road. The north bank of this reach is part of a well-vegetated alluvial bench, with the vegetation consisting primarily of grasses. The south bank, which is part of a natural hill slope, is moderately well vegetated with grasses and small shrubs. No areas of substantial channel instability were apparent in this reach at the time of our field survey.

- WQ-3: This reach is located near the point where a road departs to the northeast from the Winter Quarters Canyon road. The upper end of this reach has a sharp meander bend where active erosion is occurring on the outside of the bend. Stinging nettle covers the eroded bank at this location. The north bank through the remainder of this reach is well vegetated with grasses. The south bank is well vegetated with willows and a grass understory. Other than the erosion in the meander bend at the upper end of this reach, no areas of substantial channel instability were apparent at the time of our field survey.

- WQ-4: This reach is located near a south, ephemeral tributary of Winter Quarters Creek, downstream from a series of beaver ponds and upstream from the historic Winter Quarters Mine surface facilities. The bench mark is located in an area covered by historic coal fines. The north and south banks of the reach are well vegetated with grasses. The north bank is located immediately adjacent to the Winter Quarters Canyon road. No areas of substantial channel instability were apparent in this reach at the time of our field survey.

3.2 STREAM BED AND BANK STABILITY EVALUATION

Soil and streambed samples were collected in each reach, as indicated in Table 3. These samples were submitted to Intermountain GeoEnvironmental Services for analyses of various physical properties. The results of analyses of those samples are provided in Appendix A and summarized in Table 4.

The bank and floodplain soils along the reaches of Winter Quarters Creek that were sampled in this study consist of silty sand to sandy silt except in reach WQ-4 where the surficial material consisted of silty gravel. Channel bed materials range in size from sands through cobbles and are fairly uniform throughout the four reaches, with a median grain size that varies from 81 t0 89 mm (3.2 to 3.5 inches).

Rating tables and curves at each cross section are provided in Appendix B. These ratings were calculated using version 6.0 of FlowMaster based on the average hydraulic slope and the following judgmentally-selected Manning roughness coefficients (“n”):

- Channel bottom (i.e., gravel and cobbles): n = 0.040
- Dry bank sagebrush: n = 0.050
- Floodplain grasses: n = 0.035
- Floodplain willows: n = 0.100

The erosional stability of the channel bed at each cross section was determined based on the data provided in Appendix B and the maximum permissible velocity methods of the U.S. Natural Resources Conservation Service (2007). For the channel bed, the maximum permissible velocity was set equal to the basic velocity of Figure 6, based on the median rock diameters provided in Table 4. No corrections of this basic velocity were considered necessary since the reaches are generally straight and bank stability was evaluated separately (see below). As indicated in Table 5, the channel bed materials are considered stable at all cross sections except WQ-2 when the stream is flowing at the full stages evaluated. At WQ-2, the full cross-section velocity exceeds the erosionally-stable velocity by about 7 percent. Thus, except potentially at cross section WQ-2, substantial downcutting is not anticipated in the stream channel during high-discharge events.

The stability of the banks and floodplains was assessed based on field observations, professional judgment, and guidelines provided by Rosgen (2001). Reach WQ-1 exhibited no active erosion at the time of the field visit. Generally, the north and south banks of this reach are well vegetated and appear to be stable. However, the north bank in the middle portion of this reach is a dry, south-facing slope with a lower vegetation density. This lower vegetative density increases the erosion hazard in this section of the reach. Furthermore, a short section of the south bank has sluffed into the channel near the downstream end of this reach. At high flows, bank erosion may be increased adjacent to this sluffed section. Therefore, the erosion hazard in this reach is categorized as moderate.

The north bank in reach WQ-2 is very well vegetated while the south bank is moderately well vegetated. No evidence of active erosion was noted in this reach during the field visit. Therefore, the erosion hazard in this reach is categorized as low.

The north and south banks of reach WQ-3 are generally well vegetated throughout, except on a sharp meander bend at the upper end of the reach. At this location, active erosion is occurring on the outside of the meander bend and, in this localized area, the erosion hazard is categorized as high. Throughout the remainder of the reach, the erosion hazard is categorized as low.

The channel banks in reach WQ-4 are well vegetated and show no signs of active erosion. The erosion hazard in this reach is categorized as low.

CHAPTER 4

REFERENCES

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Rosgen, D.L. 2001. A Practical Method of Computing Streambank Erosion Rate. Proceedings of the Seventh Federal Interagency Sedimentation Conference. Volume I, Section II: Stream Restoration. pp. II-9 through II-17.

U.S. Natural Resources Conservation Service. 2007. Threshold Channel Design. Chapter 8 of Part 654: Stream Restoration Design, National Engineering Handbook. Washington, D.C.

TABLE 1

Benchmark Locations

Site	Elevation (ft)	Latitude	Longitude	State Plane Coordinates (ft)	
				Northing	Easting
WQ-1	8111.85	39° 43' 11.46"	111° 12' 08.88"	7066835	1724109
WQ-2	8064.39	39° 43' 12.60"	111° 11' 56.12"	7066954	1725106
WQ-3	8034.97	39° 43' 13.16"	111° 11' 44.07"	7067013	1726047
WQ-4	7955.11	39° 43' 11.61"	111° 11' 16.89"	7066864	1728171

Notes: Coordinates in NAD83 system
State Plane Zone: 4302

TABLE 2

Hydraulic Gradient of Each Reference Reach

Reference Reach	Hydraulic Gradient (ft/ft)		
	Maximum	Minimum	Average
WQ-1	0.059	0.002	0.026
WQ-2	0.135	0.004	0.048
WQ-3	0.038	0.005	0.024
WQ-4	0.030	0.005	0.011

TABLE 3

Samples Submitted for Analysis of Physical Properties

Sample No.	Sample Description	Analyses Requested
WQ-1A	South bank, 6-12" depth	Gradation, Atterberg limits, Soil classification
WQ-1B	South bank, 18-30" depth	Gradation, Atterberg limits, Soil classification
WQ-2A	North bank, 3-10" depth	Gradation, Atterberg limits, Soil classification
WQ-2B	North bank, 10-14" depth	Gradation, Atterberg limits, Soil classification
WQ-3A	North bank, 3-9" depth	Gradation, Atterberg limits, Soil classification
WQ-4A	North bank, 3-9" depth	Gradation, Atterberg limits, Soil classification
WQ-4B	North bank, 14-20" depth	Gradation, Atterberg limits, Soil classification
WQ-1CB	Streambed surface sample	Gradation
WQ-2CB	Streambed surface sample	Gradation
WQ-3CB	Streambed surface sample	Gradation
WQ-4CB	Streambed surface sample	Gradation

TABLE 4

Summary of Channel and Floodplain Soil Properties

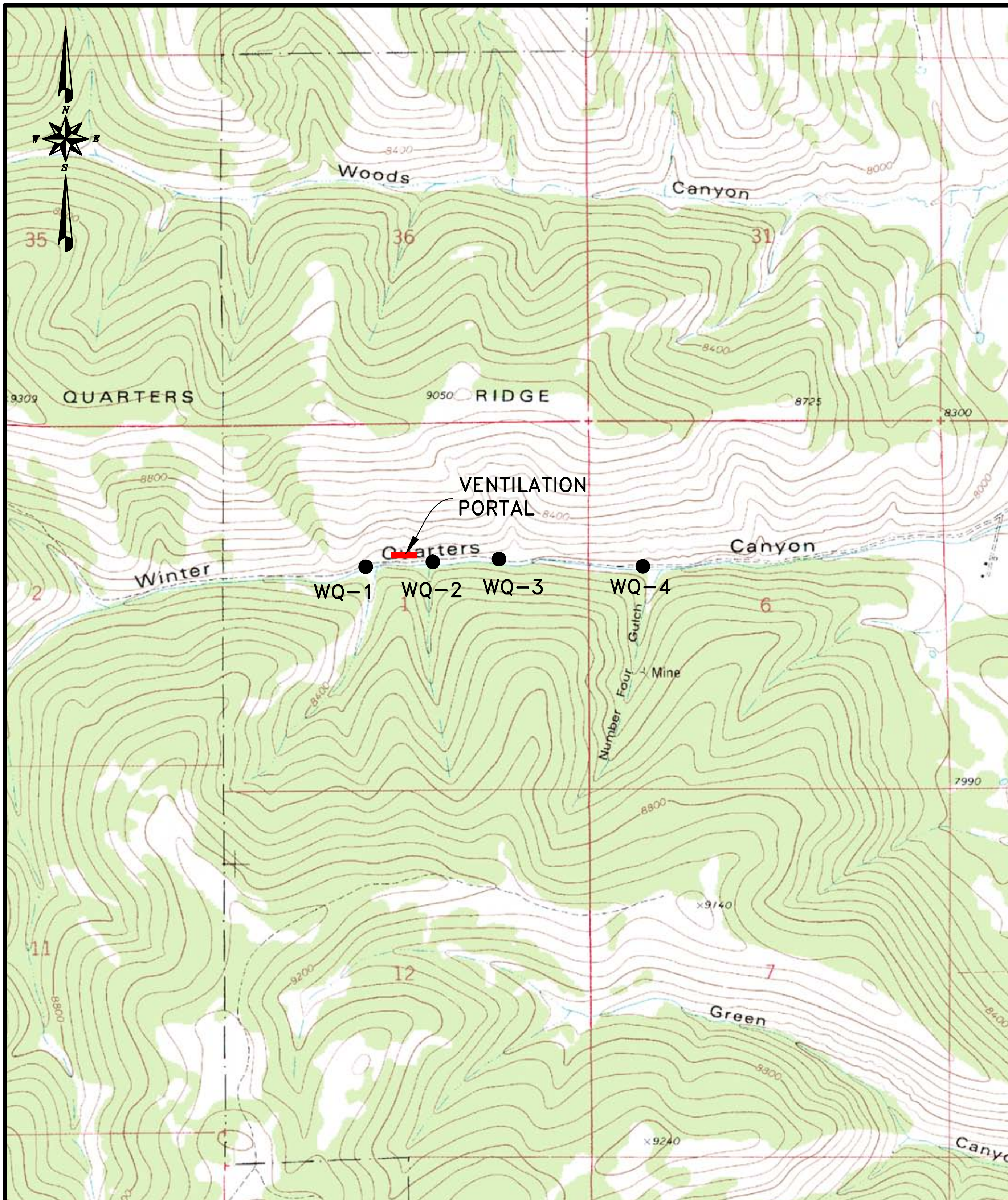
Sample No.	Sample Depth (in)	Soil Description	Grain Size (mm)		
			D_{20}	D_{50}	D_{80}
WQ-1A	6-12	Silty sand	0.07	0.13	0.21
WQ-1B	18-30	Poorly-graded gravel with silt and sand	0.18	11	33
WQ-2A	3-10	Silty sand	0.07	0.13	0.24
WQ-2B	10-14	Silty sand	0.06	0.12	0.23
WQ-3A	3-9	Sandy silt	0.04	0.07	0.15
WQ-4A	3-9	Silty gravel with sand	0.95	5.6	30
WQ-4B	14-20	Silty sand	0.05	0.11	0.22
WQ-1CB	0-6	Gravel - Channel bed	46	89	160
WQ-2CB	0-6	Gravel - Channel bed	51	89	160
WQ-3CB	0-6	Gravel - Channel bed	42	83	110
WQ-4CB	0-6	Gravel - Channel bed	41	81	130

TABLE 5

Maximum Permissible Velocities of the
Channel Bed in the Reference Reaches

Cross Section	D_{50} (mm)	Discharge at Full Cross Section (cfs)[a]	Velocity (ft/s)		Stability at Full Cross Section
			Actual Peak[a]	Permissible	
WQ-1	89	262	7.95	10.4	Stable
WQ-2	89	503	11.11	10.4	Unstable
WQ-3	83	671	7.62	10.2	Stable
WQ-4	81	554	7.51	10.1	Stable

[a] At full cross section, based on average hydraulic slope (see Appendix B)



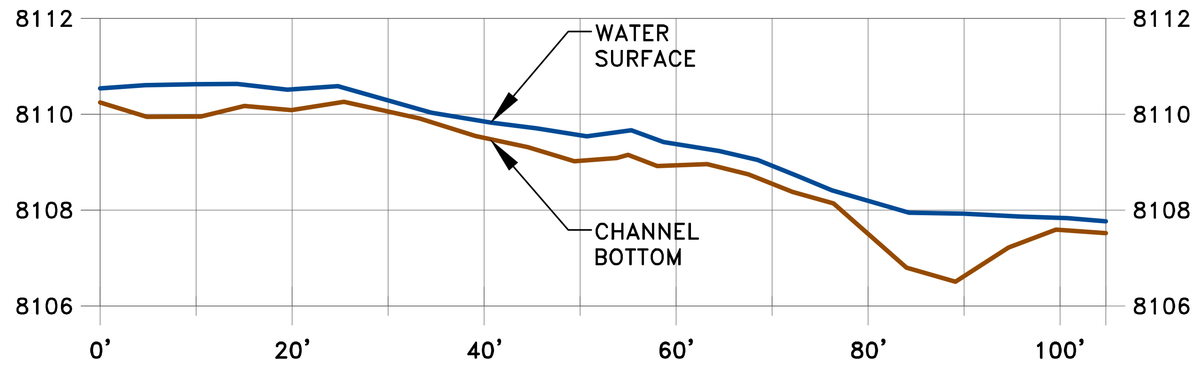
BASE MAP: USGS 7-1/2 MIN. QUADRANGLE
SCOFIELD, UTAH (1979)

0' 2000'

FIGURE 1. LOCATION OF REFERENCE SITES

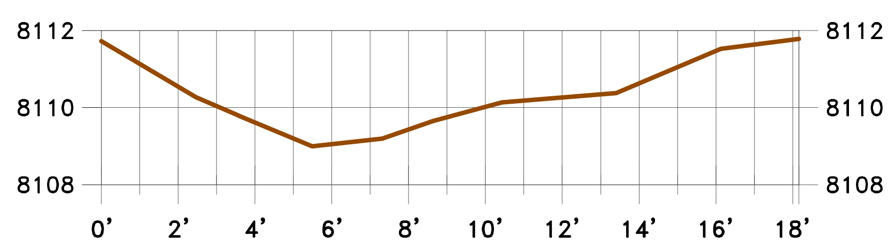
EarthFax

G:\UC794\25 — Winter Quarters Canyon geomorphology\DWG\FIGURE 1.dwg, 4/21/2017 10:51:54 AM, DWG To PDF.pc3



WQ–1 PROFILE

HORZ: 1"=20'–0"
VERT: 1"=5'–0"



WQ–1 CROSS SECTION

SCALE 1"=5'–0"

UPPER REACH

LOWER REACH

CROSS SECTION

FIGURE 2. WQ–1 CROSS SECTION, PROFILES, AND PHOTOS

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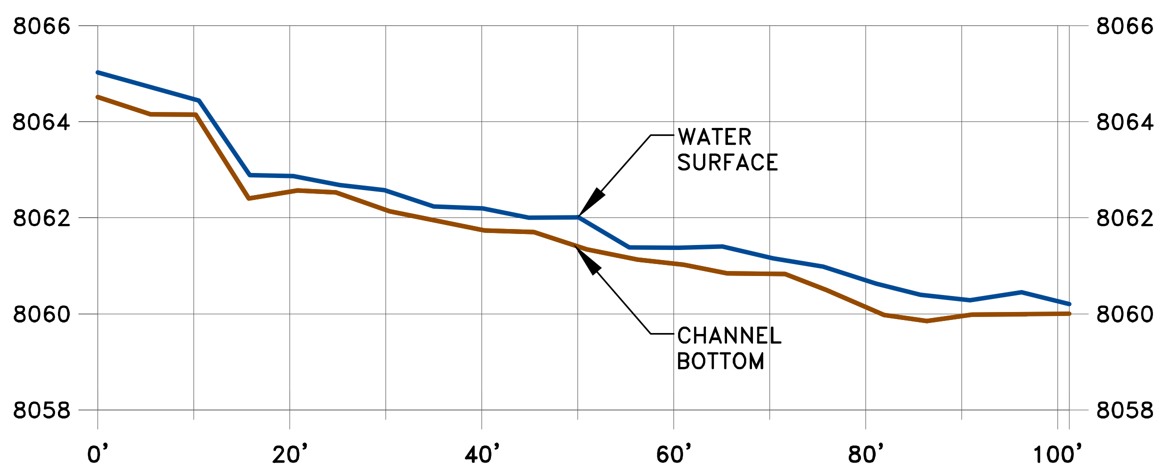
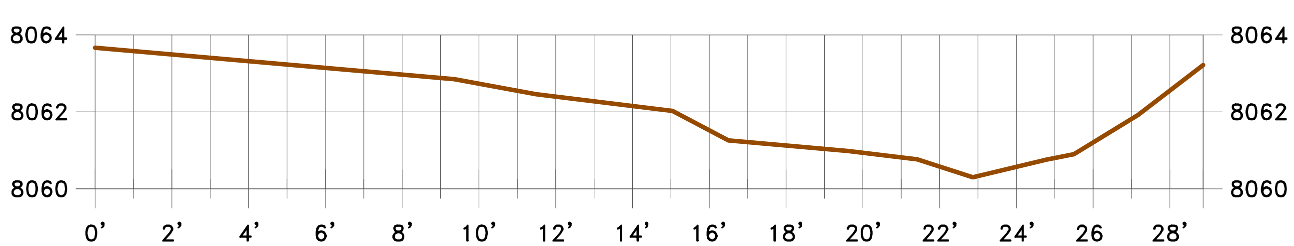


WQ–2 PROFILE

HORZ: 1"=20'–0"
VERT: 1"=5'–0"



WQ–2 CROSS SECTION

SCALE 1"=5'–0"

BENCH MARK (BURIED RAIL)

REACH

CROSS SECTION

FIGURE 3. WQ–2 CROSS SECTION, PROFILES, AND PHOTOS

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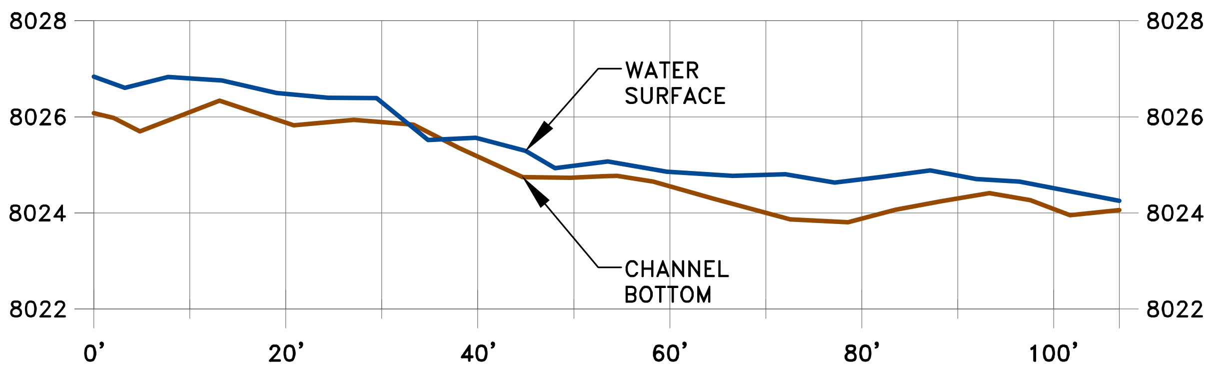
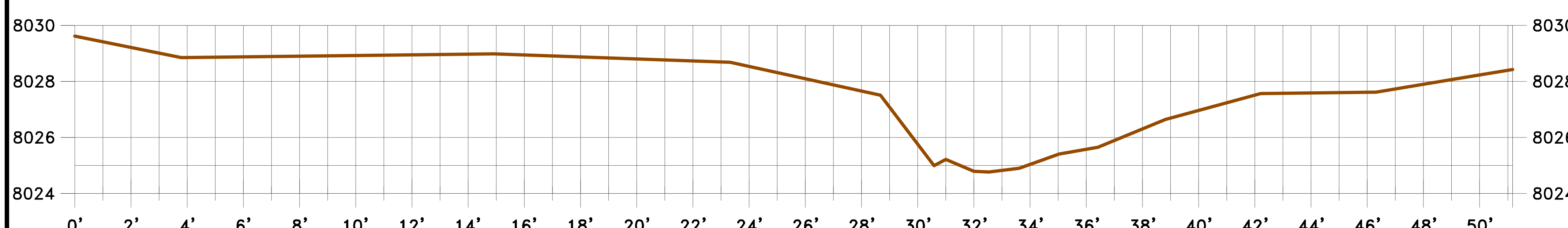


WQ–3 PROFILE

HORZ: 1"=20'–0"
VERT: 1"=5'–0"

UPPER REACH

LOWER REACH



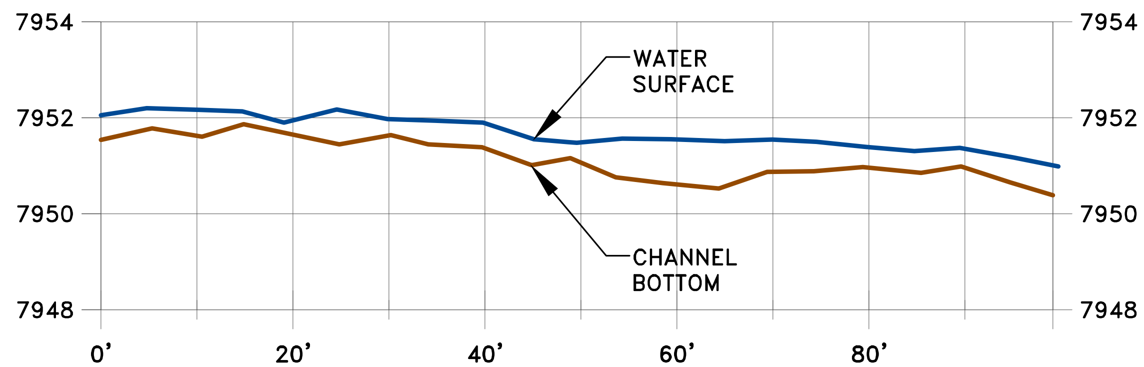
WQ3 CROSS SECTION

SCALE 1"=5'–0"

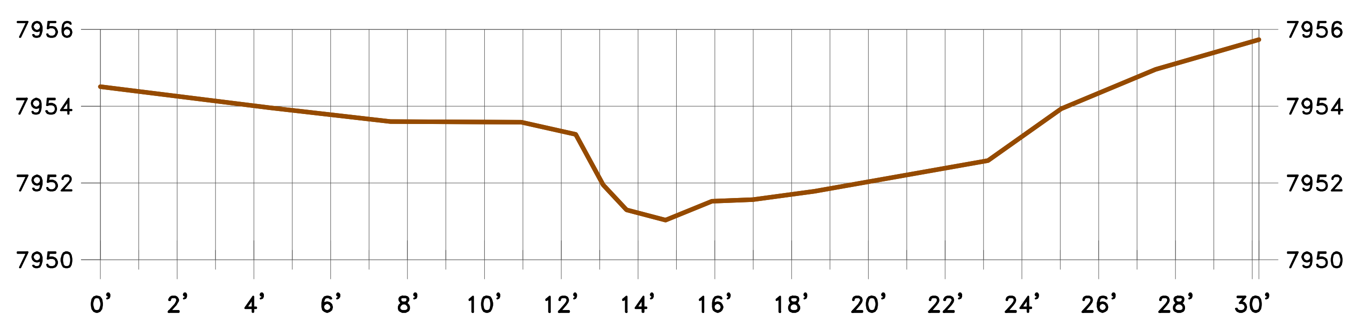
CROSS SECTION

EarthFax

FIGURE 4. WQ–3 CROSS SECTION, PROFILES, AND PHOTOS



WQ–4 PROFILE
HORZ: 1"=20'–0"
VERT: 1"=5'–0"



WQ–4 CROSS SECTION
SCALE 1"=5'–0"

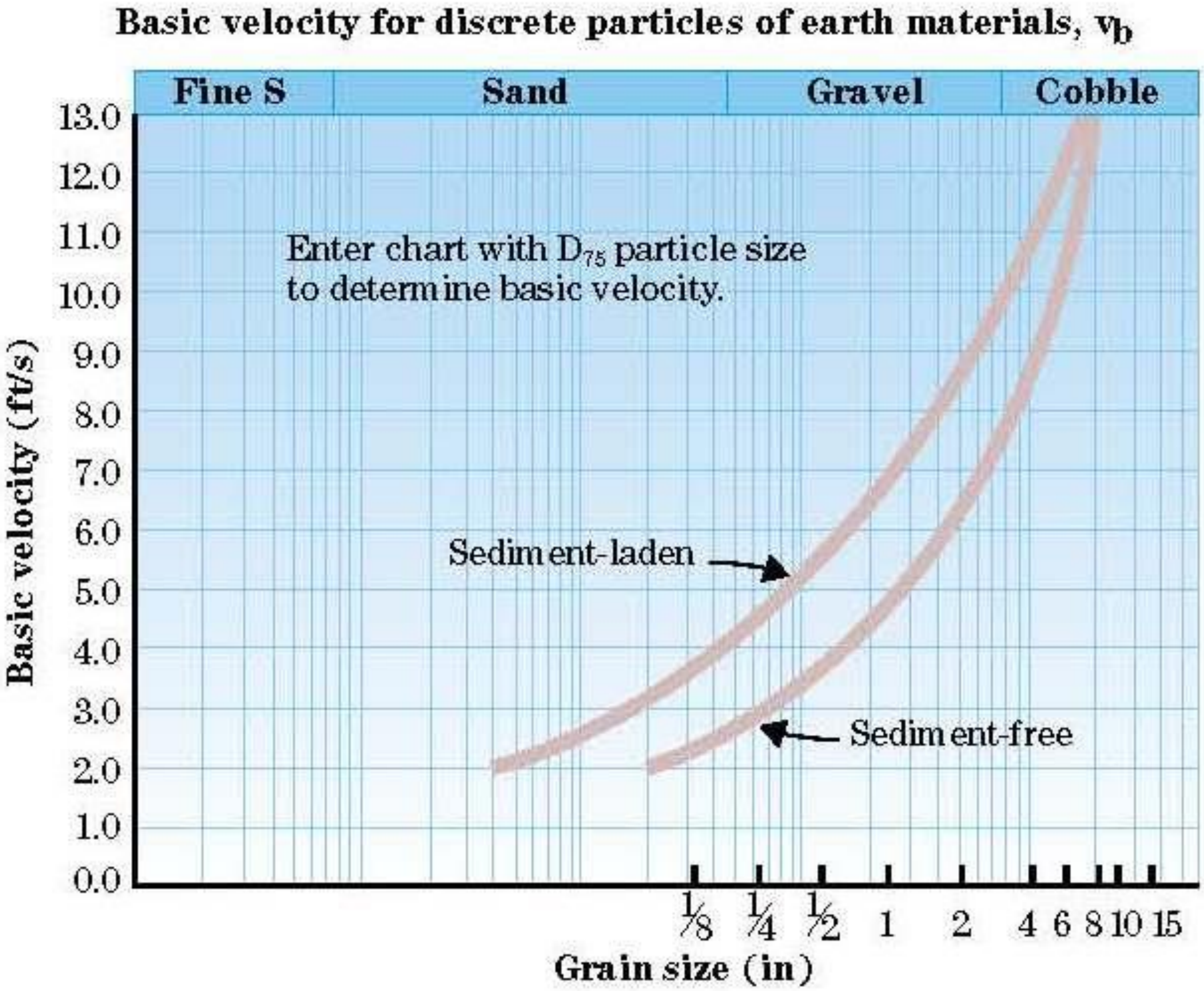
BENCHMARK

REACH

CROSS SECTION

FIGURE 5. WQ–4 CROSS SECTION, PROFILES, AND PHOTOS

EarthFax



SOURCE: US NATURAL RESOURCES CONSERVATION SERVICE (2007)

FIGURE 6. ALLOWABLE VELOCITY IN CHANNEL BED

EarthFax

APPENDIX A

Soil Laboratory Data

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/2/2016
By: BRR

Boring No.:
Sample: WQ-1A
Depth:
Description: SILT, brown

Preparation method: Wet
Liquid Limit: Could not be determined (N.P.)

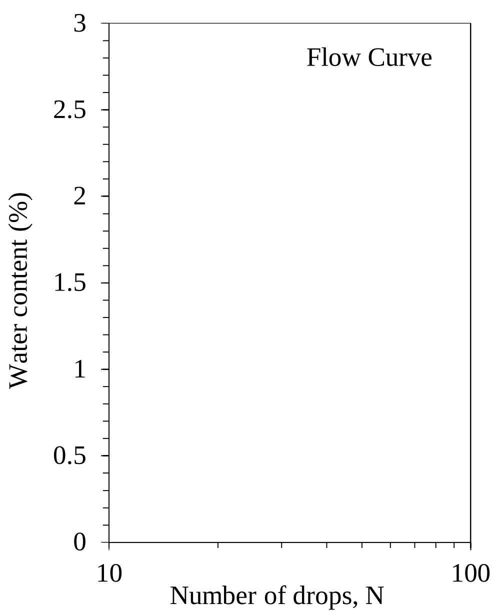
Plastic Limit

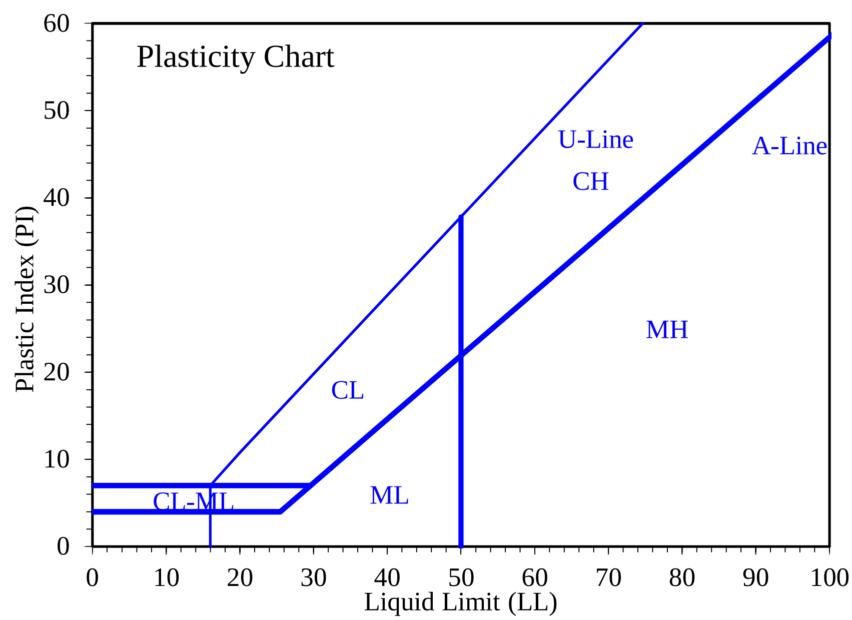
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/2/2016
By: BRR

Boring No.:
Sample: WQ-1B
Depth:
Description: SILT, brown

Preparation method: Wet
Liquid Limit: Could not be determined (N.P.)

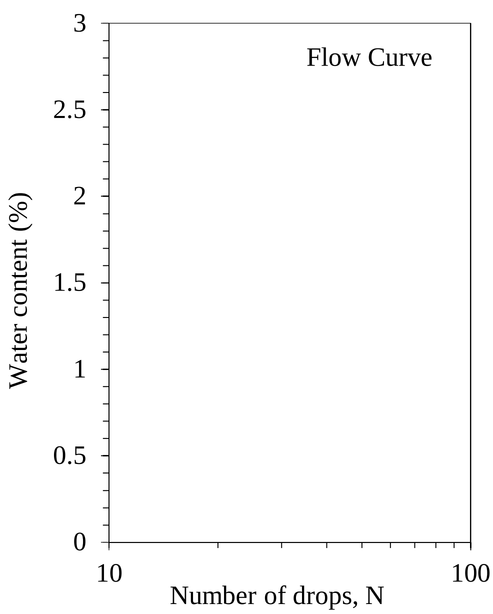
Plastic Limit

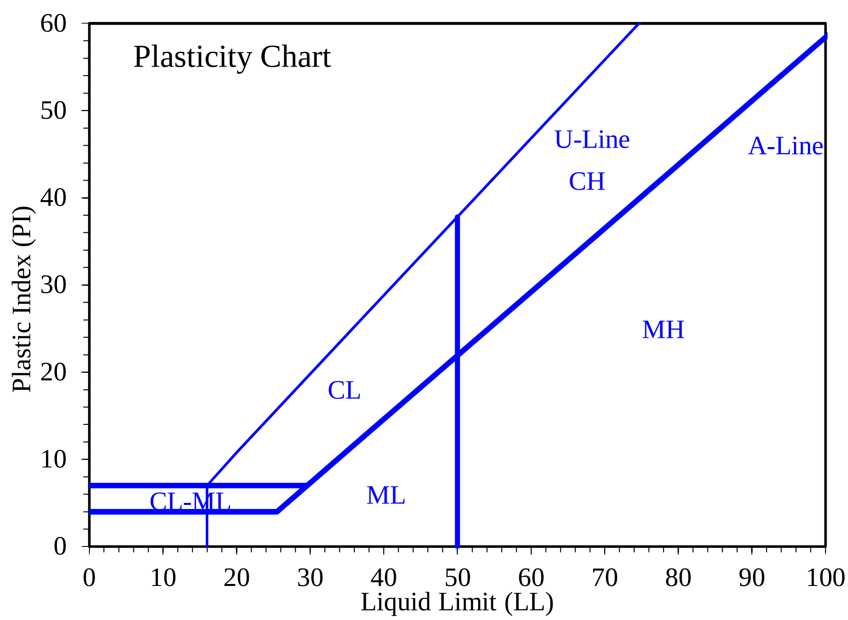
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





Entered by:___________
Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

© IGES 2004, 2016

Project: **EarthFax Engineering**
No: **M01292-027 (PO #UC-794-25)**
Location:
Date: 11/2/2016
By: BRR

Boring No.:
Sample: **WQ-2A**
Depth:
Description: SILT, brown

Preparation method: Wet
Liquid Limit: Could not be determined (N.P.)

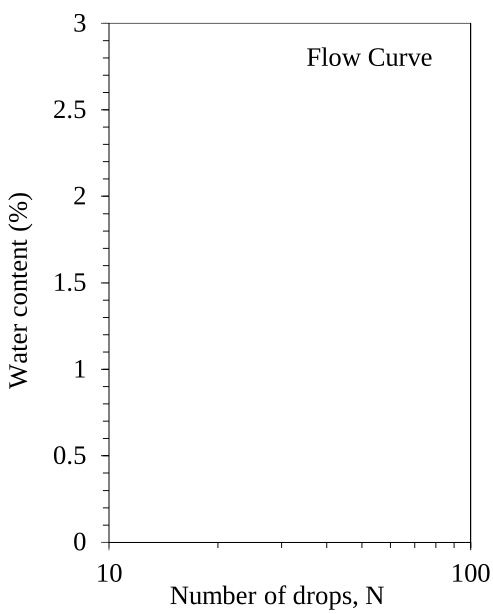
Plastic Limit

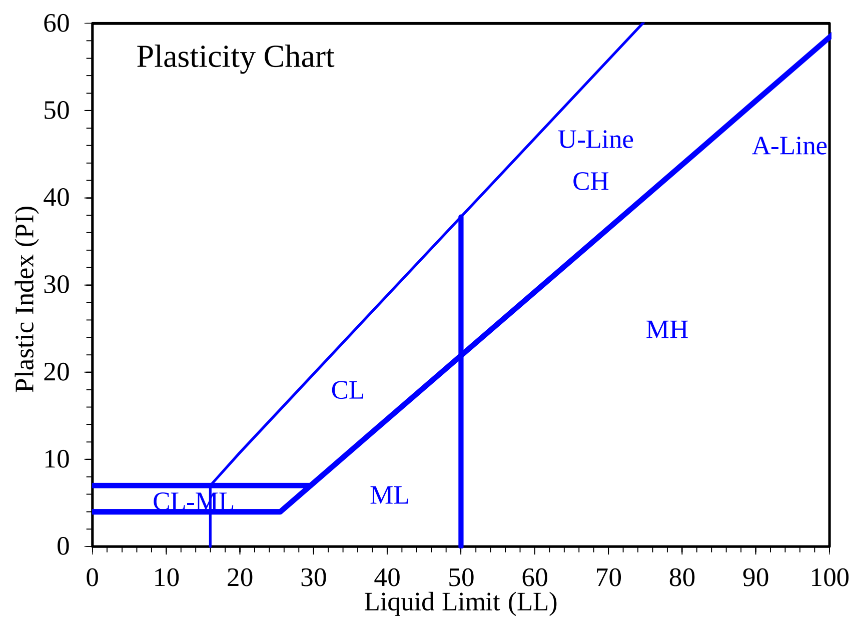
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





Entered by:___________
Reviewed:___________

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: **EarthFax Engineering**
No: **M01292-027 (PO #UC-794-25)**
Location:
Date: 11/2/2016
By: BRR

Boring No.:
Sample: **WQ-2B**
Depth:
Description: SILT, dark brown

Preparation method: Wet
Liquid limit test method: Multipoint

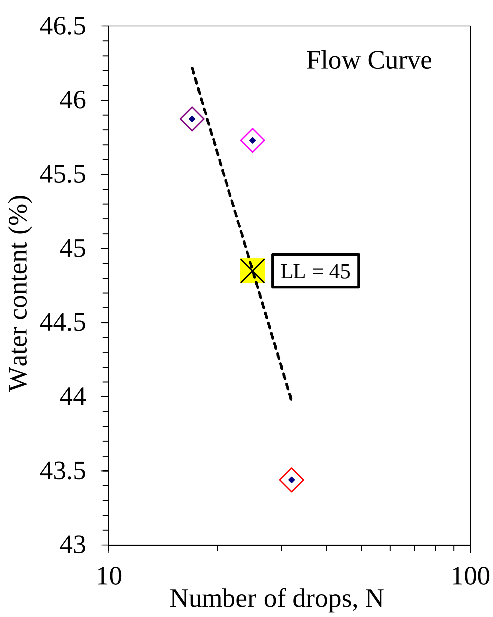
Plastic Limit

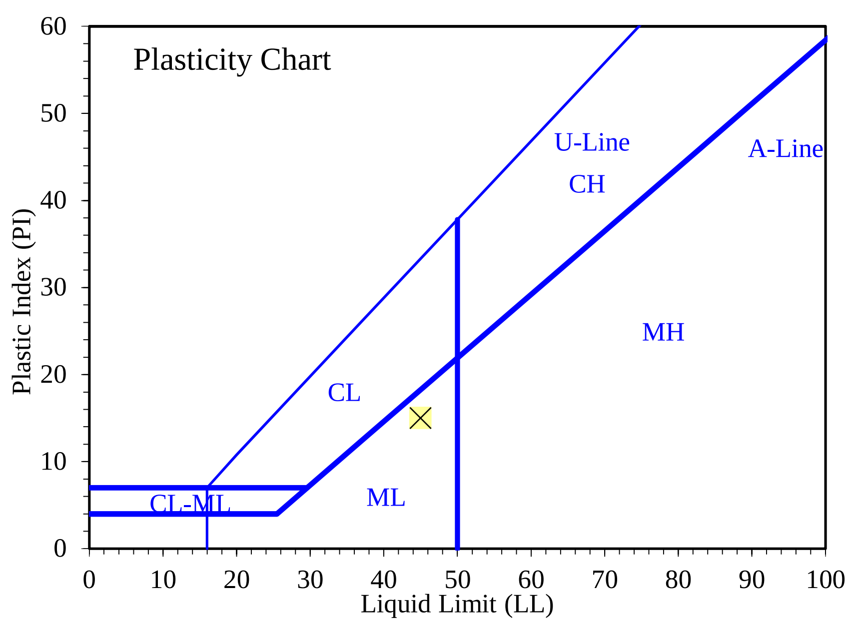
Determination No	1	2				
Wet Soil + Tare (g)	28.76	28.17				
Dry Soil + Tare (g)	27.19	26.70				
Water Loss (g)	1.57	1.47				
Tare (g)	21.90	21.90				
Dry Soil (g)	5.29	4.80				
Water Content, w (%)	29.68	30.63				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	32	25	17			
Wet Soil + Tare (g)	28.16	27.99	28.14			
Dry Soil + Tare (g)	26.24	26.17	26.25			
Water Loss (g)	1.92	1.82	1.89			
Tare (g)	21.82	22.19	22.13			
Dry Soil (g)	4.42	3.98	4.12			
Water Content, w (%)	43.44	45.73	45.87			
One-Point LL (%)		46				

Liquid Limit, LL (%)	**45**
Plastic Limit, PL (%)	**30**
Plasticity Index, PI (%)	**15**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/2/2016
By: BRR

Boring No.:
Sample: WQ-3A
Depth:
Description: SILT, dark brown

Preparation method: Wet
Liquid limit test method: Multipoint

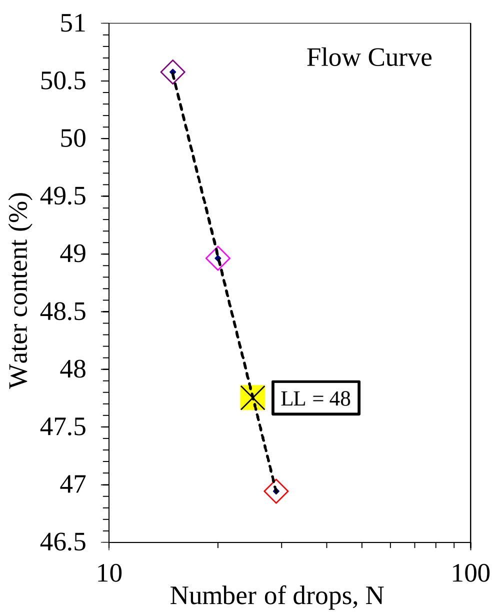
Plastic Limit

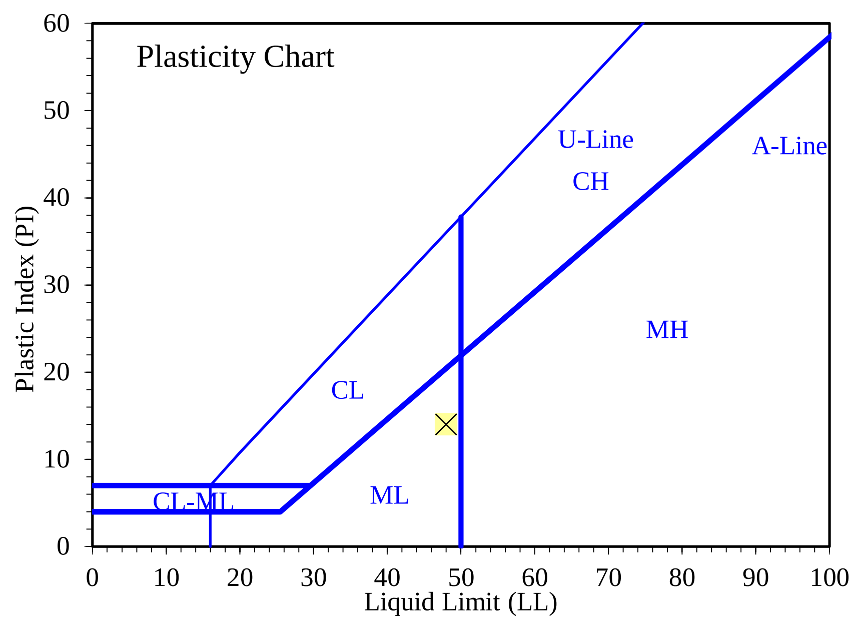
Determination No	1	2				
Wet Soil + Tare (g)	29.62	30.05				
Dry Soil + Tare (g)	27.67	28.03				
Water Loss (g)	1.95	2.02				
Tare (g)	21.94	22.07				
Dry Soil (g)	5.73	5.96				
Water Content, w (%)	34.03	33.89				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	29	20	15			
Wet Soil + Tare (g)	26.86	29.28	29.55			
Dry Soil + Tare (g)	25.17	26.92	26.92			
Water Loss (g)	1.69	2.36	2.63			
Tare (g)	21.57	22.10	21.72			
Dry Soil (g)	3.60	4.82	5.20			
Water Content, w (%)	46.94	48.96	50.58			
One-Point LL (%)	48	48				

Liquid Limit, LL (%)	**48**
Plastic Limit, PL (%)	**34**
Plasticity Index, PI (%)	**14**





Entered by:___________
Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/2/2016
By: BRR

Boring No.:
Sample: WQ-4A
Depth:
Description: SILT, brown

Preparation method: Wet
Liquid Limit: Could not be determined (N.P.)

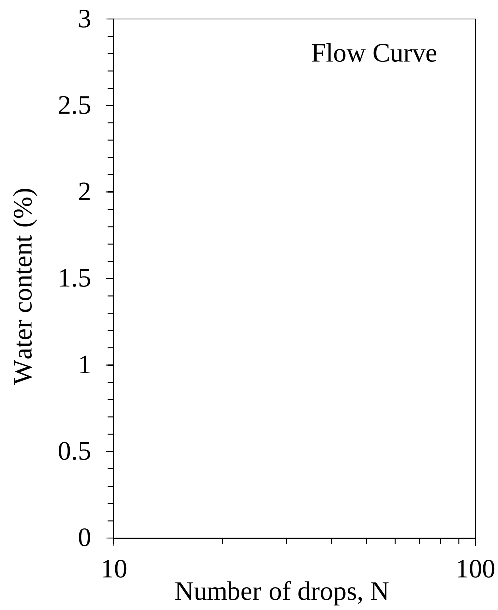
Plastic Limit

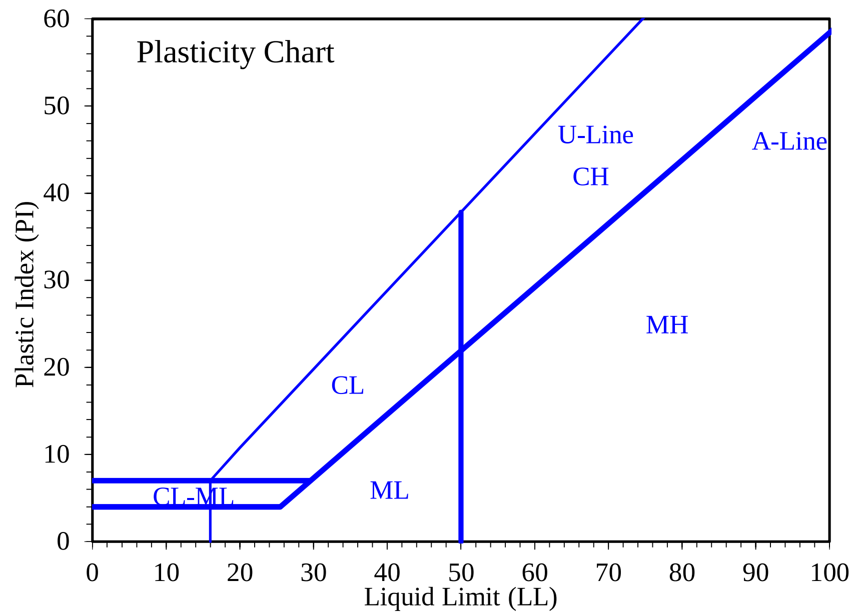
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Reviewed:___________

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils
(ASTM D4318)

Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/2/2016
By: BRR

Boring No.:
Sample: WQ-4B
Depth:
Description: SILT, dark brown

Preparation method: Wet
Liquid Limit: Could not be determined (N.P.)

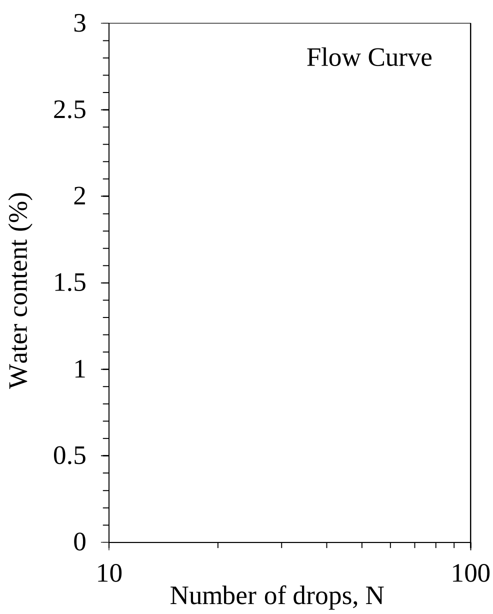
Plastic Limit

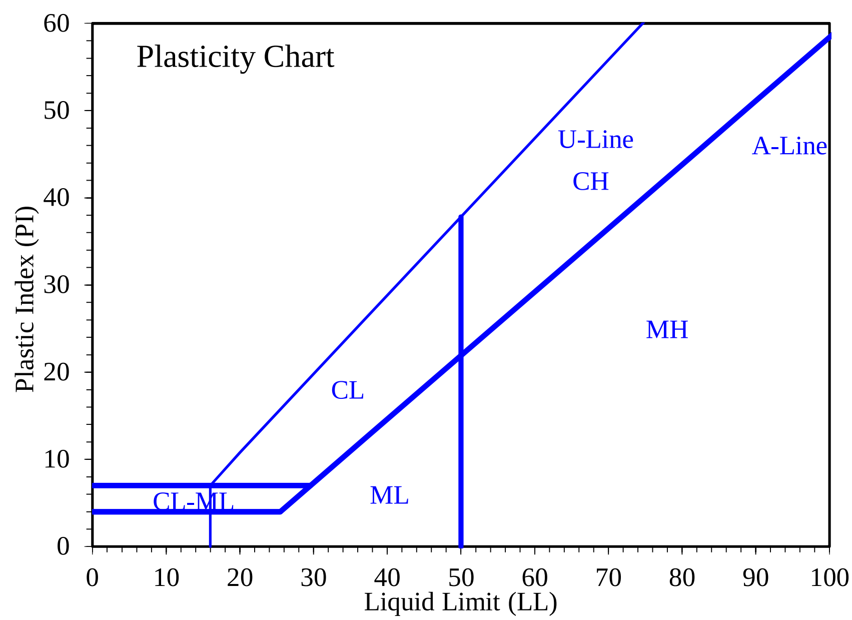
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





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Reviewed:___________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

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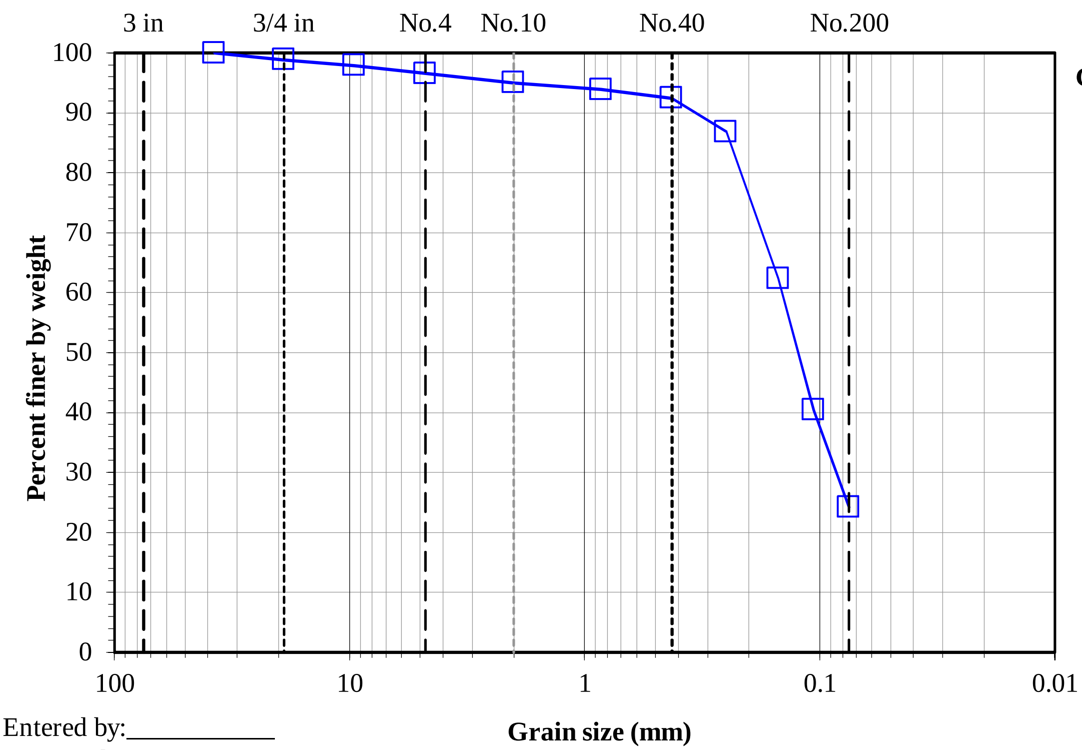
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 10/2/2016
By: BRR

Boring No.:
Sample: WQ-1A
Depth:
Description: Silty SAND, brown

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	3529.94	3144.52
+3/8" Coarse fraction (g):	70.84	66.86
-3/8" Split fraction (g):	417.52	371.48
Split fraction:	0.979	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	197.49	544.71
Dry soil + tare (g):	193.51	498.67
Tare (g):	126.66	127.19
Water content (%):	6.0	12.4

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	35.34	19	98.9	
3/8"	66.86	9.5	97.9	←Split
No.4	5.01	4.75	96.6	
No.10	10.86	2	95.0	
No.20	15.17	0.85	93.9	
No.40	20.61	0.425	92.4	
No.60	41.82	0.25	86.9	
No.100	134.77	0.15	62.4	
No.140	218.10	0.106	40.4	
No.200	279.48	0.075	24.2	



Gravel (%): 3.4
Sand (%): 72.3
Fines (%): 24.2

Entered by:___________
Reviewed:___________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

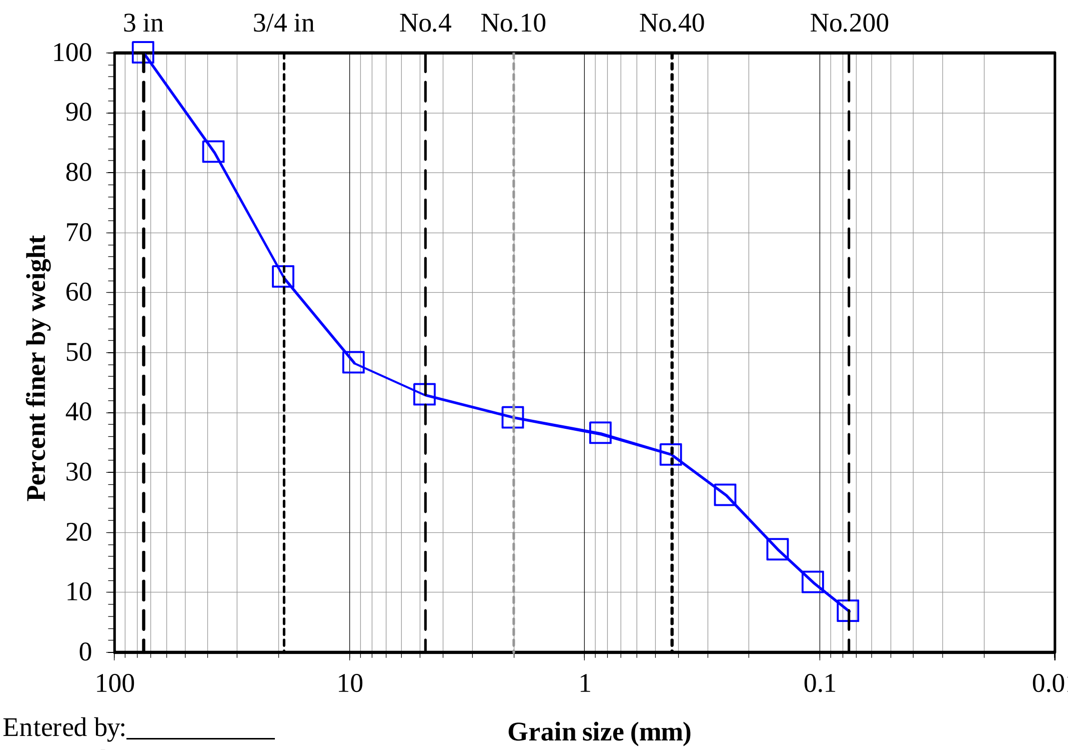
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 10/2/2016
By: BRR

Boring No.:
Sample: WQ-1B
Depth:
Description: Poorly graded GRAVEL with silt and sand, brown

	Moist	Dry
Split:	Yes	
Split sieve:	3/4"	
Total sample wt. (g):	4621.41	4158.32
+3/4" Coarse fraction (g):	1711.93	1557.25
-3/4" Split fraction (g):	1592.22	1423.44
Split fraction:	0.626	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2027.23	1903.23
Dry soil + tare (g):	1872.33	1734.45
Tare (g):	312.84	311.01
Water content (%):	9.9	11.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	691.23	37.5	83.4	
3/4"	1557.25	19	62.6	←Split
3/8"	326.10	9.5	48.2	
No.4	448.29	4.75	42.9	
No.10	534.19	2	39.1	
No.20	593.31	0.85	36.5	
No.40	675.03	0.425	32.9	
No.60	828.93	0.25	26.1	
No.100	1034.85	0.15	17.1	
No.140	1160.12	0.106	11.6	
No.200	1267.91	0.075	6.8	



Gravel (%): 57.1
Sand (%): 36.0
Fines (%): 6.8

Entered by:____________
Reviewed:____________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

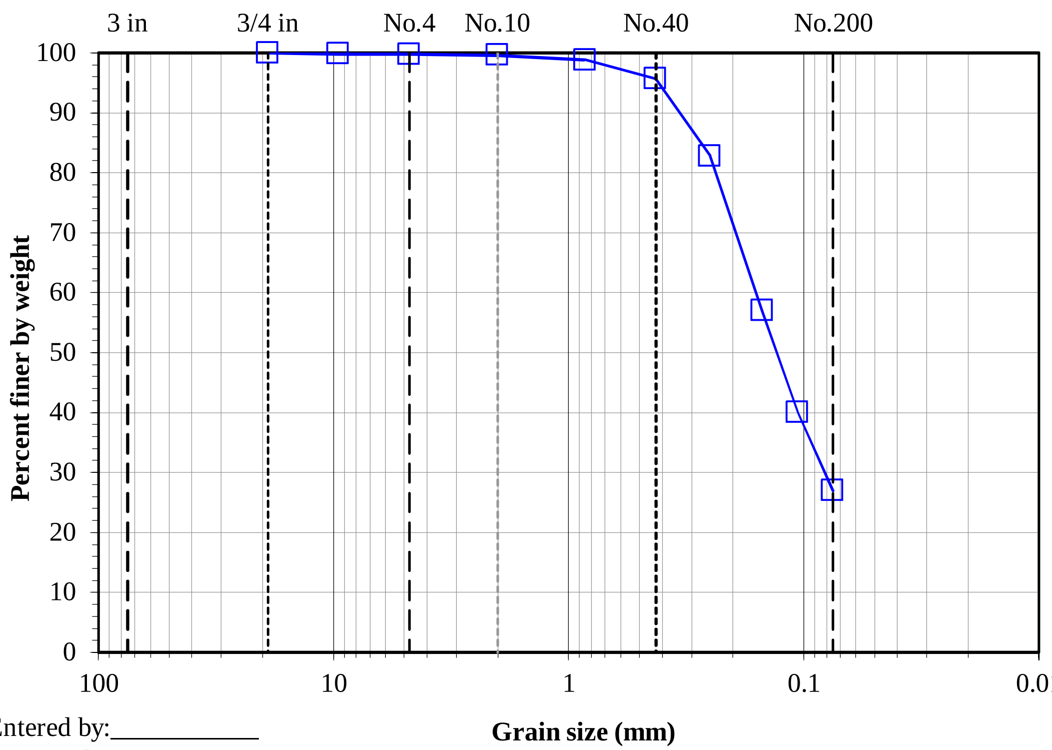
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 10/2/2016
By: BRR

Boring No.:
Sample: WQ-2A
Depth:
Description: Silty SAND, brown

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	3264.57	2623.23
+3/8" Coarse fraction (g):	5.27	4.75
-3/8" Split fraction (g):	360.35	289.50
Split fraction:	0.998	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	132.26	485.11
Dry soil + tare (g):	131.74	414.26
Tare (g):	126.94	124.76
Water content (%):	10.8	24.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	-	
3/4"	-	19	100.0	
3/8"	4.75	9.5	99.8	←Split
No.4	0.24	4.75	99.7	
No.10	0.62	2	99.6	
No.20	2.97	0.85	98.8	
No.40	12.05	0.425	95.7	
No.60	49.45	0.25	82.8	
No.100	124.17	0.15	57.0	
No.140	173.50	0.106	40.0	
No.200	211.32	0.075	27.0	



Gravel (%): 0.3
Sand (%): 72.8
Fines (%): 27.0

Entered by:___________
Reviewed:___________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

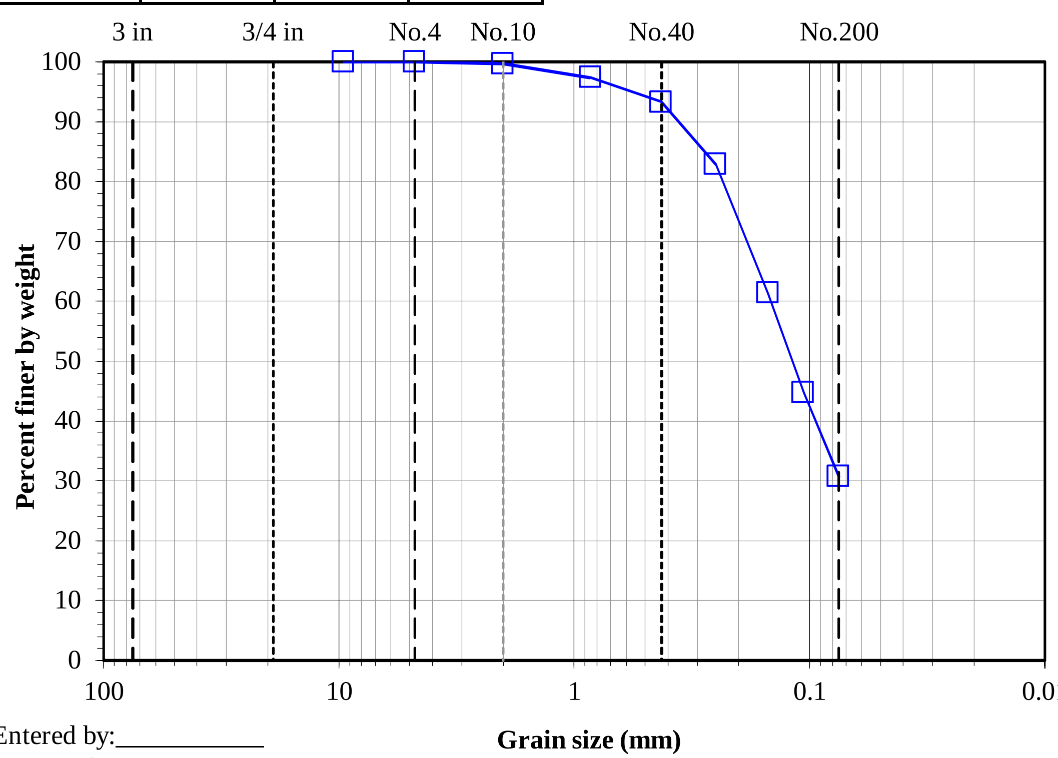
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 10/2/2016
By: BRR

Boring No.:
Sample: WQ-2B
Depth:
Description: Silty SAND, brown

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	319.15	225.23
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	445.88
Dry soil + tare (g):	-	351.96
Tare (g):	-	126.73
Water content (%):	0.0	41.7

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	100.0
No.4	0.10	4.75	100.0
No.10	0.76	2	99.7
No.20	5.91	0.85	97.4
No.40	15.25	0.425	93.2
No.60	38.67	0.25	82.8
No.100	87.06	0.15	61.3
No.140	124.43	0.106	44.8
No.200	155.98	0.075	30.7



Gravel (%): 0.0
Sand (%): 69.2
Fines (%): 30.7

Entered by:___________
Reviewed:___________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

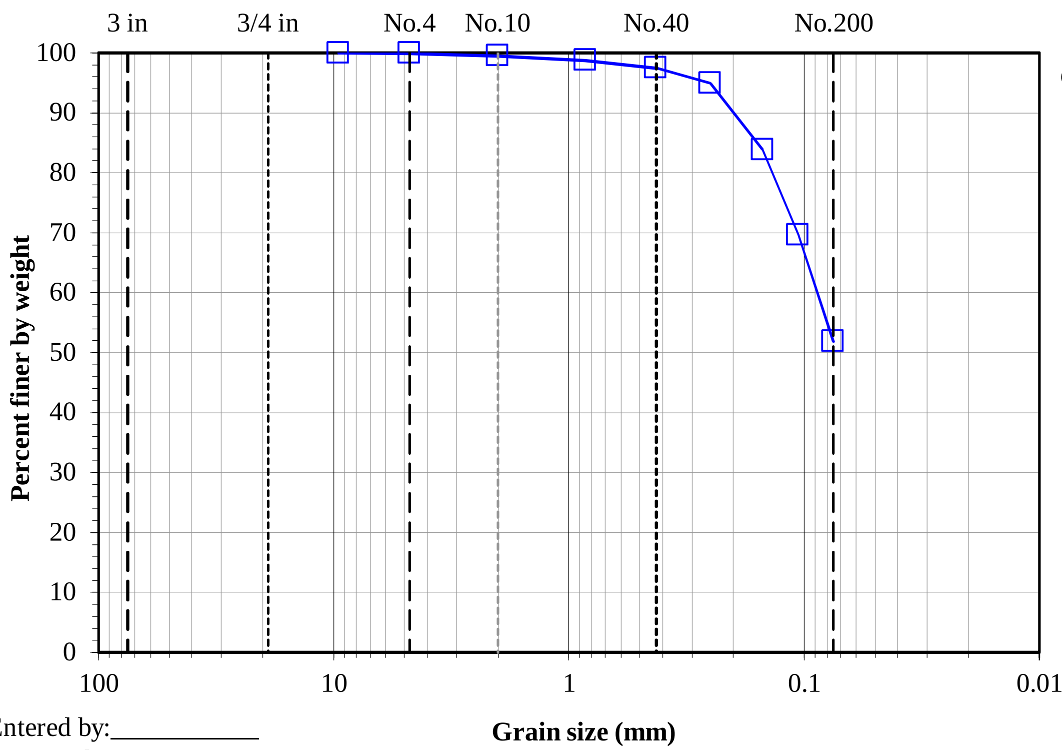
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 10/2/2016
By: BRR

Boring No.:
Sample: WQ-3A
Depth:
Description: Sandy SILT, brown

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	529.99	362.49
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	923.03
Dry soil + tare (g):	-	755.53
Tare (g):	-	393.04
Water content (%):	0.0	46.2

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	100.0
No.4	0.26	4.75	99.9
No.10	1.82	2	99.5
No.20	4.63	0.85	98.7
No.40	9.27	0.425	97.4
No.60	18.45	0.25	94.9
No.100	58.48	0.15	83.9
No.140	110.11	0.106	69.6
No.200	174.45	0.075	51.9



Gravel (%): 0.1
Sand (%): 48.1
Fines (%): 51.9

Entered by:___________
Reviewed:___________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

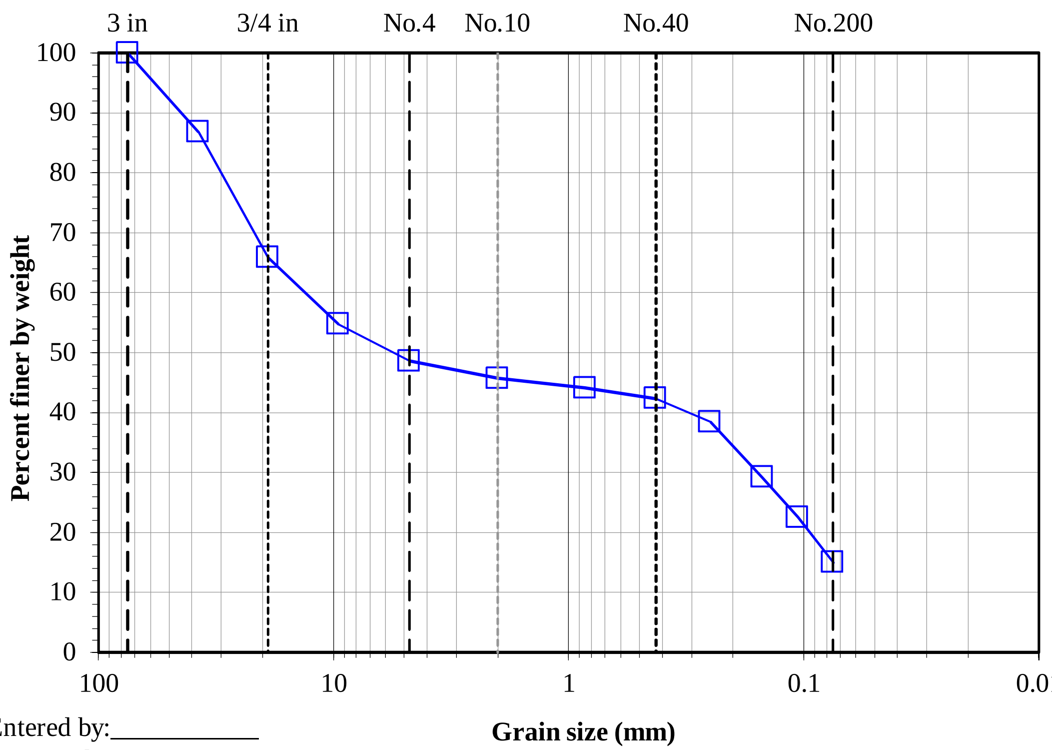
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 10/2/2016
By: BRR

Boring No.:
Sample: WQ-4A
Depth:
Description: Silty GRAVEL with sand, brown

	Moist	Dry
Split:	Yes	
Split sieve:	3/4"	
Total sample wt. (g):	3949.93	3377.53
+3/4" Coarse fraction (g):	1272.68	1151.82
-3/4" Split fraction (g):	1584.03	1316.87
Split fraction:	0.659	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	1632.88	1915.49
Dry soil + tare (g):	1507.30	1648.33
Tare (g):	310.53	331.46
Water content (%):	10.493	20.3

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	447.25	37.5	86.8	
3/4"	1151.82	19	65.9	←Split
3/8"	223.04	9.5	54.7	
No.4	346.46	4.75	48.6	
No.10	404.03	2	45.7	
No.20	435.26	0.85	44.1	
No.40	470.35	0.425	42.4	
No.60	549.04	0.25	38.4	
No.100	733.03	0.15	29.2	
No.140	866.48	0.106	22.5	
No.200	1017.15	0.075	15.0	



Gravel (%): 51.4
Sand (%): 33.6
Fines (%): 15.0

Entered by:___________
Reviewed:___________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

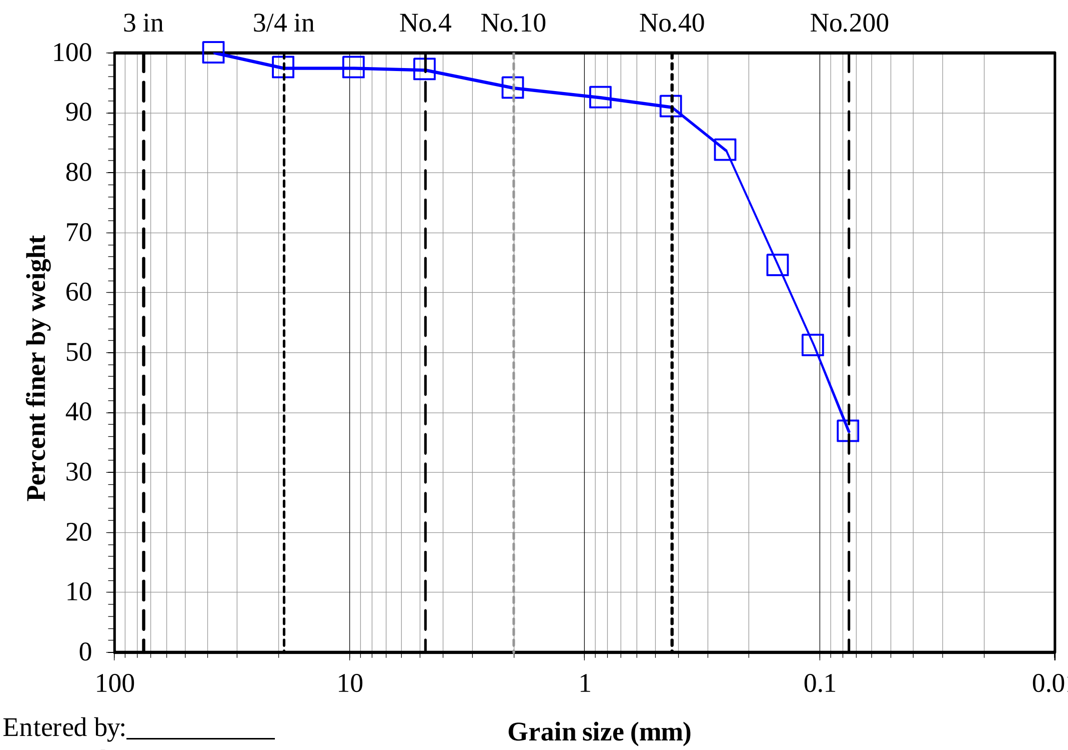
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 10/2/2016
By: BRR

Boring No.:
Sample: WQ-4B
Depth:
Description: Silty SAND, brown

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	983.31	726.56
+3/8" Coarse fraction (g):	20.18	18.29
-3/8" Split fraction (g):	338.67	249.05
Split fraction:	0.975	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	153.72	466.71
Dry soil + tare (g):	151.31	377.09
Tare (g):	127.93	128.04
Water content (%):	10.308	36.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	18.29	19	97.5	
3/8"	18.29	9.5	97.5	←Split
No.4	0.88	4.75	97.1	
No.10	8.70	2	94.1	
No.20	12.74	0.85	92.5	
No.40	16.64	0.425	91.0	
No.60	35.21	0.25	83.7	
No.100	84.31	0.15	64.5	
No.140	118.35	0.106	51.2	
No.200	155.01	0.075	36.8	



Gravel (%): 2.9
Sand (%): 60.3
Fines (%): 36.8

Entered by:___________
Reviewed:___________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

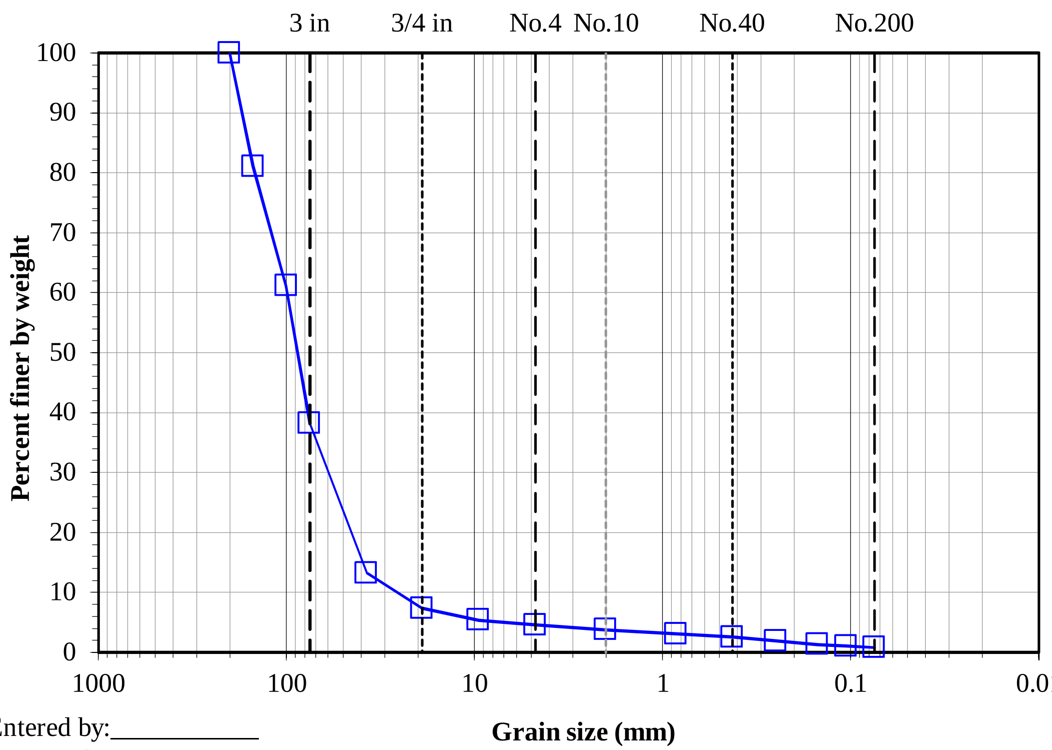
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/4/2016
By: BRR

Boring No.:
Sample: WQ-1CB
Depth:
Description: Brown gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	23071.13	20336.78
+3/4" Coarse fraction (g):	20785.26	18846.22
-3/4" Split fraction (g):	2285.87	1490.56
Split fraction:	0.073	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2332.40	2596.09
Dry soil + tare (g):	2143.78	1800.78
Tare (g):	310.51	310.22
Water content (%):	10.3	53.4

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	100.0
6"	3852.98	150	81.1
4"	7907.06	100	61.1
3"	12571.73	75	38.2
1.5"	17650.85	37.5	13.2
3/4"	18846.22	19	7.3 ←Split
3/8"	403.75	9.5	5.3
No.4	563.85	4.75	4.6
No.10	729.86	2	3.7
No.20	867.00	0.85	3.1
No.40	979.79	0.425	2.5
No.60	1101.62	0.25	1.9
No.100	1219.07	0.15	1.3
No.140	1278.76	0.106	1.0
No.200	1327.24	0.075	0.8



Gravel (%): 95.4
Sand (%): 3.8
Fines (%): 0.8

Entered by:___________
Reviewed:___________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

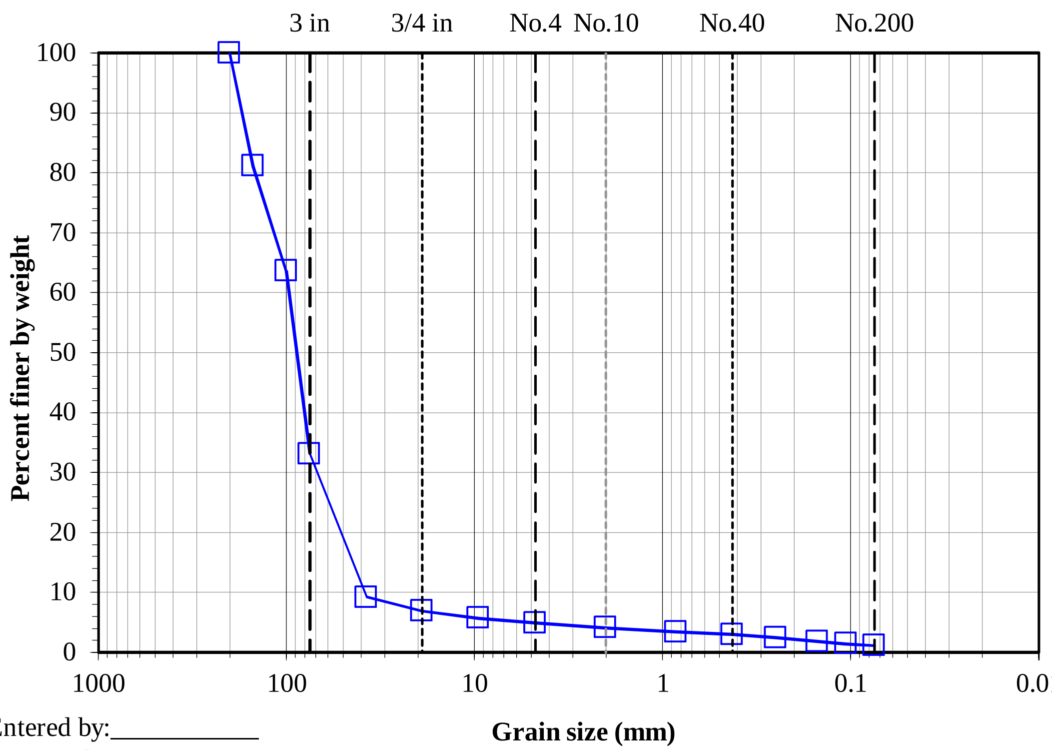
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/4/2016
By: BRR

Boring No.:
Sample: WQ-2CB
Depth:
Description: Brown gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	23303.90	21356.69
+3/4" Coarse fraction (g):	21273.02	19888.48
-3/4" Split fraction (g):	2030.88	1468.21
Split fraction:	0.069	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2243.64	2341.39
Dry soil + tare (g):	2118.98	1778.72
Tare (g):	328.28	310.51
Water content (%):	7.0	38.3

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	100.0	
6"	4028.74	150	81.1	
4"	7766.16	100	63.6	
3"	14292.15	75	33.1	
1.5"	19394.82	37.5	9.2	
3/4"	19888.48	19	6.9	←Split
3/8"	256.85	9.5	5.7	
No.4	422.37	4.75	4.9	
No.10	595.75	2	4.1	
No.20	738.52	0.85	3.4	
No.40	838.48	0.425	2.9	
No.60	952.24	0.25	2.4	
No.100	1085.37	0.15	1.8	
No.140	1162.75	0.106	1.4	
No.200	1237.21	0.075	1.1	



Gravel (%): 95.1
Sand (%): 3.8
Fines (%): 1.1

Entered by:___________
Reviewed:___________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

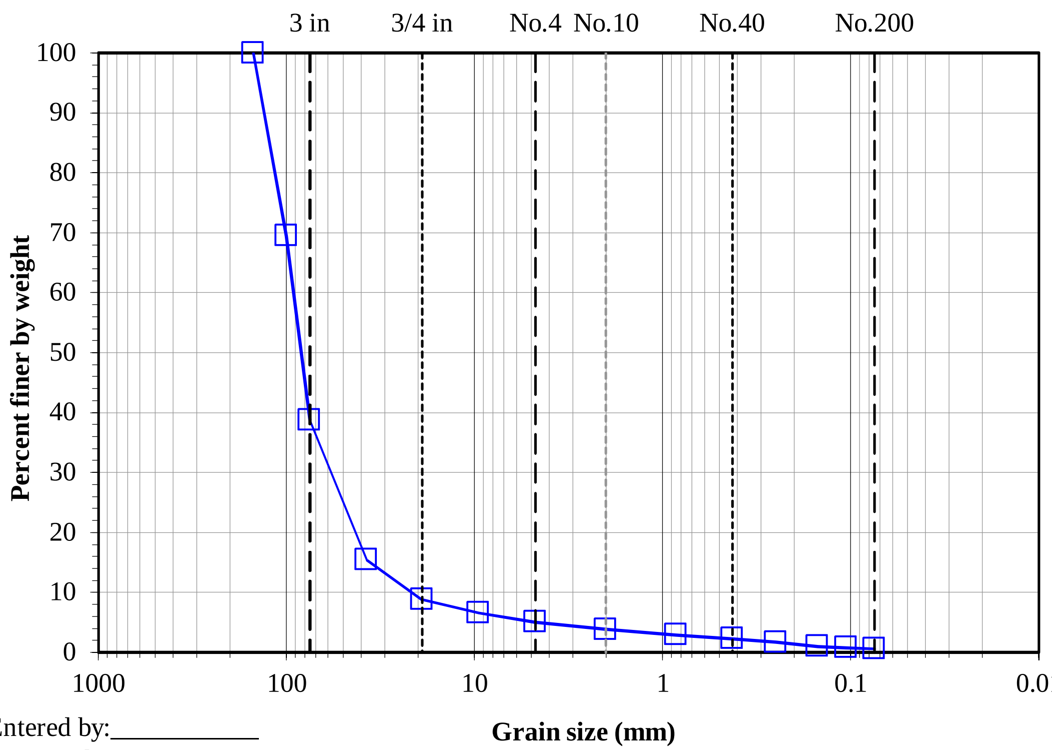
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/4/2016
By: BRR

Boring No.:
Sample: WQ-3CB
Depth:
Description: Brown gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	21494.83	18554.53
+3/4" Coarse fraction (g):	18822.18	16921.56
-3/4" Split fraction (g):	2672.66	1632.97
Split fraction:	0.088	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2540.98	3080.58
Dry soil + tare (g):	2318.04	2040.89
Tare (g):	333.16	407.92
Water content (%):	11.2	63.7

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	100.0	
4"	5663.66	100	69.5	
3"	11371.29	75	38.7	
1.5"	15691.63	37.5	15.4	
3/4"	16921.56	19	8.8	←Split
3/8"	416.08	9.5	6.6	
No.4	696.74	4.75	5.0	
No.10	925.91	2	3.8	
No.20	1090.90	0.85	2.9	
No.40	1209.14	0.425	2.3	
No.60	1319.18	0.25	1.7	
No.100	1450.77	0.15	1.0	
No.140	1492.81	0.106	0.8	
No.200	1530.92	0.075	0.5	



Gravel (%): 95.0
Sand (%): 4.5
Fines (%): 0.5

Entered by:___________
Reviewed:___________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

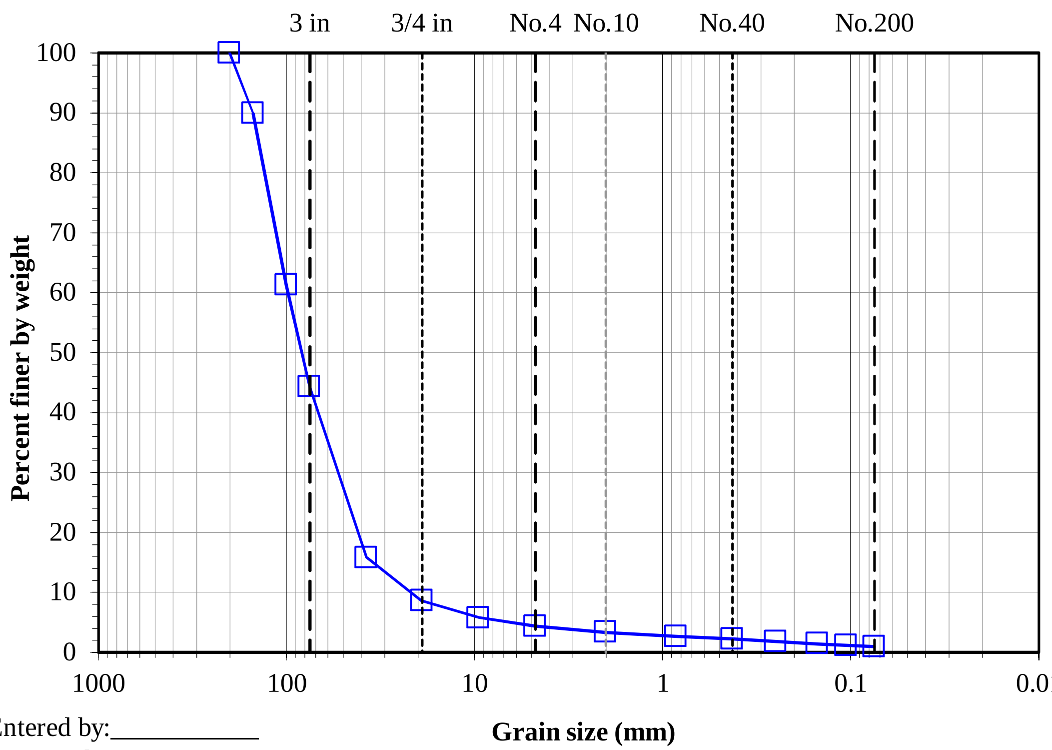
Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/4/2016
By: BRR

Boring No.:
Sample: WQ-4CB
Depth:
Description: Brown gravel

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	22028.09	18647.20
+3/4" Coarse fraction (g):	19225.06	17046.57
-3/4" Split fraction (g):	2802.97	1600.59
Split fraction:	0.086	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2527.91	3339.63
Dry soil + tare (g):	2276.53	2137.25
Tare (g):	309.49	536.66
Water content (%):	12.8	75.1

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	100.0	
6"	1874.98	150	89.9	
4"	7222.14	100	61.3	
3"	10379.62	75	44.3	
1.5"	15707.18	37.5	15.8	
3/4"	17046.57	19	8.6	←Split
3/8"	529.26	9.5	5.7	
No.4	786.22	4.75	4.4	
No.10	981.27	2	3.3	
No.20	1107.73	0.85	2.6	
No.40	1190.30	0.425	2.2	
No.60	1264.21	0.25	1.8	
No.100	1340.18	0.15	1.4	
No.140	1382.90	0.106	1.2	
No.200	1422.98	0.075	1.0	



Gravel (%): 95.6
Sand (%): 3.4
Fines (%): 1.0

Entered by:___________
Reviewed:___________

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Classification of Soils for Engineering Purposes

(*ASTM D2487*)

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Project: EarthFax Engineering
No: M01292-027 (PO #UC-794-25)
Location:
Date: 11/2/2016
By: BRR

Sample Info.								
Boring No.								
Sample:	WQ-1A	WQ-1B	WQ-2A	WQ-2B	WQ-3A	WQ-4A	WQ-4B	
Depth:								
Liquid Limit (%):	NP	NP	NP	45	48	NP	NP	
Plastic Limit (%):	NP	NP	NP	30	34	NP	NP	
Plastic Index (%):	NP	NP	NP	15	14	NP	NP	
Gravel (%):	3.4	57.1	0.3	0	0.1	51.4	2.9	
Sand (%):	72.3	36	72.8	69.2	48.1	33.6	60.3	
Fines (%):	24.2	6.8	27	30.7	51.9	15	36.8	
D_{60} (mm):		16.76						
D_{30} (mm):		0.34						
D_{10} (mm):		0.09						
Cu:		177						
Cc:		0.1						
Group Symbol:	**SM**	**GP-GM**	**SM**	**SM**	**ML**	**GM**	**SM**	
Group Name:	**Silty SAND**	**Poorly graded GRAVEL with silt and sand**	**Silty SAND**	**Silty SAND**	**Sandy SILT**	**Silty GRAVEL**	**Silty SAND**	

Entered by:___________

Reviewed:___________

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APPENDIX B

Cross Section Rating Tables and Curves

Rating Table and Curve for WQ-1

Project Description	
Worksheet	WQ-1
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Slope	0.026000 ft/ft

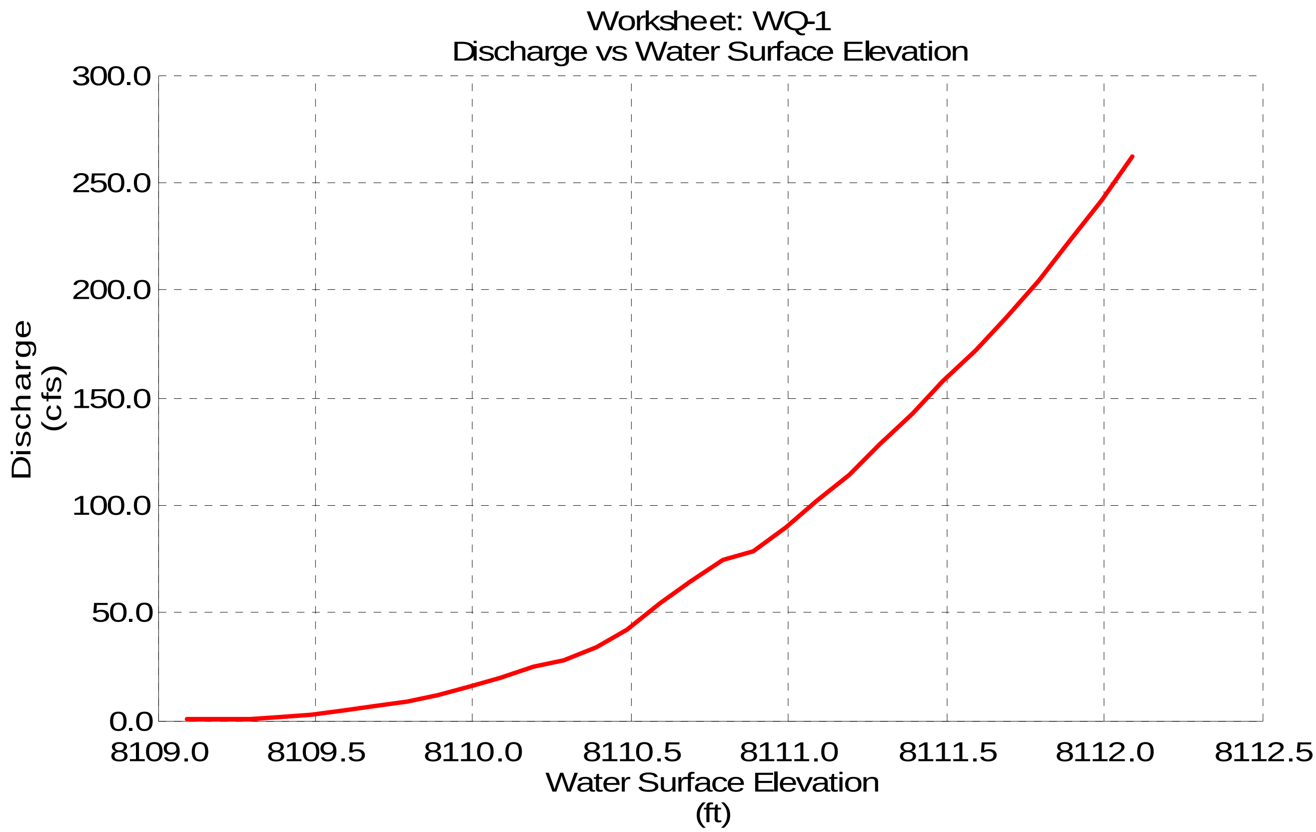
Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Attribute	Minimum	Maximum	Increment
Water Surface Elevation (ft)	8,109.09	8,112.09	0.10

Water Surface Elevation (ft)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
8,109.09	0.04	0.80	0.1	1.14	1.11
8,109.19	0.28	1.27	0.2	2.28	2.23
8,109.29	0.86	1.80	0.5	2.90	2.81
8,109.39	1.75	2.23	0.8	3.47	3.34
8,109.49	2.97	2.59	1.1	4.03	3.87
8,109.59	4.54	2.91	1.6	4.60	4.40
8,109.69	6.48	3.20	2.0	5.19	4.96
8,109.79	8.86	3.47	2.6	5.83	5.56
8,109.89	11.90	3.79	3.1	6.46	6.16
8,109.99	15.41	4.07	3.8	7.10	6.76
8,110.09	19.44	4.33	4.5	7.73	7.37
8,110.19	24.39	4.63	5.3	8.80	8.40
8,110.29	28.04	4.54	6.2	10.28	9.86
8,110.39	34.35	4.75	7.2	11.62	11.17
8,110.49	41.62	4.97	8.4	12.08	11.57
8,110.59	54.41	5.70	9.6	12.53	11.98
8,110.69	64.25	5.96	10.8	12.99	12.39
8,110.79	74.96	6.23	12.0	13.44	12.80
8,110.89	78.60	5.90	13.3	13.90	13.20
8,110.99	89.76	6.12	14.7	14.35	13.61
8,111.09	101.69	6.33	16.1	14.81	14.02
8,111.19	114.38	6.55	17.5	15.26	14.42
8,111.29	127.85	6.75	18.9	15.72	14.83
8,111.39	142.11	6.95	20.4	16.17	15.24
8,111.49	157.16	7.15	22.0	16.62	15.64
8,111.59	171.86	7.29	23.6	17.40	16.38
8,111.69	186.96	7.40	25.3	18.39	17.33
8,111.79	204.16	7.55	27.0	19.31	18.17
8,111.89	222.03	7.68	28.9	20.49	19.25
8,111.99	241.44	7.82	30.9	21.68	20.34
8,112.09	262.35	7.95	33.0	22.87	21.42

Rating Table and Curve for WQ-1

WQ-4



Rating Table and Curve for WQ-2

Project Description	
Worksheet	WQ-2
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

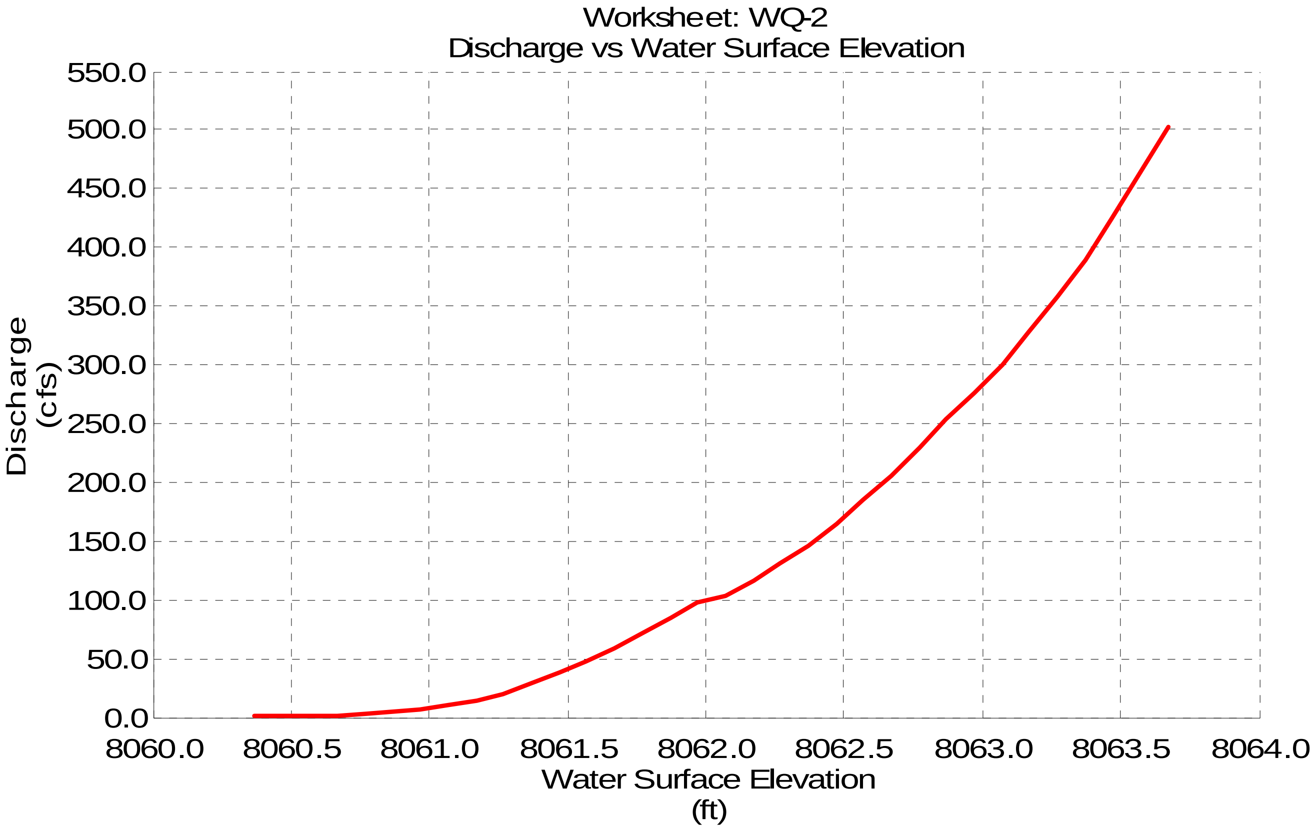
Input Data	
Slope	0.048000 ft/ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Attribute	Minimum	Maximum	Increment
Water Surface Elevation (ft)	8,060.37	8,063.67	0.10

Water Surface Elevation (ft)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
8,060.37	0.02	0.85	1.8e-2	0.53	0.51
8,060.47	0.16	1.54	0.1	1.29	1.24
8,060.57	0.56	2.09	0.3	2.05	1.97
8,060.67	1.29	2.58	0.5	2.80	2.70
8,060.77	2.47	3.06	0.8	3.62	3.49
8,060.87	4.09	3.34	1.2	4.97	4.83
8,060.97	6.61	3.75	1.8	6.09	5.92
8,061.07	10.00	4.14	2.4	7.37	7.17
8,061.17	14.34	4.48	3.2	8.68	8.44
8,061.27	19.81	4.83	4.1	9.89	9.62
8,061.37	29.26	5.75	5.1	10.30	9.98
8,061.47	38.01	6.23	6.1	10.71	10.33
8,061.57	47.87	6.69	7.2	11.12	10.69
8,061.67	58.82	7.14	8.2	11.52	11.04
8,061.77	70.84	7.57	9.4	11.93	11.40
8,061.87	83.92	7.98	10.5	12.34	11.75
8,061.97	98.09	8.38	11.7	12.73	12.09
8,062.07	103.45	7.99	12.9	13.41	12.72
8,062.17	116.39	8.16	14.3	14.39	13.66
8,062.27	130.78	8.34	15.7	15.37	14.59
8,062.37	146.67	8.54	17.2	16.35	15.53
8,062.47	164.22	8.74	18.8	17.30	16.44
8,062.57	184.41	9.01	20.5	18.02	17.12
8,062.67	206.03	9.28	22.2	18.74	17.80
8,062.77	229.12	9.54	24.0	19.47	18.48
8,062.87	252.92	9.76	25.9	20.30	19.28
8,062.97	275.41	9.87	27.9	21.61	20.55
8,063.07	300.12	10.00	30.0	22.92	21.82
8,063.17	327.10	10.14	32.3	24.23	23.09
8,063.27	357.00	10.31	34.6	25.51	24.30
8,063.37	389.86	10.50	37.1	26.75	25.44
8,063.47	425.10	10.70	39.7	28.00	26.58
8,063.57	462.77	10.91	42.4	29.24	27.72
8,063.67	502.93	11.11	45.3	30.49	28.86

Rating Table and Curve for WQ-2



Rating Table and Curve for WQ-3

Project Description	
Worksheet	WQ-3
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Slope	0.024000 ft/ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

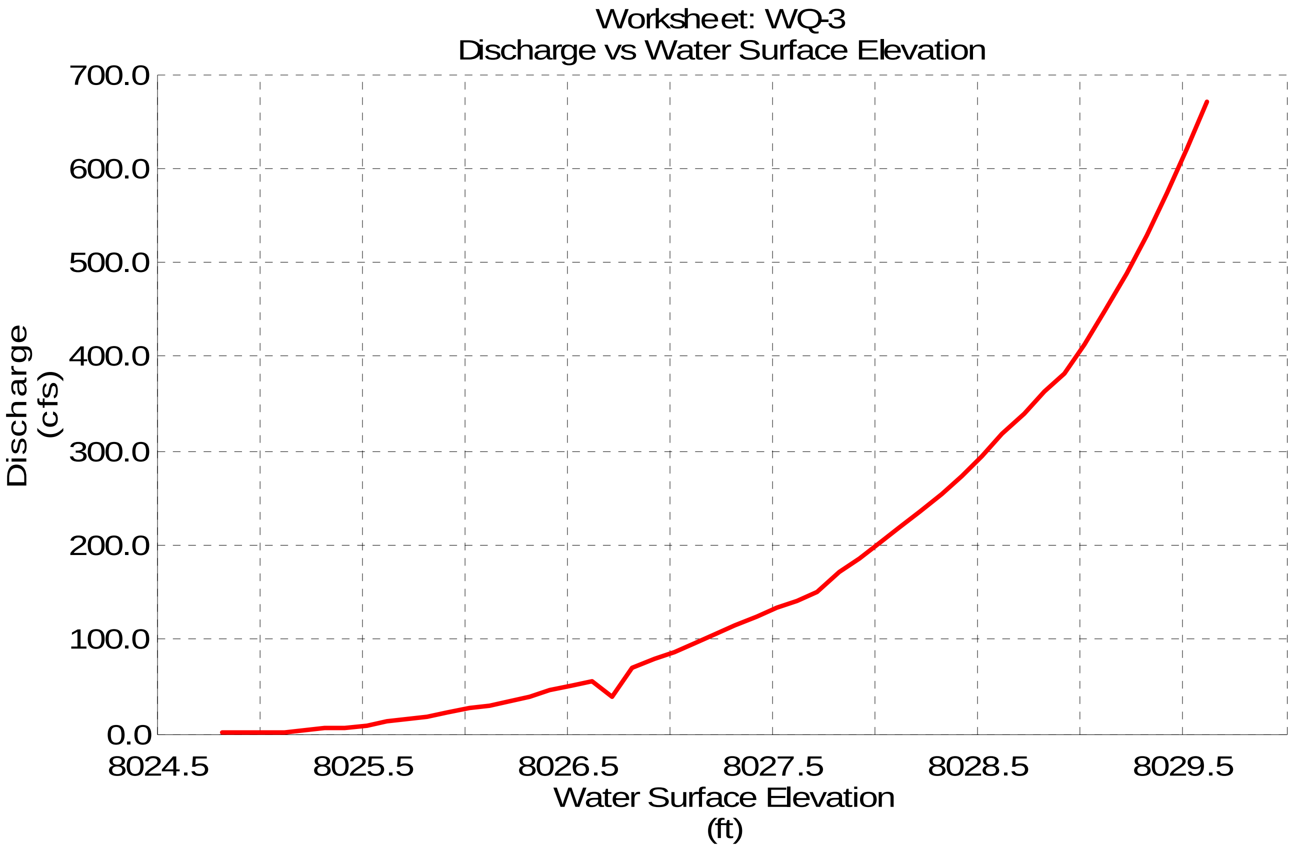
Attribute	Minimum	Maximum	Increment
Water Surface Elevation (ft)	8,024.82	8,029.62	0.10

Water Surface Elevation (ft)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
8,024.82	3.43e-3	0.35	9.8e-3	0.66	0.66
8,024.92	0.18	0.97	0.2	2.62	2.60
8,025.02	0.76	1.56	0.5	3.45	3.40
8,025.12	1.77	2.09	0.8	3.88	3.76
8,025.22	3.12	2.51	1.2	4.30	4.12
8,025.32	4.80	2.88	1.7	4.73	4.48
8,025.42	6.86	3.21	2.1	5.12	4.80
8,025.52	9.34	3.56	2.6	5.40	4.99
8,025.62	12.14	3.87	3.1	5.67	5.17
8,025.72	15.23	4.16	3.7	5.95	5.36
8,025.82	18.63	4.43	4.2	6.22	5.55
8,025.92	22.33	4.68	4.8	6.50	5.74
8,026.02	26.32	4.92	5.4	6.78	5.92
8,026.12	30.62	5.14	6.0	7.05	6.11
8,026.22	35.20	5.35	6.6	7.33	6.30
8,026.32	40.09	5.56	7.2	7.60	6.49
8,026.42	45.28	5.75	7.9	7.88	6.67
8,026.52	50.78	5.94	8.5	8.15	6.86
8,026.62	56.58	6.12	9.2	8.43	7.05
8,026.72	38.10	3.75	10.1	11.29	9.84
8,026.82	70.60	6.33	11.2	11.80	10.29
8,026.92	78.39	6.42	12.2	12.31	10.73
8,027.02	86.62	6.51	13.3	12.82	11.17
8,027.12	95.27	6.60	14.4	13.32	11.62
8,027.22	104.36	6.68	15.6	13.83	12.06
8,027.32	113.88	6.76	16.9	14.34	12.51
8,027.42	123.83	6.83	18.1	14.84	12.95
8,027.52	134.45	6.92	19.4	15.42	13.47
8,027.62	140.85	6.72	20.9	20.16	18.19
8,027.72	151.01	6.62	22.8	21.23	19.25
8,027.82	171.75	6.93	24.8	22.30	20.30
8,027.92	186.52	6.94	26.9	23.37	21.35
8,028.02	202.15	6.95	29.1	24.44	22.40

Rating Table and Curve for WQ-3

Water Surface Elevation (ft)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
8,028.12	218.70	6.97	31.4	25.51	23.45
8,028.22	236.19	7.00	33.8	26.59	24.51
8,028.32	254.67	7.02	36.3	27.66	25.56
8,028.42	274.17	7.05	38.9	28.73	26.61
8,028.52	295.34	7.11	41.6	29.34	27.12
8,028.62	317.62	7.17	44.3	29.91	27.58
8,028.72	339.54	7.21	47.1	31.41	28.97
8,028.82	361.92	7.22	50.1	34.31	31.77
8,028.92	383.09	7.14	53.7	43.56	40.91
8,029.02	412.09	7.07	58.3	50.98	48.22
8,029.12	448.13	7.10	63.1	51.58	48.71
8,029.22	487.22	7.16	68.0	52.18	49.20
8,029.32	529.19	7.25	72.9	52.78	49.69
8,029.42	573.93	7.36	77.9	53.39	50.19
8,029.52	621.36	7.49	83.0	53.99	50.68
8,029.62	671.41	7.62	88.1	54.59	51.17

Rating Table and Curve for WQ-3



Rating Table and Curve for WQ-4

Project Description	
Worksheet	WQ-4
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data	
Slope	0.011000 ft/ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

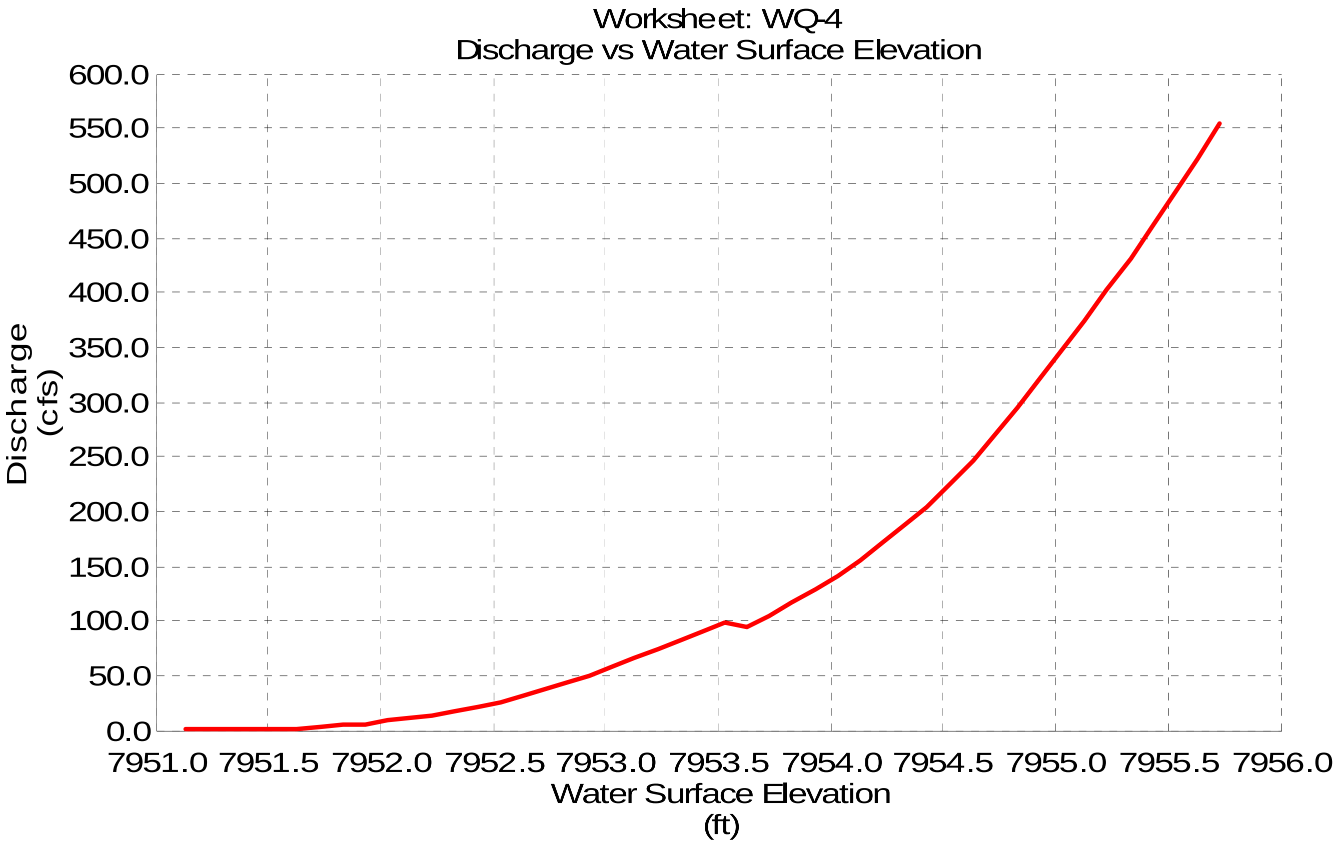
Attribute	Minimum	Maximum	Increment
Water Surface Elevation (ft)	7,951.13	7,955.73	0.10

Water Surface Elevation (ft)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
7,951.13	0.02	0.54	3.1e-2	0.64	0.61
7,951.23	0.10	0.86	0.1	1.29	1.22
7,951.33	0.31	1.15	0.3	1.86	1.75
7,951.43	0.68	1.46	0.5	2.26	2.09
7,951.53	1.19	1.72	0.7	2.66	2.43
7,951.63	1.78	1.72	1.0	4.33	4.05
7,951.73	2.84	1.91	1.5	5.23	4.90
7,951.83	4.22	2.09	2.0	6.04	5.66
7,951.93	6.06	2.32	2.6	6.74	6.31
7,952.03	8.29	2.53	3.3	7.43	6.93
7,952.13	10.92	2.73	4.0	8.11	7.55
7,952.23	13.97	2.92	4.8	8.79	8.16
7,952.33	17.45	3.10	5.6	9.48	8.77
7,952.43	21.40	3.27	6.5	10.16	9.39
7,952.53	25.82	3.44	7.5	10.84	10.00
7,952.63	31.01	3.63	8.5	11.36	10.45
7,952.73	37.04	3.86	9.6	11.65	10.64
7,952.83	43.51	4.08	10.7	11.94	10.84
7,952.93	50.41	4.29	11.8	12.22	11.03
7,953.03	57.73	4.48	12.9	12.51	11.23
7,953.13	65.46	4.67	14.0	12.80	11.42
7,953.23	73.60	4.86	15.2	13.08	11.62
7,953.33	81.39	4.98	16.3	13.57	12.05
7,953.43	89.21	5.08	17.6	14.20	12.63
7,953.53	97.61	5.17	18.9	14.83	13.22
7,953.63	94.18	4.63	20.3	18.94	17.29
7,953.73	104.52	4.73	22.1	19.99	18.30
7,953.83	115.78	4.83	24.0	21.04	19.31
7,953.93	127.97	4.93	26.0	22.09	20.32
7,954.03	141.02	5.03	28.1	23.17	21.38
7,954.13	155.14	5.13	30.3	24.24	22.43
7,954.23	170.31	5.23	32.5	25.32	23.47
7,954.33	186.57	5.34	34.9	26.39	24.52
7,954.43	203.94	5.45	37.4	27.46	25.56

Rating Table and Curve for WQ-4

Water Surface Elevation (ft)	Discharge (cfs)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
7,954.53	223.17	5.57	40.1	28.39	26.45
7,954.63	246.32	5.77	42.7	28.75	26.69
7,954.73	270.37	5.96	45.4	29.11	26.93
7,954.83	295.34	6.14	48.1	29.48	27.18
7,954.93	321.19	6.32	50.8	29.84	27.42
7,955.03	347.42	6.48	53.6	30.27	27.73
7,955.13	374.33	6.64	56.4	30.73	28.08
7,955.23	402.12	6.79	59.2	31.19	28.43
7,955.33	430.81	6.94	62.1	31.66	28.78
7,955.43	460.39	7.09	65.0	32.12	29.13
7,955.53	490.85	7.23	67.9	32.58	29.47
7,955.63	522.20	7.37	70.9	33.04	29.82
7,955.73	554.45	7.51	73.9	33.50	30.17

Rating Table and Curve for WQ-4



Date: **May 8, 2020**

To: **DOGM / file**

From: Gregg Galecki

Subject: **Surface Irrigation – Winter Quarters Creek**

As suggested in the April 30, 2020, meeting concerning impacts to downstream irrigation diversions/ditches from the addition of Mine discharge to Winter Quarters Creek from UPDES-004 Outfall. The -004 outfall is located approximately 1.2 miles upstream from the first Irrigation diversion (map attached). Between the -004 outfall and the diversions are numerous beaver dams throughout the canyon that regulate both the flow and sedimentation in the creek. A total of four (4) diversions are located on the creek. Starting furthest upstream, the first and second diversions irrigate land south of creek; the third irrigates north of the creek; and the fourth diversion irrigates both north and south of the creek. Significant improvements have been made to the fourth diversion over the last few years. Based on Utah Division of Water Rights, the diversions have been on record since 1874. All four diversions irrigate pasture located in the mouth of Winter Quarters Canyon west of SR-96. Water Rights records associated with the diversions belong to a combination of the following:

Dale Barney Cornaby and Cheri F. Cornaby
5167 South 3200 West
Spanish Fork UT 84660

Ellen R. Radakovich Marital and Family Trust
Robert Radakovich trustee
340 North 6th East
Price UT 84501

Radakovich Ranch, LLC
1016 Hill Ave
Grand Junction, CO 81501

Carbon Water Conservancy District
P O Box 509
Helper UT 84526

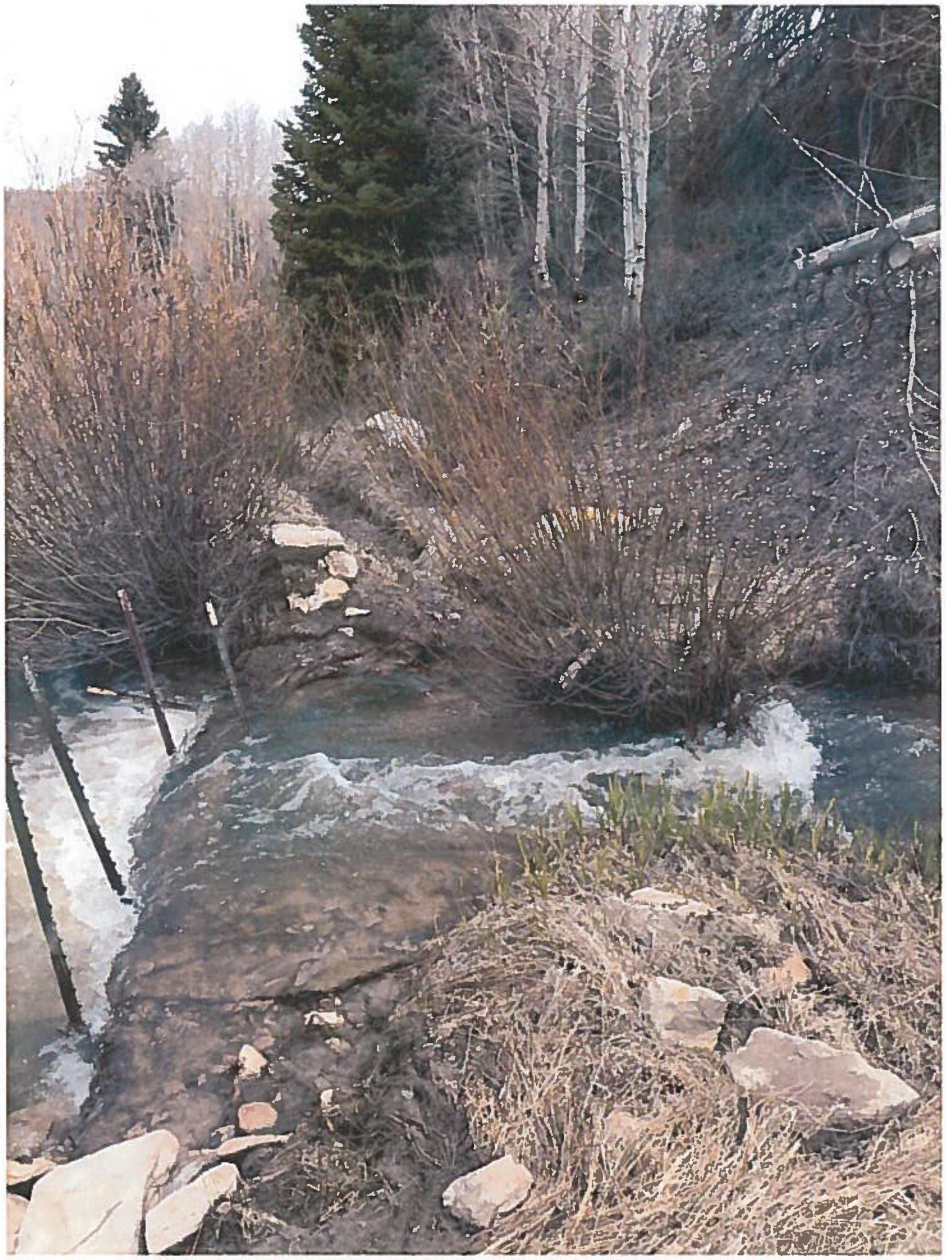
Fred and Shelia Jensen
P.O. Box 113
Goshen UT 84633

Pioneer Canal Company No. 1
PO Box 1055
Wellington UT 84542

The following photos illustrate the function, condition, and use of the diversions. Photos were taken on May 6, 2020. Runoff conditions are low to moderate based on the level and clarity of the water in the stream. The following photos illustrate that the added contribution of water from Outfall 004 to the creek will have little effect to the diversion of water and the established water rights downstream. Conversations with DOGM personnel recommended if landowners are encountered by Skyline personnel, they will inform landowners additional water will possibly be available in the coming months.

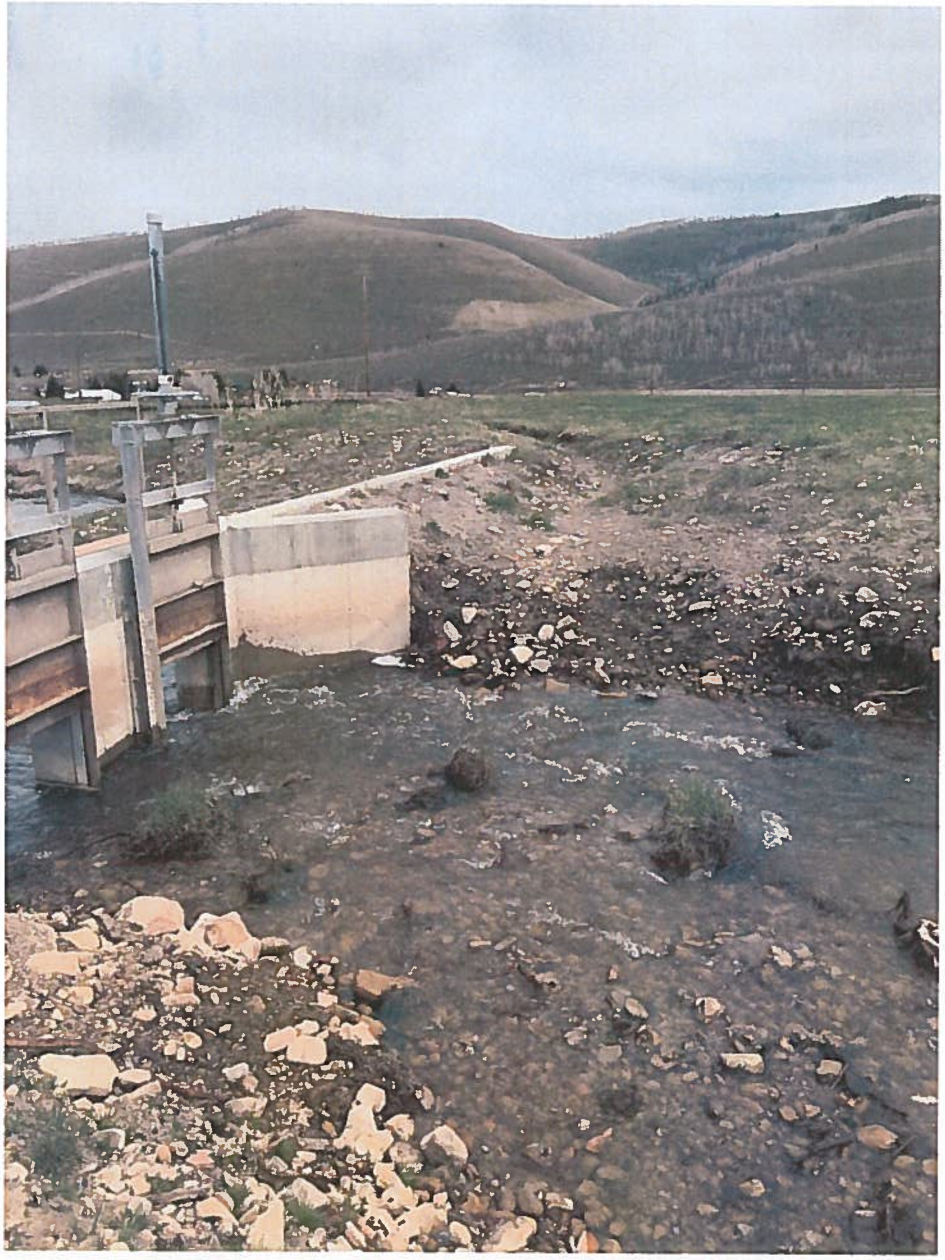
/

Diversion #1: Looking southeast. Good stream of water in creek, only minor water leaking into the ditch. The creek would need to be 'diverted' to ditch to irrigate land located south of the creek. Metal sheeting in photo likely used to divert water.



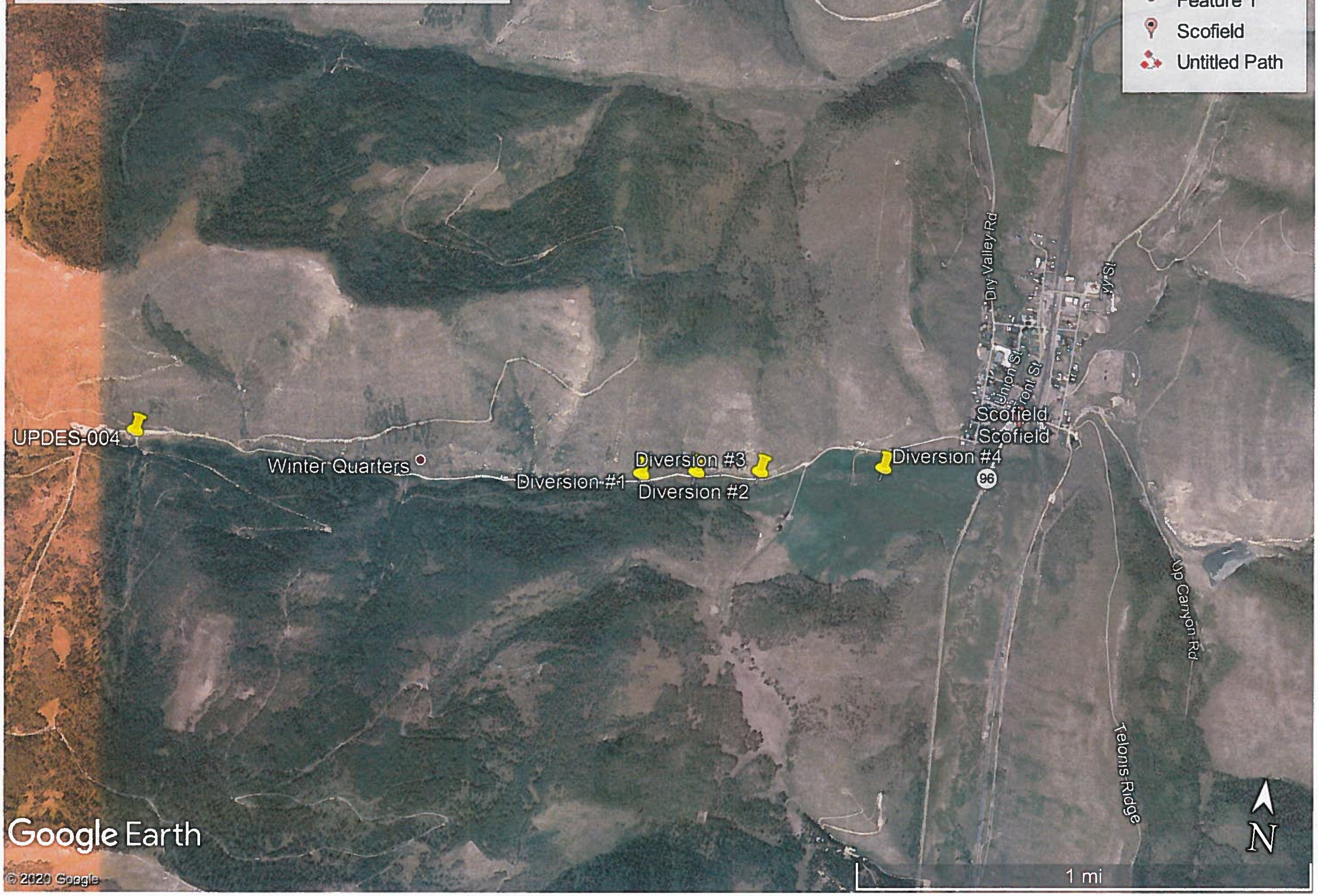
Diversion #2: Looking southeast. Well establshed, well armoured diversion ditch. Relatively good flow is in the creek yet below the diversion. Note T-posts in channel necessary to divert water into ditch. No 'daming' material apparent at site.

Diversion #3: Lookng southeast. Diverts water north of creek. Well established ditch. Minor water is leaking through the gate used to prohibit flow into the ditch. Inflow into ditch is regulated by lifting 'gate' to desired flow.



Diversion #4: Located downstream of Radakovich road. Looking east. Note signficant diversion structure built in Creek necessary to raise water into diversion ditch. Significant daming of creek is required to raise water to level of ditch.

WQ Creek Irrigation Diversions



Richard B. White, PE, PLLC
13441 South Lone Peak Lane • Draper, Utah 84020 • 801-673-6647

April 30, 2020

Gregg Galecki
Sr. Environmental Engineer
Canyon Fuel Company, LLC
HC 35 Box 380
Helper, UT 84526

Subject: Winter Quarters Canyon Discharge
Energy Dissipator Design

Dear Gregg:

Pursuant to your request, I evaluated options for dissipation of energy from water discharged from the Winter Quarters Canyon ventilation shaft. In accordance with our conversation, I assumed a peak discharge rate of 4,000 gallons per minute (8.9 cubic feet per second). It is my understanding that the water will discharge at a point near the downstream end of the sedimentation pond primary spillway riprap. This area is well vegetated with natural grasses which will provide a stable surface to direct the water to the adjacent creek once the flow velocity is reduced.

I evaluated two energy dissipator options, as detailed in Attachment A. These options consisted of:

1. Discharge initially into a catch basin, to reduce the bulk of the energy, and from the catch basin onto a riprap apron.
2. Discharge directly onto a riprap apron.

Option 1 – Catch Basin and Riprap Apron: The purpose of the catch basin is to dissipate the bulk of the energy, allowing the use of smaller riprap in the apron. The primary purpose of the apron is to spread the flow so it enters the adjacent vegetated area with an acceptably low velocity.

The design for this option is summarized as follows:

- Install a precast or cast-in-place catch basin with minimum inside surface dimensions of 4 feet by 4 feet and a minimum depth of 6 feet.
- Install the inlet pipe through one wall of the catch basin, with the invert of that pipe approximately 1.5 to 2.0 feet above the bottom of the catch basin. The inlet pipe may be installed through any wall of the catch basin that does not contain the outlet pipe.
- Install an 18-inch diameter outlet pipe through another wall of the catch basin, with the invert of the outlet pipe being at the floor of the catch basin.
- Center the inlet and outlet pipes in their respective openings and use non-shrink grout to seal around the pipes. Alternatively, an appropriate pipe boot may be installed on the inlet and outlet pipes.
- Excavate the area in which the riprap apron will be installed. This excavation should be approximately 12 inches deep. Line this area with a non-woven geotextile and placed riprap in

the lined area. The riprap should have a median diameter of at least 3 inches, ranging in size from approximately 1 inch to 6 inches.

- Avoid damage to the naturally-vegetated area downstream from the riprap apron since the water will discharge from the apron onto this vegetated area.

<u>Option 2 – Riprap Apron Only</u>: Under this option, all of the energy dissipation will occur on the riprap apron. As a result, the information presented in Attachment A indicates that a median riprap diameter of 8 inches will be required. I recommend using riprap that ranges in effective diameter from 4 inches to 16 inches. The surface of the apron will remain unchanged. However, the apron will be 20 inches deep rather than 12 inches deep. In either case, the apron excavation should be lined with a non-woven geotextile and the riprap should be angular and durable.

The calculations presented in Attachment A indicate that the velocity of flow from the downstream end of the riprap apron, under both options, will be 3.1 ft/s at the maximum discharge rate of 4,000 gpm. The vegetation in this area is sufficiently established that the soil will be stable at this velocity.

In a letter dated March 16, 2010, EarthFax Engineering determined that approximately 6,200 gpm could be discharged from the ventilation shaft into Winter Quarters Canyon without undue erosion of the natural channel. Thus, the adjacent natural channel can safely convey the anticipated discharge rate of 4,000 gpm.

Please let me know if you have any questions regarding this design.

Sincerely,

Richard B. White, P.E.

Consulting Civil and Environmental Engineer

Attachment

REGISTERED PROFESSIONAL ENGINEER
No. 168246
RICHARD B.
WHITE
30 Apr 2020
NOT VALID WITHOUT A SIGNATURE
STATE OF UTAH

ATTACHMENT A

Design Calculations

DESIGN OF WINTER QUARTERS PORTAL DISCHARGE ENERGY DISSIPATOR

Design flow = 4000 gpm
= 8.9 cfs } Evaluate two options

OPTION #1 → Discharge water into a 4'x4' catch basin and from there onto a riprap apron.

Minimum catch basin depth (D) = $0.5 + 1.2 \frac{V^2}{2g} + \frac{d}{\cos S}$ | Source: Los Angeles County Flood Control District, Hydraulic Design Manual (March 1982)

where D = depth of catch basin (ft)
V = velocity of flow at outlet (ft/s) - for full pipe
g = acceleration due to gravity (ft/s²)
d = diameter of outlet pipe (ft)
s = slope of outlet pipe (unitless)

Ground slope at outlet = 5%
Assume 18" CMP outlet (Hazen-Williams coefficient = 60)
Full flow capacity → Q = 24.5 cfs
V = 13.87 ft/s

$$D = 0.5 + (1.2)\left(\frac{13.87^2}{(2)(32.2)}\right) + \left(\frac{1.5}{\cos(0.05)}\right)$$

= 5.6 ft ⟹ Make the catch basin <u>6 ft deep</u>

Use Manning's equation to calculate actual velocity:

Pipe diameter = 1.5 ft (18")
Pipe slope = 0.05 ft/ft
Roughness coef = 0.022 (typical of CMP)
Q = 8.9 cfs

} Flow depth = 0.88 ft
Velocity = 8.35 ft/s
(See pg 2 of this calc.)

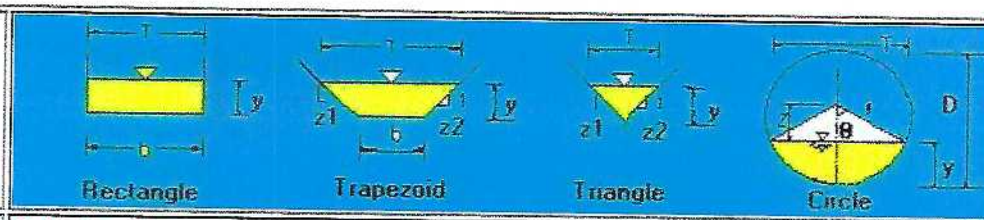
Construct riprap apron at catch basin outlet, as noted on page 3 of this calc. Avoid damage to natural vegetation downstream from apron.

Velocity at apron outflow = 3.1 ft/s ⟹ Acceptable onto vegetated area.
(see pg 6 of this calc.)

2√

The open channel flow calculator

Select Channel Type: Circle



Depth from Q | Select unit system: Feet(ft)

Channel slope: .05 ft/ft	Water depth(y): 0.88 ft	Radius (r) .75 ft
Flow velocity 8.349 ft/s	LeftSlope (Z1): to 1 (H:V)	RightSlope (Z2): to 1 (H:V)
Flow discharge 8.9 ft^3/s	Input n value 0.022 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 2.61 ft	Flow area 1.07 ft^2	Top width(T) 1.48 ft
Specific energy 1.96 ft	Froude number 1.73	Flow status Supercritical flow
Critical depth 1.16 ft	Critical slope 0.0232 ft/ft	Velocity head 1.08 ft

RIPRAP APRON DESIGN

Method: Thompson, P.L. and R.T Kilgore. 2006. Hydraulic Design of Energy Dissipators for Culverts and Channels. Hydraulic Engineering Circular No. 14, Third Edition. Federal Highway Administration. Arlington, VA.

Equation:

$$D_{50} = 0.2D\left[\frac{Q}{SQRT(g)*D^{2.5}}\right]^{4/3}\left[\frac{Q}{TW}\right]$$

Where
- D_{50} = median riprap diameter (ft)
- D = culvert diameter (ft)
- Q = design discharge (cfs)
- g = acceleration due to gravity (ft/s^2)
- TW = tailwater depth (ft)

Client:
Site:
Proj. No.:
Designer:

Calculations:

D = 1.5 ft
Q = 8.9 cfs
g = 32.2 ft/s^2
TW = 0.88 ft

D_{50} =	**0.24 ft**
=	**2.9 in**

Use D_{50}=3 inch riprap (i.e., ranging from 1" to 6" diameter)

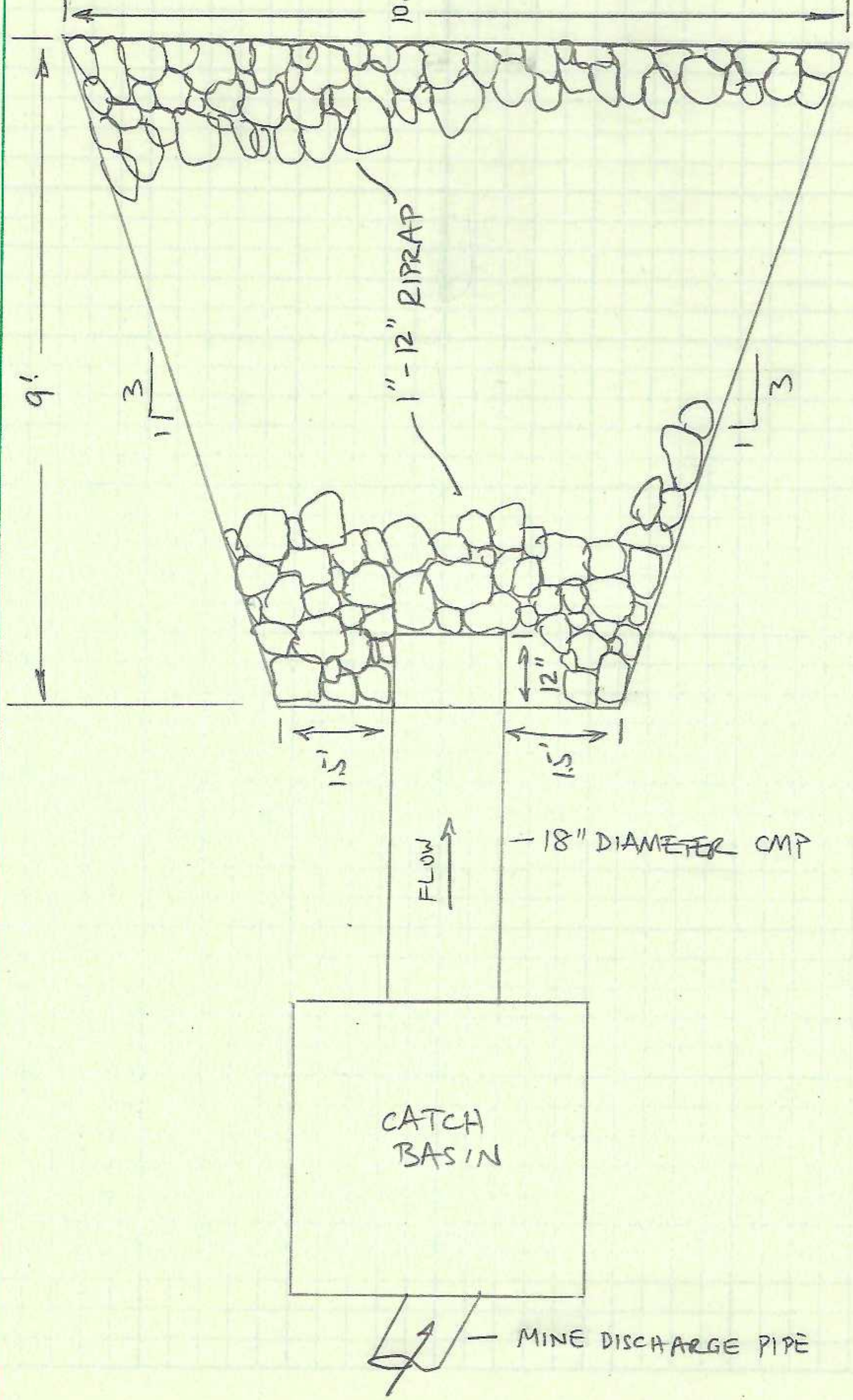
Typical Apron Dimensions (from pg. 10-18 of HEC-14)

Class	D_{50} (mm)	D_{50} (in)	Apron Length	Apron Depth
1	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	250	10	5D	$2.4D_{50}$
4	350	14	6D	$2.2D_{50}$
5	500	20	7D	$2.0D_{50}$
6	550	22	8D	$2.0D_{50}$

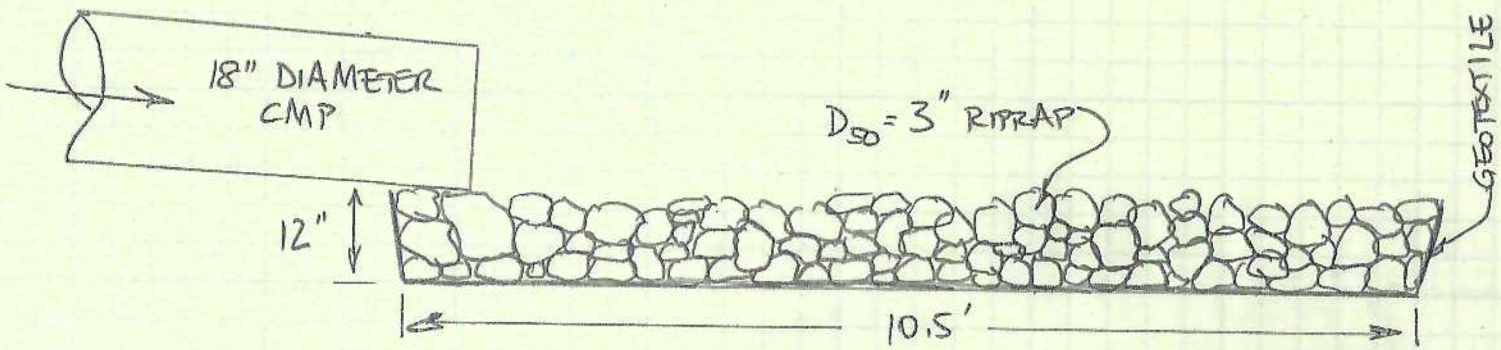
D = culvert diameter

← See pages 4 and 5 of this calc for design

Note: Because this will be a square-ended outlet pipe, 3 ft was added to the apron length, in accordance w/ HEC-14.



PLAN VIEW - RIPRAP APRON
SCALE: 1"=2'



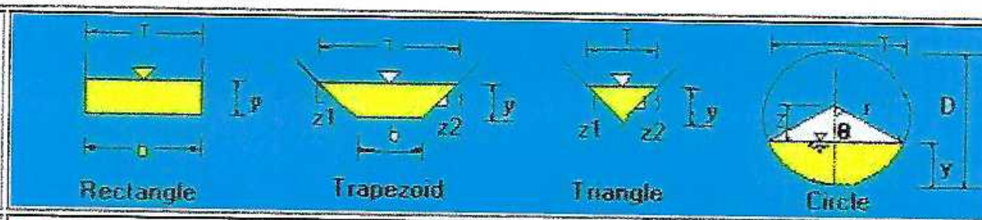
PROFILE VIEW - RIPRAP APRON

SCALE: 1"=2'

6/

The open channel flow calculator

Select Channel Type: Trapezoid ▼



Depth from Q ▼ | Select unit system: Feet(ft) ▼

Channel slope: .05 ft/ft	Water depth(y): 0.23 ft	Bottom width(b) 10.5 ft
Flow velocity 3.09592 ft/s	LeftSlope (Z1): 10 to 1 (H:V)	RightSlope (Z2): 10 to 1 (H:V)
Flow discharge 8.9 ft^3/s	Input n value 0.035 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 15.03 ft	Flow area 2.87 ft^2	Top width(T) 15.01 ft
Specific energy 0.37 ft	Froude number 1.25	Flow status Supercritical flow
Critical depth 0.26 ft	Critical slope 0.0292 ft/ft	Velocity head 0.15 ft

OPTION #2 → Discharge directly onto a riprap apron.

Assume outlet pipe diameter = 10 in
Outlet pipe slope = 0.20 ft/ft (from site topo)
Outlet velocity = 23.43 ft/s (see pg 8 of this calc)
Apron design → See pg 9 of this calc.

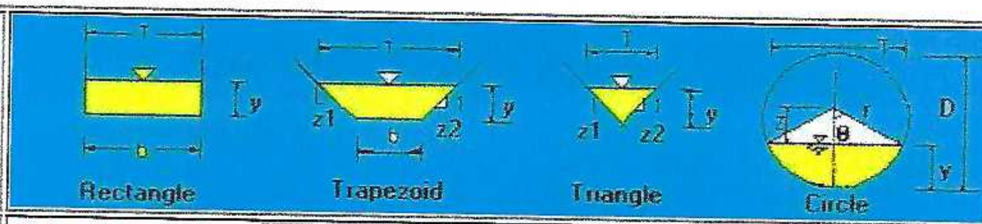
Apron surface dimensions → Same as those shown on pg 4 of this calc.

Apron depth = $2.4 D_{50}$
= (2.4)(8 in)
= ~~19.2 in~~ 20 inches

With the same surface dimensions and discharge rate as the prior apron, the exit flow velocity (3.1 ft/s) will also remain the same. This velocity will be non-erosive of the vegetated area downstream from the apron.

The open channel flow calculator

Select Channel Type: Circle



Depth from Q	Select unit system: Feet(ft)	
Channel slope: .2 ft/ft	Water depth(y): 0.55 ft	Radius (r) .417 ft
Flow velocity 23.431 ft/s	LeftSlope (Z1): to 1 (H:V)	RightSlope (Z2): to 1 (H:V)
Flow discharge 8.9 ft^3/s	Input n value .011 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 1.58 ft	Flow area 0.38 ft^2	Top width(T) 0.79 ft
Specific energy 9.07 ft	Froude number 5.95	Flow status Supercritical flow
Critical depth 0.83 ft	Critical slope 0.1142 ft/ft	Velocity head 8.53 ft

RIPRAP APRON DESIGN

Method: Thompson, P.L. and R.T Kilgore. 2006. Hydraulic Design of Energy Dissipators for Culverts and Channels. Hydraulic Engineering Circular No. 14, Third Edition. Federal Highway Administration. Arlington, VA.

Equation:

$$D_{50} = 0.2D\left[\frac{Q}{SQRT(g)*D^{2.5}}\right]^{4/3}\left[\frac{Q}{TW}\right]$$

Where
D_{50} = median riprap diameter (ft)
D = culvert diameter (ft)
Q = design discharge (cfs)
g = acceleration due to gravity (ft/s^2)
TW = tailwater depth (ft)

Client:
Site:
Proj. No.:
Designer:

Calculations:

D = 0.83 ft
Q = 8.9 cfs
g = 32.2 ft/s^2
TW = 0.83 ft

D_{50} = 0.56 ft
= 6.8 in

Use D_{50}=8 inch riprap (i.e., ranging from 4" to 16" diameter)

Typical Apron Dimensions (from pg. 10-18 of HEC-14)

Class	D_{50} (mm)	D_{50} (in)	Apron Length	Apron Depth
1	125	5	4D	3.5D_{50}
2	150	6	4D	3.3D_{50}
3	250	10	5D	2.4D_{50}
4	350	14	6D	2.2D_{50}
5	500	20	7D	2.0D_{50}
6	550	22	8D	2.0D_{50}

D = culvert diameter

← In accordance with HEC-14, the apron length should be 3' longer than 5D. As a safety factor, use the surface dimensions indicated on pg 3 of this calc., which are larger due to the larger diameter discharge pipe (18" vs. 10").