CHAPTER 2

LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION

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CHAPTER 2

LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION

110 MINIMUM REQUIREMENTS FOR LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION

111 Introduction

The Wasatch Plateau area of Carbon County, Utah, contains seams of high quality bituminous coal with a long history of coal mining activities. The Horizon Mine is located in Consumers Canyon approximately 14 miles northwest of Price, Utah.

The surface facilities, diversions, culverts and the sedimentation pond were installed in compliance with Utah Division of Oil, Gas and Mining (UDOGM) regulations.

The permit area (Plate 1-1) is characterized by steep, narrow canyons containing conspicuous sandstone cliffs. Intermittent and perennial streams occupy the drainages. The complex geological and geomorphological conditions have produced a variety of site specific soils that support a variety of vegetation communities.

A distinction of an underground mine is its minimal effect on the ecosystems. The relatively small scale of surface disturbance when operated with proper drainage and sedimentation controls, causes negligible impact to the prevailing hydrologic balance of the area. Subsidence, a potential problem with any underground mining, will be monitored as mining progresses. The temporary loss of wildlife habitat due to the construction of surface facilities is negligible in light of the available nearby habitat. Upon cessation of mining and portal sealing, the reestablishment of final topography and drainage will proceed. Revegetation of disturbed areas will replace native habitat and restore the land to accommodate proposed post-mining land use(s).

The information contained in this section is intended to fulfill the requirements of R645-301-100 and to ensure that all relevant information on the ownership and control of the mining activities is supplied to the regulatory agency(s).

112 Identification of Interests

112.100 Business Entity

Hidden Splendor Resources, Inc. is incorporated under the laws of the State of Nevada and is in good standing and has legal corporate existence.

112.200 Assignment of Permit Applicant and Mine Operator

The permit applicant and mine operator is:

Hidden Splendor Resources, Inc.
50 West Liberty Street, Suite 880
Reno, Nevada 89501
Telephone: (775) 322-0626
Employer I.D. No. 88-0315046

Applicant's Resident Agent:

The resident agent who will accept service of process is:

Alexander H. Walker, III
57 West 200 South, Suite 400
Salt Lake City, Utah 84101
(801) 521-3292

The abandoned mine land reclamation fee will be paid by:

Cecil Ann Walker
Hidden Splendor Resources, Inc.
50 West Liberty Street, Suite 880
Reno, Nevada 89501
Telephone: (775) 322-0626

112.300 Officers of the Applicant

Principal Officers	Position	Address
Cecil Ann Walker 550-22-2400	President and Director	50 West Liberty Street, Suite 880 Reno, Nevada 89501 (775) 322-0626
Alexander H. Walker III 528-06-0223	Vice President	57 West 200 South, Suite 400 Salt Lake City, Utah 84101 (801) 521-3292
Amanda W. Cardinalli 528-06-0227	Treasurer and Director	50 West Liberty Street, Suite 880 Reno, Nevada 89501 (775) 322-0626
Alexander H. Walker, Jr. 199-16-9180	Secretary and Director	50 West Liberty Street, Suite 880 Reno, Nevada 89501 (775) 322-0626

112.400 Coal Mining and Reclamation Operation Owned or Controlled

Hidden Splendor Resources, Inc., 50 West Liberty Street, Suite 880, Reno, Nevada 89501 is a corporation that controls 100% of Hidden Splendor Resources, Inc. The ownership is 50% Alexander H. Walker, Jr. and 50% Cecil Ann Walker. The officers and directors of Hidden Splendor Resources, Inc. control no other coal mining entities.

112.500 Legal or Equitable Owner of the Surface and Mineral Properties

The legal and equitable owners of the surface and mineral properties to be directly affected by this mining operation during the duration of the permit period are:

Hidden Splendor Resources
50 West Liberty Street, Suite 880
Reno, NV 89501

United States of America
Bureau of Land Management
2370 South 2300 West
West Valley City, Utah 84084

Steve and Pete (Jr.) Stamatakis
1111 South 450 West
Price, Utah 84501

Roy M. and Tessie K. Farley
5240 So. Highland Drive
Salt Lake City, Utah 84117

Arthur J. Anderson, Et al
4190 Fortuna Way
Salt Lake City, Utah 84117

J. Mark & James Jacobs
734 South Cherry Drive
Orem, Utah 84057

Surface and coal ownership are shown on Plates 4-2 and 4-3.

112.600 Owners of Record of Property Contiguous to Proposed Permit Area

Owners of Surface Properties

1. U P & L
   P.O. Box 899
   Salt Lake City, Utah 84110

2. Hidden Splendor Resources
   50 West Liberty Street, Suite 880
   Reno, NV 89501

3. J. Mark & James Jacobs
   734 S. Cherry Drive
   Orem, Utah 84057

4. Agnes and Eldred E. Peirce, Jr.
   3432 South 500 East
   Price, Utah 84501

5. Steve and Pete (Jr.) Stamatakis
   1111 South 450 West
   Price, Utah 84501

6. United States of America
   Bureau of Land Management
   2370 South 2300 West
   West Valley City, Utah 84084

~~7. R. L. Bird~~
~~1840 East Bryan Avenue~~
~~Salt Lake City, Utah 84108~~

~~8. Nielson Ltd.~~
~~P.O. Box 620~~
~~Huntington, Utah 84528~~

~~9. Roy M. and Tessie K. Farley~~
~~5240 So. Highland Drive~~
~~Salt Lake City, Utah 84117~~

~~10~~7. Robert and Linda N. Jewkes
   Wellington, Utah 84542

~~11. Luke G. and Gene S. Pappas~~
~~2030 S. Cave Hollow Way~~
~~Bountiful, Utah 84010~~

~~12. Milton A. Oman~~
~~1714 E. Millcreek Way~~
~~Salt Lake City, Utah 84106~~

~~13.~~8. Utah Division of Wildlife Resources
455 West Railroad Avenue
Price, Utah 84501

~~14. K.C. Jensen and Tonda Hampton~~
~~P.O. Box 957~~
~~Price, Utah 84501~~

~~15~~9. Carbon County
Courthouse Building
Price, Utah 84501

~~16~~10. Arthur J. Anderson, Et al
4190 Fortuna Way
Salt Lake City, Utah 84117

~~17. Utah State Fish and Game~~
~~1095 West Motor Avenue~~
~~Salt Lake City, Utah 84116~~

11. L. & E. Brown Family, LC
65 East 400 South
Orem, Utah 84058

112.700 MSHA Numbers

The MSHA numbers issued April 20, 1995 by the Department of Labor to Horizon Mining, LLC have been transferred to Hidden Splendor Resources, Inc. as follows:

- Horizon Mine MSHA Number 42-02074
- Horizon No. 2 Mine MSHA Number 42-02075 (not opening at present time)

112.800 Interest in Contiguous Lands

Hidden Splendor currently owns the Federal Coal Lease UTU-74804 (by assignment from Lodestar Energy, Inc. ("Lodestar") filed with BLM for approval) which is contiguous to the current permit area, and has fee coal interests in SE1/4 SE1/4, E1/2 SW1/4 SE1/4 Section 17; and fee coal and surface interests in S1/2 NW1/4 SW1/4, W1/2 SW1/4 SE1/4 Section 17 and NE1/4 NW1/4, NW1/4 NE1/4 Section 20, Township 13 South, Range 8 East, SLM but has no interest, options or pending bids on other contiguous lands.

112.900 Certification of Submitted Information

Information submitted to the Division is certified as required by the UDOGM regulations.

113 Violation information

Neither Hidden Splendor nor any subsidiary, affiliate, member or manager, or persons controlled by or under common control with the applicant has had a federal or state mining permit suspended or revoked in the last five years; nor forfeited a mining bond or similar security deposited in lieu of bond.

Violation notices in connection with permit C/007/020 are listed in Appendix 2-4

114 Right of Entry information

Under date of March 24, 2003, Lodestar by its Chapter 11 Trustee, pursuant to an Order dated March 18, 2003 by the U.S. Bankruptcy Court for the Eastern District of Kentucky, Lexington Division , assigned Hidden Splendor all right, title and interest in the Horizon Mine. The assignment was made subject to Division approval of the transfer of Mine Permit No. C/007/020. Concurrently, Lodestar, by its Trustee, also executed and delivered a Designation of Operator to Hidden Splendor covering the period prior to DOGM's approval of the permit transfer.

Hidden Splendor bases its right to enter and undertake coal mining on: (1) the Assignment from Lodestar by its Chapter 11 Trustee, pursuant to March 18, 2003 Order (Appendix 2-1); (2) the Designation of Operator executed by Lodestar (Appendix 2-1); and (3) the Federal coal lease UTU-74804 (Appendix 2-3).

Horizon Mine was issued a Right-of-Way SL 063011 through BLM lands in 1996 to facilitate mining coal from fee lands. The Right-of-Way was incorporated into the Federal coal lease UTU-74804 on September 1, 1998. Appendix 2-3.

~~The following is a description of lands within the permit boundary for the Horizon Mine comprised of part of the Hidden Splendor lease and a part of the Federal coal lease (Beaver Creek Tract) UTU-74804 which was acquired on September 1,1998.~~

~~Township 13 South, Range 8 East, SLM~~

~~Section 8: W1/2SE1/4, SE1/4SW1/4, S1/2SW1/4NE1/4, S1/2NE1/4SW1/4, NE1/4NE1/4SW1/4NE1/4, S1/2SW1/4SW1/4, NE1/4SW1/4SW1/4, S1/2NW1/4SW1/4SW1/4, S1/2NE1/4SW1/4NE1/4, NE1/4NE1/4SW1/4, SE1/4NW1/4NE1/4SW1/4, SE1/4SE1/4SE1/4NW1/4,SE1/4SE1/4NW1/4SW1/4~~
~~Portion NW1/4NE1/4SW1/4NE1/4 Portion NE1/4NW1/4SW1/4NE1/4~~
~~Portion SE1/4NW1/4SW1/4NE1/4 Portion SW1/4NW1/4SW1/4NE1/4~~
~~Portion SW1/4NW1/4NE1/4SW1/4 Portion NW1/4NW1/4NE1/4SW1/4~~
~~Portion NE1/4NW1/4NE1/4SW1/4 Portion SE1/4SW1/4SE1/4NW1/4~~
~~Portion SW1/4SE1/4SE1/4NW1/4 Portion NW1/4SE1/4SE1/4NW1/4~~

~~Portion NE1/4SE1/4SE1/4NW1/4 Portion SE1/4NE1/4NW1/4SW1/4~~
~~Portion NE1/4SE1/4NW1/4SW1/4 Portion NW1/4SE1/4NW1/4SW1/4~~
~~Portion SW1/4SE1/4NW1/4SW1/4 Portion SE1/4SW1/4NW1/4SW1/4~~
~~Portion NE1/4NW1/4SW1/4SW1/4 Portion NW1/4NW1/4SW1/4SW1/4~~

~~Section 17: NW1/4NE1/4, N1/2NW1/4SW1/4, NE1/4SW1/4, NW1/4SE1/4, N1/2SE1/4SW1/4, N1/2SW1/4SE1/4, SW1/4NE1/4, NW1/4~~

~~Section 18: NE1/4NE1/4~~

~~Section 7: SE1/4SE1/4SE1/4, S1/2SW1/4SE1/4SE1/4, NE1/4SW1/4SE1/4SE1/4, S1/2SE1/4SW1/4SE1/4~~
~~Portion NE1/4NE1/4SE1/4SE1/4 Portion SE1/4NE1/4SE1/4SE1/4~~
~~Portion SW1/4NE1/4SE1/4SE1/4 Portion SE1/4NW1/4SE1/4SE1/4~~
~~Portion NW1/4SW1/4SE1/4SE1/4 Portion NE1/4SE1/4SW1/4SE1/4~~
~~Portion NW1/4SE1/4SW1/4SE1/4 Portion SW1/4NW1/4SE1/4SE1/4~~

~~Containing 711 acres more or less consisting of 305 acres more or less of Fee coal (Hidden Splendor Resources) and 406 acres more or less of Federal leased coal.~~

~~The surveyed disturbed area boundary was found to contain 8.23 acres, however the reclamation bond calculations will continue to include reclamation of 9.15 acres. The disturbed area is located within:~~

~~Township 13 South, Range 8 East, SLM~~

~~Section 17: Portion NW1/4NW1/4SE1/4 Portion NE1/4NE1/4SW1/4~~
~~Portion NW1/4NE1/4SW1/4 Portion SE1/4NE1/4SW1/4~~
~~Portion SW1/4NE1/4SW1/4~~

The following is a description of the permit boundary for the Horizon Mine including the Hidden Splendor lease and a part of the Beaver Creek Tract coal lease UTU-74804 which was acquired on September 1,1998.

Township 13 South, Range 8 East, SLM

Section 6: NW1/4SE1/4, SE1/4SW1/4, SW1/4SE1/4, SE1/4SE1/4.

Section 7: NW1/4, NE1/4, SE1/4, E1/2SW1/4, NW1/4SW1/4.

Section 8: S1/2NW1/4, NW1/4NW1/4, SW1/4NE1/4, SW1/4, W1/2SE1/4.

Section 17: NW1/4, E1/2NE1/4, NE1/4SW1/4, N1/2SE1/4SW1/4, N1/2NW1/4SW1/4, NW1/4SE1/4, N1/2SW1/4SE1/4.

Section 18: NE1/4NE1/4.

Containing 1,577 acres more or less consisting of 305 acres more or less of Fee coal (Hidden Splendor Resources) and 1,272 acres more or less of Federal leased coal.

115 Status of Unsuitability Claims

The permit area is not within an area or under study as an area designated as unsuitable for mining under R645-103-400, nor has any petitions been filed with the UDOGM under R645-103-420 that could affect the proposed permit area (see Plate 1-1). No surface operations or facilities are located within 300 feet of an occupied dwelling or within 100 feet of a cemetery. A public road right-of-way passes through the permit area and provides access to public property. Coal haulage activities will occur within 100 feet of the public road right-of-way where the permit area road joins a public county road. Multiple letters were received from Carbon County during 1996 concerning the use of the county road(s) by the Horizon Mine, these letters are included in Appendix 3-1 and discussed in Chapter 3.

116 Permit Term

The Horizon Mine is proposed for a 5 year term under the Permanent Regulatory Program for 5 years. Chapter 3 discusses the extent of underground mining activities to be conducted over the 5 year permit term.

117 Insurance, Proof of Publication, and Facilities and Structures Used in Common

A copy of the Certificate of Insurance issued to Hidden Splendor Resources, Inc., is on file with the Division. Subsequent insurance renewal documents will be submitted to the Division and included in Appendix 2-2.

Notice of the permit transfer application was published in the Sun Advocate, Price, Utah on April 8, 2003. Proof of publication was submitted to the Division pursuant to R645-303-322 and a copy is included in Appendix 2-2.

118 Filing Fee

A copy of this permit application is on file with the Utah Division of Oil, Gas and Mining (UDOGM), P.O. Box 145801, Salt Lake City, Utah 84114-5801. A copy of the filing fee receipt is located in Appendix 2-2.

120 PERMIT APPLICATION FORMAT AND CONTENTS

This permit application will comply with R645-301-120.

130 REPORTING OF TECHNICAL DATA

All technical data submitted in the permit application will be accompanied by the name or organization responsible for the collection and analysis of data, dates of collection and descriptions of methodology used. Technical analyzes will be planned by or under the direction of a qualified professional in the subject to be analyzed.

140 MAPS AND PLANS

The maps and plans in the Mining and Reclamation Plan will correspond with the requirements in R645-301-140.

150 COMPLETENESS

Hidden Splendor believes the information in this permit application to be complete and correct.

Licenses and permits needed to conduct a coal mining operation are listed below.

LICENSES & PERMITS - HORIZON MINE

PERMIT	ISSUING AUTHORITY
C/007/020	Division of Oil, Gas, & Mining 1594 West North Temple, Suite 1210 P.O. Box 145801 Salt Lake City, Utah 84114-5801
Construction & Air Quality DAQE-700-00	Division of Air Quality 288 No. 1640 West P.O. Box 16690 Salt Lake City, Utah 84116-0690
Construction, Sedimentation Pond and Drainage System	Division of Water Pollution Control 288 No. 1460 West P.O. Box 16690 Salt Lake City, Utah 84116-0690
Water Rights (leased)	Division of Water Rights 453 S. Carbon Avenue Price, Utah 84501
Construction Sewer Facilities	Southeastern Utah Health District 6 East Main Street Price, Utah 84501
Carbon County Planning & Zoning	Carbon County Courthouse Price, Utah 84501
UPDES (UTG040019)	State of Utah Department of Environmental Quality Water Quality Division 288 No. 1460 West Salt Lake City, Utah 84114-4870
MSHA (see Section 112.700)	U.S. Department of Labor Mine Safety and Health Administration P.O. Box 25367 Denver, Colorado 80225

CHAPTER 3

OPERATION AND RECLAMATION PLAN

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CHAPTER 3

OPERATION AND RECLAMATION PLAN

3.1 Scope

This chapter outlines the scope of operation and reclamation for the Horizon Mine. The proposed coal mining and reclamation activities will be conducted in compliance with the operation and reclamation plans.

3.2 Surface Facilities Construction Plans

The Horizon surface facilities will be located in Jewkes Creek Canyon and Portal Canyon (see Plates 1-1 and 3-1).

Cross Sections and Maps

Previously Mined Areas. Plates 3-9 and 3-10 show the location and extent of known workings of active, inactive, or abandoned underground workings, including openings to the surface, within the permit and adjacent areas. Also areas within these mines that have been second mined. No previously surface-mined areas are known to exist within the permit area.

The general area in the vicinity of the Horizon Mine has long been used for coal mining. Four underground operations were formerly located on or within a short distance of the permit area. These mines were the Consumers, Sweets, National, and Beaver Creek Mines. Sweets, National, and Consumers were active from the late 1920s to the early 1950s and are presently closed. The Beaver Creek Mine was opened in 1969 and operated originally under the name of the Gordon Creek No. 3 Mine. The mine was purchased by General Exploration Co. in 1973 and then again by Beaver Creek Coal Company in January 1980. Much of the area to be occupied by the surface facilities has been disturbed by previous mining operations, with most of the major disturbances in this area occurring prior to 1950.

Existing Surface and Subsurface Facilities and Features. Other than the surface facilities directly associated with the Horizon Mine, no buildings are located in and within 1000 feet of the permit area. Furthermore, no major electric transmission lines, pipelines, or agricultural drainage tile fields exist within, passing through, or passing over the permit area.

Prior to construction of the Horizon Mine surface facilities, a public road, and some old concrete foundations existed within the current disturbed area. However, no intact buildings were present within the current disturbed area.

Landowner, Right-of-Entry, and Public Interest. Plates 4-1 and 4-2 of Chapter 4 show the boundaries of lands and the names of present owners of record of surface lands and subsurface coal, respectively, included in or contiguous to the permit area. Horizon has a legal right to enter and conduct coal mining operations on all of the lands within the permit area, as noted in Chapter 2 of this M&RP and the Appendices 2-1 and 2-3.

Mining Sequence and Planned Subsidence. The mine plan for the Horizon Mine is presented on Plate 3-3. No surface disturbances are currently anticipated within the permit area beyond that presented in this M&RP (i.e., within the disturbed-area boundary noted on Plate 3-1). Planned-subsidence mining methods will be used in all of the underground mine workings shown on Plate 3-3. ~~A buffer zone of one hundred feet is planned along the Beaver Creek where no subsidence is planned. A line delineating the angle of draw from subsidence is shown on Plate 3-3. No subsidence causing mining methods will be practiced in the area between the angle of draw line and the Beaver Creek.~~

Subsidence Protection. ~~The~~ Beaver Creek is a perennial stream. Subsidence protection is planned for this stream. ~~This protection will be accomplished by developing pillar centers on no less than seventy foot centers (70 foot by 70 foot undeveloped pillar projections) by driving twenty foot wide entries a fifty foot square pillar will remain. This calculates to an extraction ratio of approximately fifty percent by area. The remaining support coal should never be less than 48%.~~

~~If support pillars have been developed on larger than seventy foot centers, secondary extraction (i.e. slabbing) may be practiced. In all instances the coal pillar remaining will be at least fifty percent of the developed centers. There will not be any~~ by orienting the panels perpendicular to the stream and using full extraction ~~of coal pillars in the 100 foot buffer zone and the area delineated by the angle of draw line and the Beaver Creek~~ pillaring. As noted in Section 3.3.2.2, Section 7.3.2, and Appendix 7-13, Hidden Splendor Resources believes that no damage will occur to Beaver Creek with the mining method that is planned.

Land Surface Configuration. Surface contours of undisturbed areas adjacent to disturbed areas associated with the mine are shown on Plate 3-1. As previously stated, surface disturbances associated with mining have been in existence in the area since the mid-1920s. As a result, pre-mining topographic maps do not exist. However, the surface contours in undisturbed areas shown on Plate 3-1 are considered generally indicative of original land slopes in the vicinity of the mine.

A map showing topographic conditions prior to disturbance by Horizon is provided as Plate 3-6.

Certification. Where required by the regulations, cross sections and maps in this permit application have been prepared by or under the direction of, and certified by, qualified registered professional engineers or land surveyors. As appropriate, these persons were assisted by experts in the fields of hydrology, geology, biology, etc.

Previously Mined Areas. A certified map showing the location of previously mined areas within the permit and adjacent areas is provided as Plates 3-9 and 3-10.

3.2.1 Site Selection and Preparation

Roads and pads that will be constructed in support of the mine will be constructed with a cut and fill technique. Topsoil resources will be conserved as outlined in Chapter 8. The surface facilities will be on privately owned surface.

3.2.2 Mine Portals

See Section 3.3.1.2 for mine portal descriptions. Portal locations are noted on Plate 3-1.

3.2.3 Surface Buildings and Structures

Locations of proposed surface buildings and structures are shown on Plate 3-1. Upon termination of mining operations, all structures will be removed and the area reclaimed as outlined in Section 3.5.

Surface Facilities. Plate 3-1 shows the locations of the following surface facilities:

- Buildings, utility corridors, and facilities to be used, including:

  Water Tank - one metal tank on concrete pad,
  Fueling Station - metal tank and containment structure with fueling equipment,
  Storage Building - portable building, to be used above ground or underground,
  Transformer - portable, to be used above ground or underground,
  Portals - see Section 3.3.1.2,
  Conveyor - see subsequent portions of this Section,
  Fan - metal structure containing a fan,
  Substation (2) - metal structure sitting on gravel and concrete pad,
  Roads - see Section 3.2.3.300,
  Sedimentation Pond - see Chapter 7,
  Temporary Office Trailer - mobile trailer,
  ~~Proposed Office and Bath House - block and/or metal building on concrete pad,~~
  ~~Proposed Shop - block and/or metal building on concrete pad Temporary~~Temporary Bath House Trailer - mobile trailer,
  Parking Areas - soil pads,
  Storage Areas - soil pads,
  ~~Proposed~~ Crusher and Screen - metal structure on concrete pad/footings,
  Emergency Escapeway - corrugated metal,
  Dumpster(s) - metal, contractor owned,

- The area of disturbance at the mine mouth,

- Coal storage and loading facilities, and

- The explosive storage and handling facility, which includes approved explosive magazine(s).

Drainage facilities are shown on Plate 7-4, including the site sedimentation pond, culverts, and ditches.

Cross sections of the surface facilities are provided on Plate 3-2. The disturbed area shown on Plate 3-1 is the same as the land area for which a performance bond or other guarantee has been posted.

Transportation Facilities. Roads that have been constructed, used, or maintained by Horizon in the permit area for the mining and reclamation operations are shown on Plate 3-1. No rail systems or overland conveyor systems (other than the material-handling conveyors in the mine yard) will be associated with the permit area. Drainage structures associated with the roads are discussed in Chapter 7 of this M&RP. Typical cross sections of the primary roads are provided on Plate 3-4.

Two material handling conveyors exist on the surface at the mine site. As noted on Plate 3-1, the mine belt will transport coal from the mine to the stacker belt which will convey the coal to the coal stockpile/coal storage area, from which the coal will be loaded into trucks for off-site transport. These conveyors will be of sufficient size to handle the production levels coming from the mine and the anticipated truck loading rates. The first belt on the surface transports the coal to the crushing and screening plant, then the coal dumps on the stacker conveyor, which transports the coal to the stockpile.

The ash analyzer determines the potential quantity of ash content in coal passing through the conveyor. The analyzer relays a signal to a computerized conveyor system. The conveyor system ~~controls three~~includes two coal drop~~s~~ chutes, either allowing coal to be dropped in one~~, two,~~ or ~~three~~two stockpile locations within the disturbed area boundary. The location of the drops and analyzer are shown on Plate 3-1.

Surface Facilities. Underground development waste which is generated at the Horizon Mine will be disposed of underground within the Horizon Mine prior to bringing the waste to the surface.

Should it become necessary to bring underground development waste to the surface, a permanent stockpile will be permitted.

A map of the existing topography prior to disturbance by Horizon is provided as Plate 3-6. No areas of pre-Horizon disturbance shown on Plate 3-6 are subject to the requirements of R645-200 through R645-203.

The location of the sedimentation pond is noted on Plate 3-1. No water treatment facilities will exist at the site other than the sedimentation pond.

The following facilities or activities will not exist or occur within the permit area:

- Coal preparation plant,
- Coal cleaning,
- Coal processing waste banks, dams, or embankments,

- Disposal of non-coal (non-waste rock) waste other than durable rock-type construction materials such as cinder block, and
- Air pollution control facilities.

Hence, certified maps or cross sections of these facilities are not provided in this plan. The durable rock-type construction materials will be disposed of in underground workings within the Horizon Mine without bringing this waste to the surface or at a permitted off-site solid-waste landfill.

Surface Configurations. Certified maps and cross sections showing the proposed final (post-reclamation) surface configuration of the Horizon disturbed area are provided on Plates 3-7 and 3-7A, respectively.

3.2.3.1 Plans and Engineering Designs

All plans and engineering designs presented in this M&RP were prepared by or under the direction of and certified by a qualified registered professional engineer.

Excess Spoil. No excess spoil (R645-100-200)will be generated from the permit area.

Durable Rock Fills. No durable rock fills will exist in the permit area.

Coal Mine Waste. No coal mine waste disposal facilities will exist on the surface in the permit area.

Impoundments. The only impoundment to be constructed for the mining and reclamation operation will consist of the sedimentation pond (see Plate 3-1 and Chapter 7). This impoundment has been designed under the direction of a professional engineer using current, prudent, engineering practices. These designs were certified by a qualified registered professional engineer.

Primary Roads. The design and construction of the primary roads associated with the mine have been certified by a professional engineer as meeting the requirements of R645-301-534.200 and R645-301-742.420 (see Plate 3-4).

Variance From Approximate Original Contour. No variance from the approximate original contour requirements of the regulations is being requested in this M&RP.

3.2.3.2 Utility Installation and Support Facilities

Utility Installations. All coal mining and reclamation operations will be conducted to minimize damage, destruction, or disruption of services provided by electric lines, telephone transmission stations, water lines, and sewer lines which pass over, under, or through the permit area. Areas where these utilities will be located are within non-subsidence zones. No other utility installations

exist in the permit area. All utility installations associated with the Horizon Mine will be removed following mining in accordance with the reclamation plan discussed in Section 3.5 of this M&RP.

Support Facilities. Support facilities at the Horizon Mine will be operated in accordance with the permit issued for the mine. Support facilities will be located, maintained, and used in a manner that:

- Prevents or controls erosion and siltation, water pollution, and damage to public or private property;
- To the extent possible, using the best technology currently available, minimizes damage to fish, wildlife, and related environmental values; and
- Minimizes additional contributions of suspended solids to stream flow or runoff outside the permit area.

All support facilities will be removed following mining in accordance with the reclamation plan discussed in Section 3.5 of this M&RP.

Water Pollution Control Facilities. Water pollution control facilities at the Horizon Mine consist of the sedimentation pond and the appurtenant structures associated with the sedimentation pond. All water pollution control facilities will be removed following mining in accordance with the reclamation plan discussed in Section 3.5 of this M&RP. The sedimentation pond and appurtenant structures were constructed as discussed in Chapter 7.

3.2.3.3 Road Classification

Primary roads within the disturbed area include the lower haul road loop and the upper pad road. No ancillary roads exist within the disturbed area. The locations of these roads are shown on Plates 3-1 and 3-4. Typical cross sections representing these roads are shown on Plate 3-4.

The unimproved dirt roads outside of the disturbed area but within the permit area will not be classified. They may be used by Horizon for access to the lease area surfaces for the collection of monitoring data (environmental and subsidence data) as well as other uses deemed appropriate by Horizon and as allowed by the associated landowner.

3.2.3.4 Description of Transportation Facilities

No surface conveyors (other than those in the mine yard immediately adjacent to the portals) or rail systems will be constructed, used, or maintained within the permit area. A description of the conveyor systems that will be used in the mine yard is provided in this M&RP.

Road Specifications. Cross sections of roads that will be used or maintained by Horizon are provided on Plate 3-4. This plate provides information regarding road widths, gradients, surfaces, etc. Information regarding road drainage structures is presented in Chapter 7.

The road which will access the mine is the Beaver Creek county road that extends from Consumers Road to the town of Clear Creek. Letters from Carbon County regarding the use of both Beaver Creek Road and Consumers Road are provided in Appendix 3-1. As indicated in this appendix, these roads will be maintained by Carbon County. Carbon County has determined that "the interests of the public and affected landowners will be protected" even though mining and reclamation activities are planned within 100 feet of the road.

From the southern boundary of the permit area, the Consumers Road extends eastward approximately 11.5 miles, ending at U.S. Highway 6 south of Helper. The western 8.5 miles of Consumers Road between the permit area and U.S. Highway 6 is gravel surfaced, while the eastern 3 miles is paved.

Drainageway Alterations. Alterations of Jewkes Creek and Portal Canyon creek were installed to accommodate the needs of facility pads and transportation systems. These alterations consisted of installation of culverts beneath the pad areas along both creeks. Additional information regarding the design of these culverts is presented in Chapter 7 of this M&RP.

Installation of these culverts provided several advantages, including: allowing coal haulage trucks to efficiently enter and leave the surface facilities area, protecting the streams from coal fines and sediment which may be generated on the adjacent disturbed areas, providing space for equipment and material storage, and providing a location for snow to be stacked away from the operations area during winter months. Snow is to be stored in sites that will drain directly to the sedimentation pond.

Carbon County upgraded Beaver Creek County Road during a time that was coincident with the construction of the Horizon Mine surface facilities. The county deemed this upgrade necessary to accommodate not only the anticipated traffic at the mine, but also the logging and ranching operations up the canyon that were not associated with mining. To accommodate this upgrade, the County realigned the lower reach of Jewkes Creek, between the mine and Consumers Road. This alteration of Jewkes Creek was implemented by Carbon County, Hidden Splendor Resources and was not the responsibility of Horizon.

Road Maintenance. Beaver Creek Road which accesses the disturbed area is owned and will be maintained by Carbon County. In the event of a catastrophic event that causes damage to Beaver Creek Road or Consumers Road, Horizon will cooperate with the County to promote rapid repair of the affected road as soon as practical following the catastrophic damage. For all primary roads within the permit area that are not owned by the county, Horizon will itself repair the road (or cause it to be repaired) as soon as practical following the catastrophic damage.

The roads within the surface-facilities area will be maintained by Horizon as necessary to permit access to the respective facilities. The remaining roads in the permit area are unimproved dirt roads. Horizon will cooperate with and assist the respective land or right-of-way owners in the maintenance of these roads as required to permit access for environmental monitoring and subsidence surveying.

3.2.3.5 Refuse Piles

No refuse piles will exist in the permit area.

3.2.3.3 Coal Mine Waste

Coal mine waste resulting from mining activities at the Horizon Mine will be handled as outlined in this section and previously in this M&RP.

Waste Emplacement. Underground Development Waste (UNDW) will be disposed of in underground workings.

Excess Spoil Fills. No excess spoil (R645-100-200) fills will exist in the permit area.

Impounding Structures Constructed of Coal Mine Waste. No impounding structures will be constructed of coal mine waste in the permit area.

Disposal of Coal Mine Waste in Special Areas. As indicated previously, coal mine underground development waste generated at the Horizon Mine will be disposed of in underground workings within the permit area. MSHA inspectors have verified the storage of underground development waste meet safety requirements per 30 CFR 75.304, 305, 329, 330, 400, and 1711 and will inspect future storage. The source of this material will be UNDW resulting from partings and splits in the coal seam. As indicated in Chapter 6, neither acid- nor toxic-forming materials are present in the overburden, underburden, or coal (i.e., the material that will comprise the UNDW that will be generated from the Horizon Mine).
The UNDW which will be stowed underground will be backfilled into dead-end panels primarily near the outer extent of the area to be mined. Backfilling will occur prior to second mining to ensure that adequate roof support exists in the area. No influence on the active mining operation is anticipated from the backfilling process.

The underground development waste to be disposed of underground will be transported to the backfill area by mine haulage equipment and will be in an unsaturated condition. Hence, underground retaining walls to prevent seepage of the material into the mine workings will not be necessary.

After second mining, the roof will collapse, causing the UNDW rock in the mine to compact. Because the UNDW will be emplaced primarily in dead-end panels near the outer extent of the area to be mined, the surface effect of the backfilling operation will be to reduce the surface expression of subsidence in an area where subsidence will already be minimal. Hence, subsidence over the permit area in general will still occur uniformly.

As noted previously, the UNDW will be emplaced in an unsaturated condition using mine haulage equipment. Hydraulic transport media will not be used to emplace the material. As a result, the UNDW will not require dewatering, construction of barriers to retain water underground which might drain from the waste, or treatment of water from the waste which might be discharge to surface streams. Hence, no impacts on the hydrologic regime are anticipated due to disposal of the underground development waste in the underground workings.

Underground Development Waste. No underground development waste will be disposed of on the surface in the permit area.

Coal Processing Waste. No coal processing waste will be generated within the permit area.

Coal Processing Waste Banks, Dams, and Embankments. No coal processing waste banks, dams, or embankments will exist within the permit area.

Refuse Piles. No coal mine waste will be disposed of on the surface in the permit area.

Sediment Pond and Ditch Clean-out Material. Materials removed during the cleaning of both the surface ditches and the sediment pond will be placed in the areas designated on Plate 3-1 or disposed of at a State-approved solid waste disposal area. The materials associated with the clean-out should be clean and not degrade surface or underground water. Collectively the designated areas will store approximately 260 cubic yards. If the need arises, the clean-out material will be sampled and tested according to R645-301-233 and if found acceptable will be used as substitute topsoil or fill material.

The material stockpile behind the substation will contain 150 cubic yards and the stockpile behind the fan will contain 110 cubic yards. The stockpiles will have 2:1 slopes and the material in the stockpiles will be seeded in the Fall of 2000.

The material will be routinely compacted and a berm will be constructed around the perimeter of the pile to retain the soil within the storage area. Operation of the storage site will be conducted in accordance with all Utah and Federal Regulations

The Sediment Pond has been designed and certified and the pond will be cleaned out as discussed in Chapter 7.

3.2.3.7 Management of Mine Openings

Locations of the Hiawatha seam portals are shown on Plate 3-1. One of these openings serves as primary pathway for ingress and egress of personnel and machinery, ~~one servesand~~ as a beltway for removal of coal from the mine, and ~~one isthe~~ other three are used for mine ventilation.

Each underground mine opening will be protected from deterioration through the installation of steel sets and timbers. Concrete and liner plate steel may also be used.

Any portals which become temporarily inactive in the permit area, but have a further projected useful service, will be protected through the installation of a lockable chain-link gate to prevent unauthorized entry. Warning signs will be posted to identify the hazardous nature of the opening. These protection and warning devices will be periodically inspected and maintained in good operating condition during the period of temporary inactivity.

3.2.3.8 Mine Structures and Facilities

Pre-Existing Structures. No intact buildings existed within the current disturbed area at the mine surface at the time construction was begun on the Horizon Mine.

As indicated on Plate 3-1, the Beaver Creek county road extending from Consumers Road to the town of Clear Creek (i.e., Beaver Creek Road) runs along the west edge of the disturbed area. Those operations to be conducted within 100 feet of this public road include construction and operation of the sedimentation pond, storage and loading of coal for off-site transport, and storage of materials, snow, or equipment. The owners of the land adjacent to the disturbed area is Hidden Splendor Resources (see Figure 4-1). The interests of the public and the landowners will be protected by:

- Complying with the requirements of the surface land lease.
- Conducting the mining and reclamation operations in compliance with the permit issued by the State of Utah.
- Maintaining a berm along the west edge of the sedimentation pond to minimize the potential for inadvertent entry into the pond.

Mine-Related Structures. Generally, all mine surface facilities are located within or in close proximity to the associated operations areas. Future building construction will generally involve grading and preparation of foundation areas, excavation and installation of foundations, building erection, interior and exterior finish work, and connection of utilities. Storage areas will generally be open graded, providing outside storage for large supplies. Both building sites and storage areas will be graded to ensure effective drainage to disturbed-area ditches and culverts as noted on Plate 7-5. Operation and maintenance of support structures and facilities at the Horizon Mine will involve regular grading of facility areas, together with inspection, cleaning, and repairs as required.

General refuse that is generated on site will be stored in a dumpster(s) to be situated at a convenient location within the disturbed area. This waste will consist predominantly of old brattice cloth, ventilation tubing, broken timbers, wire, broken machinery parts, paper, cardboard, and miscellaneous garbage. This non-hazardous, non-toxic, non-coal, non-waste rock refuse will be disposed of periodically through Carbon County at a state-approved landfill.

During site construction, operation, and reclamation activities, any spilled petroleum products such as grease, hydraulic fluid, fuel, oil, joint coating, or other pollutants will be removed immediately with the associated contaminated soil and disposed of at a state-approved facility that is permitted to receive such waste. Adequate spill collection materials (including absorbents to stop or contain contaminants that may enter a stream) will be readily available at the site during these activities to contain any such spills.

During construction and other activities at the site, wet concrete will not be allowed to enter or come into contact with stream flows. Any water at the site which is contaminated with wet concrete or other contaminants will not be discharged into stream channels. Concrete trucks and

other equipment used in the mixing and placement of concrete will be washed in areas well away from stream channels.

3.2.4 Coal Handling

Coal will be brought out of the mine by conveyor. The coal stream passes under an ash analyzer to determine the potential quantity of ash content of the mined coal. The surface conveyor system consists of ~~three~~two (~~3~~2) drop points. Point~~s~~ #1 ~~and #3 are~~is manual and Point #2 is controlled by a computerized signal from the ash analyzer. The coal flow can be dropped at Points ~~1, 2 or 3 at the stockpile locations~~1 or 2 within the disturbed area boundary. The coal discharged into the stockpile will be blended by the use of a front-end loader by bucket loads or by the stacking belt into the trucks. The location of the drops and the ash analyzer are shown on Plate 3-1.

3.2.5 Power System

The power obtained from Utah Power and Light Company will reach Portal Canyon substation by [illegible] Jewkes Canyon on the east side to the substation. The location of the power line and substation are shown on Plate 3-1. See Chapter 10 for a discussion of raptor safe power lines.

3.2.6 Water Supply

Water for non-culinary use will be stored in a tank/pond within the disturbed area.

3.2.7 Sewage System

Chemical toilets will be used during initial development, construction, and operation of the mine. A service contract will be entered for maintenance of the chemical toilets and disposal of waste therefrom. Additional sewage facilities required for normal operation of the mine (after development) will be designed in accordance with UDH regulations. Plans for sewage facilities will be submitted for review and approval by UDH prior to construction of said facilities. It is anticipated that sewage facilities will consist of a collection system and holding tank.

3.2.8 Water Diversion Structures

Diversions will be installed to direct disturbed-area runoff to sediment-control structures and/or facilities. Runoff from undisturbed areas will be diverted away from the disturbed areas to the extent practical. Detailed discussions of the design of diversion structures are provided in Chapter 7.

3.2.9 Sedimentation Control Structures and Water Treatment Facilities

All runoff from the disturbed area is directed into the sedimentation pond located directly below the area of disturbance. The pond has been designed to contain runoff resulting from the 10-year,

24-hour precipitation event. The pond spillway has been designed to safely pass the peak flow resulting from a 25-year, 6-hour precipitation event.

The location of the pond is shown on Plate 3-1. Design, construction, maintenance and operation of the pond are discussed in detail in Section 7.2.3.2.

3.2.10 Transportation

Coal will be transported from the mine via a conveyor and discharged onto the coal storage area. Coal handling is discussed in Section 3.2.4. Transportation to and from the mine site (coal, personnel, and materials) is discussed in Sections 3.2.3.300 and 3.2.3.400.

3.2.11 Total Area for Surface Disturbance During Permit Term

See Section 2.117 for the acreage of the proposed surface-disturbance.

3.2.12 Additional Areas for Surface Disturbance for Life of Mine

There are no plans to disturb any additional surface area for the life of the operation beyond that to be initially disturbed.

3.2.13 Detailed Construction Schedule

Much of the area to be included in the surface facilities has been previously disturbed. Construction of the surface facilities is planned to begin when the permit is approved. Details for construction of the sediment pond are found in Chapter 7. A detailed reclamation schedule is presented in Section 3.5.

3.3 Operation Plan

In the Horizon Mine coal will be extracted using continuous miners, loaded into shuttle cars, and hauled to an underground feeder breaker. The feeder breaker will reduce the coal to an appropriate size, after which the coal will be fed onto a conveyor to be carried to the storage pile. Coal will be loaded from the storage pile ~~will be loaded~~ onto coal trucks.

Details of the groundwater monitoring program are presented in Chapter 7.

The coal from the Horizon Mine will be sold on a run-of-mine basis, not washed. Coal of differing degrees of quality will be shipped to the coal terminal and blended to be sold. Coal to be sold by Horizon will comply with the definition in R645-100 of the State of Utah Coal Mining Rules "combutible carbonaceous rock, classified as anthracite, bituminous, subbituminous, or lignite by ASTM Standard D388-95. Appendix 3-10 includes a table with ASTM classifications and their corresponding characteristics.

Underground development waste and coal mine waste are discussed in Section 3.2.3. No impacts on the hydrologic regime are anticipated due to disposal of the underground development waste in the underground workings.

No underground development waste will be brought to the surface or will haulage occur from the Horizon Mine until the specific on or off-site facility has been approved by the Division to accept the underground development waste from the Horizon Mine.

3.3.1 Mining Plans

All mining and reclamation operations will be conducted in accordance with the approved permit and the requirements of R645-301-510 through R645-301-553.

Mining plans for the term of the proposed permit are shown on Plate 3-3. This map and Plates 3-9 and 3-10 show the location and extent of known, existing, adjacent workings as well as projections for mining within the Horizon Mine. Cross-sections, drill hole elevations, coal seam and overburden stratigraphy, and other geologic data are addressed in Chapter 6. A mine workings map will be kept current from the time of opening. These updated maps will be supplied to the Division yearly or when requested.

Horizon plans to mine coal from coal lands that are a combination of fee simple and federal coal leases. Horizon controls the fee simple land under a mining lease with Hidden Splendor Resources, Ltd. Two actions have been filed with the U.S. Department of Interior, Bureau of Land Management (BLM) to secure mining rights on federal coal lands within Horizon's projected mine plan. The first action, a BLM right-of-way will enable Horizon to commence mining with approximately 1 year of reserves. The second action, an Application for Coal Lease will enable Horizon to lease coal reserves that will serve for years of mining.

Right-of-Way Application, UPU-73227, Bureau of Land Management

On June 16, 1995 Horizon filed a Right-of-Way application with the BLM. The right-of-way would allow underground access to the segmented fee simple land parcels controlled by Horizon. The BLM was prepared to issue the Right-of-Way on January 22, 1996 when Horizon asked the BLM to hold approval pending an amendment. The amendment filed on January 30, 1996 states "the results of the exploration program conducted by Horizon in the Fall of 1995 under Federal Coal Exploration License UPU-74111 have condemned the economic feasibility of mining the Castlegate seam. However, the exploration confirmed that the Hiawatha coal seam development is a feasible project. The original proposed course of the underground workings portrayed in the application applied to development of the Castlegate seam. The revised application reflects a course for the right-of-way suitable for mining the Hiawatha seam". The lands for the right-of-way are included within the permit boundary of this Mine Permit Application. The BLM issue the Right-of-Way in April of 1996 Appendix 2-3).

Coal Lease Application UPU-74804, Bureau of Land Management

On August 16, 1995, Horizon Coal Corporation filed a Coal Lease Application at the Utah State Office of the Bureau of Land Management. The application for coal lands containing 1,288.49 acres was approved on September 1, 1998. The Beaver Creek Tract coal lease UTU-74804 is included in Appendix 2-1. The data presented in the Environmental Assessment submitted to the Bureau of Land Management is included as Appendix 2-6.

Horizon was issued a Right-of-Way through BLM lands in 1996 to facilitate mining coal from fee lands. The Right-of-Way was incorporated into the Beaver Creek Tract coal lease UTU-74804 on September 1, 1998. ~~HSR~~ Horizon stipulates that it will mine only fee coal and federal coal within the approved right-of-way lease as included in the legal description in Chapter 2. Horizon projects mining on the lands ~~in years 2 through 5~~during the term of this Mine Permit Application.~~HSR began operations on the lease in August, 2003 and projects mining to continue on the lands for the duration of this permit term.~~

3.3.1.1 Orientation and Multiple Seam Considerations

Seam separation in the area ranges from approximately 150 feet to 230 feet. With this distance and land structure indicated by drill logs, it is considered neither necessary nor feasible to columnize these workings.

3.3.1.2 Portals, Shafts, and Slopes

There will be four portals in the Hiawatha seam. The return portal (existing rock slope) will be rehabilitated and expanded for use as the primary return. A second and third portal will be faced up and new rock slopes (300 feet long) will be driven to the Hiawatha seam. These two new slopes will serve as the belt/material slope and the fan portal respectively. The fourth portal is a rehabilitated slope used as a ~~secondary~~third escapeway. The secondary escapeway is located at the Castlegate A Seam horizon but connects to the Hiawatha Seam by a steeply inclined rock slope. The locations of the portals can be seen on Plate 3-1.

3.3.1.3 Mining Methods, Room and Pillar, Longwall

All mining will be done with a continuous miner/shuttle car haulage. In second-mining, a standard room-and-pillar method will be used to maximize coal recovery. Recovery within a room-and-pillar panel is estimated to be about 60 percent. Longwall mining is not planned. Pillar extraction plans are found in Appendix 3-2.

3.3.1.4 Projected Mine Development, Mains, Sub-Mains, Panels, Etc.

All entries, mains, and panels, will consist of a multiple system on various centers. Room and pillar panels will be driven off the mains. Additional rooms will be driven to widen the panels during retreat mining. Barrier pillars will be left to separate panels and mains. The mains will be pulled upon final retreat of the mining operation. Safety factors for roof conditions using uniaxial compression data are presented in Appendix 3-3.

3.3.1.5 Retreat Mining

Room and pillars are laid out so that pillar cuts can be extracted with a full cut of a continuous miner using radio remote control. The pillar is extracted with successive cuts by the continuous miner. ~~Timbers~~Timber and/or mobile roof supports will be installed to support the roof and provide roof breaker control. It is estimated that mining will provide a recovery rate of 60 percent.

3.3.1.6 Roof Control, Ventilation, Water Systems, Dust Suppression, Dewatering, Electrical

An approval of the Roof Control, Ventilation, and Dust Control Plans will be obtained from the appropriate regulatory agency.

An assessment of groundwater conditions within the Mine can be found in Chapter 7. Dewatering plans will be developed should it become necessary.

3.3.2 Barrier Pillars

Protective barrier pillars will be utilized where necessary, normally ranging from 100 feet to 300 feet in width, depending on the depth of cover and the purpose of the barrier. Barrier pillars will be left on either side of the main entries. Barrier pillars in the mains will be extracted on final retreat.

3.3.2.1 Protection of Oil and Gas Wells

There are no oil or gas wells in this area.

3.3.2.2 Protection of Surface Structures and Streams

No surface structures exist within the zone of potential subsidence.

~~S~~No stream buffer zones ~~(100 feet each side of creek)~~ will be maintained beneath Beaver Creek and the North Fork of Gordon Creek should mining proceed beneath either creek. ~~Full pillar extraction will not be practiced within these buffer zones or under raptor nests without regulatory agency permission~~See Chapter 7, Section 7.3.2 for further information.

3.3.2.3 Property Boundaries

A protective barrier pillar with a width of approximately 80 to 100 feet will be left at all property boundaries.

3.3.2.4 Outcrop Protection

A protective barrier pillar with a width of approximately 100 feet will be left when advancing toward or along an outcrop.

3.3.2.5 Other

At any time a land slide occurs which may have an adverse effect on public property, health, safety, or the environment, the Division will be notified by the fastest available means. Horizon commits to complying with remedial measures required by the Division.

As part of the operations plan, a facilities pad will be constructed from available on-site materials. On-site materials include the embankment located at the mouth of Portal Canyon. Test pits indicate that some of the material contained in the embankment is comprised of coal and coal mine waste. It is estimated that 2500 CY of coal and coal mine waste may be contained in the embankment. This material will be removed from the embankment, placed in the facilities pad area, and covered with at least four feet of appropriate backfill material. To accomplish this task, the pad area will first be stripped of vegetation and topsoil as described in Section 8.7. The appropriate cuts of overburden will be made to achieve the rough grade. The coal and coal mine waste will then be placed in the fill areas and covered with four feet of backfill.

A potential storage volume of approximately 2740 for the coal and coal mine waste was calculated from the cross-sections illustrated on Plates 3-1 and 3-2. Appendix 3-8 contains a plate showing approximate locations of buried coal mine waste.

The Portal Canyon facilities pad will be built with 4 feet of acceptable backfill covering any coal or coal mine waste materials. No coal or coal mine waste will be used as fill in the areas planned for the reclamation stream channels in Portal or Jewkes Canyon.

3.3.2.6 Underground Development Waste

See Section 3.3.

3.3.2.7 Return of Coal Processing Waste to Underground

There is no plan to return coal processing waste to the underground.

3.3.3 Conservation of Coal Resource

The maximum quantity of coal will be extracted that is consistent with safe operation of the mine and the mining methods to be employed. Engineering, production, and supervision of mining activities will be geared toward this end. If plans for resource recovery or abandonment (including portal sealing) change in the future, the U.S. Bureau of Land Management and the Division will be properly informed.

3.3.3.1 Projected Maximum Recovery

Coal reserves within the permit area are summarized below. Recoverable reserves were estimated using a recovery rate of 60 percent of the mineable reserve base.

Area	Hiawatha Seam (million tons)		
	Total	Mineable	Recoverable
Original Permit Boundary	1.303	1.30	0.663
2000 Revised Permit Boundary	13.190	2.10	1.32
Remaining Coal Lease UTU-74804	8.45	8.31	4.95
Total	13.8538	11.7131	76.6581

3.3.3.2 Justification for Non-recovery

All coal that can economically and safely be recovered will be recovered. Barrier pillars and buffer zones will be left only where required to protect surface resources, provide safe mining conditions, and as required by law or regulation.

3.3.3.3 Access for Future Reserves

Access to additional reserves will depend upon the results of exploration activities and obtaining leases. However, it is currently anticipated that the mine workings contemplated by this plan will provide access to reserves in Sections 6, 7, 8, and 18, T13S R8E.

3.3.4 Equipment Selection

Major equipment to be used underground will include the following:

2 - Continuous Miner
3 - Roof Bolter RD1-43
6 - Shuttle Cars
2 - Feeder Breaker
3 - Scoop
1 - Compressor
2 - Rock Dusters
5 - Conveyor Drives & Tail Pieces
3 - Drop Chutes
~~1 - Ash Analyzer~~
1 - Dust Wagon
1 - Power Center
3 - Transformers
2 - Pumps
1 - Substation

Major equipment to be used on the surface will include the following:

1 - Ash Analyzer
1 - Grader
1 - Loader
1 - Material Tractor
1 - Welder
3 - Flatbed Material Trailers
1 - Screen
1 - Crusher

3.3.5 Mine Safety, Fire Protection, and Security Mine Safety

The mine will be operated in accordance with Mine Safety and Health Administration (MSHA) and applicable State of Utah regulations. Safety training will be taught and policies implemented for a safe operation.

Fire Protection

All surface and underground equipment will be provided with MSHA-required fire protection. In addition, belt drives will be equipped with deluge systems for fire protection. Water lines will also be equipped with outlets and fire hoses at regular intervals. Should a mine waste fire occur, it will be extinguished using water, extinguishers, rock dust, foam, or by sealing off the fire. Mine personnel will be trained in the use of fire-fighting techniques.

There will be no open burning on the surface. All garbage will be contained in dumpsters and hauled to the Carbon County Landfill. If flammable waste materials (oil, etc.) are generated, these will be disposed of in accordance with regulations promulgated by the Utah Division of Solid and Hazardous Waste. Disposal methods and locations will be determined based on the characteristics of the flammable waste.

Impoundment Hazards

Impoundment hazards will be reported promptly to the Division and the emergency procedures formulated for public protection and remedial action.

Security

Mine portals will be signed and covered by locked gates when the mine is in cessation.

3.3.5.1 Signs

Specifications

All signs will be of a standard design that can be seen and read easily. They will be made of a durable material (treated/painted wood or metal) and supported by metal or wooden posts.

Identification Signs

Mine identification signs will be placed at the entrance to the mine yard. Signs will show the mine name, company name, business address, telephone number, ID Number, and Permit Number. These signs will be maintained until bond release following reclamation. Typical mine identification signs are presented as Figures 3-3 And 3-4.

Disturbed Area Perimeter and Buffer Zone Markers

Disturbed area perimeter markers will be steel fence posts. The posts will carry signs at selected points, with the designation "Disturbed Area Perimeter Marker" (see Figure 3-4).

Blasting Signs

When preparing to blast, "Blasting" signs will be placed along the edge of any blasting area that comes within 100 feet of any public road right-of-way, and at the point where any other road provides access to the blasting area. In addition a sign which states "Warning, Explosives in Use" which describes the audible blast warning, all clear signs and markings associated with the blasting area will be placed at the entrance(s) to the permit area from public roads or highways.

Topsoil Markers

Topsoil will be stored on the mine site at the location noted on Plate 3-1. Topsoil storage piles and topsoil layered on interim reclamation slopes will be marked with signs as shown on Figure 3-4 as "topsoil storage areas".

3.3.5.2 Fences and Gates

Mine portals will be signed and covered by locked gates when the mine is in cessation.

3.3.5.3 Fire Protection

Facilities

All facilities will be equipped with fire extinguishers. Water outlets and fire hoses will be available at specific locations.

Coal Stockpiles

The coal stockpile will be temporary and will be loaded out at frequent intervals, thus reducing the potential for spontaneous combustion.

Coal Seam

No open burning will be allowed at the mine. All coal outcrops resulting from mining will be covered with incombustible material upon cessation of operations, as discussed in Section 3.5.

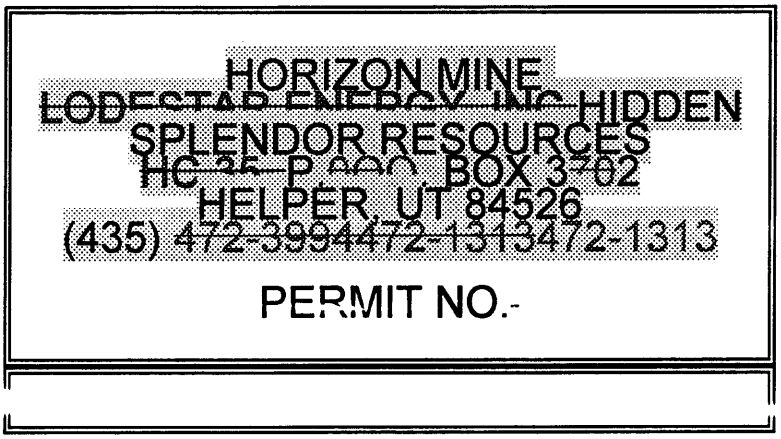


FIGURE 3-3. MINE IDENTIFICATION SIGN.

HORIZON MINE
STREAM BUFFER ZONE

18" X 12"

HORIZON MINE
BUFFER ZONE
DO NOT DISTURB

18" X 12"

HORIZON MINE
TOPSOIL STORAGE
DO NOT DISTURB

18" X 12"

HORIZON MINE
DISTURBED AREA
PERIMETER
MARKER

8" X 12"

FIGURE 3-4. IDENTIFICATION SIGNS.

3.3.5.4 Explosives

Any explosives utilized in underground operations will be used in compliance with applicable State and Federal laws. Explosives will be handled and used only by persons trained, examined, and certified as required by 30 CFR 850 and the Utah State Industrial Commission. Explosives will be stored in a facility designed for their containment and safety.

Mining and reclamation activities at the Mine may require the use of blasting or explosives on the surface during construction or destruction of the surface facilities. Horizon will comply with all local, State, and Federal laws in the use of explosives at times when blasting is required at the Mine. A certified blaster will direct all blasting operations with the help of at least one other person who has been trained (R645-301-524.140). Blasting records will be maintained per R645-301-524.700 and kept on file at the Mine for the required period of time.

A preblasting design/survey will be submitted to UDOGM when blasting activities meet the following criteria:

- Blast requires the use of more than five pounds of blasting agent or explosive,
- Residents, dwellings or structures exist within a ½ mile radius of the area of potential blasting and owners of structures request a preblasting survey.

A schedule of blasting will be made in instances when the UDOGM regulations and conditions at the Mine require a schedule.

All explosives containers used at the mine will be constructed to meet or exceed the requirements of the Mine Safety and Health Administration. The locked surface storage containers (one for caps and one for powder) will be placed in a location that will ensure the protection of the environment and personnel (see Plate 3-1).

All underground blasting activities at the Mine will be conducted under the direction of a MSHA certified blaster.

3.3.5.5 Management of Mine Openings

Four portals will serve the Hiawatha seam. Two portals exist from previous mining. Two additional rock slopes will be driven to open the new mine. For each of these portals the faceup will be secured and canopies will be installed to meet MSHA standards.

During operation of the Horizon Mine, access to all mine openings are controlled by the operator during working and nonworking hours.

Permanent sealing of underground openings is discussed in Section 3.5.3.1.

3.3.6 Operations Schedule

3.3.6.1 Annual Production Per Year for Permit Term

Coal will be produced from the mine at an anticipated rate of approximately 700,000 tons per year. The production could increase to 1.5 million tons per year when federal coal leases are secured and if the market ~~dictates~~ and mining conditions are favorable.

3.3.6.2 Operations Schedule - Days - Shifts

Production will occur in two production shifts per day and a small crew will perform maintenance work and other non-production jobs on the off production shift.

3.3.6.~~3~~ 4 Temporary Cessation

If operations are to be temporarily ceased for more than 30 days, Horizon will submit to the Division a notice of intention to cease or abandon the operations. In accordance with R645-301-529.210, each mine entry that has further projected useful service will be protected by barricades or other covering devices, fenced, and posted with signs to prevent access into the entry and to identify the hazardous nature of the opening. These devices will be periodically inspected and maintained by Horizon.

3.3.7 Mine Permit Area

3.3.7.1 Acreage and Delineation of Mine Permit Area

See Chapter 2 for the total acreage contained within the mine permit boundary.

3.3.7.2 Projected Mining by Year

The projected mining by year is shown on Plate 3-3.

3.3.8 Mine Plan Area

Horizon plans to mine within the mine permit boundary as shown on Plate 1-1 ~~1-1 until it permits the remaining area of coal lease UTU-74804. The remaining lease area is shown on Plate 3-3. The permit boundary will be modified to include this area when additional baseline groundwater data is available~~. Plans for mining beyond the permit term will be developed as additional information is acquired. No new areas will be mined until appropriate permits have been obtained from their corresponding regulatory agencies.

3.4 Environmental Protection

3.4.1 Preservation of Land Use

Upon completion of mining operations, final reclamation work will commence. Reclamation efforts will be directed to recreating the pre-mining land use. This will be achieved by use of acceptable seed mixtures. Refer to Chapter 4 for pre-mining land use information.

3.4.1.1 Projected Impacts of Mining on Current and Future Land-Use

Current and future land uses are discussed in Sections 4.4 and 4.5.

3.4.1.2 Control Measures to Mitigate Impacts

Full pillar extraction will not occur beneath the ~~stream channels and~~ raptor nests indicated on ~~Plates 3-3 and~~Plate 10-1 ~~respectively~~. Based on the boundaries of the present surface disturbance, no public parks or historic sites will be impacted by mining operations. A further discussion of Cultural Resources may be found in Chapter 5.

3.4.2 Protection of Human Values

3.4.2.1 Projected Impacts of Mining on Human Values

As discussed in Chapter 5, no historical sites listed on the National Register of Historical Places are known to exist within the proposed disturbed areas. In addition, no known archaeological sites

3.4.3 Protection of Hydrologic Balance

Horizon will employ various control measures to protect the hydrologic balance of the permit area and sedimentation controls will be provided for all disturbed areas.

Water rights on file with the Utah Division of Water Rights and located in the vicinity of the permit area are noted in Appendix 3-5. Should Horizon's mining activities cause an adverse impact on the area's water supply, the applicant intends to mitigate the effects (see Sections 3.4.8.2 and 7.1.6).

Diversions will be established to direct flow from disturbed areas to the sedimentation pond. If water is encountered during mining operations, this water will be used for underground operations when possible. An UPDES permit has been obtained for the mine (see Appendix 3-6). If the quantity of underground water encountered by mining exceeds the amount required for mining operations, discharges of water from underground workings will be monitored to ensure that effluent limitations are met.

3.4.3.1 Projected Impacts of Mining on Hydrologic Balance

The probable impacts of mining on surface or groundwater resources in the area are discussed in Chapter 7. Runoff-and sediment-control facilities within the disturbed area~~, together with coal buffer zones beneath Beaver Creek and North Fork of Gordon Creek,~~ will preclude significant impacts to surface water in the area. Groundwater investigation and monitoring activities associated with the Hiawatha seam and its adjacent strata will continue, thus allowing a determination of the potential groundwater impacts of mining in the Hiawatha seam. A subsidence monitoring program (see Section 3.4.8) will provide a basis for determining possible impacts due to subsidence.

3.4.3.2 Control Measures to Mitigate Impacts and Monitoring Procedures

Horizon will maintain sedimentation control structures to prevent impacts to the surface waters in Jewkes Creek and the North Fork of Gordon Creek. In the event that the quantity of groundwater encountered during mining is in excess of underground requirements, the water will be settled first in underground sumps and then discharged to the surface. Any such discharges will be monitored in accordance with the UPDES permit.

Surface and groundwater monitoring programs have been or will be implemented to assess the impacts of mining operations at the Mine on hydrologic resources in the area. Details of these monitoring programs are presented in Chapter 7.

3.4.4 Preservation of Soil Resources and Projected Impacts of Mining on Soil Resources

Soil resource information for the mine area is presented in Chapter 8. Soil surveys were performed in the area in May 1980 and in January 1990. Naturally-occurring and presently-disturbed soils were delineated. The purposes of the surveys were to identify soils and their stripping depths for salvaging suitable natural soil prior to additional disturbance and to determine the amount of topsoil available for final reclamation.

Most of the existing disturbance at the mine occurred prior to enactment of P. L. 95-87 or the Utah Interim Program that set forth regulations for salvaging topsoil (i.e., pre-1950's disturbance). However, some topsoil exists along the shoulders of cut areas where it was not disturbed during previous construction activities.

During construction of surface facilities, available topsoil resources will be segregated and stockpiled as indicated in Chapter 8. In addition, presently-disturbed soils will be carefully handled to salvage as much soil as possible for potential future use as substitute topsoil materials.

3.4.4.1 Control Measures to Mitigate Impacts to Soil Resources

Surface disturbances will be limited to the disturbed area boundary noted on Plate 1-1. Topsoil that is stockpiled for future reclamation efforts will be vegetated with an interim cover to reduce erosion of the stockpile. All areas disturbed during mining activities will be reclaimed in accordance with the approved reclamation plan (see Section 3.5).

3.4.5 Protection of Vegetative Resources

3.4.5.1 Projected Impact of Mining on Vegetative Resources

Previous mining activities have resulted in alteration of natural vegetation at the site area. The majority of this area has been disturbed previously by mining operations.

3.4.5.2 Mitigation Measures to be Employed to Reduce Impacts on Vegetative Resources

All mining activities will be conducted within the proposed disturbed area. Traffic will be confined to established roadways and pads. Upon completion of mining, all areas which are disturbed by Horizon will be reclaimed as described in Section 3.5.3.

3.4.5.3 Monitoring Procedures - Reference Areas and Revegetation

Sections 3.5.5, 3.5.6 and 9.8 discuss the monitoring procedures and revegetation to be undertaken during mining and reclamation operations.

3.4.6 Protection of Fish and Wildlife

3.4.6.1 Potential Impacts on Fish and Wildlife

Potential impacts on fish and wildlife are discussed in Section 10.4.

3.4.6.2 Mitigation and Management Plans

Refer to Section 10.5 for mitigation and management plans.

3.4.6.3 Fish and Wildlife Monitoring

Monitoring is discussed in Section 10.5.

3.4.7 Protection of Air Quality

Air quality information for the area is presented in Chapter 11.

3.4.8 Subsidence Control and Monitoring Plan

3.4.8.1 Structures

A search of the site files at the Utah Division of State History turned up no recorded sites in, or near, the project area. Since the identified sites are abandoned homestead cabins or mining camp dwellings and are not recorded as warranting preservation efforts, no special mining techniques are deemed necessary for their protection. The archaeologic survey is described in detail under Chapter 5 of this plan.

~~At least 6 months prior to mining beneath an area, Horizon will notify all owners of overlying surface property (see Section 4.3.1).~~

3.4.8.2 Renewable Resources

Hydrologic and vegetative renewable resources exist within the permit area. One perennial stream, Beaver Creek, and various springs are known to exist above the area to be mined. Based

on past experience and monitoring results from this area, it is not expected that mining will affect any surface hydrologic resource through subsidence.

~~Protection will be provided for the perennial stream in Section 3.2.~~

A depression of the groundwater table is expected around the active mine workings. A rebound of this water table will occur after active mining ceases and pumping activities have also ceased. This is witnessed in the water level in the Blue Blaze mine prior to the start of the Horizon Mine. Should a substantial inflow of groundwater occur, mitigation measures may include: attempts to seal off the inflow, increased monitoring efforts, lining of the stream bed through the affected area if it is determined to be surface water, and replacement of lost water if the groundwater does not rebound after mining is completed as indicated by monitoring.

An extended mitigation plan will be enacted should a measurable impact occur to surface water due to mining activity. The mitigation plan will be correlated with Water Rights and UDOGM.

The vegetation resource above the mining area consists of rangeland for stock and wildlife grazing and a limited timber resource. If subsidence should occur, the effects would be minimal, possibly resulting in some fractures or slight depressions. Thus, the effect upon vegetation resource would also be minimal. Should impacts to vegetation occur due to subsidence, mitigation measures may include: filling of fractures, regrading of broken areas, replanting degraded areas, and intensified monitoring.

3.4.8.3 Geologic Hazards

Geologic hazards in the mine area exist in the form of steep slopes and numerous inactive normal faults. Roof conditions will typically worsen in these areas due to fracturing and slickensides; however, no surface movement or new effects have been noted to date from mining through fault zones in this area.

Movement could result in rock falls from exposed outcrops; however, no evidence of such falls or movement has been noted in this area from past mining. There are no potential landslide or slump areas known to exist that were caused by previous mining activities in the area.

3.4.8.4 Subsidence

Subsidence can normally be expected to occur over areas where second mining (pillaring - removal of greater than 50% of the coal) has taken place. Maximum potential subsidence from pillar extraction in the Mine (the Hiawatha seam) has been estimated from Figure 3-5 using the following criteria:

Panel Width = 600 ft
Average Depth = 800 ft
Width/Depth Ratio = 0.75
Seam Thickness = 7.0 ft

Using these data, subsidence due to pillar extraction in the Hiawatha seam could reach 2.33 feet directly over a pillared panel. ~~The cumulative potential subsidence for areas where both seams are pillared is 6.18 feet (3.85 + 2.33).~~ Again, past experience in this area suggests that subsidence would be of a lesser magnitude.

The following observations and conclusions regarding subsidence have been made from past mining activities in the vicinity of the proposed mine:

(1) Pillaring in the upper (Castlegate "A") seam has previously occurred ~~place~~ beneath Beaver Creek (Plate 3-9). Specifically, the northernmost west panel was pillared beneath Beaver Creek by Swisher Coal Company in January 1978 in an areas where the overburden thickness was about 650 feet. In addition, in September 1981, Beaver Creek Coal Company pillared the "A" Panel area beneath Beaver Creek in an area with an overburden thickness of approximately 425 feet. Neither of these areas show any measurable effect on Beaver Creek.

(2) The Gordon Creek No. 2 Mine overlies areas pillared up to 40 years ago in the lower seam (Sweet's Mine) with no noticeable subsidence effects. The Consumers No. 3 Mine also pillared areas in the permit area which show no noticeable subsidence effects.

(3) The overburden in the permit area above the Castlegate "A" seam (with a thickness of 600 to 800 feet) contains massive sandstone units which are unlikely to allow caving effects to reach the surface. In addition, the seams are separated by over 150 feet of similar interburden with no noticeable effects from past pillaring.

(4) Subsidence, should it occur, is not likely to affect the Beaver Creek flow due to the numerous beds of swelling shales within the overburden and interburden. Fractures within these sedimentary deposits have a strong tendency to heal due to the swelling of the shales and sandy shales contained therein.

Refer to Sections 3.4.8.2 and 7.1.6 for a discussion of water resource mitigation measures.

3.4.8.5 Subsidence Control and Monitoring Plan

The subsidence monitoring network will consist of permanent survey monuments located outside of the anticipated area of subsidence and a series of monitoring stations within the potential subsidence zone (Plate 3-3). The monitoring stations will be steel re-bar/rod with aluminum caps or other permanent metal or steel structures set so that weather, frost heave, or livestock will not disturb them. Stations will be installed above the active mining area.

Multiple readings will be taken where necessary to ensure accuracy. Monitoring of the subsidence stations noted on Plate 3-3 will be performed on an annual basis for a period of two years following final cessation of mining operations. Reports of monitoring will be sent to the UDOGM on a yearly basis.

The extent of the adjacent area outside of the permit area was determined based on a maximum overburden thickness of 1500 feet (from data presented by Hansen, 1988) and an angle of draw of 35 degrees as measured from the vertical (the maximum angle of draw recommended by Dunrud [1976]). This angle of draw is significantly in excess of the 20-degree value used by Beaver Creek Coal Company for adjacent mining operations (Guy, 1985), but will result in a conservative estimate of the extent of the adjacent area. Based on the 35-degree angle of draw and a maximum overburden thickness of 1500 feet, subsidence impacts will extend a maximum of 1050 feet (0.2 mile) from the edge of the permit area. Hence, for the purpose of this application, the adjacent area for potential subsidence is defined as that area within 0.2 mile of the permit area.

3.5 Reclamation Plan

3.5.1 Contemporaneous and Interim Reclamation

Disturbed area's when no longer needed, will be backfilled, graded, retopsoiled, and revegetated. Seeding, fertilizing, and mulching will be performed as soon as practical following redistribution of topsoil. Seed Mix #2 presented in Table 3-3 will be planted, and erosion-control matting will be installed in specific areas as described in Section 3.5.5.3. Reclamation techniques are described below. Areas that will not be redisturbed will be classified as contemporaneously reclaimed. Seed Mix #1 will be used in areas requiring soil stabilization during the operational period of mining. These areas will likely be redisturbed either during the operation or reclamation of the mine site. The areas that will be redisturbed during operation or final reclamation contouring will be classified as interim reclamation. Areas where interim reclamation contacts a steep bank dropping to a diversion ditch will be protected by attempting to control the loss of topsoil by installing a mulch mat a minimum of one foot above and below the grade break.

During October 1997, the areas designated on Plate A within Appendix 8-1 are scheduled for stabilization seeding using Seed Mix No. 1. Refer to Section 8.8 for additional information.

Underground Coal Mining and Reclamation Activities. All surface equipment, structures, or other facilities not required for continued underground mining activities and monitoring, unless approved by the Division as suitable for the post-mining land use or environmental monitoring, will be removed and the affected lands reclaimed following permanent cessation of mining operations.

Reclamation Timetable. A timetable for the completion of each major step in the reclamation plan is presented in Table 3-4.

Plan for Backfilling, Soil Stabilization, Compacting, and Grading. The regrading plan for the Horizon Mine was designed to meet the objectives of balancing cut and fill quantities and maintaining a geotechnically and erosionally stable base. The primary features of this plan are:

- Removal of the pad upon which surface activities will be constructed at the mine, thereby creating a slope which will adequately drain while minimizing long-term erosion concerns;
- Backfilling to remove portal entrances (highwalls) within the objectives noted above (cut and fill balance, site stability, and erosion control),
- Construction of stable channels across regraded areas;
- Placement of topsoil;
- Revegetation and mulching of the topsoiled site; and
- Removal of the sedimentation pond (together with accompanying regrading, topsoiling, revegetation, and mulching of the sedimentation pond area) and implementation of interim sediment-control measures.

The estimated cut quantity for the Horizon facility is approximately 11,752.91 cubic yards with an estimated fill of 10,238.74 cubic yards (see Table 3-1). Regrading activities will continue until the final surface configuration defined by Plates 3-7 and 3-7A is approximated. Details regarding topsoil placement and revegetation following regrading are provided in Chapters 3 and 8, respectively.3-3

TABLE 3-4

Reclamation Timetable

Task	Months from Start of Reclamation					
	1	2	3	4	5	6
PHASE I						
Seed/Plant Ordering*						
Portal Sealing						
Demolition - Structure Removal						
Rough and Final Grading						
Construction of Reclamation Channels and Installation of Sediment Controls						
Soil Testing/Order Amendments						
Topsoil Distribution						
Seeding & Mulching						
Vegetation/Water Monitoring	10 years after seeding or until bond release					
PHASE II - To Follow Phase I Bond Release						
Seed/Plant/Amendment Ordering*						
Grading (Disturbed Area Access Road)						
Topsoil Distribution						
Seeding & Mulching						
Reclamation Monitoring	Until bonding requirements are satisfied					

* Seed and plants will be ordered one year prior to their proposed planting time.

TABLE 3-1

RECLAMATION CUT AND FILL CALCULATIONS

Using Ppresentpresent surface contours from Plate 3-7 in conjunction with revised reclamation contours through AutoCad 2000 and Survcadd 2000

Area in Cut: 186,023.6 sq ft, 4.271 acres
Area in Fill: 189,050.1 sq ft, 4.340 acres
Total inclusion area: 8.611 acres
Cut to Fill ratio: 1.15
Average Cut Depth: 1.71 ft
Average Fill Depth: 1.46 ft
Cut volume: 11,752.91 cubic yards
Fill volume: 10,238.74 cubic yards

Backfilling and Compaction. As indicated previously in this M&RP, the surface at the Horizon Mine was originally disturbed between the 1920s and the 1950s by previous mining operations. These prior operators made no effort to salvage any topsoil or other soil material for subsequent site reclamation. Therefore, restoration to a contour that approximates pre-mining conditions is neither practical nor required by the regulations. However, it is the intent of Horizon to restore the area to a topography that is compatible with the post-mining land use, using materials that are available at the site.

All vegetation, organic matter, and debris will be cleared from areas to receive fill. The cut material from site regrading will be placed as fill and graded to facilitate drainage from the mine site and contributing side areas. All fill placed during recontouring of the site will be compacted to at least 85 percent of maximum Proctor density (ASTM D698). Compaction will be accomplished using repeated passes of rubber-tired equipment, rollers, and other appropriate equipment.

Side hill embankments, where the width is too narrow to allow access by compaction equipment, will be initially constructed by spreading the soil with a dozer, but only to a width necessary to allow compaction equipment access. After this is achieved, the fill will be placed in lifts and compacted to at least 85 percent of maximum Proctor density.

Care will be taken to ensure that fill materials are not frozen during placement or compaction. Any areas that are damaged by freezing will be reconditioned, reshaped, and recompacted to at least 85 percent of maximum Proctor density. All fill placement and compaction activities will be overseen by an experienced engineer.

In general, grading and backfilling operations will proceed from the upstream end of the surface facilities to the downstream end, thus allowing the sedimentation pond to remain effective for as long as possible.

Construction of Reclamation Channels. Reclamation channels will be constructed at the locations shown on Plate 3-7. These channels will be constructed to capture runoff from undisturbed areas and convey this runoff to and through Portal Canyon and Jewkes Creek. Details regarding the design and construction of these channels are provided in Chapter 7 of this M&RP.

As noted on Plate 3-7, slopes adjacent to the reclaimed streams are generally much shallower than the natural slopes upstream from the disturbed area (where natural slopes on the hillsides adjacent to the streams are typically 1.5H:1V or steeper). Hence, access to the streams by wildlife and livestock under post-mining conditions should not be hindered within the reclaimed area.

Sedimentation Pond Removal and Interim Sediment Control. Prior to the start of reclamation activities, temporary silt fences will be emplaced in Jewkes Creek perpendicular to the flow direction. A minimum of four such silt fences will be installed in the creek downstream from the by-pass culvert (UC-1) outlet but within the disturbed area prior to removal of the culvert. The silt fences will be located in an area convenient for maintenance and cleanout. The silt fences will be removed when reclamation construction activities are completed. During reclamation, the silt fences will be periodically inspected and accumulated sediment will be removed from behind the silt fences when required to minimize downstream impacts.

The sedimentation pond will be retained for as long as practical during reclamation. Once backfilling and grading operations proceed to the location of the pond, it will be removed.

Because the pond is designed primarily as an excavated structure, removal of the pond will consist primarily of backfilling. This removal will be accomplished using backhoes, loaders, dozers, and other appropriate earthmoving equipment.

As soon as regrading of an area no longer allows that area to drain to the sedimentation pond, silt fences will be installed along the base of the slopes adjacent to the associated stream to control erosion on an interim basis prior to revegetation success. These silt fences will be installed using a supportive backing and burying the toe of the filter fabric.

On a temporary basis, straw-bale dikes may also be installed as necessary to control localized erosion prior to the establishment of revegetation efforts. If installed, locations of the straw-bale dikes will be selected to reduce sediment contributions to runoff based on field observations. Straw-bale dikes will be installed by keying the bales into the ground.

Roads. All roads within the disturbed area will be reclaimed immediately after they are no longer needed for mining and reclamation operations. These roads will be graded and/or backfilled as indicated above. Topsoil will be applied to the regraded surfaces and the area will be revegetated as discussed in Chapters 3 and 8, respectively.

3.5.2 Soil Removal and Storage

Soil surveys conducted at the mine site have distinguished disturbed lands from undisturbed soil mapping units (see Chapter 8, Plate 8-1). Areas mapped as disturbed land are areas where the soils, vegetation, or both were affected by previous mining operations. Disturbance of the roads and pads occurred prior to regulatory requirements to salvage topsoil from those areas.

All topsoil/growth medium to be generated during future disturbances will be stockpiled. The stockpiles will be contoured, fertilized, vegetated with Seed Mix #1 outlined in Section 3.5.5.2, and mulched as outlined in Section 3.5.5.3. Markers will be placed indicating that the piles contain topsoil. Berms and/or strawbales will be placed around the stockpile to minimize off-pile transport of sediment.

Areas of interim reclamation that will be redisturbed for final reclamation contouring will have the depth topsoil that was placed on those areas removed and placed back on the topsoil stockpile for redistribution onto the newly recontoured area. A qualified person will be present during the removal of the topsoil in these areas. See Plate 3-7 for areas where interim reclamation will be re-disturbed and areas where re-contouring is complete an interim vegetation has been established.

Refer to Section 8.8 for the methods being used in the removal and redistribution of soils.

3.5.3 Final Abandonment

Upon permanent cessation of operations, permanent reclamation will be performed. All surface equipment, structures and facilities (other than sedimentation control) associated with the operation will be removed during reclamation of the affected area.

FIGURE 3-6

3.5.3.1 Sealing of Mine Openings

Abandonment of Openings. When no longer needed for mining operations, all portals will be sealed and backfilled by collapsing the concrete canopies over each portal. Prior to the sealing of the mine openings, all combustible materials will be removed from the portal area. All structures that would interfere with sealing of the mine openings will also be removed. The permanent closures will be constructed to prevent access to mine workings by people, livestock, and wildlife. Potential surface drainage will also be kept from entering the sealed entries.

All mine openings will be sealed at least 20 feet inside the mine opening. Prior to installation of the seal, all loose material will be removed from the roof, floor, and rib of the mine within the seal area. The seal will then be constructed using solid concrete blocks with nominal dimensions of 8 inches high, 8 inches wide, and 16 inches long. Mortar will consist of one part cement, three parts sand, and no more than 7 gallons of water per sack of cement.

In the bottom course, each block will be laid with its long axis parallel to the rib. The long axis in succeedingly higher courses will be perpendicular to the long axis of the blocks in the preceding course. The seal will be recessed at least 8 inches deep into each rib and 8 inches deep into the floor. No recess will be made into the roof.

The seals will have a thickness of approximately 16 inches. Following seal construction, the entries will be backfilled from the seal to the outside surface with soil that is sloped at the surface to match the final slope at the entry.

Casing and Sealing of Underground Openings. Each underground opening to the mine will be sealed and backfilled when no longer needed for monitoring or other use approved by the Division upon a finding of no adverse environmental or health and safety effects. This closure method has been designed to prevent access to the mine workings by people, livestock, fish and wildlife, and machinery. The closures have also been designed to keep water from flowing from the mine workings to prevent acid or other toxic drainage from entering ground and surface waters.

Monitoring wells associated with the Horizon Mine will be sealed when no longer needed for monitoring groundwater. Sealing of these wells will occur in accordance with the requirements of the Utah Division of Water Rights (R655-4-12).

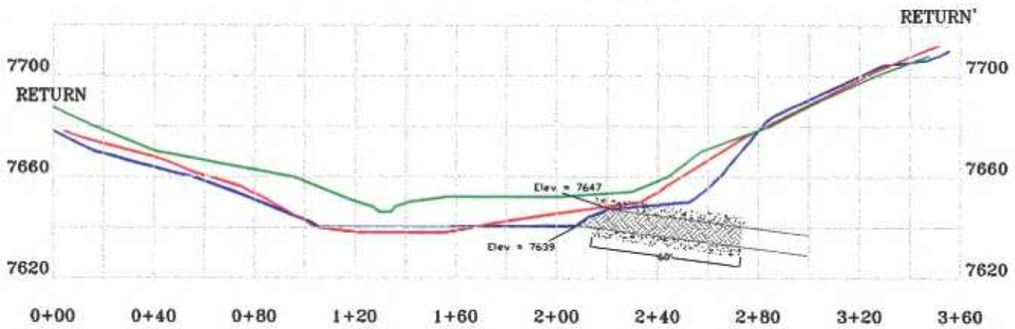
Details of the seals are shown on Figures 3-6 and 3-7.

3.5.3.2 Removal of Surface Structures

Following sealing of the portals, all surface structures and facilities associated with the mining operation will be removed. The schedule and cost of removal is detailed in Section 3.5.6 and 3.5.7, respectively.

Building Demolition. Prior to significant regrading activities at the Horizon facility, existing buildings, retaining walls, utilities, coal-handling facilities, and other above-ground structures will be removed from the area. To the extent possible, these structures and facilities will be salvaged. Nonhazardous and nonflammable materials, such as concrete and steel, may be used as backfill

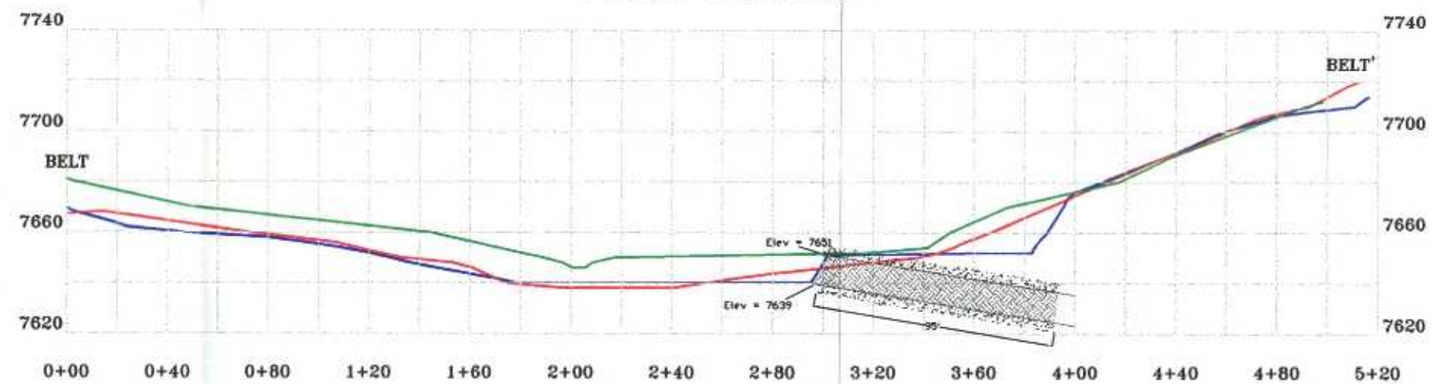
RETURN PORTAL



ELEVATION OF COAL SEAM
IN BELT LINE ENTRY = 7602
COAL SEAM IS 45' BELOW PORTAL ELEV.

COAL SEAM IS 358' FROM
THE PORTAL IN BELT LINE

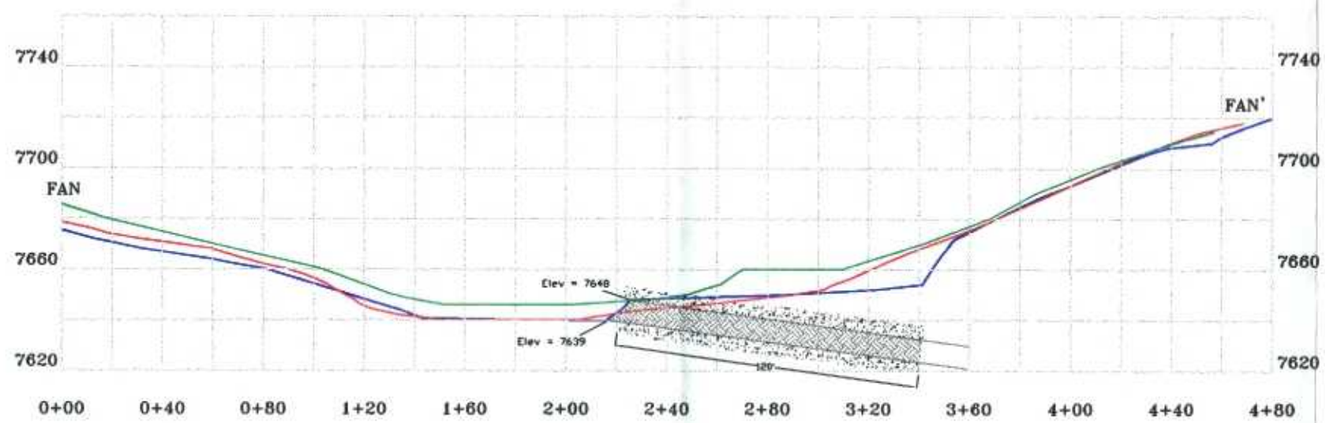
BELT PORTAL



ELEVATION OF COAL SEAM
IN BELT LINE ENTRY = 7593
COAL SEAM IS 58' BELOW PORTAL ELEV.

COAL SEAM IS 363' FROM
THE PORTAL IN BELT LINE

FAN PORTAL



ELEVATION OF COAL SEAM
IN FAN ENTRY = 7591
COAL SEAM IS 57' BELOW PORTAL ELEV.

COAL SEAM IS 374' FROM
THE PORTAL IN FAN ENTRY

LEGEND:

- ORIGINAL GROUND
- OPERATIONAL GROUND
- RECLAIMED GROUND
- FILL MATERIAL
- CONCRETE IN PORTALS

REGISTERED PROFESSIONAL ENGINEER
No. 7418
DAVID B. MILLER
STATE OF UTAH

Hidden Splendor Resources, Inc.
Horizon Mine
P.O. Box 32, Helper Ut. 84526
PH #: 435-472-1313 Fax #: 435-472-1314

Drawn By: JASON BENNETT	Date: April 8, 2001	Scale: 1" = 60'
Approval: DAVE MILLER	Drawing Name: HOR-PORTAL SECTIONS.DWG	

Drawing:

HORIZON PORTAL SEALING

FIGURE 3-6

~~3.5.3.2 Removal of Surface Structures~~

~~Following sealing of the portals, all surface structures and facilities associated with the mining operation will be removed. The schedule and cost of removal is detailed in Section 3.5.6 and 3.5.7, respectively.~~

~~Building Demolition. Prior to significant regrading activities at the Horizon facility, existing buildings, retaining walls, utilities, coal-handling facilities, and other above-ground structures will be removed from the area. To the extent possible, these structures and facilities will be salvaged. Nonhazardous and nonflammable materials, such as concrete and steel, may be used as backfill~~ in areas such as the sediment pond, portal entrances (slopes), and cut slopes. If thus disposed of, these materials will be incorporated into the backfill under at least 4 feet of soil cover in a manner that will not create voids within the backfill or reduce the effective compaction necessary for backfilling. If foundations will not interfere with regrading activities, they will be left in place for on-site burial under at least 4 feet of soil cover.

During the site regrading, if any of the toxic coal waste that is buried in the mine pad fill is uncovered, the material will be properly placed in the fill areas of the recontouring outside drainage flows so it can be covered beneath four feet of non-toxic fill material and erosion of the drainage over time will not contact these areas. The locations will be mapped at the time of placement and submitted to the Division.

Non-coal wastes found during reclamation, such as garbage, lumber, and other combustible materials generated during previous mining activities, will be segregated and stored in a controlled manner in a temporary storage area in appropriate containers.

Final disposal of all such waste will be in the backfill (as indicated above) or at a State-approved solid waste disposal facility, as appropriate. Notwithstanding any other provision of the R645 Rules, any non-coal mine waste defined as "hazardous" will be handled in accordance with the requirements of Subtitle C of RCRA and any implementing agency.

Mining equipment too large for a container will be placed in a designated temporary storage area as determined at the time of reclamation activities. Final decisions regarding salvage or disposal of structures and equipment will be made just prior to reclamation following an assessment of the salvageability of the structures and equipment.

3.5.3.3 Disposition of Dams, Ponds, and Diversions

Diversions that are not planned for permanent use following reclamation will be removed during the backfilling and regrading operations. The area will be recontoured to drain to the final reclamation channel (Section 7.2.3.2, Reclamation Hydrology Design).

Sediment control following removal of the sedimentation pond will be provided as outlined in Sections 3.5.4.3 and 7.2.3.2.

3.5.4 Backfilling and Grading Plans

Approximate Original Contour. The area of the Horizon surface facilities was disturbed by previous mining activities. No pre-mining topographic maps of the area are known to exist. The reclamation plan has been designed to backfill and grade the site to achieve the assumed approximate original contour (i.e., to blend into the surrounding topography) and eliminate highwalls associated with the Horizon Mine.

Elimination of Highwalls, Spoil Piles, and Depressions. The backfilling and grading plan has been designed to eliminate highwalls at the site that were associated with the Horizon Mine. The access to the coal seam is by three slopes from the surface to the coal seam some 46 feet below the ground elevation of the top of the slopes. The return slope uses the old Blue Blaze No. 1 Mine slope. A 50 foot concrete portal cover was constructed from the mouth of the old slope and was backfilled to eliminate any exposed highwall. The old slope was then widened to accommodate modern mining equipment. The belt slope was excavated a length of 95 feet to solid overburden where the slope could be driven down to the seam. A 95 foot concrete portal cover was constructed for the belt slope. The intake slope was excavated a length of 125 feet to solid overburden. A 125 foot concrete portal cover was constructed for the intake slope. The excavated portions of the portal covers have been covered to eliminate any highwall faces. No highwalls exist on the current disturbed area. The portal accesses to the seam are constructed for easy demolition and use of the material as backfill. No spoil piles exist. With the exception of the small depressions to retain moisture, minimize erosion and to assist in revegetation, no depressions will remain at the site following reclamation. Refer to Plate 3-7 and Figure 3-6.

Slope Stability. According to R645-301-553.130, reclamation slopes shall not exceed the angle of repose and shall have a minimum long-term static safety factor of greater than 1.3. The angle of repose of any soil is a function of the soil gradation, moisture content, plasticity, and degree of compaction of the soil. It is expected that the reclamation fill will be fairly dry and will be placed without the benefit of significant compaction or moisture conditioning. See Appendix 3-3.

Based on information provided in Chapter 8 of this M&RP, soils at the Horizon site consist of low-plasticity, cohesive materials with a wide assortment of grain sizes. The angle of repose in such soil is dependent not only on interparticle friction, but also on cohesion, which is dependent on the density, moisture content, and compaction moisture content of the soil. In general, as long as they do not become saturated or are not fissured, cohesive soils have a greater angle of repose than non-cohesive soils and can maintain vertical or near-vertical slopes under certain conditions. The angle of repose of a loose sand generally varies between 30 and 35 degrees (Holtz and Kovacs, 1981). Therefore, presumably, the angle of repose of a slightly cohesive granular soil will be greater than 30 to 35 degrees. For the purpose of this site, the angle of repose will be assigned a value of 35 degrees, which corresponds to a slope of about 1.5 horizontal to 1 vertical (1.5H:1V).

Backfilled and regraded slopes have been designed to not exceed the angle of repose. Design calculations indicate that the minimum safety factor of emplaced soil, at a slope of 1.5H:1V, is 1.4 under saturated conditions and 1.9 under unsaturated conditions. The static safety factor will increase with decreasing slope. The slopes have thus been designed to prevent slides.

Erosion and Water Pollution. Temporary sediment-control measures will be implemented during and following backfilling and regrading. During redistribution of the topsoil, silt fences will be established at the bottom of fill slopes and along the top bank of the reclamation channel to

control possible erosion from newly graded and seeded areas. As vegetation becomes established on the reclaimed surfaces, erosion potentials will be further minimized. By minimizing erosion, water pollution will also be precluded. Additional water-quality concerns do not exist at the site (see Chapter 7).

In order to blend with natural slopes, soil may be replaced during reclamation at slopes of up to 1.5H:1V. The steepness of these slopes will be reduced at their base, providing a concave slope. As noted above, these slopes will be geotechnically stable. Dozers will be used during placement of the topsoil or substitute topsoil on these steep slopes, taking care to achieve a reasonably uniform thickness of the final soil cover.

Post-Mining Land Use. The disturbed area will be backfilled and regraded in a manner that supports the approved post-mining land use.

Exposed Coal Seams. No coal seams are currently exposed in the disturbed area. Should any coal seams be exposed during the recontouring phase of reclamation, the coal outcrops exposed will be covered with a minimum of 4 feet of nontoxic and noncombustible materials during final backfilling and grading. This cover material may consist of material removed during grading of the site, subsoil, and/or topsoil.

Acid- and Toxic-Forming Materials. Buried waste materials from mining operations that used Portal Canyon are shown on Plate 3-7.

Combustible Materials. All combustible materials that are exposed, used, or produced during mining will be disposed of off site.

Cut-and-Fill Terraces. No cut-and-fill terraces occurring from or used by the Horizon operation will be retained at the site following final grading activities.

Highwalls From Previously Mined Areas. Several highwalls exist outside the disturbed area that are the result of previous mining operations. The reclamation plan has been designed to eliminate the faceup area made by Horizon Mine within the disturbed area. The anticipated post-mining contours indicate that the available materials are sufficient to eliminate the face up highwall within the disturbed-area boundary during reclamation.

The schedule for backfilling and grading is detailed in Section 3.5.7.1.

3.5.4.1 Removal or Reduction of Highwalls

No exposed highwalls exit on the current disturbed area. Final reclamation cross sections and contours of the portal accesses show that no new highwall features will be created after the collapse of the portal covers. See Figure 3-6 and Plate 3-7 and refer to Section 3.5.4.

3.5.4.2 Recontouring

All surface reclaimed areas will be protected and stabilized to effectively control erosion.

Final grading, preparation of overburden, and placement of topsoil will be done along the contour to minimize subsequent erosion and instability. Rills and gullies which form in areas that have been regraded and topsoiled and either disrupt the approved post-mining land use or the reestablishment of the vegetative cover, or, cause or contribute to a violation of water quality standards for receiving streams, shall be filled, regraded, or otherwise stabilized; topsoil shall be replaced; and the areas shall be reseeded or replanted. This will be accomplished using the best technology currently available.

3.5.4.3 Fencing and Erosion Control

The sedimentation pond will be retained as discussed in Section 7.2.3.2. Fencing will be placed as required to protect revegetation efforts from livestock grazing. This fencing will be removed prior to requesting final bond release. Refer to Section 3.5.4 for additional information on erosion control.

3.5.4.4 Soil Redistribution and Stabilization

When final reclamation begins, the disturbed areas to be reclaimed will be loosened by ripping to allow easier backfilling and grading operations. During redistribution of soils, care will be taken to prevent excessive compaction.

Soils disturbed during mining, including but not limited to fill material, will be placed within the disturbed area boundary. Refer to Section 8.8 for further information concerning plans for soil redistribution.

3.5.5 Revegetation Plan

The revegetation plan has been designed to assure that all disturbed lands will be returned to productive self-perpetuating plant communities once the mining operation has been completed. The plan calls for temporary revegetation of disturbed areas where possible during the mining operation as well as permanent reclamation of all areas once mining has ceased.

The goal of the plan is to create diverse plant communities which are at least as productive and in comparable amounts to plant cover existing on the site prior to this mining operation.

3.5.5.1 Soil Preparation

After backfilling, grading, recontouring, scarifying, and the redistribution of topsoil, the seed bed will be prepared using the best technology currently available. Prior to seeding, composite soil samples as will be collected and analyzed as discussed in Section 8.9. Based on the results of these analyses, fertilizer will be applied at the time of seeding.

3.5.5.2 Seeding

Areas which have been disturbed during mining operations will be reseeded with either Seed Mix #1 (Table 3-2) or with Seed Mix #2 (Table 3-3), as outlined below. These mixes are composed primarily of native species which either occur on the site or would be expected to grow on the site, especially on reclaimed areas. The mixes have been designed to include species which will provide sufficient cover to prevent soil erosion, and should contain sufficient species diversity to produce a stable self-perpetuating plant community. All seeds will comply with applicable state and federal seed laws.

Temporary Seed Mix

On those sites where revegetation is needed during the operating years, a temporary seed mix will be used. This mix (Table 3-2) is composed primarily of native species and is designed for quick establishment and erosion control. Only one introduced grass species (pubescent wheatgrass - Agropyron trichophorum), is included in the mix. It has been included since it is known to do well on dry sites, and will assist in controlling soil erosion. Cicer milkvetch (Astragalus ciscer) has been included because of its ability to fix nitrogen. No shrubs or forbs are included in the temporary mix, since these areas will be re-disturbed prior to final reclamation. At the actual time of planting, the mix may be altered depending on availability of the listed species and under the approval of the Division prior to substitution.

Permanent Seed Mix

The permanent revegetation mix is composed of a mixture of native grasses, forbs, shrubs and trees (Table 3-3). The grasses, forbs, and some of the shrubs will be planted as seeds. The remaining shrubs and trees will be planted as containerized stock. A variety of species are included in the mix in order to obtain a higher level of diversity on the revegetated surfaces. This will increase habitat diversity as variations in the microenvironments of the reclaimed surface will enhance or inhibit the germination and development of the various species.

The permanent seed mix reflects the composition of the original communities which occurred on the site. It is included because of its ability to fix nitrogen. Approval will be obtained from the Division prior to using any substitution in seed mixtures and on the number of containerized shrubs needed per acre.

The riparian seeding mix is included in Table 3-3.

Seeding Methods

Reclaimed areas will be seeded by broadcasting. Seeds when broadcast will be raked to ensure proper seed/soil contact. See Tables 3-2 and 3-3 for the seeding rates. If the first seeding does not establish, the area will be reseeded. Reclaimed areas will be seeded in the fall. Since the majority of the species in the mix are cool season grasses, fall is a better time to plant. The containerized stock will be planted in late fall or early spring, attempting to avoid undesirable conditions such as overly wet, overly dry, or frozen soils. Should the planting window close prior to completion of seeding, a sterile, quick growing ground cover will be planted to control erosion during the winter months. The final reclamation seed mixture will be planted during the following

year. Small depressions will be left in areas where containerized stock is planted to accumulate water during wet periods.

In the riparian disturbed area (see Section 9.4.1.2) the containerized or cuttings of willow stock will be planted in clumps along the banks of Jewkes Creek. Other containerized shrubs and sedges will be planted in clumps within the riparian area. The seed mix (Table 3-3, Riparian Reclamation Seeding Mix) will be planted using the methods described above.

TABLE 3-2

Reclamation Seed Mix #1

Species	Pounds of PLS per acre
PERENNIAL GRASSES	
Streambankkd Wheatgrass (Agropyron riparium)	8.0
Bluebunch Wheatgrass (Agropyron spicatum)	4.0
Slender Wheatgrass (Agropyron trachycaulum)	8.0
Pubescent Wheatgrass (Agropyron trichophorum)	6.0
Indian Ricegrass (Oryzopsis hymenoides)	4.0
FORBES	
Cicer Milkvetch (Astragalus cicer)	4.0
TOTAL	34.0

TABLE 3-3

Reclamation Seeding Mix #2

Species	Pounds of PLS Per Acre
SHRUBS	
Serviceberry Amelanchier utahensis	4.0
Big Sagebrush (Vasey) Artemisia tridentata	0.4
Min. Mahogany Cercocarpus ledifolius	4.0
Wyoming Big Sagebrush (Gordon Creek Var.) Artemisia tridentata wyomingensis	1.0
FORBS	
Yarrow Achillea millifolium	0.2
Pacific Aster Aster chilensis	0.4
Northern Sweetvetch Hedysarum boreale	3.0
Lewis Flax Linum lewsii	2.0
Palmer's Penstemon Penstemon palmeri	1.0

TABLE 3-3 (Continued)

Reclamation Seeding Mix #2

Species	Pounds of PLS Per Acre
GRASSES	
Gt. Basin Wildrye Elymus cinereus	6.0
Thickspike Wheatgrass Elymus lanceolatus	4.0
Western Wheatgrass Elymus smithii	6.0
Bluebunch Wheatgrass Elymus spicatus	6.0
Indian Ricegrass Stipa hymenoides	4.0
TOTAL	42.0
CONTAINERIZED STOCK	PLANTS/ACRE
Oak Brush Quercus gambelii	400
Aspen Populus tremuloides	300
White Fir Abies concolor	200
Big-tooth Maple Acer grandidentatum	400
Serviceberry Amelanchier alnifolia	300

TABLE 3-3 (Continued)

Reclamation Seeding Mix #2

SPECIES	PLANT/ACRE
Mountain Mahogany Cercocarpus montanus	400
Oregon Grape Mahonia repens	500
TOTAL	2,500

Riparian Reclamation Seeding Mix

SPECIES	PLANT/ACRE
SHRUBS	CONTAINERIZED/ROOT CUTTING STOCK
Snowberry Symphoricarpos oreophilus	300
Wood Rose Rosa woodsii	300
Willow Salix	1,100
Water Birch Betula occidentalis	300
TOTAL	**2,000**

TABLE 3-3 (Continued)

Riparian Reclamation Seeding Mix

SPECIES	POUNDS OF PLS PER ACRE
FORBS	
Yarrow Achillea millifolium	1.0
Pacific Aster Aster chilensis	1.0
Prairie Sage Artemisia ludoviciana	1.0
Marsh Indian Paintbrush Castelleja exilis	1.0
Wild Geranium Geranium viscosissimum	1.0
TOTAL	**5.0**
GRASSES	
Blue Wildrye Elymus glaucus	8.0
Kentucky Bluegrass Poa pratensis	4.0
Gt. Basin Wildrye Elymus cinereus	6.0
Idaho Fescue Festica idahoensis	4.0

TABLE 3-3 (Continued)

Riparian Reclamation Seeding Mix

SPECIES	POUNDS OF PLS PER ACRE
Western Wheatgrass Elymus smithii	6.0
Bluebunch Wheatgrass Elymus spicatus	6.0
Indian Ricegrass Stipa hymenoides	6.0
TOTAL	**40.0**
CONTAINERIZED/ROOT CUTTING STOCK	PLANT/ACRE
Nebraska Sedge Carex nevrascensis	200
Beaked Sedge Carex rostrata	200
TOTAL	**400**

Locations where containerized stock will be planted:

Oakbrush	South & East Slopes
Aspen	North Slopes & Canyon Bottoms
White Fir	North Slopes
Big-tooth Maple	North Slopes & Canyon Bottoms
Serviceberry	South Slopes
Mountain Mahogany	Ridge tops & South Facing Slopes
Oregon Grape	North, East, West Slopes & Canyon Bottom
Willow	Along Creek Banks

3.5.5.3 Mulching

During reclamation mulch will be applied to all newly reseeded areas in order to provide a more equitable environment for seed germination and initial growth. A mulch will be applied at a rate of 2000 pounds per acre. Once applied, the mulch will be incorporated while the surface is being roughened before seeding. Erosion control matting will be placed on all slopes 2 1/2H:1V or steeper.

At the time of reclamation the most beneficial type of mulch to be used will be determined by Horizon and UDOGM, for bonding purposes the price will be assumed to be that for alfalfa.

3.5.5.4 Reclamation Management

The reclaimed and revegetated areas will be closely monitored to determine if any maintenance is necessary (refer to Sections 3.5 and 9.8 for a description of the monitoring program). Problems which may require management include severe erosion, excessive weeds, bare patches of failed planting, and damage by wildlife. Rills and gullies which form in areas that have been regraded and topsoiled and which either disrupt the approved post-mining land use or the reestablishment of the vegetative cover, or, cause or contribute to a violation of water quality standards for receiving streams, shall be filled, regraded, or otherwise stabilized; topsoil replaced; and the areas shall be reseeded or replanted. If weeds occur, a weed control plan will be proposed to UDOGM and implemented upon approval. No weed control will be attempted during the first growing season. It is likely that weed species will form a conspicuous part of the vegetation on the reclaimed areas during the first year but will be replaced by revegetative species thereafter.

3.5.5.5 Revegetation Monitoring

Revegetated areas will be monitored in accordance with Section 9.8 of this permit application.

3.5.5.6 Establishment of Wildlife Habitat

Reclamation is particularly important as a means of controlling erosion and restoring disturbed areas to a productive state. To assist in meeting these desirable ends, the following aspects have been incorporated into the reclamation plan: (1) planting a diverse mixture of native grasses, forbs, and (where appropriate) woody species, (2) using seedling stock rather than relying solely on seeds for trees or shrubs, and (3) planting vegetation to create an edge effect by clumping selected shrub or tree species.

Section 10.5 provides a detailed discussion of the reclamation, mitigation and management plans for terrestrial habitats and wildlife.

Enhancement of the area for wildlife will be accomplished by the installation of rock piles for smaller mammals, the improved revegetation of the area, and planting of Salix cuttings per acre along the creek banks within the disturbed area. Rock piles will be scattered along the perimeter of Jewkes Creek, and through Portal Canyon. Containerized shrub stock will be planted near the rock piles to provide additional cover and as a food source. The appropriate regulatory agencies

(i.e., UDOGM, DWR) will be consulted as to the frequency and placement of the rock piles during reclamation.

3.5.6 Reclamation Monitoring

The standards for success in the previously disturbed areas of the site are outlined in section R645-301-356.250 of the regulations. The applicant intends to return the previously disturbed areas to stable plant communities capable of withstanding the intended post-mining land use and controlling erosion (see Section 9.8).

3.5.7 Schedule of Reclamation for Horizon Mine

3.5.7.1 Timetable for Completion of Major Reclamation Processes

The approximate schedule of reclamation activities is outlined in Table 3-4. The graphical schedule has been extended by approximately 10 percent beyond the numerical estimates presented below to account for unanticipated delays. Reclamation is proposed to be initiated within 90 days (weather permitting) of final abandonment of the mining operation. Each listing is for an 8-hour work day.

The Phase I reclamation tasks are therefore proposed to be completed within 24 weeks following the start of reclamation activities, assuming adequate weather conditions. Eight weeks are planned for the completion of Phase II reclamation tasks.

Due to the size and topography of the mine site, the concept of completing reclamation activities in Portal Canyon prior to starting reclamation activities in Jewkes Canyon is not feasible. Potential problems include having to move topsoil twice and not having the fill in Jewkes Canyon to reclaim slopes in Portal Canyon. Horizon commits to begin reclamation activities in Portal Canyon and to leave the sediment pond and UC-1 located in Jewkes Canyon in place as long as possible. Prior to the removal of the sediment pond during reclamation, UDOGM hydrologist will be notified and given the opportunity to inspect and endorse the removal. The timetable and sequence for removal of sediment control structures will depend upon the season of the year and precipitation.

3.5.8 Cost Estimate for Final Reclamation

The estimated cost to reclaim the Horizon Mine surface facilities is provided in Appendix 3-7.

The reclamation costs were evaluated to determine if the 100-foot culvert extension planned for 1997 (Appendix 3-9) would be covered by the estimated amount.

CHAPTER 6

GEOLOGY

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CHAPTER 6

GEOLOGY

6.1 Scope

This chapter includes the geologic information for the Horizon Mine area in accordance with the requirements set forth in R645-301-600.

6.2 Methodology

Previously assembled geologic data obtained from Beaver Creek Coal Co. has been used as a basis for this chapter. The data from Beaver Creek Coal Co. included drill logs generated during their mining efforts. This chapter also includes information from more recent drilling and mining operations in the Horizon Mine area. Information from recent geologic publications and in-house reports is also included to supplement the information obtained from Beaver Creek Coal Co.

6.3 Regional Geologic Framework

The Horizon No. 1 Mine is located in the northern portion of the Wasatch Plateau (Figure 6-1). The Wasatch Plateau is the northwestern outlier of the eroded San Rafael Swell. The plateau dips westward producing a great monoclinal fold that is interrupted by faults in the borderlands of the Great Basin. Superimposed over the region are numerous structural features including anticlines, synclines, faults and igneous intrusions.

The Wasatch Plateau is comprised primarily of Cretaceous to Tertiary age sedimentary rocks. These rocks are principally siliciclastic of both continental and marine origin. Coal seams of economic significance occur in the Cretaceous sediment (Table 6-1).

The Upper Cretaceous Rocks of the Wasatch Plateau were deposited along the western margin of the Western Interior Basin. The dynamic depositional sequence of the Mesaverde Group is the result of deltaic sedimentation. During the Upper Cretaceous, the area now occupied by the Wasatch Plateau was a trough, gradually subsiding, attracting drainage and receiving terrigenous clastics from the tectonically active Sevier highlands. Wave-dominated delta complexes prograded easterly into this epicontinental sea. The Sevier orogenic belt was tectonically active during the entire Cretaceous Period. Near the end of the Cretaceous Period, rocks that were deposited in the marginal marine environments were deformed as the result of the Laramide Orogeny.

TABLE 6-1
CENTRALIZED STRATIGRAPHIC SECTION - NORTHERN WASATCH PLATEAU

SYSTEM	STRATIGRAPHIC UNIT		THICKNESS (feet)	DESCRIPTION
TERTIARY	WASATCH GROUP	North Horn Formation	500-2,500	Variegated shales with subordinate sandstone, conglomerate and freshwater limestone, slope former; sandstone and limestone units may supply limited quantities of groundwater.
CRETACEOUS	MESA VERDE GROUP	Price River Formation	600-1,000	Gray to white gritty sandstone interbedded with subordinate shale and conglomerate, ledge and slope former, little potential for groundwater.
		Castlegate Sandstone	150-500	White to gray, coarse-grained often conglomeratic sandstone, cliff former, weathers to shades of brown, good aquifer material, groundwater not present if outcrops occur nearby.
		Blackhawk Formation (Major Coal Seams)	700-1,000	Yellow to gray, fine to medium-grained sandstone, interbedded with subordinate gray and carbonaceous shale, several thick coal seams; perched groundwater may occur in sandstone units.
		Star Point Sandstone	90-1,000	Yellow-gray massive cliff-forming sandstone, often in several tongues separated by Masuk Shale.
	MANCOS SHALE	Masuk Shale	300-1,300	Yellow to blue-gray sandy shale, slope former.
		Emery Sandstone (Coal)	50-800	Yellow-gray friable sandstone tongue cliff former. Coal present in subsurface; major regional aquifer.
		Blue Gate Member	1,500-2,400	Pale blue-gray, nodular and irregularly bedded marine mudstone and siltstone with several arenaceous beds, weathers into rolling hills and badlands.
		Ferron Sandstone Member (Major Coal Seams)	50-950	Alternating yellow-gray sandstone, sandy shale and gray shale with important coal beds of Emery coal field, resistant cliff former; major regional aquifer.
		Tununk Shale Member	400-650	Blue-gray to black sandy marine shale slope forming mudstone.

(Modified from Doelling, 1972)

6.4 Geology of Project Vicinity

6.4.1 Stratigraphy

The coal beds of interest lie within the Upper Cretaceous Mesaverde Group. This group is divided into four stratigraphic units and include in ascending order: The Star Point Sandstone, the Blackhawk Formation, the Castlegate Sandstone, and the Price River Formation. The minable seams are found in the lower 350 feet of the Blackhawk Formation. Plates 6-2 and 6-3 are geologic cross sections that illustrate the stratigraphic relationships of the Blackhawk and Star Point Formations and the mappable coal beds present in the Horizon No. 1 Mine area.

Star Point Sandstone

The Star Point Sandstone is the oldest stratigraphic unit exposed in the lease areas. It is the basal unit of the Mesaverde Group and is approximately 440 feet thick. The formation contains the Panther, Storrs, and Spring Canyon Sandstone Members which consist of coarsening upward littoral sequences of white to light gray, fine to medium grained, tight, quartzose sandstone (Blanchard 1981). The Star Point Formation overlies and intertongues with the marine Mancos Shale. The Star Point is the lowest cliff-forming unit over most of the east side of the Wasatch Plateau.

Blackhawk Formation

The Blackhawk Formation measures approximately 900 feet thick in the Gordon Creek area and consists of interbedded fluvial and marine sandstone, siltstone, and shale. The Blackhawk Formation conformably overlies the Star Point Sandstone and the boundary between the two formations is sharp; the massive Spring Canyon Sandstone member of the Star Point Sandstone is overlain by an easily erodible, shaley sandstone.

A total of eight coal seams can be identified in the Gordon Creek region. Four of the eight seams are present in the mine area and outcrop on the walls of the North Fork of Gordon Creek Canyon, Coal Canyon, and Bryner Canyon. Weathering, burning and vegetation obscures the majority of coal outcrops of the Hiawatha, Gordon, Castlegate "A", and Bob Wright seams. Only the Hiawatha and Castlegate "A" seams have been economically mined in the area. The Hiawatha seam marks the base of the Blackhawk Formation. The Castlegate "A" seam overlies the Aberdeen Sandstone. The Aberdeen is a marine sandstone sequence that coarsens upward, and is similar in character to the Star Point Sandstone. The Aberdeen measures over 120 feet at Price Canyon (Sec. 12, T13S, R9E) and thins to the west. In the vicinity of the Horizon No. 1 Mine and the National Mine (Sec. 17, T13S, R8E), the Aberdeen Sandstone is apparently discontinuous and not easily recognizable on outcrop. The westward pinch-out of the Aberdeen Sandstone is illustrated on the west-east stratigraphic section between drill hole LMC-4 and the Arco measured section near the National Mine as illustrated on Plate 6-3.

In the lease area, the Blackhawk Formation is the principal surficial bedrock unit. The Blackhawk is disconformably overlain by the massive, coarse grained, fluvial Castlegate Sandstone.

Castlegate Sandstone

The Castlegate Sandstone is exposed in the central and northeastern portion of the lease block (Plate 6-1) The formations consists of a white to gray, coarse grained to conglomeratic fluvial sandstone. Exposures of the Castlegate Sandstone typically form cliffs to steep slopes. The Castlegate Sandstone is approximately 300 feet thick in the Gordon Creek area.

Price River Formation

The Price River Formation occurs in the northeastern portion of the lease block (Plate 6-1). The Price River is also a fluvial deposit and contains gray to white silty sandstones with interbedded subordinate shale and conglomerate. The formation typically forms ledges and slopes. The Price River formation ranges from 600 to 1,000 feet in thickness.

Unconsolidated Deposits

Unconsolidated deposits composed of silt and fine grained sand, alluvial sediments and talus debris occur along valley floors and at the base of steep slopes. The thickness of these sediments is variable. In the Horizon No. 1 Mine area, the thickest alluvial deposits occur along Beaver Creek. Based on field observations, the alluvial sediments appear to exceed 10 feet in thickness.

Igneous Dikes

Several igneous dikes have been reported in area mines including the Beaver Creek Coal Mines #2 and #3. The dikes are reported to be Miocene age and are a mica peridotite (Tingey, 1986). The dikes are typically associated with faults that bisect the area and trend east-west to northwest-southeast.

6.4.2 Structure

The area of the permit is heavily faulted (Plate 6-1). Two major fault zones affect the lease block: the North Gordon and Fish Creek fault zones (Figure 6-2). The North Gordon fault zone measures three miles wide and five miles in length and is located east of the lease. The Fish Creek fault zone averages two miles wide and enters the lease from the northwest.

The permit area contain essentially two major fault trends. They are the N60 degree west trending faults (Range N50-75W) associated with the Fish Creek fault zone, and the N-S trending faults associated with the North Gordon fault zone. Sympathetic faulting also occurs within the mine area. Displacements of the faults in the mine area are variable ranging from a few feet to as much as 200 feet.

FIGURE 6-2

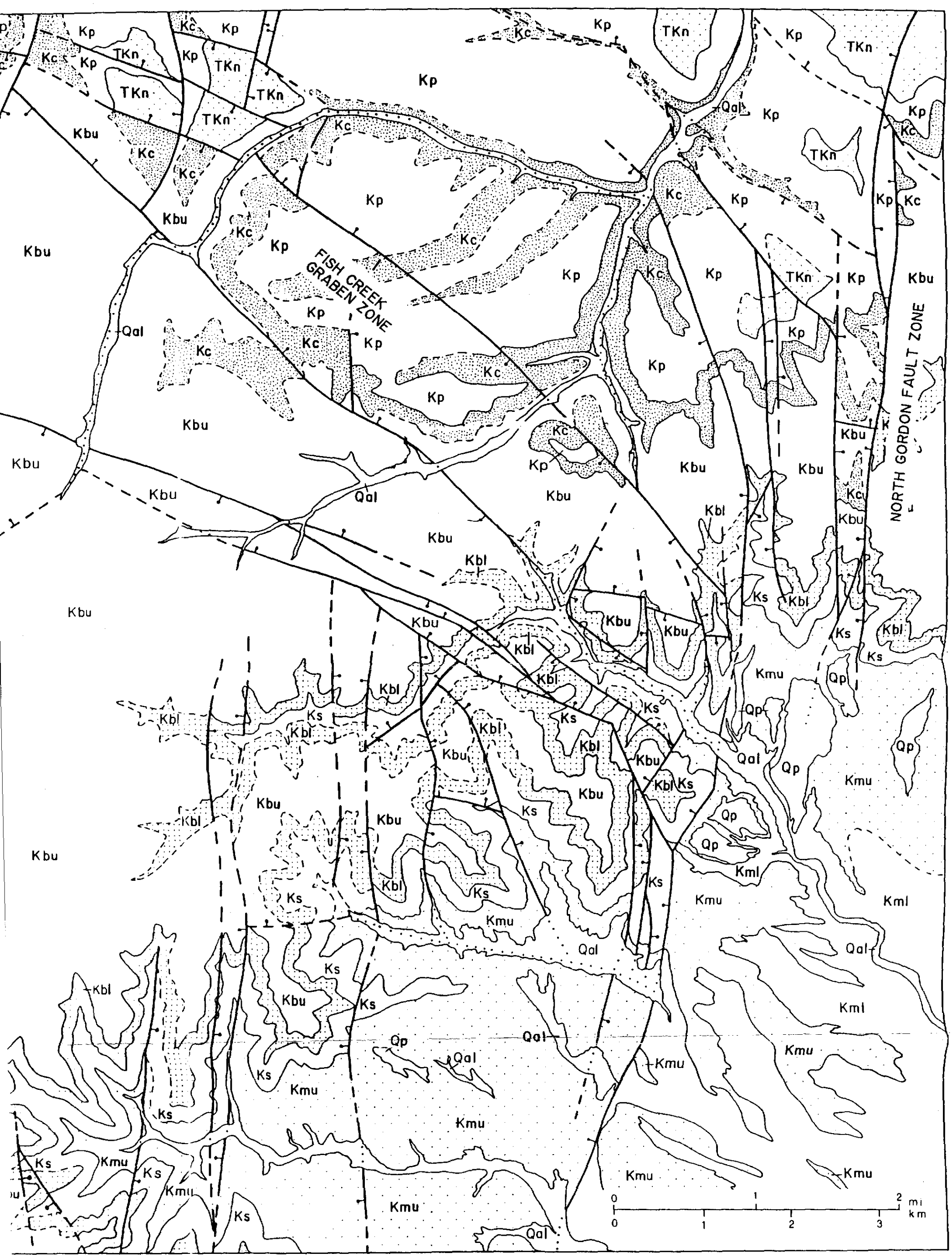

FIGURE 6-2. REGIONAL GEOLOGY MAP OF THE BLUE BLAZE NO. 1 & 2 MINE PERMIT AREA (HANSEN, 1988).

The faulting in the mine area appears to have influenced the development of stream courses. For example, the North Fork of Gordon Creek drainage appears to have formed subsequent or contemporaneously with the movement along the Gordon Creek Fault Zone (Plate 6-1).

Faulting may also effect the locations of springs and seeps in the mine area. The faulting and fracturing of the bedrock in the mine area may provide open conduits for surface water to enter into the subsurface or allow groundwater movement between aquifers. A series of springs at the head of the North Fork of Gordon Creek in the northwest corner of Section 18 T13S R8E may be related to the faults bisecting the area. Immediately east of the permit area, groundwater associated with faulting was encountered in the Beaver Creek #3 mine. The effects of faulting on the groundwater system in mine area is discussed further in Section 7.1.2.

Another major structural feature which influences the lease is the Beaver Creek Syncline (Figure 6-3). The synclinal axis trends NE-SW and actually crosses the southern portion of the lease. The strata dip toward this axis at approximately 3.5 degrees.

The igneous dikes of the area generally trend parallel to the Fish Creek fault trend. The dikes range from 0.1 to 14.0 feet in thickness.

6.5 Geology of Coal Beds and Adjacent Strata

6.5.1 Exploration and Drilling

Numerous surface exploration and surface development holes have been drilled by various energy companies and government agencies in the area surrounding the Horizon No. 1 and 2 Mine lease areas. Many of these drill holes were drilled under the direction of the Beaver Creek Coal Company during exploration and evaluation projects for their Gordon Creek mines. Four holes, LMC 1 - 4, were drilled within the lease boundaries under the direction of LMC Resources. The LMC drill hole geophysical logs were interpreted and lithologic logs were constructed by the Bureau of Land Management (BLM). The location of LMC holes are shown on Plate 7-1. Table 6-2 provides the date and depth drilled, the measured depth (February 1992), depth to the top of the Castlegate and Hiawatha seams for the LMC drill holes. Copies of the LMC drill hole logs are included in Appendix 6-1 and the HZ logs are included in Appendix 7-5.

A re-interpretation of the geophysical and lithologic log of LMC-2 was made by after discovering that the previous interpretation of the LMC-2 logs did not correlate with the lithologic interpretation of other drill holes in the area. Initially, the Castlegate "A" seam was identified at approximately 370 feet below ground surface (elevation 7880) and the Hiawatha seam at 518 feet below ground surface (elevation 7732). In drill hole LMC-3, which is located less than 2000 feet west of LMC-2, the same seams were identified at approximately 630 feet (elevation 7590) and 791 feet (elevation 7429) respectively. No faults have been

FIGURE 6-3

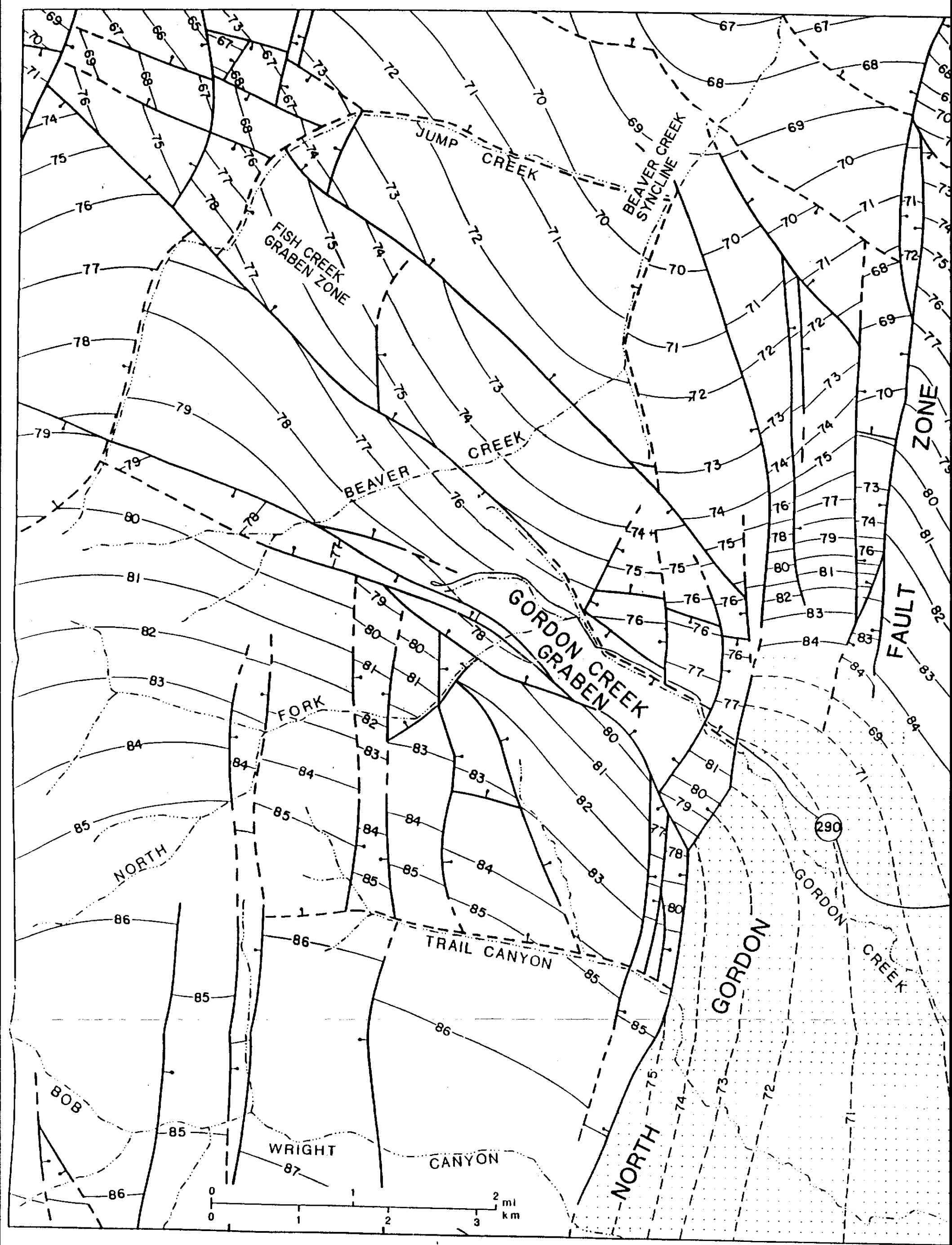

FIGURE 6-3. REGIONAL STRUCTURAL CONTOUR MAP.

DATUM IS TOP OF SPRING CANYON MEMBER OF STARPOINT FORMATION EXCEPT IN SHADED AREAS. IN SHADED AREAS, DATUM IS TOP OF EMERY SANDSTONE MEMBER OF MANCOS SHALE. (HANSEN, 1988).

TABLE 6-2

DRILL HOLE EVALUATION

Hole ID	Date Drilled	Depth Drilled	Measured Depth (Feb. 1992)	Depth to Top of Castlegate (ft)	Depth to Top of Hiawatha (ft)
LMC-1	Sep 1976	900 ft	599 ft	793	*
LMC-2	Oct 1976	568 ft	None	518	*
LMC-3	Nov 1976	836 ft	664 ft	630	791
LMC-4	Jan 1980	430 ft	217 ft	105.2	215.3
HZ-95-1	10/8/95	1075 ft	-	857	1012
HZ-95-2	10/15/95	1195 ft	-	1025	1149
HZ-95-3	10/28/95	465 ft	-	225	413

* Drilling completed before reaching the Hiawatha seam.

Hole ID	Date Drilled	Depth Drilled	Measured Depth (11/17/01)	Depth to Top of Castlegate (ft)	Depth to Top of Hiawatha (ft)
HZ-01-6-1	Oct 2001	1550 ft	944 ft	+	1383

+ Castlegate Seam not intercepted.

mapped in the area that would offset the formations encountered in the two drill holes. Assuming the current interpretation by the BLM is not correct, a better stratigraphic and structural fit is achieved if the coal seam initially identified as the Hiawatha is re-interpreted as the Castlegate "A" seam and the overlying coal seams initially identified as the Castlegate "A" are reclassified as local coal beds. Personnel at the Salt Lake Office of the BLM were contacted and questioned about the accuracy of their interpretation of the LMC boreholes. The BLM personnel feel that many of the interpretations of the logs are suspect.

A north to south geologic cross-section and an east to west geologic cross-section were generated from the logs of several of the drill holes advanced under the direction of Beaver Creek Coal Company, LMC, and the U.S.G.S. The cross sections are shown on Plates 6-2 and 6-3 respectively. The locations of the drill holes from which the logs were used to construct the cross sections are shown on an index map included on the plates. The cross sections provide a graphic illustration of the stratigraphic and structural relationships of the coal seams in the lease area.

6.5.1.1 Casing and Sealing

Drill holes LMC 1, 2, 3, and 4 will be plugged and abandoned following State approved methods. ~~Three~~Four new holes have been (HZ-1, HZ-2, HZ-3, and HZ-4) drilled and completed as monitoring wells within the uppermost saturated zone beneath the Hiawatha seam to better predict the potential of inflow into the mine.

When no longer needed for monitoring or other use approved by the UDOGM and upon a finding of no adverse environmental or health and safety effects, or unless approved for transfer as a water well, each well or boring will be capped, sealed, backfilled, or otherwise properly managed, as required by UDOGM. Permanent closure measures will be designed to prevent access to the borings or monitoring wells by people, livestock, fish and wildlife, machinery and to keep acid or other toxic drainage from entering the groundwater system.

6.5.2 Stratigraphy - Coal Seams

The commercial coal beds on the tract occur in the Blackhawk Formation. Only the Castlegate "A" and Hiawatha Seams are minable.

6.5.2.1 Hiawatha Seam

The Hiawatha Seam is the lowest stratigraphic coal in the Horizon mining lease. It directly overlies the Star Point Sandstone and is the most laterally persistent seam in the area. It can be correlated with the Kinney or Upper O'Connor seams mined in the Pleasant Valley area in the western part of the plateau (Plate 6-3). The Hiawatha seam ranges in thickness from 6.0 to 11.0 feet, averaging 7.0 feet within the lease block. A thin rider seam overlies the Hiawatha in the southwestern part of the lease.

The floor rock of the Hiawatha seam ranges from the competent littoral Spring Canyon of the Star Point Sandstone to fluvial overbank shales and siltstone and channel sandstones.

6.5.2.2 Gordon Coal Zone

The Gordon seam is stratigraphically located about 80 feet above the Hiawatha. It is very lenticular and generally less than 5.0 feet in thickness with multiple splits. It is not economically mineable in the Gordon Creek area. The roof and floor consist essentially of shale and because of this, the outcrop is often covered by slump and soil.

6.5.2.3 Castlegate "A" Seam

The Castlegate "A" seam is stratigraphically located 150 to 230 feet above the Hiawatha seam. The seam ranges 4.0 to 14.0 feet in thickness. The average thickness in this area is 8.3 feet. The Castlegate "A" seam nearly pinches out and becomes unmineable in areas near the southwestern boundary.

The floor of this seam appears to vary from a carbonaceous silty shale to a fine grained fluvial sandstone. Water production from this floor strata has not been observed in other mining operations in the area.

The roof consists essentially of overbank carbonaceous silty shales (approximately 80%). In the northeastern part of the lease a persistent rider seam is present. The remainder of the mine roof consists of fluvial channel sandstones. The frequency of channeling increases to the west. Local scouring of the seam occurs in some of the channels. The general channel trend is NE-SW and range 100 to 500 feet in width. During mining, some channels may initially produce water which will, more than likely, dry within weeks. However, if sustained flows are encountered during mining operations, the water will be managed as described in Chapter 7.

Poor top conditions generally are located adjacent to channel margins due to differential compaction of the adjacent shale units. This is indicated by the abundance of slickenside features in the shale.

6.5.2.4 Bob Wright Seam

The Bob Wright seam lies about 120 feet above the Castlegate "A" seam. It is very lenticular and contains abundant partings. It does not achieve minable thickness (4.0 ft.) within the Gordon Creek area. However, the seam does thicken above 4.0 feet southwest of the lease. Within the Horizon mining leases, the seam contains a shale roof and floor. Locally, sandstone occurs in the roof.

6.5.3 Oil and Gas Wells

No oil and gas exploration or production wells are located in the permit area.

6.5.4 Detailed Cross Sections

Plates 6-2 and 6-3 are geologic cross sections which show the general stratigraphic relations through the Horizon Mine area. The stratigraphic relationships of the Castlegate "A" and Hiawatha seams are illustrated in these sections. Tables 6-3 and 6-4 list the borings and their locations used to construct the cross sections.

6.5.5 Coal Reserves

For coal reserve calculations see Section 3.3.3.1.

6.5.6 Coal Quality and Characteristics

Table 6-5 summarizes the quality of the Hiawatha coal seam. The analyses were performed on core samples from drill hole LMC-4 as well as the HZ drill holes. Supporting laboratory data sheets are provided in Appendix 6-2.

According to data provided in Table 6-5, the average moisture content of the Hiawatha coal seam is 7.99 percent. The pyritic sulfur content of the coal is low, with a maximum of 0.07 percent and an average of 0.05 percent.

Data presented in Appendix 6-2 and summarized in Table 6-6 indicate that the Hiawatha coal seam does not possess toxic-forming characteristics. Boron and selenium concentrations, as well as sodium adsorption ratios, are all within a range classified as "good" by Leatherwood and Duce (1988). However, the acid-base potential of each of the three coal samples which were collected from the HZ-series holes suggests that the coal has a potential to be acid-forming.

The acid-forming potential of the coal will be tempered by its slightly alkaline nature (with a pH that varies from 7.3 to 7.8, according to Appendix 6-2). Furthermore, impacts to the environment of the permit and adjacent areas resulting from this acid-forming potential will be minimized by two factors. First, coal will be stored on the surface for only short periods of time before being shipped off site, thus reducing the potential for weathering, oxidation, and generation of acid drainage. Second, runoff from the coal stockpile will be routed through the facility sedimentation pond, where it will mix with more-alkaline runoff from additional areas, thus neutralizing any acidic drainage which might form.

6.5.7 Adjacent Units (Overburden and Underburden)

6.5.7.1 Rock Characteristics, Acid-toxic, Pyrite, Clay and Alkalinity

Table 6-6 lists the analytical results of tests performed to determine the acid- and toxic-forming potential of floor and roof samples collected adjacent to the Hiawatha coal seam from LMC-4 and from the HZ holes. Comparing the data in Table 6-6 with the guidelines presented by Leatherwood and Duce (1988) indicate that the roof and floor materials should be neither

TABLE 6-3

CROSS SECTION BORING LOCATIONS
NORTH-SOUTH CROSS SECTION

Boring	Location (BY SECTION)	Location (BY U.S. CADASTRAL SYSTEM)
BCCC MC-2-2	T13S R8E SW NE sec. 18	(D-13-8) 18ac
ARCO (1980) GC-8	T13S R8E NW SW sec. 8	(D-13-8) 8cb
Blue Blaze Coal Co. Consumers (1927) DH-3	T13S R8E NW NE sec. 8	(D-13-8) 8ab
USGS (1976) W-BC-4-S	T13S R8E NE NE sec. 8	(D-13-8) 8aa
ARCO (1980) GC-7	T13S R8E SE SE sec. 5	(D-13-8) 5dd
ARCO (1980) GC-6	T13S R8E NE SE sec. 6	(D-13-8) 6da
USGS (1976) W-BC-5-S	T12S R8E SW SW sec. 32	(D-12-8) 32cc

TABLE 6-4

CROSS SECTION BORING/MEASURED SECTION LOCATIONS
EAST-WEST CROSS SECTION

Boring/Measured Section	Location (Section)	Location (U.S. Cadastral System)
ARCO Measured Section No. 3 & No. 6 Mines at Portals	T13S R8E NE SW Sec. 16	(D-13-8) 18ac
Beaver Creek Coal Co. Mine Core MC-3-1	T13S R8E NW SW Sec. 16	(D-13-8) 8cb
Beaver Creek Coal Co. No. 3 Mine Workings MW-3-2 (1976)	T13S R8E SW SW Sec. 16	(D-13-8) 8ab
LMC Resources (1976) C & W Coal Co. Submittal LMC-4	T13S R8E SW NE Sec. 17	(D-13-8) 8aa
ARCO (1980) Measured Section Near National Mine	T13S R8E SE SW Sec. 17	(D-13-8) 5dd
Beaver Creek Coal Co. (1976) Certified Point OC-2-1	T13S R8E SE SE Sec. 18	(D-13-8) 6da
Beaver Creek Coal Co. (1976) No. 2 Mine Core MC-2-2	T12S R8E SW NE Sec. 18	(D-12-8) 32cc
Beaver Creek Coal Co. (1976) Certified Point OC-2-2	T13S R8E SE SW Sec. 18	(D-13-8) 18cd
USGS (1976) W-BC-3-S	T13S R7E SE SW Sec. 12	(D-13-7) 12cd
ARCO (1980) GC-3	T13S R7E NW SW Sec. 13	(D-13-7) 13cb
ARCO Measured Section N. Fork Gordon Creek	T13S R7E NE NE Sec. 23	(D-13-7) 23aa
Arco (1980) GC-2A	T13S R7E SW SE Sec. 15	(D-13-7) 15dc
USGS (1980) UGC-3	T13S R7E SE SE Sec. 16	(D-13-7) 16dd
USGS (1980) UGC-5	T13S R7E NE NE Sec. 16	(D-13-7) 16aa

TABLE 6-5

QUALITY OF HIAWATHA COAL SEAM[a]

Hole Number	Interval Sampled (ft)	Moisture Content (%)	Ash Content (%)	Volatile Matter (%)	Fixed Carbon (%)	Heat Energy (Btu/lb)	Total Sulfur (%)	Pyritic Sulfur (%)
LMC-4	224.0-227.5	5.38	7.63	42.51	44.48	12,448	0.47	0.04
HZ-95-1	1012.4-1012.8	8.06	6.10	40.57	45.27	12,230	0.58	0.02
HZ-95-1	1013.3-1015.4	9.17	5.26	40.51	45.06	12,450	0.57	0.07
HZ-95-1	1015.4-1015.8	8.81	19.00	36.31	35.88	10,287	0.45	0.04
HZ-95-1	1015.8-1017.6	8.94	5.24	40.20	45.62	12,533	0.45	0.05
HZ-95-1	1017.6-1019.0	10.49	13.27	35.10	41.14	10,957	0.38	0.03
HZ-95-2	1147.3-1148.4	9.11	5.68	40.10	45.11	12,306	0.49	0.05
HZ-95-2	1148.4-1149.7	7.63	17.38	37.44	37.55	10,665	0.38	0.04
HZ-95-3	412.6-414.0	7.41	4.22	41.11	47.26	12,768	0.59	0.05
HZ-95-3	415.5-417.05	6.87	4.26	42.24	46.63	12,940	0.61	0.07
HZ-95-3	417.05-418.2	7.57	4.64	41.03	46.76	12,672	0.58	0.06
HZ-95-3	418.2-419.2	7.53	14.10	36.40	41.97	11,187	0.53	0.06
HZ-95-3	419.2-420.1	6.84	11.89	38.33	42.94	11,846	0.56	0.04

[a] On an "as-received" basis. Laboratory reports provided in Appendix 6-2.

-

TABLE 6-6

ACID- AND TOXIC-FORMING POTENTIAL OF
HIAWATHA COAL, ROOF, AND FLOOR SAMPLES[a]

Hole Number	Interval Sampled (ft)	Unit Sampled	Boron Conc. (ppm)	Selenium Conc. (ppm)	Sodium Adsorp. Ratio	pH	Acid/Base Pot.[b]	Total Sulfur (%)	Pyritic Sulfur (%)
LMC-4	214.0-217.0	Roof	1.61	<0.1	1.98	7.12	--	-	0.24
LMC-4	224.0-227.5	Coal	--	--	--	--	--	0.47	0.04
LMC-4	227.3-230.5	Floor	<0.1	<0.1	1.04	8.09	--	-	0.05
HZ-95-1	1011.2-1012.4	Roof	--	--	0.35	7.96	20.3	-	--
HZ-95-1	1012.4-1012.8	Coal	0.13	<0.01	0.40	7.32	-13.6	0.58	0.02
HZ-95-2	1146.2-1147.3	Roof	0.22	0.05	1.36	7.94	64.0	-	--
HZ-95-2	1147.3-1148.4	Coal	0.17	<0.01	0.91	7.77	-9.1	0.49	0.05
HZ-95-2	1158.2-1159.3	Floor	0.21	0.07	1.29	8.53	30.1	-	--
HZ-95-3	411.9-412.6	Roof	0.29	0.05	0.68	7.89	22.3	-	--
HZ-95-3	412.6-414.0	Coal	0.17	<0.01	0.41	7.31	-15.8	0.59	0.05
HZ-95-3	420.3-421.0	Floor	0.05	0.01	0.55	7.21	29.0	--	--

(a) Analyses performed in accordance with Leatherwood and Duce (1988). Laboratory reports provided in Appendix 6-2.

(b) In tons of $CaCO_3$ per 1000 tons of material

acid-generating nor toxic-forming. One sample (LMC-4 roof material) did contain an anomalously-high pyritic sulfur content of 0.24 percent. However, comparison with other samples collected in the area indicates that this high pyritic sulfur content is likely of limited areal extent. This is further verified by the high neutralization potential of the remaining roof and floor materials (with acid/base potentials varying from 20.3 to 64.0 tons of $CaCO_3$ per 1000 tons of material).

To monitor conditions of the overburden and underburden, samples will be taken at 2,000 ft intervals throughout the mine and will be tested according to the Divisions requirements.

6.5.7.2 Roof and Floor Properties

As discussed in Section 6.5.2, the roof and floor rock of the Castlegate "A" and Hiawatha seams varies from shale to competent sandstone. Information obtained from the LMC drill holes and selected drill holes from the Beaver Creek Coal Company permit application for their mines in the area have been utilized to determine roof and floor conditions that can be anticipated while mining the Hiawatha seam. The location of the of the Beaver Creek drill holes are included on Plate 3-3. Logs of the wells used to determine the properties of the roof and floor rock are included in Appendix 6-1.

The logs of drill hole LMC-3 and LMC-4 indicate the floor rock of the Hiawatha consists of five feet of carbonaceous silty shale and silty sandstone overlying the massive sandstone of the Spring Canyon Member of the Star Point Formation. No cores were obtained from LMC-3 and LMC-4 to determine the geotechnical properties of roof or floor rock. However, uniaxial strength tests were performed by Beaver Creek Coal Company on samples of shales and sandstones obtained from drill holes GCD-4, 7, and 10. These drill holes are located approximately one mile west-southwest of the Horizon Mine portals. The results of the tests are provided in Table 6-7.

The logs from drill hole LMC 1 indicate the roof of the uppermost split of the Castlegate "A" seam is approximately 35 feet of sandstone. The floor of the seam consists of four feet of shale overlying approximately 30 feet of sandstone. In LMC-2, the upper split roof rock consists of 42 feet of carbonaceous shale and the floor consists of 38 feet of shaley silty sandstone. In LMC-3, the upper split roof rock consists of 4.5 feet of shale overlain by 19 feet of silty sandstone and the floor rock consists of four feet of shale overlying 8.5 feet of sandstone. In LMC-4, the roof rock consists of 15 feet of sandstone and the floor rock is five feet of siltstone overlying 26 feet of sandstone. Information from Beaver Creek Coal Company GCD-4 indicates that the roof rock of the Castlegate"A" seam in the area of the drill hole consists of sandstones interbedded with shales and the floor consists of shale. The results of uniaxial strength tests for samples obtained from the roof and floor rock of the Castlegate "A" seam in drill hole GCD-4 is provided in Table 6-7.

TABLE 6-7

UNIAXIAL STRENGTH TEST RESULTS
BEAVER CREEK COAL COMPANY, DRILL HOLES GCD-10, 4, AND 7

Sample I.D.	Depth Interval (feet)	Diameter (inches)	Length (inches)	Description	Compressive Strength (psi)	Young's Module (psi x 10^6)
GCD-10	80.0 - 85.0	1.85	3.86	Shale	14327	1.0994
GCD-10	76.2 - 76.8	1.85	3.74	Shaly sandstone	8448	2.9047
GCD-10	20.0 - 20.5	1.86	3.64	Shaly sandstone	16874	2.4769
GCD-10	29.7 - 30.2	1.86	3.75	Shaly sandstone	N/A	5.0169
GCD-10	35.8 - 36.9	1.85	3.75	Shaly sandstone	15977	2.0718
GCD-10A	26.4 - 27.6	1.85	3.67	Shale	7772	1.1189
GCD-10B	26.4 - 27.6	1.85	3.71	Shale	16601	1.753
GCD-4	364.0 - 366.0	2.87	5.20	Roof rock, sandstone interbedded w/shale	9130	1.1977
GCD-4	366.0 - 368.0	2.58	4.73	Roof rock, sandstone interbedded w/shale	5860	1.0791
GCD-4	369.0 - 370.0	2.41	4.91	Roof rock, sandstone interbedded w/shale	10606	1.9149
GCD-4	381.0 - 382.0	2.40	4.93	Floor rock, shale	10616	1.7017
GCD-7	122.0 - 122.5	1.85	3.80	Sandstone interbedded w/shale	11257	1.6076

6.6 Geologic Effects of Mining

6.6.1 Mining Hazards

The types of mining hazards which have been encountered at other mines in the immediate area and within the Wasatch Plateau are anticipated to be encountered while mining in the Horizon No. 1 Mine. Roof conditions vary from excellent to poor depending upon the type of rock overlying the coal. Methane has never been detected in the mine workings in this area. The maximum thickness of overburden is not excessive: therefore, explosive rock bursts and "rib rolls" are not expected to occur.

6.6.2 Surface Hazards

Rockfalls occur naturally, but can be more frequent with activities associated with mining such as increased men, machinery, noise, and bulk movement of soil using tractors and mining equipment. This is a relatively minor problem and nothing of any more concern is expected to occur.

6.6.3 Impacts of Mining

There will be no geologic effects other than the possible disturbance of the groundwater and surface subsidence. These potential problems have been discussed in Chapter 7 and Section 3.4.8.

6.6.4 Subsidence

Subsidence of the sediments overlying the mining area will be monitored. A detailed description of the subsidence monitoring plan, including a map illustrating the location of monitoring stations, is presented in Section 3.4.8.

6.7 Post Mining Reclamation

Reclamation of the mine site following completion of the mining operations as required by state regulations R645-301 and R645-302 will be accomplished. The reclamation plan is discussed in detail in Section 3.5 of this permit application.

6.8 References

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CHAPTER 7

HYDROLOGY

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CHAPTER 7

HYDROLOGY

The purpose of this chapter is to present a review of hydrologic information relevant to the Horizon No. 1 Mine. A plan of action is presented to ensure that underground coal mining operations are in compliance with Office of Surface Mining (OSM) and UDOGM hydrology regulations.

This chapter includes a description of hydrologic conditions in the permit and adjacent areas and a determination of the probable hydrologic consequences of mining activity.

7.1 Ground Water Hydrology

7.1.1 Method of Study

To assist in this investigation, a field reconnaissance of the area was made with the aid of the Division of Oil, Gas and Mining (Darin Worden 1988-1990). Hydrologic data collected from wells and springs in the area were evaluated. Data evaluated also include drill hole logs, mine maps from the permit and adjacent areas, published and open file reports from the U.S. Geological Survey, Utah Geological Survey, Bureau of Land Management, and the U.S. Forest Service. Beaver Creek Coal Company records were also used to study the hydrology of the area.

Field reconnaissance of the mine area permitted observation of the geologic setting of springs and seeps, and confirmation of the geologic observations made from aerial photo reconnaissance. In addition, information on hydrologic conditions encountered, in the adjacent Beaver Creek Mines, were reviewed.

Furthermore, at the request of UDOGM, a reconnaissance of the permit area and surrounding areas was performed for seeps and springs. Areas evaluated included Sand Gulch, Coal Canyon and several unnamed drainages which contribute to Jump Creek. The seeps and springs thus located are presented on Plate 7-1. The flow and temperature for each of the seep or spring are summarized in Appendix 7-2. These data were gathered to provide baseline information in anticipation of future mining.

7.1.2 Existing Ground Water Resources

7.1.2.1 Regional Ground Water Hydrology

The lithologic nature of the Upper Cretaceous strata generally render these units unsuitable as significant aquifers. Price and Arnow (1974) do not identify Gordon Creek area as a region for potential large scale ground water development. In general, all the upper Cretaceous sediments of the area have low hydraulic conductivities and low specific yields (0.2 to 0.7 percent) (Price and Arnow, 1974). Much of the precipitation that falls in the Wasatch Plateau exits the area by overland flow and evaporation. Much of the water that does enter the ground moves only short distances before discharging as springs and seeps (field observations made by Darin Worden -

UDOGM and Roger Skaggs - Blue Blaze Coal Company). Detailed descriptions of the formations discussed below are presented in Chapter 6.

The lowest principal water-bearing formations of the Wasatch Plateau are the sandstone units of the Mancos Shale Group. These include the Emery and Ferron Sandstones (Price and Arnow, 1974). These sandstone units occur in the southern portions of Emery County, and probably do not extend into the in the Gordon Creek area (Fisher et al., 1960).

The Star Point Formation overlies the Mancos Shale. It is composed of littoral sandstones interbedded with tongues of the Mancos Shale. The Star Point Formation contains the Panther, Storrs, and Spring Canyon sandstone members. Lines (1985) identified the Blackhawk Formation and Star Point Sandstone as an aquifer in the region. The majority of the water contained in the Blackhawk-Star Point aquifer resides in the sandstone tongues of the Star Point Formation. It is likely that the Star Point Sandstone is the only formation within the permit and adjacent areas that contains groundwater on an areally-extensive basis.

The Blackhawk Formation overlies the Star Point Sandstone and contains the principal coal beds mined in the area. The Blackhawk is comprised of several hundred feet of interbedded sandstone, shale, siltstone, and coal. The Aberdeen Sandstone is a marine sandstone unit of the Blackhawk Formation. Sandstone units of the Blackhawk are generally very-fine grained, and have a significant clay content. Ground water that occurs in this formation generally occurs in laterally discontinuous perched aquifers. As a result, the Blackhawk is not a significant regional aquifer, and little work has been done to determine its hydraulic characteristics.

Two pump tests conducted in the basal part of the Blackhawk in Eccles Canyon show that this formation is a very poor aquifer (Vaughn Hansen Associates, 1979). Transmissivities determined from these pump tests were 21.0 and 16.3 gallons per day per foot (gpd/ft). Recovery tests on these same two wells resulted in transmissivities of 16.6 and 17.9 gpd/ft.

Minor seeps and springs occur along valley flanks where water infiltrates from the surface above the valley floor, moves a short distance, and discharges at a point lower on valley flanks. More substantial springs occur where the surface recharge area is more significant and the water moves through the subsurface a greater distance before discharging near the valley floors. These two types of springs are dependant upon the amount of precipitation available for recharge and frequently exhibit seasonal flow variations.

A third type of spring occurs when a relatively extensive aquifer containing large quantities of water in storage discharges to the surface. The discharge rate from this type of spring is not as affected by short term fluctuations in recharge as the two types of springs described in the preceding paragraph.

Geologic conditions play an important role in the occurrence of springs. Water that percolates into the ground moves down gradient through the permeable sediments, until an impermeable unit is encountered. Ground water flow is then redirected along the impermeable interface until the ground surface is intersected and spring discharge occurs or the impermeable unit pinches-out and the ground water again moves vertically.

The Castlegate Sandstone, which overlies the Blackhawk Formation, is principally composed of massive sandstones with minor amounts of shale, siltstone, and conglomerate (local occurrence). Within the Wasatch Plateau, the Castlegate Sandstone typically erodes to form very steep cliffs that are commonly deeply incised by steep-walled canyons.

The Price River Formation overlies the Castlegate Sandstone and consists of interbedded sandstone, shale, and siltstone. Groundwater contained within the Price River Formation occurs within perched aquifers. Laboratory tests on sandstone from the Price River show that it has generally high porosity (21%) but apparently a low permeability (Cordova, 1964).

7.1.2.2 Mine Plan Area Aquifers

This section contains groundwater information pertinent to the mine area. Included herein are the following: 1) a description of the potential aquifers in the mine area; 2) depth to water measured in wells within the permit area; and 3) approximate rates of discharge or usage.

Geologic Occurrence

Formations which outcrop within the proposed Horizon permit and adjacent areas include quaternary alluvium, the Price River Formation, the Castlegate Sandstone, the Blackhawk Formation, the Star Point Sandstone, and the Mancos Shale. A regionally extensive groundwater system has not been identified in the permit area (Engineering Science, 1984). Characteristics of these formations, and their potential to serve as aquifers in the permit and adjacent areas, is presented below.

Price River Formation. The Price River Formation consists of interbedded sandstone, shale, and claystone. Due to its limited outcrop extent within the permit and adjacent areas, the presence of claystone and shale within the formation, and drainage of the formation by deeply incised canyons, the Price River Formation is not considered to be a significant aquifer within the permit and adjacent areas. According to the Cumulative Hydrologic Impact Assessment, completed by UDOGM (1989) for the Upper Gordon Creek Area, "groundwater associated with the Price River Formation may be characterized as occurring within a 'perched' aquifer and represents a relatively insignificant hydrologic resource."

Castlegate Sandstone. The Castlegate Sandstone consists of 150 to 500 feet of white to gray, coarse-grained often conglomeratic sandstone with a few thin interbedded mudstones or shales near the base. Cliffs often form along outcrops of the Castlegate Sandstone. Based on the limited area of exposure for surface recharge (due to the steep slopes), the limited potential for recharge from the overlying perched aquifers of the Price River Formation, and drainage of the sandstone into the deeply incised canyons of the area, water contained within the Castlegate is insignificant. Consequently, this formation is not considered to be a significant aquifer.

Blackhawk Formation. The Blackhawk Formation underlies the Castlegate Sandstone and consists of several hundred feet of interbedded sandstone, siltstone, shale, and coal. The Hiawatha coal seam is located near the base of the Blackhawk Formation. The Blackhawk Formation has a mixed lithology of sandstones, shales, and coals which produce alternating

perched aquifers and impermeable beds (Doelling, 1972). Four springs were identified in the area by the 1989 Cumulative Hydrologic Impact Assessment with "all springs discharging from the Blackhawk Formation". Figure 7-1 shows an example of perched aquifer flow in the Blackhawk Formation.

The above-mentioned springs are associated with fractures and/or channel sands that are of limited areal extent, which contain water perched over shale beds and have limited recharge areas. This type of spring commonly has considerable variation in flow because of the limited recharge area and the limited amount of storage in the aquifer (Engineering Science, 1984).

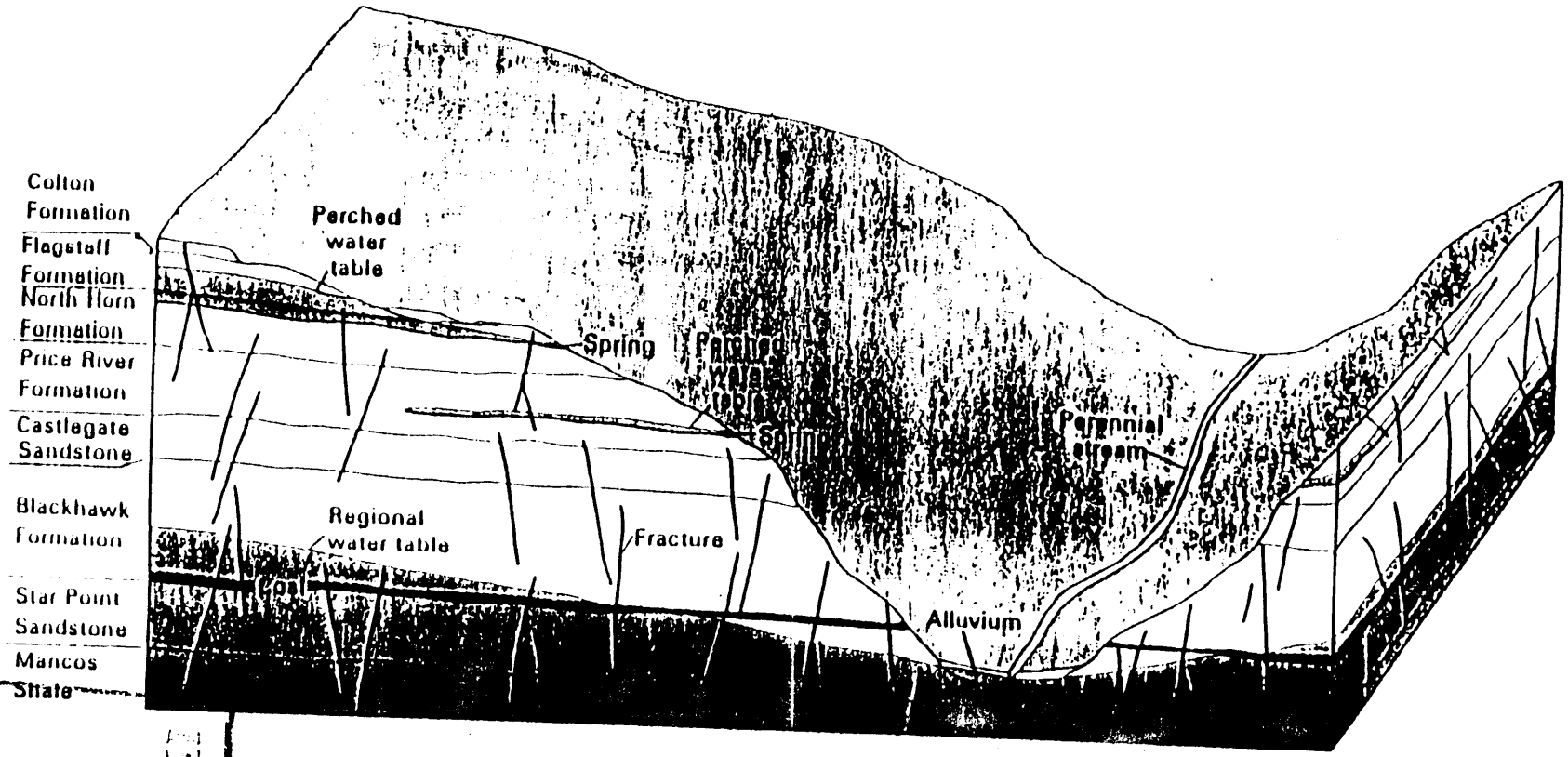
According to UDOGM (1989), mine inflows into mines in the area of the Horizon No. 1 Mine are insignificant. Since mining in the area occurs within the Blackhawk Formation, this indicates that extensive aquifers are not present within the Blackhawk Formation in the permit and adjacent areas.

The areal extent of the Aberdeen Sandstone has been mapped in the mine area using data from drill hole logs and surface exposures. It has been found to be thin (only several feet in thickness) and it undergoes a facies change within the mine area where sandstone beds grade into finer-grained sediments (Hansen, 1988). As a result, the Aberdeen is present as a very thin fine-grained sandstone, interbedded with siltstones and shales in the Horizon No. 1 Mine area. Due to this lithologic condition, the Aberdeen Sandstone is not anticipated to be a significant aquifer in the permit area. This conclusion is supported by the fact that, although a few springs within the permit or adjacent areas issue from the Blackhawk Formation, none of these issue from the Aberdeen Sandstone.

Selected springs within the permit and adjacent areas have been monitored by Horizon Coal Company and others in the past. These springs are labeled as sampling points SP-1, SP-2, SP-4, and SP-6 on Plate 7-1. These sampling points, which all issue from the Blackhawk Formation, have been monitored during accessible periods from 1989 to the present, with the resulting monitoring data presented in Appendix 7-2. Previous sampling efforts have referred to these springs as Station No. 1, Station No. 2, and Station No. 3, respectively. The change in terminology referencing the springs has been made solely to enable easier identification and discussion in this permit application.

SP-1 is located on a hillside and flows to Jewkes Creek. This spring discharges at an elevation of approximately 8195 feet above mean sea level from the Blackhawk Formation. SP-2 discharges from the Blackhawk Formation at an elevation of approximately 8005 feet above mean sea level. Water issuing from this seep does not flow far enough to enter the main stream channel of Jewkes Creek. Usually, this seep can not be seen flowing on the surface more than approximately 100 feet from its origin.

figure 7-1



Modified from Lines (1986)

FIGURE 7-1. GENERAL HYDROSTRATIGRAPHIC CROSS SECTION

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SP-4 is also located in the Jewkes Creek drainage. This spring discharges from the Blackhawk Formation at an elevation of approximately 8102 feet above mean sea level and flows along the road until it empties into Jewkes Creek.

SP-6 was identified by Darin Worden of UDOGM during an initial site reconnaissance as a desirable sampling point. This site, which is located in the Blackhawk Formation, is situated in an area east of and upstream from the proposed mine portals. However, this "spring" has been consistently dry during the years of sampling (1989 through 1995). It is presumed that the location was initially designated by Mr. Worden during a period of ephemeral runoff and that it does not, in fact, represent a spring. Therefore, this location will not be included in future hydrologic monitoring efforts.

Flow measurements collected at the time of sampling for the springs have been plotted as indicated in Appendix 7-2. The flow of springs within the permit and adjacent areas is typical of springs in the region, with the highest flow rates in the late spring, followed by lower flow rates in the late summer and early fall. Spring SP-1 generally flows at approximately 10 to 15 gallons per minute (gpm) during late spring, with a high of 45 gpm occurring in May 1989. The flow then tapers off to approximately 5 to 6 gpm in late summer and early fall. The gradual tapering off of flow is probably the result of a decrease in recharge to the aquifer during the dry summer months.

Spring SP-2 typically discharges at a rate of 1 to 2.5 gpm in late spring and then tapers off to approximately 1 gpm or less. Records indicate that the spring was dry in July and August 1991 and July through at least December 1992. Flow conditions at SP-4 have been very similar to those encountered at SP-2 during the 6.5-year period of record.

Also noted on Plate 7-1 is a sample point identified as SP-9 (referred to locally as Jewkes Spring). This spring, which will be monitored in the future by Hidden Splendor Resources, was monitored by the U.S. Geological Survey during the period of 1979 through 1983 and by Beaver Creek Coal Company from 1985 through 1995. During its period of record, Beaver Creek Coal Company referred to the spring as station 2-5-W.

SP-9 (Jewkes Spring) issues from the Blackhawk Formation at an elevation of approximately 8550 feet above mean sea level. Typical flow rates vary from 20 to 60 gpm in the late spring, decreasing during the late summer and early fall. The maximum flow rate listed in Appendix 7-2 for SP-9 (Jewkes Spring) was 1372 gpm in July 1985. However, since this flow is a factor of 7.4 higher than the next highest flow rate, and since flow rates measured in June and August of that year were 36 and 39 gpm, respectively, this flow rate is considered inaccurate and spurious.

Springs CC-5 and MC-4 issue from the Storrs Unit of the Star Point Formation. These springs are located approximately one mile southeast of the permit area and are accessed from County Road 290 (see Plate 7-1).

Star Point Sandstone. The Star Point Sandstone consists of fine to medium grained sandstone that decreases in grain size with depth. This unit consists of several littoral sandstone tongues separated by Mancos shales (Doelling, 1972). Regionally, recharge to the Star Point occurs primarily from vertical movement of water through the overlying Blackhawk Formation. Due to the

low vertical permeability of the Blackhawk Formation, the magnitude of this recharge is limited. This formation is monitored via monitoring wells HZ-95-1, HZ-95-2, HZ-01-06-1 and HZ-95-3, which have been installed into the uppermost Spring Canyon tongue at the locations noted on Plate 7-1.

Mancos Shale. Underlying the Star Point Sandstone is the Masuk member of the Mancos Shale. The Masuk Shale consists of blue-gray fissile claystone or silty claystone which weathers light blue-gray to light tan. Although the Masuk Member of the Mancos Shale may be locally saturated beneath the Star Point Sandstone, it is not considered to be an aquifer. Except where extensively fractured, the low-permeability shales in the Masuk will transmit only relatively small quantities of water (Lines, 1985).

Quaternary Alluvium. Unconsolidated Quaternary deposits are present in the floors of drainages and generally consist of silts, sands, and gravels. The alluvial deposits receive water from the adjacent bedrock in some of the deeply incised canyons. Water is probably supplied to the alluvium by seepage from the Blackhawk and Star Point Formations. Discharge from the Quaternary alluvium is to the surface water system. Due to the limited areal extent of alluvium in the area, this unit is not considered to be a significant aquifer.

Homestead Spring (2-6-W), which discharges from alluvial deposits and was monitored previously by Beaver Creek Coal Company, was added to the Horizon's monitoring program in 1996. Although Homestead Spring is outside of the permit and adjacent area and will not be effected by the proposed mining operation, the spring will supply valuable baseline flow data because of it's contribution to Beaver Creek. Care will be taken during sampling since the landowner requested that trespass be limited due to previous vandalism on the property.

Depth to Water

Four exploratory holes (LMC-1 through LMC-4) were drilled within the permit boundary in the late 1970's and early 1980's. Drill hole locations are shown on Plate 7-1. Three wells (LMC-1, LMC-3, and LMC-4) were retained as open holes. Water-level data have been collected from these holes. Table 6-2 contains drill hole data pertinent to the hydrologic resources of the area. Drill hole logs are found in Appendix 6-1.

Water-level measurements collected from the three open holes (LMC-1, LMC-3 and LMC-4) are provided in Table 7-1. Water level and depth measurements were collected by means of a 1500-foot electric water-level indicator manufactured by Solinst. All three wells were found to be dry during the period of February 1992 through October 1995.

table 7-1

TABLE 7-1

WATER-LEVEL DATA OBTAINED FROM
LOCAL MONITORING WELLS

Date	LMC-1		LMC-3		LMC-4	
	Depth (ft)	Elev. (ft)	Depth (ft)	Elev. (ft)	Depth (ft)	Elev. (ft)
2/27/92	>599	<7852	>664	<7556	>217	<7587
3/28/92	>599	<7852	>664	<7556	>217	<7587
4/25/92	>599	<7852	>664	<7556	>217	<7587
5/17/92	>599	<7852	>664	<7556	>217	<7587
6/25/92	>599	<7852	>664	<7556	>217	<7587
7/25/92	>599	<7852	>664	<7556	>217	<7587
8/24/92	>599	<7852	>664	<7556	>217	<7587
9/29/92	>599	<7852	>664	<7556	>217	<7587
10/25/92	>599	<7852	>664	<7556	>217	<7587
11/22/92	>599	<7852	>664	<7556	>217	<7587
12/28/92	>599	<7852	>664	<7556	>217	<7587
5/30/93	>599	<7852	>664	<7556	>217	<7587
6/25/93	>599	<7852	>664	<7556	>217	<7587
7/25/93	>599	<7852	>664	<7556	>217	<7587
8/20/93	>599	<7852	>664	<7556	>217	<7587
9/27/93	>599	<7852	>664	<7556	>217	<7587
10/22/93	>599	<7852	>664	<7556	>217	<7587
11/6/93	>599	<7852	>664	<7556	>217	<7587

TABLE 7-1 (Continued)

WATER-LEVEL DATA OBTAINED FROM
LOCAL MONITORING WELLS

Date	LMC-1		LMC-3		LMC-4	
	Depth (ft)	Elev. (ft)	Depth (ft)	Elev. (ft)	Depth (ft)	Elev. (ft)
6/24/94	>599	<7852	>664	<7556	>217	<7587
7/24/94	>599	<7852	>664	<7556	>217	<7587
8/25/94	>599	<7852	>664	<7556	>217	<7587
9/24/94	>599	<7852	>664	<7556	>217	<7587
10/22/94	>599	<7852	>664	<7556	>217	<7587
11/2/94	>599	<7852	>664	<7556	>217	<7587
12/6/94	>599	<7852	>664	<7556	>217	<7587
5/26/95	>599	<7852	>664	<7556	>217	<7587
8/8/95	>599	<7852	>664	<7556	>217	<7587
10/27/95	>599	<7852	>664	<7556	>217	<7587

TABLE 7-1 (Continued)

WATER-LEVEL DATA OBTAINED FROM LOCAL MONITORING WELLS

Date	HZ-95-1		HZ-95-1S		HZ-95-2		HZ-95-3		HZ-01-06-1	
	Depth (ft)*	Elevation (ft)	Depth (ft)*	Elevation (ft)	Depth (ft)*	Elevation (ft)	Depth (ft)*	Elevation (ft)	Depth (ft)*	Elevation (ft)
12/5/95	--	--	135.0	8221.5	828.0	7519.6	--	--		
12/13/95	786.00	7570.70	--	--	--	--	--	--		
12/21/95	--	--	--	--	--	--	378.80	7522.70		
7/9-10/96	711.30	7585.40	133.80	8222.70	830.00	7517.60	380.80	7520.70		
8/5/96	770.80	7585.90	133.50	8223.00	829.40	7518.20	387.80	7513.70		
9/11/96	769.40	7587.30	132.50	8224.00	829.40	7518.20	387.70	7513.80		
10/23/96	776.40	7580.30	132.50	8224.00	829.20	7518.40	380.70	7520.80		
11/1/96	776.40	7580.30	132.50	8224.00	829.20	7518.40	380.80	7520.70		
12/13/96	#		#		829.50	7518.10	379.50	7522.00		
1/6/97	771.05	7584.75	133.00	8223.50						
2/10/97	+		+		+		+			
3/25/97	+		+		+		+			
4/1/97	+		+		+		+			
5/28/97	770.95	7584.90	131.50	8225.10	828.05	7519.55	379.90	7522.40		
6/30/97	770.20	7585.60	132.14	8224.36	827.72	7519.88	379.90	7522.40		
9/16/97	773.50	7583.90	132.50	8224.00	827.20	7520.40	379.90	7522.40		
10/17/97	773.70	7583.70	132.50	8224.00	827.20	7520.40	379.90	7522.40		
6/30/98	817.80	7538.90	133.10	8223.40	836.60	7511.00	395.10	7506.40		
9/1/98	745.00	7611.70	134.50	8222.00	840.90	7506.70	398.00	7503.50		
6/1/99	758.80	7597.90	133.70	8222.80	847.80	7499.80	399.50	7502.00		
7/1/99	758.10	7598.60	134.40	8222.10	845.90	7501.70				
11/1/99	+		+		+		397.00	7504.50		
5/20/00	862.70	7494.00	132.80	8223.70	849.80	7497.80	401.50	7500.00		
9/8/00							402.10	7499.40		
9/26/00	875.00	7481.70	134.40	8222.10	863.80	7483.80				
10-12/31/00	$		$		$		$			
12/12/00	+		+		+		+			
3/23/01	+		+		+		+			
5/31-6/1/01	870.55	7486.15	133.75	8222.75	856.75	7490.85	414.17	7487.33		
9/20/01	876.85	7479.85	134.50	8222.00	862.40	7485.20	416.10	7485.40		
10/19/01	873.36	7483.34	134.65	8221.85	858.71	7488.89	415.70	7485.80		
11/17/01									944.20	7817.20
2/18/02	@		@		@		@		@	
3/25/02	@		@		@		@		@	
6/12/02	876.68	7480.02	135.08	8221.42	867.38	7480.22	458.12	7443.38	1029.6	7731.82
9/4/02	876.85	7479.85	136.37	8220.13	869.28	7478.32	%465.1	%7436.4	1036.9	7724.55
10/8/02	876.55	7480.15	136.00	8220.50	869.65	7477.95	%465.1	%7436.4	1037.5	7723.95
5/14/03	@		@		@		%465.1	%7436.4	@	
5/28/03	875.12	7481.38	135.35	8221.15	872.00	7475.60	%465.1	%7436.4	1036.6	7724.80
9/5/03	876.22	7480.48	135.51	8220.99	871.73	7475.87	%465.1	%7436.4	1036.7	7724.66
10/16/03	876.24	7480.46	135.45	8220.93	871.92	7476.06	%465.1	%7436.4	1036.5	7724.46
3/1/04	@		@		@				@	
3/29/04	@		@		@		%465.1	%7436.4		

* Depth measured from top of 2" tubing

Well site inaccessible 12/16/96, access attempted with Bill Malencik, UDOGM

\+ Mine site declared inaccessible by Bill Malencik

$ Landowner refused access until pending agreement was completed.

@ Inaccessible due to snow cover

% Dry

Surface Elevations

	Top of Casing	Top of Tubing	Ground Elevation
HZ-95-1	8357.1	8356.7	8352.6
HZ-95-1S	8357.6	8356.5	8352.6
HZ-95-2	8348.1	8347.6	8346.3
HZ-95-3	7902.2	7901.5	7897.6
HZ-01-06-1		8761.4	8759.4

Hole LMC-1 was drilled to a depth of 900 feet below ground surface in September 1976. A log of this hole is provided in Appendix 6-1. LMC-1 was drilled into the Blackhawk Formation through the Castlegate A coal seam with the bottom subsequently being sealed to a depth of approximately 600 feet below ground surface and remaining open above that depth. Hole depth was determined to be 599 feet below ground surface on February 27, 1992 and the hole has been dry during all monitoring visits. Personal communication with Mr. Joseph A. Harvey (1992) indicates that LMC-1 was dry to 900 feet below ground surface during drilling.

In October 1976, hole LMC-2 was drilled to a depth of 568 feet below ground surface. The hole was advanced through the Castlegate A coal seam. A log of this hole is provided in Appendix 6-1. The hole was subsequently sealed to a depth of 50 feet below ground surface. Due to its shallow remaining depth, no groundwater measurements have been collected from this hole. Mr. Harvey (1992) indicated that the hole was dry to a depth of 568 feet below ground surface during drilling.

Hole LMC-3 was drilled to a depth of 836 feet below ground surface in November 1976. This hole was subsequently sealed to a depth of about 665 feet below ground surface, remaining open above that depth. A log of this hole is provided in Appendix 6-1. On February 27, 1992, LMC-3 was probed and found to be dry to a total hole depth of 664 feet below ground surface. Subsequent measurements in this hole have also indicated a dry condition (see Table 7-1). Mr. Harvey (1992) indicated that the hole was dry to a depth of 836 feet below ground surface during drilling.

In January 1980, hole LMC-4 was drilled through the Blackhawk Formation to a depth of 430 feet below ground surface. The hole was advanced through the Castlegate A coal seam and into the Hiawatha coal seam. This hole was subsequently sealed to a depth of approximately 220 feet below ground surface, remaining open above that depth. A log of this hole is provided in Appendix 6-1. On February 27, 1992, LMC-4 was probed to a depth of 217 feet below ground surface and water was not detected. Subsequent measurements have indicated that this hole has remained dry (see Table 7-1). Mr. Harvey (1992) indicated that this hole was also dry to total depth during drilling.

Each of the LMC drill holes is open (i.e., uncased) from the surface to total depth. Thus, the measured dry conditions indicate that the strata exposed by the holes are dry in each of the holes. In addition to the above measurements, data were collected from wells LMC-1 and LMC-3 by Mr. Roger Skaggs of Blue Blaze Coal Company in December 1991. These measurements were collected by attaching two test tubes to the end of a steel cable, lowering the cable into the drill hole until the bottom of the hole was reached, and allowing the test tubes to rest on the bottom for several minutes before retrieving the cable. The length of the cable was measured at the surface while the cable was extracted. Using this method, drill hole LMC-1 was found to be dry at a depth of 600 feet. Well LMC-3 was found to be dry at a depth of 650 feet. Although non-standard methods were used, the December 1991 data corroborate the subsequent data by indicating that holes LMC-1 and LMC-3 are dry.

Discussions with Mr. Joseph A. Harvey (1992), who was present at the time the holes were drilled, further corroborate the absence of groundwater within the LMC holes. According to Mr. Harvey, who was under contract with C & W Coal Producers Corp. at the time the holes were drilled, each

hole was dry during drilling and upon completion. Completion dates were September 1976 for LMC-1, November 1976 for LMC-3, and January 1980 for LMC-4. Hole LMC-2 (completed in October 1976) was also reported to be dry during drilling. Appendix 7-1 contains a notarized letter from Mr. Joseph A. Harvey outlining his responsibilities and observations regarding ground water at these drill holes.

It is important to note that two exploration drill holes were drilled in the Beaver Creek valley north of the permit area by Beaver Creek Coal Company in the late 1970's. Both of these drill holes are located very near the Beaver Creek channel and both have artesian flow. The first of the two wells, here named BC-1, is located in the SW 1/4 of the SE 1/4 of Section 5, T. 13 S., R. 8 E. The second hole, here named BC-2, is located in the NW 1/4 of the NW 1/4 of Section 4, T. 13 S., R. 8 E. These wells are assumed to produce water from approximately 80 to 100 feet below ground surface. BC-1 was spud in the top of the Blackhawk Formation while BC-2 was spud approximately 60 to 80 feet above the Castlegate Sandstone and Blackhawk Formation contact. This suggests that water is contained in some of the upper sandstone units of the Blackhawk Formation north of the permit area. Since these are artesian wells, this also suggests that the bedrock units producing water rest upon aquitards and are overlain by confining units. A more detailed description of the wells and their relationship to the local ground water system is included in Appendix 7-11.

In October 1995, Horizon Coal Company completed four additional monitoring wells within the permit and adjacent areas at the locations noted on Plate 7-1. Three of the monitoring wells (HZ-95-1, HZ-95-2, and HZ-95-3) were completed in the Spring Canyon tongue of the Star Point Sandstone (i.e., immediately below the Hiawatha coal seam - the coal seam to be mined at this location). The remaining well (HZ-95-1S) was completed in a local perched saturated zone within the Blackhawk Formation. In November 2001 an additional monitoring well (HZ-01-06-1) was drilled at the far north end of the permit area. This well was completed in the Spring Canyon tongue of the Star Point Sandstone.

Logs of the HZ holes are provided in Appendix 7-5. Each monitoring well except for HZ-01-06-1 was completed with 2-inch diameter steel casing and 10 feet of 20-slot wire-wound stainless-steel screen. Monitoring well HZ-01-06-01-1 was completed with 60 feet of stainless steel screen. A filter pack was placed in the annulus of each hole adjacent to the screen. The annulus of each hole was grouted with a cement/bentonite mixture above the filter pack.

Water-level data obtained from the HZ monitoring wells are provided in Table 7-1 of the annual reports. The data collected from the HZ wells in December 1995 (with the exception of HZ-95-1S, which is completed in a localized perched aquifer), together with the information obtained from the LMC holes, were utilized to prepare the potentiometric surface map contained in Figure 7-2. Subsequent data collected from the HZ wells in 1996 verify the December 1995 data and do not indicate a substantial difference in the potentiometric surface presented in Figure 7-2 (see Figure 7-2a and Table 7-1). Further discussion of the HZ wells can be found under the subheading "Hydraulic Conditions" in this section.

figure 7-2

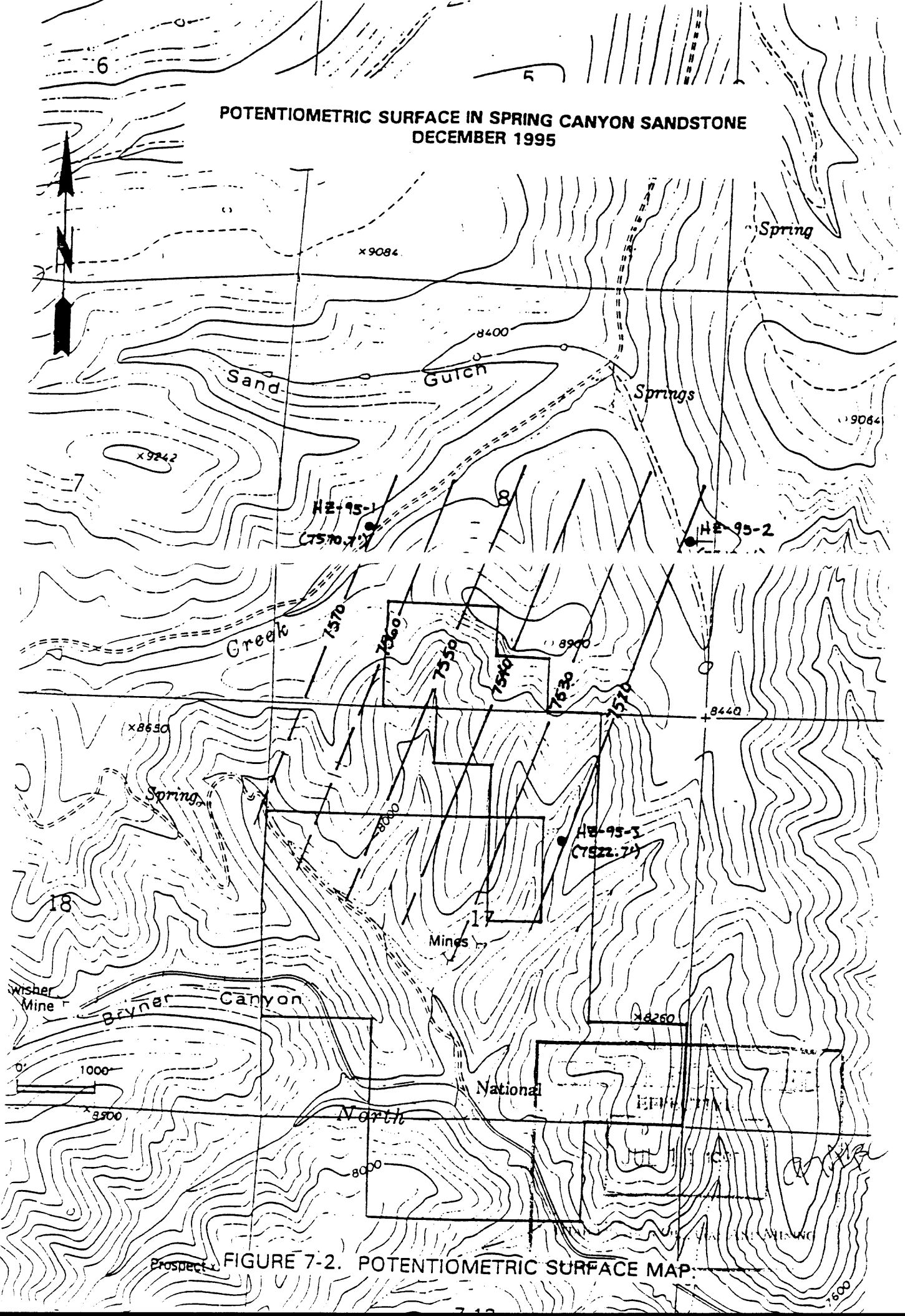

FIGURE 7-2. POTENTIOMETRIC SURFACE MAP.

figure 7-2a

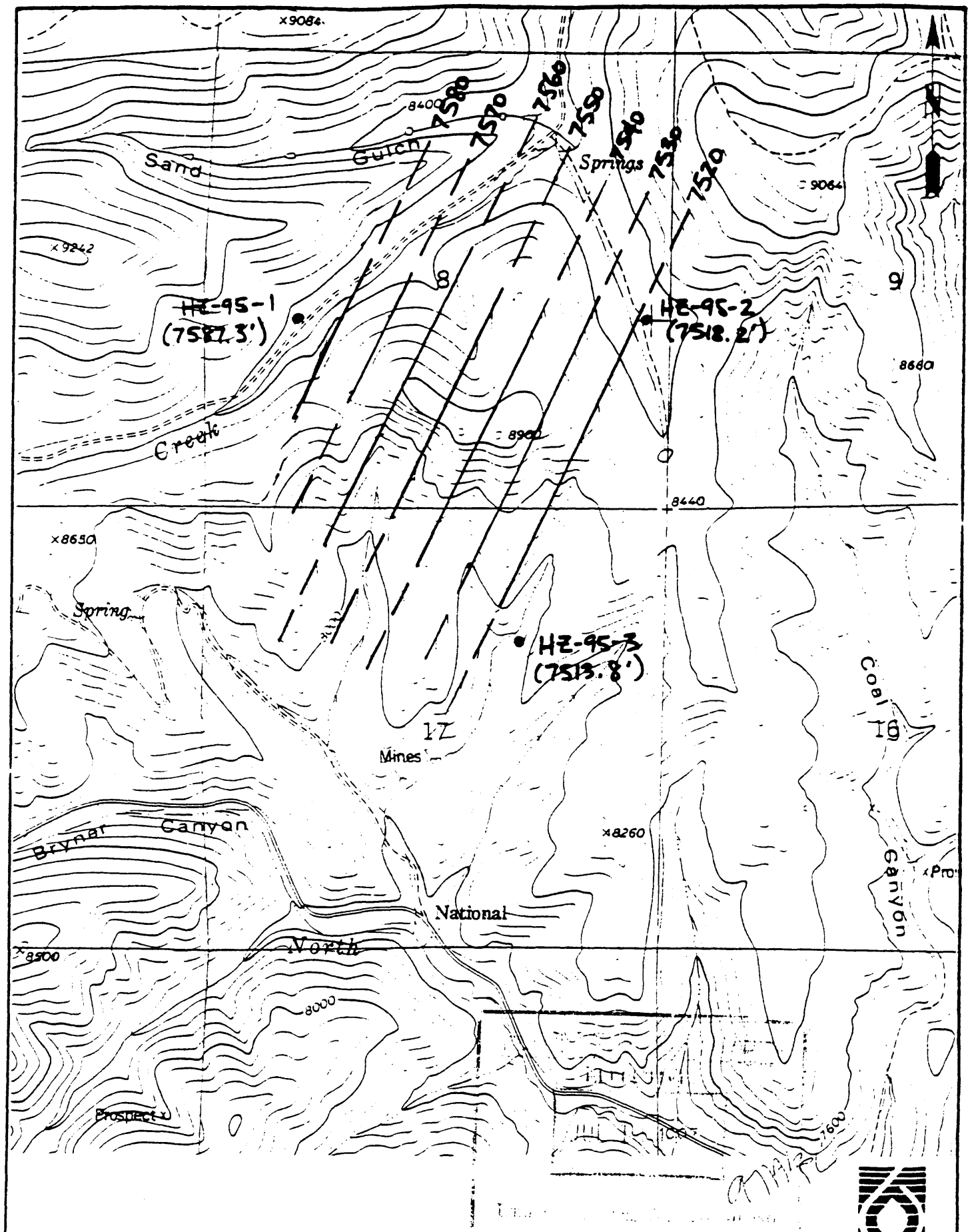

FIGURE 7-2A. SEPTEMBER 1996 POTENTIOMETRIC SURFACE IN SPRING CANYON SANDSTONE.

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The data presented in Table 7-1 indicate that the water level in well HZ-95-1 rose approximately 15 feet between the December 1995 measurement and the July 1996 measurement. Notes provided in Appendix 7-11 indicate that this well was sampled 8 days prior to the December 1995 water-level measurement. Prior to collection of the sample, the well had been pumped periodically over a period of approximately 3 weeks in an attempt to purge the well and obtain a representative water sample. Each time the well was pumped, only 1 to 10 gallons of water could be evacuated from the hole prior to the well going dry. The sampler would then wait for a period of a few days, pump the well dry again (after only a few gallons), and repeat the cycle. This information indicates that the well recharges very slowly. Hence, it is reasonable to conclude that the water-level in December 1995 had not fully stabilized prior to measurement. Thus, the July 1996 and subsequent data are considered more representative of local conditions.

The data for HZ-95-3 presented in Table 7-1 also indicate a 7-foot decrease in the water level in that well between the July and August 1996 measurements. This change in water levels was verified by the September 1996 measurement, thus indicating that measurement error was probably not the source of the change. Until additional data are collected, the source of this change cannot be determined.

As indicated in Figures 7-2 and 7-2a, the flow of groundwater within the permit and adjacent areas is to the east-southeast, essentially following the strike of the predominant fracture system. The pre-mining hydraulic gradient, based on the December 1995 data presented in Figure 7-2, is 0.014 ft/ft. The pre-mining hydraulic gradient was 0.019 ft/ft using the September 1996 data (Figure 7-2a).

The potentiometric surface contained in Figure 7-2 was overlain on a map showing the elevation of the top of the Spring Canyon tongue of the Star Point Sandstone as developed by Hansen (1988). Since the Hiawatha coal seam directly overlies the Spring Canyon tongue, a comparison of the elevation of the potentiometric surface and the elevation of the top of the Spring Canyon tongue would indicate the areas where the Hiawatha coal seam may be expected to be saturated within the permit and adjacent areas.

Figure 7-3 presents the results of the above evaluation. This figure presents lines of saturation based not only on the December 1995 water-level data but also based on an assumed maximum water-level fluctuation of ±30 feet. This assumed maximum water-level fluctuation was derived following a review of water-level monitoring records from nearby mining operations. The longest period of water-level record in the region is at the Skyline Mine, located approximately 7 miles west of the Horizon No. 1 permit area, where water-level data have been collected from monitoring wells during the period of 1982 to the present. During this period, the maximum water-level fluctuation has been 58 feet (as recorded at Skyline well 79-35-1A). The assumed water-level fluctuation presented in Figure 7-3 totals 60 feet, thereby encompassing the maximum fluctuation measured in the region.

Data presented previously in this section indicate that hole LMC-4 (which was drilled near the proposed portal for the Horizon No. 1 Mine) was dry when it was drilled into the Hiawatha

figure 7-3

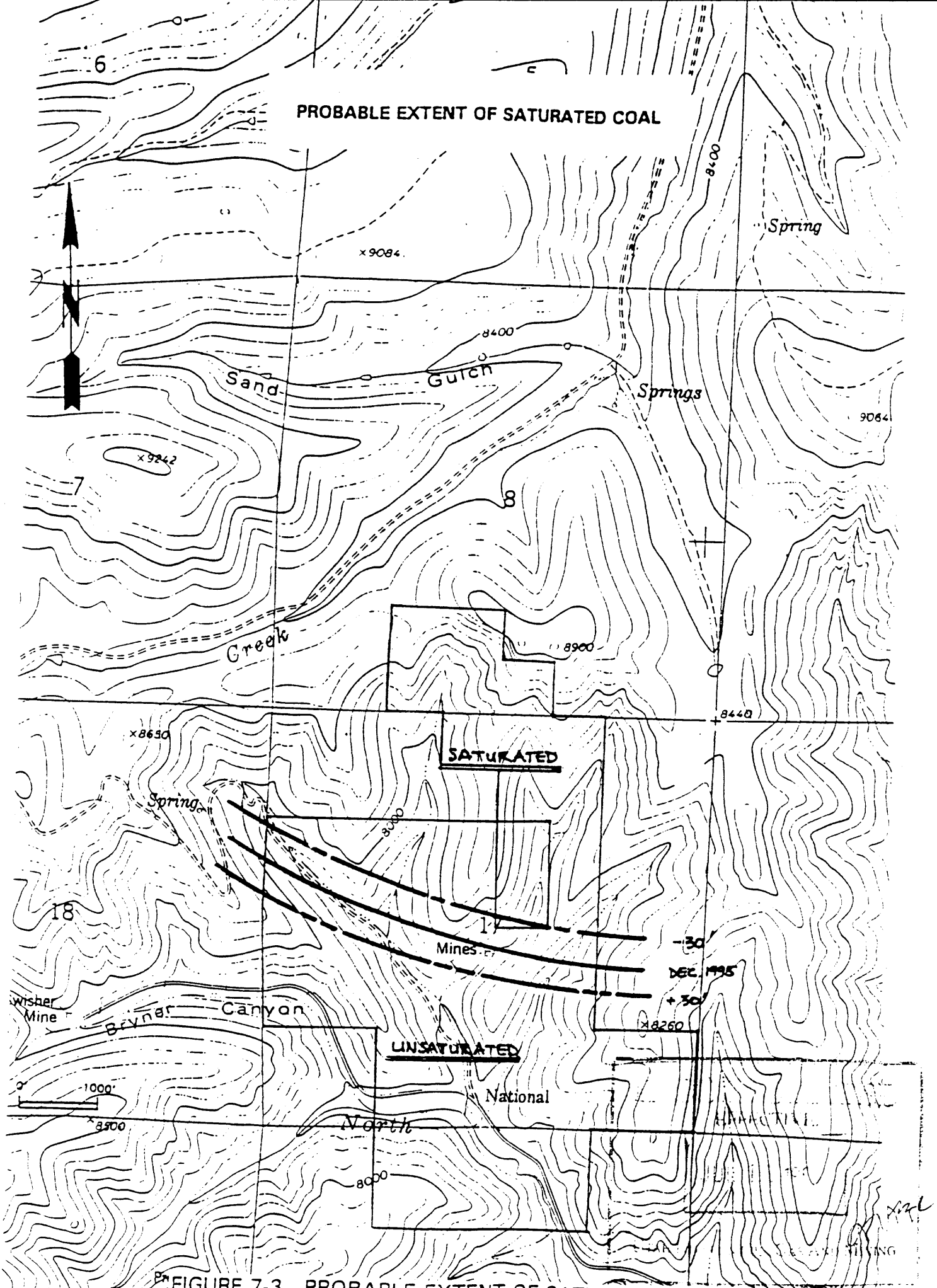


FIGURE 7-3. PROBABLE EXTENT OF SATURATED COAL.

coal seam. However, a comparison of Figure 7-3 and Plate 3-3 indicates that the Hiawatha coal seam can be expected to be saturated very soon into mining operations. Anticipated maximum fluctuations in water levels will not significantly influence this conclusion.

A review of records on file with UDOGM, as well as discussions with former Beaver Creek Coal Company mining personnel, indicate that the Gordon Creek No. 2 Mine (operated by Beaver Creek Coal Company in the Castlegate A seam) immediately southwest of the proposed permit area, was a dry mine with only sporadic occurrences of groundwater inflow that dried up within a short time. The Gordon Creek No. 3 Mine (operated by Beaver Creek Coal Company in the Hiawatha seam immediately east and downgradient of the proposed permit area) was dry until a 12-foot graben was encountered in the northeast portion of the mine. This occurrence is consistent with the above conclusion since the Hiawatha coal seam is anticipated to become increasingly saturated with distance to the north. Groundwater from the graben was produced from the floor of the mine at a peak rate of approximately 400 gallons per minute. During retreat mining, the same faulted zone was dry, either as a result of previous dewatering, or as a result of elevation differences. It is possible that groundwater was stored in the fault zone, and when the fault zone was dewatered, there was insufficient recharge from overlying strata to maintain the groundwater discharge.

After removal of the Castlegate "A" coal seam in mines adjacent to the permit area, water occasionally seeped into these stratigraphically-higher mines from the roof or, more rarely, from the floor. Generally, minor amounts of water were encountered when mining took place beneath a fluvial sandstone channel. The channels behave as perched aquifers that are confined by associated flanking shales. Such a condition, enhanced by local fracturing, appears to occur at the shallow monitoring well completed by Horizon Coal Company in the Blackhawk Formation (HZ-95-1S).

Based on the water level measurements collected from the permit and adjacent areas and information gathered from mines in the region, it is concluded that the Hiawatha coal seam, as well as the immediately underlying and overlying strata, will be saturated in the Horizon No. 1 Mine essentially from the beginning of mining operations. The rate of inflow of groundwater while mining in the Hiawatha coal seam will depend primarily on whether a faulted zone is encountered that contains groundwater in storage or that is hydraulically connected with an overlying perched zone. Based on the dry nature of previous mine workings in the area, as well as observations and measurements obtained from the LMC and HZ drill holes, the probability of significant sustained inflows to the Horizon No. 1 Mine is considered minimal. This conclusion is in agreement with Cumulative Hydrologic Impact Assessments prepared for the area by Engineering Science (1984) and UDOGM (1989). Additional information regarding potential inflows to the Horizon No. 1 Mine is presented in Section 7.3 of this document.

Hydraulic Conditions

The hydraulic conductivity of the Spring Canyon Tongue of the Star Point Sandstone was estimated by performing slug tests in monitoring wells HZ-95-1, HZ-95-1S, HZ-95-2, and HZ-95-3. A slug test is conducted by rapidly changing the water level in a well or borehole by means of the injection or withdrawal of a body of known volume (a "slug") into or from the water column, and monitoring the rate of water level recovery to the static, pre-test level. When the slug is rapidly lowered into the water column, the water level rises abruptly. Rapid withdrawal of the slug after the water level has fully recovered causes the water level to drop abruptly. The slug used in this investigation consisted of a 6-foot length of 1-inch diameter 316-stainless steel rod attached to stainless steel cable.

It is recognized that the radius of influence of a slug test is smaller than that of a long-term pumping test. However, slug tests are considered adequate when studies are not aimed at designing an exploitation program of the aquifer (Freeze and Cherry, 1979). EarthFax Engineering has found that slug tests produce similar results to pumping tests if performed under similar field conditions.

Prior to performance of the slug test, an electric water level indicator was used to measure the static water level in each completed monitoring well. The measurements were made relative to the top of the well casing. Together with the well completion information, these data were used to determine the degree to which each well penetrates the Spring Canyon Tongue. An average saturated thickness for the Spring Canyon Tongue of 75 feet was assumed based on multiple observations in the area by Hansen (1988).

A pressure transducer with a maximum operating pressure of 15 pounds per square inch was used to measure water-level changes during the slug tests. After pre-test water-level measurements, the pressure transducer was lowered into the water to a depth that was below the lowest point to which the slug would be injected, but within the depth range of the transducer. The slug was then rapidly lowered into the water column in the monitoring well. Data derived from the transducer were recorded using a model 21X Micrologger manufactured by Campbell Scientific. The data logger was programmed to record water-level changes to within 0.001 foot at half-second intervals.

Data recorded on the data-storage module in the field were transferred to diskette by means of either a model PC201 tape and serial I/O card and associated software or a PC208 software package and serial cable with adapter, both developed by Campbell Scientific. These data sets are stored as comma-delineated ASCII data files. The contents of each data file were subsequently transferred to an analytical program (AQTESOLV™), which allows rapid, graphical representation and log-linear regression analysis of test data.

The software AQTESOLV™ (Duffield and Rumbaugh, 1989) was used to evaluate the slug test data. The method of Bouwer and Rice (1976), which determines hydraulic conductivity for wells which partially or fully penetrate unconfined aquifers, is available in the AQTESOLV™ software, and was used to estimate the hydraulic conductivities of aquifer tested for this study. This method

is applicable to both unconfined and confined aquifers, since both types of aquifers behave similarly during short-term tests (Neumann, 1974).

To evaluate the slug-test data, values of time and actual water-level displacement due to injection of the slug are displayed on a semi-logarithmic plot (i.e., water-level displacement is represented on a logarithmic y-axis and time is represented on an arithmetic x-axis). The hydraulic conductivity ("K") is estimated from the equations:

where: = (11)

y_o	=	initial drawdown or residual drawdown in well due to instantaneous removal or injection of the slug from the well (ft)
y_t	=	drawdown in well at time t (ft)
L	=	length of well screen (ft)
r_c	=	radius of well casing (ft)
R_e	=	equivalent radius over which head loss occurs (ft)
r_w	=	radius of well, including gravel pack (ft)
H	=	static height of water in well (ft)
t	=	time (min)

and

= + - (12)

where:

C	=	dimensionless parameter which is a function of L/r_w

and other parameters are as previously defined.

According to Bouwer and Rice (1976), Equation (1) allows the hydraulic conductivity to be calculated from the water-level change in the well. Because the hydraulic conductivity, casing radius, well radius, the radius over which head loss occurs, and the screen length are constants, $(1/t) \ln y_o/y_t$ must also be a constant. Thus, the time/drawdown data should approximate a straight line if plotted in terms of $\ln y_o$ versus t. The quantity $(1/t) \ln y_o/y_t$ in Equation (1) is obtained from the first straight-line segment drawn through the field data.

The AQTESOLV™ software program prompts the user to supply values of well casing radius, drill hole radius, saturated aquifer thickness, well screen length, and static height of water in the well. Time and water-level data are read into the software program in the form of ASCII data files, which are down-loaded from the data logger.

Once the field data and constants are entered, the AQTESOLV™ software generates semi-log plots of the data and automatically fits a straight line to the data according to user-defined

weighting. If the entire range of field data do not approximate a straight line, only those early data which form a valid straight-line segment are weighted by the user such that the software produces the desired straight line approximation through the valid part of the data set.

The straight-line fit produced by AQTESOLV™ automatically determines the value of y_o (y-intercept) and an arbitrary value of y_t at time t to solve Equation (1). Based on user-defined values of screen length and drill hole radius, the software determines the value of C to evaluate R_e in Equation (2).

The AQTESOLV™ software generates the straight line approximation by means of a nonlinear weighted least-squares parameter estimation technique known as the Gauss-Newton linearization method (Duffield and Rumbaugh, 1989). The estimation technique minimizes the difference between observed and estimated values through iterative solution of the system of linearized equations until convergence is achieved. To ensure the fit of the straight line, the software prints out the values of actual water levels, calculated water levels, and residual values (the difference between the actual and calculated water levels) derived by the parameter estimation technique. Additionally, the statistical values of mean, standard deviation, and variance are provided for the weighted residuals. These statistics indicate the goodness-of-fit of the straight line generated by the estimation technique.

Slug test plots for the wells tested are presented in Appendix 7-8. Included with the time/drawdown plots are printouts of well constants used to estimate values of hydraulic conductivity. Statistical values of mean, standard deviation, and variance also are provided for the weighted residuals. From the analyses presented in Appendix 7-8, the following hydraulic conductivities were determined for the tested monitoring wells:

Well	Hydraulic Conductivity (ft/day)
HZ-95-1	16.1
HZ-95-1S	20.7
HZ-95-2	0.25
HZ-95-3	0.20

The average hydraulic conductivity of the Spring Canyon Tongue at wells HZ-95-2 and HZ-95-3 is 0.23 ft/day, while the hydraulic conductivity at HZ-95-1 and HZ-95-1S is 18.4 ft/day (nearly two orders of magnitude higher). Conditions at HZ-95-1 and HZ-95-1S are apparently affected by local fracturing, as suggested not only by the difference in hydraulic conductivity but also the presence of a northwest-trending fault adjacent to HZ-95-1 as indicated on Plate 6-1. Although no fracturing was noted by Hansen (1988) along the alignment of Beaver Creek near HZ-95-1, a short northeast-trending fracture just north of HZ-95-1 may have also locally enhanced fracturing of the bedrock encountered by the monitoring well (see Plate 6-1). The lack of noted fracturing along the alignment of Beaver Creek, together with the continuity of the potentiometric surface presented in Figure 7-2, indicates that the increased hydraulic conductivity at HZ-95-1 should not be interpreted as being representative of a separate groundwater system. Rather, localized

fracturing appears to have enhanced the local hydraulic conductivity, without significantly affecting the direction of groundwater flow.

It is of note that the Horizon monitoring wells are completed in the Spring Canyon Tongue (i.e., the aquifer immediately below the coal seam), rather than in the Blackhawk Formation wherein the coal occurs. Because the Blackhawk Formation consists of interbedded sandstone, siltstone, shale, and coal, the hydraulic conductivity of this formation is generally considered to be lower than that of the Spring Canyon Tongue. For the purpose of this assessment and in keeping with the convention of Lines (1985), the hydraulic conductivity of the unfractured Blackhawk Formation is estimated to be one-half that of the Spring Canyon Tongue (i.e. 0.11 ft/day). Where fractured, the hydraulic conductivity of the Spring Canyon Tongue and the Blackhawk Formation are estimated to be 18.4 and 9.2 ft/day, respectively, based on data collected from HZ-95-1 and HZ-95-1S.

Recharge

Snowmelt and rain are the main sources of recharge to the groundwater system in the permit and adjacent areas. Normal annual precipitation in the area is approximately 20 inches per year (Waddell et al., 1981). Approximately 65 percent of this precipitation normally falls during the months of October through April (Waddell et al., 1981), mostly as snowfall.

Groundwater recharge primarily occurs where permeable lithologies are exposed at the surface. Vertical migration of groundwater occurs through permeable rock units and/or along zones of faulting and fracturing. Lateral migration initiates when groundwater encounters impermeable rocks and continues until either the land surface is intersected (and spring discharge occurs) or other permeable lithologies or zones are encountered that allow further vertical flow (UDOGM, 1989). This condition creates the perched aquifers in the Price River and Blackhawk Formations discussed previously.

In areas that are capped by the Price River Formation and the Blackhawk Formation (such as occurs within the proposed permit and adjacent areas), Danielson et al. (1981) indicated that "steep slopes promote rapid snowmelt runoff and reduce recharge to the groundwater system." This condition is intensified by the relatively low permeability of the Price River and Blackhawk Formations. The limited amount of recharge in the area is reflected by the small number of springs as well as the dry conditions encountered by previous mine workings in the permit and adjacent areas and the LMC drill holes.

Figure 7-4 is a map of potential recharge areas in the mine vicinity. Areas identified as "very limited recharge potential" are underlain by the Blackhawk Formation (limited by its steep

figure 7-4

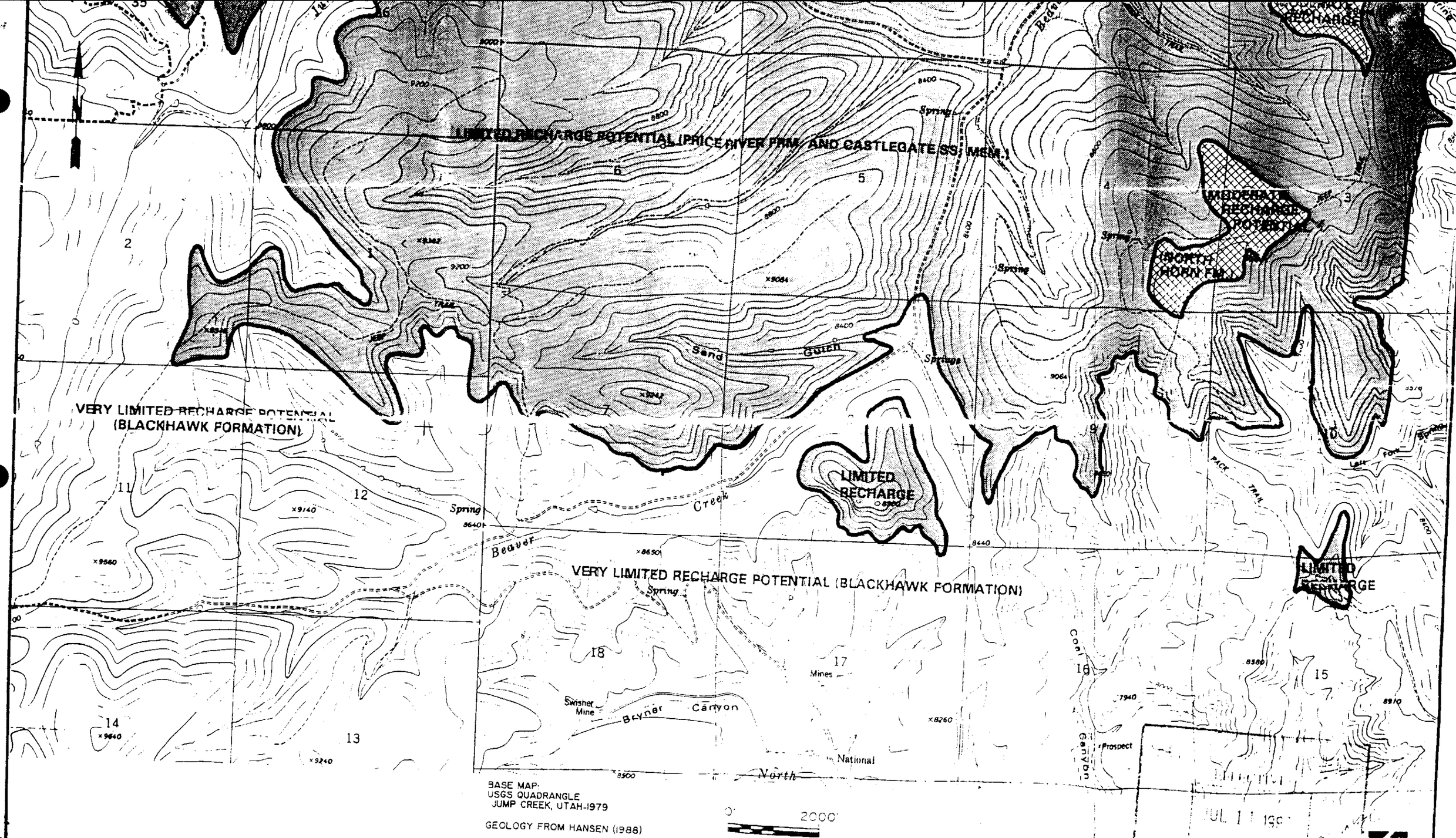


FIGURE 7-4. POTENTIAL RECHARGE AREAS.

slope and its shale content). Areas identified as "limited recharge potential" are underlain by the Price River Formation, Castlegate Sandstone, the Star Point Sandstone, and thin alluvium (limited either by their steep slope, their shale content, or their limited thickness). Areas identified as "moderate recharge potential" are underlain by the North Horn Formation (moderately permeable strait on moderate slopes). Note that, with the exception of the extreme northern portion of the permit area and the canyon bottom downstream from the proposed surface facilities, all of the permit and adjacent areas are in a zone of very limited recharge potential.

Groundwater occurrence and availability may also be controlled by faults and fractures. The control of faulting on the direction of groundwater flow can be seen by comparing the potentiometric surface map on Figure 7-2 with the geologic structure data provided on Plate 6-1. However, due to the low permeability of the formations surrounding the Hiawatha coal seam, and the plan to avoid mining into faulted zones, inflow to the mining operations from faulted zones is projected to be minimal (see Section 7.3 of this document).

Springs CC-1, CC-5, CC-6, SP-1, SP-4, SP-9, CV-1, CV-2, CV-3, CV-8, GV-25, and GV-70 (see Plate 7-1) appear to be fault related. To assess the extent of the influence of faulting on the hydrogeologic system and evaluate the potential for recharge of coal zones by seepage from the surface through fractures, a seepage evaluation was conducted along Beaver Creek on September 11, 1996. This evaluation was conducted by measuring the flow of Beaver Creek and its inflow points at the locations indicated on Figure 7-4a. All measurements were collected using portable cutthroat flumes which were installed in accordance with accepted procedures (Skogerboe et al., 1973).

Results of flow measurements collected during the Beaver Creek seepage evaluation are presented in Table 7-1a. These data are summarized in Table 7-1b and Figure 7-4b. In evaluating the seepage data, it should be noted that Reaches 2 and 3 contain several abandoned beaver ponds. An abnormal quantity of alluvium has deposited behind the abandoned beaver dams, creating broad areas across which the stream flows. Although the data indicate that a net gain occurs through these reaches, it is likely that some streamflow is lost into the alluvial deposits as the stream braids and the bottom gradient becomes less steep.

The data indicate a net gain of streamflow in Reach 4 of 38.0 gpm. Although this reach crosses the primary fault which will serve as the southwest boundary of the proposed mine workings, it is doubtful that this gain results from inflow along the fault. Rather, because the alluvium in the canyon bottom narrows significantly in Reach 4, the gain is likely the result of streamflow being measured which was lost into the alluvial deposits behind the upstream abandoned beaver dams.

Reach 5 crosses the fracture zone which was encountered by wells HZ-95-1 and HZ-95-1S. The loss in this zone was measured at 6.8 gpm. The loss in Reach 6, which crosses the northeast boundary fault, was 6.6 gpm. Although these losses occur in areas where fractures have been mapped, it is unlikely that a significant quantity of this water is flowing from the

Table 7-1a

TABLE 7-1a

RESULTS OF BEAVER CREEK SEEPAGE EVALUATION

Station	Description	Throat Width[a] (in)	Flow Depth (ft)	Flow Rate	
				(cfs)	(gpm)
HZ-1	Beaver Creek	1	0.20	0.02	9.0
HZ-2	Unnamed tributary	1	0.17	0.01	6.5
HZ-3	Beaver Creek	1	0.44	0.10	43.4
HZ-4	Unnamed spring	1	0.39	0.08	34.1
HZ-5	Unnamed spring	1	--	--	1[b]
HZ-6	SP-9 tributary	1	0.41	0.08	37.7
HZ-7	Beaver Cr. at SS-7	1	0.61	0.19	83.5
HZ-8	Beaver Cr. - south split	1	0.16	0.01	5.7
HZ-9	Beaver Cr. - north split	4	0.30	0.19	84.0
HZ-10	Beaver Cr. by LMC-1	4	0.37	0.28	127.7
HZ-11	Beaver Cr. by HZ-95-1	4	0.36	0.27	120.9
HZ-12	Beaver Cr. at SS-8	4	0.35	0.25	114.3
HZ-13	Beaver Cr. at road crossing	4	0.29	0.17	78.5

(a) All measurements collected on September 11, 1996 using a portable cutthroat flume.

(b) Estimate based on visual observation

table 7-1b

TABLE 7-1b

SUMMARY OF BEAVER CREEK GAIN/LOSS MEASUREMENTS

Reach No.[a]	Upstream Station(s)	Upstream Flow (gpm)	Downstream Station	Downstream Flow (gpm)	Gain/Loss (gpm)	Distance (ft)	Unit Gain/Loss (gpm/100 ft)	Remarks
1	HZ-1, HZ-2, HZ-4, HZ-5	50.6	HZ-3	43.4	-7.2	2300	-0.3	
2	HZ-3, HZ-6	81.1	HZ-7	83.5	+2.4	2850	+0.1	Approx. 1.5 gpm est. inflow observed on surface
3	HZ-7	83.5	HZ-8, HZ-9	89.7	+6.2	1850	+0.3	Downstream from extensive area of abandoned beaver ponds. Broad area of alluvium.
4	HZ-8, HZ-9	89.7	HZ-10	127.7	+38.0	2300	+1.7	Canyon bottom narrows significantly. Limited alluvium.
5	HZ-10	127.7	HZ-11	120.9	-6.8	2100	-0.3	Up- and downstream from HZ-95-1 fracture area.
6	HZ-11	120.9	HZ-12	114.3	-6.6	1750	-0.4	Approx. 0.5 gpm est. inflow observed on surface
7	HZ-12	114.3	HZ-13	78.5	-35.8	1650	-2.2	Colluvium from Castlegate Sandstone more prevalent.

[a] See Figure 7-4b

figure 7-4a

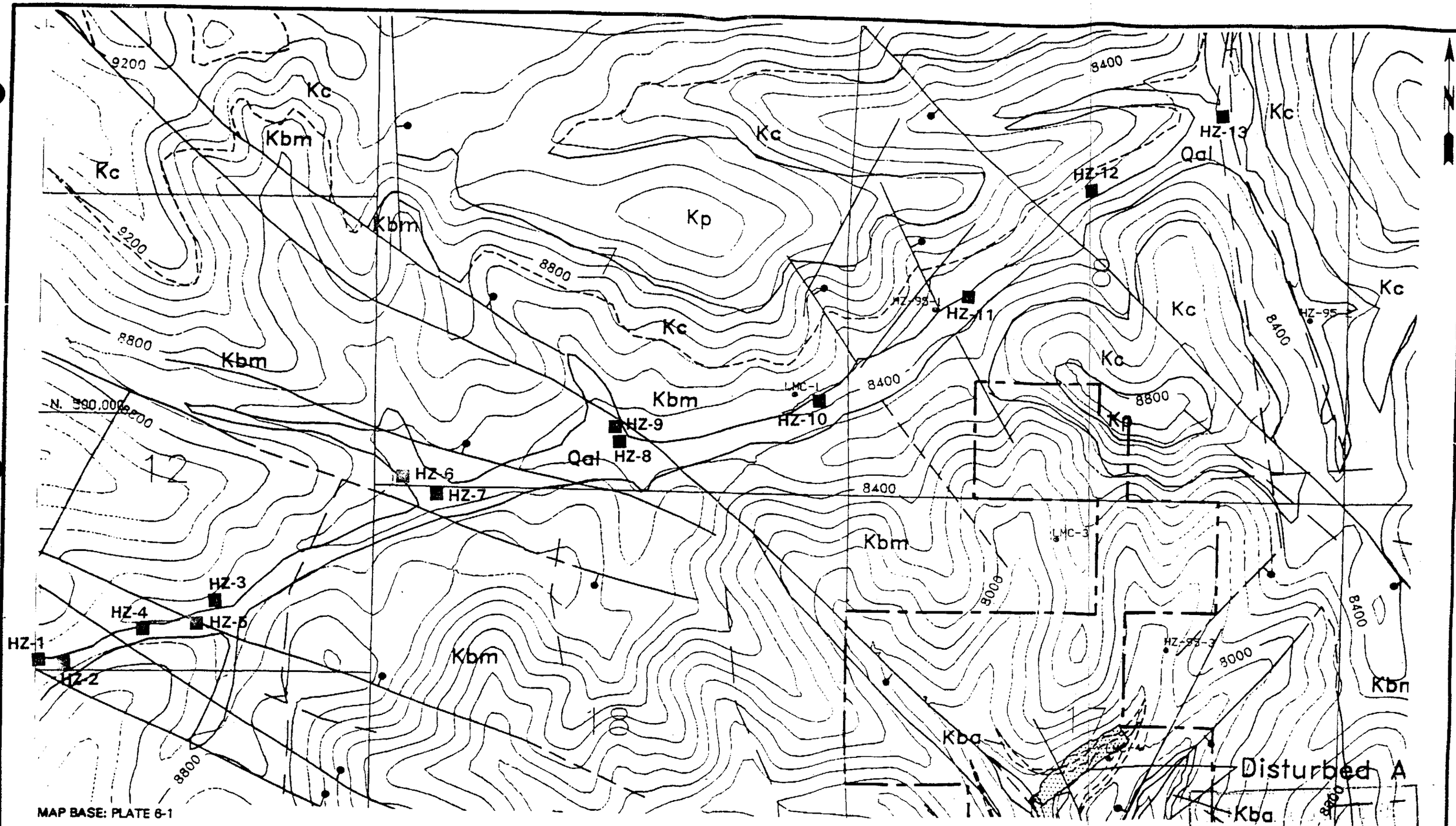


FIGURE 7-4A. LOCATIONS OF SEEPAGE MEASUREMENTS.

figure 7-4b

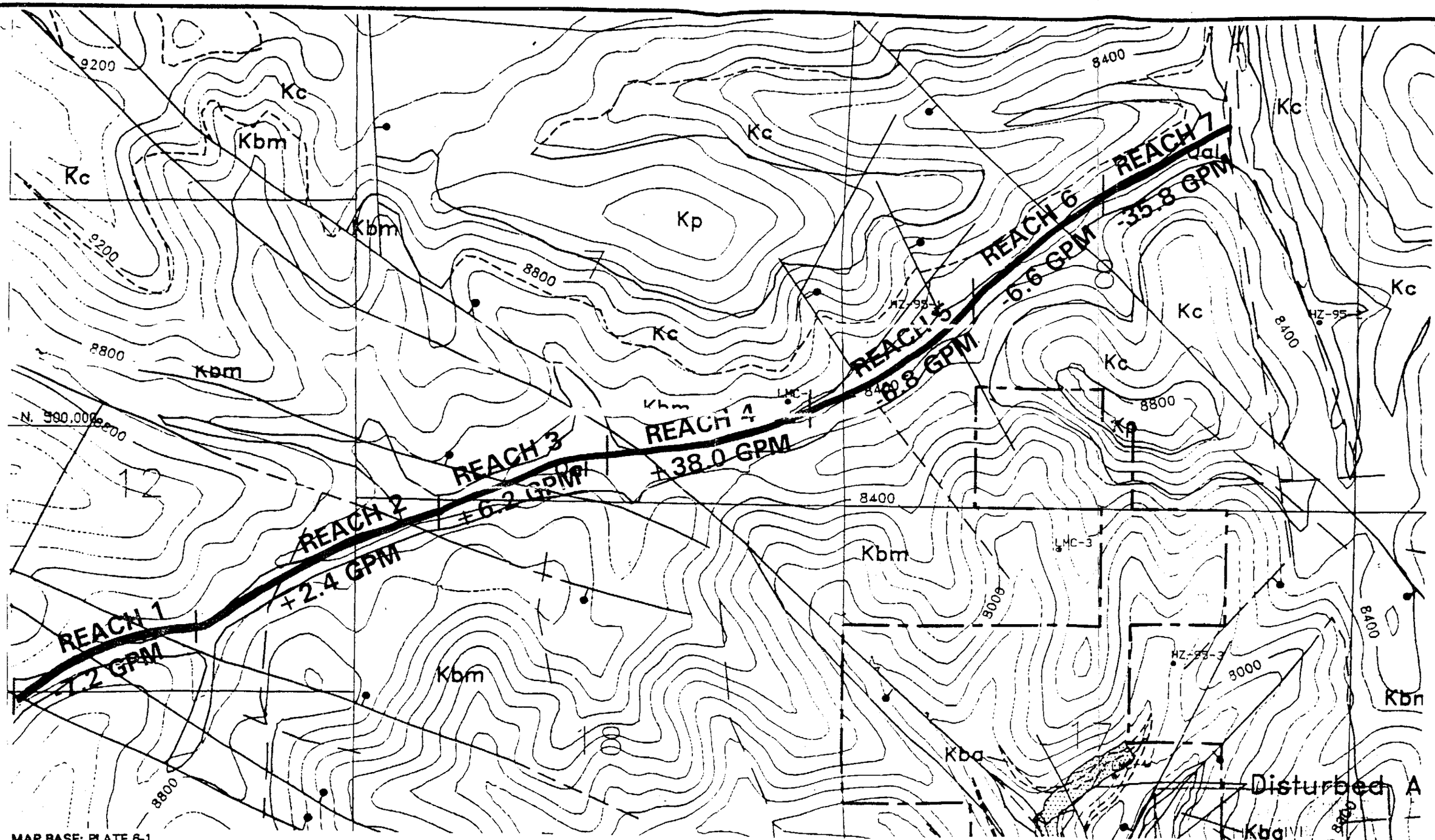


FIGURE 7-4B. SUMMARY OF SEEPAGE MEASUREMENTS.

surface into the fractures. The head difference in the flumes at the stations marking the up-and downstream ends of Reaches 5 and 6 was only 0.01 foot (see Table 7-1a). These insignificant decreases in head could easily have resulted from measurement error as opposed to actual streamflow losses. Hence, losses into the fractures in these reaches are considered insignificant.

The loss in Reach 7 was measured at 35.8 gpm. The Castlegate Sandstone outcrops in the stream bottom a short distance downstream from this reach. Alluvium in the stream bottom within Reach 7 appears to have been influenced by erosion of the nearby Castlegate Sandstone. Hence, it is likely that the loss in Reach 7 is a result of seepage into the coarser alluvium that typifies that reach.

Upstream from Reach 7 (where stratigraphic changes have likely affected the characteristics of the alluvium), the net seepage within the Beaver Creek system is a gain of 26.0 gpm. Together with the insignificant changes in streamflow noted in Reach 5 (where the shallow and deeper bedrock is known to be fractured as demonstrated by data collected from monitoring wells HZ-95-1 and HZ-95-1S), these data indicate that Beaver Creek is not hydraulically connected to bedrock aquifers that underlie the creek.

7.1.3 Water Quality

Groundwater from the Upper Cretaceous sediments in the Wasatch Plateau is characterized by total dissolved solids (TDS) contents of less than 1,000 milligrams per liter (mg/1) (Waddell et al., 1981). The following range of TDS concentrations have been measured in springs, wells, and mines issuing from or completed in formations found in the permit and adjacent areas, as reported for the Wasatch Plateau and the Book Cliffs areas by Waddell et al. (1981):

- Price River Formation 122-792 mg/l
- Castlegate Sandstone 315-806 mg/l
- Blackhawk Formation 63-796 mg/l
- Star Point Sandstone 335-391 mg/l

Groundwater quality data have been collected from the permit and adjacent areas since 1989 when sample sites were accessible. Prior to 1996, these data were generally collected in accordance with UDOGM guidelines published in 1986. Beginning in 1996, data have been collected, where feasible, in accordance with UDOGM guidelines published in April 1995. The data collected from the monitored sites, together with tables outlining the parameters which have been monitored, are presented in Appendix 7-2.

Data contained in Appendix 7-2 indicate that the TDS concentration of water issuing from spring SP-1 has typically varied from about 230 to 330 mg/l. At SP-2, these concentrations have generally varied from about 480 to 540 mg/l. The TDS concentrations of water issuing from SP-4 has typically varied from approximately 350 to 480 mg/l. The pH of water issuing from these spring is generally slightly alkaline (typical pH range of 7.5 to 8.5). Each of these springs issue from the Blackhawk Formation.

Results of chemical analyses of water collected from springs SP-1, 2, and 4 indicate that the groundwater in the area is a calcium bicarbonate type as illustrated in the Stiff diagrams included Appendix 7-2. Concentrations of the major cations and anions as well as TDS concentrations in the water discharged from these springs appears to have shown a general negative correlation with flow rate (i.e., lower concentrations at higher flows) since monitoring began in 1989.

Data collected by others from SP-9 (Jewkes Spring - see Appendix 7-2) indicate that water issuing from this spring typically has a TDS concentrations which varies from 240 to 300 mg/l. As with the other springs monitored in the permit area which issue from the Blackhawk Formation, this water is a calcium bicarbonate type. Concentrations of TDS and major ions tend to vary inversely with flow rate. Similar to other springs in the permit area issuing from the Blackhawk Formation, the pH of water issuing from SP-9 is generally slightly alkaline (typical pH range of 7.5 to 8.5)

Two samples (one in May 1992 and one in November 1995) have been collected of water standing on the floor of the old Blue Blaze No. 1 Mine approximately 440 feet into the old mine workings. Results of chemical analyses of these water samples are provided in Appendix 7-2. The total dissolved solids concentrations of these samples ranged from 414 to 452 mg/l (i.e., within the range noted for springs issuing from the Blackhawk Formation in the permit and adjacent areas). Similar to springs in the area, this water is a calcium bicarbonate type. The pH of this water has varied from 6.80 to 7.66.

Also included in Appendix 7-2 are the results of analyses of water-quality samples collected from monitoring wells HZ-95-1, HZ-95-2, and HZ-95-3 in December 1995, November 1995, and January 1996, respectively. Although these samples may still have been somewhat affected by the foam drilling fluid used during installation of the holes, the data indicate that the TDS concentration of water encountered in the monitoring wells ranges from 380 to 680 mg/l. Water quality data from the LMC wells have not been collected since these holes have been dry during the period of monitoring.

During the monitoring of wells HZ-95-2 and HZ-95-3 in September through December of 1996, HZ-95-2 fluctuated 0.3 feet and HZ-95-3 raised from 7513.8 to 7522.0 feet. HZ-95-1 and HZ-95-1S were monitored in September, October, November of 1996 and January of 1997. HZ-95-1's water level dropped 7 feet between September and November and rose approximately 5 feet between November 1996 and January 1997. HZ-95-1S remained constant September through November, but dropped 0.5 feet between November and January. These readings are more closely related to the seasonal fluctuation than the measurement taken directly after the completion of the wells.

7.1.4 Water Rights

The use of water in the Gordon Creek area is almost exclusively for stock watering. No groundwater rights have been filed by Horizon; however, water is leased (see Appendix 3-5). This lease involves water right 91-330 (underground water from the former Sweet Coal Mine) as well as water rights 91-94 and 91-353 (covering different time periods from the same

unnamed spring). A change-in-point-of-diversion application has been filed with the Division of Water Rights for use of this water within the permit area (see Appendix 3-5). A right for the evaporative loss of water from Sweet's Pond (91-4956) has also been assigned to Horizon Coal by agreement (see Appendix 3-5). The applications for change-in-point-of-diversion were approved on November 20, 1996 by Robert L. Morgan, P.E., Utah State Engineer for water rights 91-330, 91-94 and 91-353. Horizon will inform UDOGM if the change in point of diversion is altered in the future.

It should be noted that the change-in-point-of-diversion which has been filed on water right 91-330 would permit use of the water where it is encountered within the proposed Horizon No. 1 Mine workings. This water will not be diverted from the former Sweet Coal Mine workings into the Horizon No. 1 Mine.

Locations of water rights within the permit and surrounding areas are shown on Plate 7-3. Data contained in Appendix 3-5 indicate that water rights have been filed on a limited number of springs in the permit and adjacent areas. Legal rates of usage of spring water are all less than 0.25 cfs.

No water rights exist within the permit and adjacent areas for water wells. However, rights exist for the use of water from several springs in the permit and adjacent areas. Typically, these rights are for the use of less than 5 gallons per minute of water from springs issuing from the Blackhawk Formation. As noted above, this formation is not considered to be an extensive aquifer within the permit and adjacent areas. Water in this formation issues from perched aquifers of limited areal extent. This accounts for the low flow and usage rates of the springs.

One right exists within the adjacent area for the use of water encountered in underground coal mining operations (File No. 91-330 in the name of Florence A. Sweet). Horizon has leased this water right from Florence A. Sweet and requested change of diversion to water anticipated within the Horizon No. 1 Mine.

7.1.5 Groundwater Monitoring Plan

Monitoring points SP-1, 2, and 4, as shown on Plate 7-1, have been monitored for baseline information since 1989. SP-9 (Jewkes Spring) was monitored by the U.S. Geological Survey during the period of 1979 through 1983 and by Beaver Creek Coal Company from 1985 through 1995.

Groundwater monitoring during operation of the mine will be conducted in accordance with UDOGM regulation R645-301-723 and will consist of the following: collection of flow and water-quality data from springs SP-1, 2, 4, 9, 2-6-W (Homestead Spring) and GV-70; collection of flow and water-quality data from sustained inflows to the mine and mine water discharge quantities (temporary or permanent); and collection of water-level data from the HZ monitoring wells. Temporary mine discharge quantities will be reported monthly and submitted to UDOGM with quarterly monitoring data. Reports will contain the period of pumping (i.e. 6:15 a.m. to 7:30 p.m.) and the daily flow rate, until a continuous flow

meter/guage is installed. Refer to Section 7.2.3.2 for a discussion of temporary mine water discharge monitoring. A continuous flow meter was installed in 2001 and has been used to report mine discharge quantities since that time.

Each of the springs to be monitored issue from portions of the Blackhawk Formation which are stratigraphically higher than the Hiawatha coal seam. Therefore, data collected from the springs will allow quantification of potential impacts to perched aquifers within the permit and adjacent areas of both the initial permit term and future permit terms. Spring SP-2 is within approximately 400 feet of the initial planned workings and in an area which overlies future workings (see Plate 3-3). Springs SP-1, SP-4, and GV-70 are in an area which lies within 200 to 700 feet of proposed future workings. These distances are all within the zone of potential subsidence as defined in Section 3.4.8.5. Hence, data collected from these springs will assist in determining the impacts of subsidence on the groundwater resources of the Blackhawk Formation.

Springs SP-9 and 2-6-W lie approximately 1800 feet and 4900 feet southwest of the proposed future mine workings. As a result, they are in areas which will not likely be impacted by subsidence effects (see Section 3.4.8.5). Hence, these springs will be monitored to provide background data on groundwater conditions within the Blackhawk Formation in areas that will not likely be impacted by mining.

During the operational and reclamation phases of the mine, the above-noted springs will be monitored once each calendar quarter when the springs are accessible. The data to be collected from these springs are listed in Table 7-2. Monitoring data will be reported to the Division on a quarterly basis.

Sampling of springs CC-5 and MC-4 will begin in 1997 and continue through 1999. If requested by UDOGM the sampling may continue beyond 1999. CC-5 and MC-4 will be sampled quarterly and analyzed for calcium, magnesium, sodium, potassium, carbonate, TDS, sulfate, and chloride. Flow, pH and conductivity data will also be collect for springs CC-5 and MC-4. The data from the analyses will be included in Appendix 7-2.

Data collected from mine inflows will allow impacts to be quantified to all hydrologic resources that are affected by mine dewatering. Changes in the quantity and quality of mine inflows will be evaluated with the additional groundwater data to assess the overall hydrologic impacts of the mining operation.

Data collected from the HZ wells will allow quantification of potential impacts to the regional groundwater system. Specifically, data collected from wells HZ-95-1 and HZ-95-1S will assist in evaluating the impacts of mine dewatering on the quantity of groundwater in the Blackhawk Formation and the underlying Spring Canyon tongue. This will be particularly helpful in estimating potential future impacts as the mining operation expands to the northwest beneath Beaver Creek.

Data collected from HZ-95-2 will allow quantification of impacts to groundwater in the Spring Canyon tongue outside of the assumed adjacent area. Furthermore, if impacts are noted to water levels at the location of HZ-95-2, these data may provide information regarding the extent of the hydraulic connection across the northeast boundary fault. Finally, since HZ-95-3 is located near

the initial mine workings, data collected from this location will allow early assessments of mining impacts to be made. Monitoring Well HZ-01-06-1 was installed in November 2001 to monitor the effects of mining on the potentiometric surface in the Spring Canyon Sandstone at the northern extents of the permit area.

Representative points of inflow will then be selected based on the source or the areal zone, and samples will be collected from those representative points for analyses in accordance with Table 7-2. The sampling will continue once each quarter as long as the inflow point remains accessible during mining operations or until the flow diminishes. Data will be collected as close to the point of issuance as possible to prevent contamination by mining operations.

Sampling information for in-mine water flow was collected at the locations noted on Plate A, Appendix 7-2, Attachment A and Plate 7-1. The analyzes associated with the samples are included in Appendix 7-2, Attachment A. Additional sampling for TSS was requested by Utah Division of Water Quality, these analyzes are also included in Attachment A.

The in-mine water pumped and discharged to the surface was measured daily when personnel were at the mine (Appendix 7-2, Attachment A, Horizon In-Mine Water Log, 1998 - 1999). Other days, such as weekends and holidays the flow was estimated. The flow was measured as the water exited through a pipe or a weir and collected in a bucket.

The Horizon In-Mine Water Log, 1998 - 1999 shows the flow in gallons per minute. Empty boxes in the chart signify no discharge of in-mine water. See annual reports for additional pumping data.

Discharge water from the mine will be treated in underground sumps, to meet effluent limitations. Discharged water will be monitored as described above and in accordance with the discharge permit issued by the Division of Water Quality (Appendix 3-6).

While sampling the HZ wells immediately after drilling, each well was pumped for a period of 2 to 4 weeks, during which time the wells were repeatedly pumped dry and allowed to recover. The samples were collected at the end of the above periods. Given the fact that the wells still appeared to be influenced by foam drilling fluids when sampled (based on pH, discoloration, etc) and the fact that sampling required an extended period of time due to the low yield of the wells, future sampling of the wells for water-quality analyses is not proposed. Rather, data collected from the wells in the future will consist solely of water-level information. Springs and mine-water inflows will be used to monitor changes in water quality within the permit and adjacent areas.

Water-level data will be collected during the operational and reclamation phases from the HZ wells once each quarter when accessible. All water-level measurements will be corrected to depth from top of 2" casing to permit correlation with previous measurements. ~~Horizon commits to discuss with UDOGM a more stringent monitoring program for well HZ-95-1 prior to entering the northernmost mining block in Section 8.~~

Data collected from the springs to be monitored (SP-1, SP-2, SP-4, SP-9, 2-6-W, and GV-70) will provide information on the potential impacts of mining activities on localized aquifers. Similar information will be obtained by monitoring sustained inflows to the mine workings. Data obtained

from the HZ monitoring wells will assist in evaluating potential losses of groundwater from the Blackhawk/Star Point aquifer system.
table 7-2

Once every five years, during the low-flow season of the year (i.e., late summer or early autumn), each monitored spring and mine-inflow point will be sampled for baseline parameters. This list of parameters is the same as that provided in Table 7-2 plus the following:

Acidity	Molybdenum (dissolved)
Aluminum (dissolved)	Ammonia
Arsenic (dissolved)	Nitrate
Boron (dissolved)	Nitrite
Cadmium (dissolved)	Phosphate (ortho)
Copper (dissolved)	Selenium (dissolved)
Lead (dissolved)	Zinc (dissolved)

By the end of each month following each calendar quarter (i.e., April 30, August 31, October 31, and January 31), a report will be submitted to the Division summarizing monitoring activities during the previous quarter. Annual reports summarizing monitoring activity will also be submitted to the UDOGM. Quarterly reports will include field measurements, observations, and analytical results received during the previous quarter. Annual reports will include field measurements, observations, and analytical results received during the entire year. If any data indicate non-compliance with permit conditions, Hidden Splendor Resources will promptly notify the Division and take appropriate actions as provided for in R645-300-145 and R645-301-731.

7.1.6 Mitigation and Control Plan

As noted in Section 7.3 of this permit application, Horizon does not foresee any significant impacts to groundwater as a result of mining in the permit area. Inflows to the mine are anticipated to be small. A more complete discussion of potential groundwater impacts and mitigation measures is provided in Sections 7.3 and 3.4.8.2. Should a perennial or intermittent water resource be impacted by mining activities, both UDOGM and Water Rights will be contacted. Approval for a site-specific mitigation plan will be received from UDOGM and Water Rights prior to implementation of the plan.

7.2 Surface Water Hydrology

Scope

Surface water hydrology information has been assembled to satisfy regulations set forth by UDOGM for the Horizon No. 1 Mine. A description of the baseline information for the existing resources, as well as a discussion of the runoff control plans for operations and reclamation, are provided below.

For the purpose of clarification, the following creek and drainage names will be used in this permit application. The confusion was prompted by the previous applicant's use of names familiar to the populous of the area and not the names of waterways used by the USGS on their 7.5 minute Quads. The new names will be used on all plates in the current submittal.

PREVIOUS NAME	NEW NAME
Gordon Creek	North Fork Gordon Creek
North Fork Gordon Creek	Jewkes Creek
Right Fork North Fork Gordon Creek	Portal Canyon Creek
Right Middle Fork North Fork Gordon Creek	Spring Two Canyon Creek

7.2.1 Methodology

The baseline hydrologic study was based on review of literature and available data obtained from the U.S. Geological Survey, the U.S. Forest Service, the State of Utah, Beaver Creek Coal Company, Blue Blaze Coal Company, and mine permit applications for the surrounding mines. A field reconnaissance was performed to confirm the location and characteristics of surface water courses, springs, and seeps.

7.2.2 Existing Surface Water Resources

7.2.2.1 Regional Surface Water Hydrology

Most of the regional area is drained by tributaries to the Green and Colorado Rivers. The principal tributaries in the region are the Price and San Rafael Rivers and Muddy Creek. The Green River flows through the eastern edge of the Central Utah region.

The U.S. Geological Survey completed a report entitled "Hydrologic Reconnaissance of the Wasatch Plateau - Book Cliffs Coal Field Area, Utah" which considers the development of coal resources in central Utah (Waddell et al., 1981). The Horizon No. 1 Mine lies within the study area near the headwaters of tributaries to the Price River.

Approximately 50 to 70 percent of the stream flow in the region occurs during the May-July snowmelt runoff period (Waddell et al., 1981). Summer precipitation usually results in minor amounts of runoff. Intense convective rainfall during the summer period may cause short duration, high intensity runoff in localized areas.

Water quality in the Price River and its tributaries can be classified as good at the higher elevations, with TDS concentrations of 250 mg/1 and below. As is the case with springs in the area, these surface waters tend to be a calcium bicarbonate type. At lower elevations below diversions, the water changes to a sodium sulfate type with dissolved solids ranging from 2,500 to more than 6,000 mg/1 (Waddell et al., 1981). These changes are caused by leaching of salts from irrigation return flows and natural runoff from areas underlain by Mancos Shale.

7.2.2.2 Mine Plan Area Surface Water Hydrology

Stream Flow

The three principal surface water courses found within and adjacent to the mine permit area are Beaver Creek to the north of the permit area, Jewkes Creek through the center of the property, and North Fork Gordon Creek to the south of the property (Plate 7-2).

Beaver Creek is a perennial stream that flows immediately north of the permit area. Perennial flow is maintained by small seeps and springs. One of the contributing springs, the Homestead Spring (labeled as 2-6-W on Plate 7-1), is an area of seeps located in a small tributary to Beaver Creek in the SW¼ NE¼ Sec. 13, T. 13 S., R. 7 E. (approximately 1.5 miles west of the permit area). Past measurements collected by Beaver Creek Coal Company personnel have indicated that this spring discharges from 3 to 136 gallons per minute, with the higher flow rates in June including surface runoff from snowmelt conditions.

Jewkes Spring (noted above in Section 7.1.2.2 as monitoring station SP-9) is located near the Beaver Creek stream channel in the SW¼ SW¼ Sec. 7, T. 13 S., R. 8 E., approximately 1 mile west of the permit area (see Plate 7-1). With the exception of a spurious measurement in July 1985 (see Section 7.1.2.2), discharges from this spring have generally varied during the period of record from about 1 to 40 gpm, with no observable flow during drought periods.

The general flow direction of Beaver Creek is to the northeast toward the Price River. The drainage pattern in the upper portions of the Beaver Creek basin near the permit area is dendritic. This drainage pattern is detailed on Plate 7-2. The valley profile is not as steep as the North Fork of Gordon Creek.

The USGS formerly maintained a gauging station near the mouth of Beaver Creek (Station No. 09312700) approximately 9 miles northeast of the permit area. During the 29-year period of record from October 1960 to October 1989, the minimum annual discharge of 254 acre-feet occurred during water year 1981. The maximum annual discharge of 9,950 acre-feet occurred two years later in water year 1983 (Appendix 7-7). The average annual discharge of Beaver Creek at the USGS monitoring station during the 29-year period of record has been 3,310 acre-feet.

The annual variability of flow in Beaver Creek can be seen by the fact that the annual maximum and the annual minimum during a 29-year period of record were separated by only two years. This variability is also evident in the high coefficient of variation for the station (74 percent).

Stream flow at the Beaver Creek USGS station was typically highest in the spring and early summer (April through June, as a result of snow melt) and lowest during the autumn and winter months. Occasional late summer rapid increases in flow were also observed, probably as a result of summer thunderstorms. Several days of no flow were also reported during the period of record (mostly in the winter and late summer).

Jewkes Creek, an intermittent stream, drains a small basin with a drainage area slightly greater than 1 square mile. This watershed drains much of the permit area. Jewkes Creek empties into North Fork of Gordon Creek in the SE¼ SW¼ Sec. 17, T. 13 S., R. 8 E. The channel gradient of Jewkes Creek is relatively uniform across the coal lease property. The canyon sides are steep and rocky. The characteristics of the channel and valley are indicative of a stream in a youthful stage of development.

The flow data presented in Appendix 7-3 indicate that Jewkes Creek occasionally ceases flowing at station SS-3 even though it continues to flow (albeit at low rates) at the upstream station (SS-5). Although no observations have been made in the field regarding the re-emergence of this water, it likely continues to contribute to the baseflow of North Fork of Gordon Creek, given the fact that the Mancos Shale outcrops a short distance downstream from the permit area, which outcrop should force baseflow in the alluvium to the surface.

A small drainage discharges into Jewkes Creek from the northeast in SE¼ SW¼ Sec. 17, T. 13 S., R. 8 E. In this report this drainage is referred to as Portal Canyon Creek (Plate 7-2). This canyon will contain the mine facilities and surface operations.

North Fork Gordon Creek flows along County Road 290 southeast of the permit area. The elevation of the creek is lower than the Hiawatha coal seam, the lowest minable seam in the area. Proposed mining operations will occur north of the creek and should not significantly affect the quantity or quality of the flow in North Fork Gordon Creek (see Section 7.3 of this permit application).

Stream locations from which samples have been collected within the permit and adjacent areas are noted on Plate 7-1. Stations SS-3 and SS-5, located on Jewkes Creek down- and upstream from the proposed surface facilities, respectively, have been monitored from 1989 through the present. Stations SS-7 and SS-8, located on Beaver Creek north of the permit area, have been monitored from 1991 through the present. Stations SS-10 (Unnamed Tributary) and SS-11 (Sand Gulch) were monitored beginning in May of 1996. Data collected from these stations are provided in Appendix 7-3.

It should be noted that previous sampling efforts have referred to the surface-water sampling stations within the permit and adjacent areas as Station No. 3, Station No. 5, Station No. 7, and Station No. 8. These locations are now referred to as SS-3, SS-5, SS-7, and SS-8. The change in terminology for these stations has been made solely to enable easier identification and discussion in this permit application.

Stream flow within the permit and adjacent areas is typical of the region, with maximum stream flows typically occurring the late spring and early summer as a result of snow melt runoff. Flows decrease significantly during the autumn and winter months, with Jewkes Creek and Beaver Creek both having experienced no flow during the period of record (primarily in the winter and late summer months).

The flow of Jewkes Creek diminishes in a downstream direction, as measured at sample points SS-3 and SS-5 in September 1990, August and September 1991, and August through December

1992. After passing sampling point SS-5, the channel become less defined and meanders though a 50-foot wide area, where the flow infiltrates into the alluvium. This flow does not apparently reappear immediately downstream from SS-3. However, given the presence of the impermeable Mancos Shale in the stream bed of North Fork Gordon Creek approximately one-half mile downstream from the proposed surface facilities (Hansen, 1988), it is likely that the stream flow reappears within North Fork Gordon Creek. Graphs illustrating the flows measured at the monitoring stations within the permit and adjacent areas are included in Appendix 7-3.

Downstream decreases in flow have also been observed in Beaver Creek between monitoring stations SS-7 and SS-8. This situation is most prevalent during the low-flow season. However, during periods of high flow, discharge rates have been observed to be occasionally higher at the upstream station (SS-7) as compared with the downstream station (SS-8). The reasons for these variations are not yet clear.

Surface Water Quality

Surface-water quality data have been collected from the permit and adjacent areas since 1989 when sample sites were accessible. Prior to 1996, these data were generally collected in accordance with UDOGM guidelines published in 1986. Beginning in 1996, data have been collected, where feasible, in accordance with UDOGM guidelines published in April 1995. The data collected from the monitored sites, together with tables outlining the parameters which have been monitored, are presented in Appendix 7-3.

The Price River and its tributaries from the confluence with Green River to Castle Gate, are classified 3C and 4. This reach includes the flows from Gordon Creek and its tributaries. Class 3C means that the particular stream is protected for non-game fish and other aquatic life, and Class 4 means that the stream is protected for agricultural use. Tables 7-3 and 7-4 list numerical standards for both of these classes.

Beaver Creek is included in the classifications for the Price River and tributaries from Castle Gate to it's headwaters. These are 1C (protected for domestic use with prior treatment), 3A (agricultural). Tables 7-3 and 7-4 list numerical standards for classes 1C and 3A.

Baseline sampling point locations are shown on Plate 7-1. Station SS-3 is located upstream of the intersection of Jewkes Creek and North Fork of Gordon Creek and below the proposed surface facilities. Sampling point SS-5 is located immediately upstream from the proposed surface facilities, just downstream from the confluence of Spring Two Canyon and Jewkes Creek. Station SS-7 is located on Beaver Creek upstream from potential future expansions of the permit area. Sampling point SS-8 is also located on Beaver Creek but downstream of potential future expansions of the permit area. The water quality data that have been collected at these sites is included in Appendix 7-3.

table 7-3

TABLE 7-3

NUMERIC CRITERIA FOR AQUATIC WILDLIFE

Parameter	Aquatic Wildlife 3A	3B	3C	3D
PHYSICAL				
Total Dissolved Gases	(1)	(1)		
Dissolved Oxygen (mg/l) (2)				
30 Day Average	6.5	5.5	5.0	5.0
7 Day Average	9.5/5.0	6.0/4.0		
1 Day Average	8.0/4.0	5.0/3.0	3.0	3.0
Max Temperature °C	20	27	27	
Max Temperature Change °C	2	4	4	
pH (Range)	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0
Turbidity Increase NTU	10	10	15	15
Metals (3) Dissolved (ug/l) (4)				
Arsenic (Trivalent)				
4 Day Average	190	190	190	190
1 Hour Average	360	360	360	360
Cadmium (5)				
4 Day Average	1.1	1.1	1.1	1.1
1 Hour Average	3.9	3.9	3.9	3.9
Chromium (Hexavalent)				
4 Day Average	11	11	11	11
1 Hour Average	16	16	16	16
Chromium (Trivalent (5)				
4 Day Average	210	210	210	210
1 Hour Average	1700	1700	1700	1700
Copper (5)				
4 Day Average	12	12	12	
1 Hour Average	18	18	18	18
Cyanide (Free)				
4 Day Average	5.2	5.2	5.2	
1 Hour Average	22	22	22	22
Iron (Maximum)	1000	1000	1000	1000
Lead (5)				
4 Day Average	3.2	3.2	3.2	3.2
1 Hour Average	82	82	82	82
Mercury				
4 Day Average	0.012	0.012	0.012	0.012
1 Hour Average	2.4	2.4	2.4	2.4

TABLE 7-3 (Continued)

NUMERIC CRITERIA FOR AQUATIC WILDLIFE

Parameter	Aquatic Wildlife 3A	3B	3C	3D
Nickel (5)				
4 Day Average	160	160	160	160
1 Hour Average	1400	1400	1400	1400
Selenium				
4 Day Average	5.0	5.0	5.0	5.0
1 Hour Average	20	20	20	20
Silver				
4 Day Average	0.12	0.12	0.12	0.12
1 Hour Average	4.1	4.1	4.1	4.1
Zinc (5)				
4 Day Average	110	110	110	110
1 Hour Average	120	120	120	120
INORGANICS (mg/l) (3)				

table 7-4

TABLE 7-4

NUMERIC CRITERIA FOR DOMESTIC, RECREATION, AND AGRICULTURAL USES

Parameter	Domestic Source	Recreation and Aesthetics		Agriculture
	1C	2A	2B	4
BACTERIOLOGICAL (30 DAY GEOMETRIC MEAN) (#/100 ml)				
Max Total Coliforms	5000	1000	5000	
Max. Fecal Coliforms	2000	200	200	
PHYSICAL				
Min. Dissolved Oxygen (mg/l)	5.5	5.5	5.5	
pH (Range)	6.5 - 9	6.5 - 9	6.5-9	6.5-9
METALS (ACID SOLUBLE) MAX. (mg/l)(2)				
Arsenic	0.05			0.1
Barium	1.0			
Cadmium	0.01			0.01
Chromium	0.05			0.10
Copper				0.2
Lead	0.05			0.1
Mercury	0.002			
Selenium	0.01			0.05
Silver	0.05			
INORGANICS (MAX.) (mg/l)				
Boron				0.75
Fluoride	1.4 - 2.4			
Nitrates as N	10			
Total Dissolved Solids (4)				1200
RADIOLOGICAL (MAX. pCi/L)				
Gross Alpha	15			15
Radium 226, 228 (combined)	5			
Strontium 90	8			
Tritium	20000			
ORGANICS (MAX. ug/l)				
Chlorophenoxy Herbicides				
2,4-D	100			
2,4,5-TP	10			
Endrin	0.2			
Hexachlorocyclohexane	4			
Methoxychlor	100			
Toxaphene	5			

TABLE 7-4 (Continued)

NUMERIC CRITERIA FOR DOMESTIC, RECREATION, AND AGRICULTURAL USES

Parameter	Domestic Source	Recreation and Aesthetics		Agriculture
	1C	2A	2B	4
POLLUTION INDICATORS (5)				
Gross Beta (pCi/L)	50			50
BOD (mg/l)		5	5	5
Nitrate as N (mg/l)		4	4	
Phosphate as P (mg/l)(6)		0.05	0.05	

The data contained in Appendix 7-3 indicate that the TDS concentration of water in Jewkes Creek is typically 300 to 500 mg/l. Iron concentrations are generally less than 1 mg/l, while manganese concentrations are typically less than 0.1 mg/l. Total suspended solids concentrations have varied from <1 to 245 mg/l during the period of record. The pH of water in Jewkes Creek generally varies from 8.0 to 8.6.

The water in Jewkes Creek is typically a calcium bicarbonate type. In general, the concentrations of dissolved constituents are inversely proportional to flow, while the concentrations of total constituents are directly proportional to flow. Hence, the concentrations of total dissolved solids tend to be lowest in the late spring and highest in the autumn and winter months, while total suspended solids concentrations tend to be highest in the late spring and lowest in the autumn and winter months.

Water in Beaver Creek tends to have a low TDS concentrations than in Jewkes Creek. Data contained in Appendix 7-3 indicate that the TDS concentration of Beaver Creek near the permit area typically varies from about 200 to 350 mg/l. Similar to Jewkes Creek, iron and manganese concentrations in Beaver Creek are generally less than 1 mg/l and 0.1 mg/l, respectively. Total suspended solids concentrations in Beaver Creek have varied from <1 to 297 mg/l. The pH of water in Beaver Creek typically varies from 7.5 to 8.5.

As with Jewkes Creek, the water in Beaver Creek is typically a calcium bicarbonate type. As also noted at Jewkes Creek, the concentrations of dissolved constituents tend to be inversely proportional to flow, while the concentrations of total constituents tend to be directly proportional to flow.

7.2.2.3 Surface Water Monitoring Plan

In the Horizon No. 1 Mine area, Beaver Creek and North Fork Gordon Creek are perennial streams. Jewkes Creek is an intermittent stream. Both Portal Canyon and Spring Two Canyon are ephemeral streams, flowing primarily in response to snow-melt and runoff from thunderstorms. Since these ephemeral streams are usually dry, no monitoring points have been established thereon.

Surface-water monitoring within the permit and adjacent areas will be performed in accordance with R645-301-723. As noted in Section 7.2.3.2, Horizon will install silt fences (see Figure 7-5), containment berms, and straw-bale dikes during construction to minimize the potential for sediment to be discharged to local stream channels. To assist in monitoring the effectiveness of these sediment-control measures, samples will be collected on a weekly basis during construction from Jewkes Creek up- and downstream from the construction area (at the approximate locations of stations SS-5 and SS-3, respectively). These samples will be analyzed in the field for turbidity.

Stations SS-3, SS-5, SS-7, SS-8, SS-10, and SS-11 will be monitored once each calendar quarter (as access conditions permit) during the operational and reclamation periods. Data will be collected from these stations in accordance with Table 7-5. Stations SS-3 and SS-5 are

Table 7-5

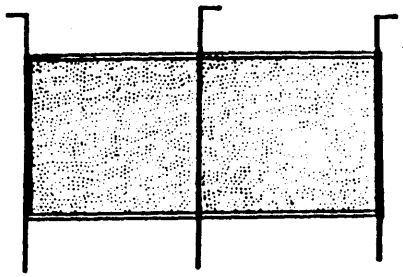
TABLE 7-5

OPERATIONAL AND RECLAMATION PERIOD
SURFACE WATER MONITORING PARAMETERS

Field Parameters	
Flow (gpm)	pH (standard units)
Specific Cond. (µmhos/cm @ 25 °C)	Temperature (°C)
Dissolved Oxygen (mg/l)	
Laboratory Parameters (mg/l)	
Total Dissolved Solids	Total Settleable Solids
Total Suspended Solids	Total Hardness (as $CaCO_3$)
Bicarbonate	Carbonate
Calcium (dissolved)	Chloride
Iron (dissolved)	Iron (total)
Magnesium (dissolved)	Manganese (dissolved)
Manganese (total)	Potassium (dissolved)
Sodium (dissolved)	Sulfate
Oil & Grease	Cations (meq/l)
Anions (meq/l)	Alkalinity (total)

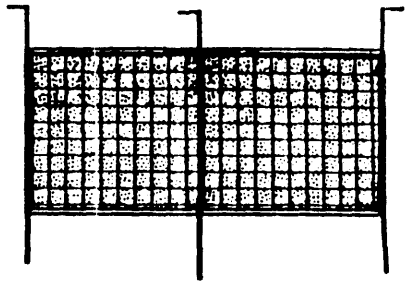
figure 7-5

SILT FENCE



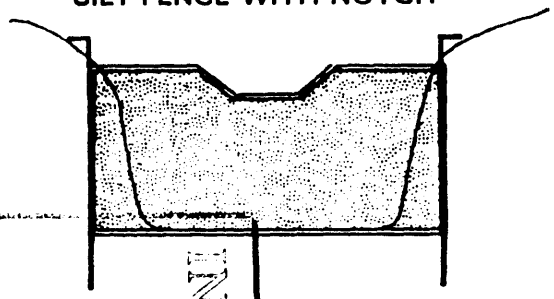
BOTTOM SECURED TO PREVENT BYPASS;
FILTER FABRIC TOE BURIED IN TRENCH;
SIDES SECURED WHEN NECESSARY;
WIDTH AND HEIGHT VARY.

SILT FENCE AND MESH



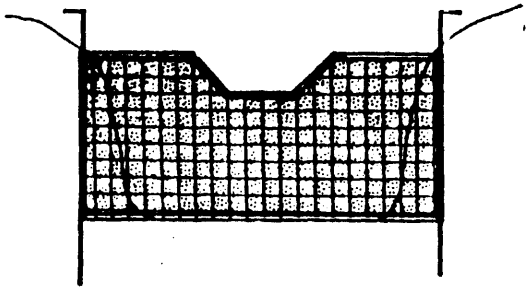
BOTTOM SECURED TO PREVENT BYPASS;
FILTER FABRIC TOE BURIED IN TRENCH;
SIDES SECURED WHEN NECESSARY;
WIDTH AND HEIGHT VARY.

SILT FENCE WITH NOTCH



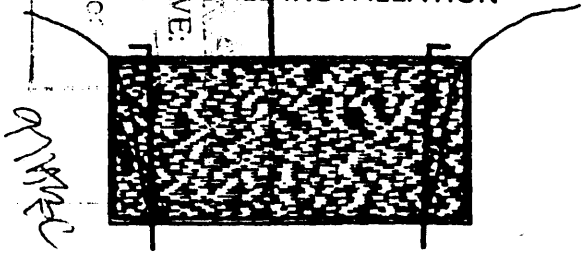
BOTTOM AND SIDES SECURED TO PREVENT BYPASS;
FILTER FABRIC TOE BURIED IN TRENCH;
WIDTH AND HEIGHT VARY.
NOTCHED TO ALLOW OVERFLOW.

SILT FENCE AND MESH WITH NOTCH



BOTTOM AND SIDES SECURED TO PREVENT BYPASS;
FILTER FABRIC TOE BURIED IN TRENCH;
WIDTH AND HEIGHT VARY.
NOTCHED TO ALLOW OVERFLOW.

STRAW-BALE INSTALLATION



BOTTOM AND SIDES SECURED TO PREVENT BYPASS;
WIDTH AND HEIGHT VARY.

DIRT BERM

HEIGHT AND WIDTH VARY.

NOT TO SCALE

EarthFax

FIGURE 7-5. TYPICAL ALTERNATIVE SEDIMENT CONTROL STRUCTURES.

UTAH DIVISION OIL, GAS AND MINING

located on Jewkes Creek down- and upstream from the proposed surface facilities, respectively, and will provide information regarding the impacts of surface disturbances. Stations SS-7 and SS-8 are located on Beaver Creek up- and downstream from potential future expansions of the mine. Similarly, stations SS-10 and SS-11 are located in tributaries to Jump Creek and Beaver Creek, respectively, downstream from potential future expansions of the mine. Through the collection of flow and water-quality data up- and downstream from underground mining activities, these latter four stations will provide information on the potential impacts of underground mining activities (e.g. increases or decreases in flow and water quality due to subsidence and other potential interruptions to the hydrologic regime) on surface hydrologic conditions.

Flow data collected from stations SS-7 and SS-8 will be compared to determine variations in flows up- and downstream from the proposed workings. It should be noted that wide variations have been noted historically between these stations, with flows increasing and decreasing in the downstream direction. If the data suggest that abnormal variations in flow are occurring between stations SS-7 and SS-8, additional seepage evaluations will be conducted along Beaver Creek, similar to those described above in Section 7.1.2.

In addition to the above monitoring program and in accordance with a request by UDOGM, North Fork of Gordon Creek will be monitored for flow below Coal Canyon (see Plate 7-1) on a quarterly basis when the site is accessible. Data collected from this site will serve as a basis for evaluating the potential overall hydrologic impacts of mining within the permit area. Furthermore, station SS-12 (Plate 7-1) will be established for the collection of flow data from Beaver Creek to further evaluate flow conditions in the creek as mining progresses to the northwest. These flow data will be collected on a quarterly basis during normal monitoring periods.

Once every five years, during the low-flow season of the year (i.e., late summer or early autumn), each stream station will be sampled during the low-flow season for baseline parameters. This list of parameters is the same as that provided in Table 7-5 plus the following:

Acidity	Molybdenum (dissolved)
Aluminum (dissolved)	Ammonia
Arsenic (dissolved)	Nitrate
Boron (dissolved)	Nitrite
Cadmium (dissolved)	Phosphate (ortho)
Copper (dissolved)	Selenium (dissolved)
Lead (dissolved)	Zinc (dissolved)

During field reclamation activities following mining, samples will again be collected from Jewkes Creek above and below the disturbed area on a weekly basis. These samples will be analyzed in the field for turbidity as a measure of the effectiveness of the sediment-control measures that will be implemented during reclamation construction.

By the end of each month following each calendar quarter (i.e., April 30, August 31, October 31, and January 31), a report will be submitted to the Division summarizing monitoring activities during the previous quarter. Annual reports summarizing monitoring activity will also be submitted to the UDOGM. Quarterly reports will include field measurements, observations, and analytical results

received during the previous quarter. Annual reports will include field measurements, observations, and analytical results received during the entire year. If any data indicate non-compliance with permit conditions, Horizon Coal Company will promptly notify the Division and take appropriate actions as provided for in R645-300-145 and R645-301-731.

7.2.3 Surface Water Development, Control and Diversions

7.2.3.1 Water Supply (Surface)

Locations of surface water rights within the permit and surrounding areas are shown on Plate 7-3. Data contained in Appendix 3-3 indicate that water rights have been filed on a limited number of streams in the permit and adjacent areas. These rights are primarily for stock watering. As such, they typically have no usage rate associated with them. Rather, they are for watering of stock along a length of stream.

The water supply for use underground will be pumped from the North Fork Gordon Creek to the mine. The pump house will be located as noted on Plate 3-1. The leasing of water rights for this use is discussed in Section 3.4.3 of this permit application.

7.2.3.2 Sedimentation Control Structures and Diversions

General Description

The runoff and sediment control plan for the facility area during operations is shown on Plates 7-4 and 7-6. The undisturbed runoff from above the site area on the Portal Canyon and Jewkes Creek drainages will be diverted beneath the disturbed area and drainage from the disturbed and small, contiguous undisturbed areas will be collected and routed to the sedimentation pond. The drainage network was developed with several objectives in mind:

1. To divert undisturbed area runoff around the facilities area where feasible;
2. To route all runoff from disturbed areas through a sedimentation pond;
3. To provide adequate drainage of roads and parking areas;
4. To create channels, culverts, and diversions which are stable; and
5. To satisfy UDOGM design standards.

During the initial stages of site development and prior to installation of the sedimentation pond, Horizon Coal Corporation will install a combination of containment berms, straw-bale dikes, and silt fences to contain sediment. The selection of the actual sediment-control technology will depend upon site conditions. However, in each case, these sediment-control structures will be located between the stream channels and the areas being disturbed by site construction.

Sedimentation control structures and diversions will be installed using the best technology currently available. Silt fence fabric and wire mesh (when used) will be buried in a trench on the upstream side of the silt fence. The depth of trench will vary, however an attempt will be made to use 6" as a standard depth. When silt fence is installed in a channel the silt fence will be installed flush with the sides and top of the channel to prevent seepage from occurring around the fence. The fence will be constructed parallel to the contours of the slope, with the ends bent upslope. The type, height, and width will be analyzed on a case by case basis to determine the best technology to be used for each situation.

Straw-bales will be installed in a trench the width of the bale (when weather conditions permit) and the length of the proposed sediment structure. The soil from the excavated trench will be placed against the bales. Straw-bales will be secured with a minimum of two stakes inserted into the bales and extending a depth sufficient to securely anchor the straw-bale into the ground. The structure will be constructed parallel to the contours of the slope, with the ends bent upslope. Loose straw will be wedged into gap spaces.

Installation of the culverts will proceed from the lower end of the pad area in an upstream direction. To the extent possible, Horizon Coal Corporation will limit construction activities associated with culvert installation to those periods when the stream is not flowing. Alternatively, stream flow will be bypassed around construction activities within the channels. The sedimentation pond will be constructed as soon as practical following installation of the culvert.

Methodology

The following methods were used to determine runoff volumes and peak flows for design of diversions, culverts, and the sedimentation pond:

Determination of Precipitation Depth. Precipitation depths were determined for the 10-year, 6-hour; 10-year, 24-hour; 25-year, 6-hour; and 100-year, 6-hour storms using data developed by Miller, et al. (1973). The precipitation depths for these events are 1.5 inches, 1.8 inches, 1.6 inches, and 1.8 inches, respectively.

Determination of Runoff Volume. The SCS curve number method was used to determine the runoff volume resulting from the design precipitation events. According to this method (U.S. Soil Conservation Service, 1972), the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations:

and $$= \frac{-}{+} \qquad (3)$$

$$= \frac{}{} - \qquad (4)$$

where Q = Direct runoff volume (inches)
S = Watershed storage factor (inches)
P = Rainfall depth (inches)
CN = Runoff the curve number (dimensionless)

It should be noted that (a) Equation (3) is valid only for P >= 0.2S (otherwise Q = 0), (b) Equation (4), as stated, is in inches, with the values of 1000 and 10 carrying the dimensions of inches, although metric conversions are possible, and (c) CN is only a convenient transformation of S to establish a scale of 0 to 100 and has no intrinsic meaning.

Curve numbers for the watersheds of concern were obtained by evaluating the watershed surface characteristics based on soils, vegetative type, and other characteristics. This determination was based on maps and field reconnaissance of the site. The curve numbers for undisturbed areas were determined using the estimated cover density of the vegetative community and tabulated values provided by the U.S. Soil Conservation Service (1986), assuming hydrologic soil groups B and C (as is typical of much of the region). For the disturbed areas, curve numbers were chosen from professional judgement and tabulated values presented by the U.S. Soil Conservation Service (1972).

Weighted-average curve numbers were determined based on the percentage of each watershed occupied by a given land type. Antecedent Moisture Condition II was used for all runoff estimates.

Hydrograph Synthesis. Runoff hydrographs were developed, for the storm events, using the SCSHYDRO computer program, originally developed by Hawkins and Marshall (1980), modified to add additional rainfall distributions and allow batch file processing. The SCSHYDRO program was designed to simulate the surface runoff response of a drainage to precipitation, using the SCS triangular hydrograph method.

The SCS method yields a total rainfall excess, the difference between rainfall depth and precipitation loss. For a given storm, the incremental excess for a given time period of a storm can be computed as the difference between the accumulated excess at the end of the current time period and the accumulated excess at the end of the previous period (U.S. Soil Conservation Service, 1972). The computer program calculates the incremental volume using:

$$\Delta = \left(\frac{+\ \Delta \quad -}{+\ \Delta \quad +} \right) - \left(\frac{-}{+} \right) \qquad \textbf{(5)}$$

where S is as previously defined and values for P(t+Δt) and P(t) are determined from the rainfall mass curve.

This rainfall excess is then translated to an outflow hydrograph using the SCS triangular dimensionless unit hydrograph (U.S. Soil Conservation Service, 1972). The unit hydrograph shown in Figure 7-6 is a typical curvilinear hydrograph. It is characterized by its time to peak (T_p), recession time (T_r), time of base (T_b), and the relations between these parameters (i.e., $T_r = 1.67T_p$; $T_b = 2.67T_p$). Thus, from the geometry of a triangle, the incremental runoff (ΔQ can be defined by the equation:

$$= \frac{\Delta}{} \qquad \textbf{(6)}$$

where q_p = Peak flow rate (in/hr, if Q is in inches and T_p in hours)

and other parameters previously defined.

The flow at any time $0 < t < T_r$ may be determined by simple linear proportioning of the triangular unit hydrograph. The time to peak is related to the familiar expression "time of concentration" (T_c) by the equation:

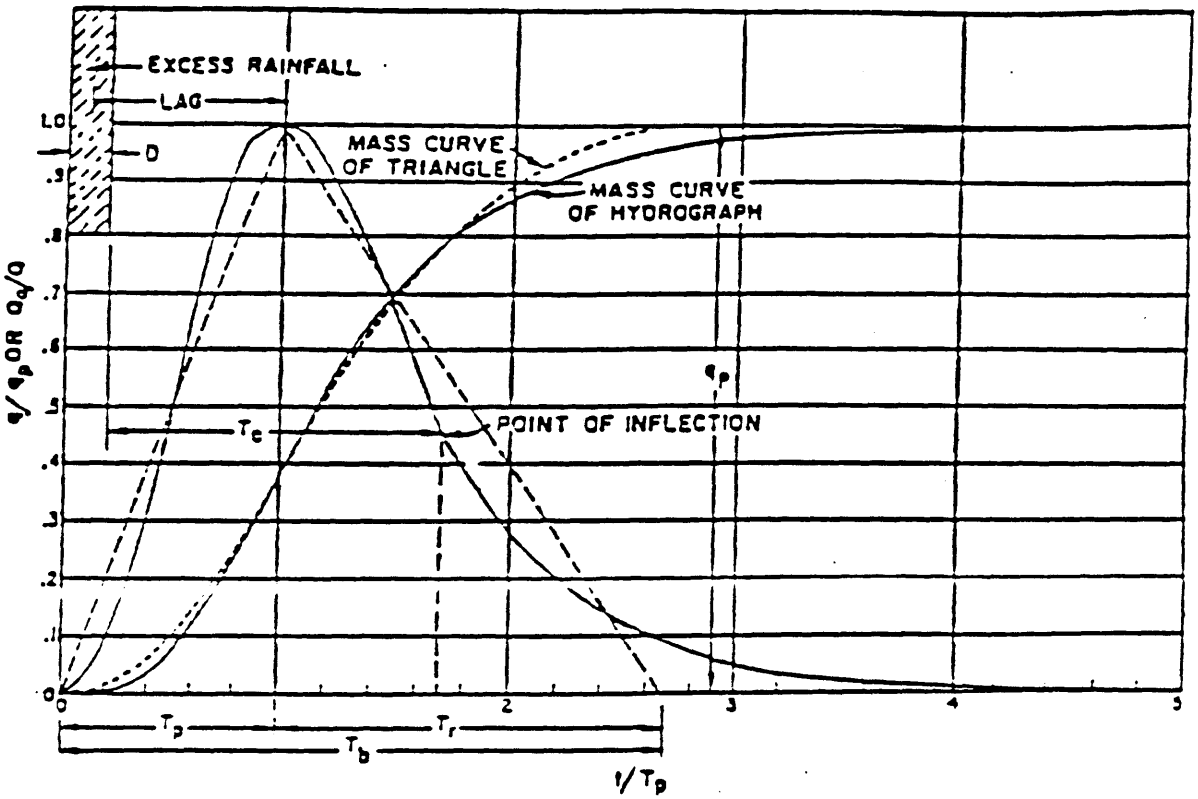
$$+ \Delta \quad = \qquad (7)$$

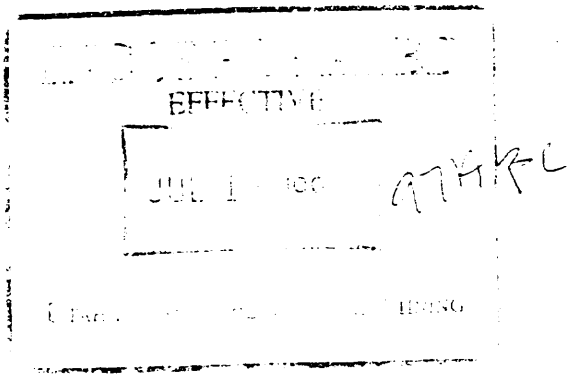
in which the factor 1.7 is an empirical finding cited by the U.S. Soil Conservation Service (1972).

The time of concentration may be estimated by several formulas. For this document, T_c was determined from the following equations (U.S. Soil Conservation Service, 1972):

figure 7-6

FIGURE 7-6





DIMENSIONLESS UNIT HYDROGRAPH AND MASS-CURVE.

and $= \frac{\lambda \quad +}{}$ **(8)**

$=$ **(9)**

where L = Watershed lag time (hours)
λ = Hydraulic length of the watershed, or distance along the main channel to the watershed divide (feet)
S = Watershed storage factor defined in Equation (4)
Y = Average watershed slope (percent)
T_c = Time of concentration (hours)

The U.S. Soil Conservation Service (1972) shows that Δt must equal $0.2T_p$. Hence, the computer code uses only T_c, and from this value computes Δt, T_p, T_r, and interim unit hydrograph ordinates. To convert the unit hydrograph ordinates to cubic feet per second, the following relation is used:

$= ___ * \quad *$ **(10)**

where Area =Drainage area (square miles)
q = Discharge (cubic feet per second)

Channel Hydraulics. The capacity of the undisturbed and disturbed area diversion channels, at the design flow rate, was determined using the FlowMaster I™ program developed by Haestad Methods (1990). This program solves for prismatic channel capacity using the Manning equation:

and the continuity equation:

$$= \quad * \qquad (11)$$

where V = Velocity (feet per second)
R = Hydraulic radius (feet)
S = Hydraulic slope (feet per foot)
n = Manning's roughness coefficient
Q = Discharge (cubic feet per second)
A = Flow area (square feet)

$$= \frac{\quad}{\quad} * \quad * \qquad (12)$$

Channel parameters required for the solution of Equations (11) and (12) were obtained from design cross sections and the proposed longitudinal profile of the various channels. Values of the roughness coefficient were obtained by comparing proposed conditions with [illegible] values provided by Chow (1959) and the U.S. Soil Conservation Service (1956).

For the design of the undisturbed area diversions and the reclaimed channels, a maximum permissible velocity of 5 feet per second was determined to be non-erosive. This was determined from Barfield, et. al. (1981) based on a graded loam soil with gravel for sediment laden flows.

Undisturbed Area Runoff Control

General. Runoff from the undisturbed area upstream of the surface facilities in Portal Canyon and Jewkes Creek will be diverted beneath the mine facilities via three culverts. The culverts are designed as temporary structures for the life of the facility and will be removed following the operations. The undisturbed-area culverts are sized to pass the peak flow resulting from the 100-year, 6-hour precipitation event. Calculations supporting these designs are presented in Appendix 7-4. A copy of the stream alteration permit from the Utah Division of Water Rights required for installation of the undisturbed-area culverts is included in Appendix 7-12.

Diversions. The bypass culverts are sized to safely pass the peak flow resulting from the 100-year, 6-hour precipitation event. Plate 7-5 shows the location of the culverts and the drainage area to each structure, respectively.

Undisturbed area culvert UC-1 will bypass drainage runoff from culverts UC-2 and UC-3 (i.e., Portal Canyon and Jewkes Creek, respectively). The combined 100-year, 6-hour peak flow from these drainages is 27.9 cfs. The culvert to be installed in this section of the drainage will have a diameter of 36 inches, based on the minimum slope section and open-channel flow conditions for the culvert.

Culvert UC-2 will receive runoff from Portal Canyon. The 100-year, 6-hour peak flow for this culvert is 8.3 cfs. A 24-inch diameter culvert is planned to be installed at this location. This size

is based on inlet control and a headwater to depth ratio of one or less. A trash rack will be installed on the inlet to this culvert, as indicated in Figure 7-8.

Culvert UC-3 will receive runoff from Jewkes Creek. The 100-year, 6-hour peak flow to this culvert is 19.6 cfs. This flow can adequately be handled by a 30-inch diameter culvert, based on inlet control and a headwater to depth ration of one or less. An extension of UC-3 is discussed in Appendix 3-9.

Discharge at the outlet of culvert UC-1 will have an exit velocity of approximately 10.4 fps (see Appendix 7-4). This will be controlled by installing an outlet channel and impact pool. The outlet channel will have graded riprap on the bottom and along the sides of the channel for an approximate distance of 30 feet downstream from the culvert outlet to a transition to a compound channel with a riprapped low flow channel and vegetated flood plain, as proposed for the final reclamation channel (see Plates 7-4 & 7-6). The riprap in the outlet channel and the low flow channel will have a median diameter of 0.5 foot and will be placed at a thickness of 12 inches. The gradation of the riprap is presented in Table 7-6. A geotextile material will be installed beneath the outlet channel riprap as a filter blanket. A sand filter will be installed beneath the low flow channel riprap.

The outlet channel will act as an impact pool for flows from the culvert or emergency spillway. The impact pool will be created by the transition to the compound channel, due to the shallower depth of the low flow channel versus outlet channel. Under flow conditions, the water will fill the outlet channel and spill to the low flow channel until its capacity is exceeded and then spread out into the flood plain. This will ensure that low flows can be conveyed through the area, while high flows will spread over the flood plain. Additionally, the shallow depth of the low flow channel will ensure the capability of sub-irrigation and seepage into the surrounding flood plain.

By constructing these channels during operations, the area will not need to be disturbed again during reclamation. The riparian area will already be established around the channels and the area will be stabilized. If these channels are not included in the initial disturbance, then the area will be redisturbed upon reclamation.

Calculations contained in Appendix 7-4 indicate that the flow capacity of the unaltered Jewkes Creek upstream from culvert UC-3 is 27.7 cfs. The flow capacity of the unaltered Jewkes Creek downstream from culvert UC-1 is 38.7 cfs. Culverts UC-1 and UC-3 have design capacities of 59 cfs and 40 cfs, respectively. Hence, the capacities of these culverts exceed the capacity of Jewkes Creek in its unaltered state.

As indicated in Appendix 7-4, the capacity of the unaltered Portal Canyon Creek upstream from culvert UC-2 is 13.1 cfs. All of the downstream portion of this creek will be subject to the culverted diversion. Culvert UC-2 has a capacity of 22 cfs. Hence, the capacity of this culvert exceeds that of Portal Canyon Creek in its unaltered state.

FIGURE 7-8

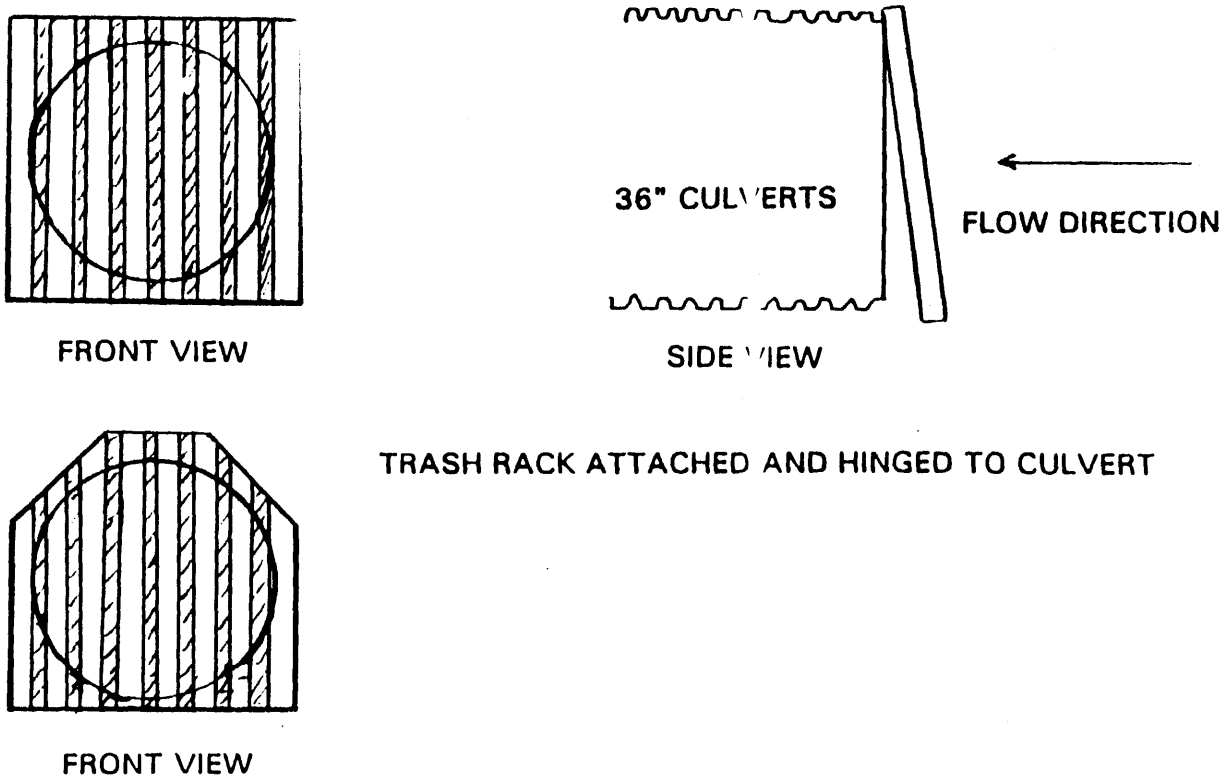


FIGURE 7-8. TYPICAL VIEW TRASH RACKS.

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table 7-6

TABLE 7-6

RIPRAP GRADATIONS

Diameter Gradation	Diameter Size
4-inch Riprap	
D_{100}	0.66 foot
D_{85}	0.5 foot
D_{50}	0.33 foot
D_{15}	0.03 foot
6-inch Riprap	
D_{100}	1.0 foot
D_{85}	0.75 foot
D_{50}	0.5 foot
D_{15}	0.05 foot
8-inch Riprap	
D_{100}	1.5 feet
D_{85}	1.1 feet
D_{50}	0.6 foot
D_{15}	0.06 foot
12-inch Riprap	
D_{100}	2.0 feet
D_{85}	1.5 feet
D_{50}	1.0 foot
D_{15}	0.1 foot

Disturbed Area Runoff and Sediment Control

General. The runoff from the majority of the disturbed areas will be collected in a sedimentation pond and treated prior to discharge (see Plate 7-6). Areas being treated by alternative sediment controls and not reporting to the sediment pond are discussed below. The sedimentation pond has been designed to contain runoff from the 10-year, 24-hour storm event. Calculations supporting the design of the sedimentation pond are presented in Appendix 7-4.

Two areas within the disturbed area boundary do not flow to the sediment pond and are, therefore, treated by alternative sediment controls. The first such area is at the upstream end of the Topsoil Stockpile in Portal Canyon, adjacent to the inlet of culvert UC-2. This area slopes towards the culvert and is treated with straw bales and berms directing any flow through the straw bales prior to leaving the disturbed area and reporting to the undisturbed drainage culvert. During November 1996, the area was revegetated with Seed Mix #1 in accordance with the procedures outlined in Section 3.5.5. The straw bales and berms will be maintained at least until the vegetative cover is sufficient to control erosion.

The second area requiring alternative sediment control includes the exterior embankment slopes of the sedimentation pond. This area is treated with a combination of straw bales and a silt fence. During November 1996, this area was revegetated with Seed Mix #1 in accordance with the procedures outlined in Section 3.5.5. The straw bales and silt fence will be maintained at least until the vegetative cover is sufficient to control erosion.

Disturbed Area Diversions. The major portion of the disturbed area will be collected by disturbed-area diversion ditch DD-1 (see Plate 7-4). This diversion will consist of two segments. The upper segment will consist of a small ditch on each side of the canyon. Both ditch segments will drain to the lower portion of DD-1 which will flow directly to the sedimentation pond. To be triangular in shape, this diversion will be constructed with 2H:1V sideslopes and a channel slope ranging from 0.033 to 0.143 foot/foot. The channel will be constructed in pad fill materials. The 25-year, 6-hour peak flow for the drainage is 1.28 cfs (see Appendix 7-4). To handle this event, the upper channel will have a maximum flow depth of 0.45 foot and a maximum velocity of 4.8 fps. The channel depth is planned to be 1 foot deep, resulting in a free board of 0.55 foot (see Plate 7-4). For diversion slopes less than 11.7 percent, the peak design velocity is less than 5.0 fps. Hence, no riprap protection is required for these reaches. For the diversion reaches greater than 11.7 percent, riprap is required. Based on the maximum channel slope with a 0.5 foot D_{50}, the peak design velocity is 4.8 fps.

The lower reach of DD-1 will have a peak flow of 1.32 cfs. The design is based on the same channel configuration as the upper section. The channel will have a maximum flow depth of 0.46 foot and a maximum velocity of 4.83 fps. The channel depth is planned to be 1 foot deep, resulting in a free board of 0.54 foot (see Plate 7-4). For diversion slopes less than 11.5 percent, the peak design velocity is less than 5.0 fps. Hence, no riprap protection is required for these reaches. For the diversion reaches greater than 11.5 percent, riprap is required. Based on the maximum channel slope with a 0.5 foot D_{50}, the peak design velocity is 4.83 fps.

Disturbed-area culverts will be installed to convey runoff beneath roadways on the facility pad. Culvert DC-1 will be installed to carry runoff from the fan-portal access road beneath the main pad roadway into diversion DD-1. The peak discharge to this culvert from the 25-year, 6-hour precipitation event will be 0.60 cfs. An 18-inch diameter culvert is planned to be installed at this location, based on inlet control conditions with a headwater to depth ratio of one or less. This culvert will be extended to facilitate the installation of a transformer adjacent to the conveyor. The culvert is shown on Plate 7-4.

Culvert DC-2 was installed to convey runoff from the coal loadout area beneath the main facility roadway and into the sediment pond. The peak discharge to this culvert from the 25-year, 6-hour precipitation event will be 0.59 cfs. Culvert DC-2 will consist of an 18-inch diameter culvert, based on inlet control conditions for the culvert with a headwater to depth ratio of one or less.

Culvert DC-3 was installed to convey runoff from the hillside on the north side of Portal Canyon and below culvert DC-1. Waters discharging to DC-3 will run beneath the roadway and into diversion DD-1. The peak discharge to this culvert from the 25-year, 6-hour precipitation event will be 0.04 cfs. Culvert DC-3 consists of an 18-inch diameter culvert, based on inlet control conditions for the culvert with a headwater to depth ratio of one or less.

Drainage from the ancillary roads will be controlled by the use of water bars and berms. Plate 7-4 shows the location of the water bars on the ancillary roads to the fan portal and the monitoring well. Plate 3-4a shows the details of the water bars. Each of the water bars has been sized to handle the drainage from the 10 year - 6 hour event for the largest area reporting to a water bar. The worst case peak flow is estimated to be 0.24 cfs (maximum discharge). Based on the water bar details, the anticipated flow depth for this peak flow is 0.2 foot with a flow velocity of 1.48 feet per second. Appendix 7-4 presents the design calculations and a diagram outlining the largest drainage area reporting to a water bar on either ancillary road. The design depth of the water bar is 1 foot, thence the freeboard is 0.8 foot. The velocity is not erosive as it is less than 5 feet per second. Therefore, the proposed design for water bars on the ancillary roads, as indicated on Plate 3-4a, is adequate.

The water diverted by the water bars will be collected in a half-round culvert and conveyed over the downslope into a gravel lined basin. The water will then travel overland into the diversion channel and into the sediment pond.

In two places the ancillary road will need to cross the DD-1 ditch. In both locations, the cross-section of ditch DD-1 will transition to a 1 foot deep, 5H:1V sideslope, triangular shaped ditch. The channel slope through the transition section will be limited to 0.05 foot per foot. Based on the calculations presented in Appendix 7-4, the flow depth through these transition section will be 0.29 foot deep and the design velocity will be 3.02 fps.

Sedimentation Pond Design. Runoff from the disturbed area and adjacent undisturbed areas will be directed to the sedimentation pond as indicated above. The areas around all surface facilities, including buildings, trash containers, coal storage, and the topsoil stockpile, will be sloped so that the drainage from these facilities will be directed to the sedimentation pond.

facilities, including buildings, trash containers, coal storage, and the topsoil stockpile, will be sloped so that the drainage from these facilities will be directed to the sediment pond.

A direct discharge of in-mine water has been applied for however while approval is pending mine water discharge will be routed to the sediment pond and decanted through the currently approved UPDES discharge point. Waters decanting through the point will be monitored in accordance with the parameter\s of the UPDES permit.

During the period of discharge three monitoring points will be sampled: upstream of Culvert UC-3, at the discharge of the decant pipe from the sediment pond, and in the mixing zone below the UC-1 Culvert. The three samples points will be monitored for TDS, sulfate, and selenium by the laboratory. Field parameters will include pH, conductivity and flow. Sampling will begin when the first discharge occurs from the decant and a sample will be collected within each two wekk period thereafter. Sampling will be discontinued once the additional UPDES discharge point (Outfall 002) has been approved or when UDOGM otherwise approved the discontinuance of these monitoring points.

The sedimentation pond will be constructed at the location presented on Plate 7-4 as soon as possible following construction of the downstream sections of the undisturbed-area bypass culvert. All runoff from disturbed areas will be directed to the sedimentation pond.

The required storage volume for runoff from a 10-year, 24-hour precipitation event for all areas draining to the sedimentation pond is 0.56 acre-foot (see Appendix 7-4). Based on a disturbed area of 9.2 acres draining to the pond and a sediment storage volume of 0.1 acre-foot per acre of disturbed area, a total sediment storage volume of 0.92 acre-foot has been designed into the pond, resulting in a minimum pond storage requirement of 1.48 acre-feet.

To account for possible future changes in pad design and to provide a safety factor in the sedimentation capacity of the pond, the sedimentation pond has been designed with a total capacity of 2.6 acre-feet (see Appendix 7-4). At this total capacity, the quantity of runoff storage is 0.7 acre-foot and the quantity of sediment storage is 1.9 acre-feet. Based on the stage-capacity curve presented in Appendix 7-4, the pond will have a spillway crest elevation of 7585.0 feet, with a maximum sediment storage elevation of 7582.0 feet, and a sediment cleanout elevation (at 60% of maximum sediment storage) of 7580.6 feet). Plate 7-6 presents the plan view and cross-sections of the pond.

As indicated in Appendix 7-4, the peak inflow to the sedimentation pond resulting from the 25-year, 6-hour storm is 1.40 cfs. The spillway on the pond has been designed as an armored, open channel over the southeast corner of the embankment, as presented in Plate 7-6. A cross section drawing of the spillway is provided in Plate 7-6. The spillway will have a depth of 1.5 feet and a crest width of 10 feet, with a slope of 5 percent for the crest section through the embankment. The flow depth above the crest of the spillway at the design flow will be 0.08 foot (assuming no routing of the hydrograph through the pond). This will provide 1.42 feet of freeboard between the water surface in the spillway at the design flow and the top of the pond embankment at 7586.5 feet. The flow down the steep section of the spillway will have a maximum velocity of 3.5 fps (see Appendix 7-4).

The spillway crest and outlet will be riprapped (see Plate 7-6). The riprap will have a median diameter of 6 inches with a gradation as presented in Table 7-6. The riprap will be placed in a

layer with a minimum thickness of 12 inches and will be underlain by a geotextile filter fabric. The riprap will consist of angular riprap placed to the point where it intersects the UC-1 outlet channel. The angle of entrance of the spillway channel into the UC-1 outlet channel will be no greater than 45° from the alignment of the outlet channel.

Riprap will also be placed on the slope of the inlet channel (DD-1) to the pond (see Appendix 7-4 and Plate 7-6). This will consist of 15-inch riprap with a minimum thickness of 30 inches. This will minimize erosion and potential structure stability problems to the impoundment.

The runoff storage volume will be maintained by the use of a 2-inch diameter dewatering/decant line. As indicated on Plate 7-6, the inlet of the decant will be located at the top of the sediment storage pool. The discharge from this decant will be controlled by a locking valve located on the outslope of the sediment pond embankment at the pipe outlet. This valve will used to drain the excess water from the sedimentation pond after allowing for settling of the sediment in the pond. Samples of the pond water will be collected as appropriate prior to decanting the pond to ensure that the requirements of R645-301-751 will be met. The decant invert will be 2.5 feet above the 60% sediment clean out level (see decant/dewatering design on Plate 7-6).

The decant/dewatering system acts as a baffle to oils and scum that may collect on the surface of the sediment pond. During operation the intake end of the baffle remains below the water's surface, therefore it is also below the oil/scum layer. The inlet will only draw water from below the water's surface, therefore having limited contact with the layer of oil/scum.

A sediment marker will be placed at the edge of the pond to indicate the depth and volume of sediment in the pond. The marker will have designations which will indicate when cleaning of the pond is necessary.

A percolation test was performed in the area of the proposed sedimentation pond. Results of this test are provided in Figure 7-11. The site is situated in seismic zone 2B which, under the Utah Building Code, indicates that the area is safe for the construction of the sedimentation pond. The Static Safety Factor calculations are located in Appendix 3-1. A report of construction and inspection on the sediment pond, by a registered professional engineer, will be provided to the Division at the end of construction.

Runoff Control Maintenance and Monitoring. The sedimentation pond will be inspected after each major storm to determine if water needs to be discharged and to check the sediment level. The pond will be cleaned when sediment builds to 60 percent of the maximum sediment storage level. Sediment removed from the pond will be handled in a manner consistent with the waste rock.The sedimentation pond will also be inspected quarterly by a registered professional engineer. Any weakness or defect in the structure which is noted during this inspection will be corrected as quickly as possible. The pond discharge will be monitored in accordance with the requirements of the UPDES Permit until bond release or until the pond is removed. An application for an additional UPDES discharge point at the mine portal was denied (August 14, 1996) until the water within the mine could be sampled and submitted for analysis. Horizon commits to obtaining a UPDES discharge permit for the mine water prior to discharge of water from the mine portal.

Ditches, culverts, and other drainage controls will be inspected after each major storm, and repaired as necessary. The pond embankments will be revegetated with the temporary seed mix described in Section 3.5.5.2 following construction of the pond. Any areas where revegetation is not successful or where rills and gullies develop will be repaired and revegetated accordingly.

figure 7-11

FIGURE 7-11

UTAH STATE DEPARTMENT OF HEALTH

PERCOLATION TEST CERTIFICATE

I certify that percolation tests have been conducted on property located at future mine site lying in the SE¼, NE¼, SW¼ of Section 17, T13S, R8E, SLB&M.

in accordance with requirements specified in the Code of Waste Disposal Regulations, Parts IV and V, adopted by the Utah State Board of Health and the Utah Water Pollution Control Board, and that percolation rates, calculated as specified by said regulations, are as follows:

Test Hole No.	Test Hole Depth	Inches Drop Final 30 Minute Period	Percolation rate Minutes per inch
1	36"	7/8"	34min/"

Statement of soil and ground water conditions to a depth of 10 feet, or at least for a minimum of 4 feet, below the bottom of the proposed absorption system:

0 - 18" Sandy Loam
18-- 20" coal mixture
20 - 36" sandy Loam (some rock)

no gnoand water was encountered.

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Signed [signature] PE

Date Oct '90

Address 905 N 600 East
Price, Ut 84501

Reclamation Hydrology Design

General. Following the completion of mining operations, the mine site area will be reclaimed as discussed in Chapter 3 of this application. As part of the reclamation activities, Horizon will reestablish the natural drainage patterns and reconstruct the drainage channels.

The channels to be reestablished are Portal Canyon Creek and Jewkes Creek. These channels will need to be reestablished within the canyon bottom. Due to the proposed reclamation site configuration and the location of the sedimentation pond embankment, it is not practical to retain the operations sedimentation pond through the entire reclamation period. Prior to the removal of the sedimentation pond during reclamation, a UDOGM hydrologist will be notified and given the opportunity to inspect and endorse the removal. Several options are available to handle the reclamation drainage. For one pond to handle the total runoff from the entire 551 acres, a pond larger than the disturbed area would be needed. If the undisturbed runoff were past through the site using open channels, a minimum of three ponds, one at the bottom of the wedge formed by the junction of Portal Canyon Creek and Jewkes Creek and two ponds, one on each side of Jewkes Creek, at the lower end of the disturbed area boundary, would be required to contain the runoff, due to the presents of the open channels.

Also, each of these ponds would require a series of disturbed and undisturbed diversion ditches to bypass the undisturbed water above the reclaimed areas and to collect the reclaimed area drainage and convey it to the ponds. Additionally, once the portions of the site draining to the ponds were revegetated and the ponds and disturbed and undisturbed diversion ditches were ready to be removed, almost half of the revegetated area draining to the ponds would need to be disturbed again, due to the limited area between the open channel and the disturbed area boundary. As a result, the use of sedimentation ponds during the entire reclamation period would lengthen the time necessary to establish permanent vegetation throughout the permit area. Therefore, Horizon proposes to retain the sedimentation pond for as long as practical during regrading of the site area and removal of the bypass culverts. Once it is no longer practical to retain the sedimentation pond, it will be removed and the area will be reclaimed. Based on calculations presented in Appendix 7-4, the use of alternative sediment control measures (such as mulching, deep gouging, and reseeding) will produce less sediment than undisturbed watersheds at the same site.

If feasible, efforts will be made to minimize reclamation activities during periods of wet weather. During short periods when reclamation construction activities will be suspended (i.e., evenings and weekends), the construction site will be left in a condition which would minimize the impact on the hydrologic system if a precipitation event were to occur. Since conditions will vary between each area to be protected and each event, various siltation structures will be used. Horizon commits to establish and maintain sediment control using the best technology available at the time of reclamation. Refer to Section 7.2.3.2, Sediment Control for various possible structures.

Reclamation Channel Design. Reclamation channels have been designed to convey the peak flow from the 100-year, 6-hour precipitation event. Plate 7-7 presents the drainage areas of the proposed drainages following reclamation activities. Appendix 7-4 presents the calculations for the peak flows for these drainages. As indicated in Appendix 7-4, the design capacities of the reclamation channels exceed the capacities of the natural stream channels up- and downstream from the proposed reclamation channels. Specifically, as indicated in Appendix 7-4, the natural and reclaimed capacities of Portal Canyon Creek and Jewkes Creek are as follows:

Creek	Upstream Capacity (cfs)	Downstream Capacity (cfs)	Reclamation Capacity (cfs)
Portal Canyon (RD-1)	13.1	—	56.7
Jewkes (RD-2)	27.6	38.7	143.5
Jewkes (RD-3)	27.6	38.7	150.6

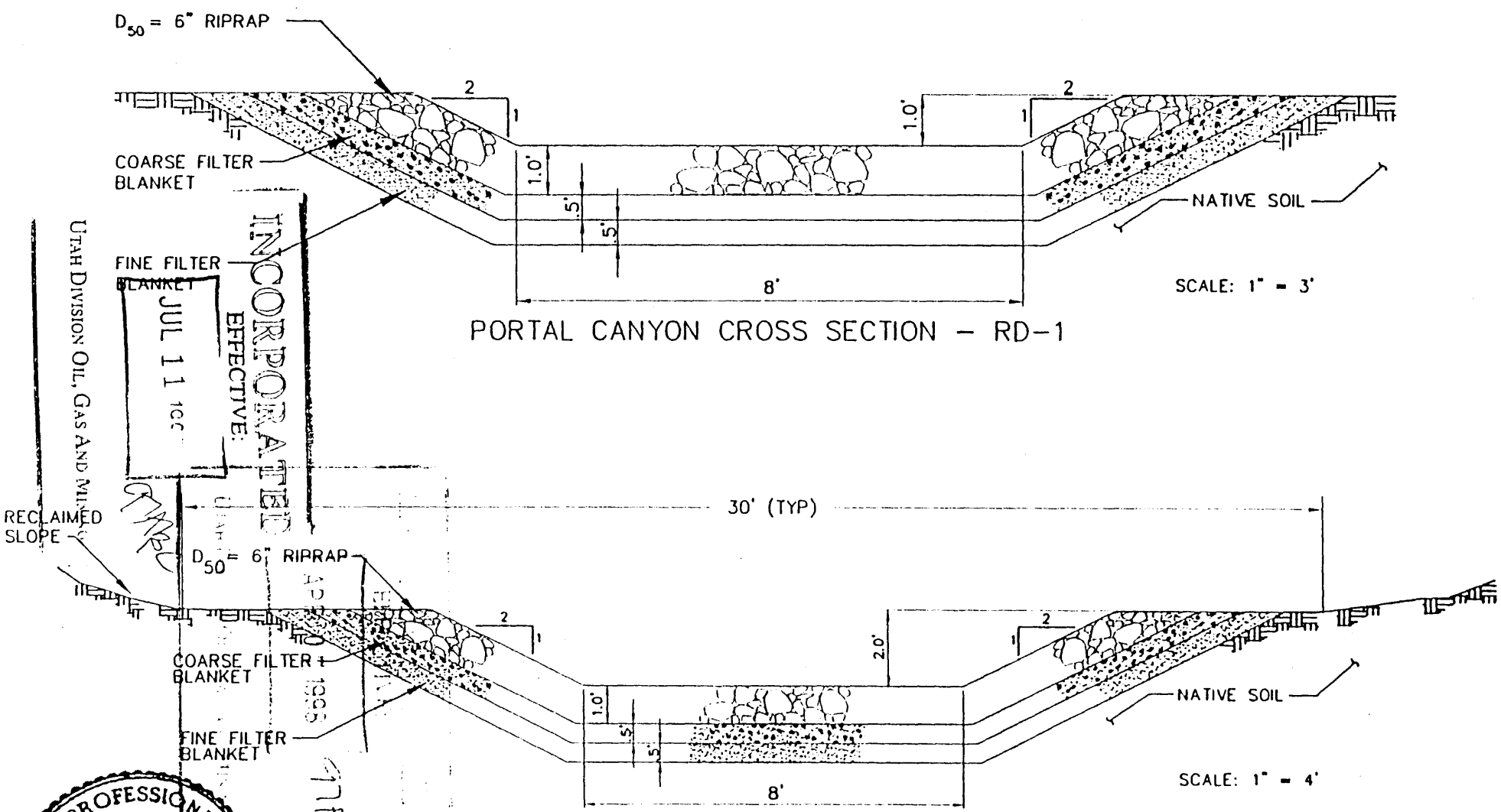
Drainage from the 181.2-acre Portal Canyon watershed will flow through the reclaimed stream channel RD-1. As indicated in Appendix 7-4, the peak flow for the 100-year, 6-hour event for this drainage is 9.95 cfs. The reclaimed channel will be trapezoidal in shape and will be constructed with an 8-foot bottom width, 2H:1V sideslopes, and a channel slope ranging from 0.038 to 0.167 foot/foot (see Figure 7-12 and Plate 3-7). The channel will be constructed in regraded materials and will be riprapped to provide a stable stream section. To handle this event, the channel will have a maximum flow depth of 0.36 feet and a maximum velocity of 5.79 fps. The channel depth is planned to be a minimum of 1 foot, resulting in a freeboard of 0.68 feet. Riprap with a median diameter of 0.5 foot will be installed to enhance long-term erosion protection. Material gradation for this riprap is presented in Table 7-6. A sand filter blanket will be installed beneath the riprap as indicated in Appendix 7-4 and Figure 7-12.

Reclamation channel RD-2 will receive flow from the 358.2 acre Upper Jewkes Creek drainage. The reclaimed channel will be a compound channel to provide channel stability and assist in establishment of the riparian/wet meadow vegetative community which currently exists along portions of Jewkes Creek. The base channel will be trapezoidal in shape and will be constructed with an 8-foot bottom width, 2H:1V sideslopes, and a channel slope of 0.013 to 0.087 foot/foot (see Figure 7-12 and Plate 3-7). Peak flow for this low flow channel, based on the 100-year, 6-hour event, is 19.75 cfs. The channel will be constructed in regraded materials and will be riprapped to provide a stable stream section. To handle this event, the channel will have a maximum flow depth of 0.65 foot and a maximum velocity of 6.06 fps. The channel depth is planned to be 2.0 feet deep, resulting in a freeboard of 1.35 feet. According to Appendix 7-4, the channel will be lined with riprap which will have a median diameter of 0.5 foot, with a material gradation as presented in Table 7-6. A sand filter blanket will be installed beneath the riprap as indicated in Appendix 7-4 and Figure 7-12.

Two procedures will be implemented during reclamation to assist in the re-establishment of riparian/wet meadow vegetation along Jewkes Creek. First, following installation of the filter blanket and the riprap, soil will be worked into the voids of the riprap using the bucket of a backhoe. The purpose of this soil will be to provide a growth medium for the seeds and seedlings that are planted in the channel during revegetation.

figure 7-12

FIG7-12.DWG UC572-02 8-12-97



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RICHARD B. WHITE
6/16/97
STATE OF UTAH

FIGURE 7-12. TYPICAL CROSS SECTIONS FOR RECLAIMED CHANNELS

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Second, loose-rock check dams will be installed at the locations indicated on Plate 3-7 in accordance with Figure 7-12a. These check dams have been designed in accordance with the procedures outlined by Heede (1976) as indicated in Appendix 7-4 and will cause naturally-occurring sediment in the stream to be deposited in the reclaimed channel. As noted in Appendix 7-4, the rock used in the check dams will have a median diameter of 9 inches, which size has been found by Heede (1976) to be stable under conditions similar to those at the Horizon site. This deposited sediment will provide an additional soil base for re-establishment of the riparian/wet meadow vegetation and will also provide a cross section which is more typical of that which currently exists. Nonetheless, should a major storm event occur, the underlying base channel will provide long-term protection against excessive erosion.

The check dams have been designed with a spillway that is capable of passing the peak flow resulting from the 10-year, 6-hour precipitation event. Discharge in excess of that event will flow onto the adjacent flood plain. By spreading this flow, moisture will be provided to the riparian/wet meadow vegetation to assist in its re-establishment. Data included in Appendix 7-4 indicate that the soil in the flood plain will be erosionally stable during runoff resulting from the 100-year, 6-hour rainfall event.

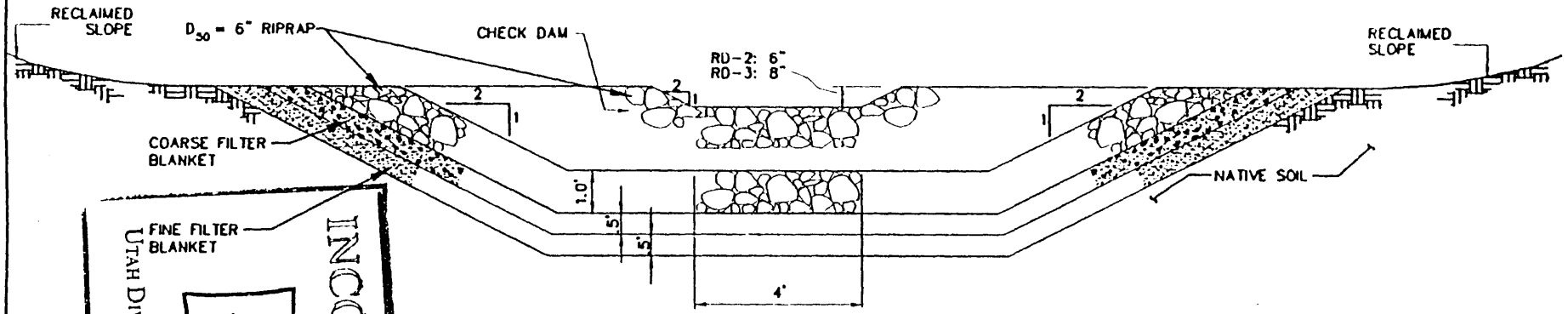
The width of the reclaimed flood plain will be at least equal to that of the current riparian/wet meadow vegetation community, as defined on Figure 2 of Appendix 9-2. The planned width of the reclamation flood plain is indicated on Plate 3-7. Check dams will be installed within the flood-plain sections as indicated on Plate 3-7. Even though the calculations provided in Appendix 7-4 indicate that the flood plain soils will be erosionally stable, a temporary jute matting will be installed in these flood plain areas to provide additional protection for the seeds until vegetation is established.

The flood plain of channel RD-2 will also be trapezoidal in shape and will be constructed with a typical bottom width of 30 feet, 2H:1V sideslopes, and a channel slope ranging from approximately 0.013 to 0.087 foot/foot (see Figure 7-12 and Plate 3-7). Peak flow for this flood plain channel, based on the 100-year, 6-hour event, is 19.75 cfs. Allowing for the capacity of the low flow channel, the flood plain will only be required to handle 10.29 cfs. The channel will be constructed in regraded materials and will be stabilized using a temporary jute mesh erosion control blanket. This blanket will be in place only until the vegetation planting for the flood plain mature and provide natural protection. To handle this event, the flood plain channel will have a maximum flow depth of 0.19 foot and a maximum velocity of 3.24 fps. The velocity is less than the 5.5 fps allowed for jute mesh.

Reclamation channel RD-3 will receive flow from the 551.0 acre Lower Jewkes Creek drainage, below the confluence of Jewkes Creek and Portal Canyon. The reclaimed channel will also be a compound channel. It will consist of a base channel and a flood plain, with loose-rock check dams. The base channel will be trapezoidal in shape and will be constructed with an 8-foot bottom width, 2H:1V sideslopes, and a channel slope ranging from approximately 0.022 to 0.100 foot/foot (see Figure 7-12 and Plate 3-7). Peak flow for this base channel, based on the 100-year, 6-hour event, is 30.21 cfs. The channel will be constructed in regraded materials and will be riprapped to provide a stable stream section. To handle this event, the base channel will have a maximum flow depth of 0.71 foot and a maximum velocity of 7.38 fps. The channel depth is planned to be 2.0 feet, resulting in a

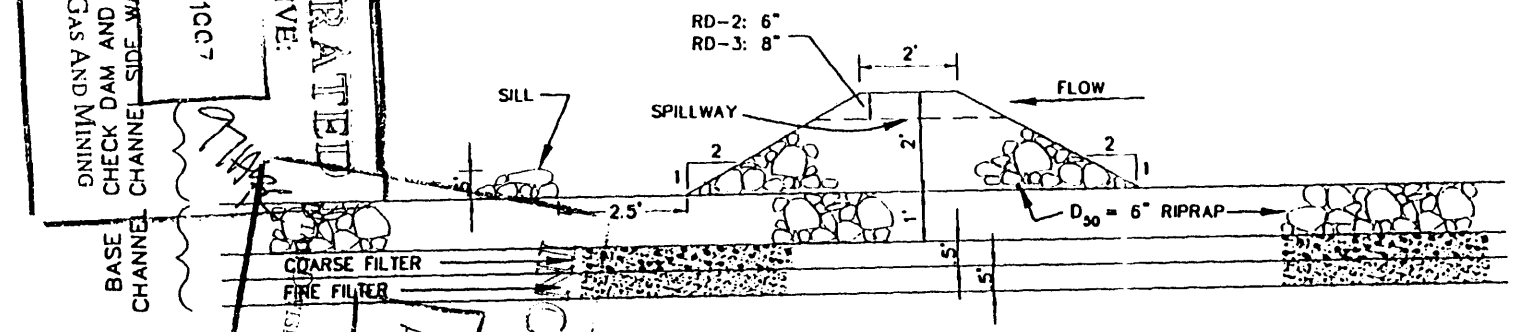
figure 7-12a

FIG7-12A.DWG UC572-02 8-13-97



TYPICAL CROSS SECTION – CHECK DAM
RD-2 AND RD-3

SCALE: 1" = 3'



LONGITUTINAL CROSS SECTION
CHECK DAM
RD-2 AND RD-3

SCALE: 1" = 3'

UTAH DIVISION OIL, GAS AND MINING
CHECK DAM AND SIDE WALL
CHANNEL
JUL 11 1997
INCORPORATED
EFFECTIVE:
APR 07 1998
EFFECTIVE:
REGISTERED PROFESSIONAL ENGINEER
No. 7102
RICHARD B. WHITE
6/16/97
STATE OF UTAH

FIGURE 7-12A. TYPICAL CHECK DAM CROSS SECTIONS

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freeboard of 1.29 feet. The velocity is greater than 5 fps, requiring riprap protection. According to Appendix 7-4, this riprap will have a median diameter of 0.5 foot, with a material gradation as presented in Table 7-6. A sand filter blanket will be installed beneath the riprap as indicated in Appendix 7-4 and Figure 7-12.

Soil will be worked into the channel riprap and loose-rock check dams will be installed in channel RD-3 as indicated above. The flood plain will also be trapezoidal in shape and will be constructed with a typical bottom width of 30 feet (but at least equal to the extent of the pre-mining riparian/wet meadow vegetation community as defined on Figure 2 of Appendix 9-2), 2H:1V sideslopes, and a channel slope ranging from approximately 0.022 to 0.100 foot/foot (see Figure 7-12 and Plate 3-7). Peak flow for this flood plain channel, based on the 100-year, 6-hour event, is 30.21 cfs. Allowing for the capacity of the low flow channel, the flood plain will only be required to handle 15.66 cfs. The channel will be constructed in regraded materials and will be stabilized using a temporary jute mesh erosion control blanket. This blanket will be in place only until the vegetation planting for the flood plain mature and provide natural protection. To handle this event, the flood plain channel will have a maximum flow depth of 0.20 foot and a maximum velocity of 3.99 fps. The velocity is less than the 5.5 fps allowed for jute mesh.

As indicated on Plate 3-7, no check dams will be installed in the middle portion of the channel RD-3. This section is currently narrow and the reclamation plan seeks to re-establish the riparian/wet meadow vegetation in this area at a width which is indicative of current conditions. Only the base channel will exist in this section, wherein the establishment of riparian/wet meadow vegetation will be enhanced by working soil into the riprap as indicated above.

Sediment Control. To minimize the hydrologic impacts of the reclamation work, Horizon commits to construct the reclaimed stream channels commencing at the upstream end of each channel. Horizon Coal Corporation proposes to employ the following alternative methods during reclamation to control sediment:

1. Silt fences
2. Surface ripping, pocking, and deep gouging
3. Mulching
4. Straw-bale dikes
5. Seeding
6. Reseeding areas that do not exhibit successful germination

The approximate locations of silt fences to be installed during the reclamation period are indicated on Plate 7-7a. The fences will be installed parallel to the contours with the ends of the fences turned up perpendicular to the contours to contain the sediment. Silt fences will be installed in accordance with Figure 7-5. The filter fabric will be installed against a supportive backing. To prevent sediment runoff from passing under the fence, the fabric will be secured by burying the bottom edge in a small trench along the length of the fence. In addition silt fences or straw-bale dikes will be installed in roadside ditches immediately downstream from the disturbed area.

Upon completion of the redistribution of the soil (Section 8.8), the reclaimed area will be seeded as outlined in Chapter 3.

Erosion control during and following reclamation will be assisted by the addition of a vegetative mulch and erosion-control matting, as indicated in Section 3.5.5 of this permit application. Erosion-control matting will be installed on all slope steeper than 2 1/2H:1V (see Plate 7-7a). The mulch or matting significantly reduces the amount of sediment yield from an area (Simons, et. al., 1983) The mulch or matting also helps retain moisture to allow for seed germination.

Prior to commencing with reclamation, specifications regarding the specific erosion control matting which is proposed for installation will be submitted to UDOGM for approval as one of the Best Technologies Currently Available. Horizon will install all erosion control matting in accordance with manufacturer's instructions.

An evaluation of the effectiveness of the reclamation sediment-control measures outlined above is provided in Appendix 7-4. This evaluation compared the sediment production from the reclaimed surface assuming:

- Bare Surface
- Bare, Ripped Surface
- Ripped and Mulched Surface
- Ripped and Mulched Surface with Silt Fences

The sediment production from these surfaces was compared to the sediment production expected from the reclaimed surface with an established vegetative cover required for bond release. The Universal Soil Loss Equation was used to make these comparisons. According to this comparison, the proposed alternative sediment control measures will actually provide better erosion control than the control planned for the Phase II reclaimed/revegetated surface. This level of protection justifies removal of the sediment pond. Once the sediment pond is removed and the low flow channel constructed, the riparian habitat/vegetation can be established. Therefore, the alternative measures are considered to an be adequate replacement for the sedimentation pond.

Sediment Control Monitoring and Maintenance. The alternative sediment controls constructed during reclamation will be inspected monthly and after every major storm event. Required repairs will be implemented immediately to prevent future sediment contributions to the main stream channel.

Corrective action will consist of repairing, replacing, or adding silt fences as necessary, replacing straw bales, localized regrading of the ground surface as necessary to fill in gullies caused by erosion, and reseeding and mulching to reestablish vegetation. Soil material trapped by sediment control measures that is not used in repairing the site will be removed and disposed of in an approved area.

7.3 Probable Hydrologic Consequences

The Probable Hydrologic Consequences (PHC) of the proposed Horizon No. 1 Mine are herein determined as per Utah Coal Mining Regulation R645-301-728.100 and R645-301-728.200. Baseline geologic information is presented in Chapter 6. Baseline hydrologic information is presented in Sections 7.1 and 7.2.

7.3.1 Potential Impacts to Surface and Groundwater

Potential impacts of coal mining on the quantity and quality of surface and groundwater flow may include:

- Increased sediment yield from disturbed areas;
- Diminution of springs in perched aquifers overlying the mine area;
- Decreased availability of groundwater in the regional aquifer system;
- Impacts on surface and groundwater availability due to subsidence;
- Hydrocarbon contamination due to spills or leaks;
- Contamination of surface and groundwater from road salting;
- Impacts to the chemical quality of surface and groundwater;
- Impacts to public water supplies; and
- Flooding or stream flow alteration.

These potential impacts are discussed in the following sections of this permit application.

7.3.2 PHC Determination

Sediment Yield. In accordance with State and Federal regulations, a runoff conveyance and sedimentation control plan has been developed which mitigates the impacts of mining operations. Surface runoff originating upon or traveling across disturbed areas will be diverted into a sedimentation pond which will improve water quality and decrease peak flows.

Although some surface waters are temporarily diverted out of their original channels, they shortly thereafter re-enter the main channel and continue their course downstream having experienced little overall modification. Disturbed waters exiting the sedimentation pond will re-enter the natural downstream drainage system.

The potential impact of construction, mining, and reclamation on sediment yield is an increase in suspended sediment in the surface waters downstream from the disturbed area. However, sediment-control measures (such as sedimentation pond, diversions, silt fences, straw-bale dikes, etc.) will be utilized during construction, operation, and reclamation phases (Section 7.2) to

minimize the impact that could result from elevated TSS concentrations. These facilities will be regularly inspected (see Section 7.2) and maintained as outlined in the permit and UDOGM regulations.

Impacts to the Perched Aquifer System. The hydrologic data presented in Section 7.1 indicate an absence of significant perched aquifers within the Blackhawk Formation overlying the coal to be mined. The geology of the area and the occurrence of springs in the Blackhawk Formation (Section 7.1) indicate the presence of small, laterally discontinuous perched aquifers in the Blackhawk. These small perched aquifers within or adjacent to the mine plan area may be impacted as a result of mining related subsidence. These water sources will be monitored as discussed in Section 7.1.

The perched aquifers of the Blackhawk Formation characteristically produce water from channel sandstones bounded by impervious shale beds at their bases. If subsidence fractures do intersect these perched aquifers, clay minerals contained within these shale beds will likely seal the fracture planes. Sealing of the fracture planes may allow spring discharge to continue uninterrupted.

According to the Cumulative Hydrologic Impact Assessment prepared for the area by UDOGM (1989), "Subsidence impacts are largely related to extension and expansion of the existing fracture system and upward propagation of new fractures." Vertical and lateral migration of water is partially controlled by fracture conduits. Potential changes include increased flow rates along fractures and diverting flow along new fractures or within permeable lithologies. Subsurface flow diversion may result in diminution and/or loss of flow to springs that are undermined.

Retreat mining also results in uniform downwarping and lowering of strata above the mined interval. This uniform downward movement is generally not accompanied by a significant degree of fracturing. As a result, the original attitude and integrity of the strata are maintained. Little impact on the perched aquifers of the overburden are expected to result from downwarping.

The probable consequences of mining on the hydrologic resources associated with perched aquifers are considered minimal due to: 1) small number of springs, 2) low and/or erratic spring flow, 3) absence of municipal water use rights, 4) water loss experienced at one location may be accompanied in an increased flow at another location, and 5) possible sealing of subsidence fractures by clay minerals.

Impacts to the Regional Aquifer System. As previously discussed (Section 7.1), it is anticipated that the coal in the Horizon No. 1 Mine will be saturated essentially from the beginning of mining. The potential inflow to the Horizon No. 1 Mine workings was estimated using methods presented by Lines (1985), who modeled the impacts of coal mining on groundwater conditions in the Trail Mountain area located in the Wasatch Plateau approximately 20 miles south-southwest of the proposed Horizon No. 1 permit area. From

this modeling effort, Lines (1985) presented estimates of mine inflow for various lengths and widths of mine workings as well as various hydraulic gradients. These estimates are presented in Figure 7-13.

Currently, the proposed workings within the permit area are anticipated to have a width of approximately 1,500 feet and a length of about 4,000 feet. The maximum future potential mine workings may extend over a width of 4,000 feet and a length of 8,000 feet.

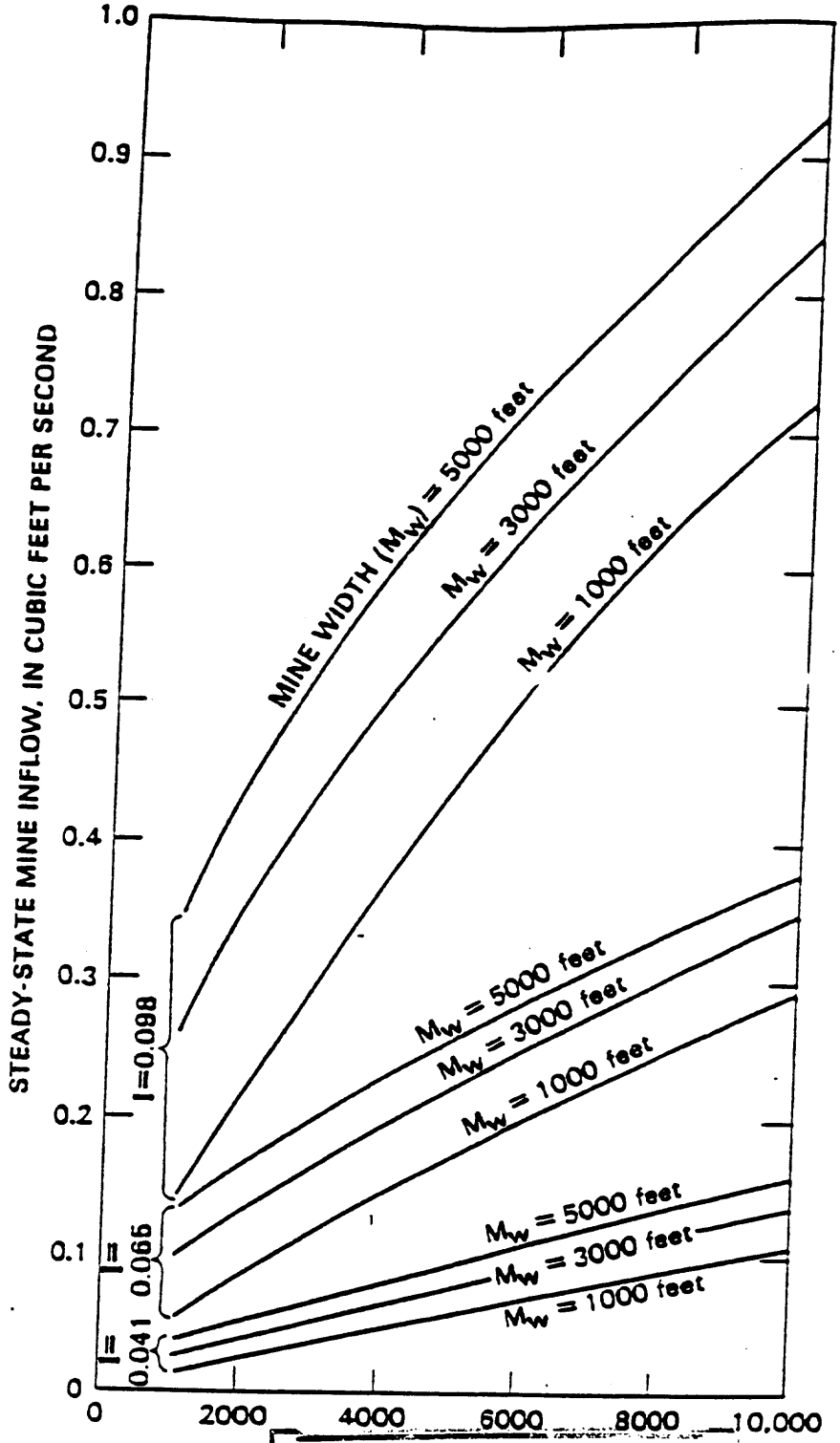
The pre-mining hydraulic gradient in the permit and adjacent areas is 0.014 ft/ft, based on the data presented in Figure 7-2. This hydraulic gradient is lower than the lowest values presented in the analysis of Lines (1985) on Figure 7-13. Hence, the data presented in Figure 7-13 were utilized to prepare curves of inflow versus hydraulic gradient, based on the mine dimensions anticipated at the Horizon No. 1 Mine. These curves are presented in Figure 7-14.
The curves presented in Figures 7-13 and 7-14 are based on assumed hydraulic conductivities of 0.01 ft/day for the Blackhawk Formation and 0.02 ft/day for the Star Point Sandstone, which values are approximately one order of magnitude lower than that for unfractured bedrock within the permit area (see Section 7.1.2.2). According to Lines (1985), if the hydraulic conductivity is one order of magnitude higher than the values assumed for Figure 7-13, the estimated steady-state inflow to the mine will be one-order of magnitude larger than that predicted by Figure 7-13 (and Figure 7-14). Hence, utilizing average hydraulic conductivities of 0.2 ft/day for the Star Point Sandstone and 0.1 ft/day for the Blackhawk Formation, the potential groundwater inflow to the Horizon No. 1 Mine was estimated to be 0.08 cfs (10 times the value predicted by Figure 7-14, or 36 gpm) under current plans. Potential future expansion of the mine workings may increase this inflow to 0.20 cfs (90 gpm). Hence, inflow to the mine workings during the initial and future permit terms can be expected to be in the range of 36 to 90 gpm.

As indicated in Appendix 7-9, average water usage for the mining operation (underground and surface) will be approximately 30,888 gallons per day (21 gpm). Of this, 21,256 gallons per day (15 gpm) will be used underground and the remainder (6 gpm) will be used in surface operations (road watering, shop use, bathhouse, etc.). The water which is used underground is not considered a consumptive use, since it will remain with the coal or seep back into the ground. Therefore, of the 21 gpm water use requirement for mining operations, only 6 gpm is considered a consumptive use. Additional consumptive use beyond that accounted for in Appendix 7-9 will occur with water that is removed from the mine as moisture in the coal and that which is lost to evaporation in the mine ventilation system.

Based on an average moisture content of 7.99 percent in the Hiawatha coal seam (as noted in Section 6.5.6) and a maximum production of 700,000 tons per year (as noted in Section 3.3.6.1), approximately 41 acre-feet per year (25 gpm) of groundwater will be removed in the coal. Data presented in Appendix 7-9 indicate that the net loss of water by evaporation due to mine ventilation will be approximately 6 gpm (10 acre-feet per year). Hence, the total consumptive loss to the hydrologic system will be 37 gpm (6 gpm for surface consumptive uses, 25 gpm as moisture in the coal, and 6 gpm as evaporative loss in the mine ventilation system - a total of 60 acre-feet per year). When mining commenced it was discovered that the old mine workings had intercepted a water bearing fault that produced in excess of 450 gpm when the mine was first de-watered. After a few months the flow from the fault decreased to an average of about 300 gpm. The inflow to the mine other than from the fault is expected to average 36 gpm. With an average inflow of 336 gpm and an average consumptive use of 37 gpm during the initial permit term, it is likely that ~~only a minimal amount of~~ groundwater will be discharged from mine during the initial permit term. ~~(recognizing that 25 of the 37 gpm of consumptive use is bound moisture in the coal rather than free water, with this excess being balanced by peak demands for additional underground water).~~ However, under the expanded conditions anticipated in the future, ~~up to~~ approximately 30~~050~~ gpm of water may be discharged from the mine during average operating periods. ~~During peak~~

~~operating periods when additional water is required, it is unlikely that water would be discharged from the mine.~~ For a short period after mining intercepts this water bearing fault the discharge from the mine may approach 523 gpm for a short period of time.

figure 7-13
figure 7-14



Source: Lines (1985)

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EFFECTIVE:
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FIGURE 7-13. PREDICTED MINE-WATER INFLOW AS A FUNCTION OF MINE LENGTH.

FIG7-14.DWG UC458-07 7-22-96

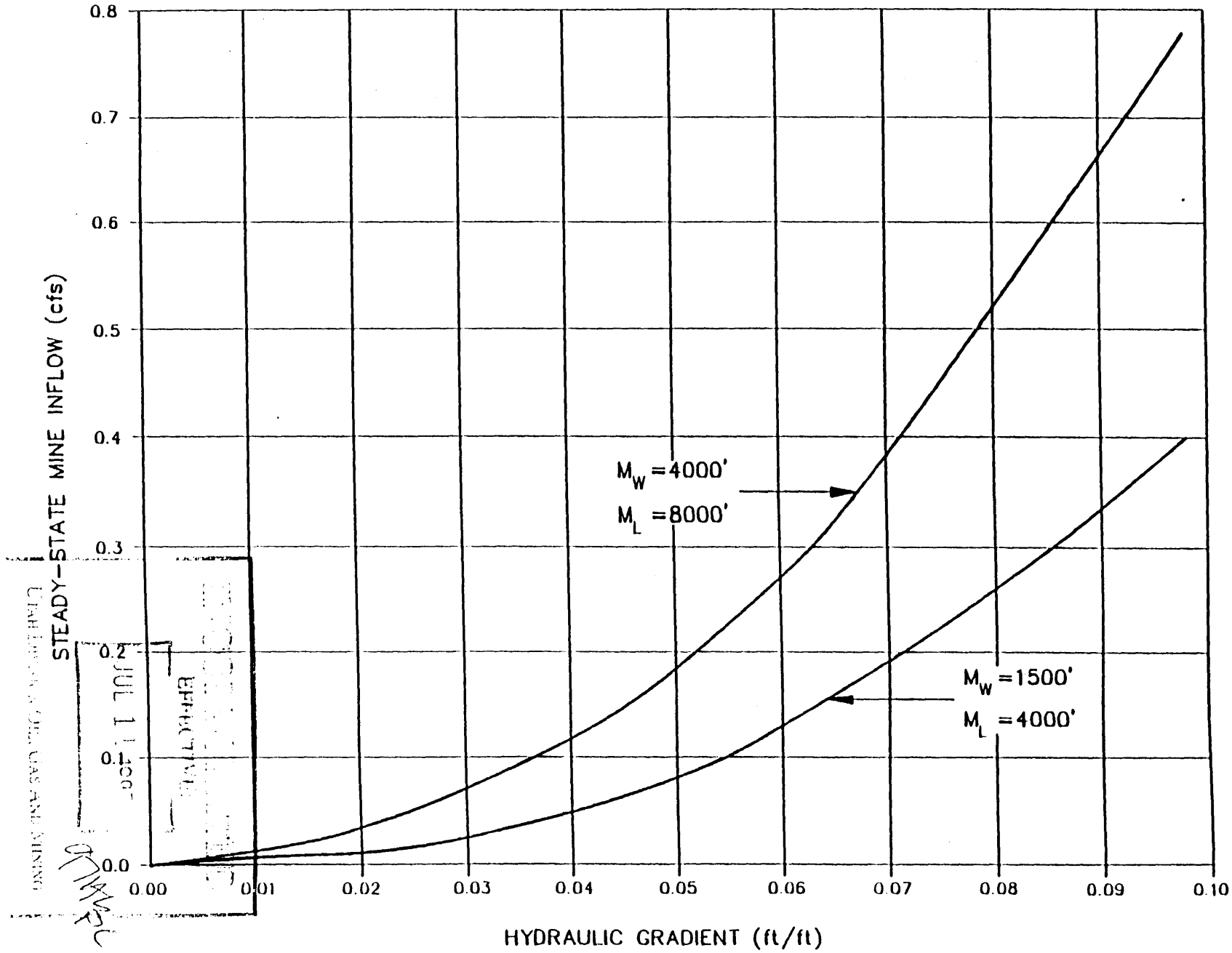

FIGURE 7-14. STEADY-STATE MINE INFLOW AS A FUNCTION OF HYDRAULIC GRADIENT

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During early 1998 quantities of water greater than previously expected were encountered while mining. Due to a delay in issuance of a discharge permit for Outfall 002, in-mine water will be discharged to the sediment pond. Flow quantities and potential hydrologic impacts will be assessed as additional data is collected.

It should be noted that the above estimates assume that groundwater inflow to the mine workings will occur primarily as a result of porous-medium flow rather than fracture flow. Historically, large amounts of the Hiawatha Coal seam have been mined out to the southwest of the proposed permit area by Sweet Coal Company's Sweet Mine, Blue Blaze Company's No. 1 Mine, National Coal Company's No. 1 Mine, and Beaver Creek Coal Company's No. 3 Mine. Based on a review of mine records (Skaggs, 1992), many faults have been mined through in the Hiawatha seam with only insignificant/minor amounts of water being encountered.

Only one fault has produced significant quantities of water when mined through. This fault lies in the east portion of the permit area and was intersected in mining of the Beaver Creek Coal Company No. 3 Mine. Inflows of approximately 400 gpm occurred when this fault was encountered (Skaggs, 1992). This fault will be located and avoided when mining the proposed Horizon No. 1 Mine by evaluating mine maps from the Beaver Creek No. 3 Mine and, if necessary, by periodically drilling horizontally from the Horizon No. 1 workings into the fault zone.

Soon after initiating mining it became evident that far more than 36 to 90 gpm was flowing into the mine. The old workings had intercepted a fault that was conveying a large volume of groundwater into the workings. This fault may be the same fault encountered in the Beaver Creek Coal Company No. 3 Mine or a fault connected to it. The North Mains and a panel were extended to the north until the same water bearing fault was encountered. When mining first encountered the fault the inflow was greater than 450 gpm. After the initial surge of groundwater, which lasted approximately 2 months, the fault produced between 200 and 300 gpm. During a period when the mine was shutdown in 2002 and 2003 the mine pumped an average of 279 gpm from the mine. During the period of shutdown the pumping data shows a slight decrease in the pumping rate over time. During the period of shutdown in 2002 the average pumping rate was 294 gpm. During the period of shutdown in 2003 the average pumping rate was 269 gpm. Thus the formation is slowly being de-watered and is producing less water with time. Upon resuming mining in the West Mains in August of 2003 the average pumping rates increased due to groundwater encountered at the mining face. Operators estimate the inflow at the face to be approximately 30 gpm. Operators have also observed that approximately 100 feet back from the face the entries no longer produce water. At this time the mining is in an area that has not had any faulting identified and water is being produced by porous-medium flow rather than fracture flow. Based on observation the inflow estimate based on Lines (1985) is valid if mining is occurring in unfractured areas. However, when mining encounters faulting or other geologic structures such as channel sands the inflow to the mine greatly exceeds the estimated inflow based on Lines (1985). Please see annual reports for pumping rates from the mine.

Based on the where the mine workings have intercepted the water bearing fault the strike of the fault is roughly the same as the strike of the coal of (N. 68° W). Thus, based on the mining plan mining can be expected to intercept the fault in the future. The maximum inflow to the mine can be expected to be similar to the maximum inflow rate encountered when the water bearing fault was first encountered plus whatever groundwater is being produced by the mine workings in unfractured areas. Based on the highest monthly average pumping rate from March of 2002 of 473 gpm and the maximum estimated inflow based on Lines (1985) methods the maximum inflow

would be approximately 560 gpm. This is considered a conservative estimate since the formation is being further de-watered as mining continues. Also an inflow of this magnitude would be expected to only last a short period of time before returning to an average inflow between 200 and 300 gpm.

With an average consumptive use of 37gpm the maximum discharge from the mine would be approximately 523 gpm with the average discharge from the mine being between 200 and 300 gpm.

Surface mapping and mining experience in the overlying Castlegate "A" seam within the permit area indicate that fracturing within the permit area is not significant. Therefore, the previous estimates of potential groundwater inflow rates to the mine workings are considered adequate for non faulted areas.

~~Based on a consumptive use of 37 gpm and assuming an inflow to the mine of 36 gpm, significant water which will be pumped into the mine only during initial operations. Thereafter, during the initial permit term, it is anticipated that water will be pumped into the mine only to meet the demands of peak operating conditions.~~

As noted in Section 7.1.4 of this permit application, groundwater which is encountered underground and consumed in the mining operation will be used in accordance with water right number 91-330. Water needed to operate the mine equipment will be derived from a spring which is covered by water rights 91-94 and 91-353. These rights have been leased by Hidden Splendor Resources, Inc..

In November 2001 a monitoring well (HZ-01-06-1) was installed to provide potentiometric surface data for the area north of Beaver Creek. As can be seen on Table 7-1 in the annual reports the potentiometric surface dropped 85 feet between the first and second readings. It is unclear whether the drop was due to the mine de-watering the aquifer or if the initial reading was inaccurate. During drilling circulation was lost numerous times resulting in drilling fluid flowing into the formation. The loss of the drilling fluid may have artificially elevated the potentiometric surface for the first reading. However, HZ-95-1 experienced a 104' drop in a similar time period between the fall of 1999 and spring of 2000. Due to the rapid drop in the potentiometric surface and the magnitude of the drop at HZ-95-1 it can be concluded that the influence of water bearing fault discussed above extends at least as far north as Beaver Creek. If the initial water level reading for HZ-01-06-1 is valid then it can be concluded that the influence of the water bearing fault on the potentiometric surface extends at least to the northern permit boundary.

Water level monitoring indicates that mining will depress the regional aquifer to the maximum depth of the mined entries. Due to the a large amount of water being transported by faulting in the area the potentiometric surface will be depressed in an area much larger than the permit area. However, when pumping ceases the potentiometric surface will return to pre-mining conditions as evidenced by the conditions prior to the Horizon Mine beginning production. The old workings had intercepted the water bearing fault thus dropping the potentiometric surface during the period when this area was first mined. When mining ceased in the old workings the potentiometric surface recovered as shown by the water level measurements taken prior to initiating mining at the Horizon Mine. Thus, the impact to the regional aquifer is expected to be temporary. The potentiometric surface will return to pre-mining conditions as soon as pumping ceases.

Impacts to the Hydrologic System Resulting From Subsidence. As noted in Section 3.3.2.2, stream buffer zones will not be maintained ~~for a distance of 100 feet on either side of~~ under Beaver Creek~~, within which second mining will not occur~~. According to Gentry and Abel (1978), topographic lows (e.g., stream channels) tend to be protected by upwarping of adjacent slopes during subsidence. Therefore, mining-induced surface fracturing should be very limited (or nonexistent) within the Beaver Creek stream channel area. With an overburden of approximately 1000 feet and a coal thickness of 7.5 feet there is little potential for subsidence cracks to propigate to the surface. Any fracturing that does occur in the stream channel is likely to fill rapidly as a result of sedimentation. Appendix 7-13 contains the Skyline Mine subsidence study which, among other things, concluded that with more than 800 feet of cover, panels oriented perpendicular to the stream, and full extraction of the coal, some short term effects occurred to the stream but after three years the stream had reverted to a pre-mining configuration. The study was carried out at the Skyline Mine from 1992 to 1998 by the Forestry Science's Laboratory, Rocky Mountain Research Station in conjunction with the Manti-Lasal National Forest and Arch Coal Company/Canyon Resources LLC. The study was completed on an area of the mine that was undermining Burnout Canyon and a perennial stream. Two seams were extracted (Upper and Lower O'Conner) under the stream over the six year period and, in summary, the conclusions were:

1. There were no "measurable" significant impacts due to subsidence on stream flow, silt, or vegetation.

2. There was year to year variability in the stream, but it was less than the year to year variability of the nearby control stream.

3. There were temporary changes during the first year after mining in the number of pools, stream drops, and stream width, but the stream had reverted to normal by the third year after mining. The coal seams at Skyline are in the Blackhawk formation as is the coal seam at Horizon.

It is also not anticipated that subsidence will significantly affect springs within the permit and adjacent areas. Von Schonfeldt et al. (1980) found that uniform subsidence "rarely causes problems to renewable resources such as aquifers, streams, and ranch lands." Since second mining will occur uniformly across the permit area ~~except in buffer zones,~~ the resulting subsidence should also be uniform, minimizing the potential impacts to overlying springs.

As noted in the Cumulative Hydrologic Impact Assessment, mining in the area adjacent to the proposed Horizon permit area has not resulted in hydrologic impacts due to subsidence. Given the lack of extensive aquifer systems in lithologic units that overlie the coal within the permit and adjacent areas, it is not anticipated that groundwater will be significantly affected by subsidence. Thus, subsidence caused as a result of mining by Hidden Splendor Resources, Inc. should not cause significant surface or groundwater impacts within the permit or adjacent areas.

Potential Hydrocarbon Contamination. Diesel fuel, oils, greases, and other hydrocarbons products will be stored at the mine site. Diesel fuel will be contained in above-ground tanks. Diesel fuel may spill during filling of the storage tank, leakage of the tank, and filling of vehicle tanks. Hydrocarbons may be spilled during use in surface and underground activities.

The extent of contamination by spillage of hydrocarbons will likely be small since storage tanks will be located above-ground and thus leakage can be readily detected and abated. Furthermore,

and spillage of hydrocarbons during filling of the tank and mine vehicles will be minimized to avoid loss of an economically valuable product, and the fuel storage area will be surrounded by an ~~concrete~~ enclosure of sufficient size to contain a fuel spill if the tanks were to rupture. In the event of a fuel or hydrocarbon leak or spill, Hidden Splendor Resources, Inc. will abate the problem in accordance with the Spill Prevention, Control, and Countermeasure Plan (see Appendix 7-10). Absorbent materials will be kept within easy access for the purpose of spill clean up and control.

Hidden Splendor resources does not intend to abandon any equipment underground. However if it becomes necessary to abandon any equipment underground all petroleum products will be drained from the equipment. Also any equipment to be abandoned will be located on a mine map and submitted to the Division for reference purposes.

Road Salting. The access road to the mine is a gravel road maintained by the county. Paving of the road is not expected. Since the road is to remain gravel, the likelihood of road salting is extremely small. As a result, the likelihood of road salting impacting water quality is very remote.

Impacts to Water Quality. Data presented in Appendix 7-3 indicate that the average TDS concentration of the surface water measured at station SS-3 (immediately downstream from the proposed surface facilities) is 427 mg/l, with a standard deviation of 122 mg/l. The calculated 95-percent confidence interval for the average concentration is 407 to 447 mg/l, based on the historical record.

As noted in Section 7.1.3, water standing in the old mine workings of the Blue Blaze No. 1 Mine has a TDS concentration which has been measured at 414 to 452 mg/l. These values are approximately within the 95-percent confidence interval range of the mean calculated for station SS-3. Hence, assuming that water must be discharged from the mine workings, the salinity of the surface water should not be adversely impacted by the salinity of the underground water.

It is currently anticipated that a calcium-carbonate rock dust will be used in mining operations rather than a calcium-sulfate rock dust. Since surface and groundwater within the permit and adjacent areas is characterized as a calcium bicarbonate type, changes in the general chemical characteristics of water in the area should not occur if water from the mine seeps into the adjacent groundwater or under the condition that water is discharged from the mine to surface water resources.

North Fork Gordon Creek flows across the Mancos Shale immediately downstream from the mine area. Since the Mancos Shale is a gypsiferous formation, sulfate and TDS concentrations naturally increase as the surface water contacts this formation (Waddell et. al., 1981). Thus, increases in TDS concentrations downstream from the surface facilities, if they occur, will more likely result from natural conditions rather than mining impacts.

It is anticipated that water will be discharged from the mine workings to the surface during the initial permit term. As mining progresses during future permit terms, additional water will likely be pumped from the mine. As also noted above, the mine water is anticipated to have a TDS concentration which approximates that of the surface water immediately downstream from the proposed surface facilities.

If the excess groundwater encountered in the mining operation was allowed to flow naturally rather than being discharged from the mine, this water would flow naturally downgradient and eventually

3. The flow routing that occurs through the sediment control devices reduces peak flows from the disturbed areas. This precludes flooding impacts to downstream areas.

Following reclamation, stream channels will be returned to a stable state, thus minimizing detrimental effects that may result from flooding.

7.4 Alluvial Valley Floor Determination

A reconnaissance investigation of the permit and adjacent areas was conducted to delineate alluvial deposits which might be considered to be alluvial valley floors. Identification of locations where unconsolidated stream-laid deposits occur was performed using surficial geology and soils maps of the area. Further, field reconnaissance and an analysis of aerial photographs of the mine permit and adjacent areas were conducted. Locations of stream-laid deposits thus identified are the same as those identified on Plate 6-1 as Qal (Recent Alluvium) and Qoa (Older Alluvium).

From a geomorphic standpoint, the rugged mountainous terrain of the permit and adjacent areas has resulted in drainages still in a youthful stage of development. The streams are confined in narrow, steep-sided, V-shaped valleys with steep channel gradients. Meanders normally associated with AVF development are absent except in a few isolated locations.

Information presented on Plate 6-1 indicates that alluvial deposits exist in the permit and adjacent areas along Beaver Creek, North Fork Gordon Creek, and Jewkes Creek, as well as short distances into tributaries of the above drainages. Alluvial deposits along Beaver Creek exhibit minor stream meandering and contain numerous beaver ponds. Some of the stream-laid deposits along Beaver Creek, particularly at the mouths of small tributary canyons, appear to be debris flows. Soils in the valley exhibit localize signs of being flooded or water logged during a field visit to the site.

Alluvial deposits were also identified at the mouth of Jewkes Creek and along North Fork Gordon Creek. The alluvial deposits at these locations are below the coal outcrop and thus, could not be directly impacted by mine subsidence. The soils investigation showed the upper reaches of the alluvial deposit along Jewkes Creek and North Fork Gordon Creek to be disturbed and consisting of about 90 percent fill material (i.e., from road cuts and coal waste). Included in the area are small areas of Patmos and Podo soils as well as areas of rock outcrops. Even before disturbance, this area had limited range and wildlife capability. The valley floor is quite narrow along these reaches.

Agricultural developments are not found along North Fork Gordon Creek, Beaver Creek, or their tributaries in the permit and adjacent areas. The agricultural potential of the valley floors in the area is limited by the soil capability and the short growing season. The narrow valleys are occupied by the stream and the road and both break up the narrow valley so that development of hay meadows or improved pasture is impractical.

The valley floor along Beaver Creek, North Fork Gordon Creek, and their tributaries would be incapable of supporting agricultural activities without proper drainage. Even with adequate drainage, agricultural development would be restricted to grasses and pasture because of the high elevations and short growing seasons. Hence, given the extensive prior disturbance in the proposed disturbed area, the narrowness of the valleys, and climactic conditions in the area, the

stream-laid deposits in the permit and adjacent areas are not considered to be alluvial valley floors. This conclusion is supported by the opinion of Mr. T.B. Hutchings, State Soil Scientist with the U.S. Soil Conservation Service (see Appendix 7-6).

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APPENDIX 7-13

SKYLINE MINE SUBSIDENCE STUDY

Skyline Mine Subsidence Study

Changes in Stream Channel Characteristics and Hydraulic Parameters Related to Surface Subsidence

Research Work Unit 4301
Forestry Sciences Laboratory
Rocky Mountain Research Station
Logan, Utah

Final Report July 1998

In Cooperation with:
Arco Coal Company/Canyon Resources LLC
Skyline Mine
and
Manti-Lasal National Forest
Region 4, U.S. Forest Service

SKYLINE MINE SUBSIDENCE STUDY

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Introduction

Underground coal mining has been associated with adverse environmental impacts because of subsidence. Subsidence can cause loss of productive land (Guither, 1986), damage to underground pipelines (Hucka et al., 1986) and above ground structures (Kaneshige, 1971), decreased stability of slopes and escarpments (Shea-Albin, 1992), contamination of groundwater by acid drainage (Emrich and Merritt, 1969), and dewatering of streams (Cifelli and Rauch, 1986; Dixon and Rauch, 1990) and groundwater supplies (Stoner, 1983; Matetic and Trevits, 1992).

One of the major concerns regarding the longwall mining of coal is the effect on hydrologic conditions. Surface and subsurface cracking associated with mining subsidence can alter and create preferential flow paths, thus causing dewatering and rerouting of surface water and groundwater (Mather et al., 1969; Sells et al., 1992). Many of these effects are short-term but appear to be dependent on the characteristics of the overburden (Whittaker et al., 1979). Studies in Appalachia have shown that loss of water was much less and streamflow recovered within one year when mixed sedimentary overburdens were at least 500 ft (152 m) in depth (Tieman and Rauch, 1987; Dixon and Rauch, 1990). Of the more than 70 references to hydrologic impacts of underground coal mining recently compiled by Kadnuck and Fejes (1994) only two were from the western states. These two studies represent overviews and modeling efforts and present no new field data. Rather rapid closure of surface tension cracks has been measured at undermined sites in the Wasatch Plateau (DeGraff and Romesburg, 1981), thus indicating that this region may respond differently to subsidence than other lithologies.

Another potential impact on surface drainages in steep terrain is the alteration in channel and drainage morphology resulting from subsidence. Such changes could affect channel erosion, sediment delivery and routing in streams, and riparian habitat. While speculation exists concerning such morphologic changes associated with subsidence, these impacts have not been substantiated in controlled studies.

This study was initiated in 1992 in cooperation with Utah Fuel Company and the Manti-LaSal National Forest to address the effects of longwall mining and related subsidence in the Wasatch Plateau on hydrology, channel condition and habitat changes in perennial and intermittent reaches of a mountain stream. The initial phase of this study will continue through 1997 to assess the cumulative effects of longwall mining oriented approximately perpendicular to the stream channel and proceeding in a downstream direction. Interim reports covering the results of this study were submitted in February 1993, March 1995 and May 1997. This final report updates the earlier reports and contains results thru 1997.

Site Conditions

The Skyline Mine is located in the Upper Huntington Creek drainage on the Manti-LaSal National Forest about 27 miles east of Price, Utah (Figure 1). Huntington Creek flows into Electric Lake just downstream of the mine and eventually discharges into the San Rafael River, part of the Colorado River Basin. Much of the current mining activity is in the upper coal seam under Burnout Canyon. The next canyon south of Burnout is James Canyon. Both James and Burnout Canyons are predominantly west facing. Only very minimal mining will occur under James Canyon and this should not cause any subsidence near the stream channel. Thus James Creek can be used as an uncalibrated control in our investigations. The entire drainage areas of Burnout and James Canyons are 1,166 and 1,075 acres respectively. Surface elevation in the area ranges from 8,575 to 9,860 feet (2,614 to 3,005 m). Two and possibly three extractable coal seams exist in the Blackhawk Formation at depths of 600 to 800 feet (183 to 244 m). The formation is composed of marine sedimentary rocks, sandstones and mudstones. Bedrock dips to the west and numerous springs discharge from the west facing slopes of Burnout and James Canyons. The bentonite associated with the mudstones of the formation imparts a swelling characteristic to the lithology, thus most tension cracks in this area tend to close quite rapidly.

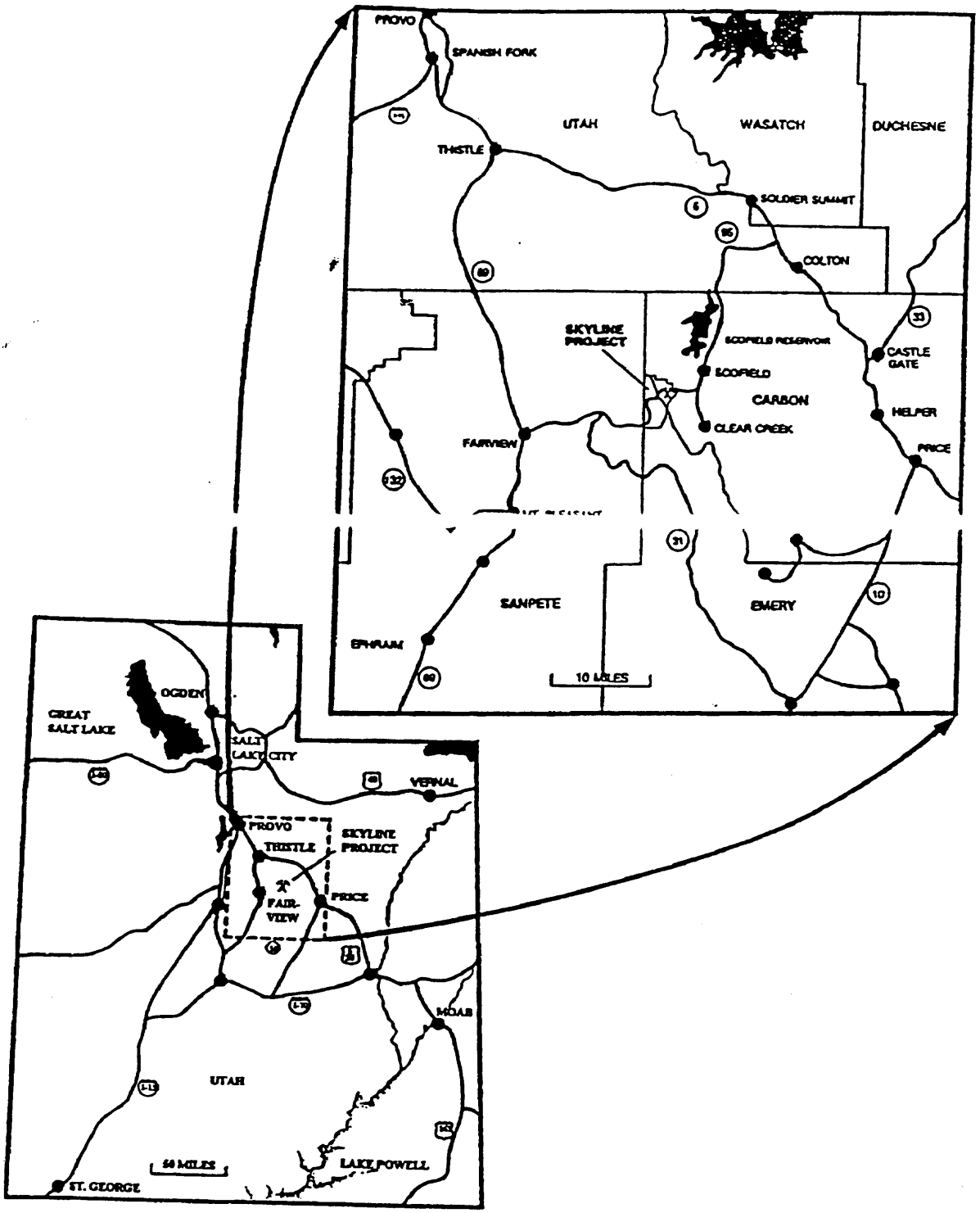


Figure 1. General location of the Skyline Mine in central Utah

Six panels of coal are proposed to be mined in the upper coal seam under Burnout Canyon. These are all oriented approximately perpendicular to the stream channels (either the main reach of Burnout Creek or the South Fork) and coal extraction in each panel takes about one year (Figure 2). Mining started at the top of the watershed (panel 5L) in 1991 and coal from panels 6L and 7L were removed during 1992-1993 and 1993-1994, respectively. Panel 8L was mined in 1995-'96 and panel 9L also in 1995-'96. Panel 10L will not be mined. The company now plans to initiate mining in the second seam of coal starting from the top of the drainage and progressing downslope. Approximately 2 million tons of recoverable coal are located in the seams below Burnout Canyon.

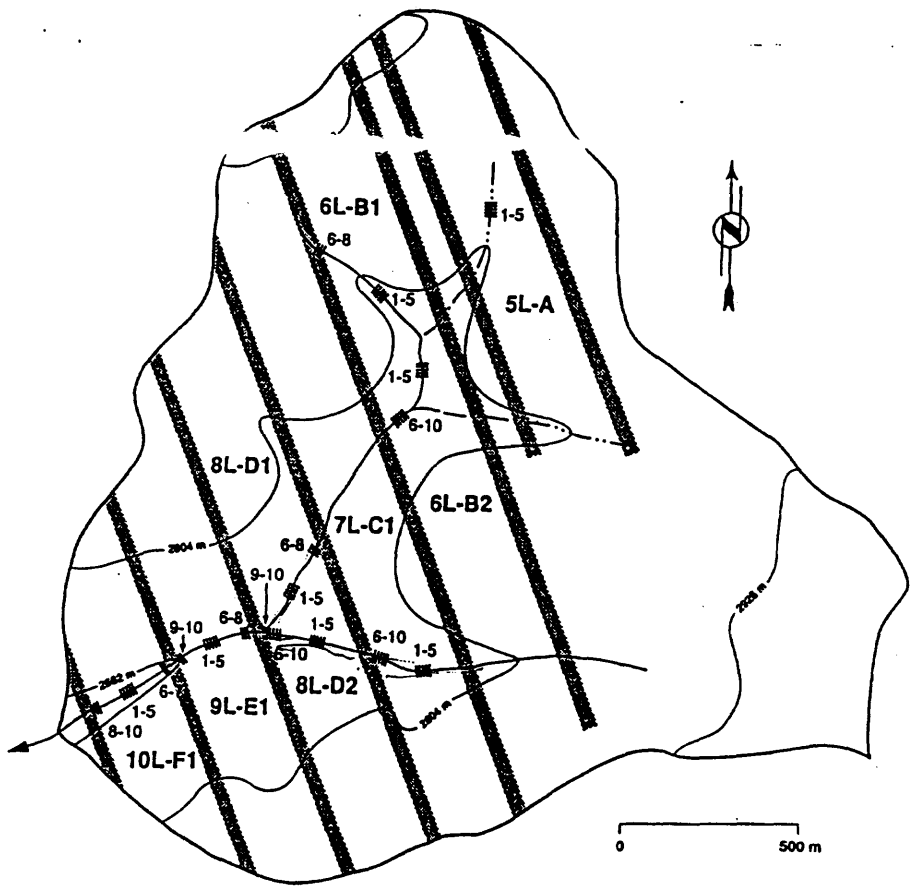


Figure 2. Map of Burnout Canyon showing the locations of documented cross-sections in relation to longwall mining panels. (Note: the darkened areas are support walls between mined panels.)

Mean annual precipitation is 30 to 35 inches (762 to 889 mm) with much of the precipitation occurring as winter snowfall. The snowpack is typically at a maximum in early April. Average water equivalent in the snowpack on April 1 is 21.5 inches (546 mm) according to the Mammoth Cottonwood SNOTEL station at 8,800 feet (2,682 m). This station is located approximately 4 miles northwest of the mouth of Burnout Canyon. Rainfall from May through September is 7 to 10 inches (178 to 254 mm) each year (Jeppson et al., 1968). Peakflows in these drainages are caused by peak snowmelt, episodic, convective summer storms or frontal storms.

Federal Coal Lease Laws and the Manti-LaSal's Forest Plan state that the hydrology of perennial streams must be protected from any impacts of underground mining. Thus, Utah Fuel Company is required to monitor the effects of coal mining on subsidence and hydrology and to prevent subsidence that would damage or substantially reduce flow in perennial streams. Up until now it has been the Forest's policy not to allow mining under perennial channels. The long-term findings of this cooperative investigation will have application to future longwall coal mining in the Wasatch Plateau which contains an estimated 6.4 billion tons of coal reserves. The Skyline Mine is one of the largest underground coal producers in the U.S. and it contributes substantially to the economy of Price, Utah, and the surrounding area.

Methodology and Instrumentation

Documented channel cross-sections were surveyed with an engineer's level at various locations along both Burnout and James Creeks in 1992, 1993, 1994, 1995, 1996 and 1997 (Harrelson et al., 1994) (Platt et al.,1983). Cross-sections in Burnout Creek were located in sets corresponding to the zones of maximum subsidence (compression) and maximum tension over each longwall panel. A typical subsidence profile which indicates the zone of maximum subsidence or compression (near the middle of each panel) and the zones of maximum tension (near the inflection points along the subsidence profile) is shown in Figure 3.

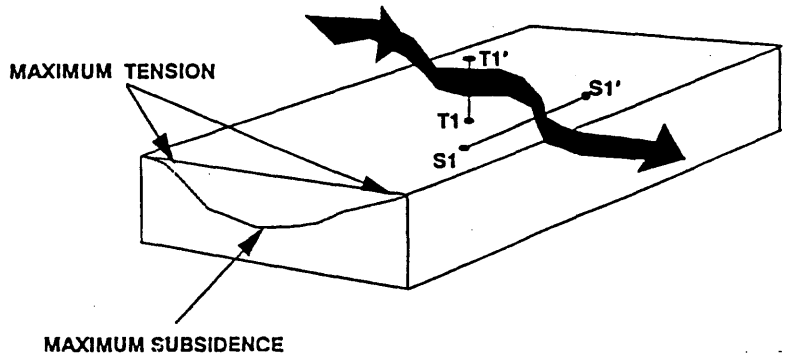


Figure 3. A typical subsidence profile showing the locations of maximum subsidence and maximum tension above each longwall panel and respective documented cross-section panels.

Burnout Creek flows approximately perpendicular to longwall panels 7L, 8L, 9L, and 10L (Figure 2). Ten cross-sections were monitored for each of these panels: 5 in the region of maximum subsidence and 5 in the region of maximum tension. Stream reaches above panel 5L and 6L were not necessarily oriented perpendicular to the underlying panels, thus, five tension zone cross-sections could not always be located (the last number on the I.D.# indicates subsidence/tension status: numbers 1-5 represent subsidence cross-sections and 6-10 tension cross-sections; see Table 1). For panel 5L, cross-sections were placed only in the zone of maximum subsidence since initial subsidence had already occurred in that panel prior to the 1992 survey. Table 1 lists the 73 cross-sections surveyed in Burnout Creek with respect to the underlying coal panel. Locations of these cross-sections are given in Figure 2.

In James Creek, the drainage directly to the south, five documented cross-sections were established in 1992 in each of four stream reaches. These four reaches were selected as representative geomorphic units comparable to documented reaches in Burnout Creek. Thus, **James Creek serves as an uncalibrated control to assess the natural temporal variability of channel geometry.** These cross sections were installed to help analyze effects of extreme events (floods, droughts, etc.) from effects of subsidence on channel cross-sectional changes in neighboring Burnout Creek. The 20 documented cross-sections are listed in Table 1 and their approximate location is shown in Figure 4.

Table 1. List of documented cross-sections in Burnout and James Creeks.

Burnout Creek:

5L-A-1	6L-B1-1	6L-B2-1	7L-C1-1	8L-D1-1	8L-D2-1
5L-A-2	6L-B1-2	6L-B2-2	7L-C1-2	8L-D1-2	8L-D2-2
5L-A-3	6L-B1-3	6L-B2-3	7L-C1-3	8L-D1-3	8L-D2-3
5L-A-4	6L-B1-4	6L-B2-4	7L-C1-4	8L-D1-4	8L-D2-4
5L-A-5	6L-B1-5	6L-B2-5	7L-C1-5	8L-D1-5	8L-D2-5
	6L-B1-6	6L-B2-6	7L-C2-6	8L-D1-6	8L-D2-6
	6L-B1-7	6L-B2-7	7L-C2-7	8L-D1-7	8L-D2-7
	6L-B1-8	6L-B2-8	7L-C2-8	8L-D1-8	8L-D2-8
		6L-B2-9	7L-C2-9	8L-D1-9	8L-D2-9
		6L-B2-10	7L-C2-10	8L-D1-10	8L-D2-10
9L-E1-1	9L-E1-6	10L-F1-1	10L-F1-6		
9L-E1-2	9L-E1-7	10L-F1-2	10L-F1-7		
9L-E1-3	9L-E1-8	10L-F1-3	10L-F1-8		
9L-E1-4	9L-E1-9	10L-F1-4	10L-F1-9		
9L-E1-5	9L-E1-10	10L-F1-5	10L-F1-10		

James Creek:

W-1	X-1	Y-1	Z-1
W-2	X-2	Y-2	Z-2
W-3	X-3	Y-3	Z-3
W-4	X-4	Y-4	Z-4
W-5	X-5	Y-5	Z-5

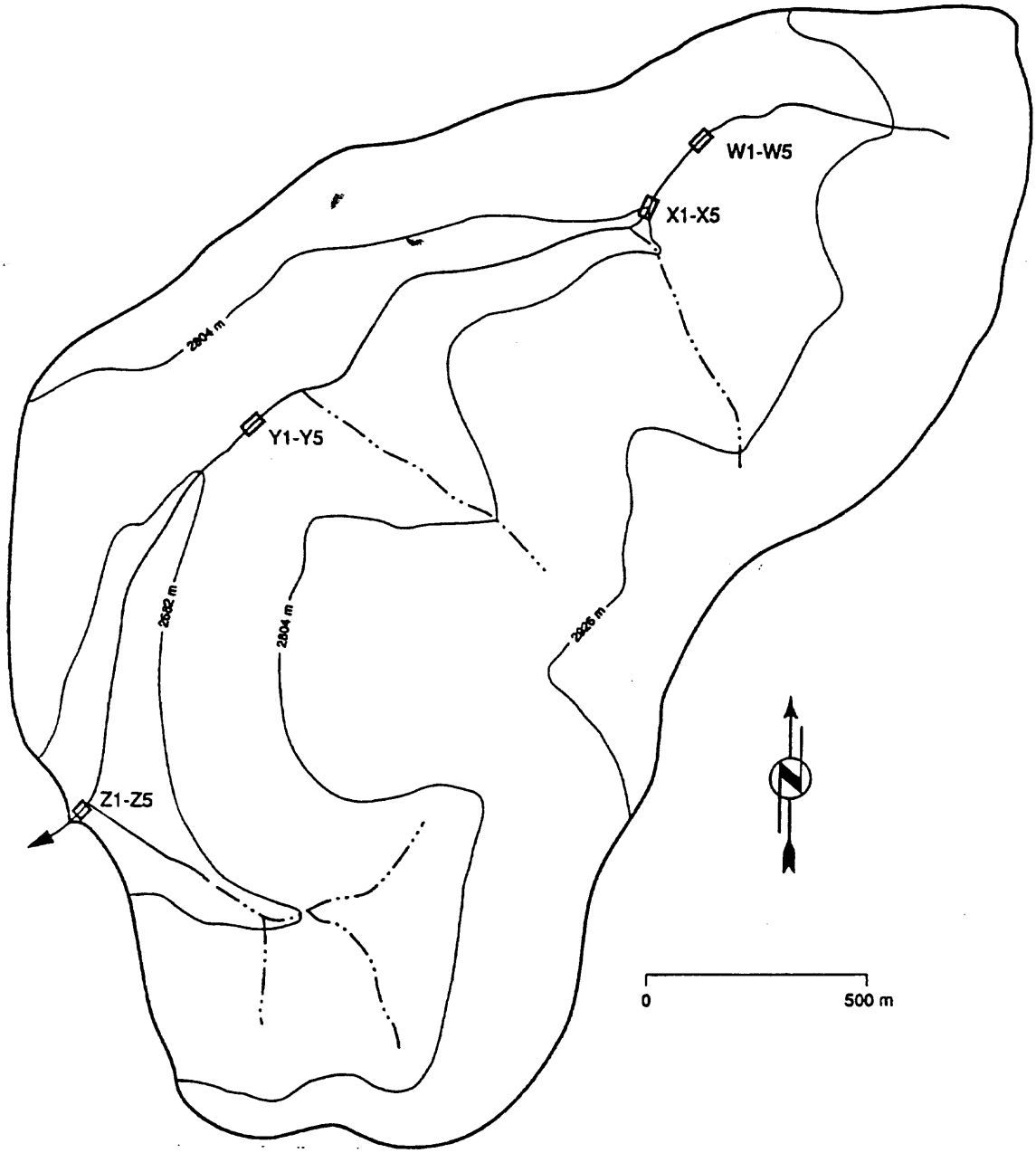


Figure 4. Map of James Canyon showing location of documented cross-sections.

Longitudinal profiles of both Burnout and James Creeks were surveyed each year with a hip chain and engineer's level. Survey points were taken in the channel thalweg at 10 m intervals along the stream. Significant kickpoints or channel steps were surveyed in addition to the 10 m intervals. In Burnout Creek, both the main channel and the South Fork were surveyed upstream of the highest elevation cross-section. Since only intermittent stream flow occur in the upper reaches of the Main Channel of Burnout Creek above 1700 m, channel characteristics were not measured much beyond this point in 1996 and 1997. The summaries presented here contain only measurements below the 1800 m distance for the Main Channel of Burnout.

Samples of streambed sediment were collected in every pool within Burnout and James Creeks. Pools were selected as the sampling unit since they are the depositional environment in channels and should most quickly reflect temporal changes, especially silting, related to erosion, channel adjustment, and flow regime. Sediment samples were transported to the laboratory where they were dried, organic matter was hand removed, and samples were sieved for particle size analysis. The following particle size classes were determined: <0.05 mm, 0.05 - 0.125 mm, 0.125 - 0.25 mm, 0.25 - 0.50 mm, 0.5 -1.0 mm, 1.0 - 2.0 mm, 2.0 - 4.0 mm, 4.0 - 8.0 mm, 8.0 - 16.0 mm, 16.0 - 32.0 mm and >32mm. At each measured pool ($\geq$ 0.5 m in length), the predominant formation element (e.g., rock, woody debris, bank slough) was noted for all years prior to 1996. Formation elements were not used in this report.

Dimensions of each pool were measured in the field so that pool volume could be calculated. For pools lengths $\geq$ 1 m, three sets of measurements were made for each pool for each year 1994 thru 1997: widths and maximum depths (based on baseflow conditions) at the lower, middle and upper portions of the pool. For these large pools, pool volume was estimated by averaging the cross-sectional areas of the two half-ellipses that comprise the lower and upper halves of each pool and then multiplying this value by one half of the pool length (L/2). Thus the volume (V) of the pool is computed as:

$$V = \pi/4\ [L/2\ (W_u/2 \cdot D_u + W_m/2 \cdot D_m) + L/2\ (W_m/2 \cdot D_m + W_d/2 \cdot D_d)]$$

$$= \pi/16 \cdot L \cdot (W_u \cdot D_u + 2W_m \cdot D_m + W_d \cdot D_d)$$

where, W_m is the middle width of the pool, W_u is the width at the upper end of the pool, W_d is the width at the lower end of the pool, D_m is the depth at the middle of the pool, D_u is the depth at the upper end of the pool, D_d is the depth at the lower end of the pool, and L is the length of the pool. These dimensions are shown schematically in Figure 5. For small pools (> 0.5 m and < 1 m in length), only mid-pool dimensions were measured. Thus, volumes of these small pools were calculated as a half of an elliptical cross-section assuming an average pool length of 0.75 m. The minor over-estimation in pool volume (because the presumed tapered "tails" of small pools would be considered to have the same depth as at mid-pool) would be compensated by the fact that more pools were in the upper portion of the length distribution (>.75<1.0 m).The formula used to calculate small pool volume (V_s) is:

$$V_s = \pi/2\ (W/2 \cdot D) \cdot 0.75\ m$$

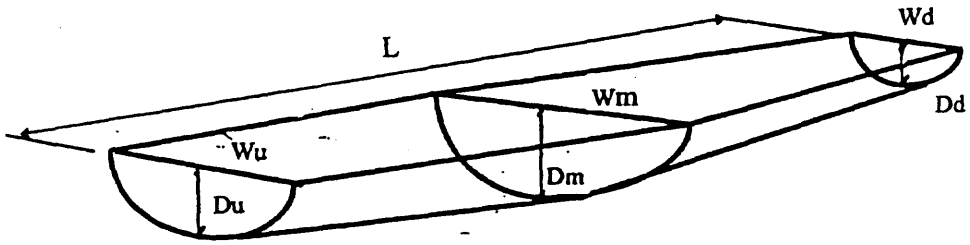


Figure 5. Schematic of large pool dimensions used in calculating pool volume.

A precipitation storage gage and a tipping bucket rain gage were installed near the upper divide between James and Burnout Canyons. The tipping bucket rain gage is only operated during the snow-free period (approximately June through October). The Company also maintains a rain gage at the mine site.

The Company installed five Parshall flumes in various reaches of Burnout Creek to monitor streamflow during the snow-and ice-free seasons. The 9-inch flume installed in the lower

reach of Burnout Creek is of greatest interest in this study. This site is the same as where pre-mining water quality samples were collected from 1981 to 1991. In summer 1992, a recorder was installed at this flume. Prior to 1992, instantaneous flow was measured at the time of water quality sample collection. The Company also installed a flume in the lower reach of James Creek.

Channel Characteristics

Channel features were surveyed along the entire study reaches of both Burnout and James Creeks each year from 1992 thru 1997. Channel units were qualitatively classified as cascades, riffles, runs, glides, and pools in approximate order of decreasing unit stream power. A total of about 1,700 m of channel was surveyed in both Burnout and James Creeks. In analyzing the results from the first three years of the study, it became apparent that inconsistencies arose in distinguishing between riffles and runs in the field and in pool formation elements. Thus, in our analysis we have lumped riffles and runs into one type of channel unit and pools are not classified as to formation element. The habitat implications of runs and riffles are very similar therefore we can justify combining these characteristics. *Unfortunately, classifying channel characteristics is subjective and personal bias often distorts the results.* Different observers classified these characteristics in three of the six years covered by this report, thus year-to-year difference might well be a result of classification inconsistencies. However, in any one year both the James Canyon control area and Burnout were classified by the same individual to maintain within-year consistency between Burnout and the control area. All channel features are presented as lengths or as the percentage of length of the system (or portion of the system).

James Canyon (Control Area):

James Canyon has not been extensively subjected to mining and consequent subsidence, thus yearly differences in channel characteristics here result from a combination of natural causes (normal yearly variation), grazing, timber harvesting and observational error. There was a small portion of James Creek undermined in 1995 between cross sections X and Y(at about 2200 M). Mine survey data indicates about one-third meter subsidence occurred at this location. Beyond that small subsidence no other changes as a result of this mining have been observed.

James Creek serves as basis for judging the meaningfulness of changes that occur in Burnout. **Differences in Burnout that substantially and consistently exceed changes in James Canyon can reasonably be attributed to mining and subsidence.**

The percentage of the entire measured channel in James Canyon that was classified as rills and riffles over the six-year period varied between 71.8% and 83.5%, as cascades from 2.4% to 22.7%, as glides from 0.4% to 11.0%, and as pools from 1.6% to 6.0% (Figure 6). It is worth noting that the percentage of the entire length classified as pools decreased every year to a low of 1.6% in 1997. The number of pools varied between 18 and 45/km (Figure 7), and their total volume between 4 and 17 m^3 (Figure 8). The only trend apparent was as increase in the percentage of cascades apparently at the expense of runs and riffles which probably results from classification error. The number of pools decreased greatly in 1995 through 1997, and consequently total volume. Average pool volume varied between 0.25 and 0.12 m^3 over the six year period (Figure 9).

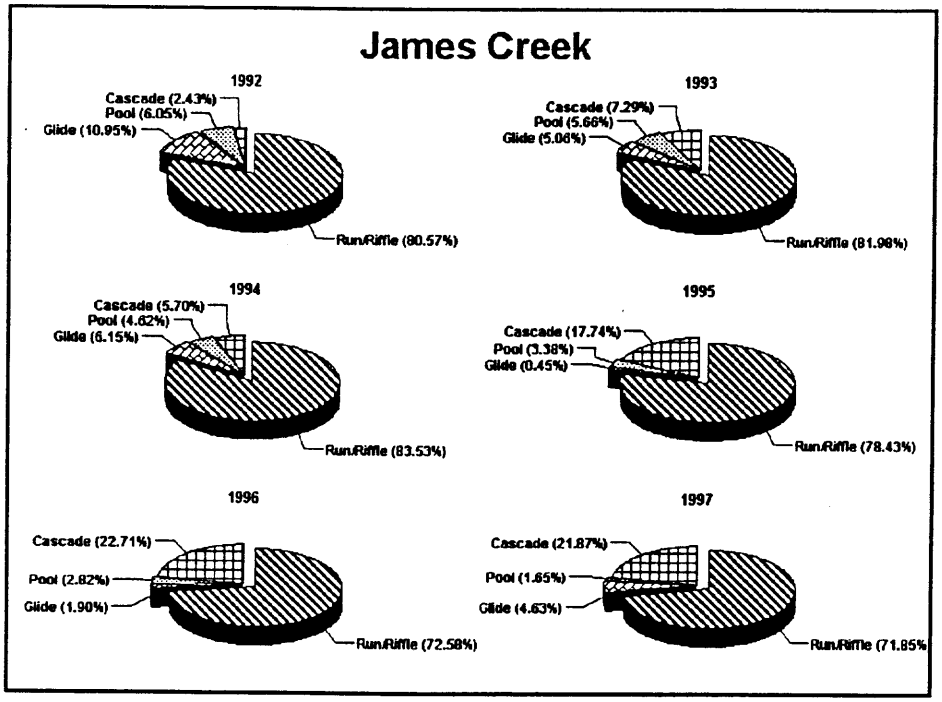


Figure 6. Distribution of channel elements in James Creek for 1992 through 1997.

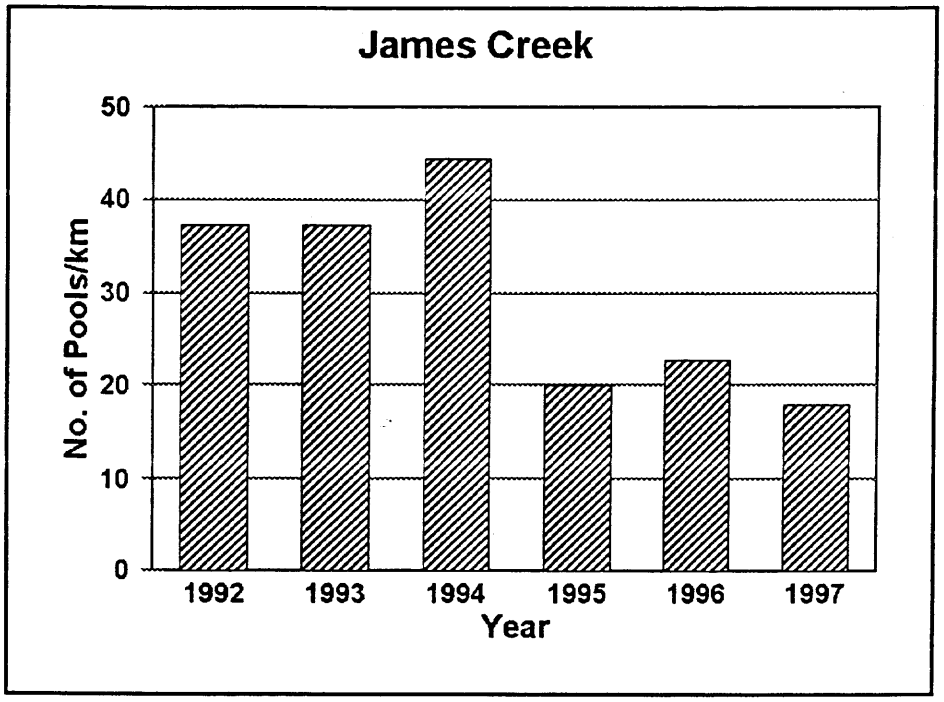


Figure 7. Total pool density in James Creek for 1992 through 1997.

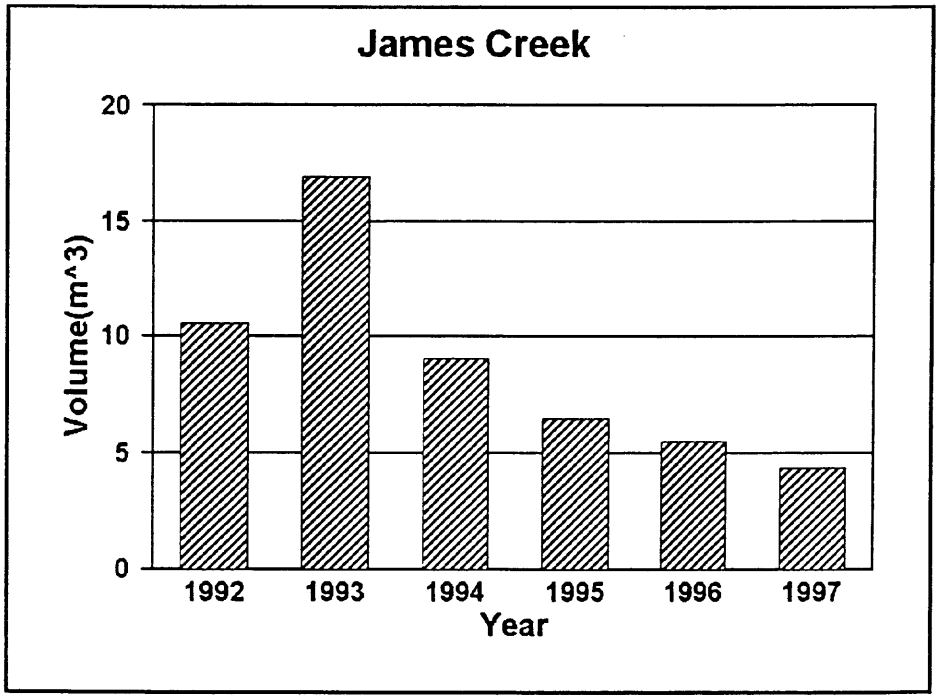


Figure 8. Total pool volume in James Creek for 1992 through 1997.

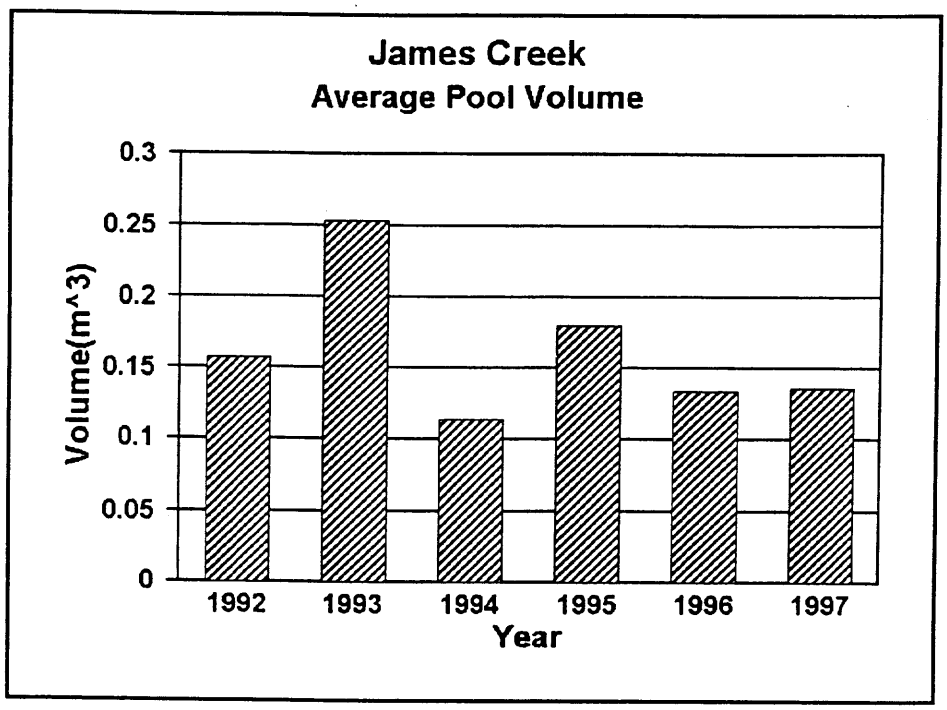


Figure 9. Average pool volume in James Creek for 1992 through 1997.

These data were subsequently broken into Upper James (1000 to 1800 m) and Lower James (0 to 1000 m) for further analysis of channel characteristics because of the apparent differences in steepness of the channel. The Upper James (Figure 10) consisted of a much greater percentage of channel length occupied by cascades than Lower James (Figure 11), and less length in runs/riffles and glides in all but the first year. Pool numbers were generally greater in Upper James than in Lower James; however, number of pools in both reaches decreased substantially in 1995 through 1997 (Figure 12 and Figure 13). Total pool volume varied four-fold in Upper James (from 1.2 to 4.7 m^3), and approximately six-fold (2.6 to 12.1 m^3) in Lower James (Figures 14 and 15) . Average pool volume in Upper James varied between 0.08 and 0.20 m^3, and in Lower James between 0.14 and 0.42 m^3 (Figures 16 and 17). Average pool volume in the gentle reach of Lower James changed very little from 1994 on.

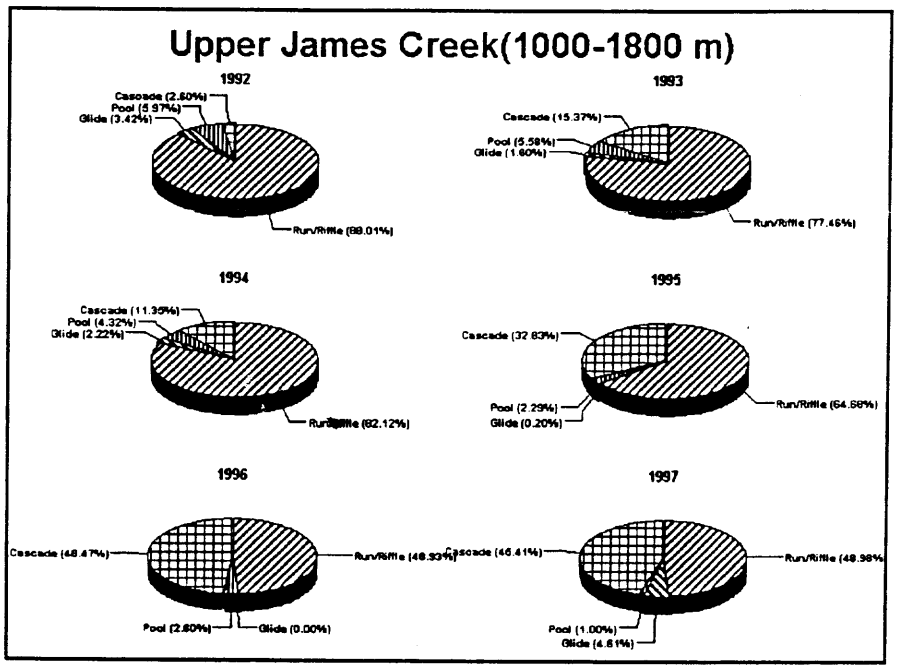


Figure 10. Distribution of channel elements in the upper reach of James Creek for 1992 through 1997.

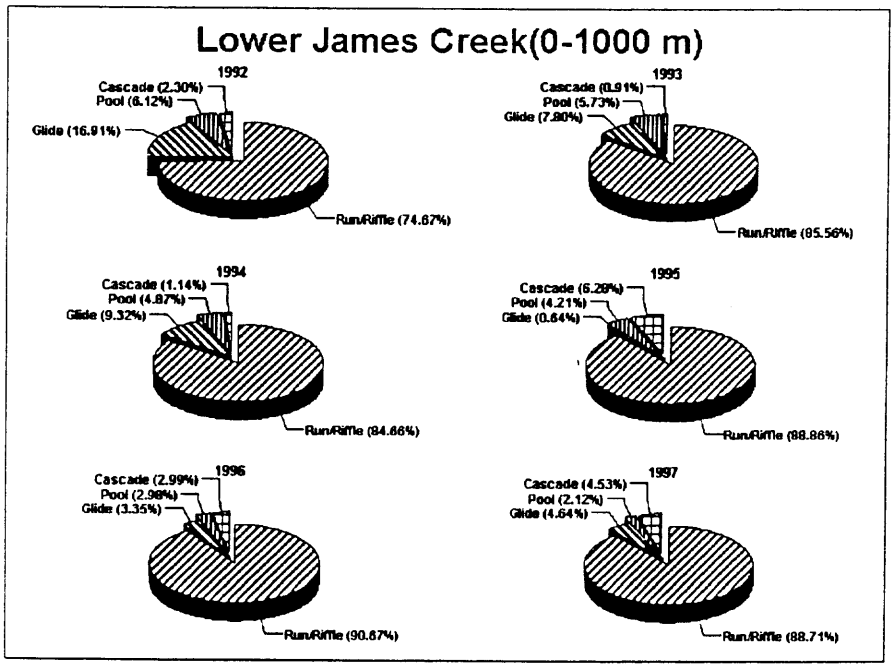


Figure 11. Distribution of channel elements in the lower reach of James Creek for 1992 through 1997.

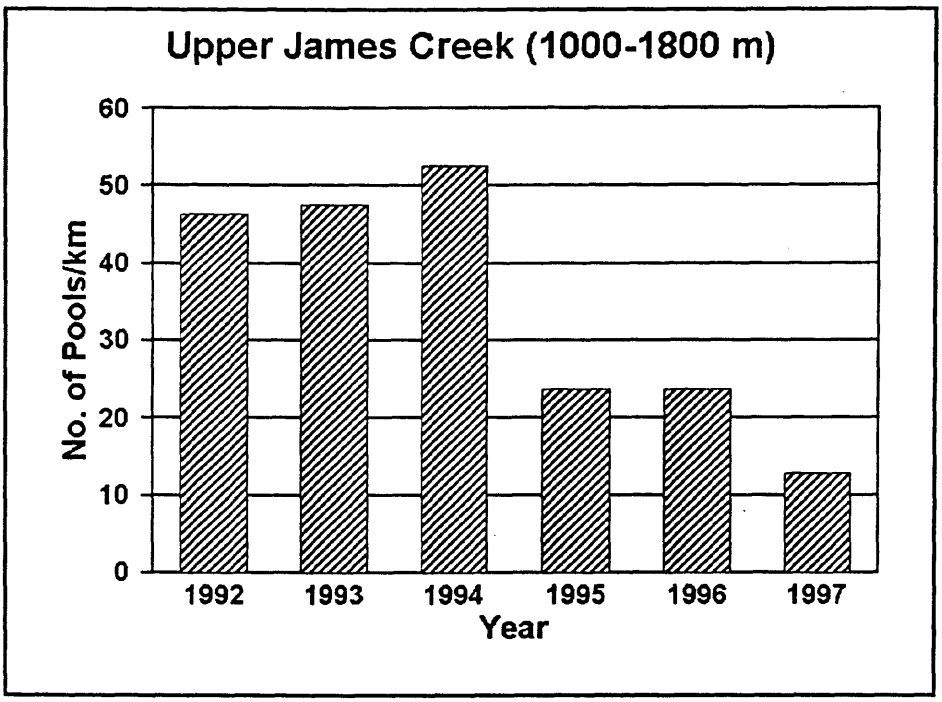


Figure 12. Pool density in the upper reach of James Creek for 1992 through 1997.

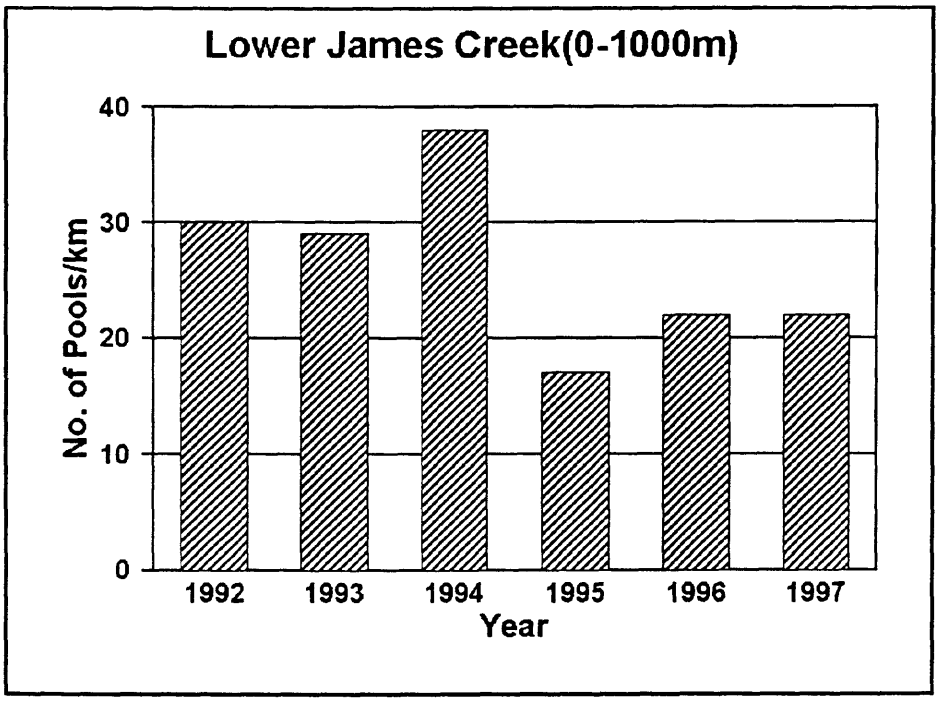


Figure 13. Pool density for the lower reach of James Creek for 1992 through 1997

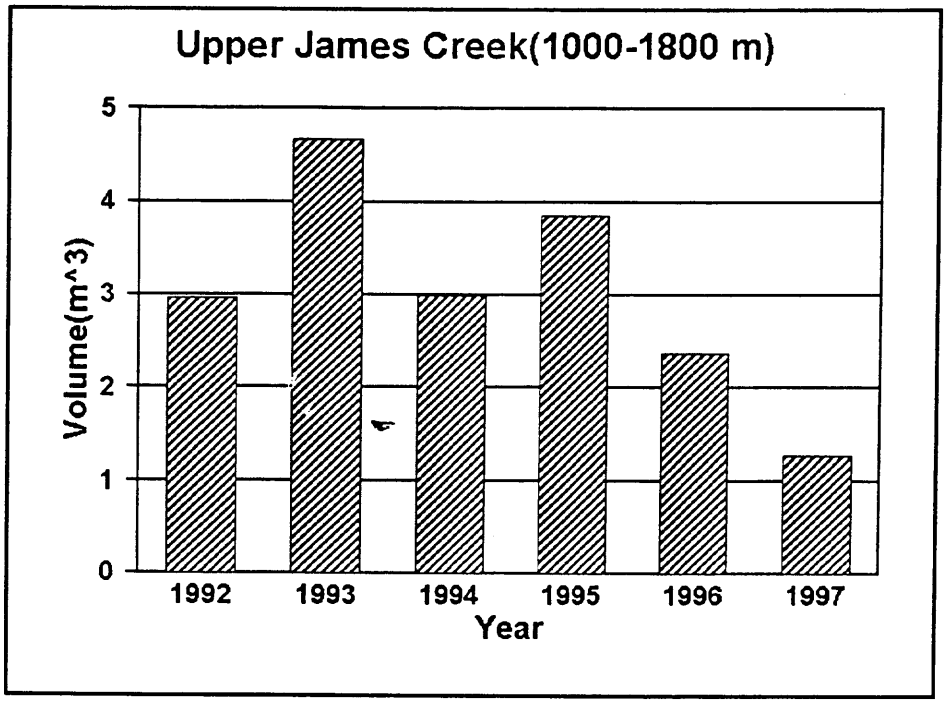


Figure 14. Total pool volume in the upper reach of James Creek for 1992 through 1997

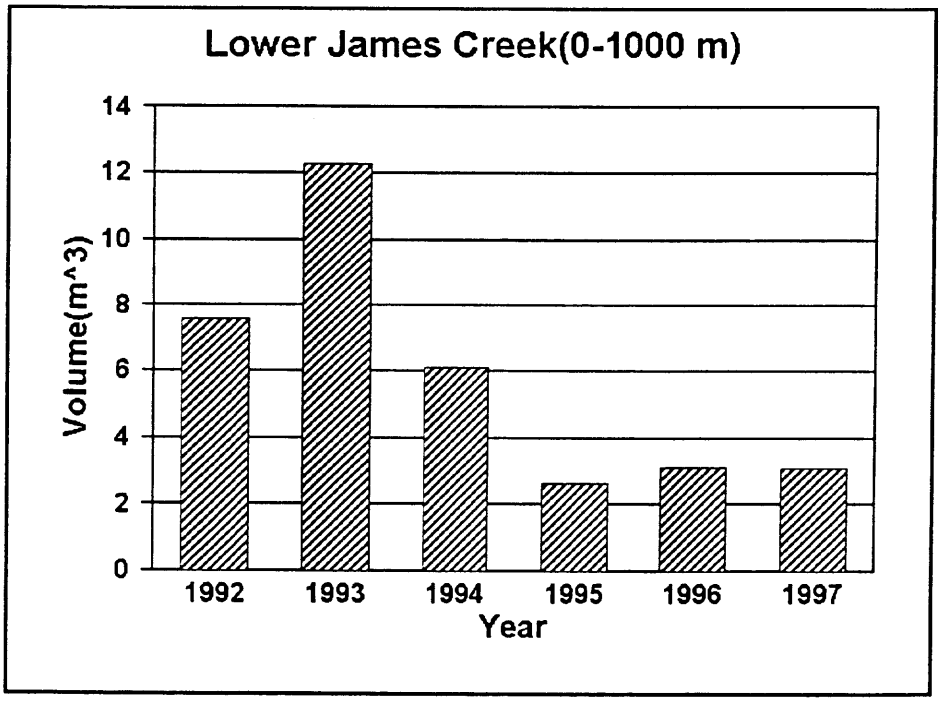


Figure 15. Total pool volume fore the lower reach of James Creek for 1992 through 1997.

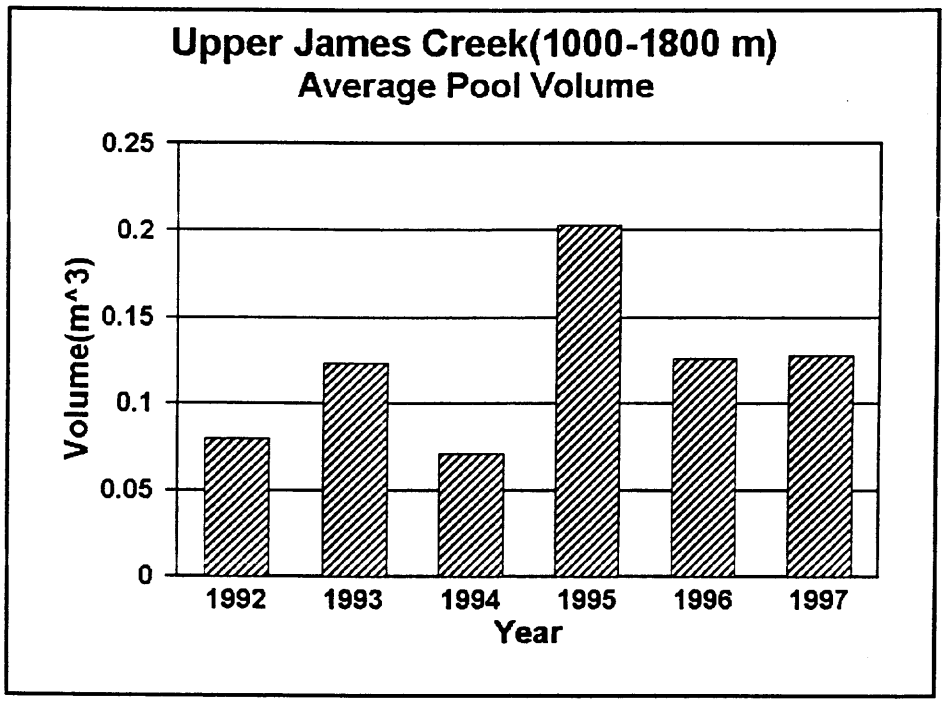


Figure 16. Average pool volume for the upper reach of James Creek for 1992 through 1997.

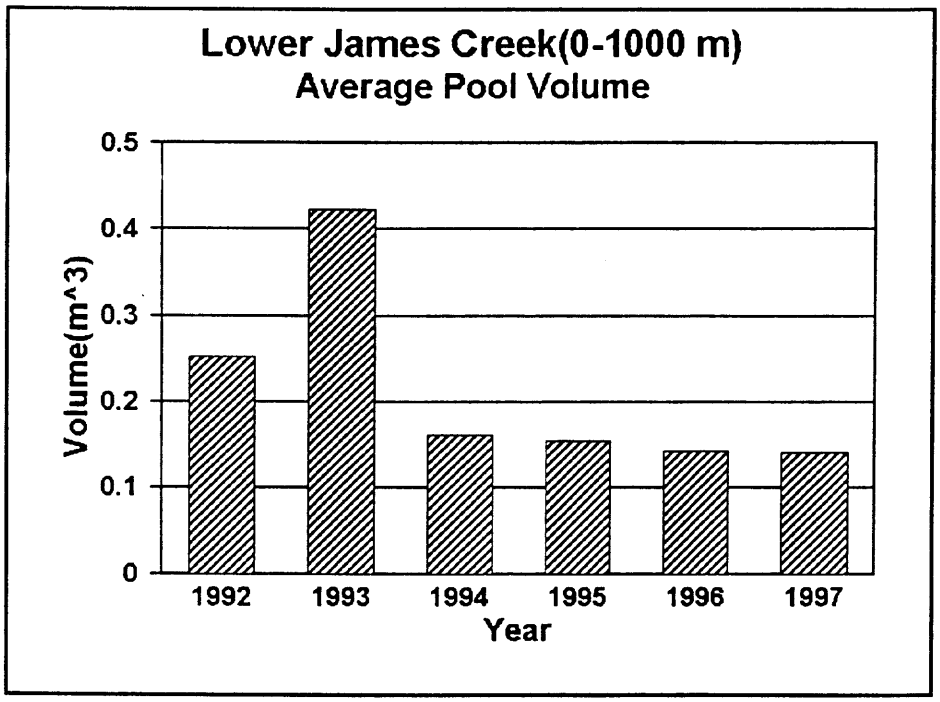


Figure 17. Average pool volume for the lower reach of James Creek for 1992 through 1997.

Burnout Main Channel:

For the entire main channel system in Burnout Canyon, the length of runs/riffles remained relatively constant throughout the 6-year period (Figure 18). The length of the channel in runs/riffles ranged from a high in 1993 of 88.3% to a low in 1995 of 79.7% and may easily be attributed to classification error. The percentage of channel in cascades increased greatly between 1994 and 1995 (from 3.3% to 15.2%), but then decreased to 8.1% in 1996 and again increased to 12.2% om 1997. This type of variability also could be caused by different observers classifying some of the steeper riffles as cascades. Pool length did not change appreciably during the six years, varying between 5.9% in 1992 and 2.5% in 1995. Such changes in pool length could well result from normal variations in sedimentation and flushing depending on variability in precipitation events from year to year.

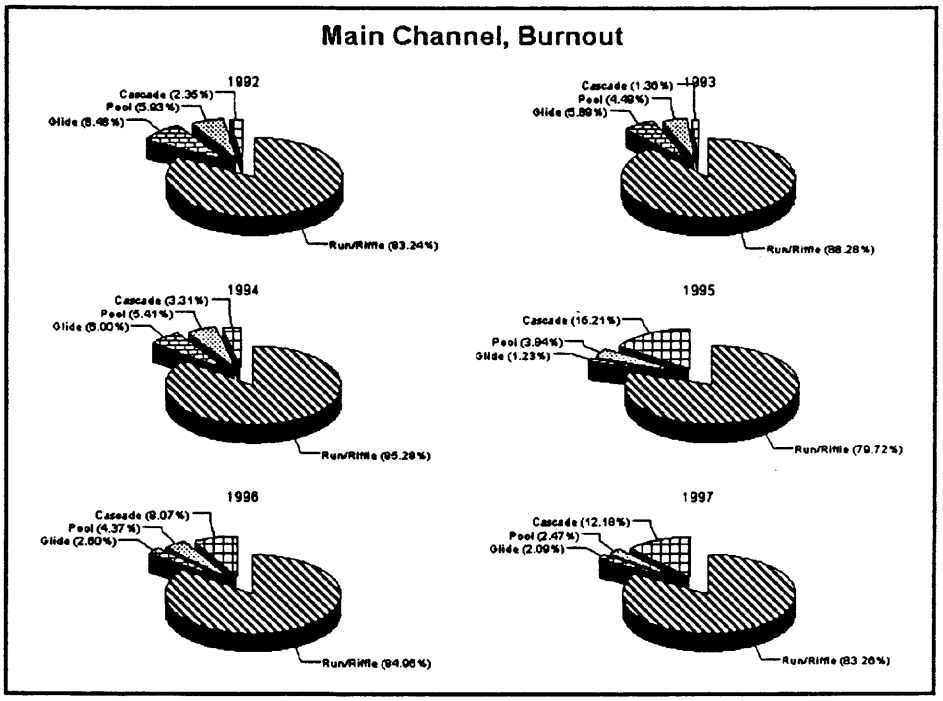


Figure 18. Distribution of channel elements in the Main Channel of Burnout Creek; 1992-1997

Total volume of all pool types in the Main Channel ranged between a high of 13.7 m^3 in 1993 to a low of 7.2 m^3 in 1997 (Figure 19). No consistent trend is apparent. The total number

of pools, however, appears to show a gradual decline from a high of about 42/km in 1992 to a low of 24/km in 1997, with the exception of 1994 with 39 pools/km (Figure 20). Average pool volume, however, did not demonstrate a consistent trend. This varied from 0.13 m^3 in 1994 to 0.23 m^3in 1993 and 1995 (Figure 21).

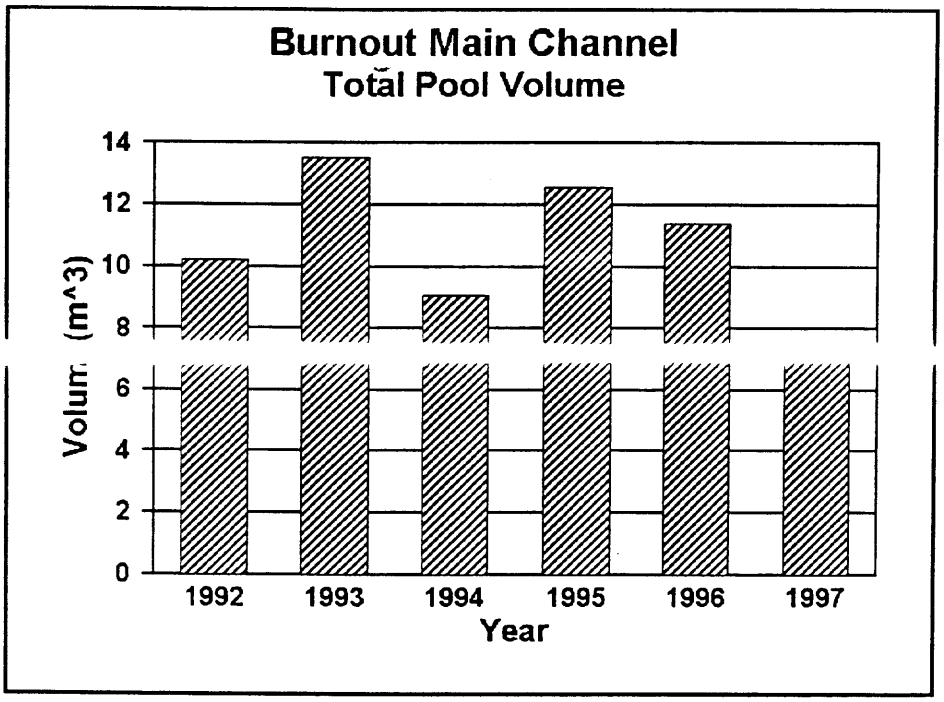


Figure 19. Total pool volume of all pools in the Main Channel of Burnout Creek; 1992-1997.

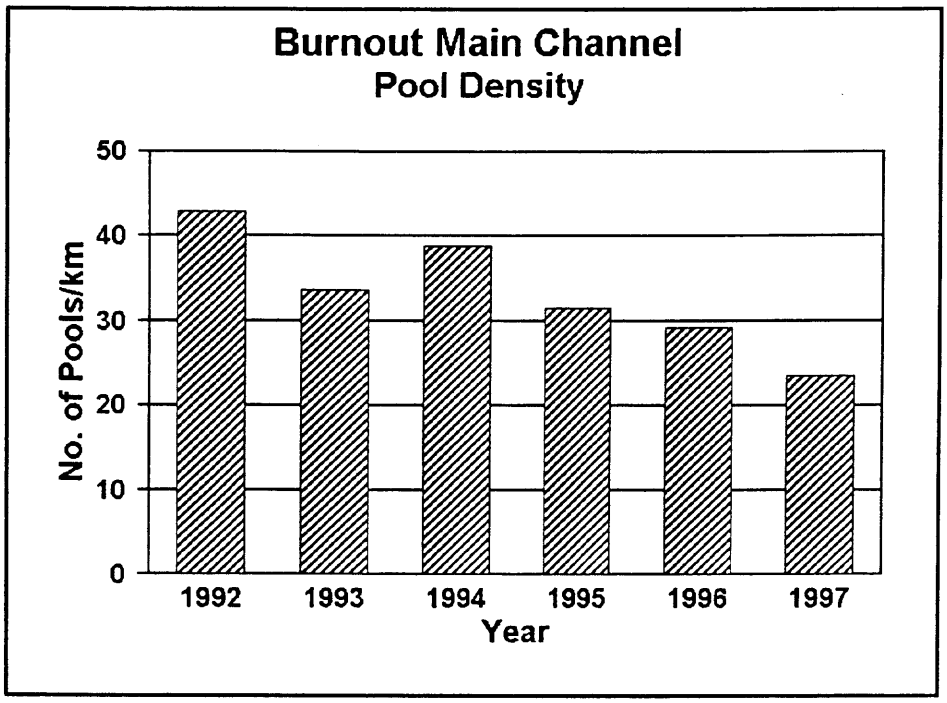


Figure 20. Pool density in the total Main Channel of Burnout Creek; 1992-1997.

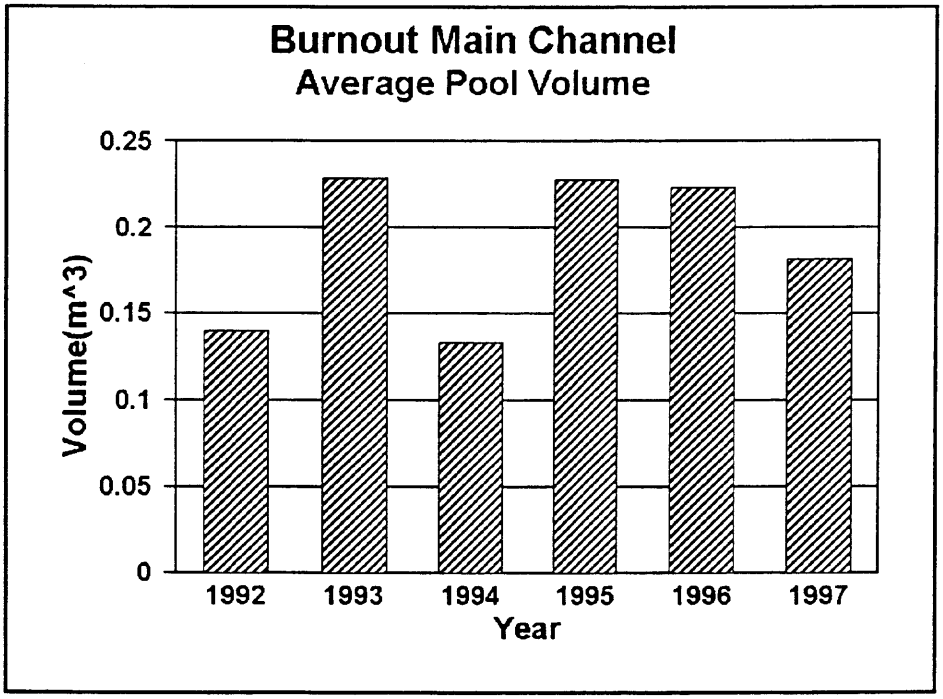


Figure 21. Average volume of pools in the Main Channel of Burnout Creek, 1992-1997.

South Fork Burnout:

Channel characteristics were also surveyed along ~640 m of the lower reach of the South Fork of Burnout Creek. Cascades increased progressively from 12.5% in 1992 to 53.6% in 1996, then dropped to 38.4% in 1997 (Figure 22). The proportion of stream channel classified as cascades in the South Fork was very much greater than in the Main Channel throughout the 6-year period, no doubt reflecting the greater steepness of the South Fork channel. Total volume of all pools varied greatly from a high of ~4.8 m^3 in 1995 to a low of ~1.1 m^3 in 1996 and 1997 (Figure 23). This precipitous decrease in pool volume in the South Fork differs markedly from the relatively small change that occurred in the Main Channel (Figure 19). Pool density in the South Fork remained approximately 70/km between 1992 and 1995, but then dropped greatly to ~30/km in 1996 and 1997 (Figure 24), reflecting the precipitous drop in total pool volume. Average pool volume in 1996 and 1997 was approximately the same, between 0.5 and 0.6 m^3, as in 1992 and in 1994 (Figure 25).

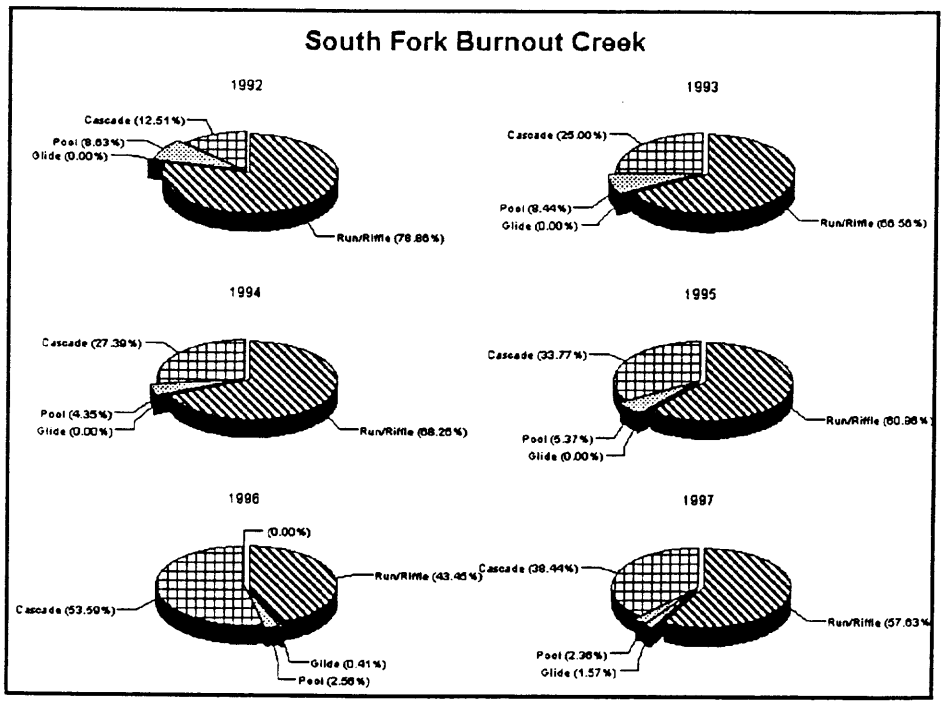


Figure 22. Distribution of channel elements in South Fork of Burnout Creek; 1992-1996.

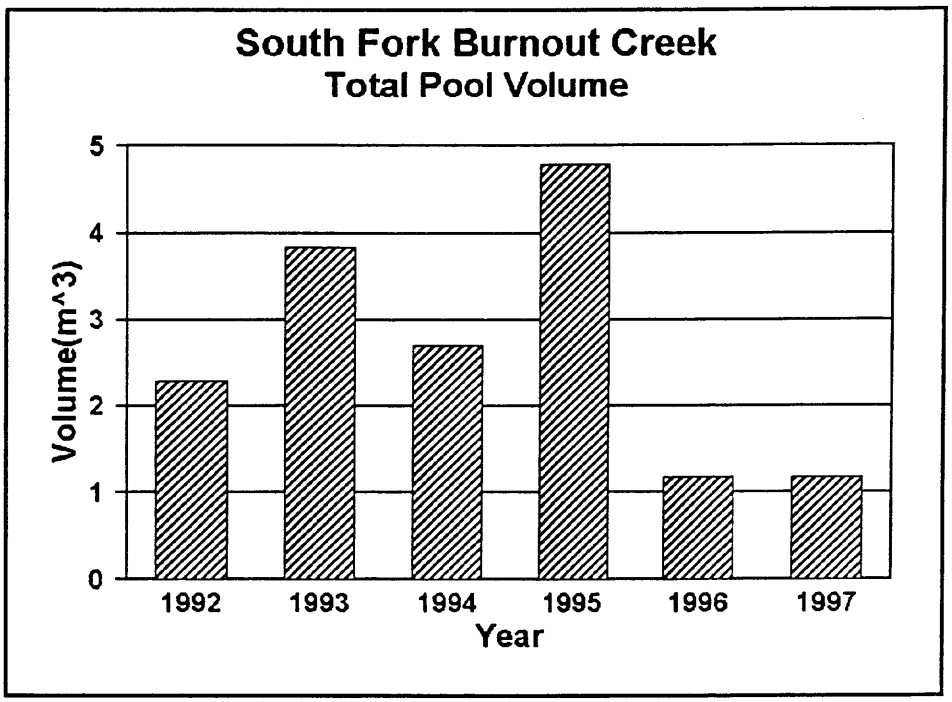


Figure 23. Total pool volume in the South Fork of Burnout Creek; 1992-1997.

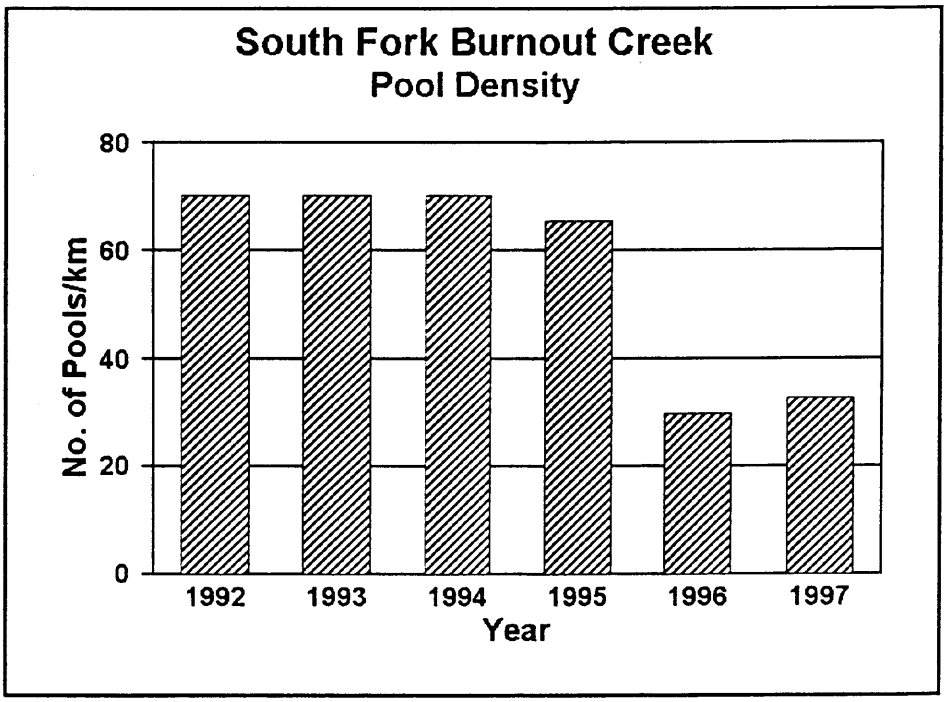


Figure 24. Pool density of all pools in the South Fork of Burnout Creek; 1992-1997

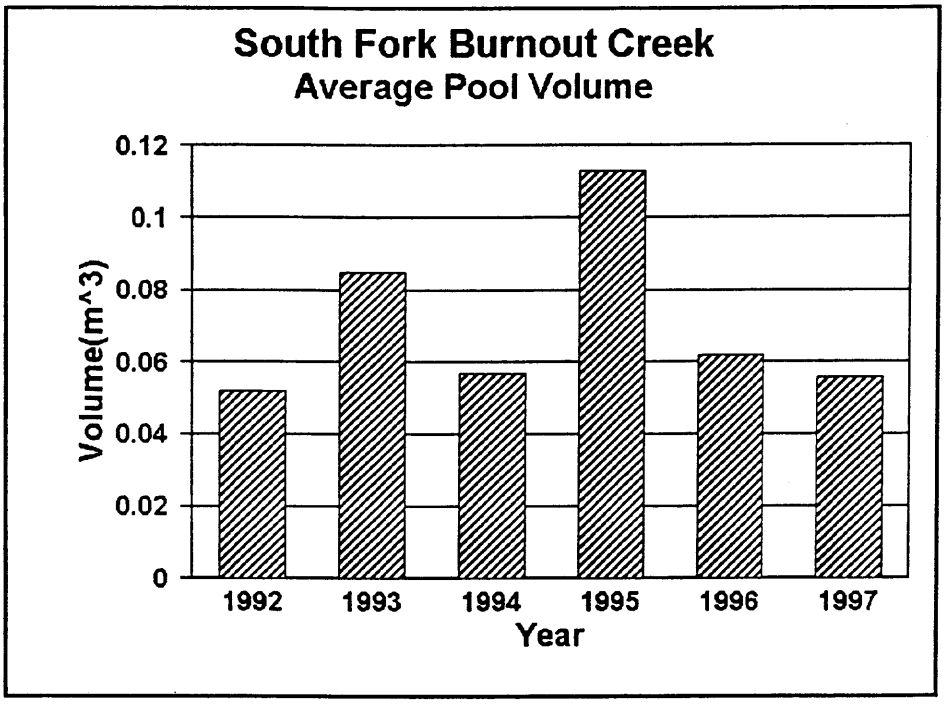


Figure 25. Average volume of pools in the South Fork of Burnout Creek, 1992-1997.

Changes over the 6-year period in stream channel characteristics within mining panels were evaluated separately since the panels were mined in different years: panel 7L in 1993-'94; panel 8L in 1994-'95; and panel 9L in 1995-'96. Panels 5L and 6L, in the upper reach of Burnout Creek beyond 1700 m, were not included in this analysis because they contained only intermittent stream flow and were not measured in beyond 1995. Sections of both the Main Channel and South Fork of Burnout crossed panels 7L and 8L. Subsidence was greater in the South Fork (0.5 to 4.5 feet) over panel 7L than in the Main Channel (0.0 to 1.0 feet) because of the presence of an intrusive dike in the latter. Only the lower reach of the Main Channel crossed panel 9L (Figure 2).

Panel 7L:

The proportion of the Main Channel length occupied by runs and riffles in panel 7L varied from 65.6% in 1995 to 89.6% in 1993, by cascades from 2.8% in 1993 to 25.9% in 1995, and by pools from 2.0% in 1997 to 8.5% in 1995 (Figure 26). Thus the length of cascades and perhaps pools appears to have increased the year following mining at the expense of runs and riffles in the Main Channel. In the South Fork section of panel 7L, runs and riffles ranged from 39.6% in 1996 to 79.6% in 1992, cascades from 10.6% in 1992 to 58.2% in 1996, and pools from 1.6% in 1997 to 9.7% in 1992 (Figure 27). Here, the percentage of cascades did not increase markedly until 1996, the second year following mining, again at the expense of the runs and riffles. However, the percentage of length occupied by pools in the South Fork had decreased prior to mining in 1994. The number of pools in the Main Channel of this panel remained fairly constant from 1992 thru 1994 (50 to 57/km) but then dropped to only 22/km in 1995, the year following mining (Figure 28). By 1996, pool numbers were back up to 52/km but then again dropped to 20/km in 1997. In the South Fork of panel 7L, pool numbers remained high (53 to 59/km) until 1996, the second year following mining, when they dropped to 32/km and by 1997 were only 25/km (Figure 29). Pool volumes in the Main Channel of panel 7L varied between ~1.6 m^3 and ~2.7 m^3, with the greatest volume measured in the year of lowest pool density, 1995 (Figure 30). Although total number of pools in this reach decreased by more than half in 1995 immediately following mining, these pools were more than twice as large (0.38 m^3) as the pools before mining (0.10 to 0.16 m^3), resulting in the high total pool volume for 1995 (Figure 31). Total pool volume in the South Fork varied between ~0.2 and ~1.5 m^3 (Figure 32), with the lowest volume corresponding to the lowest number of pools in 1996 and 1997. In contrast to the Main Channel in Panel 7L, average pool volume in the South Fork were lowest in 1997 (Figure 33).

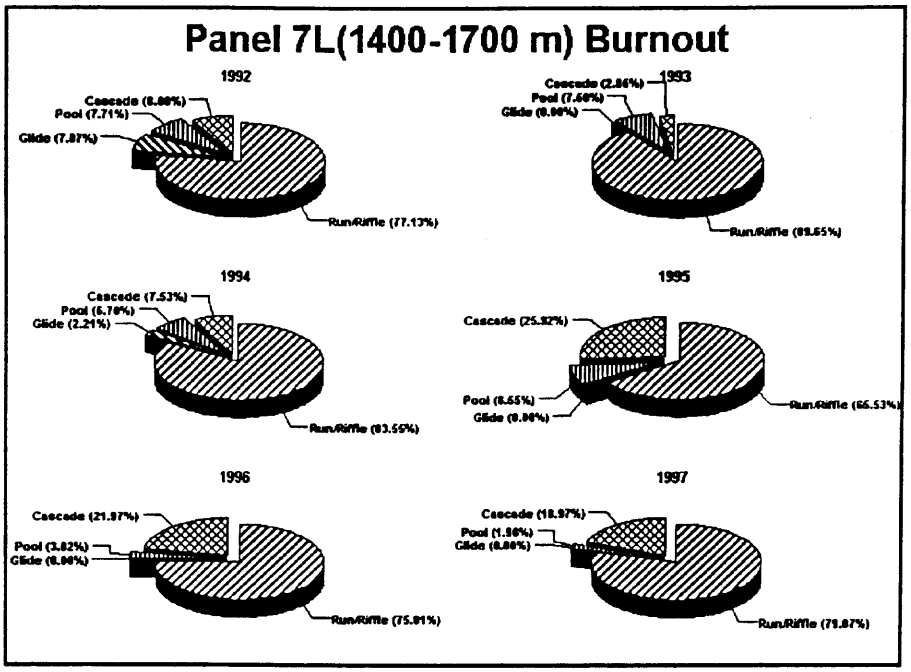


Figure 26. Distribution of channel elements in the Main Reach of Burnout Creek impacted by panel 7L (1400-1700 m) for all years

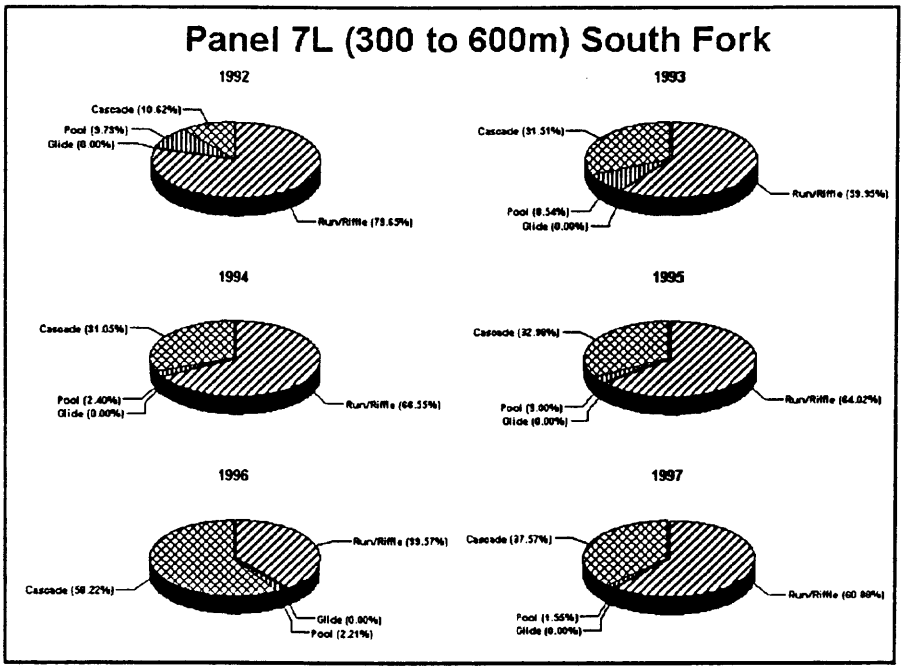


Figure 27. Distribution of channel elements in the upper reach of the South Fork overlying panel 7L for all years.

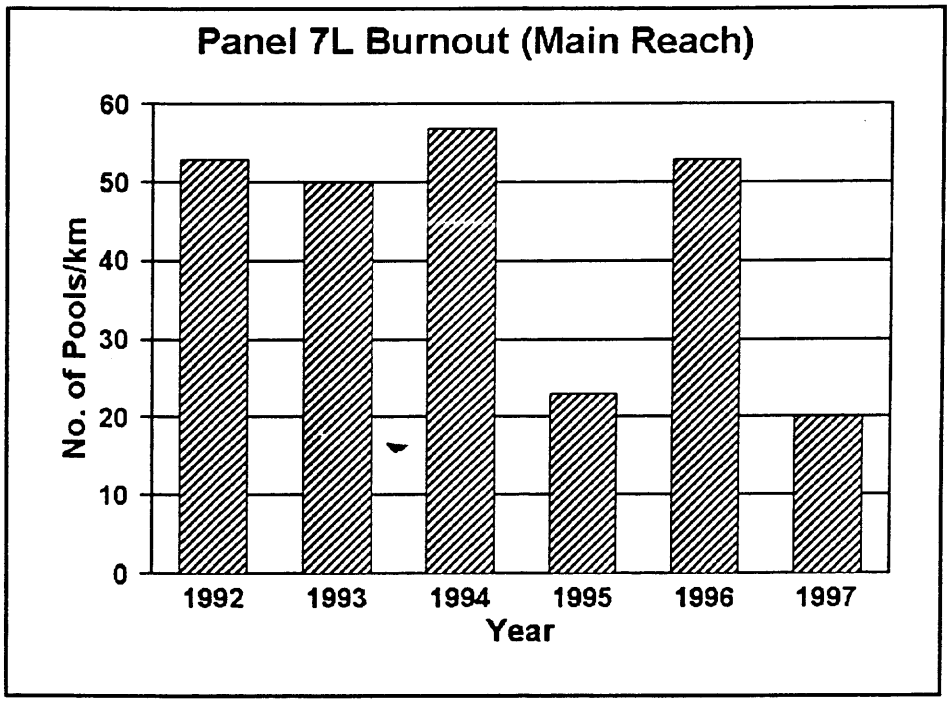


Figure 28. Pool density in panel 7L of the Main Reach of Burnout Creek; 1992-1997.

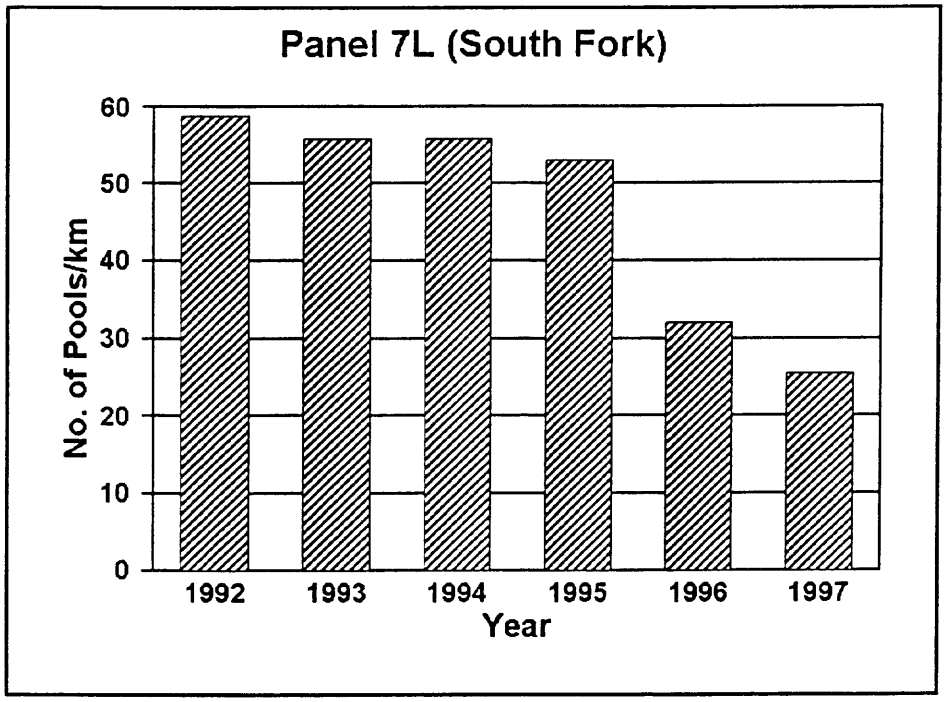


Figure 29. Pool density in the upper reach of the South Fork overlaying panel 7L for all years.

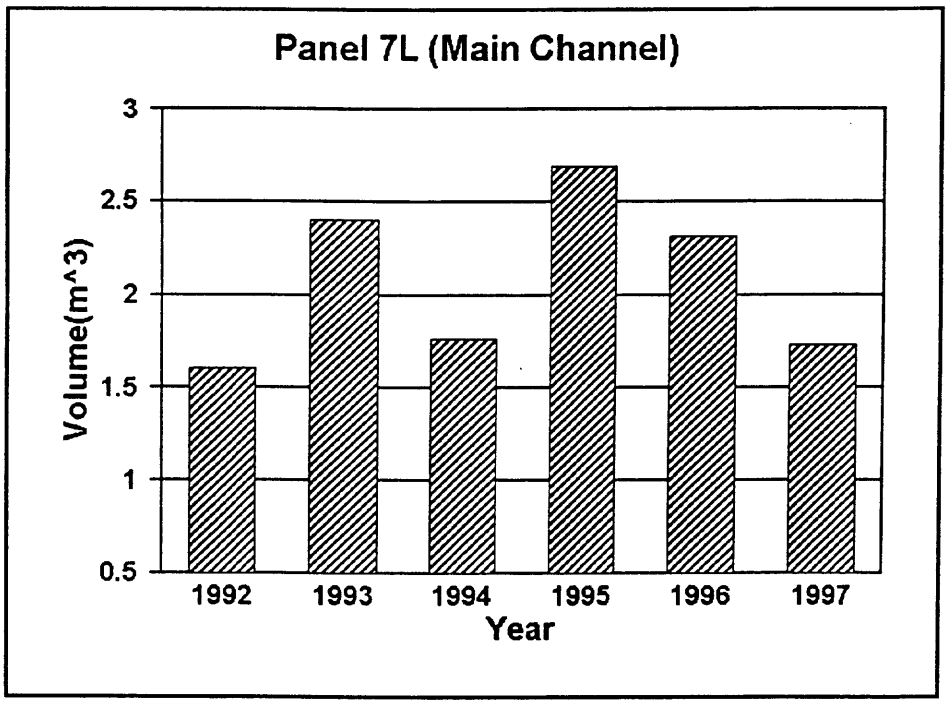


Figure 30. Total pool volume in panel 7L of the Main Reach of Burnout Creek for 1992-1997.

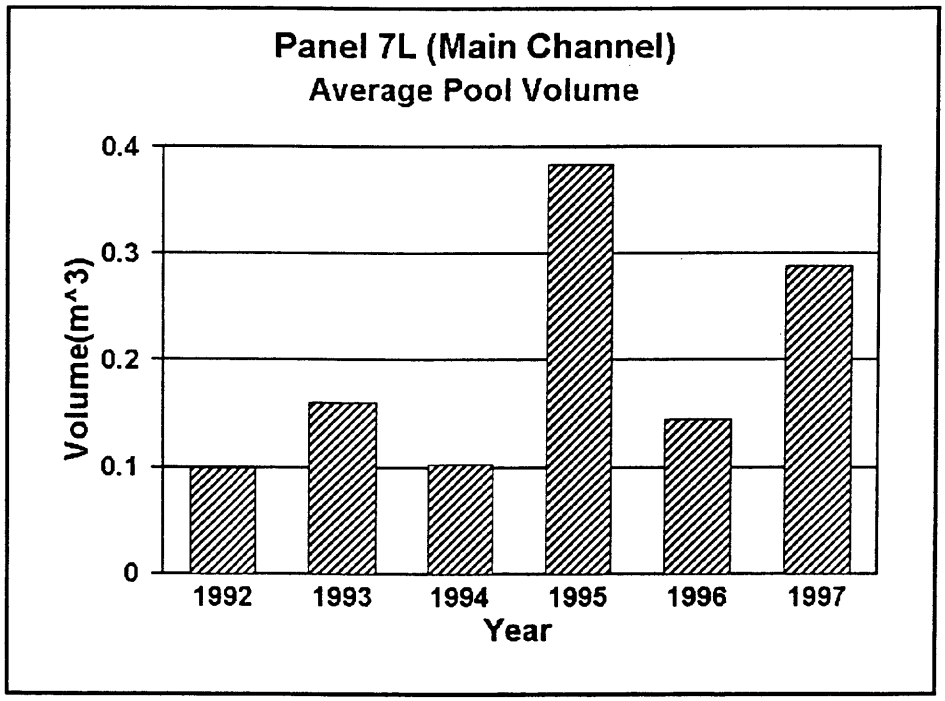


Figure 31. Average volume of pools in Panel 7L of the Main Reach of Burnout for 1992-1997.

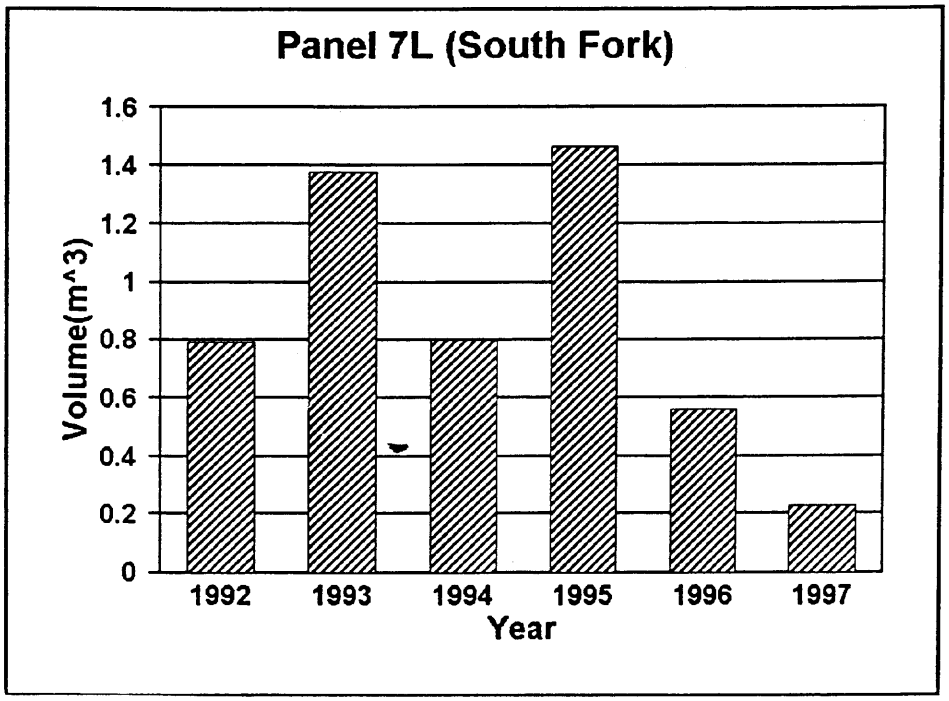


Figure 32. Total pool volume in panel 7L of the South Fork (300-600 m) for 1992-1997.

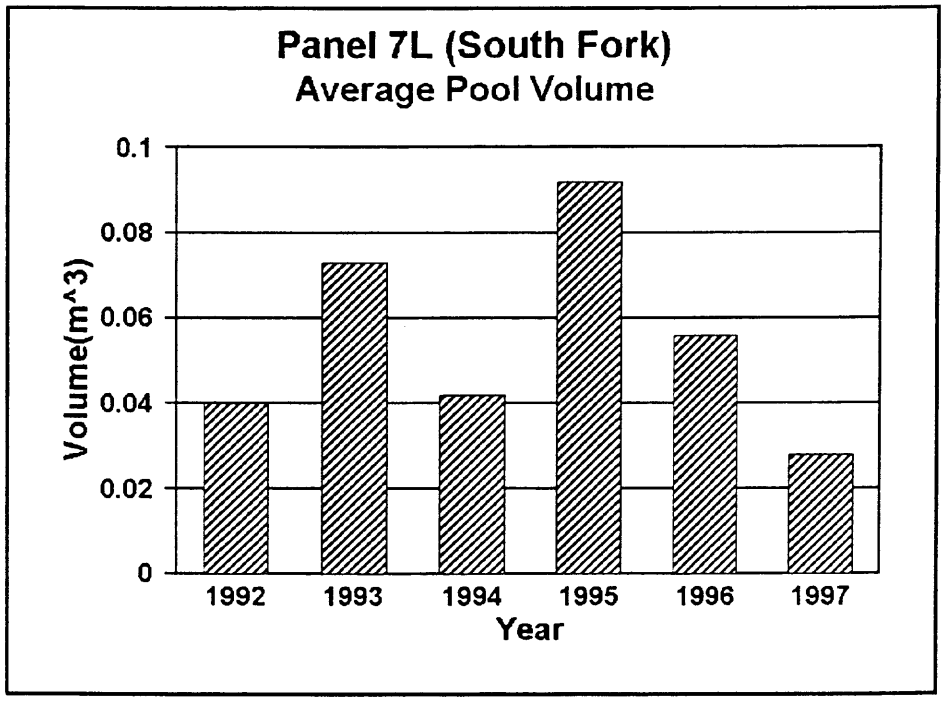


Figure 33. Average volume of pools in Panel 7L of the South Fork of Burnout, 1992-1997.

Panel 8L:

The proportion of channel length in the Main Channel section of panel 8L (mined in 1995-'96) occupied by runs and riffles decreased following mining from 89% to 77% (Figure 34), while that in the South Fork decreased consistently between 1992 to 1996 from 70% to 46%. but then increased to 55% in 1997 (Figure 35). The proportion of cascades in the Main Channel abruptly increased from 1.0% in 1994 to 12.9% in 1995, and then decreased to 6.1% in 1996 and then increased greatly to 18.2% in 1997. However, the proportion of cascades in the South Fork increased rather markedly and consistently between 1992 and 1996 (from 15% to 50%) with a corresponding decrease in runs and riffles, but then decreased to 39% in 1997. This suggests that as cascades increase, runs and riffles decrease, which could result from classification error. The proportion of Main Channel pools varied between 1.6% in 1995 to 7.2% in 1994, and in the South Fork from 2.8% in 1996 to 8.4% in 1994. A conspicuous decrease in channel occupied by pools occurred in the Main Channel in 1995 and in the South Fork in 1996.

The number of pools in the Main Channel varied between 12 and 20/km (Figure 36), and the total volume between 1.3 and 3.5 m^3 (Figure 37). In the South Fork, number of pools remained fairly constant (80 to 92/km) until 1996 when they decreased strikingly to only 28/km following mining (Figure 38). Pool volumes in the South Fork varied between ~0.6 and 3.3 m^3, with the lowest total volumes occurring in 1996 and 1997 when numbers were lowest (Figure 39). Average pool volume in the Main Channel was greatest in 1996, almost double that of preceding years (Figure 40). Greatest average pool volume in the South Fork occurred in 1995, then decreased by 1997 to about one-fourth this size (Figure 41).

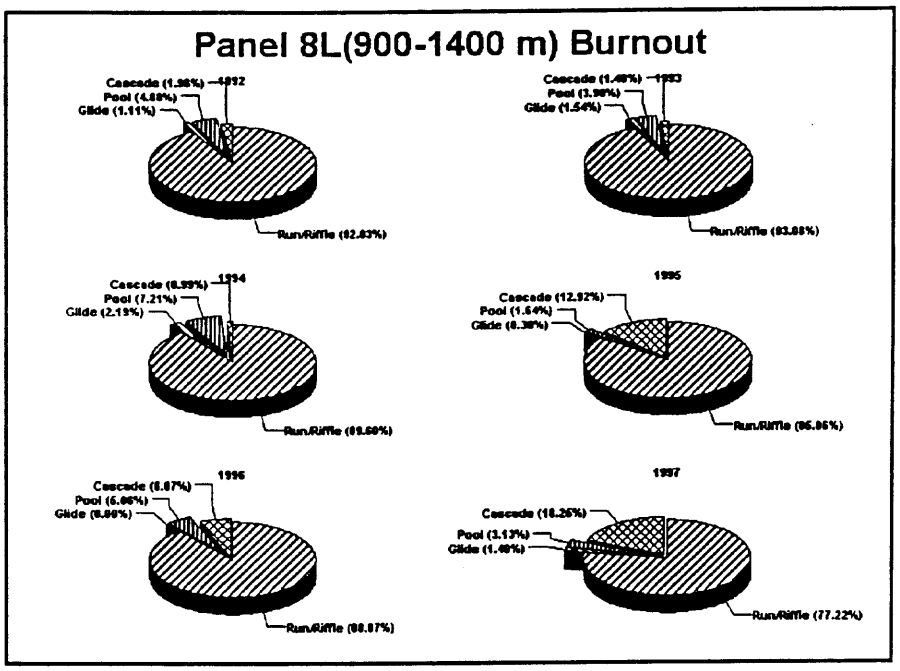


Figure 34. Distribution of channel elements in the Main Reach of Burnout Creek impacted by panel 8L (900-1400 m) for 1992-1997.

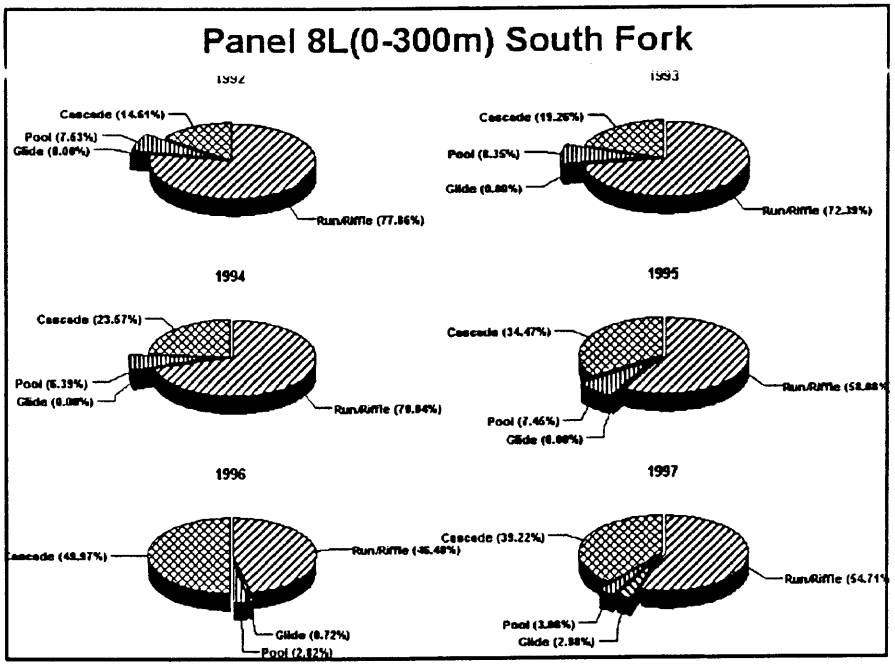


Figure 35. Distribution of channel elements in the South Fork of Burnout Creek impacted by panel 8L (0-300 m) for 1992-1997.

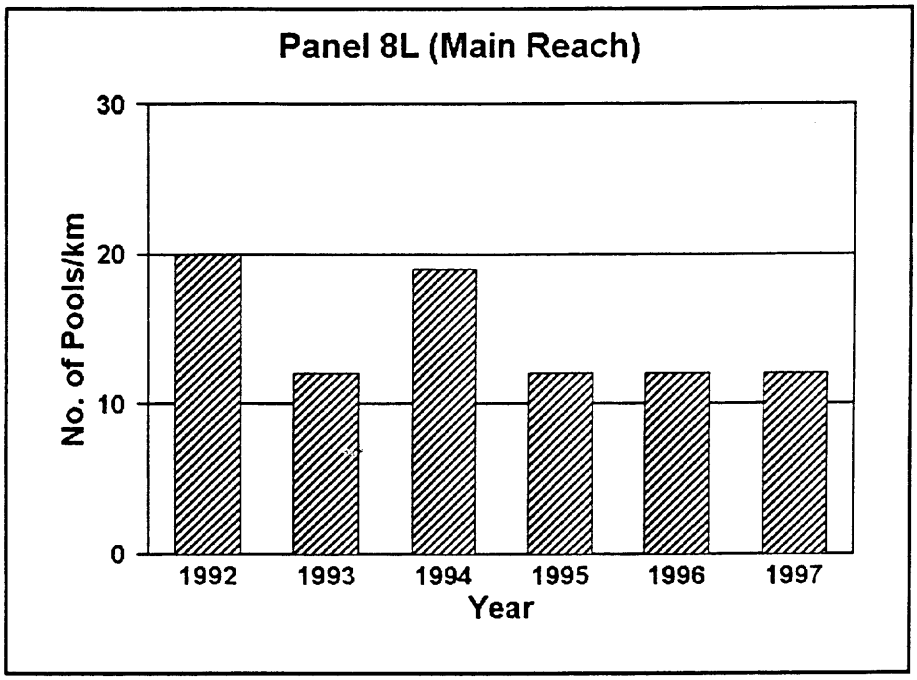


Figure 36. Pool density in the Main Reach of Burnout Creek impacted by panel 8L for 1992-1997

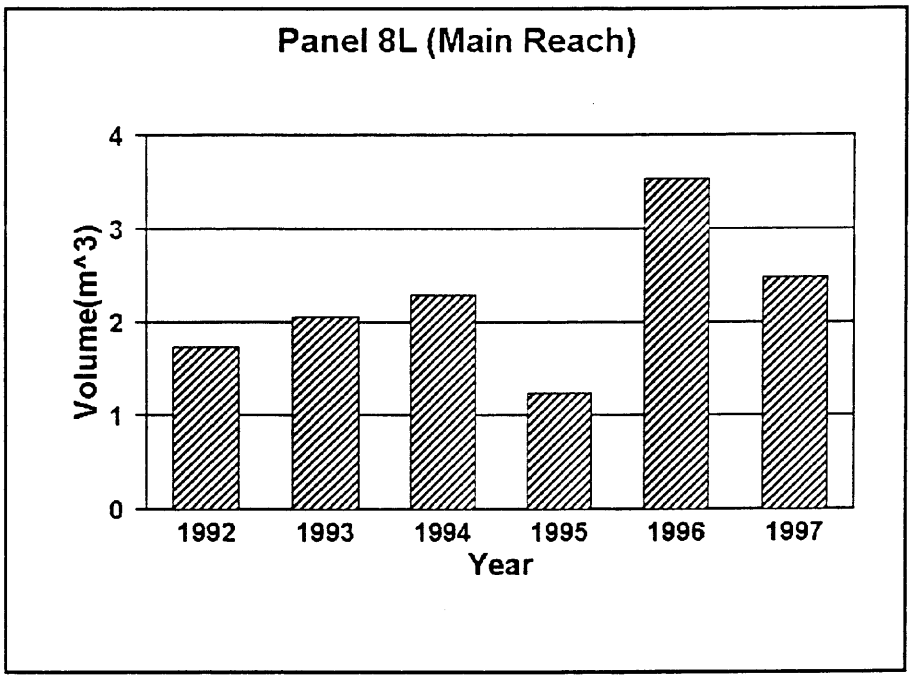


Figure 37. Total pool volume in the main reach of Burnout Creek impacted by panel 8L; 1992-1997.

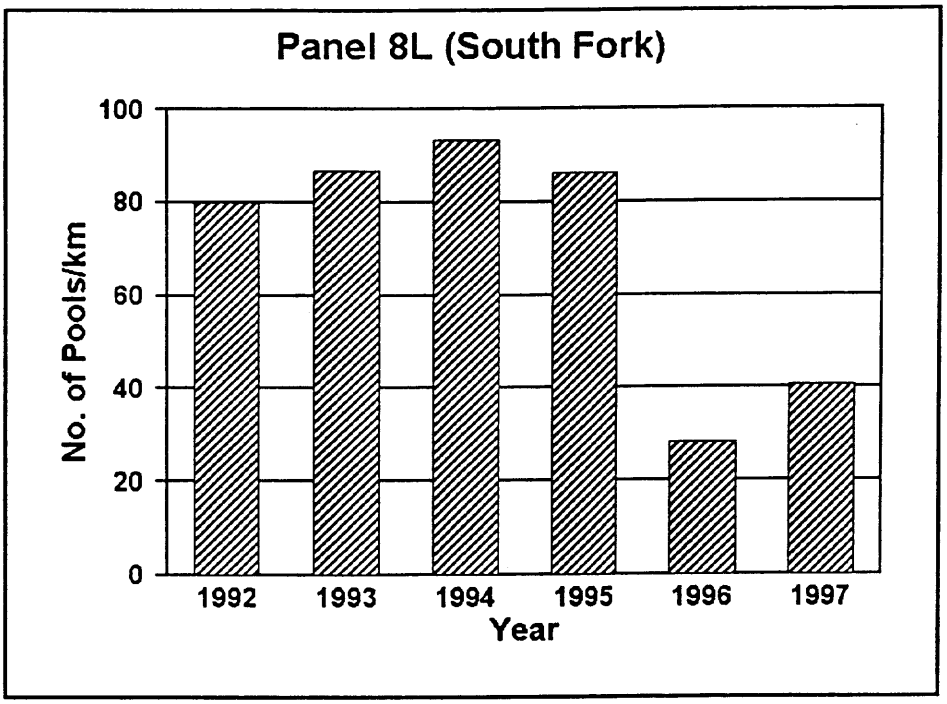


Figure 38. Pool density in the lower reach of the South Fork (0-300m) overlying panel 8L.

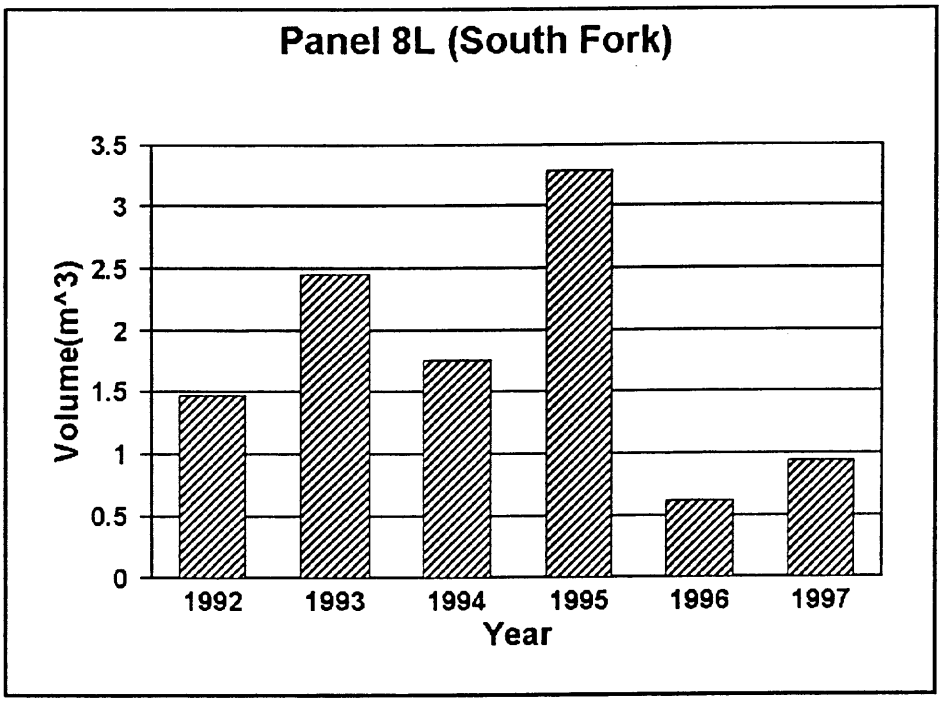


Figure 39. Pool volume in the lower reach of the South Fork (0-300 m) overlying panel 8L

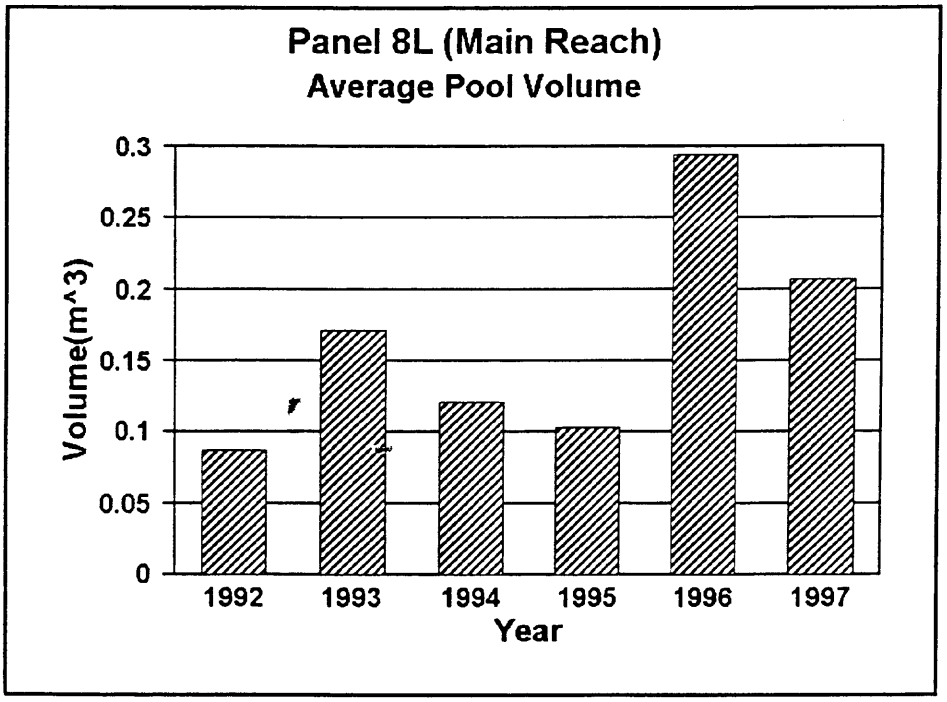


Figure 40. Average pool volume in the Main Channel of Burnout Creek impacted by Panel 8L (0-300 m) for 1992-1997.

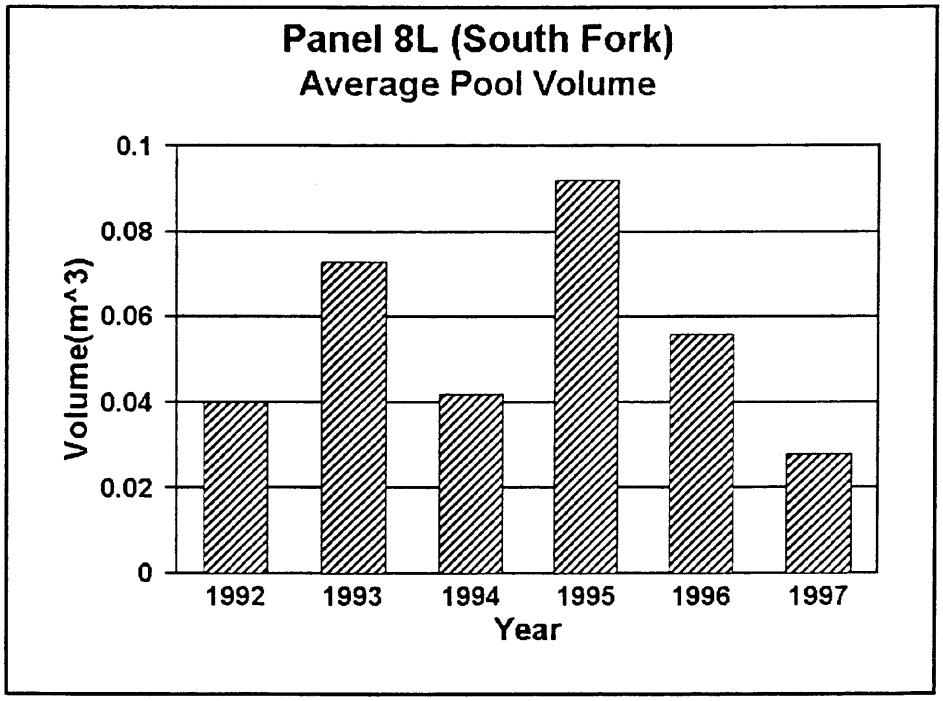


Figure 41. Average pool volume in the South Fork of Burnout Creek impacted by Panel 8L.

Panel 9L:

The proportion of channel length in panel 9L (mined in 1995-1996) occupied by runs and riffles varied between 80.6% and 87.8%, without showing any difference that could be attributed to subsidence (Figure 42). The proportion of channel in cascades varied between 0.0% and 9.8%, with a substantial increase occurring in 1995 and again in 1997, which might be attributed to classification error since it occurred at the expense of the proportion of glides. The proportion of channel occupied by pools was greatest in 1992 (6.6%) and then decreased to between 2.4% and 4.4% for the remaining years. Pool density in this panel varied between 23/km and 44/km (Figure 43) with the fewest occurring in 1997 following subsidence. Pool volume on the other hand decreased from ~2.1 m^3 in 1992 to ~1.0 m^3, and then increased to ~1.5 m^3 in 1994, 2.9 m^3 in 1996, and then decreased to 1.3 m^3 in 1997 (Figure 44). The timing suggests that the latter increase in pool volume might have resulted in part from the effects of subsidence and also higher stream flows in 1995 and 1996. Average pool volume was also greatest in 1996 (Figure 45).

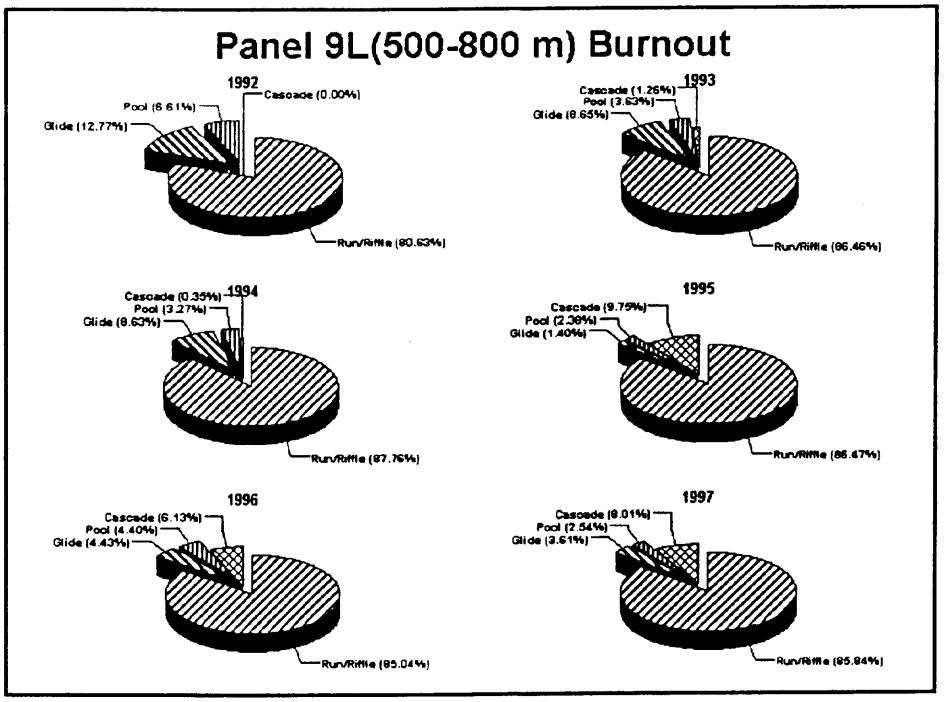


Figure 42. Distribution of channel elements in the Main Reach of Burnout Creek impacted by panel 9L (500-800 m) for 1992-1997.

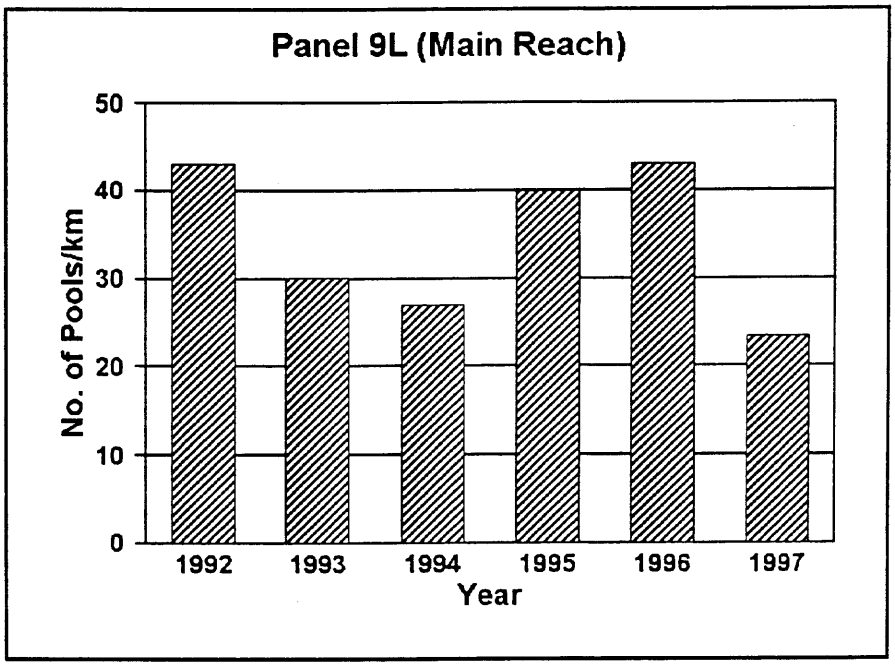


Figure 43. Pool density in the Main Reach of Burnout Creek impacted by panel 9L (500-800 m) for 1992-1997.

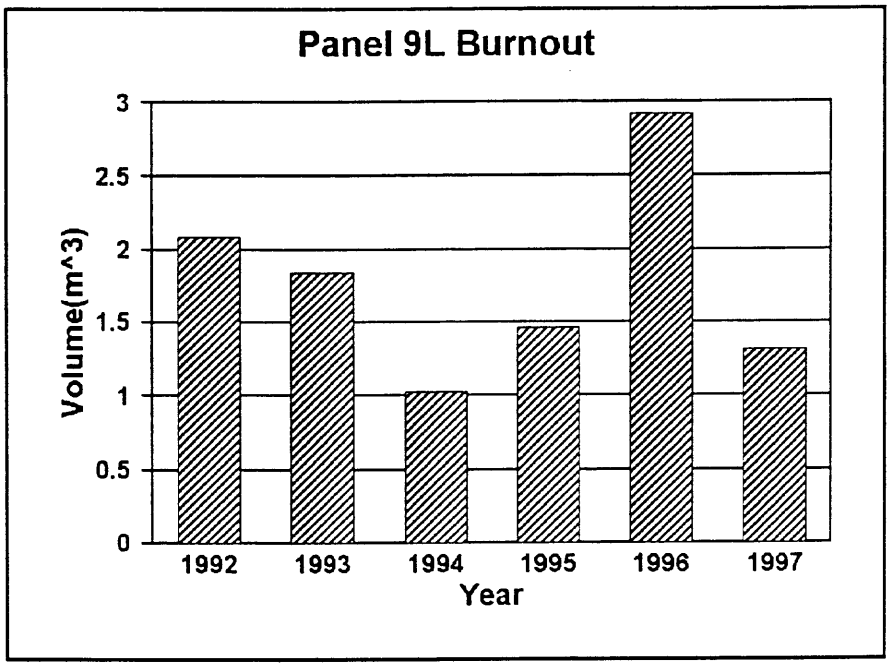


Figure 44. Total pool volumes in the Main Reach of Burnout Creek impacted by panel 9L for 1992 through 1997.

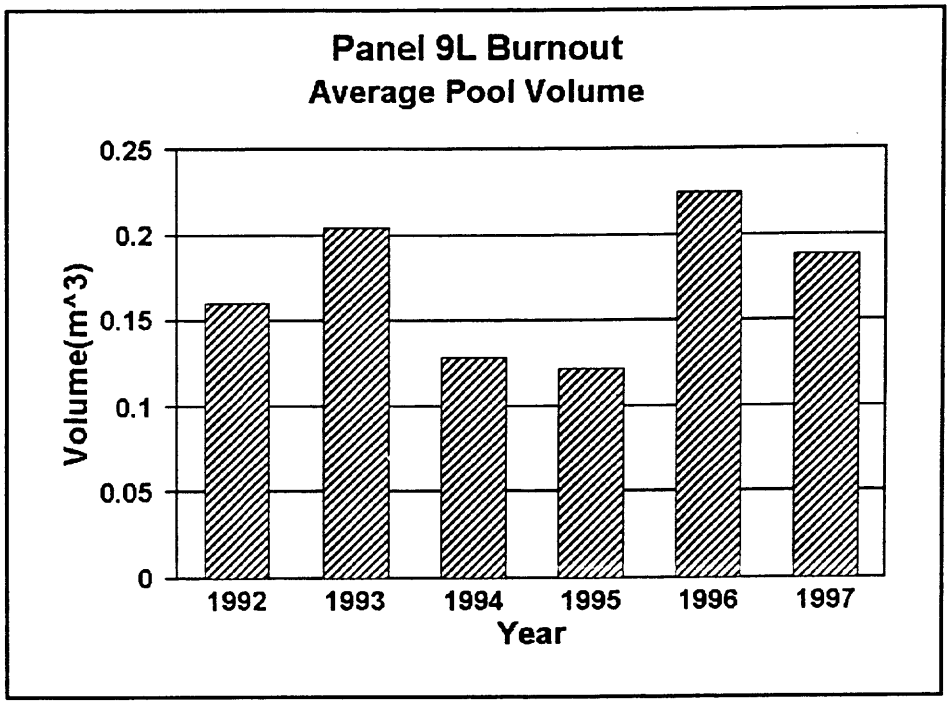


Figure 45. Average pool volume in the Main Reach of Burnout Creek impacted by Panel 9L for 1992-1997.

It appeared that many of the pools surveyed in 1994 were filling in with sediment. Some of the source of the sediment in this steep, incised reach may have been due to channel cross-sectional adjustment following subsidence, however, much of the sediment appeared to come from excessive animal use near the channel. While grazing has been assumed to be relatively constant during the 3-year period (based on grazing allotments), it was obvious from the field investigations that sheep congregated more heavily in the drainage bottoms of the upper perennial reaches of the South Fork during the dry summer of 1994. The steep side slopes that are directly connected to the channel in much of this reach are very susceptible to grazing and to the heavy elk use in the area. Many sheep and game trails were noted in sub-reaches that had some of the largest sedimentation in old pools.

Stream Flow Records:

Flumes were installed to measure variation in stream flow over the 1991 thru 1997 period on both the Main Channel and the South Fork of Burnout Creek. The flume on the Main Channel is close to the mouth of Burnout where it flows into Huntington Cr. at the head of Electric Lake. The South Fork flume is at its junction with the Main Channel of Burnout. These stream flow records should facilitate interpretation of channel characteristic changes that might be attributed to normal yearly differences in stream flow versus changes due to subsidence following mining.

Stream flow in the Main Channel varied over four-fold between years in June and July (from less than 1 cfs to over 4 cfs) but then by August flow tended to stabilize between about 0.3 and 0.6 cfs (Figure 46). Stream flow in the South Fork also varied over four-fold between years in June and July (from less than 0.1 cfs to over 0.4 cfs), and then decreased to between 0.01 and 0.05 cfs during August, September, and October (Figure 47). Unfortunately, mid-month measurements were not obtained for June in three of the seven years: 1991, 1993, and 1995. However, judging from the records available it appears that 1992 and 1994 were years of generally low stream flow and 1995, 1996, and 1997 were years of fairly high stream flow.

Stream flow in the flume at the Forest boundary in the James Canyon control varied at least as much as that in the lower channel of Burnout Creek (Figure 48).

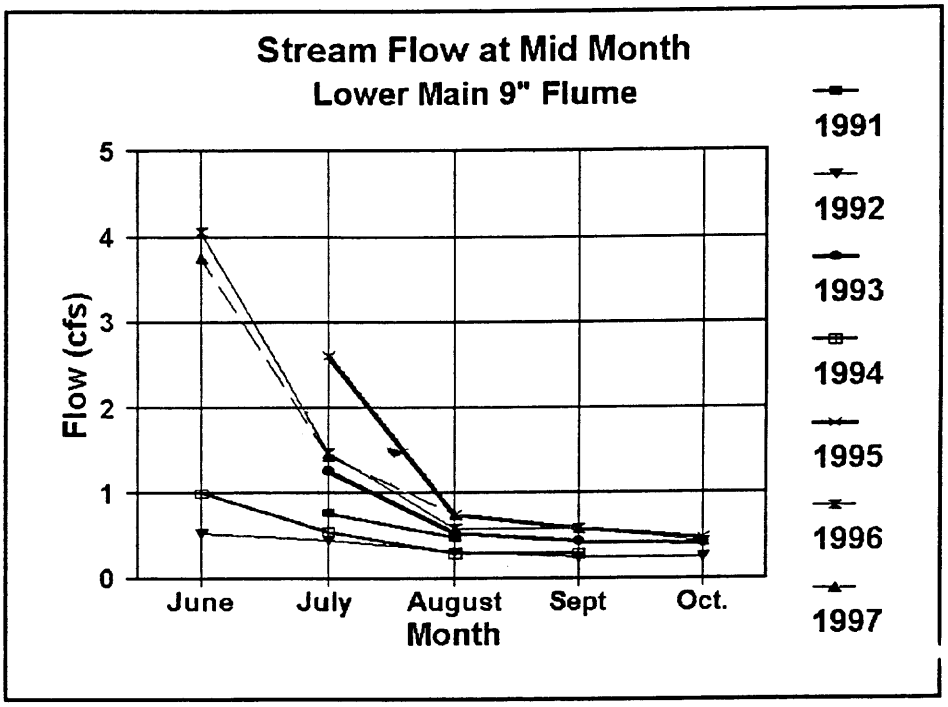


Figure 46. Stream flow records for Main Reach of Burnout Creek from 1992 through 1997.

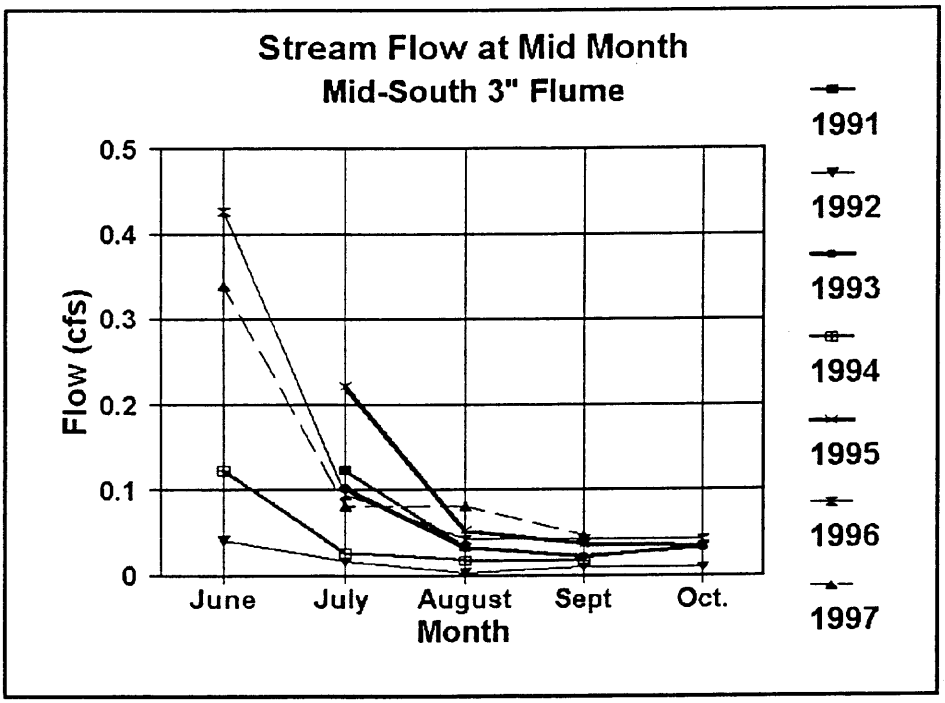


Figure 47. Stream flow records of the South Fork of Burnout Creek from 1992 through 1997.

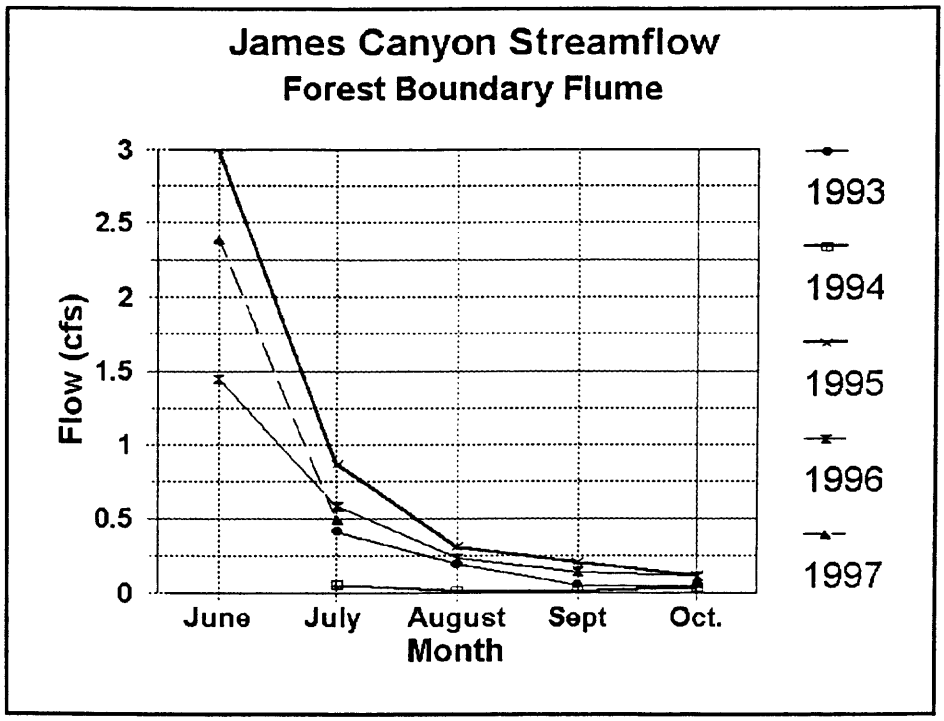


Figure 48. Stream flow records for the flume located at the Forest boundary in James Canyon, from 1993 through 1997.

CHANNEL CHARACTERISTICS DISCUSSION & CONCLUSION:

The James Canyon control area serves as a basis for judging whether a change in channel characteristics in Burnout might be attributed to subsidence following mining. If a substantial change in channel characteristics is markedly and consistently greater in Burnout than in James during the same time period, one can assume that the change results from subsidence, especially if the change is consistent in both the Main Channel and the South Fork of Burnout. To facilitate this comparison, the measured value for the year after change (X) is expressed as a percent of the value immediately prior to change (Y); thus percent change would equal 100(X/Y) - 100.

Following the 1993-1994 mining in Panel 7L, substantial changes occurred by 1995, but few can reliably be attributed to subsidence. For example, cascades in the Main Channel Panel 7L increased 244%, but they increased almost as much (+189%) in Upper James (Table 2) which is

the comparable steeper section of the control. In the South Fork Panel 7L, the proportion of the channel in cascades did not increase nearly as much as in the James control suggesting, if anything, that subsidence negatively affected the proportion of cascades. By 1997, it appears that mining had a negative impact on the proportion of cascades since they did not increase nearly as much as in the James control (Table 3). The proportion of channel in pools, however appeared to have temporarily increased in both the Main Channel Panel 7L and in the South Fork Panel 7L compared to the control (Table 2). However by 1997, this difference was no longer evident (Table 3). The number of pools in the South Fork Panel 7L appear to have increased somewhat in 1995, but again this increase was temporary. Any increase in total pool volume in Panel 7L in 1995 also appears to have diminished by 1997. The inconsistencies in response between the Main Channel section and South Fork section of Panel 7L makes any generalizations regarding the effect of subsidence on channel characteristics in this panel difficult.

Table 2. Percent change between 1994 and 1995 in Panel 7L on the Main Channel and South Fork of Burnout Creek, and in the Upper James control.

STREAM ELEMENT	MAIN CHAN. PANEL 7L	UPPER JAMES		SOUTH FORK PANEL 7L	UPPER JAMES
Runs/Riffles	-22	-21		-4	-21
Cascades	+244	+189		+6	+189
Glides	-100	-91		0	-91
Pools	+28	-47		+25	-47
Pool Numbers	-60	-54		-7	-54
Pool Volume	+59	+27		+81	+27
Av. Pool Volume	+280	+186		+124	+186

Table 3. Percent change between 1994 and 1997 in Panel 7L on the Main Channel and South Fork of Burnout Creek, and in the Upper James control.

STREAM ELEMENT	MAIN CHAN. PANEL 7L	UPPER JAMES		SOUTH FORK PANEL 7L	UPPER JAMES
Runs/Riffles	-8	-40		-9	-40
Cascades	+152	+300		+21	+300
Glides	-100	+108		0	+108
Pools	-71	-77		-35	-77
Pool Numbers	-65	-77		-54	-77
Pool Volume	0	-60		-73	-60
Av. Pool Volume	+190	+73		-33	+73

Panel 8L was mined in 1995-1996, and data were evaluated for both the Main Channel section and for the South Fork section of this panel. (The data on changes in proportion of glides is not reliable because of the very small percentages involved.) The most relevant changes attributable to mining in the Main Channel is the increases in the proportion of channel occupied by pools as well as the number and volume of pools compared to the Upper James control (Table 4). These increases in pool attributes, however, did not occur in the South Fork Panel 8L. Although the proportion of runs and riffles decreased following mining, they did not decrease nearly as much as in Upper James, and thus probably increased somewhat following mining; this occurred in both sections of Panel 8L.

Table 4. Percent change between 1995 and 1997 in Panel 8L on the Main Channel and South Fork of Burnout Creek, and in the Upper James control.

STREAM ELEMENT	MAIN CHAN. PANEL 8L	UPPER JAMES		SOUTH FORK PANEL 8L	UPPER JAMES
Runs/Riffles	-9	-24		-6	-24
Cascades	+41	+38		+14	+38
Glides	+268	+2205		-----	+2205
Pools	+91	-56		-59	-56
Pool Numbers	0	-48		-53	-48
Pool Volume	+108	-67		-71	-67
Av. Pool Volume	+110	-37		-70	-37

Lower James most closely resembles the lower reach of Burnout Creek where Panel 9L is located; it is therefore used as the basis for determining possible changes here attributable to mining. Panel 9L was mined during 1995-1996, thus any effects of subsidence on channel characteristics should be noticed by 1997. Subsidence appears to have resulted in an increase in the amount of channel occupied by pools; although the actual increase was only +7%, Lower James experienced a decrease of 50% (Table 5). However, both the number of pools and the total pool volume appears to have decreased, especially when compared to increases in these attributes in Lower James. Although subsidence resulted in fewer pools, the average volume of these pools had increased substantially by 1997 (+50% in Panel 9L versus a -13% in Lower James). Thus mining caused fewer but larger pools in this panel. The actual length of channel in cascades in these lower reaches was small and the differences may well have resulted from classification inconsistencies.

Table 5. Percent change between 1995 and 1997 in Panel 9L of Burnout Creek and in the Lower James control.

STREAM ELEMENT	MAIN CHANNEL PANEL 9L	LOWER JAMES
Runs/Riffles	-1	-1
Cascades	-18	-25
Glides	+158	+625
Pools	+7	-50
Pool Numbers	-43	+29
Pool Volume	-13	+14
Av. Pool Volume	+50	-13

Whether mining has had an effect on channel characteristics along the entire monitored length of the Main Channel and South Fork channel of Burnout might be answered by comparing the relative differences between the 1993 data and the 1997 data in these channels with differences during the same period in James Canyon.

The response of the Main Channel to mining were not always consistent with changes in the South Fork. Whereas the proportion of the Main Channel occupied by cascades appeared to have increased, that in the South Fork may have decreased (Table 6). On the other hand, the total number of pools may have increased in both the Main Channel and South Fork drainages, but changes in pool volume were inconsistent.

The most reasonable conclusion regarding the effects of subsidence on stream channel characteristics in the Burnout drainages is that no meaningful differences occurred that can be attributed reliably to subsidence. Great year-to-year variability occurred in both the James Canyon control as well as Burnout Creek.

Table 6. Percent change between 1993 and 1997 in the entire Main Channel and the South Fork of Burnout Creek, and in their respective control reaches in James Canyon.

STREAM ELEMENT	BURNOUT CREEK	JAMES CANYON		SOUTH FORK BURNOUT	UPPER JAMES
Runs/Riffles	-6	-12		+13	-37
Cascades	+796	+200		+54	+195
Glides	-65	-8		------	+188
Pools	-45	-71		-72	-82
Pool Numbers	-30	-51		-36	-75
Pool Volume	-47	-77		-72	-74
Av. Pool Volume	-26	-44		-33	+4

Channel Cross-Section

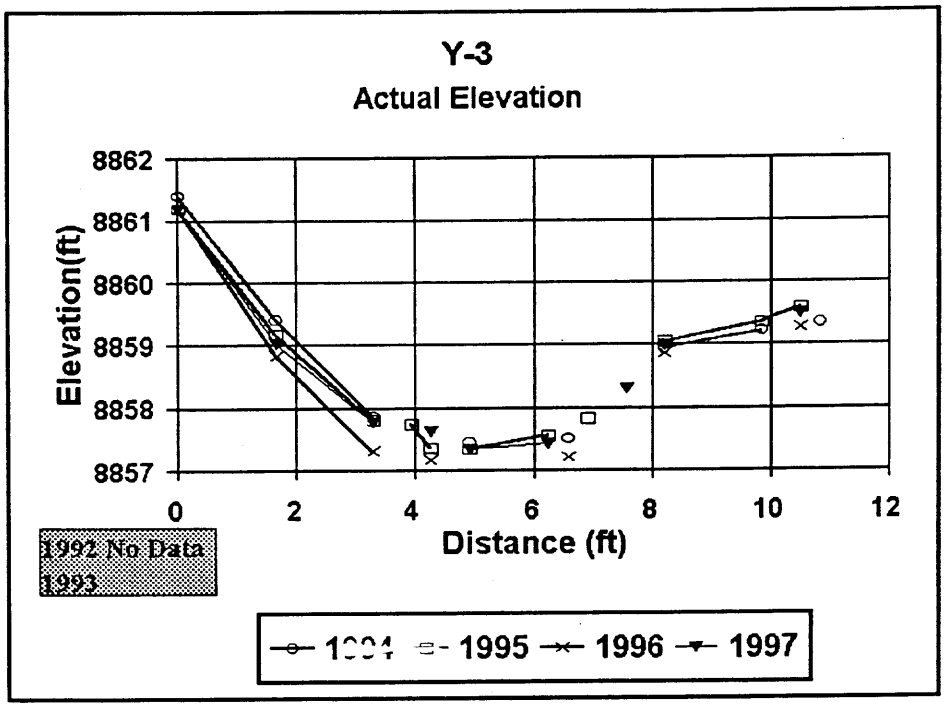
Scour and fill values are only meaningful directly for James Creek and the panel 10L cross-section in Burnout Creek that were not mined. For the subsided cross-sections, horizontal and vertical movement of either or both survey pins would introduce large errors in scour and fill calculations. Thus, it would be impossible to tell if a channel change was due to scour (or fill) or to subsidence. Therefore, in analyzing channel cross-sections that experienced subsidence, a routine to align yearly channel profiles by adjusting both vertical and horizontal axes was used. We could then align the major channel feature (e.g., thalweg) in a qualitative way to compare year to year channel changes.

Of the 73 channel cross-sections surveyed in Burnout Creek, we focus the majority of our attention on the cross-sections located above longwall panels 5L, 6L, 7L, 8L and 9L where mining and subsidence has already occurred from 1992 to 1997. Longwall mining and most of related subsidence above panel 5L had already occurred by early 1992, prior to our initial survey. Thus, documented cross-sections in this upper ephemeral reach of Burnout Creek were located only in the zone of maximum subsidence with the objective to monitor any residual subsidence or recovery of channel geometry. Subsidence in this monitored reach was approximately 5 feet and did not change appreciably after the 1992 survey.

Rather than describe changes in each of the 73 cross-sections monitored during the 6-year period, we selected cross-sections that typified the behavior of each set of cross-sections in zones of subsidence and zones of tension. Changes in these selected cross-sections thus represent changes in the stream channel and are discussed below.

James Canyon (Control Area):

Differences in cross-section profiles in James Canyon serve as a basis for determining the amount of cross-section changes in Burnout that might be attributable to subsidence. The differences between years in James Canyon cross-sections result from the normal yearly flux of cut and fill combined with minor differences in survey measurements. Figures 49 and 50



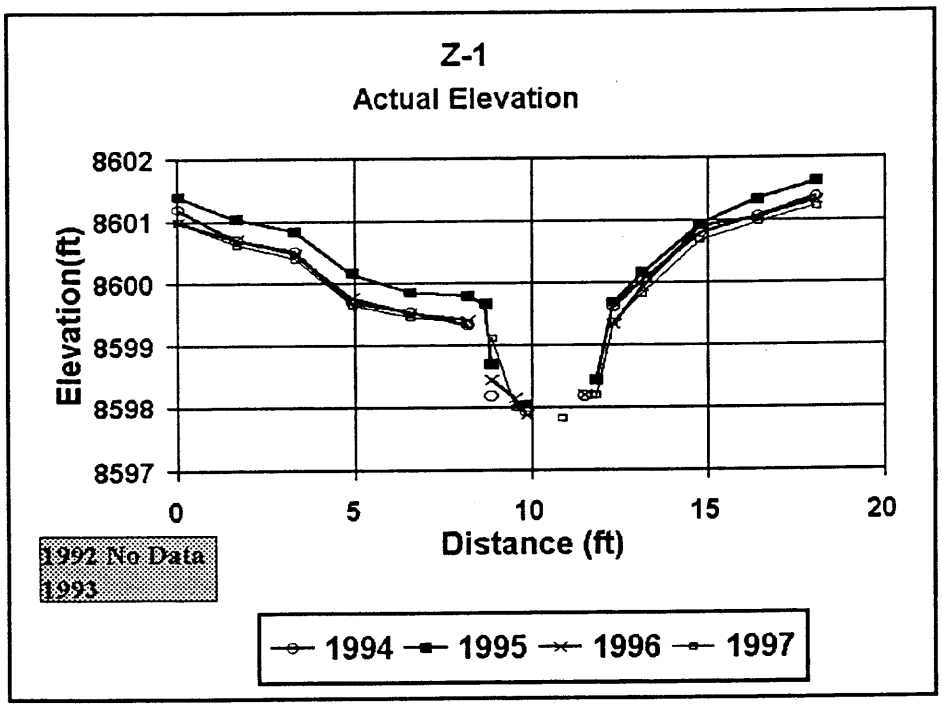
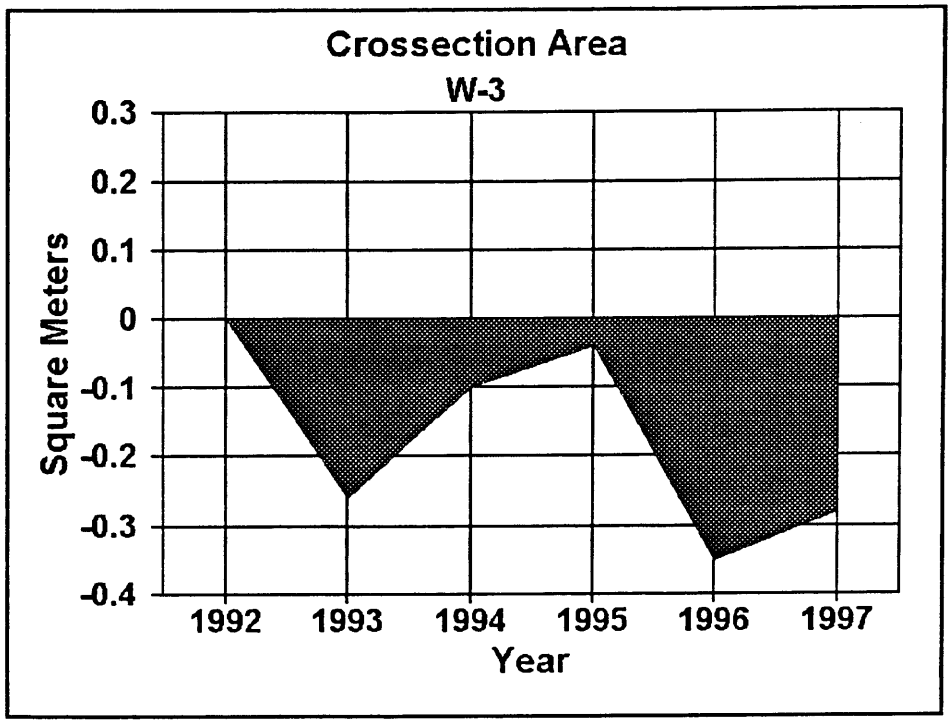


Figure 50. Examples of channel cross-section changes in the lower reach of James Canyon.



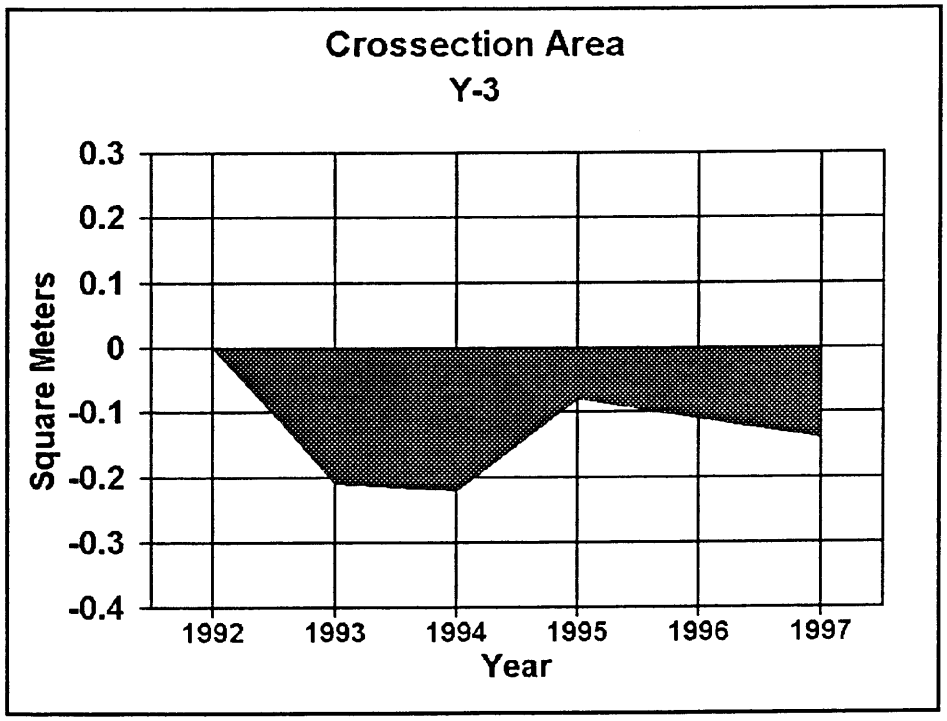


Figure 51. Examples of variations in cut and fill in the upper reach (W-3) and lower reach (Y-3) of James Canyon over the study period.

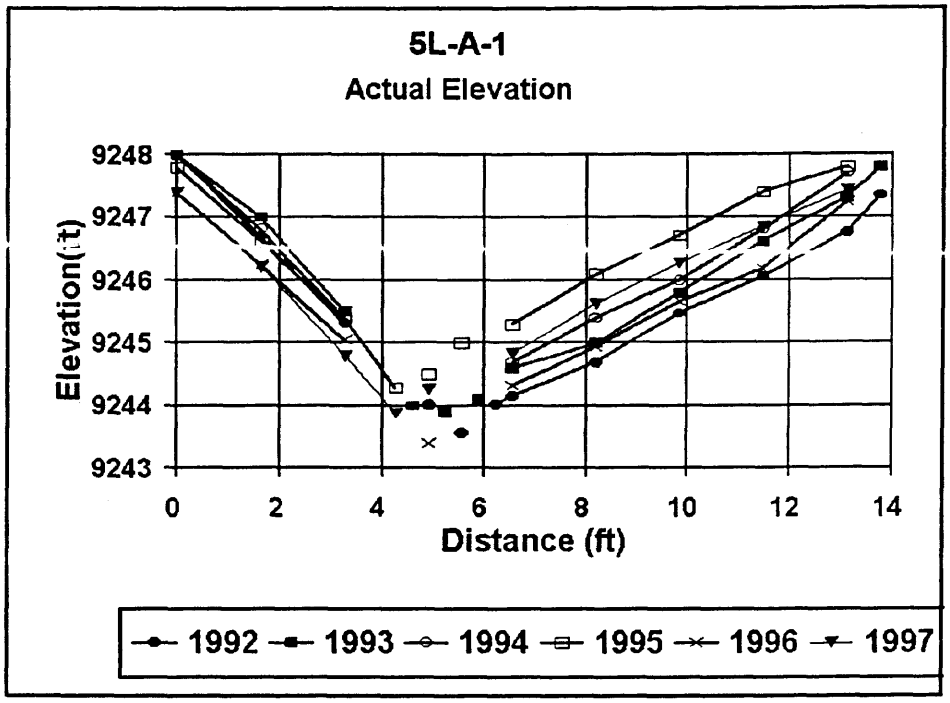
illustrate examples of cross-section profile differences in James Canyon between 1994-'97. Elevational differences between years in the profile of cross-section W-1 varied no more than 0.3 feet, cross-section X-4 varied nor more than 0.5 feet, cross-section Y-3 varied 0.6 feet, and cross-section Z-1 0.5 feet.

Distance between the staked ends (channel width) varied between 0.0 and 0.3 feet, which can be attributed to measurement error. Thus, we can assume that any cross-section elevational differences between years in Burnout that exceed ~0.5 ft. can be attributed to subsidence as well as any channel width exceeding ~0.3 feet.

Figure 51 shows the amount of channel cut and fill variation than can be expected to occur from normal erosion and deposition caused by yearly flux in stream flow. Between 1992 and 1993 both cross-sections W-3 and Y-3 lost over 0.2 m^2 in cross-section area. Deposition in subsequent years almost replaced this, but then section W-3 lost ~1/3 m^2 again in 1996. Almost 0.1 m^2 of this in W-3 was replaced in 1997, but Y-3 continued to lose. Obviously, substantial normal changes in cut and fill can be expected to occur yearly.

Panel 5L:

Two examples (5L-A-1 and 5L-A-5) of the changes occurring between 1992 and 1997 in the five cross sections in panel 5L are shown in Figure52. Both of these examples are in the zone of subsidence; however, this subsidence must have occurred prior to the installation of the cross-sections in 1992. The 1995 data appear to be an aberration, suggesting that the right side of the cross sections rose approximately 1 ft. but then fell again to approximately previous levels in 1996, which is an unlikely occurrence. The width of the 5L-A-5 channel (distance between pins) narrowed progressively by 1.0 foot between 1992 and 1995, but then widened by 0.6 feet in 1996, where it remained in 1997. This panel is located on the toe of a mass earth flow and the channel narrowing can be attributed to this slope movement. The widening in 1996 is probably also related to movement within this zone.



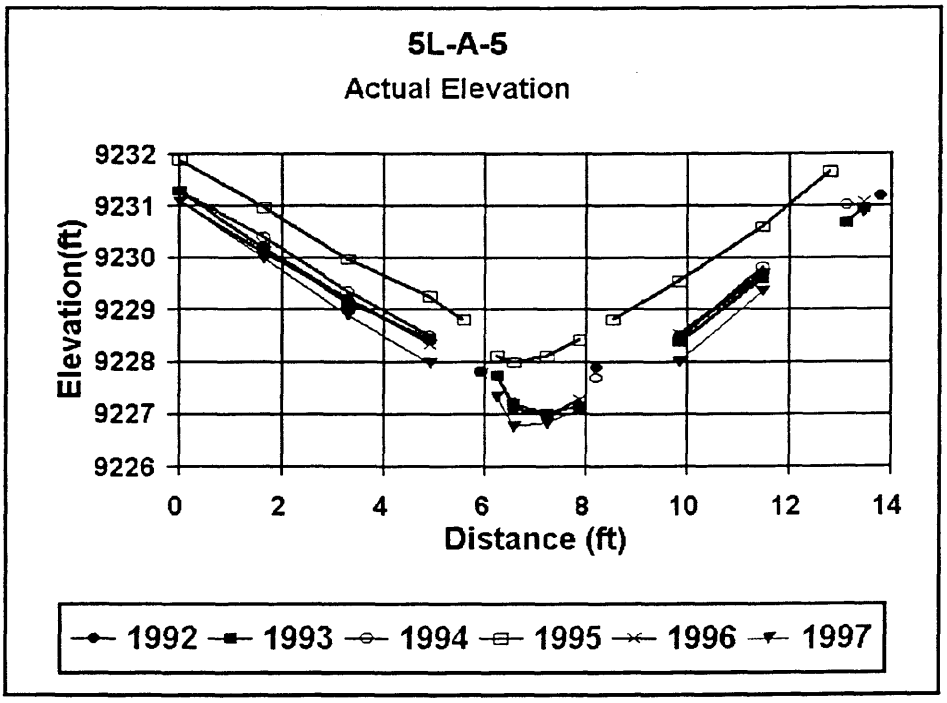
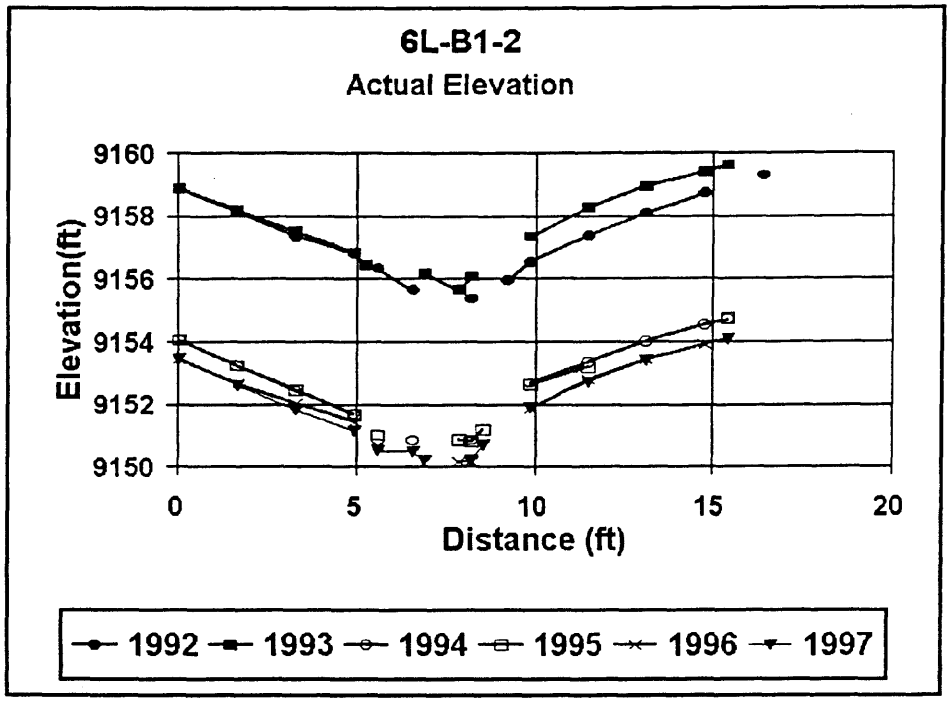


Figure 52. Examples of cross-section changes in the ephemeral reach of Burnout Creek.

Panel 6L:

Two reaches of the main branch of Burnout Creek overlying panel 6L (mined in late 1992 to early 1993) had cross-sections installed. The uppermost perennial reach of Burnout Creek (from about 2150 to 2450 m) had five cross-sections in the maximum subsidence zone and, because of the orientation of the panel, only three in the zone of maximum tension. Figure 53 shows an example of a cross-section in the subsidence zone (6L-B1-2) and one in the tension zone (6L-B1-7). The cross-sections in the subsidence zone dropped ~5.0 feet between 1993 and 1994, with possibly additional settling of 0.5 ft. by 1996. The channel narrowed by 1.0 feet at that time. The drop was less in the tension zone, ~ 3.2 feet between 1993 and 1994, with possibly some slight additional settling by 1996. The channel here narrowed progressively between 1992 and 1995 for a total of 1.5 feet.

In the lower reach of panel 6L, the effects of subsidence were not quite as noticeable. Cross-section 6L-B2-2 serves as an example of those cross-sections in the subsidence zone, and 6L-B2-6 an example for the tension zone (Figure 54). The cross-sections in the subsidence zone here dropped approximately 3.5 feet between 1993 and 1994, and settled perhaps an additional 0.5 feet by 1996. Subsidence in the tension zone, however, was much less (~1.5 feet) and appeared to occur gradually, with the major drop occurring between 1995 and 1996. The channel in the tension zone appears to have widened (~ 2.5 feet), whereas it didn't change in the subsidence zone.



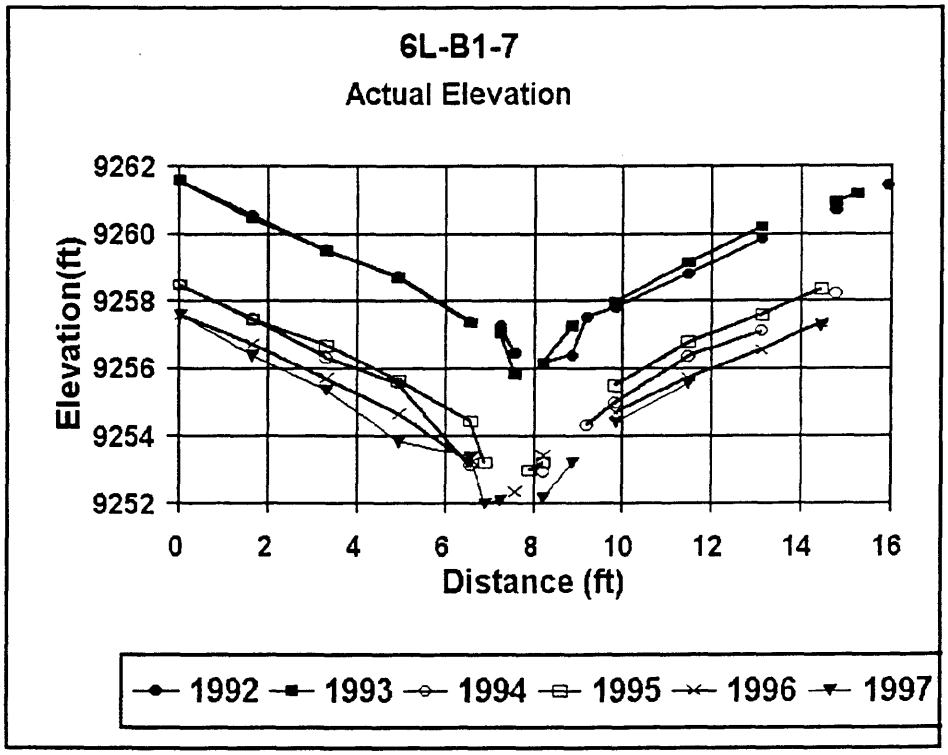
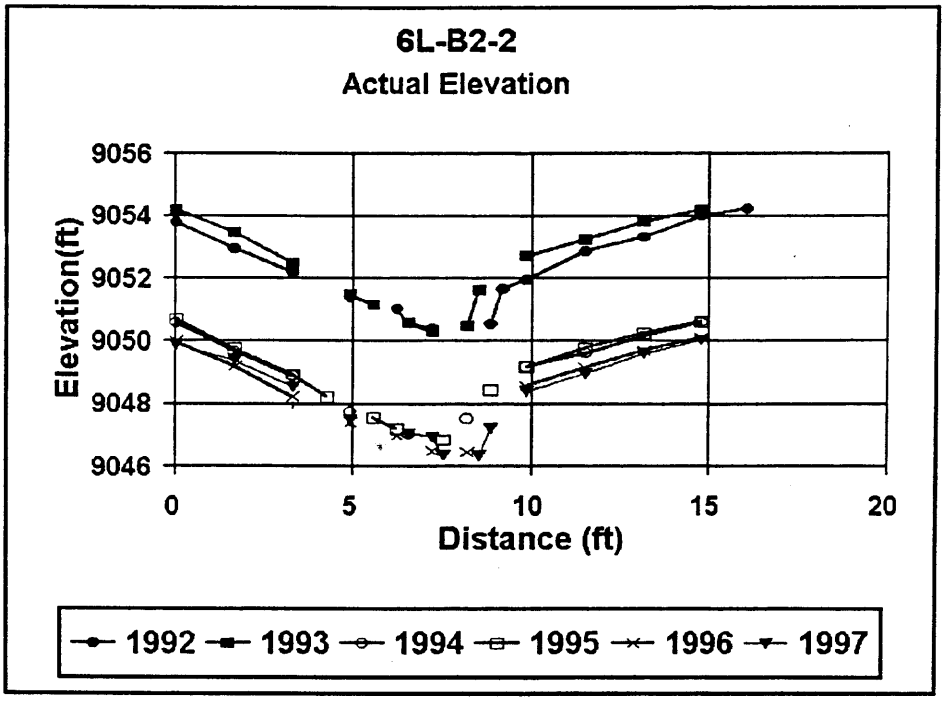


Figure 53. Examples of cross-section changes in the zones of subsidence (6L-B1-2) and tension (6L-B1-7) of Burnout Creek.



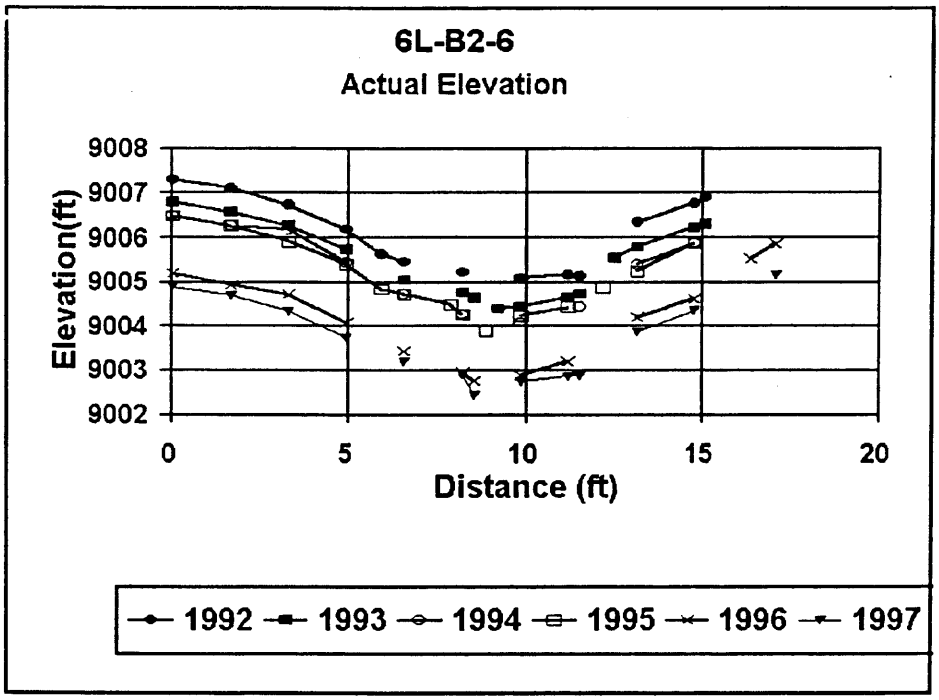
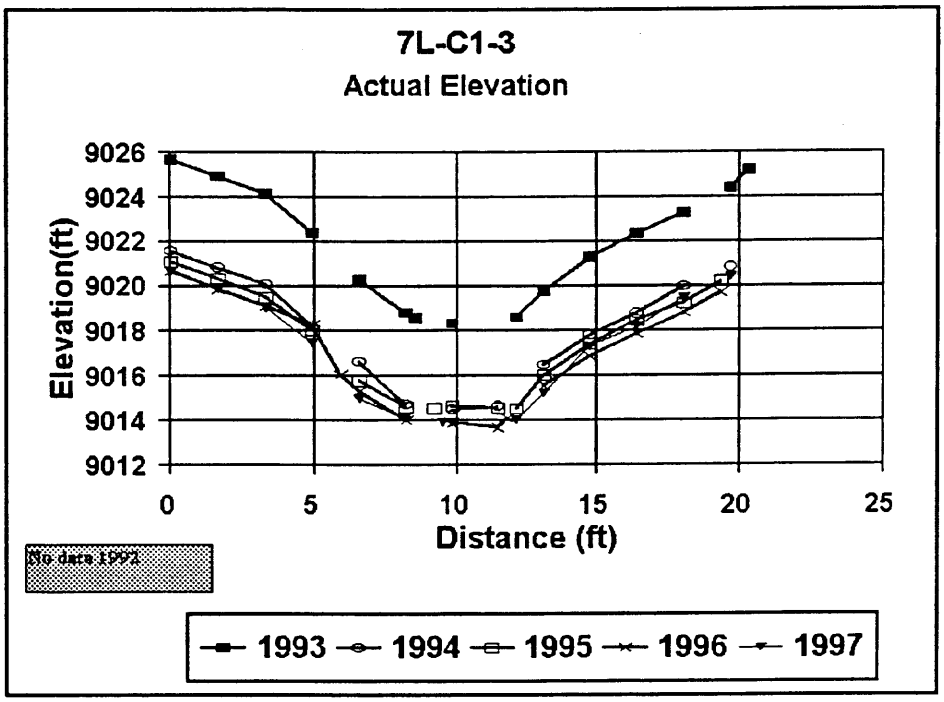


Figure 54. Examples of cross-section changes in the zones of subsidence (6L-B2-2) and tension (6L-B-6) of panel 6L in Burnout Creek.

Panel 7L:

Five maximum subsidence and five tension cross-sections were located above longwall panel 7L in the South Fork of Burnout Creek. Cross-section examples in this panel, mined in late 1993 and early 1994, are 7L-C1-3 for the zone of subsidence, and 7L-C2-8 for the tension zone (Figure 55). The cross-sections in the subsidence zone dropped 3.5 to 4.0 feet between 1993 and 1994, with very little further settling. The channel may have narrowed ~1.5 feet in the process. Cross-sections in the tension zone dropped comparatively little, between 1.5 and 2.0 feet, and more gradually, but the channel appears to have widened ~1.5 feet in this process.

Cross-section 7LC2-6 in the tension zone of the South Fork was used as an example of cut and fill changes (Figure 56). Following subsidence, a minor amount (<0.2 m^2) of deposition occurred in contrast to the erosion in James Canyon.



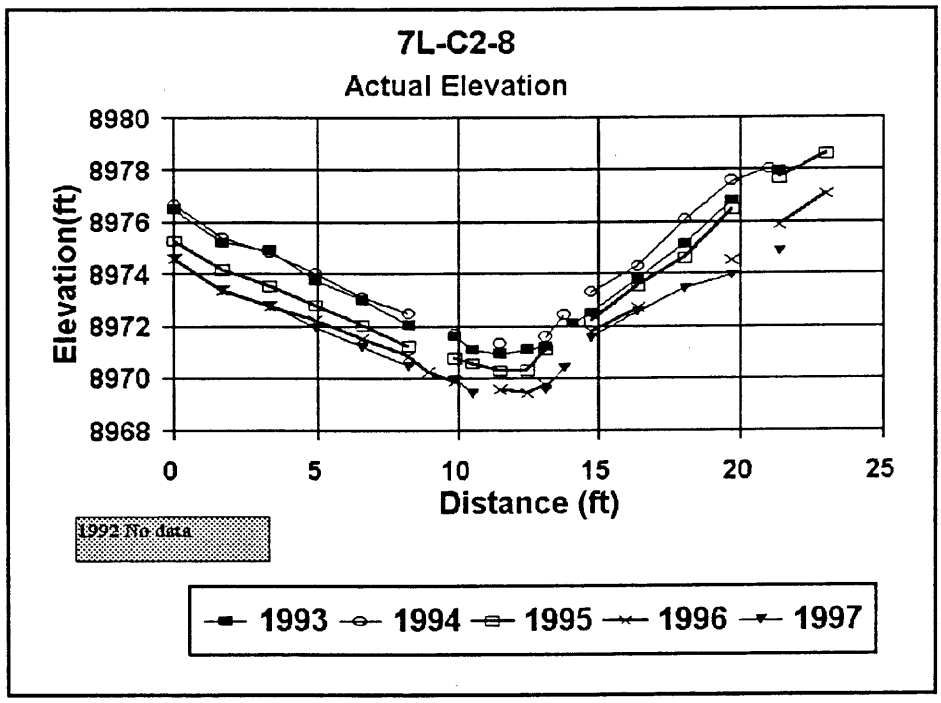


Figure 55. Examples of cross-section changes in the zones of subsidence (7L-C1-3) and tension (7L-C2-8) of panel 7L in the South Fork of Burnout Creek.

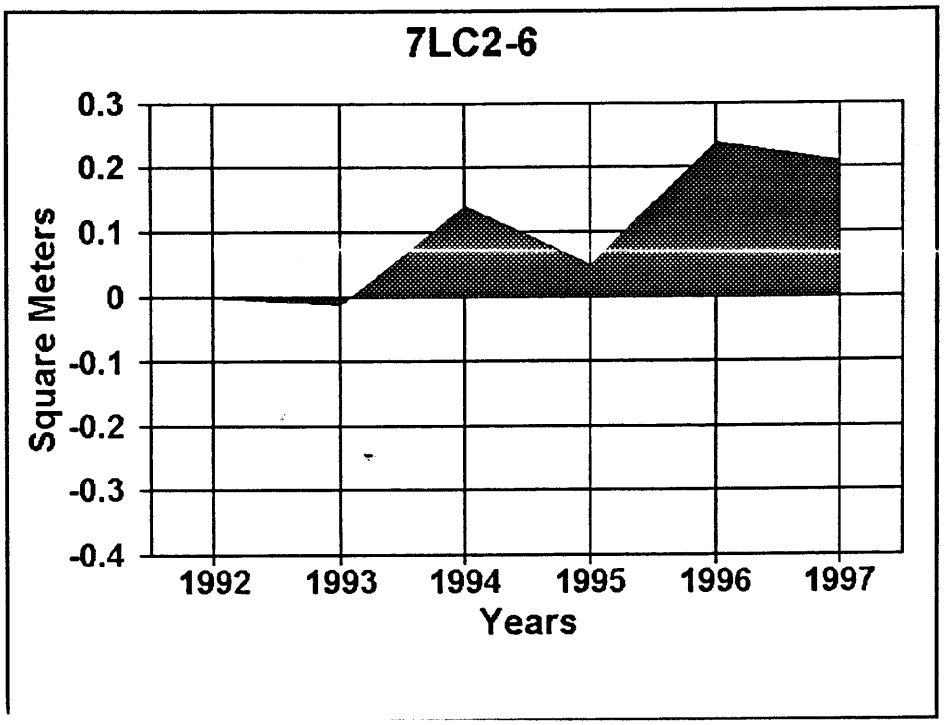


Figure 56. Example of cut and fill changes over the study period in tension zone of the South Fork section of panel 7L.

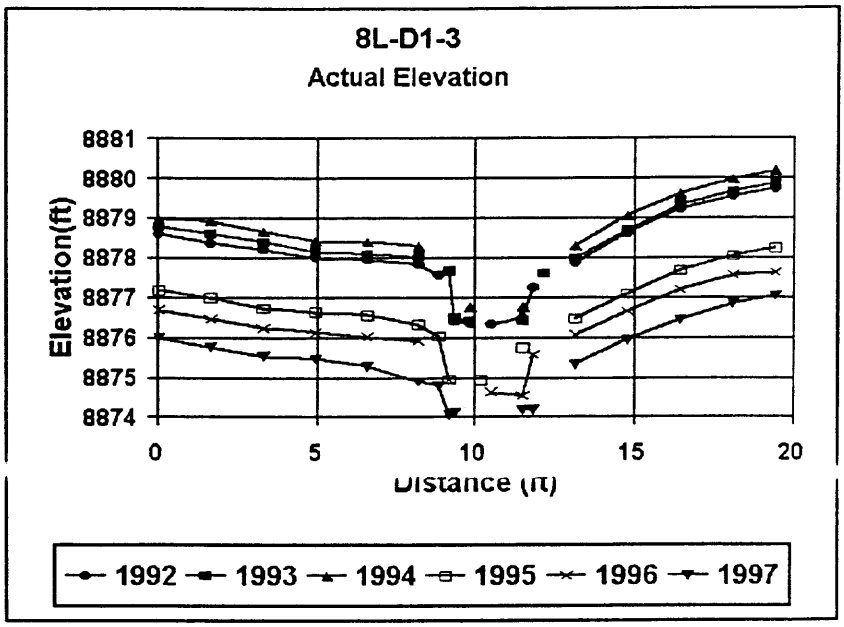
Panel 8L:

Four cross-sections are shown as examples of changes in panel 8L which was mined in 1995 and early 1996: two (8L-D1-3, subsidence; 8L-D1-9, tension; Figure 57) are in the Main Channel of Burnout, and two (8L-D2-4, subsidence; 8L-D2-10, tension; Figure 58) are in the lower reach of the South Fork. In the Main Channel the cross-sections in the subsidence zone dropped gradually, with ~1.0 foot in 1995, followed by an additional drop of ~ 0.5 feet in 1996, and an additional ~0.5 feet in 1997. The channel width did not change. The cross-sections in the tension zone of the Main Channel also dropped gradually, ~2 feet in 1995, with an additional drop of ~0.8 feet in 1996, and another ~1 foot in 1997. The channel width here decreased ~ 0.5 feet.

The South Fork cross-sections in the subsidence zone (8L-D2-4) dropped ~3.0 feet in 1995, with no further settling. Cross-sections in the tension zone (8L-D2-10) dropped ~2.0 feet

in 1995, with a further drop of ~ 1.0 feet in 1996. Neither set of cross sections showed appreciable change in either width or shape.

Cut and fill measurements in the Main Channel (Figure 59) did not show differences in either erosion or deposition patterns in excess of those found in the control area.



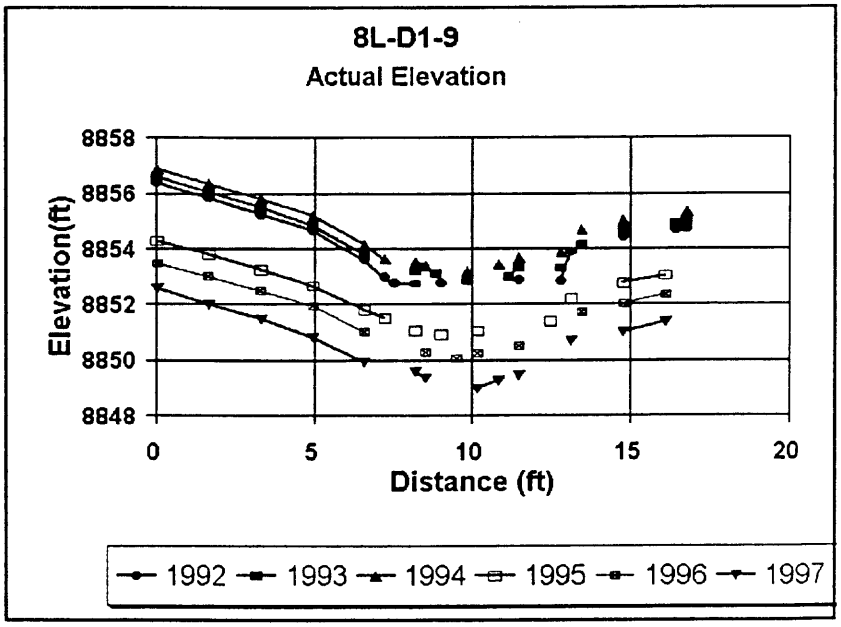
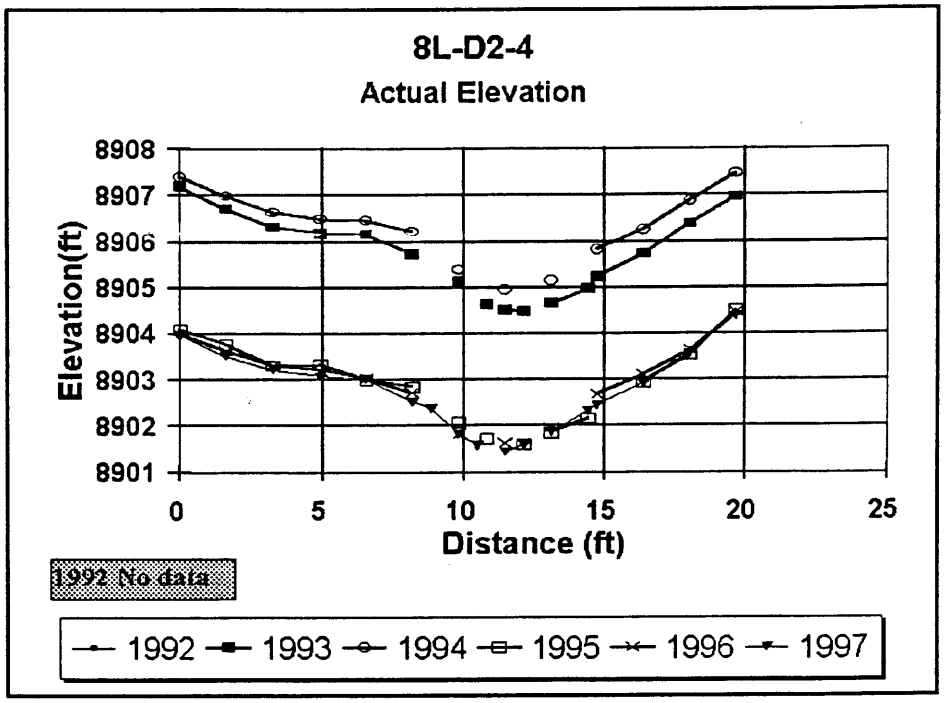


Figure 57. Examples of cross-section changes in the zones of subsidence (8L-D1-3) and tension (8L-D1-9) of panel 8L in the Main Channel of Burnout Creek.



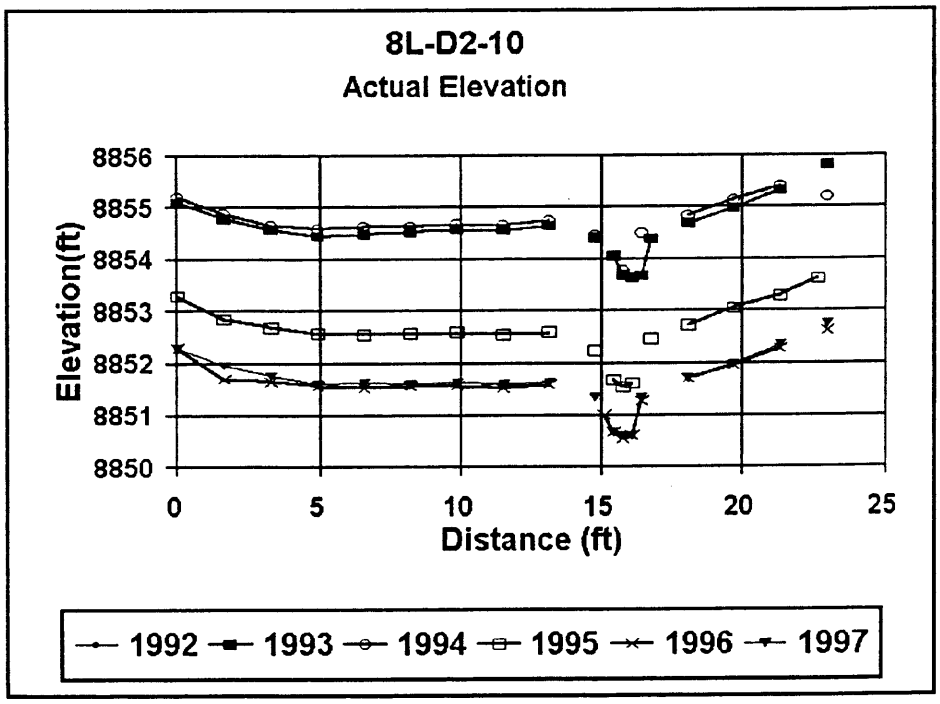


Figure 58. Examples of cross-section changes in the zones of subsidence (8L-D2-4) and tension (8L-D2-10) of panel 8L in the South Fork of Burnout Creek.

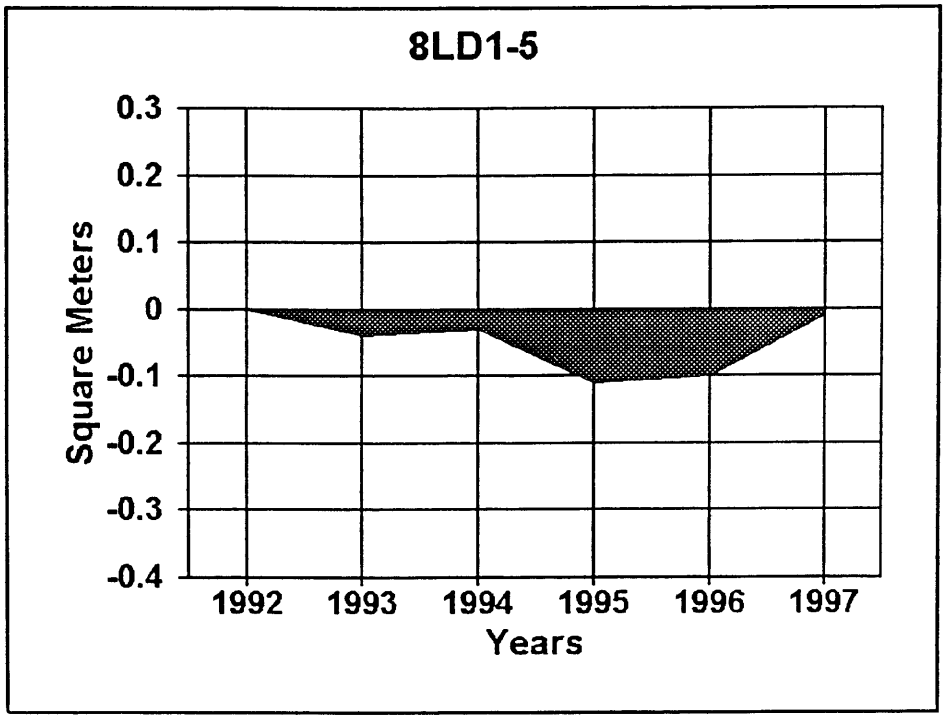
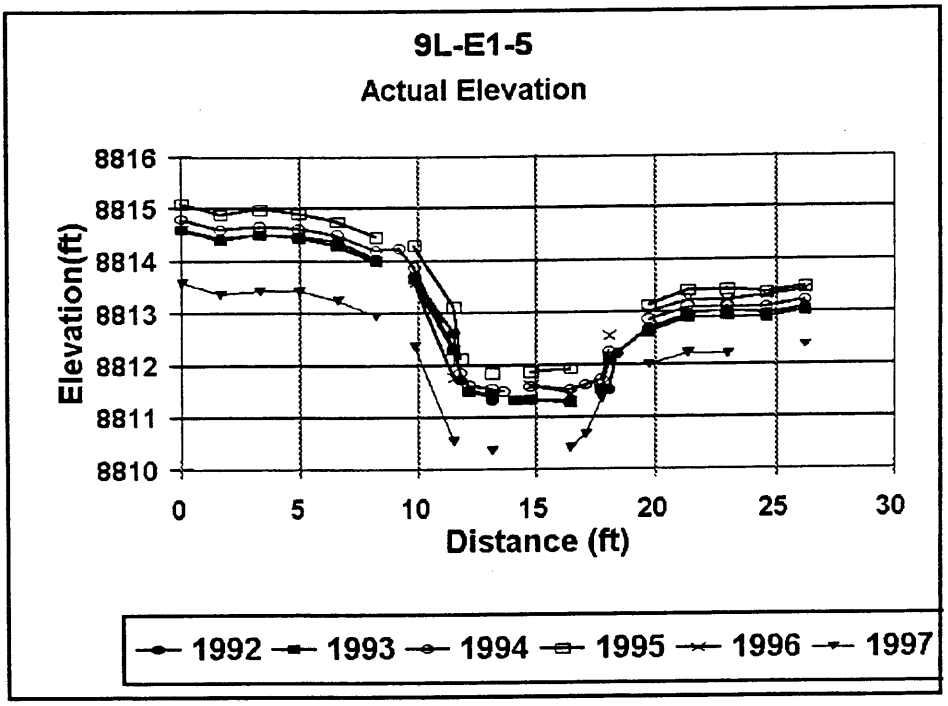


Figure 59. Example of cut and fill changes over the study period in the subsidence zone in panel 8L of the Main Channel of Burnout.

Panel 9L:

Panel 9L was mined in 1995 and 1996. Cross section 9L-E1-5 is used as an example of changes in the zone of subsidence, and cross section 9L-E1-8 of changes in the tension zone (Figure 60). Data collected in 1996 had not yet been affected by mining. By 1997, however, a drop of ~1 foot had occurred in the subsidence zone and a little over 1 foot in the tension zone. No change was noted in channel width. Some channel deposition occurred (Figure 61), especially in contrast to the channel erosion in the James Canyon control (Figure 51).



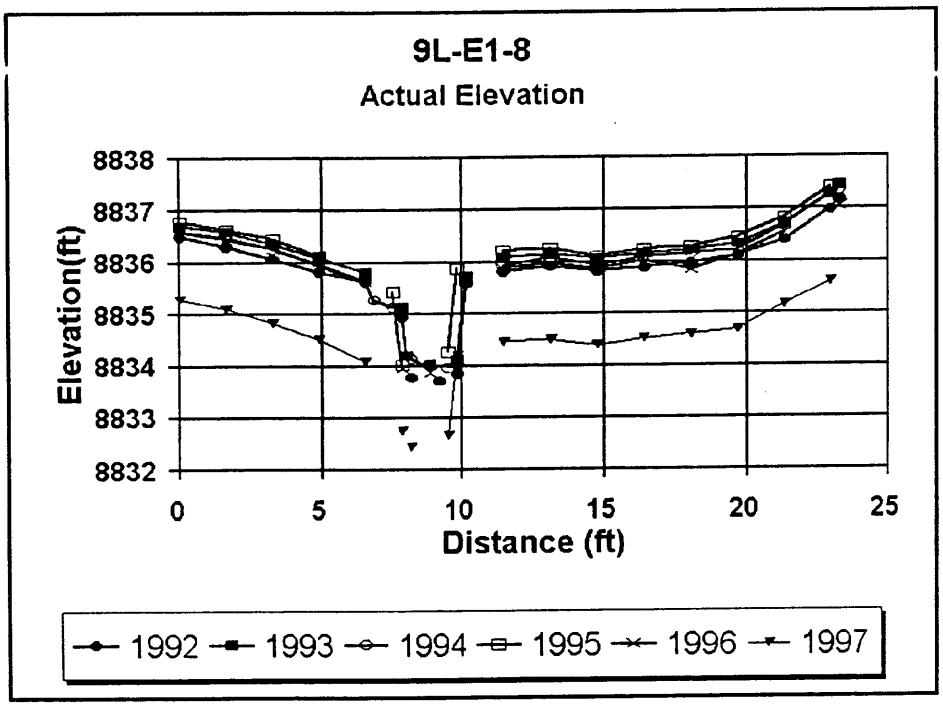


Figure 60. Examples of cross-section changes in the zones of subsidence (9L-E1-5) and tension (9L-E1-8) of panel 9L in Burnout Creek.

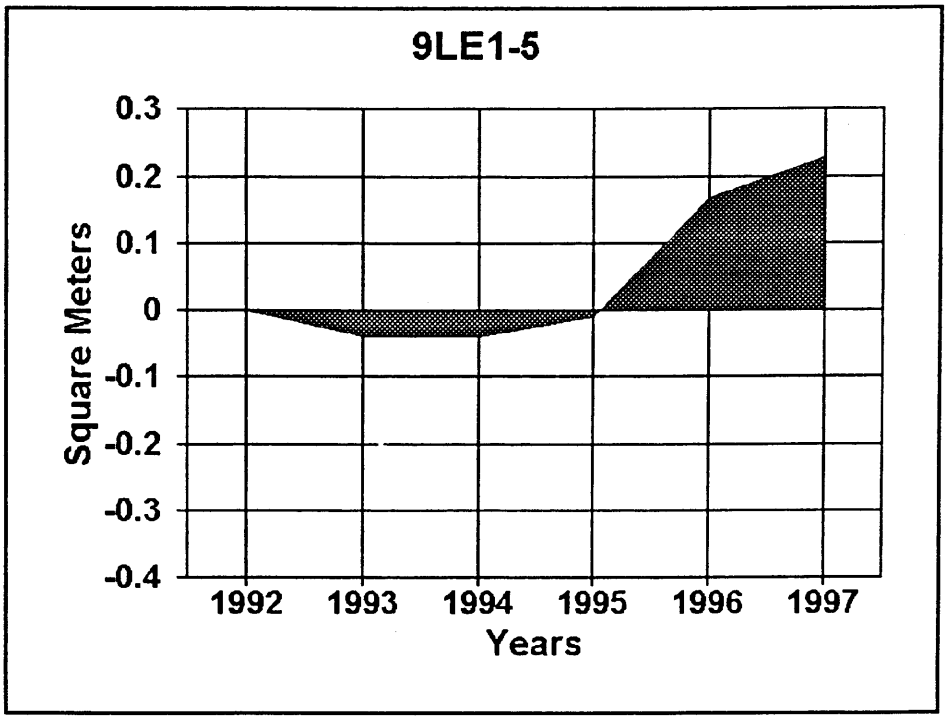
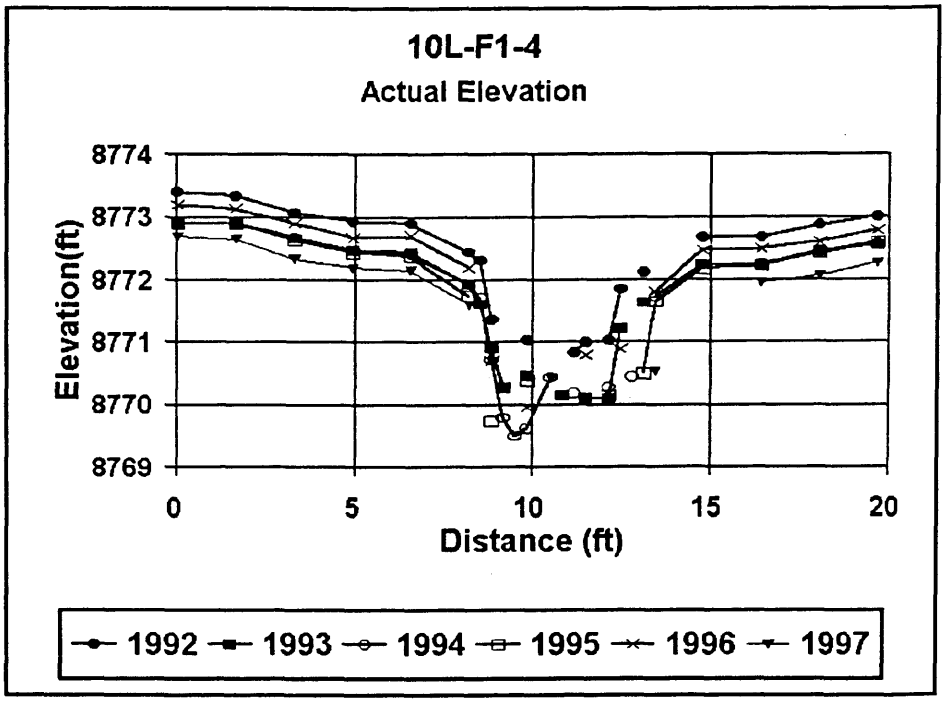


Figure 61. Example of cut and fill changes over the study period in the subsidence zone in panel 9L in Burnout Creek.

Panel 10L:

Panel 10L was not mined, therefore no changes beyond what might be expected from measurement error plus normal channel movement should be evident. The reason for the up to 1.5 feet differences in the thalweg area of cross-section of 10L-F1-49 (Figure 62) are caused by normal channel fluctuations caused by erosion and deposition or possibly some survey error. Changes in cut and fill in cross-sections here were considerably less than in the James Canyon control (Figure 63).



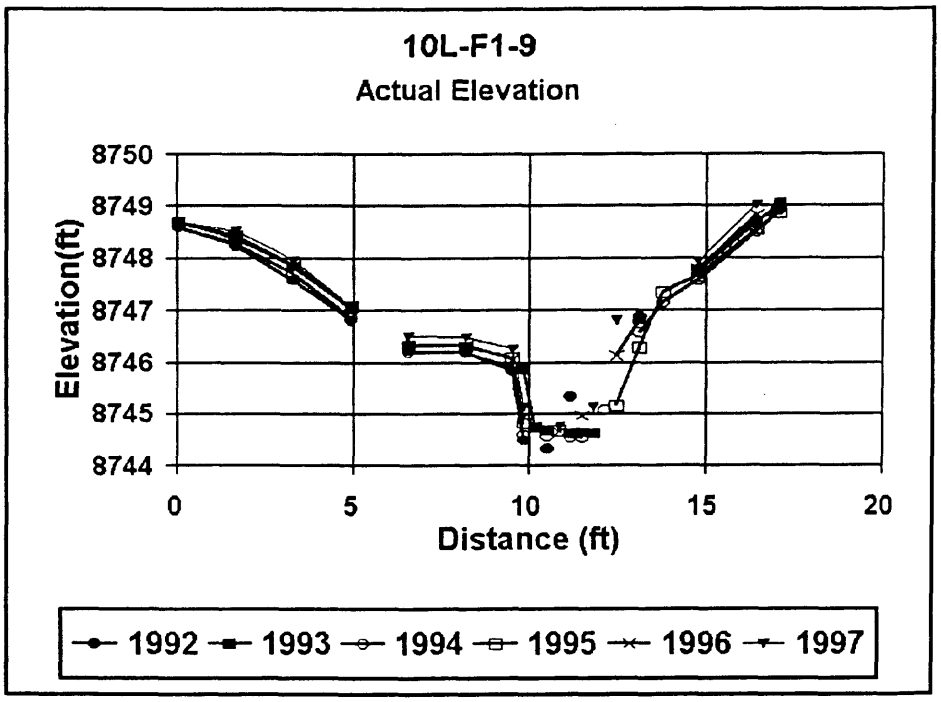


Figure 62. Examples of cross-section changes in the zones of subsidence (10L-F1-4) and tension (10L-F1-9) of panel 10L in Burnout Creek.

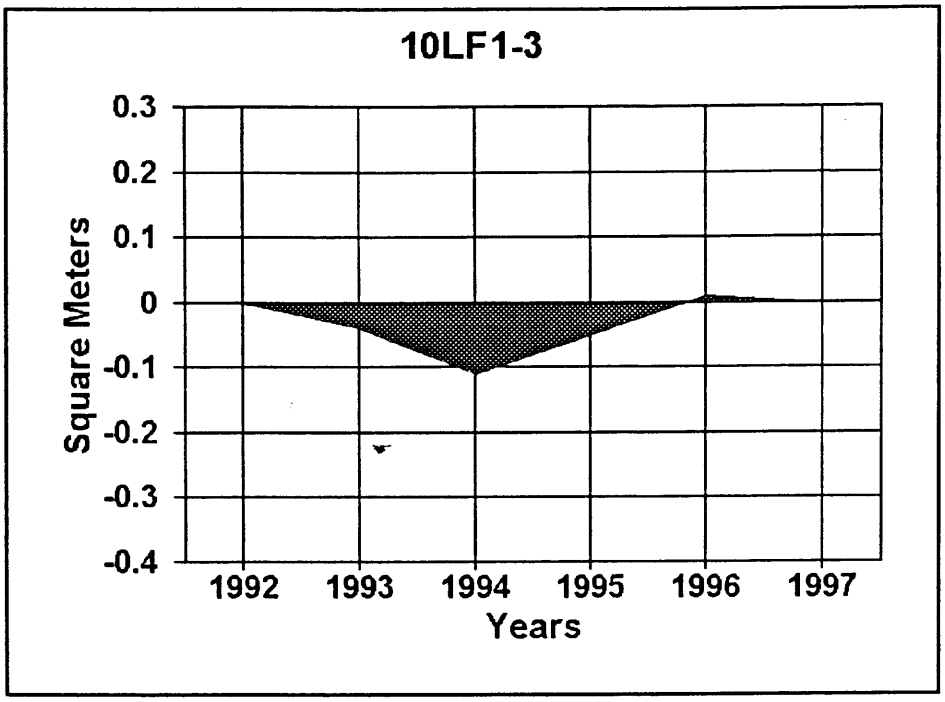


Figure 63. Example of cut and fill changes over the study period in the subsidence zone in panel 10L in Burnout Creek.

CROSS-SECTION CONCLUSIONS:

Subsidence following mining on Burnout Creek resulted in elevation drops of between approximately 1.5 to 5.5 feet in the zones of subsidence in the mined panels, but of only about 1.5 to 3.2 feet in the tension zones. If channel width changed in the subsidence zone, it usually was a narrowing of up to ~ 1.5 feet. Changes in channel width in the tension zone of a panel usually resulted in a widening of up to ~2.5 feet, but in some cases the width narrowed at least 1.5 feet. Thus the effect of subsidence on both channel drop and channel width varied considerably.

Amount of erosion and deposition in Burnout Creek attributable to subsidence did not appear to exceed that caused by normal processes in the James Canyon control area.

Longitudinal Channel Profiles

The longitudinal profile of both Burnout and the James Canyon control were surveyed by the use of a hip chain for distance along the thalweg and an engineer's level for elevational differences. The hip chain, with an estimated inherent measurement error of 10%, plus channel routing changes at the lower stream gradients, resulted in highly variable data. In addition, the 1995 profile survey in Burnout (main channel) was obviously distorted (probably by unrecognized equipment failure) and has been removed from any comparisons. The channel profiles in 1996 and 1997 were surveyed by a professional surveyor while surveys earlier than 1995 were conducted by graduate students with little training. The 1996 and 1997 elevation measurements were periodically tied to known elevation benchmark to verify accuracy. The 1996 and 1997 longitudinal profile data, therefore, are believed to more accurately represent the actual channel profile then the data obtained in earlier years where these controls were not employed.

Profile of the entire reach of James Canyon is shown in Figure 64, and of the lower and upper sections of James Canyon are shown in Figure 65. The differences in profiles between years is suggestive of the amount of error involved in the method selected to measure longitudinal profiles. Figure 66 shows enlarged 200 meter sections of Lower James Canyon (0 to 200 m) and of Upper James Canyon (1300 to 1500 m) controls for 1995, 1996, and 1997 to better illustrate the yearly variation of channel profile measurements attributable to a combination of natural fluctuations and measurement error. Stream profile elevation differences between these years in the lower reach of James Canyon are as much as 5 feet, and in the upper reach of the Canyon as much as 15 feet. The upper portion of James Canyon at about the 2050 to 2400 m distance lies over panel 8L which was mined in 1995-1996. The stream profile measurements do not show any effect that can reliably be attributed to subsidence (Figure 67).

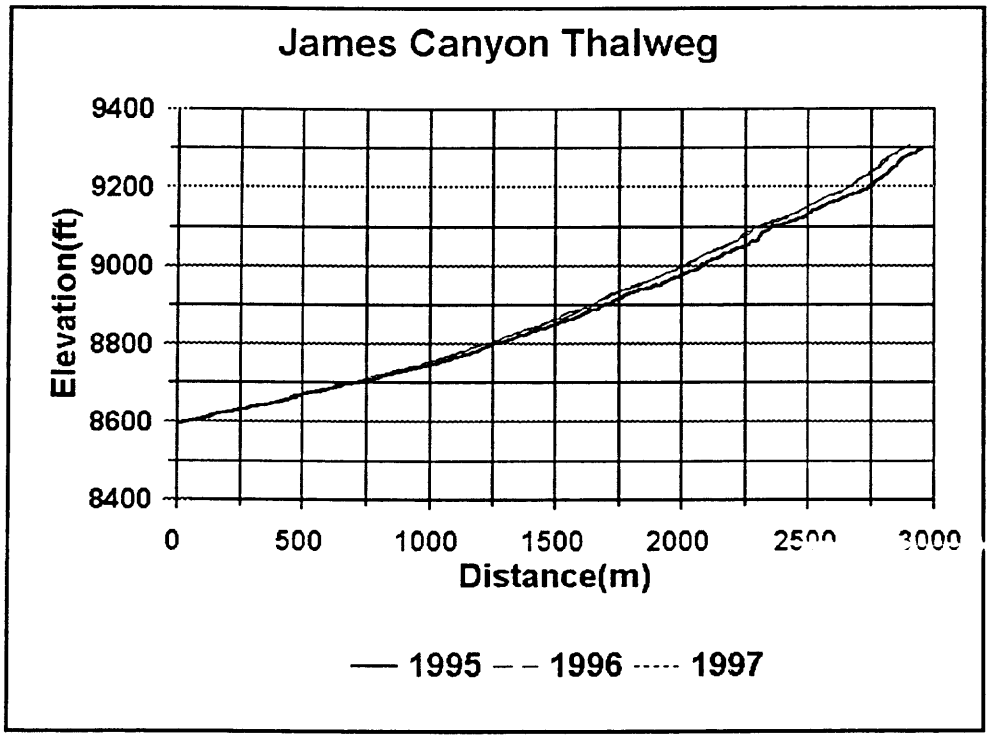
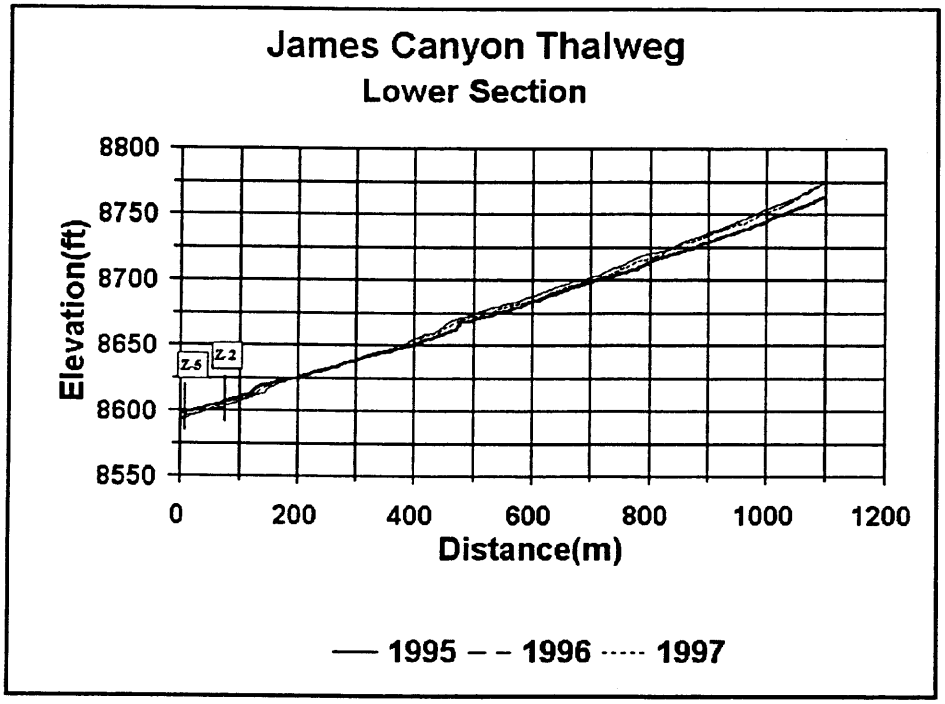


Figure 64. Longitudinal channel profile of the entire James Canyon reach, 1995-1997.



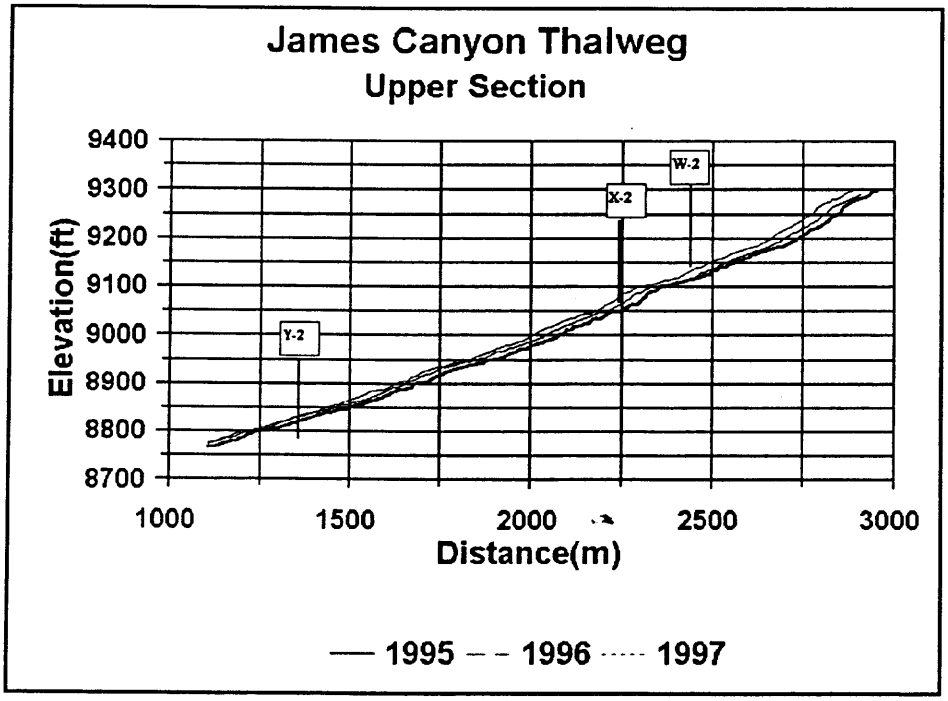
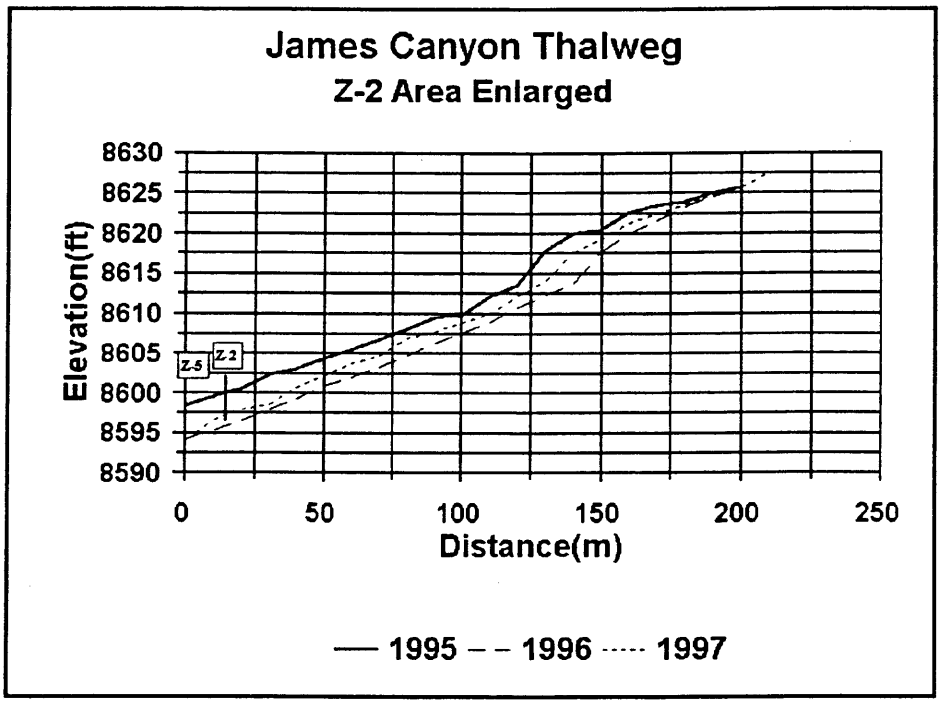


Figure 65. Longitudinal channel profile of the lower (0-1200 m) and upper (1000-3000 m) sections of James Canyon, 1995-1997.



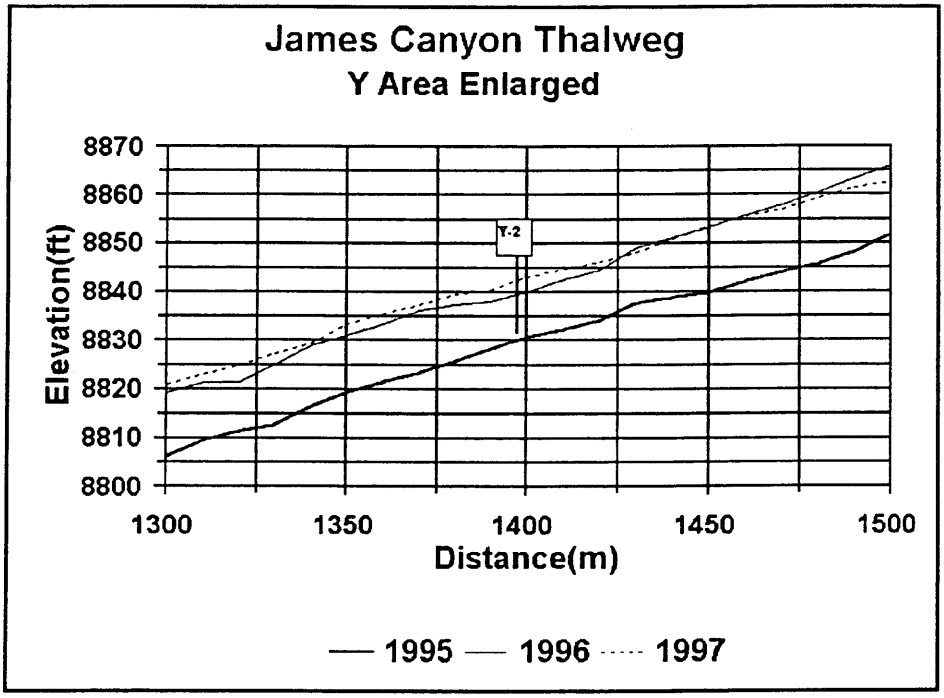


Figure 66. Longitudinal channel profile of the lower (0-200 m) and upper (1300-1500 m) sections of James Canyon, 1995-1997.

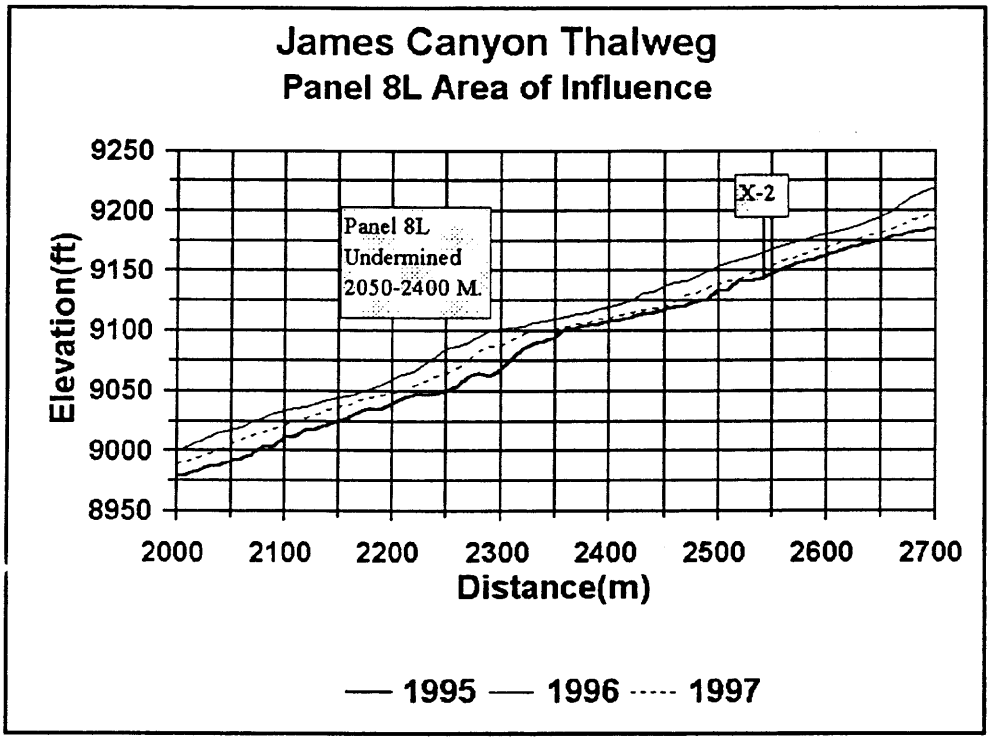


Figure 67. Longitudinal channel profile of the section of James Canyon underlain by Panel 8L, 1995-1997.

Because of the small magnitude of any vertical changes that occurred in the longitudinal profile of the main channel of Burnout Creek, it is difficult to assess any possible gradient changes related to subsidence (Figure 68). Even when examining specific reaches of Burnout Creek that were impacted by subsidence, significant changes in longitudinal profiles are not evident (Figure 69, 70, and 71). In the reach above panel 6L (1700 to 2370 m), mined in 1992-'93, some minor deviations between 1992 and other measurement years were noted but these tended to impact only very localized gradients. Some shifting of channel steps was apparent, but overall, the diverse character of the stream profile was preserved. (Note the vertical scale differences in Figures 68 through 71.) Where the vertical scale was expanded, a minor drop of ~ 1 foot appears in the panel 9L section between 1996 and 1997 in this panel mined in 1995-'96 (Figure 70), but this difference was well within the year-to-year variability of the sampling method. Generally, profile differences were as great before subsidence as were those measured following subsidence.

This would indicate that changes measured from year to year were caused primarily by natural channel changes, measurement bias, and measurement error. Also, it should be remembered that subsidence due to mining (between 1993 and 1994) in reach above panel 7L was minimal (<1 foot) because of the existence of an intrusive dike.

Changes in the South Fork (Figures 72 and 73) also cannot be attributed to subsidence. Gradient and roughness (steps) in the lower 500 m of this reach do not appear to have been appreciably affected.

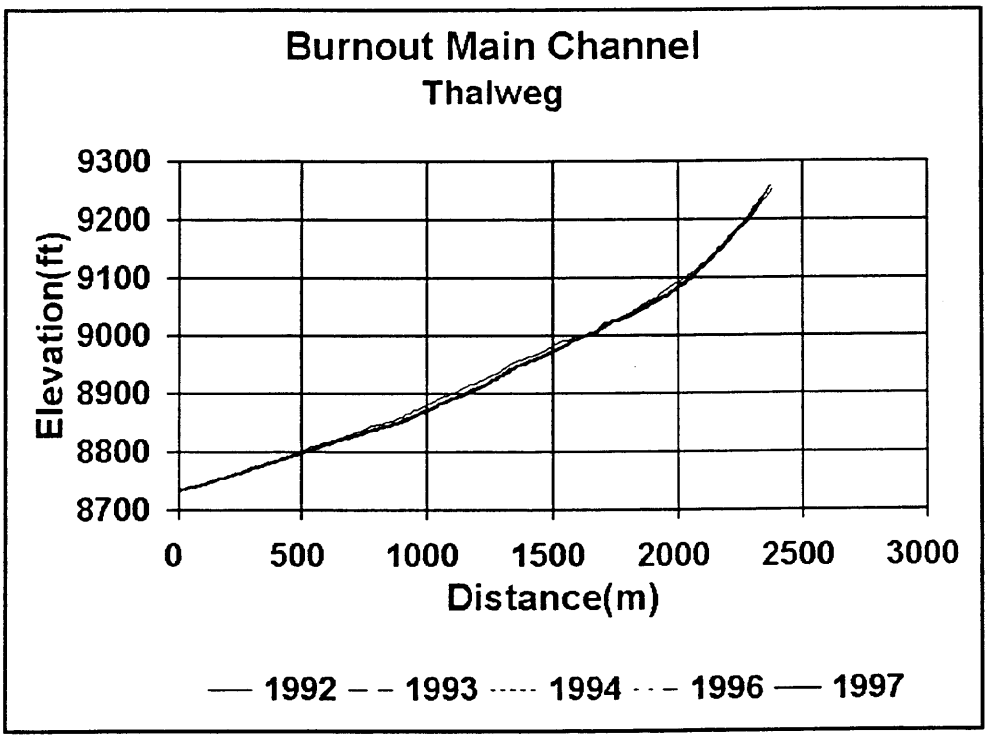
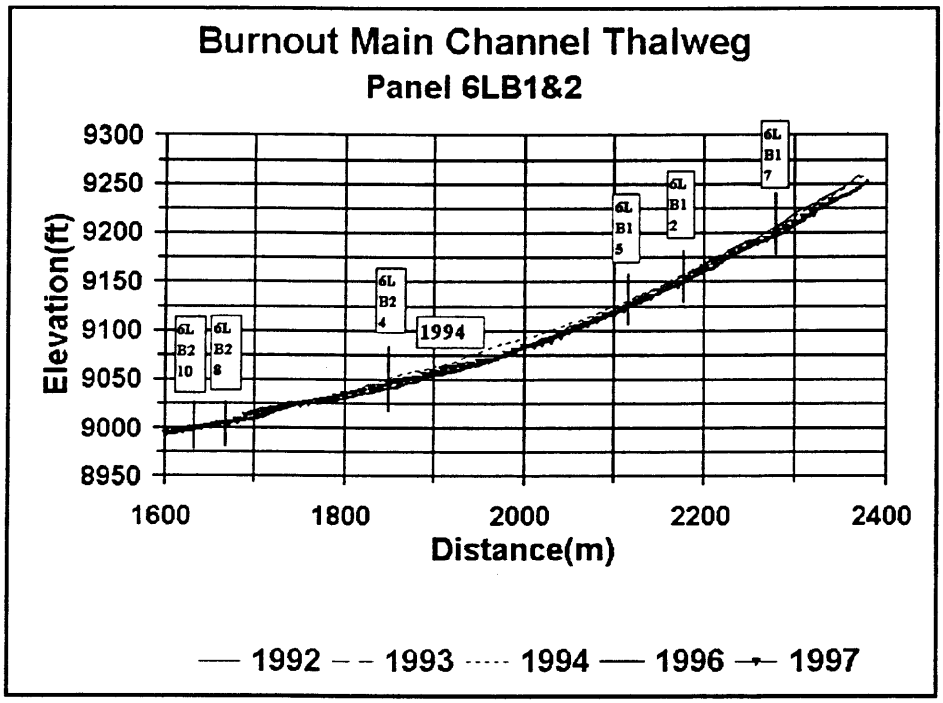


Figure 68. Longitudinal profile of the entire main channel of Burnout Creek, 1992-1997.



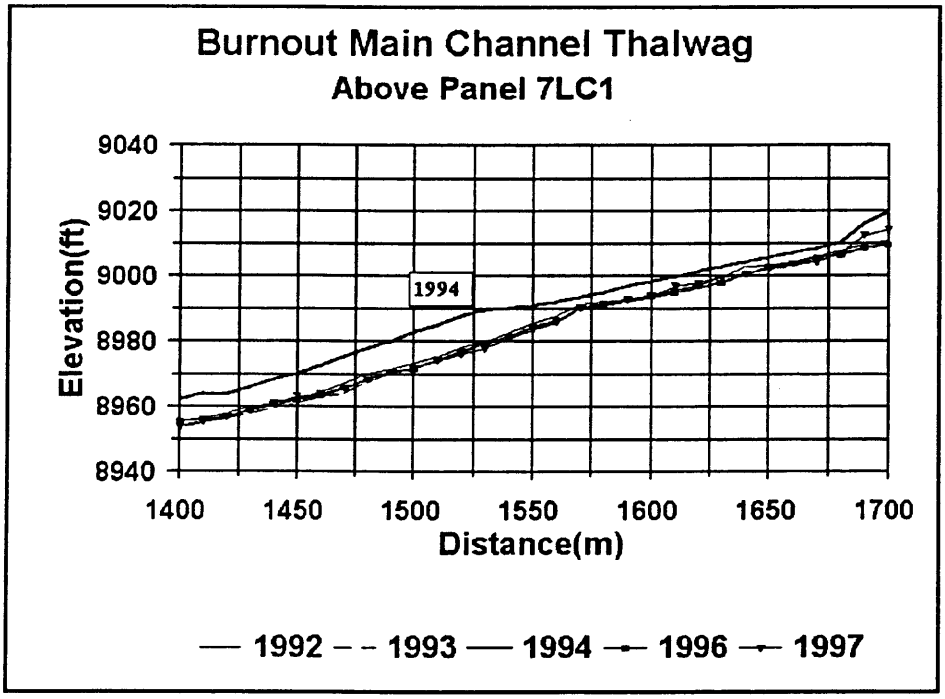
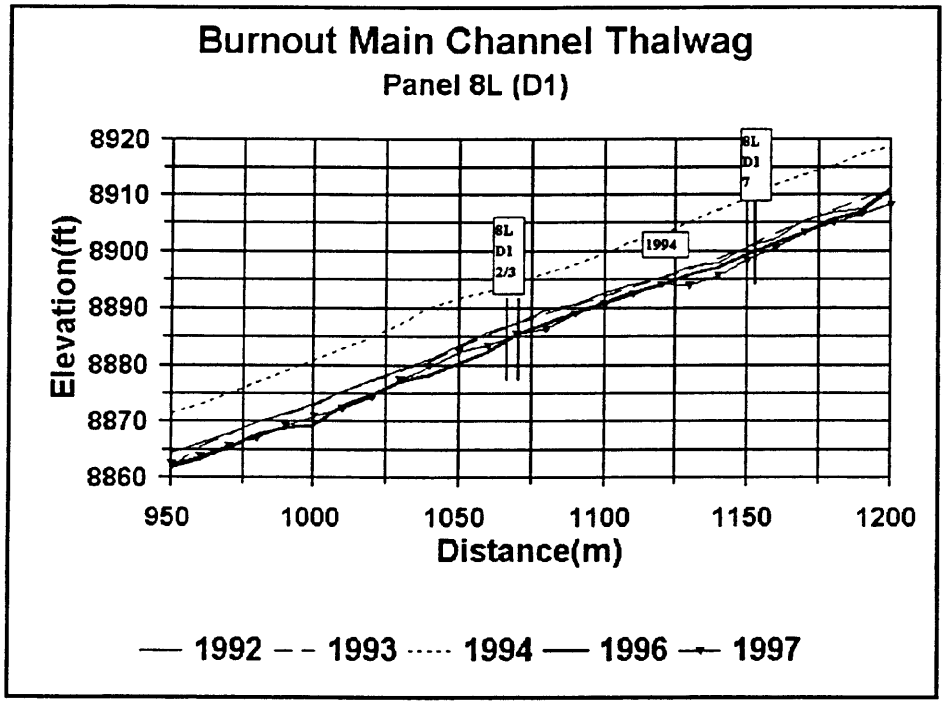


Figure 69. Longitudinal channel profile in panel 6L and the 7L portion of the main channel of Burnout Creek, 1992-1997.



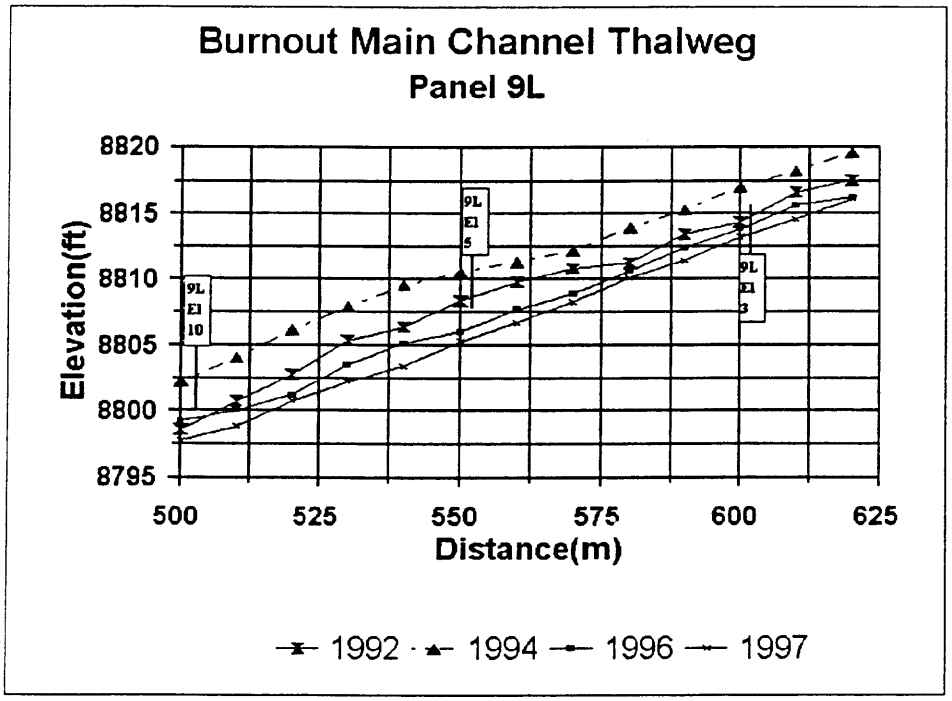


Figure 70. Longitudinal channel profile in panel 8L portion of the Main Channel, and panel 9L of Burnout Creek, 1992-1997.

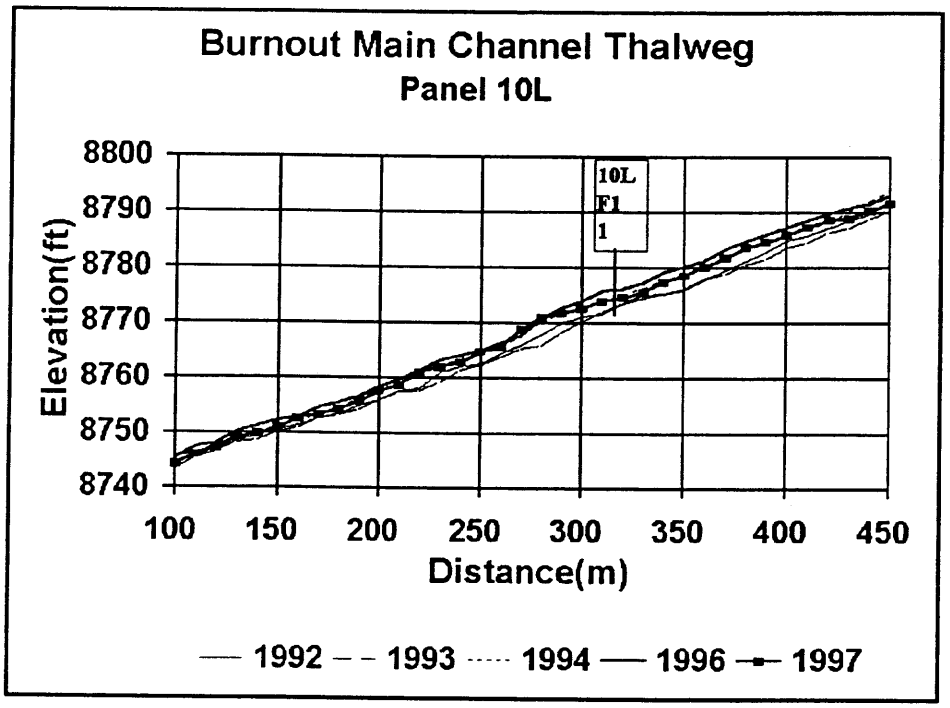


Figure 71. Longitudinal channel profile in panel 10L portion of the Main Channel of Burnout Creek, 1992-1997.

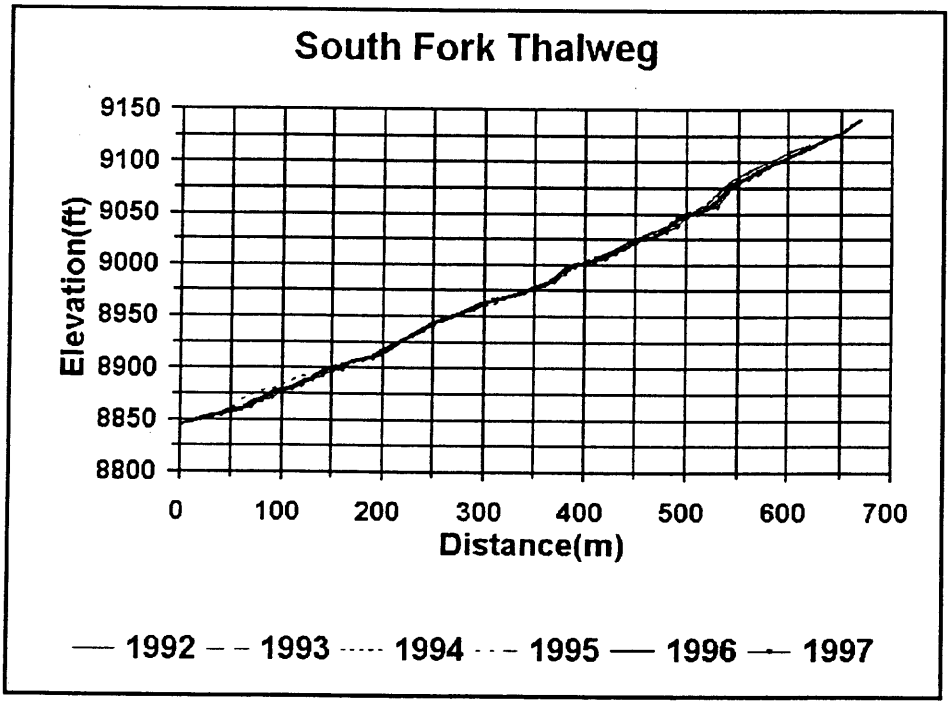
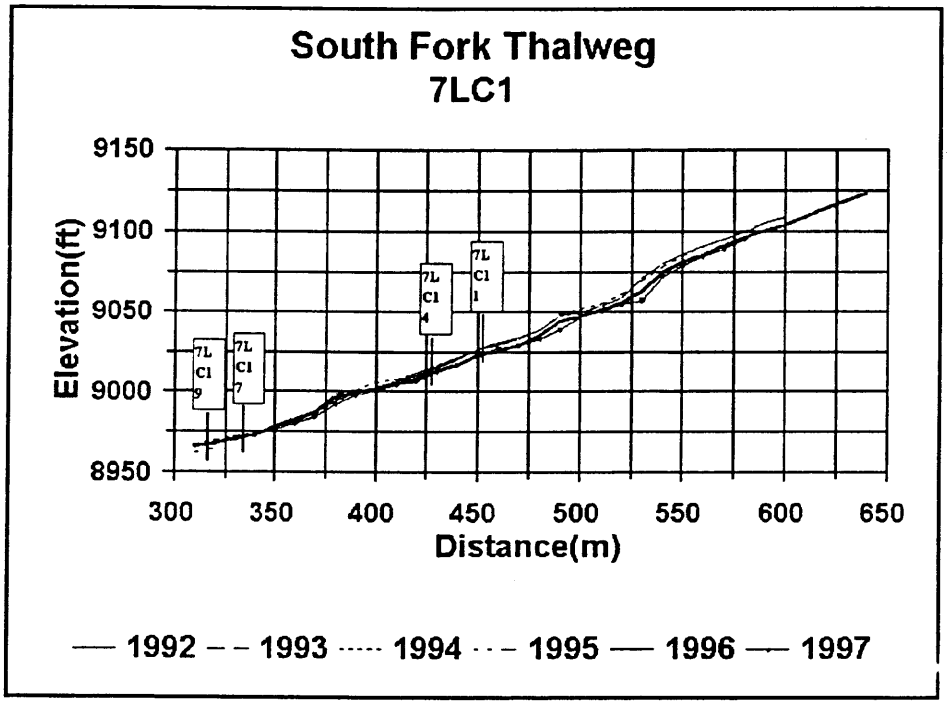


Figure 72. Longitudinal channel profile of the South Fork of Burnout Creek, 1992-1997.



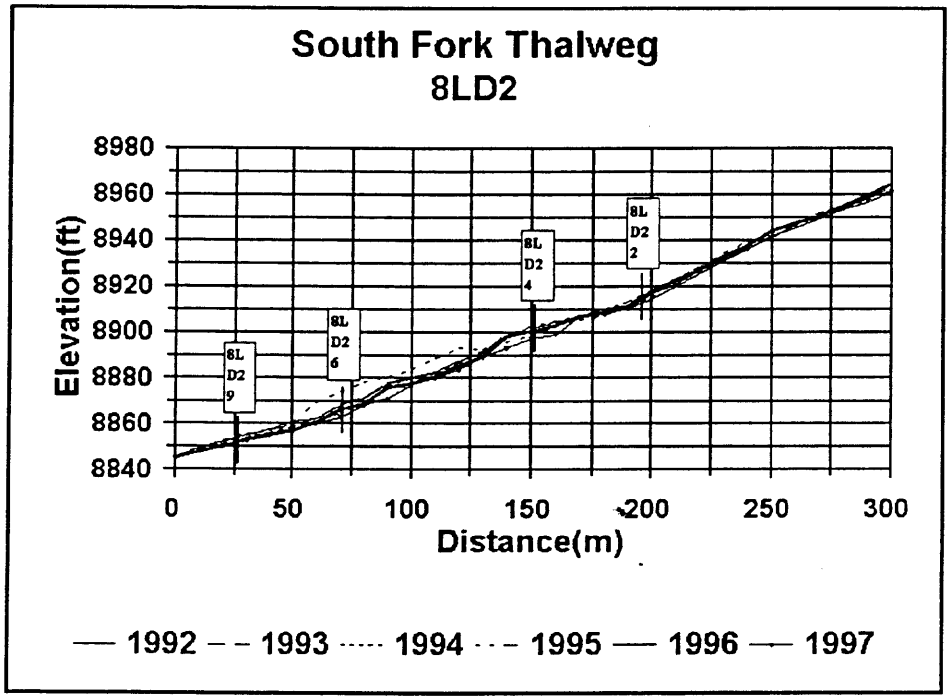


Figure 73. Longitudinal channel profile of the panel 7L and panel 8L portions of the South Fork of Burnout Creek, 1992-1997.

Longitudinal Channel Profile Conclusions:

Overall, channel profile surveys with the techniques used have not been very useful for interpreting impacts related to specific regions of subsidence in this study area. More careful and detailed measurements will be needed for such data to be of use in interpreting subsidence impacts.

Effect of Flood Routing on Potential Channel Erosion/Sedimentation

We evaluated possible impacts of changes in channel shape and localized longitudinal gradient due to subsidence, grazing, or natural geomorphic processes on the potential for future channel erosion and sedimentation within Burnout Creek. The procedure involved an estimation of channel runoff for each of the first three years (1992, 1993, and 1994) assuming a design flow; survey years 1995 and 1996 were not used in this analysis. The design flow is based on a 6-hour storm that produces a total precipitation excess of 1.02 inches. Runoff is generated using the SCS method and channel flow is routed by the Muskingum method. The drainage basin is partitioned into 5 sub-drainages to focus on discrete components that have been impacted by mining. A schematic of Burnout Canyon basin with the sub-drainages and channel segments used in the calculations for routing design peak flows is given in Figure 74. Areas of the sub-drainages range from 92.1 to 223.1 acres. Average sideslope gradients used in the SCS runoff prediction method ranged from 22 to 28% in the various sub-drainages and an average curve number of 60 was used throughout. Calculated design peakflows ranged from 0.88 m^3/s in the uppermost sub-drainage to 3.80 m^3/s in the lower portion of the study reach. These values seem to represent a moderate to extreme instantaneous peak flow for this watershed based on channel morphology.

For each of the 73 documented cross-sections in Burnout Creek, a flow depth is calculated in 1992,1993, and 1994 for the design storm. This calculation involves a discharge value derived from the runoff analysis, an assumption for Manning's roughness coefficient (n=0.04-0.05 for natural stream channels), channel gradient obtained from the localized longitudinal profile (just above and below each measured cross-section), and the shape of each cross section. The channel cross-section was surveyed each year and changes related to subsidence, grazing, or natural geomorphic processes are reflected in the flow depth calculations. We rearrange Manning's equation and iteratively input different water depths to minimize f_x as follows:

$$f_x = Q - 1/n\ A\ R^{2/3}\ S^{1/2}$$

where, Q is the discharge, R is the hydraulic radius defined as channel cross sectional area (inundated by water) divided by the wetted perimeter (R = A/P), S is the channel gradient, n is

Manning's coefficient, and f_x approaches zero value when the desired depth is obtained. This calculation is repeated for all cross sections in Burnout Creek to address any downstream effects of the morphometric changes occurring in the upper reaches of the drainage. Values of both wetted perimeter (P) and R are then calculated and compared for all three years throughout the drainage since these both relate to the potential for channel erosion and subsequent sedimentation at high flows.

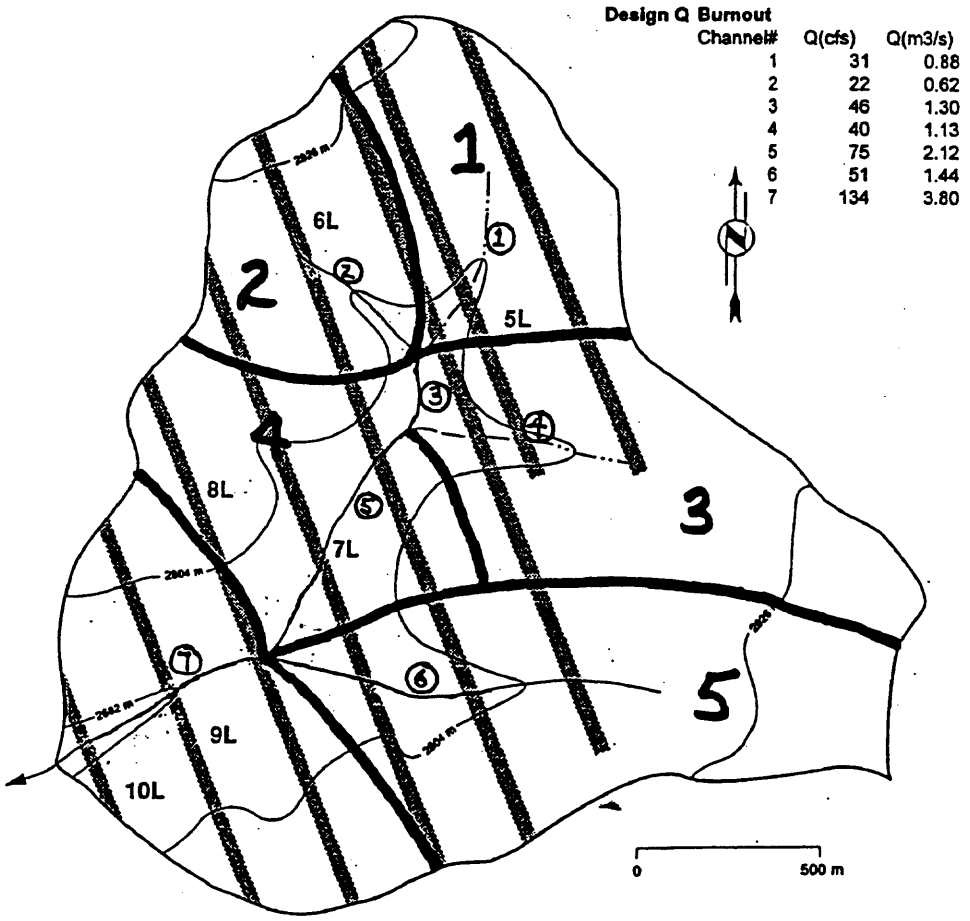


Figure 74. Sub-drainage and channel segments in Burnout Canyon used in peak flow routing.

For the most part, channels are somewhat armored on the bottom, but virtually unarmored and poorly vegetated along the channel sides (at heights that would be inundated by stormflows). Thus, channel erosion potential could be viewed to be directly proportional to the wetted perimeter of the channel (P) exposed to a given stormflow. On the other hand, P is inversely proportional to average shear stress along the channel bed (τ_0) described by :

$$\tau_0 = \gamma RS$$

where γ is the specific weight of water, R is the hydraulic radius (R = A/P), and S can be approximated by the channel gradient. Thus, as wetter perimeter (P) decreases, the channel becomes more "efficient" in routing water and the shear stress (which causes bed sediment transport) increases. Conversely, hydraulic radius is directly proportional to shear stress along the channel bottom. Several factors can influence the value of R: (1) the basic geometric shape of the channel and (2) the overall "smoothness" of the channel profile. These factors are, of course, also determinants of P. For example, given the same bankfull width, the wetted perimeter (P) of rectangular channel is 1.137 times that of a semi-circular channel and P of a triangular channel is 1.287 times that of a semi-circular channel. In the interpretation of our results, we should be aware that an increase in P could be interpreted as an increase in the potential for the streambanks to erode and a likely increase in suspended sediments transport due to the high silt content of the soils. This is especially true in the upper channel where streambanks are largely unvegetated, partly due to grazing pressure. However, a decrease in P would result in increased shear stress at high flows along the channel bottom and would increase the potential for channel downcutting and bedload sediment transport.

In the mining-impacted portion of main channel of Burnout Creek, only the reach overlying panel 6L was surveyed for cross-sectional changes. Two sets of cross-sections (6L-B1 with 8 cross-sections and 6L-B2 with 10 cross-sections) were located in this reach from about 1700 m to 2450 m upstream. Only a few significant changes in P values were found between 1992 and 1993 when the majority of the subsidence occurred (Figure 75). Percentage change in P values less than about 5-10% are not considered to be very significant because of the potential for cross-section measurement discrepancy from year to year. All of the three cross-sections which had changes in P values in excess of 10% between 1992 and 1993 were in the upper reach of 6L-

B1, which experienced the most subsidence (4.0 to 4.5 feet) along the main channel. One of the cross-sections was in the zone of maximum tension and the other two were in the zone of maximum subsidence from 2210 to 2230 m. Examples of changes in channel geometry that generate these changes in P are shown in Figure 76. Only one cross-section in this impacted reach (6L-B1) experienced a >+10% change in P during this same period. Additional channel adjustment occurred between 1993 to 1994 in the 1700 to 2400 m reach. By 1994 there was greater evidence of decreases in P in this upper reach (6L-B1) compared with trends in the lower portion of the reach (6L-B2) (Figure 77). Of the 18 surveyed cross-sections in the upper reach, 6 had P declines in excess of 10% and all but 3 cross-sections experienced some decrease in P from 1992 to 1994 (Figure 76). Both subsidence and tension cross-sections exhibited these decreases. Differences in percentage change in P between the 18 cross-sections in panel 6L and the 30 cross-sections downstream (panels 8L, 9L, and 10L) were statistical tested ($\alpha = 0.05$) for 1992-93, 1993-94, and 1992-94 survey data. In all cases, mean change in %P was greater in panel 6L than in the lower portion of the channel, however, this difference was significant for the 1993-94 and 1992-94 data; not for the 1992-93 data because of the high variability in this post-subsidence data set.

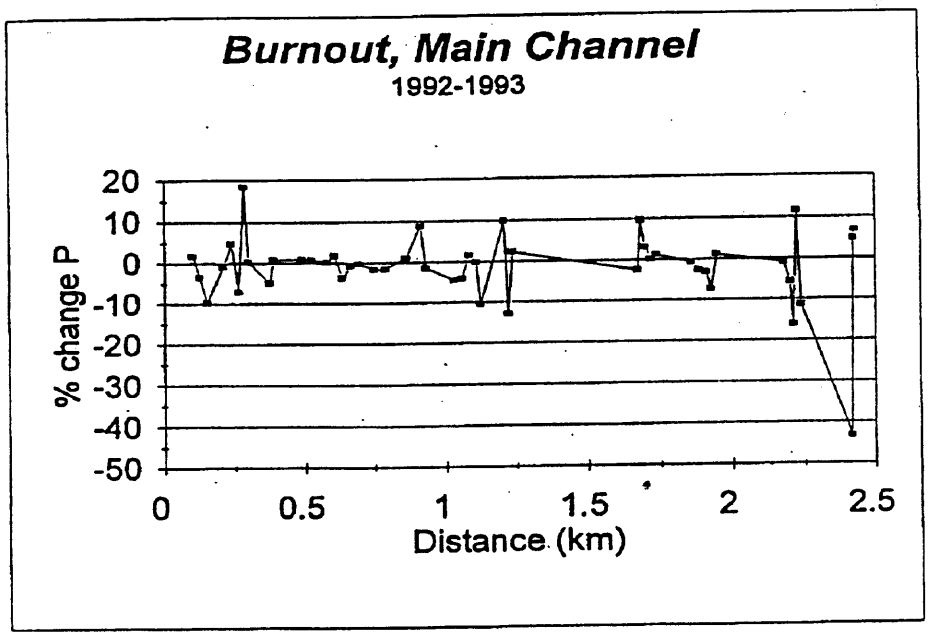


Figure 75. Percent change in wetted perimeter from 1992 to 1993 along the Main Channel of Burnout Creek.

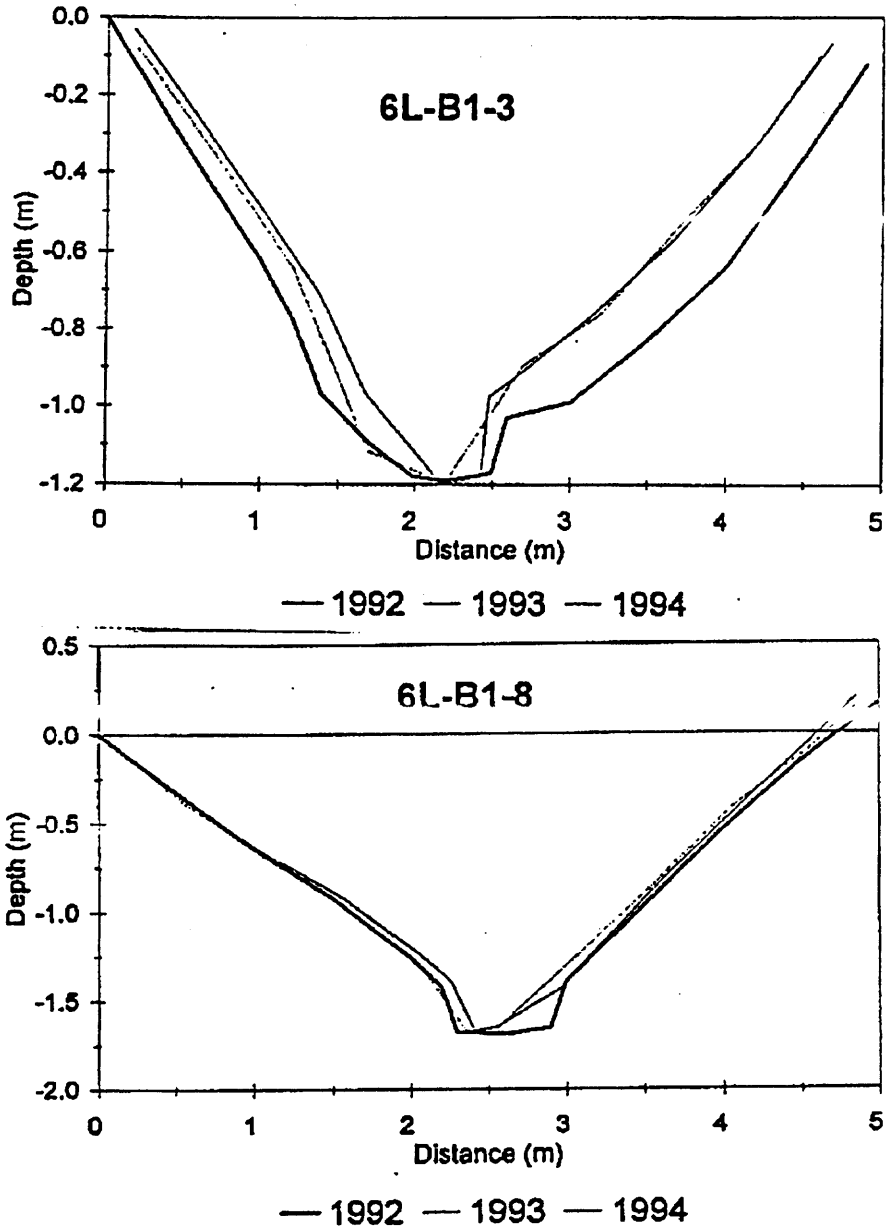


Figure 76. Examples of increases in hydraulic radius (R) and decreases in wetted perimeter (P) with time at cross-sections 6L-B1-3 and 8.

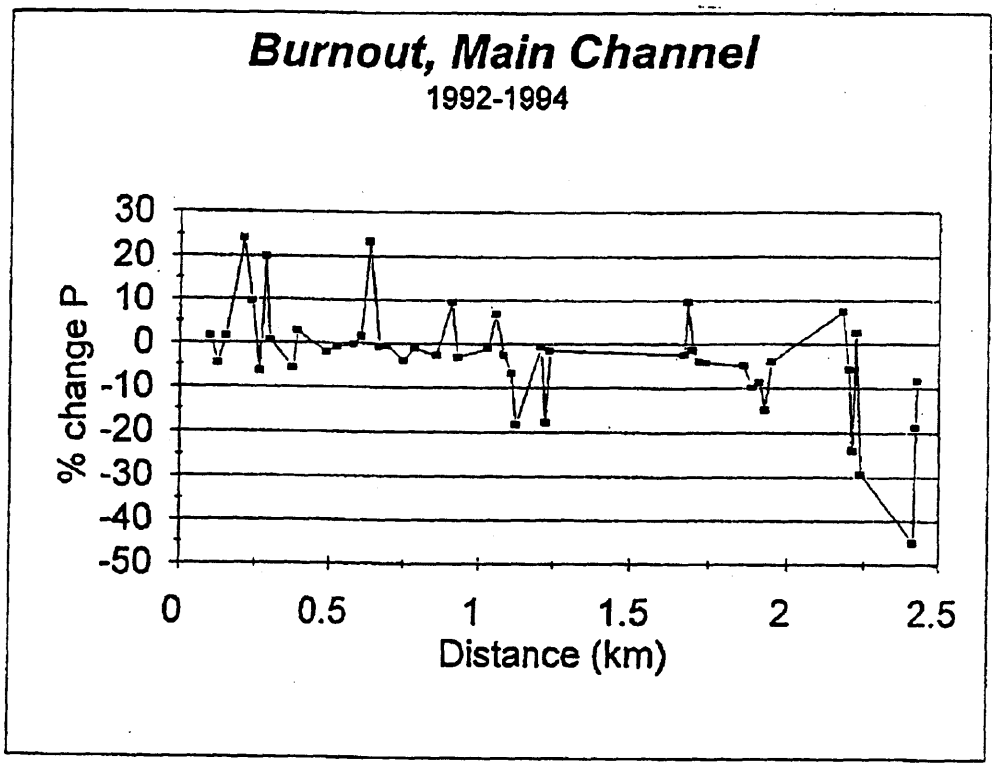


Figure 77. Percent change in wetted perimeter from 1992 and 1994 along the Main Channel of Burnout Creek.

As anticipated, changes in R followed somewhat of an opposite pattern as those for P. From 1992 to 1993, a few scattered increases in R were noted in the impacted (1700 to 2450 m) reach (Figure 78). The mean change in R from 1992 to 1993 was not significantly different between the 18 cross-sections above panel 6L (2.46%) and the 30 cross-sections in the lower portion of the channel (1.78%). Between 1992 and 1994 more increases in R were noted in this reach, but not quite to the extent as those calculated for P (Figure 79). The mean change in R from 1993 to 1994 was significantly different between the cross-sections above panel 6L (4.28%) and those in the lower reaches (1.11%). Examples of increases in R with time are shown for two cross-sections in Figure 76. Given the downstream variability in R changes from year to year, the trend of increase R in the upstream reach is not as notable as the respective temporal change in calculated P.

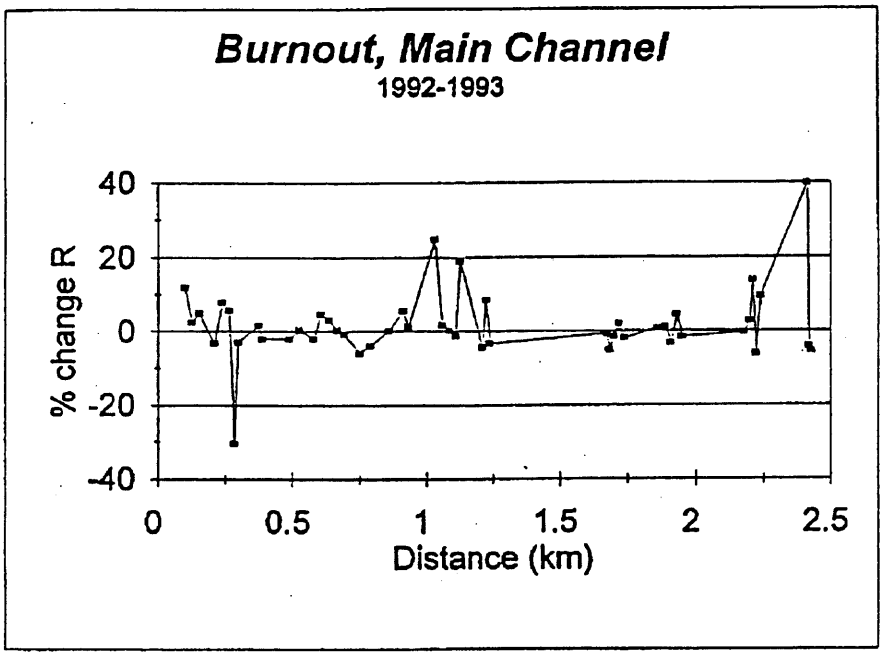


Figure 78. Percent change in hydraulic radius from 1992 to 1993 along the Main Channel of Burnout Creek.

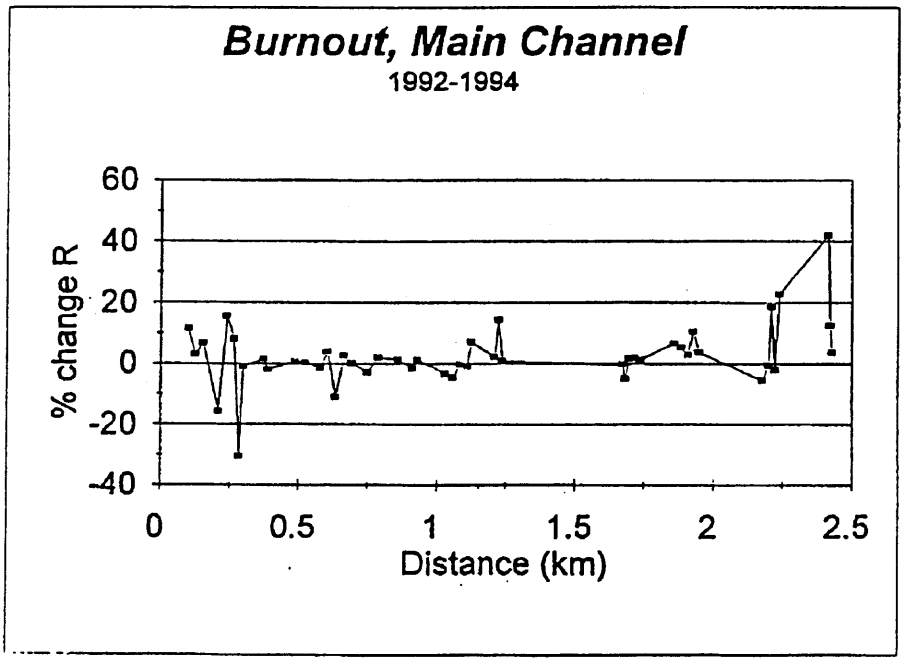


Figure 79. Percent change in hydraulic radius from 1992 to 1994 along the Main Channel of Burnout Creek.

Changes in hydraulic characteristic of the South Fork channel in the vicinity of panel 7L (cross-sections located between 290 and 450 m) were less apparent than changes above panel 6L in the main reach of Burnout Creek. None of the yearly comparisons (1992-93, 1993-94, or 1992-94) showed significant differences in percent change in P or R between the impacted and non-impacted reaches of the South Fork. Since mining occurred in panel 7L in late 1993 and early 1994, changes between the 1993 and 1994 cross-section surveys and flood routing simulations should provide insights into any mining-related changes. Eight of 10 cross-sections above panel 7L experienced decreases in wetted perimeter (P) between 1993 and 1994. Unlike in the main channel (above panel 6L), these decreases were generally very small (only 2 of the profiles exceeded 10%, Figure 80). In addition, 8 of the 10 cross-sections above panel 8L (not mined) experienced decreases in P during this same period (Figure 79). Hydraulic radius (R) increased slightly during the 1993 to 1994 period for most cross-sections, although only one of these increases was greater than 5% (Figure 81). The apparent increase in R in the upper reach of the South Fork between 1993 and 1994 was in the range of variability in R values calculated in the lower portion of the reach, thus the changes cannot be directly attributed to subsidence.

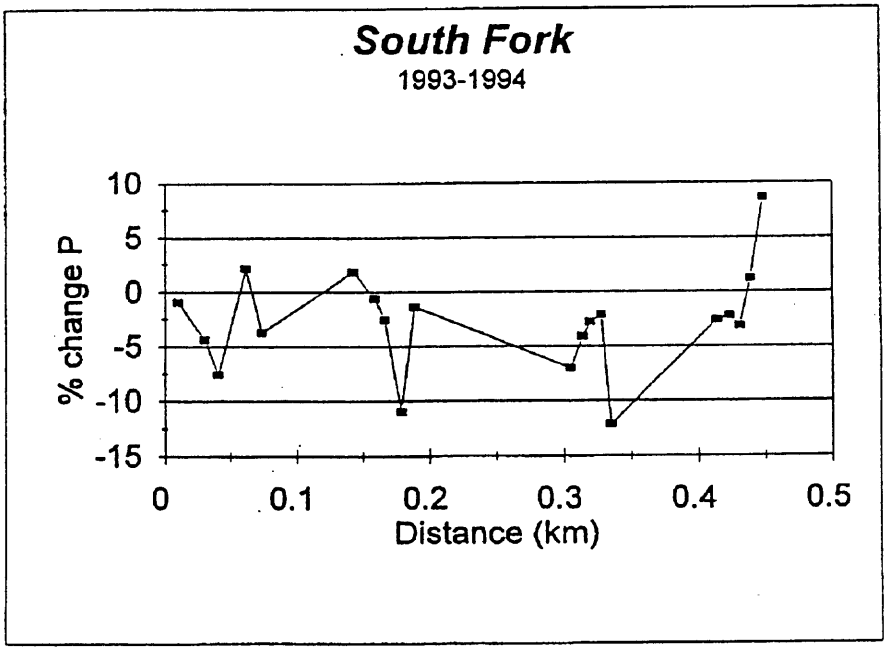


Figure 80. Percent change in wetted perimeter in the South Fork, 1993-1994.

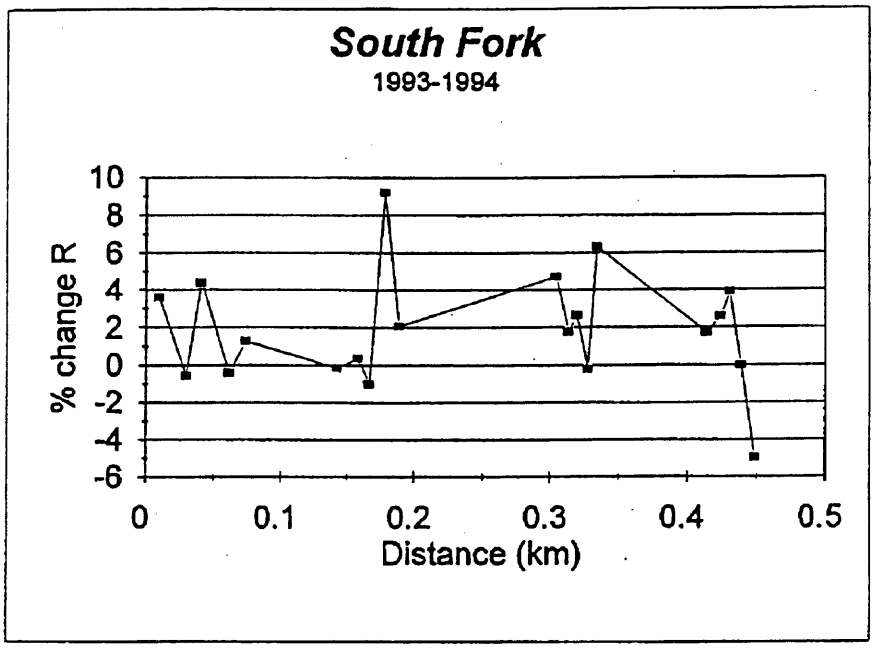


Figure 81. Percent change in hydraulic radius in the South Fork, 1993-1994.

Flood Routing Conclusions:

The overall findings of this hypothetical flood routing study in the main channel of Burnout Creek show that possibly channel bottom scour (and thus bedload sediment) would increase immediately following mining because of localized channel adjustments. This potential for increase in scour appears to be concentrated in the upper reaches (above 1990 m) and does not extend into any of the lower portions of the drainage where fish habitat is important. On the other hand, the significant decreases in P measured in numerous crossections in the 1700 to 2450 m reach indicate that bank erosion in this upper portion of the drainage may actually be less during peak flows. This would potentially result in decrease suspended sediment during peak flows. Since suspended sediment is transported much greater distances compared with bedload sediment, the relative impacts of these potential reductions would be experienced at very different spatial scales: i.e., increased bedload transport would likely have a localized impact (e.g., scouring and subsequent localized deposition) and decreased suspended sediment transport would reduce

sediment loads into receiving water bodies (i.e., Upper Huntington Creek and Electric Lake). In the next section we discuss the spatial and temporal distribution of bed sediment in pools throughout Burnout Creek and the relationship of sediment distribution to our hypothetical hydraulic calculations.

It should also be stated that these hydraulic calculations and subsequent inferences are strongly dependant on cross section results. If cross sections are in error then these inferences will also be in error.

Sediment Characteristics of Pools

Sediment characteristics in dynamic equilibrium environments throughout Burnout Creek and the James Canyon control were evaluated by sampling and analyzing bottom sediments from every pool in the system during 1992, 1993, 1994, 1995, 1996, and 1997. Samples were collected from the middle of each pool using a small scoop. They were then dried and sieved to characterize sediment size classes. Changes in composition of sediments in pools should reflect erosion and sediment transport processes in the near vicinity or from upstream. Prolonged increases in fine sediment composition of pool bottoms are known to be detrimental to fish habitat (Phillips et al., 1975).

James Canyon:

Median particle size (D_{50}) in James Canyon pools ranged from a low of ~ 4.5 mm in 1992 to a high of ~ 17 mm in 1994, or approximately a four-fold difference over the 6-year period (Figure 82). The variation among pools of this median particle size is shown in Figure 83 for both 1994 and 1997. Median particle size ranged from < 0.1 to ~ 60.0 between pools. These data show the extreme natural variation that occurs in particle size both between years and also between pools distributed along the stream channel.

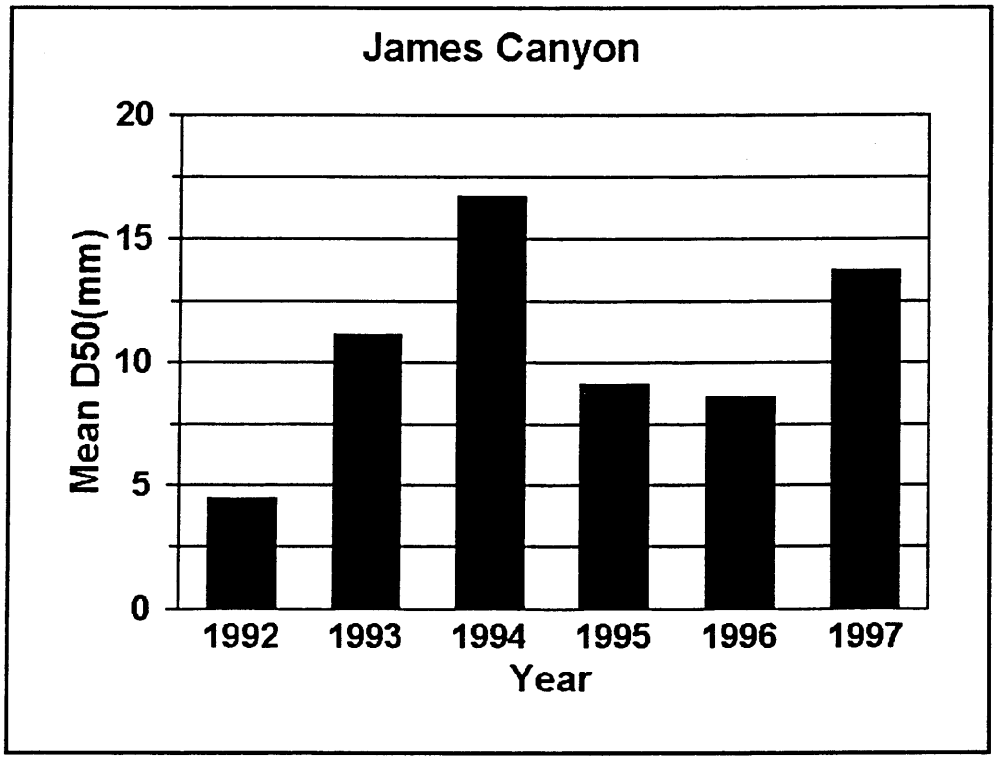
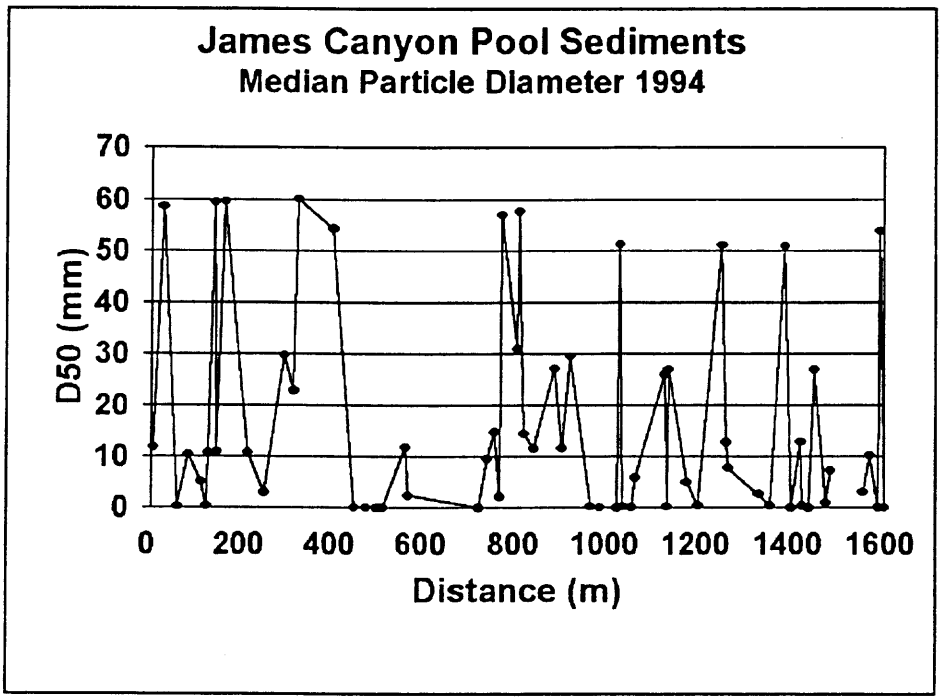


Figure 82. Changes over the study period in median particle diameter (D_{50}) of pool sediments in James Canyon, 1992-1997.



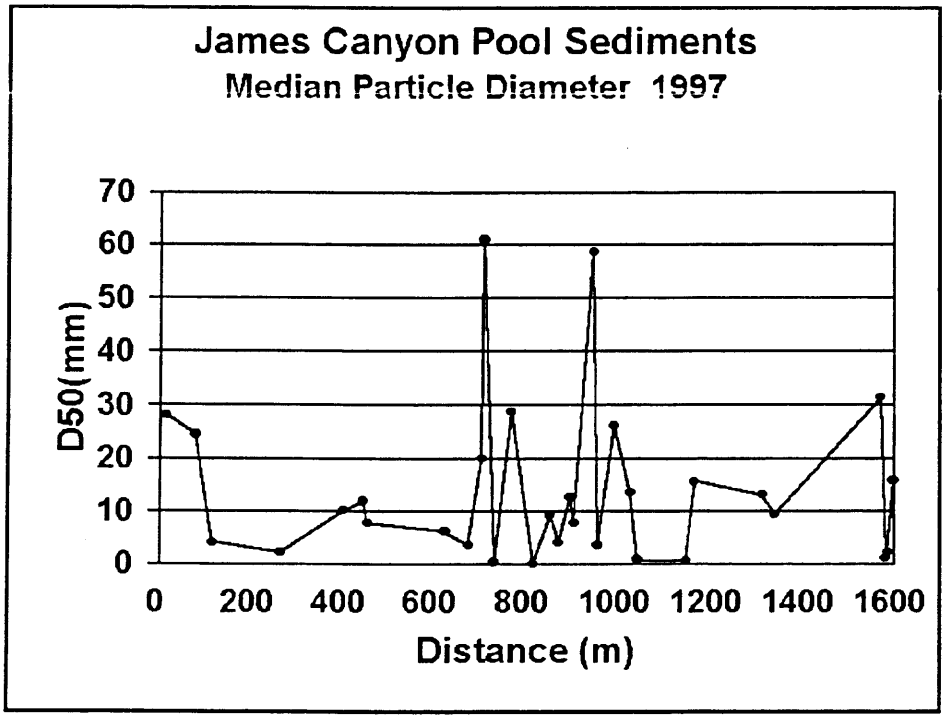


Figure 83. Distribution of median particle diameter (D_{50}) of pool sediments along the channel of James Canyon in 1994 and in 1997.

The fine sediments so detrimental to fish habitat ranged from a high of ~ 72% in 1992 to a low of ~ 34% in 1997 (Figure 84), or a two-fold difference attributable to normal variation. The variation in fine sediments among James Canyon's pools varied between < 1% to > 80% in both 1994 and 1997 (Figure 85).

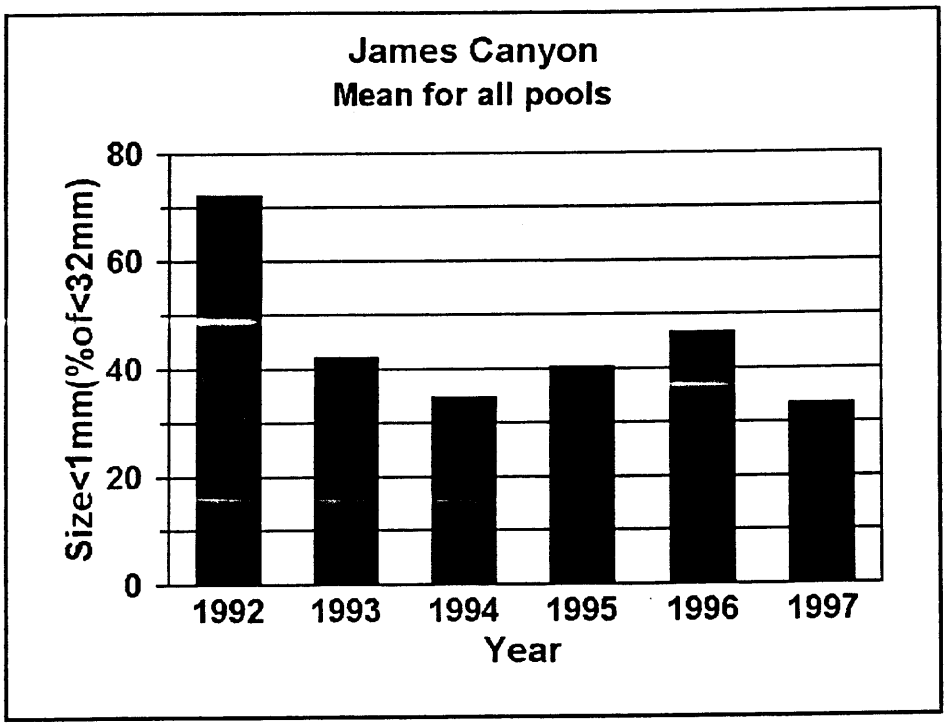
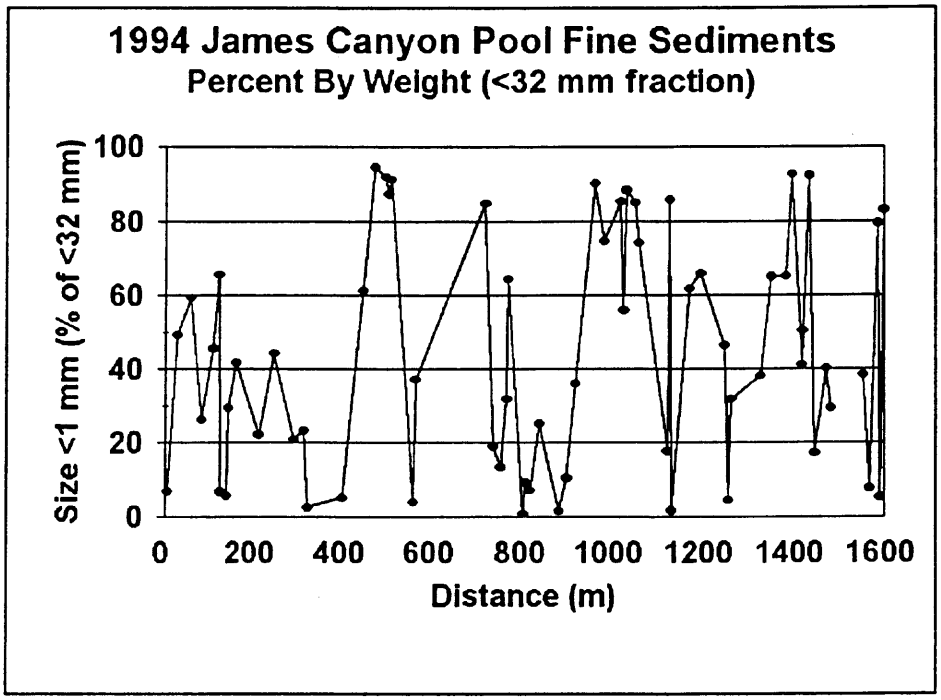


Figure 84. Changes over the study period in pool fine sediments (< 1 mm size) in James Canyon, 1992-1997.



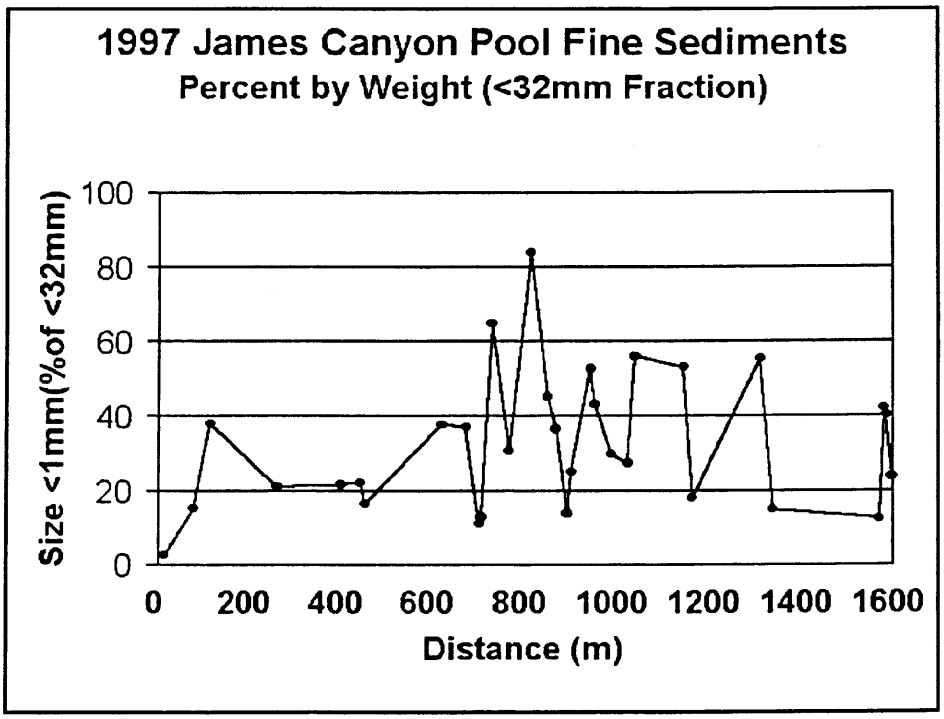


Figure 85. Distribution of fine sediments in pools along the channel of James Canyon in 1994 and in 1997.

Burnout Creek:

Two reaches of Burnout Creek were analyzed for changes in sediment composition: the Main Channel and the South Fork. The yearly variation in median particle size in the Main Channel (Figure 86), ranging between ~ 9 mm in 1993 to ~21 mm in 1997, was slightly less than that in the James Canyon control. The variation in mean particle size among pools was about the same in both the Main Channel (Figure 87) and in James. The fine sediments < 1.0 mm in size decreased in the Main Channel from a high in 1992 of ~ 54% to a low in 1995 of ~30% (Figure 88), a pattern of change similar to that in James Canyon. The variation of fine sediments among pools in 1994 and 1997 is shown in Figure 89.

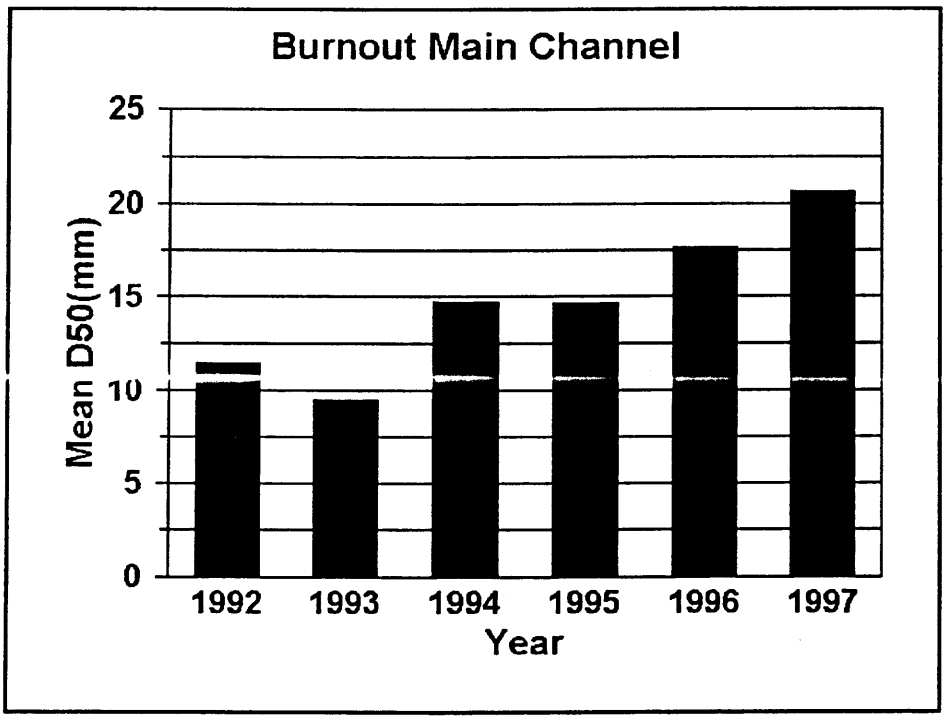
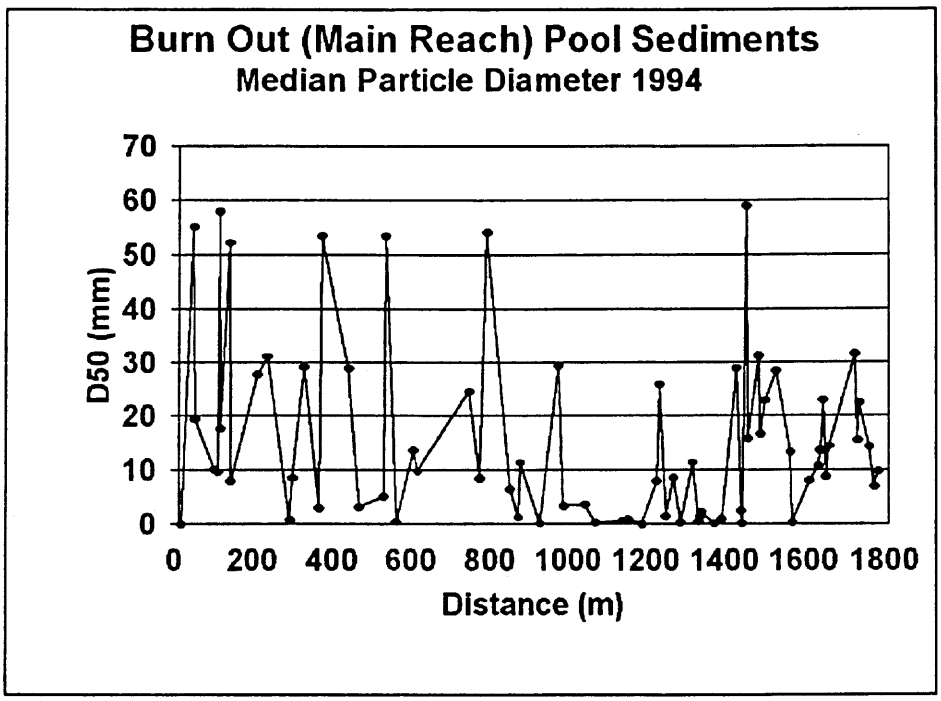


Figure 86. Changes over the study period in median particle diameter (D_{50}) of pool sediments in the Main Channel of Burnout Creek, 1992-1997.



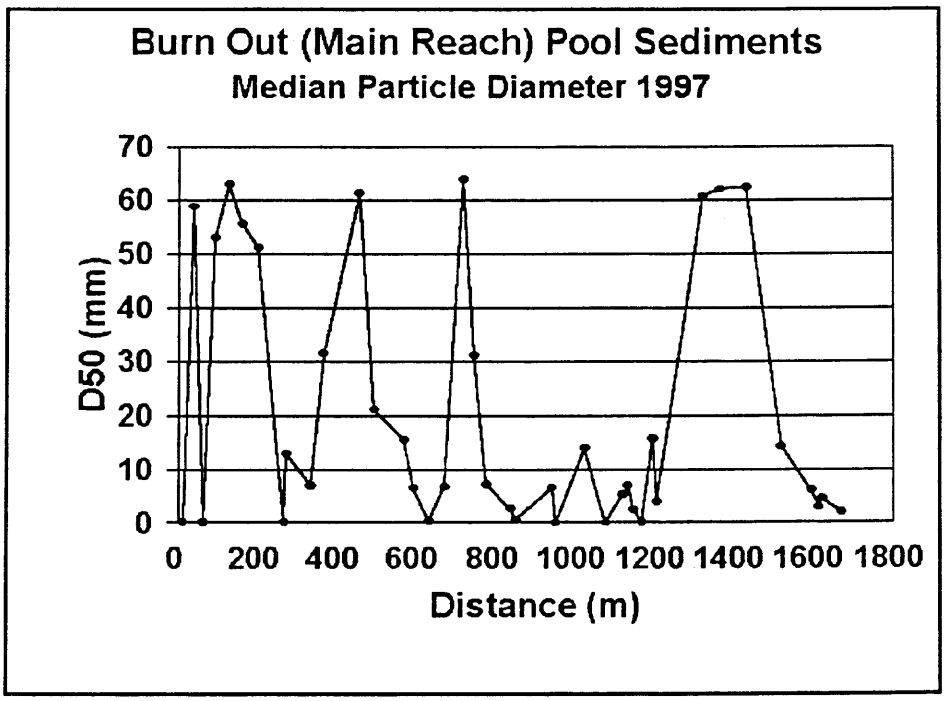


Figure 87. Distribution of median particle diameter (D_{50}) of pool sediments along the Main Channel of Burnout Creek in 1994 and in 1997.

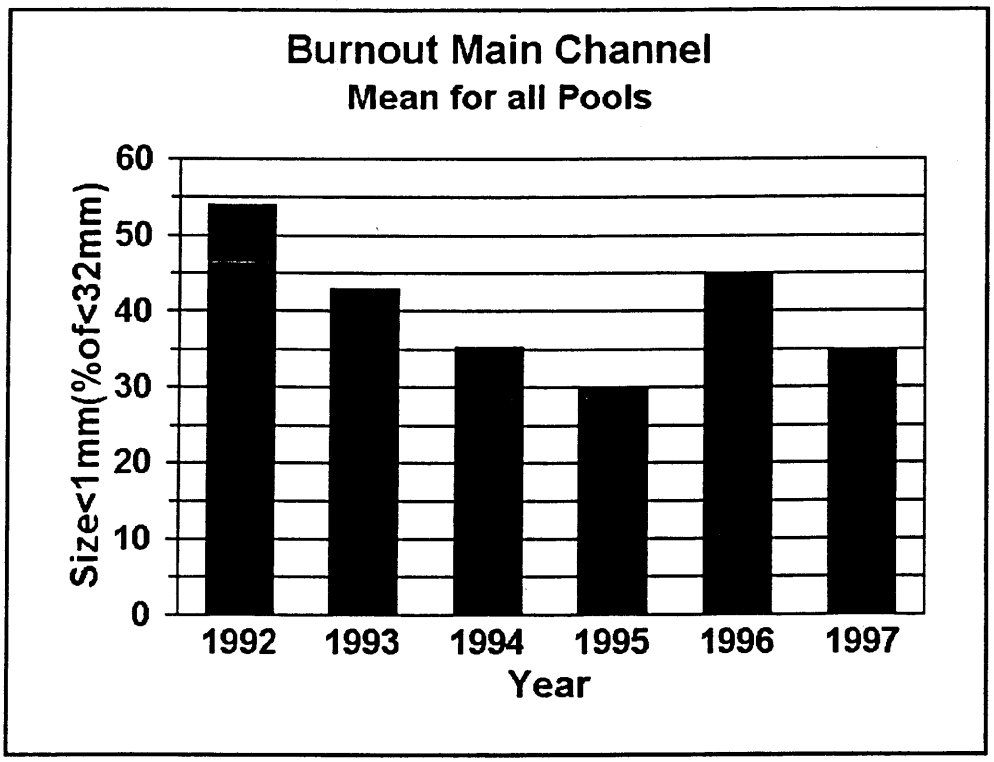
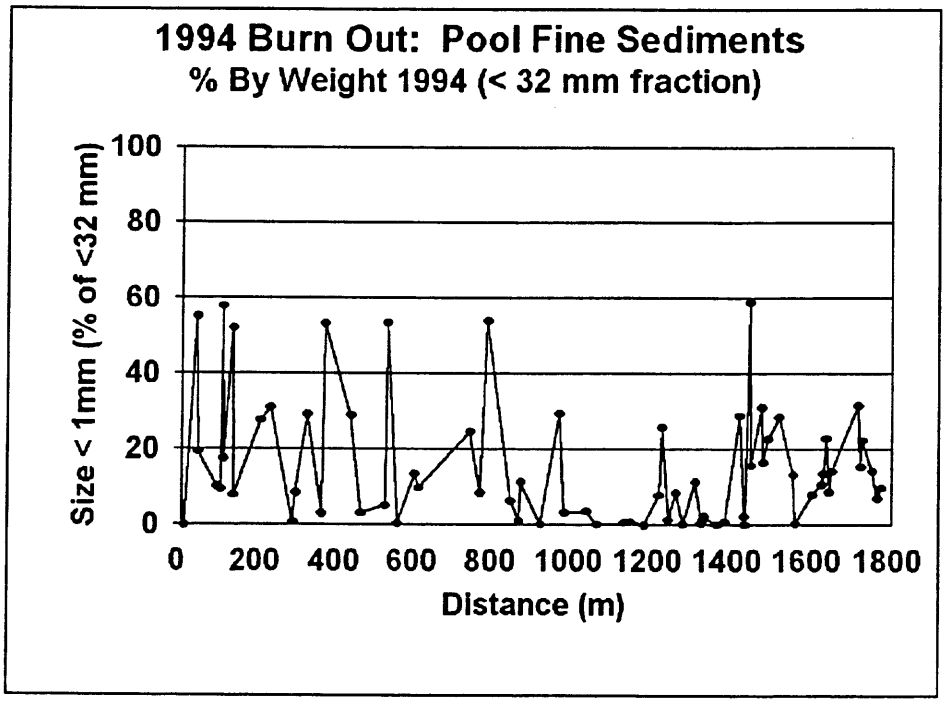


Figure 88. Changes over the study period in pool fine sediments (< 1 mm size) in the Main Channel of Burnout Creek, 1992-1997.



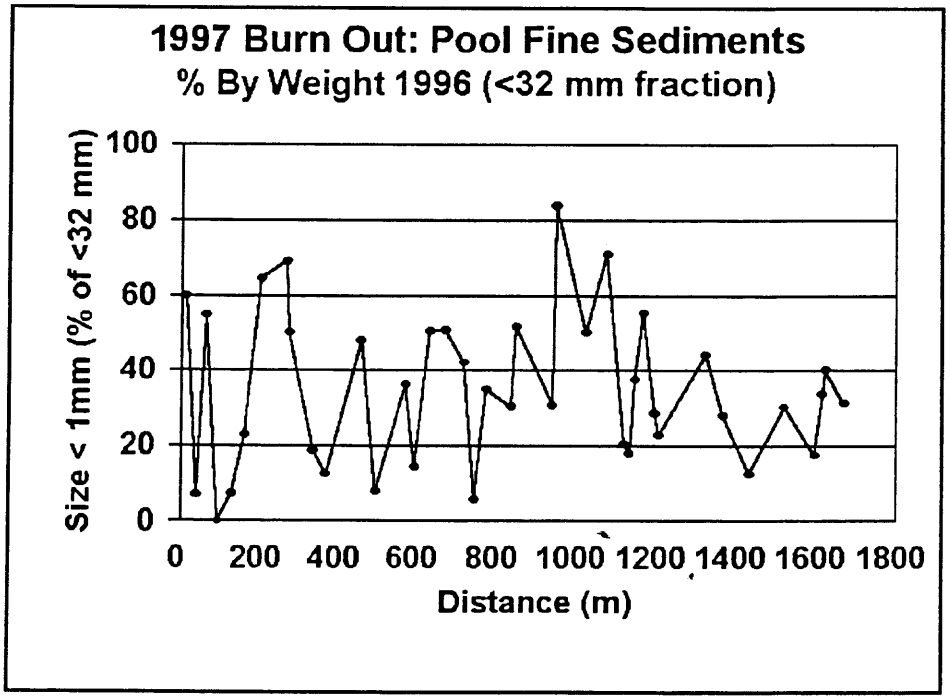


Figure 89. Distribution of of fine sediments in pools along the Main Channel of Burnout Creek in 1994 and in 1997.

Changes between years in the mean particle size in the South Fork did not match what occurred in the Main Channel. The largest median particle size occurred in 1994 with 1996 being almost as large but then decreased again in 1997 (Figure 90). Differences in median particle size among pools in the South Fork was considerably less in 1997 than in 1994 (Figure 91). Differences between years in fine sediments (Figure 92) showed a somewhat similar pattern as in the Main Channel of Burnout and in James. The highest proportion of fine sediments occurred in 1992, and the lowest in 1994. The variation of fine sediments among pools in the South Fork is shown in Figure 93.

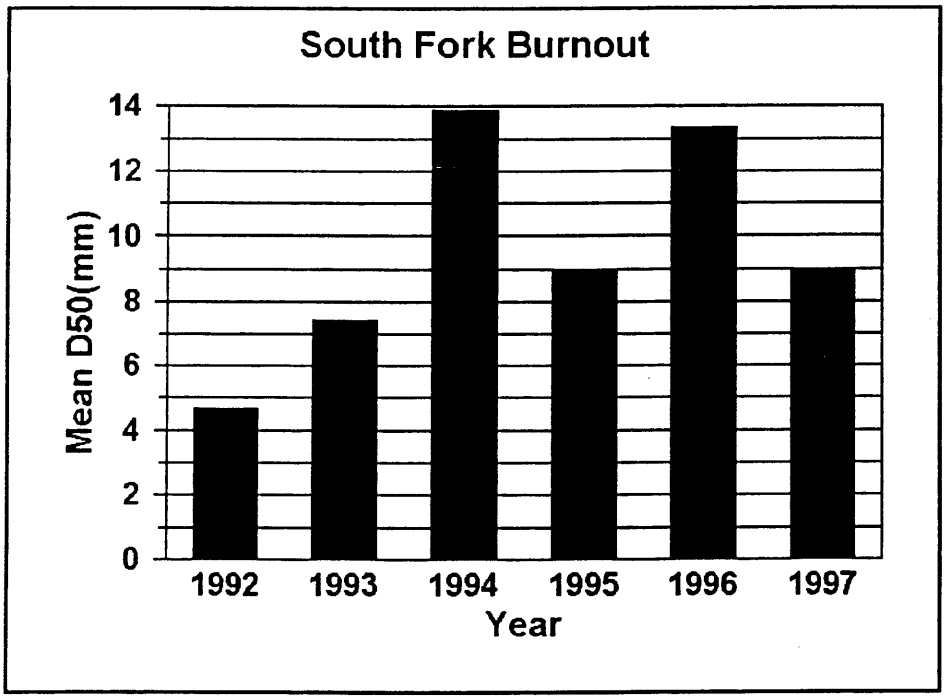
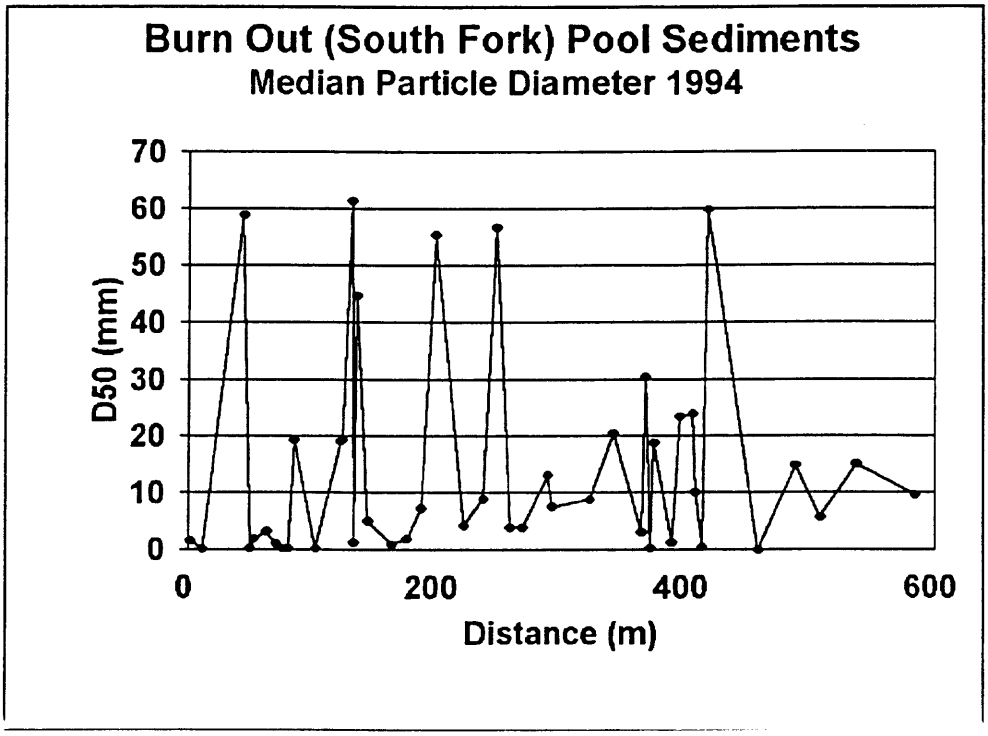


Figure 90. Changes over the study period in median particle diameter (D_{50}) of pool sediments in the South Fork of Burnout Creek, 1992-1997.



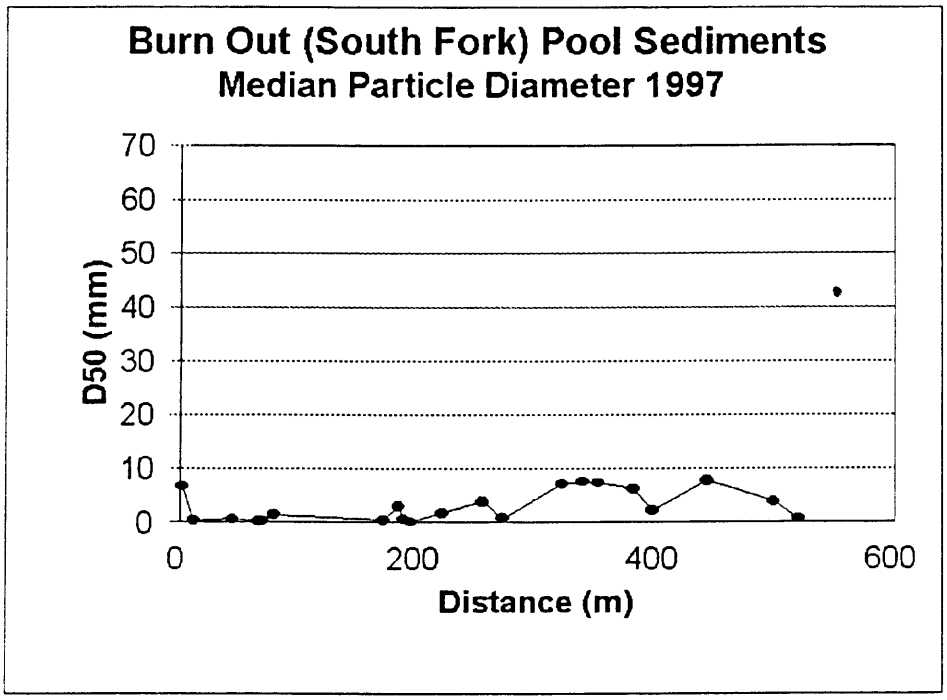


Figure 91. Distribution of median particle diameter (D_{50}) of pool sediments along the South Fork of Burnout Creek in 1994 and in 1997.

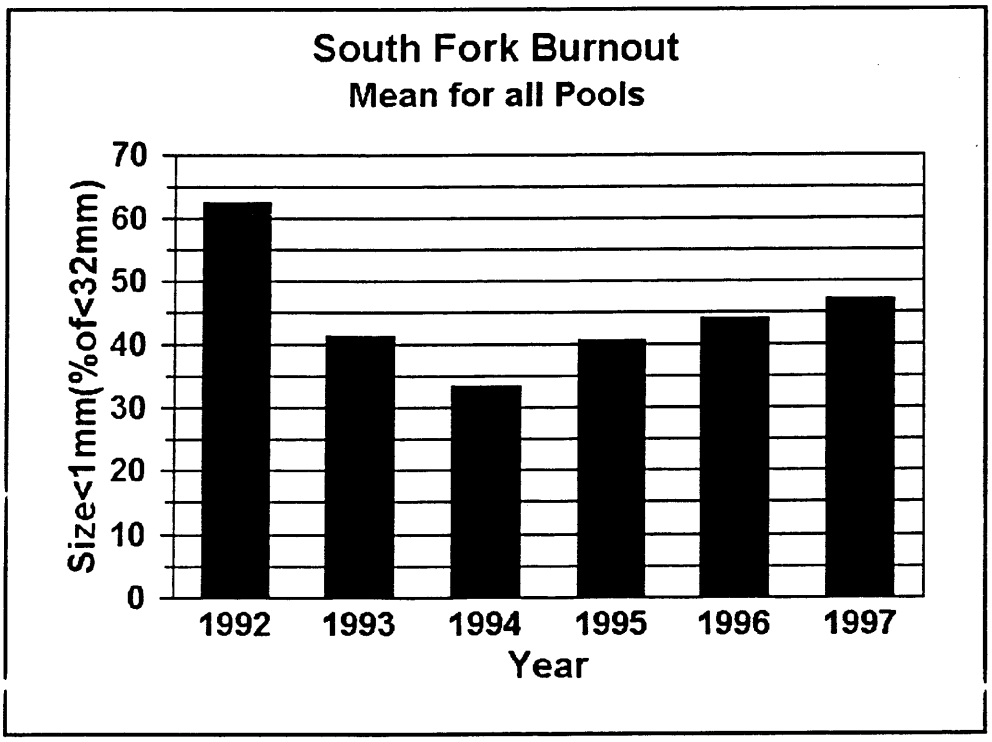
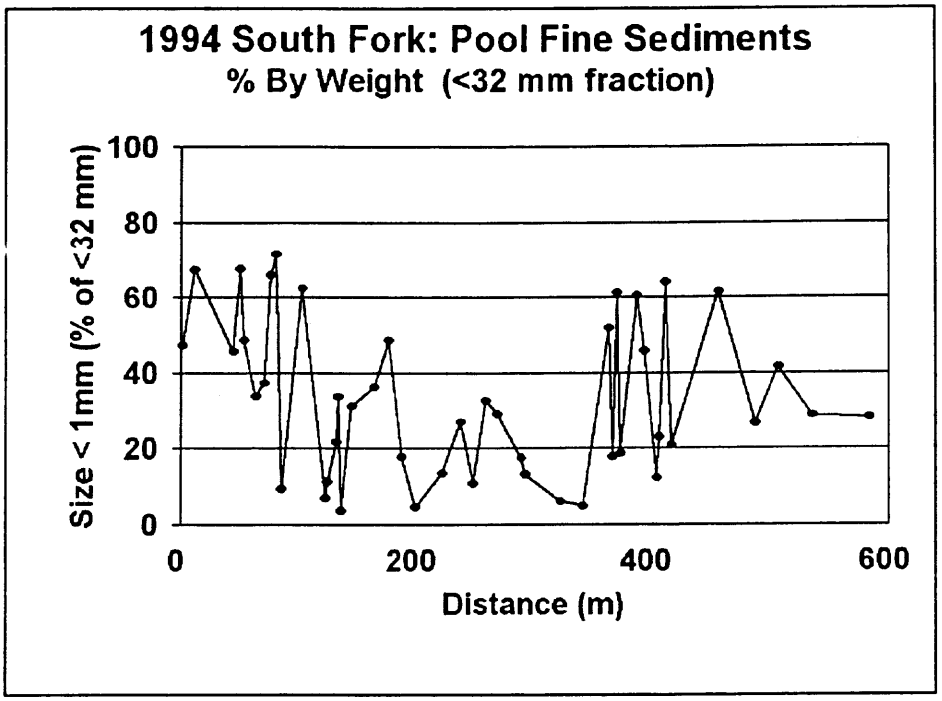


Figure 92. Changes over the study period in pool fine sediments (< 1 mm size) in the South Fork of Burnout Creek, 1992-1997.



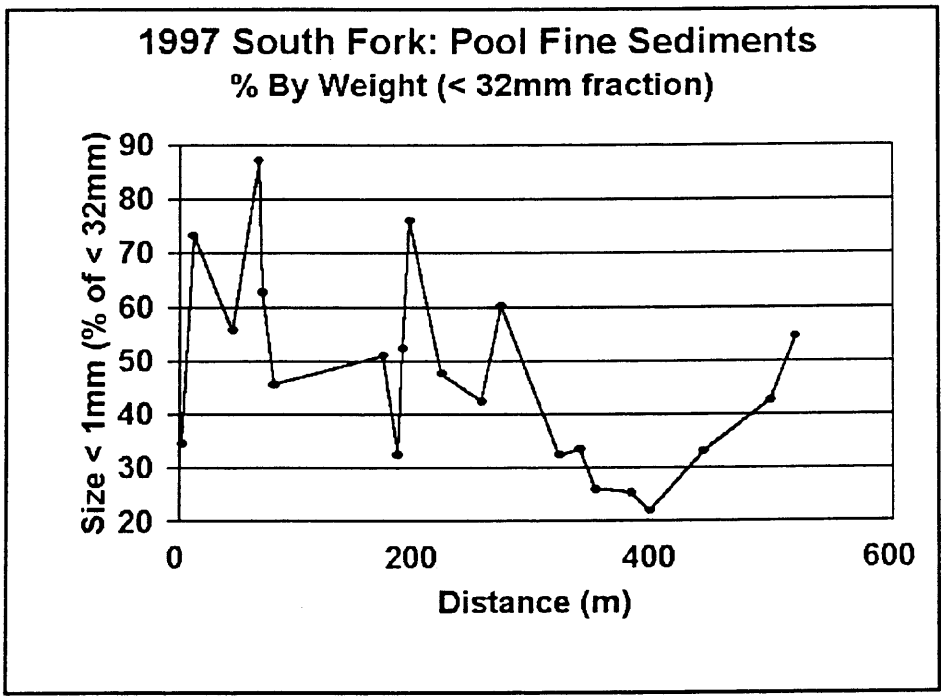


Figure 93. Distribution of fine sediments in pools along the South Fork of Burnout Creek in 1994 and in 1997.

Sediment Characteristics Conclusions:

Although the two-fold variation between years in mean particle size (D_{50}) in the Main Channel and three-fold variation in the South Fork of Burnout Creek did not exceed that experienced in the James Canyon control area, the pattern of changes differed (Figures 82, 86, and 90). Mean particle size tended to increase progressively from initial lows in the early years to higher levels especially in the later years. The highest level in James Canyon was in 1994, but then decreased by ~1/2 in 1995 and 1996, but increased again in 1997. This suggests that subsidence may have resulted in an increase in the mean particle size.

The two-fold variation between years in percentage of fine sediments in Burnout did not exceed that in James Canyon. The pattern of change between years was the same in both drainages (Figures 84, 88, and 92). This suggests that subsidence had no detectable effect on the proportion of fines <1 mm in size in the mined drainage.

Riparian Survey

Two types of vegetation surveys were conducted in 1992 in both the upper and lower reaches of Burnout and James Creeks. The upper and lower riparian survey sites in Burnout Canyon are located in the middle of panels 9L and 10L, respectively. The upper and lower riparian reaches in James Canyon are located just downstream of cross-section group Y and just upstream of cross-section group Z, respectively. At each site, seven cross-sections were established perpendicular to the riparian complex so that the entire riparian area was traversed (Figure 94). Both ends of each transect were marked and photographed for future reference. A tape measure was stretched across each transect and spatial changes in riparian community types were documented. Riparian transect varied in length from 6.5 to 33 m depending on topography and drainage position. In general, riparian transect in the upper reaches were shorter than those in the lower reaches. A total of 15 riparian community types were identified in the four areas and common names are included in Table 7. Community designations closely followed those given by Padgett et al. (1989). **Because composition of riparian communities would be slow to respond to hydrologic or geomorphic alterations due to subsidence, these survey are**

intended to serve as benchmarks for future evaluation with re-measurements that may be appropriate if community change becomes suspect.

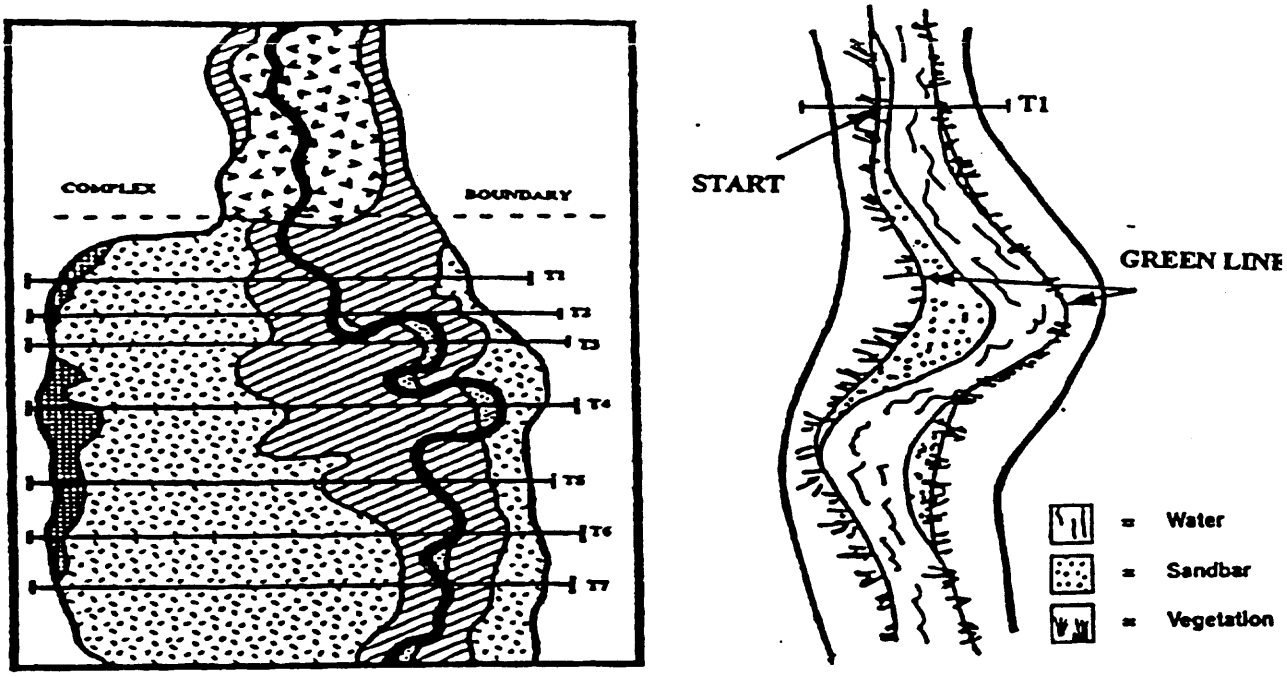


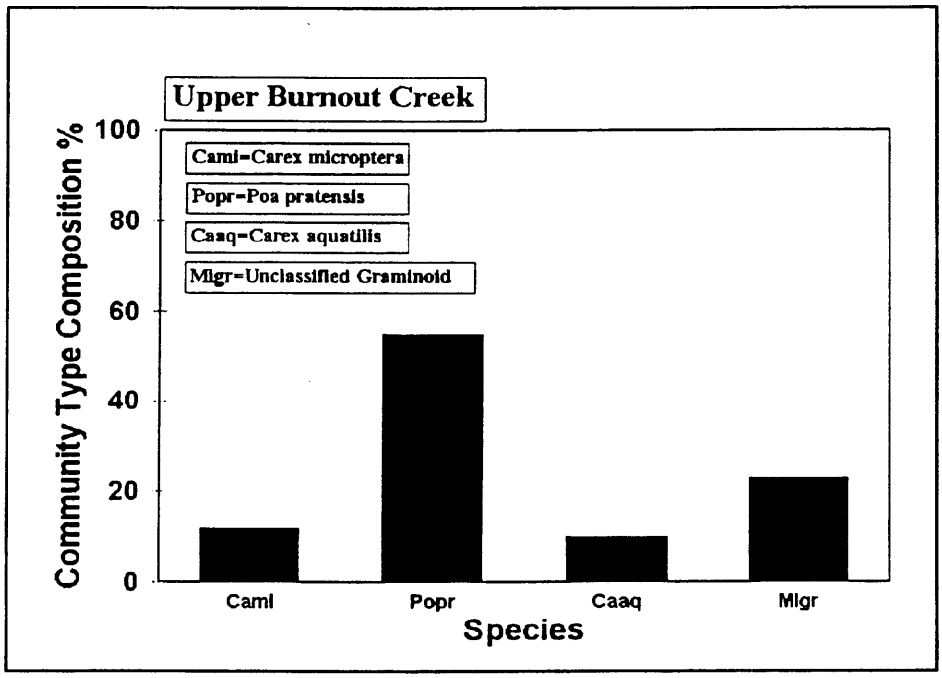
Figure 94. Example of vegetation transects and greeline survey at each riparian complex.

Riparian transects selected in the lower reach of Burnout Creek were dominated by four community types (Figure 95) -- *Carex microptera* (37%), *Artemisia cana*/unclassified graminoid (22%), *Artemisia cana/Poa pratensis* (17%), and *Poa pratensis* (15%). The riparian reach in the lower portion of James Creek was dominated (50%) by *Juncus balticus* (Figure 96), only a minor component of the vegetation complex in the lower Burnout Creek riparian reach. The other two most abundant vegetation community types in lower James Creek were *Artemisia cana*/unclassified graminoid (24%) and *Artemisia cana/Poa pratensis* (12%). The riparian reach in upper Burnout Creek had only four vegetation community types: *Poa pratensis* (55%), unclassified graminoid dominated (23%), *Carex microptera* (12%), and *Carex aquatilis* (10%) (Figure 95). *Poa pratensis* also dominated (55%) the riparian transects in upper James Creek. The other three community types were present, but were less abundant (Figure 96). Several other community types were also present, including *Deschampsia caespitosa* (11%).

Table 7. Scientific and common names of vegetation found in riparian areas.

	Latin Name	Common Name
Species encountered in veg. community types.	*Artemisia cana*	silver sage
	Carex aquatiles	water sedge
	Carex microptera	smallwing sedge
	Deschampsia caespitosa	tufted hairgrass
	Juncua balticus	Baltic rush
	Poa pratensis	Kentucky bluegrass
	Potentilla fruticosa	bush cinquefoil
	Other Groups of Species	
	Unclassified conifer	mixed conifers
	Unclassified deciduous trees	mixed deciduous
	Unclassified forb dominated	mixed forbs
	Unclassified graminoid dominated	mixed grasses
Other woody species encountered along greenline	*Abies lasiocarpa*	subalpine fir
	Picea engelmannii	Engelmann spruce
	Ribes spp.	gooseberry
	Symphoricarpos oreophilus	mountain snowberry

To assess vegetation condition directly along the stream edge, a "greenline" vegetation survey was conducted in each of the four riparian reaches (Figure 94). The greenline represents the first continuous vegetation encountered when moving away from the perennial water source. Oftentimes the greenline is at the water's edge. The greenline survey consisted of identifying vegetation community types encountered along both sides of the channel. Total length of the greenline survey on each side of the channel was about 100 m. In addition to assessing vegetation community types encountered along both sides of the channel. Total length of the greenline survey on each side of the channel was about 100 m. In addition to assessing community types, stem counts (both live and dead) were made for all trees and shrubs encountered within a 1-m wide strip with the left edge of the greenline (measured from the greenline away from the channel). This allowed woody vegetation to be expressed on a stems per unit area basis. A total



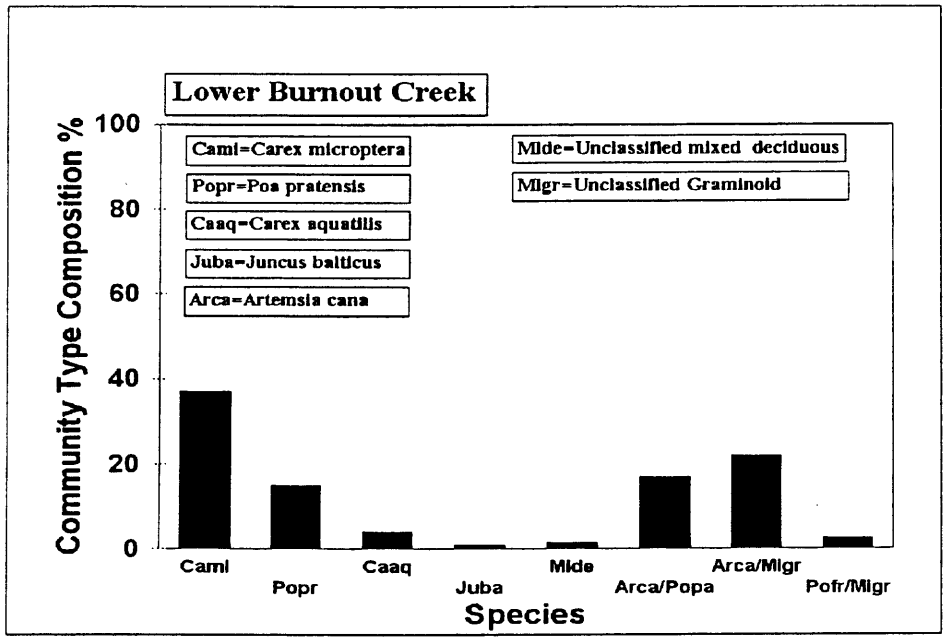
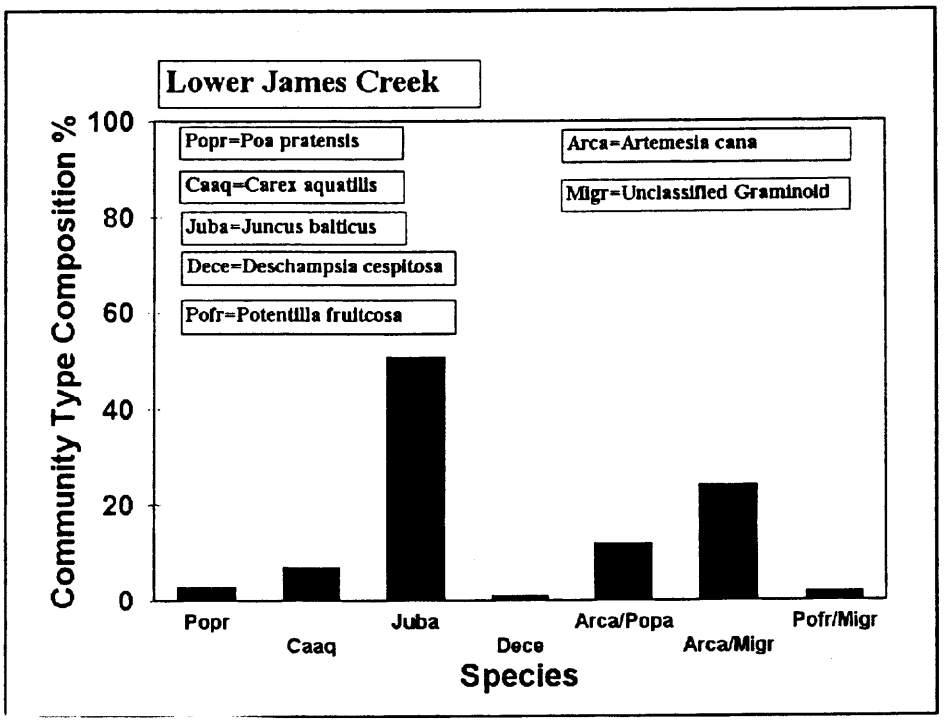


Figure 95. Vegetation community composition along transects for upper and lower riparian complexes along Burnout Creek.



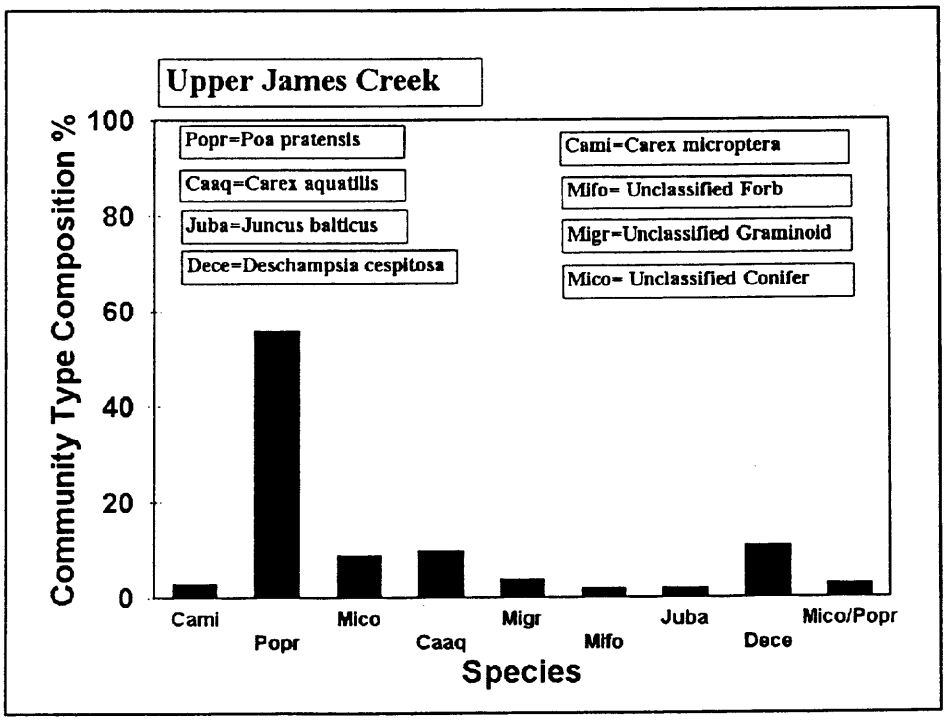


Figure 96. Vegetation composition along transects for upper and lower riparian complexes along James Creek.

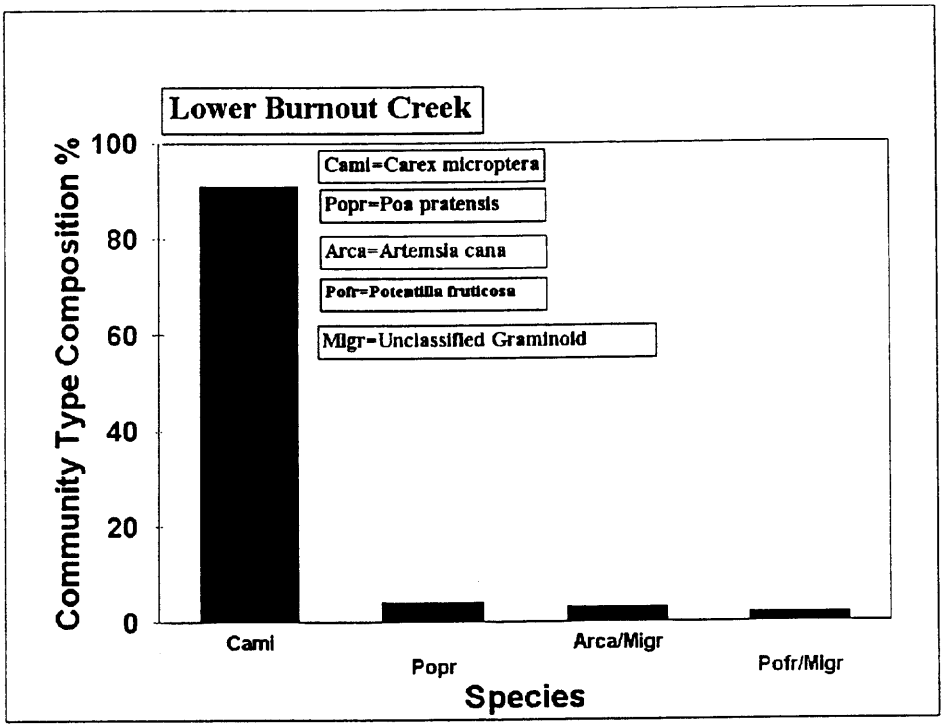
of six species of woody plants were found and their common names are given in Table 7.

Along the greenline in lower Burnout Creek, *Carex microptera* comprised 90% of the vegetation community types (Figure 97). In the riparian reach in lower James Creek, *Juncus balticus* occupied 55% of the greenline; however, significant amounts of *Carex aquatilis* (24%) and *Deschampsia caespitosa* (20%) were present (Figure 98). More than 30 live *Potentilla fruticosa* plants and 10 live plants of *Artemisia cana* per 100 m of greenline were found in the lower portion of Burnout Creek. *Artemisia cana* was more abundant (16 live plants per 100 m of greenline) in the lower reach of James Creek; however, *Potentilla fruticosa* was less abundant (about 3 live plants per 100 m of greenline). In the riparian reach along the upper portion Burnout Creek, six community types were present -- *Carex microptera* (27%), *Poa pratensis* (23%), *Carex aquatilis* (18%), unclassified graminoid dominated (16%), unclassified conifer dominated (9%), and unclassified forb dominated (7%) (Figure 97). Most of these same community types occurred along the streambank of upper James Creek; however, *Deschampsia caespitosa* was most abundant (50%) (Figure 98). Englemann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) along with *Ribes* spp. were present in small numbers (<2.5 live stems per 100 m of greenline) in the upper reach of Burnout Creek. *Symphoricarpos oreophilus* was the dominant woody shrub (12.5 live plants per 100 m of greenline) in upper James Creek. More than six Engelmann spruce per 100 m of greenline were noted in the upper reach of James Creek.

As a part of the riparian survey, qualitative assessments of stream cover were made for: (1) overhanging banks, and (2) vegetation and rock cover. An assessment of streambank stability was made as well. Continuous estimates of each of these three parameters were made along the entire surveyed reach (approximately 100 m) in each of the four riparian survey areas. Overhanging bank cover was estimated as the degree of bank overhang above the perennial water course (including soil and sod material, but not overhanging vegetation) measured perpendicular to the bank in the following intervals: 0 = no overhang; 1 = slight overhang (0-5 cm); 2 = moderate overhang (5-10 cm); and 3 = large overhang (>10 cm). In-stream vegetative/rock cover was estimated as the relative amount of waterway shaded or protected by overhanging vegetation, vegetation in the channel, or rocks in the channel. Qualitative estimates were as follows: 0 = no

cover; 1 = slight cover; 2 = moderate cover; and 3 = heavy cover. Photographs were taken of all cover classes to correlate with qualitative assessments. Streambank stability was qualitatively rated in one of four classes: 0 = stable; 1 = slightly unstable; 2 = moderately unstable; and 3 = highly unstable.

The greatest differences in overhanging bank cover between the two streams surveyed occurred in the lower reaches. The lower channel of James Creek was narrow with larger overhanging sod-covered banks than in Burnout Creek (Figure 99). In the upper reaches of both Burnout and James Creeks, either no or very small (0-5 cm) overhanging banks were most common (Figure 99). In-stream vegetation cover and bank stability were both averaged over the greenline based on a weighted linear distance occupied by various qualitative estimates. Average in-stream vegetative/rock cover was highest (1.98) in the lower riparian reach of James Creek and lowest in the upper reach of James Creek (Table 8). The higher cover in the lower reach of James Creek was due to plants hanging over the relatively narrow channel. In-stream cover index was intermediate in the lower (1.25) and upper (1.39) reaches of Burnout Creek. Qualitative estimates of streambank stability indicated that banks were least stable in the upper riparian reach of Burnout Creek (1.91). Bank stability in the other her reaches of the two streams ranged from 1.06 to 1.34 (Table 8).



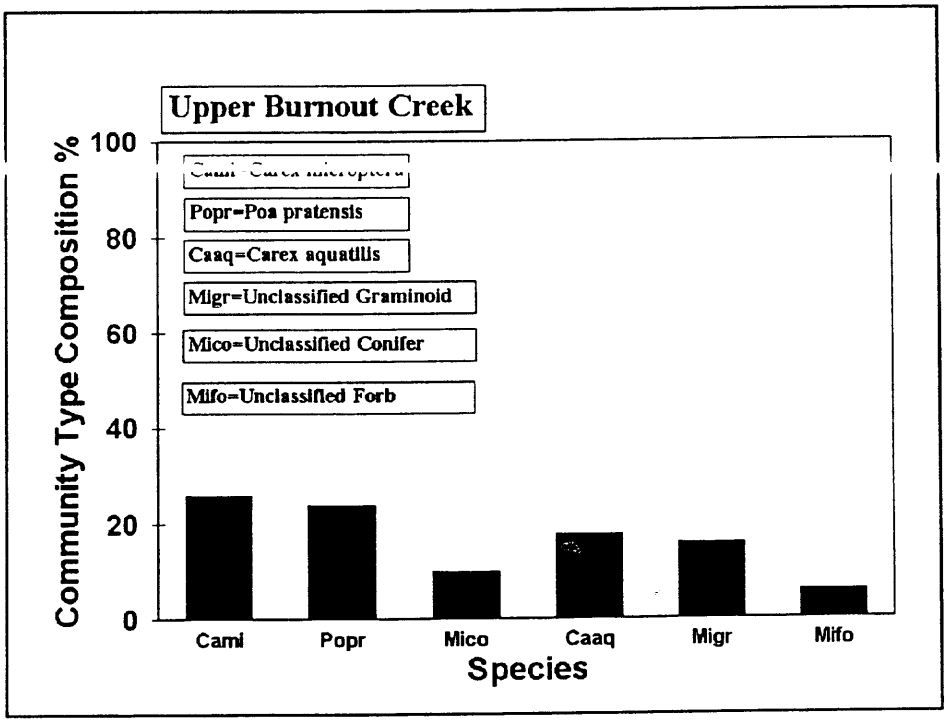
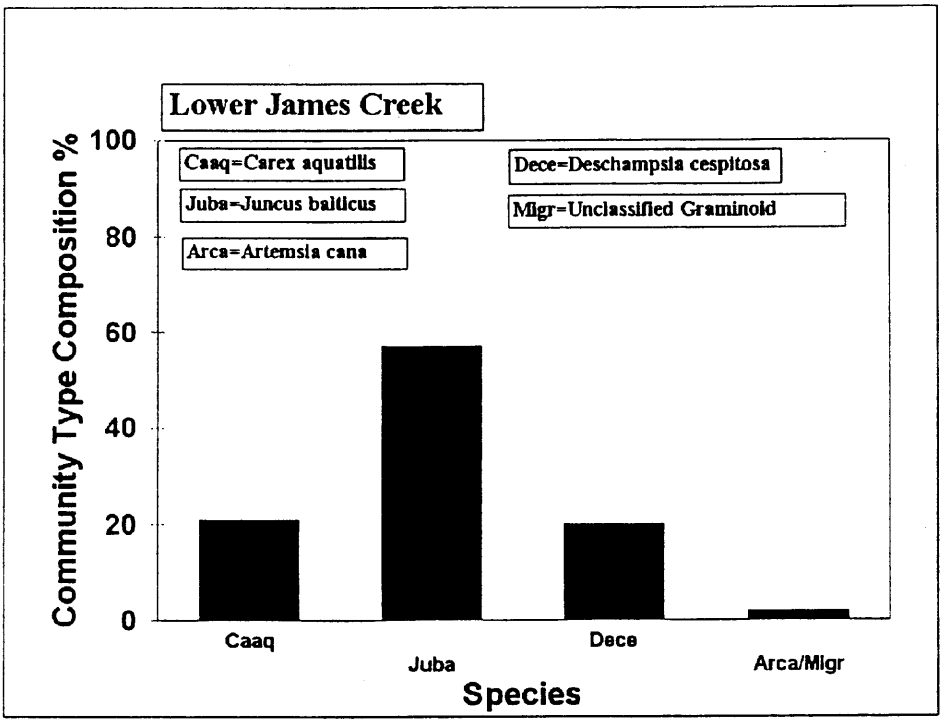


Figure 97. Vegetation communities along the greenline for the lower and upper riparian complexes along Burnout Creek



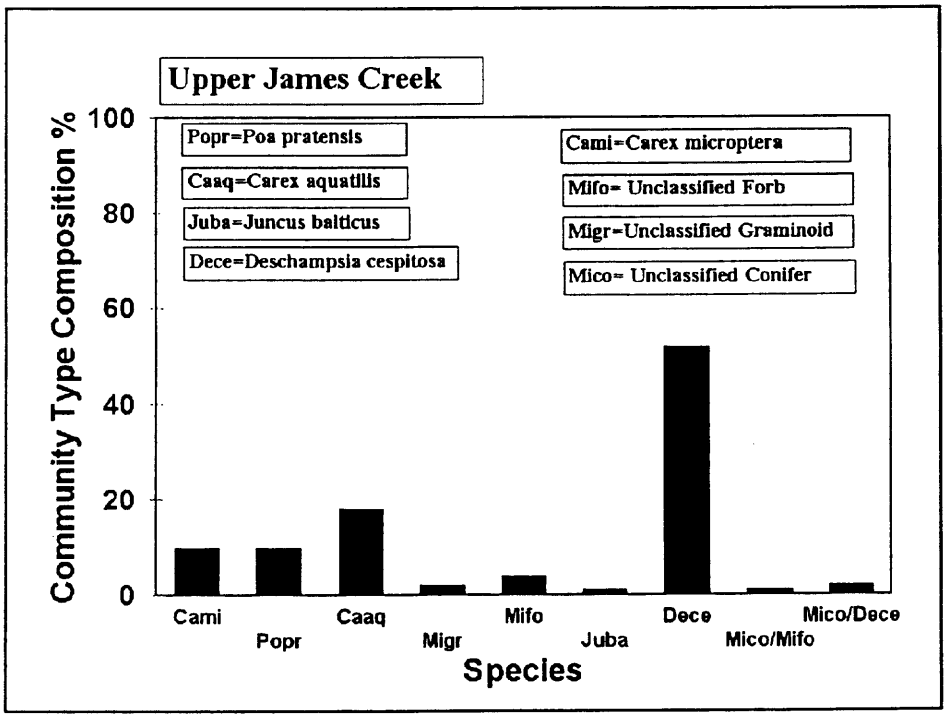


Figure 98. Vegetation communities along the greenline for the lower and upper riparian complexes along James Creek.

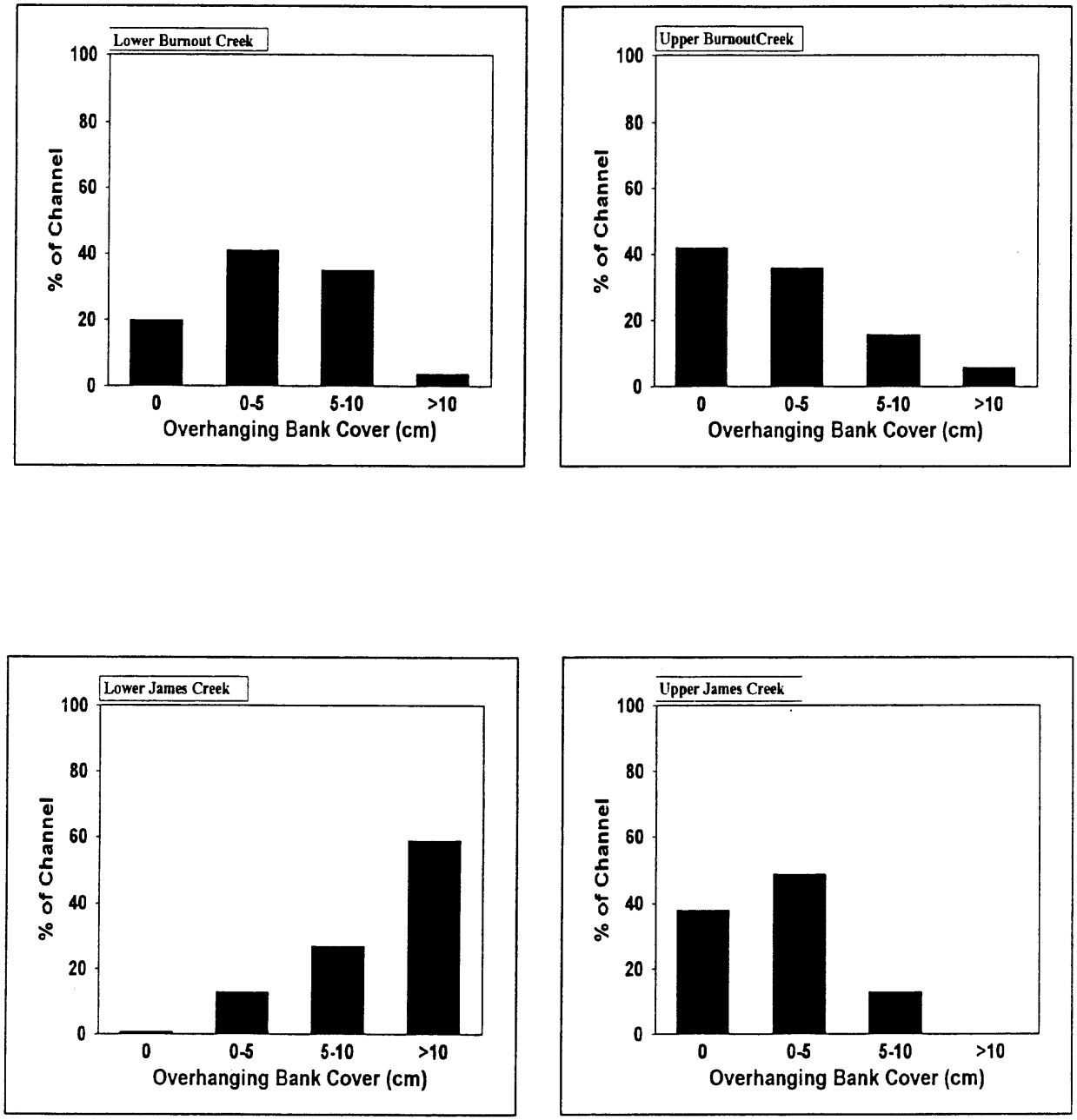


Figure 99. Degree of bank cover for various riparian reaches of Burnout and James Creeks.

Table 8. Qualitative estimates of bank stability and in-stream cover weighted by stream distance.

Reach	Mean Bank Stability Class	Mean In-Stream Cover Class
Lower Burnout Creek	1.34	1.25
Upper Burnout Creek	1.91	1.39
Lower James Creek	1.20	1.98
Upper James Creek	1.06	.98

Landslide Inventory

A comprehensive landslide survey was conduced along the monitored reaches of Burnout Creek in autumn 1992. Only landslides that were adjacent to the channel or visible from the channel were noted. Recent slides were defined as those that appeared to occur after 1980. For recent slides larger than 10 m^3, detailed measurements were taken on the numbers and sizes of soil pipes that may have contributed to failure initiation. For older slides it was impossible to accurately estimate failure dimensions, thus only relative position and size of these failures are shown in Figure 100. These data provide a background for comparison with post-subsidence landsliding frequency. In 1993 and 1994, surveys were conducted to document any new landslides that occurred along Burnout Creek.

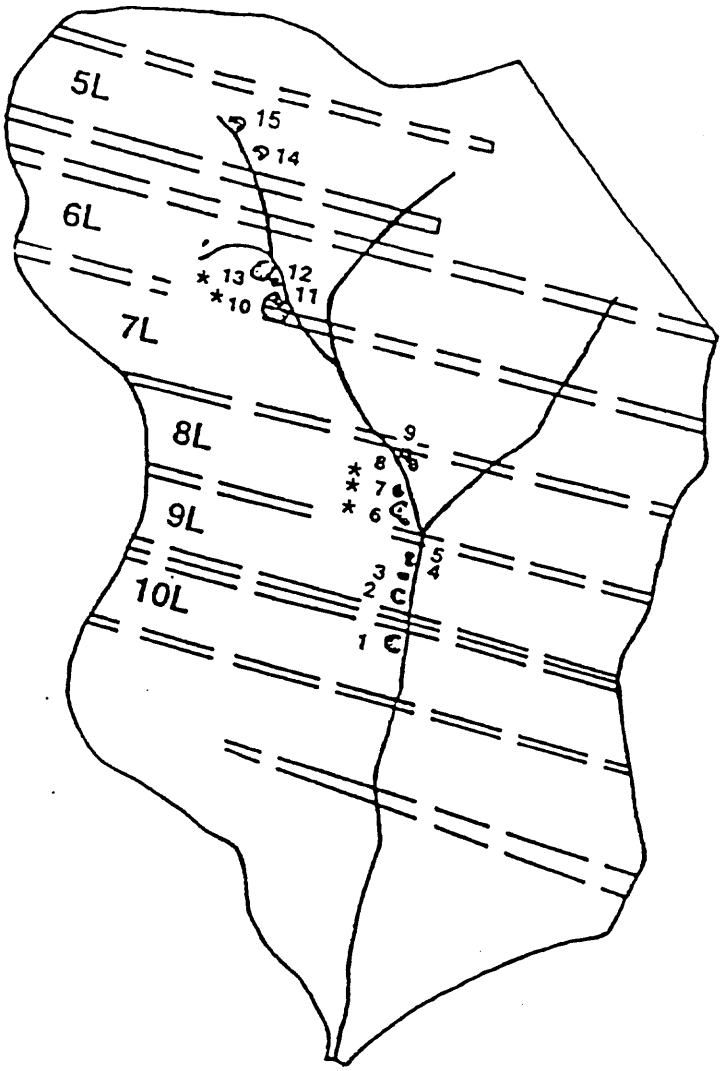


Figure 100. Location of landslides along Burnout Creek (* indicates old landslides).

Nine recent landslides occurred prior to mining along Burnout Creek. These ranged in size from 1.9 to 156 m^3. All but two of these failures were on approximately south-facing slopes (Table 9). Headscarps of six of these recent failures contained one or more soil pipes that are believed to be contributory factors in triggering these events (Blong and Dunkerley, 1976; Tsukamoto et al., 1982; Sidle et al., 1985). Soil pipes ranged in size from < 1 cm to 17 cm (Table 9). All but two of these recent landslides were translational failures (debris slides or avalanches); the remaining two were rotational slumps. The two largest failures (#11 and 12),

located along the upper main channel of Burnout Creek, were associated with previous disturbances (Figure 100). Failure #11 was a localized slump/deep-seated slide that occurred in the eastern portion of a stabilized ancient slump block (failure #10). Failure #12 was associated with an old road cut and fill from a logging operation.

Table 9. Characteristics of recent, pre-mining landslides along Burnout Creek.

Land-slide #	Failure Type	Vol. (m^3)	Estimated Date of Failure	Aspect	Visible Pipes Present	# of Pipes	Pipe Diameters (cm)
1	Debris avalanche	32	- 1990	S20°E	Yes	6	2,2,2,3,7,8
2	Debris avalanche	30	- 1983-87	S22°E	Yes	4	2,6,7,4
3	Debris slide	7	- 1983-87	South-facing	Yes	several	-------
4	Debris slide	1.9	- 1990	South-facing	No		
5	Debris slide	5.6	- 1990	South-facing	No		
9	Slump	7	- 1983-87	NW-facing	No		
11	* Slump/ slide	135	- 1983-84	S40°E	Yes	1	17
12	Debris slide	156	- 1983-84	E15°S	Yes	3	6,6,5
14	Debris slide	10.5	- 1988-90	NW-facing	Yes	1	1.5

* Within old landslide #10.

A total of five older landslides were noted. These were all very large, old (>50 years) slumps or combination slump/deep-seated slide failures. It is likely that some smaller "old" slides existed, but they were impossible to recognize in the field due to infilling of the scoured zone and revegetation. Approximate size and location of these old landslides are shown in Figure 100. Any future activation of these older slumps and deep-seated slides will be noted. All 14 landslides, both recent and old, were photographed.

In the post-mining surveys (1993 and 1994), only one new landslide (#15) was documented -- a small debris slide along the north-facing streambank in the upper ephemeral reach of Burnout Creek above panel 5L. This landslide was likely triggered by snowmelt in early spring 1993. It is located upstream of slide #14 and has similar dimensions and volume. Since subsidence had already occurred in panel 5L (mostly during late 1991 and early 1992), the initiation of this small failure was not associated with mining. None of the older landslides were reactivated during the 1992 to 1994 period. No recer [illegible] were noticed during 1996. Thus far, it appears that subsidence from underground mining has not increased the landslide potential along Burnout Creek. However, it should be understood that 1993 and 1994 were relatively dry years with only modest snowpacks. Thus, pore water pressures needed to initiate or accelerate landslides on unstable slopes may not have been present during this period.

Baseflow

Instantaneous baseflow measurements for sites CS-7, near the outlet of Burnout Creek, were summarized for the pre-mining period from 1981 to 1991. Flow measurements were excluded from the analysis if they were influenced by spring snowmelt runoff or by a storm event. Generally, data collected during the period from late June to late October were included in the analysis. The mean baseflow discharge for the 41 pre-mining measurements is 0.43 cfs; standard deviation is 0.28 cfs. A total of 49 baseflow data points were analyzed for the post-mining period from 1992 to 1994. These data represent actual flume readings taken throughout the summer and autumn of 1992 and 1994 (Figures 46 and 47). Again, storm events and snowmelt runoff were

excluded from this data base. When weekly direct measurements were not available, baseflow was taken from the recorder (daytime values) at CS-7. The mean baseflow discharge for the 49 post-mining measurements is 0.40 cfs; standard deviation is 0.12 cfs. There was no significant difference between pre-mining and post-mining baseflows based on t-test comparisons (α=0.05).

Summary

This report analyzes channel changes and related hydraulic parameters in a mountain stream (Burnout Creek) that has been partially impacted by subsidence from underground coal mining. Comparisons are made between reaches of streams that have been subsided, the entire stream channel of the mined drainage, and an uncalibrated control stream in James Canyon. The James Canyon serves as a basis for judging whether a change in channel characteristics in Burnout might be attributed to subsidence following mining. Channel characteristics classified in the James Canyon control varied considerably between years, probably resulting from a combination of subjective classification differences between observers in different years combined with normal fluctuation attributable to variations in stream flow. However, changes in Burnout Creek that exceed those in James are attributed to the effects of mining.

Changes in channel characteristics were inconsistent between mined panels as well as between the Main Channel and South Fork. The most likely change in both sections of Panel 7L (mined in 1993-'94) was a temporary increase in the number and proportion of the channel in pools compared to the appropriate section of the James control. By 1997, however, this increase was no longer detectable. An increase in pools was also apparent in the Main Channel portion of Panel 8L (mined in 1995-'96), but not in the South Fork portion of this panel. In Panel 9L (mined in 1995-'96) subsidence appears to have resulted in an increase in the proportion of the channel occupied by pools, but not in the total number of pools. The pools here were fewer and larger.

The effect of mining on stream channel characteristics in the entire Burnout drainage between 1992 and 1997 appears to be a general increase in number of pools in both the Main Channel and South Fork, but changes in pool volume were inconsistent. The proportion of the Main Channel in cascades may have increased, but cascades decreased in the South Fork. Great

year-to-year variability in measurements in the stream channel of the control area (James Canyon) obscure the reliable detection of other changes that may have occurred in Burnout.

Overall, channel profile surveys with the techniques used have not been useful for interpreting impacts related to specific regions of subsidence in this study. More careful and detailed measurements will be needed for such data to be of use in interpreting subsidence impacts.

Changes in the cross-sections of the stream channel attributable to mining consisted largely of decreases in elevation and some changes in channel width. Drops of 1.5 to 5.5 feet in elevation occurred in zones of subsidence, whereas drops of only 1.5 to 3.2 feet occurred in the tension zones of mined panels. Any observed changes in width were usually a narrowing of up to ~ 1.5 feet in subsidence zones, and a widening of up to ~ 2.5 feet in tension zones. The amount of erosion and deposition measured by these cross-sections did not exceed that caused by normal processes in James Canyon. Here again we want to add a word of caution, not so much for the method, but for the number of different people doing this work from year to year. Further studies should try for more consistency. Actual techniques varied from year to year, resulting in data that presented problems during analysis.

Typically, during the summer or autumn after initial subsidence, some channel constriction was measured. However, one year later, some recovery to pre-subsidence geometry was observed. This so-called recovery could be related to fluvial reworking of the channel bottom, stress relief after subsidence, or even animal traffic. Changes in channel geometry (especially in the channel bottom) affected hydraulic properties: wetted perimeter often decreased after subsidence and, conversely, hydraulic radius increased (but not to the extent of the decreases noted for wetted perimeter). These hydraulic properties were calculated based on routing of design stormflow through the basin and allowing for temporal changes in channel cross-sections. Calculations for the impacted reach over panel 6L suggest that bed shear stress may increase during peakflows, thus causing potential increases in channel scour, bedload transport, and winnowing of finer bed material. On the other hand, the calculations indicate that channel erosion may be less because of the smaller wetter perimeter measured following subsidence. This potential for reduced channel bank erosion could decrease suspended sediment transport. Some

of these predicted changes are partially confirmed by analyzing the substrate data collected from pools throughout Burnout Creek.

Although the two-fold variation between years in mean particle size (D_{50}) in the Main Channel and three-fold variation in the South Fork of Burnout Creek did not exceed that experienced in the James Canyon control area, the pattern of changes differed somewhat. Mean particle size tended to increase progressively from initial lows in the early years to higher levels especially in the later years. This suggests that subsidence may have resulted in an increase in the mean particle size. Subsidence had no detectable effect on the proportion of fines <1 mm in size in the mined drainage.

Riparian vegetation surveys were conducted in 1992 along the stream channel in Burnout as well as along the James Canyon control. These survey are intended to serve as benchmarks to compare with future remeasurements that may be appropriate to detect possible changes in riparian plant communities that might be attributed to mining.

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