C/041/002 Incoming

Task #4581

**Canyon Fuel Company, LLC**
A Subsidiary of Arch Western Bituminous Group, LLC

**Sufco Mine**
Kenneth E. May
General Manager
597 South SR24
Salina, Utah 84654
(435) 286-4400
Fax (435) 286-4499

April 17, 2014

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

Re: Amendment to Permit to Provide Vegetation Information and Final Reports for Biological Studies, Task ID #4513, Canyon Fuel Company, Sufco Mine, C/041/002

Dear Sirs:

Please find enclosed with this letter two copies of an amendment to address final reports for vegetation sampling in the Box Canyon Area, Link Canyon and a macroinvertibrate study of portions of the South Fork of Quitchupah creek. The vegetation sampling/study reports have been included in the annual reports over the past years, this amendment includes a summary of the past annual reports and the information gathered in 2013.

Through discussions last year with both Joe Helfrich and Ingrid Campbell of the Division staff it was determined that the commitment for these studies had most likely been met, but the review and approval of this amendment will be the final determination.

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

CANYON FUEL COMPANY, SUFCO Mine

Vicky S. Miller for

John D. Byars
Technical Services Manager

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cc: DOGM Correspondence File

# APPLICATION FOR COAL PERMIT PROCESSING

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

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

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

Les A. Topham
Print Name

Les A. Topham 04/17/14
Sign Name, Position, Date

Subscribed and sworn to before me this 17 day of April, 2014

Jacquelyn Nebeker
Notary Public

My commission Expires: _____, 20____}
Attest: State of Utah } ss:
County of Sevier

JACQUELYN NEBEKER
Notary Public
State Of Utah
My Commission Expires 3/24/2015
Commission# 606049

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Form DOGM- C1 (Revised March 12, 2002)

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

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Les A. Topham
Print Name

Les A. Topham 04/17/14
Sign Name, Position, Date

Subscribed and sworn to before me this 21 day of April, 2014

Notary Public
My commission Expires: _____, 20___}
Attest: State of Utah } ss:
County of Sanpete

JACQUELYN NEBEKER
Notary Public
State Of Utah
My Commission Expires 3/24/2015
Commission# 606049

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# CHAPTER 2

# SOILS

# APPENDIX 2-9

## Link Canyon Portal Vegetation, Aquatic Fauna, and Soil Investigations

# LINK CANYON MINE PORTAL
# VEGETATION STUDY

Prepared by
Keith W. Zobell
Environmental Specialist
July 16, 2013 (Revised)

Photographs were retaken at the Link Canyon Mine Portal area on June 25, 2013. The area has received limited moisture this spring and winter. Due to low moisture the growth on the perennial plants has been below normal. The area at the West Portal has been heavily grazed by cattle this spring and has made plant measurements difficult and in some cases impossible. Many of the perennial plants have been grazed down to almost ground level and therefore identification could not be made on all the species at the site. There has been some regrowth on a few of the species. There are very few Halogeton (*Halogeton glomeratus)* in the plot, however the roadway leading into the site has a good stand of Halogeton plants. There is no evidence that there has been any overland flow in the adjacent stream bed this year. There is no water being discharged from either of the portals and there is no evidence that there has been any.

Using the ocular estimate method the plant density is approximately 55 percent. This is about the same as it was last year. There are very few annuals, including Halogeton, growing on the site.

The plant composition is made up of a mixture of grasses and shrubs. The following plants were found and measured a the site: ( 1) Indian Rice Grass (*Stipa hymenoides)* has been heavily grazed and there are no seed heads, there is 4-6 sparse regrowth, (2) Crested Wheatgrass (*Agropyron desertorum)* has been heavily grazed but has a few 10-12 inch seed heads and sparse regrowth 6 inches high, (3) Great Basin Wild Rye (*Elymus cinereus)* has been heavily grazed but has a few 36-48 inch seed heads and 24-36 inches of growth, (4) Slender Wheatgrass (*Elymus trachycaulus)* has been heavily grazed and has a grazed height of less of 1 inch and therefore no measurement could be made, (5) Clematis (*Clematis liqusssticifolia)* continues to invade the lower portion of the site. It has not been grazed and is providing a good ground cover, (6) Bluestem Wheatgrass (*Agropyron spicatum)* has been heavily grazed but has 6-8 of growth with sparse 8-10 inch seedheads, (7) Rabbit brush (*Chrysotahmnus spp. )* has 4-6 in new growth and has had some light grazing, (8) Squaw Bush *(Rhus aralmatica var. trrilobata)* has 4-6 inches of new growth, (9) Herbaceous sage ( *Artemensia spp. )* has 9-10 inches of new growth, Annuals including Halogeton are sparse and except for Halogeton have matured and gone to seed. (10) Willow *(Salix spp.)* 4-8 inches of new growth with some light grazing.

Plant vigor is still considered low fair to poor. The is due to the drought conditions at the site. This site has been grazed by domestic livestock. Using the ocular estimate method the site has an overall density of approximately 35 percent. There are a few annual that have matured and gone to seed. The following plants were found and measured at the site" (1) Clematis, continues to invade the site and has good growth and provides good ground cover, (2) Rabbit brush has 4-6 inches of new growth, (3) Indian Rice Grass has good seed production with seed heads 26-28 inches tall and basal growth of 10-12 inches, (4) Willow 4-8 inches of new growth ,(5) Wire Grass (*Juncus spp. )* plants are sparse and have 10-14 inches of growth and are in flower, (6) Bluegrass (*Poa pratensis)* no plants were found, (7) No Slender Wheatgrass plants were found.

There is no water flowing from the portal and no evidence of overland flow.

Link Canyon West Portal Photographic Point

Link Canyon East Portal Photographic Point

# LINK CANYON MINE PORTAL
# VEGETATION STUDY

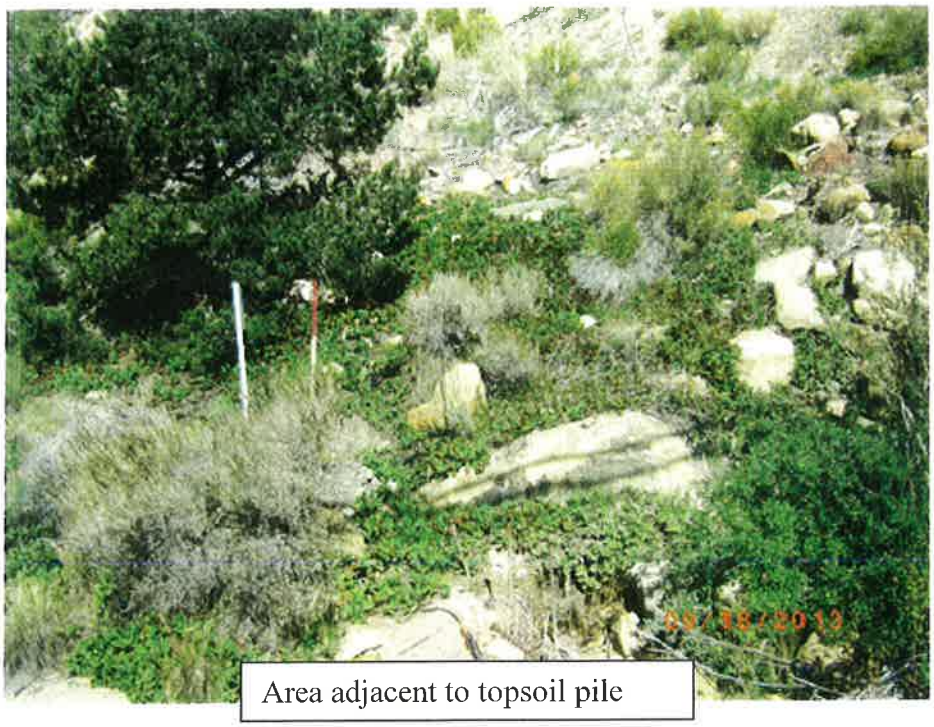
September 18, 2013

Photographs were retaken at the Link Canyon Mine Portal area one week after rains finished in September. Due to low moisture the remainder of the year, growth on the perennial plants has been below normal. Due to the heavy rains the first part of September there was evidence of overland flow in the adjacent stream bed this year. There is no water being discharged from either of the portals and there is no evidence that there has been any.

The plant composition is made up of a mixture of grasses and shrubs. The following plants were noted at the site: Indian Rice Grass (*Stipa hymenoides),* Crested Wheatgrass (*Agropyron desertorum),* Great Basin Wild Rye (*Elymus cinereus),* Slender Wheatgrass (*Elymus trachycaulus), Woods Rose,* Clematis (*Clematis liqusssticifolia),* Bluestem Wheatgrass (*Agropyron spicatum),* Rabbit brush (*Chrysotahmnus spp.),* Squaw Bush *(Rhus aralmatica var. trrilobata),* Herbaceous sage (*Artemensia spp.),* Willow *(Salix spp.), Mormon Tea (Ephedra spp) and Oregon grape (Mahonia qurfolium).*

Plant vigor was considered fair, the cattle had not grazed the area since spring and had not come down off the mountain yet when these photographs were taken.

Link Canyon West Portal Area




Area adjacent to topsoil pile

Topsoil Storage Pile

Link Canyon Substation, looking up the canyon

# Vegetation Monitoring at the Link Canyon Portal Area: An Update

2013

View From the Link Canyon Portal Site

*Prepared by*

**MT. NEBO SCIENTIFIC, INC.**
330 East 400 South, Suite 6
P.O. Box 337
Springville, Utah 84663
(801) 489-6937

Patrick D. Collins, Ph.D.

*for*

**CANYON FUEL COMPANY, LLC**
SUFCO MINE
597 South SR 24
Salina, Utah 84654

February 2014

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# INTRODUCTION

In 2002, engineers for Canyon Fuel Company designed a new access portal and other minor surface facilities for the SUFCO Mine. The new portal was constructed in Link Canyon at the site of an old portal that was created from earlier mining activities. Construction of the portal created about 1/4 acre of new land disturbance, or more appropriately called re-disturbance.

The portal site in Link Canyon is located in Sevier County, Utah about 7 miles northwest of the town of Emery (GPS coordinates: NAD 27, 12 S, 471190E, 4312294N). Native plant communities at the site consisted primarily of pinyon-juniper and riparian types. Elevation at the site was approximately 7,600 ft above sea level.

The purpose of this document is to provide an update of the vegetation at the Link Canyon Portal site and also to provide recommendations for future studies.

Prior to construction of the new portal, field studies were conducted by *Mt. Nebo Scientific, Inc.* One such study provided a report called: Survey Report, Aquatic Fauna, Link Canyon Portal Area (July 2002). The objectives of this study were to 1) survey for presence of specific sensitive aquatic fauna species and 2) to assess the potential for the habitat to support other sensitive aquatic species. Another field study was conducted that resulted in a report called: Vegetation of the Link Canyon Portal Surface Facilities (August 2002). This study provided information about the plant communities at the site as well as proposed vegetation reference areas that could be used for revegetation success standards when the site is ultimately reclaimed. Information about potential threatened, endangered and sensitive plant species was also provided in that report.

Since the time the portal was constructed, the vegetation has been monitored by Mr. Keith W. Zobell, an environmental specialist. Mr. Zobell's reports provided color photographs at specific locations as well as a qualitative assessments of the vegetation at the Link Canyon Portal site.

# METHODS

Field work was conducted at the Link Canyon Portal site on September 18, 2013. The entire disturbed area was surveyed including the portal, its access road, stream buffer zones, culverts and road cut slopes. The reference areas were also visited on that day. Qualitative notes as well as photographs were recorded.

# RESULTS

The cover, density, diversity, productivity and vigor of the vegetation at the Link Canyon Portal site were in excellent condition. A list of plant species observed is shown on Table 1. One relevant or telling method of assessing the site it to observe the photographs taken during the field work. The portal site entrance gate is shown in Fig. 1, whereas the access road behind the gate is shown in Fig. 2. Not surprising because the road was not seeded, this is where some "weedy" species were located. The topsoil pile was covered with desirable vegetation (Fig. 3), and is was controlling erosion. Signs have been placed and remain in good condition at the stream buffer boundaries (Figs. 4 and 5). The stream has been protected by these buffer zones. The actual portal entrance is closed to the public by a chainlink gate (Fig. 6). The drainage culverts are clear, the bank around them is stable and has good vegetative cover (Fig. 7). Fig. 8 shows some of the general disturbance area – note the good cover and vigor of the vegetation here too. The access road fill banks have also been stabilized by plant growth, although some of it is comprised of a few weedy plants (Fig. 9). The weeds were a minor component here however, adding to the bank stability and probably not enough to be concerned about implementing weed control measures at this time.

The reference areas, or those communities chosen to represent future revegetation success standards at the time of final reclamation, remain in good condition. The Pinyon-Juniper Reference Area is shown in Fig. 10; the Riparian Reference Area is shown in Fig. 11.

**Table 1: Plant species observed at the Link Canyon Portal Site.**

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| **Trees & Shrubs** | |
| *Betula occidentalis* | Water birch |
| *Chrysothamnus nauseosus* | Rubber rabbitbrush |
| *Clematis ligusticifolia* | White virgins-bower |
| *Cornus sericea* | Red-osier dogwood |
| *Ephedra viridis* | Mormon tea |
| *Eriogonum corymbosum* | Corymb buckwheat |
| *Juniperus osteosperma* | Utah Juniper |
| *Pinus edulis* | Pinyon-pine |
| *Pseudotsuga menziesii* | Douglas fir |
| *Rhus aromatica* | Squaw bush |
| *Ribes aureum* | Golden current |
| *Rosa woodsii* | Wood's rose |
| *Salix exigua* | Coyote willow |
| | |
| **Forbs** | |
| *Aster foliaceous* | Leafy-bract aster |
| *Halogeton glomeratus* | Halogeton |
| | |
| **Grasses & Grass-likes** | |
| *Agropyron cristatum* | Crested wheatgrass |
| *Elymus cinereus* | Gt. Basin wildrye |
| *Elymus smithii* | Western wheatgrass |
| *Elymus salinus* | Salina wildrye |
| *Juncus arcticus* | Wiregrass |
| *Stipa hymenoides* | Indian ricegrass |

# SUMMARY & RECOMMENDATIONS

Over 10 years ago, a new mine portal was constructed at Link Canyon in south-central Utah. The new portal was placed in an area that was once disturbed by another portal from earlier mining operations. In 2002, prior to construction of the new portal, biological studies were conducted to gather baseline information at the site. These studies included aquatic fauna, vegetation and sensitive species work. Following construction of the new portal, the area was seeded and the vegetation has been regularly monitored. Status reports have been provided to the State of Utah, Division of Oil, Gas & Mining (DOGM).

This report provides the general condition of the vegetation at the Link Canyon Portal site in 2013. Vegetation has become well established on the road-cuts, road banks, topsoil pile, culvert bank, stream buffer zones and other disturbed areas. Signs and access gates are also in good condition.

The reference areas previously chosen to represent future revegetation success standards remain in good condition and continue to be viable to be used for comparisons at the time of final reclamation.

Because the vegetation has become well established, has stabilized over-time and remains in good condition with respect to cover, diversity, density and productivity, there appears no practical reason to continue to monitor the site on an annual basis – at least from a vegetation prospective – unless more mine-related disturbance is conducted, or until the time of final reclamation and revegetation.

Fig. 1: Portal Entrance

Fig. 2: Portal Access Road

Fig. 3: Topsoil Pile

Fig. 4: Stream Buffer Zone

Fig 5: Stream Buffer Zone

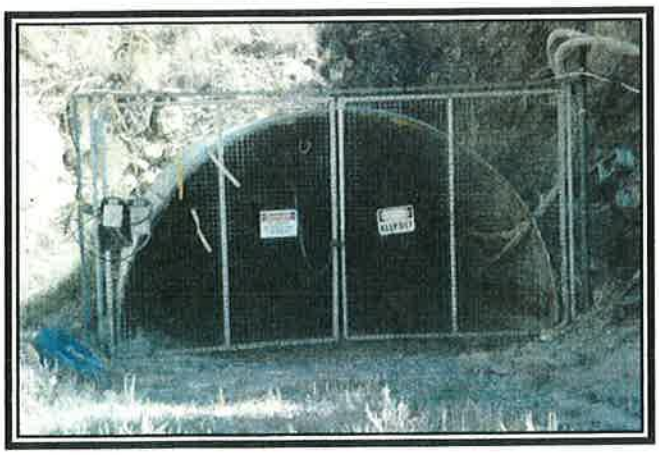

Fig 6: Link Canyon Portal

Fig 7: Drainage Culverts

Fig 8: General Disturbance

Fig 9: Road Fill Bank

Fig 10: Pinyon-Juniper Reference Area

Fig 11: Riparian Reference Area

# CHAPTER 3

# BIOLOGY

plateau area through the cliffs to the valley floor to the southeast. It appears that these trails are important to elk migration from summer to winter range, and therefore construction of ventilation portals has not been allowed to interrupt this limited number of access routes.

No endangered or threatened mammal species occur within the mine boundary as recorded in a study performed by H. Duane Smith and Clyde L. Pritchett (WIL, Appendix 3-3).

A peregrine falcon eyrie existed in 1997 about one half mile from the site but during aerial surveys conducted in 1998 and 1999 no falcons were sighted. Discussion about threatened, endangered or otherwise sensitive plant and animal species of the Pines Tract Project area is given in Appendix 3-9.

The disturbed area of the Link Canyon Mine Portals contains approximately 0.05 acres (2000 square feet) of riparian vegetation typified by willow, alder, stinging nettle, rose, horsetail, carex, Kentucky Bluegrass, rush, and clematis (Zobell, 2000). A vegetation study of the western portal area was conducted by Mt. Nebo Scientific in July 2002 and September 2013. The 2002 report of this study includes a detailed map of the western portal area vegetation. A copy of the reports are included in Appendix 2-9. The vegetation is supported by discharge from the abandoned Link Canyon Mine and subsurface moisture within the Link Canyon Drainage. Only the western-most portal area will be disturbed as part of Sufco's plan to re-open Link Canyon portals to establish an escape-way and ventilation for mining in the Pines Tract and access to the Link Canyon substation. The natural discharge of water from the portals will be maintained at rates similar to those that existed prior to reopening of the western portal. Only water from the existing abandoned works will be allowed to discharge from the portals. Thus, no harm due to a reduction in flow is anticipated to the riparian areas downstream of the portals. Additionally, the discharges from the portals have the potential to ~~will~~ remain after the western Link Canyon Portal is reclaimed.

A vegetation study was performed by Keith Zobell from 2000 through 2013(discontinued). The reports identified the vegetation and their associated vigor at the Link Canyon Mine portal which has been similar for the past thirteen years. The primary impacts to the vegetation have been from grazing and drought conditions. Discharge for the portal has been discussed in these reports, the water discharge has been low to non-existent the majority of the years. The drainage adjacent to the portals runs with waters associated with storm events. Refer to Appendix 2-9 for a copy of the study

information collected in 2013, study information from previous years is located in the annual reports for the corresponding years.

**Species of High Federal or State Interest.** The species of interest to the state of Utah are listed on Table 3-2. The species are divided into eight categories (extinct, extirpated, endangered, threatened, declining populations, limited distribution, declining populations/limited distribution and conservation). The Western Bluebird classified as sensitive, appears to be restricted to the Ponderosa Pine as a nesting bird. It can be locally common and its habitat is widespread over the state. It therefore does not represent any special problem in the lease area.

**Sensitive Species of High Federal Interest.** The species of interest to the federal Forest Service are listed on Table 3-3. The species are all sensitive as determined by the FS MLS Sensitive Species List and have the potential to occur within the permit area.

The Link Trail Columbine is the only Forest Service Region 4 sensitive species known to exist on the mine areas called the Pines Tract and Muddy Tract. SUFCO monitors populations of the Link Trail Columbine within the East Fork of the Box Canyon where it has been determined that mining might negatively affect the populations within the permit area. A discussion about threatened, endangered or otherwise sensitive plant and animal species of the Pines Tract Project area and Muddy tract is given in Appendices 3-9 and 3-11.

**150-Acre Incidental Boundary Change.** Sensitive species listed in Table 3-3 may be found within the boundary area. Species of most concern are the Link Trail columbine, Northern Goshawk, Northern Three-Toed Woodpecker, Flammulated Owl, and the Spotted Bat.

- Link Trail columbine - No populations have been found within the 150 acre IBC area. The boundary area is located on a plateau. Adjacent to the boundary area is Box Canyon that has suitable habit for this vegetation. A survey of the canyon will be conducted to locate representative populations of the columbine. The location of the populations of the columbine will be recorded using a topographic map and a GPS survey will be used to verify the coordinates. Photographs of the colonies will be taken during the survey. The survey will be conducted during the growing season to ensure as many colonies as reasonably possible are located.

- Northern Goshawk - No populations have been found within the 150 IBC boundary area. The Goshawk requires wooded areas for nesting and the vegetative cover of the area is generally sagebrush with few trees.
- Northern Three-Toed Woodpecker - The woodpecker is likely to use the general area but no populations have been found within the 150 acre IBC. The woodpecker requires forests containing spruce, fir, aspen, pine, and tamarack for nesting. The vegetative cover of the area is sagebrush with few trees.
- Flammulated Owl - The owl has been seen in the general area but no populations have been found within the 150 acre IBC area. The owl prefers mature ponderosa pine or Douglas fir forests with open canopies. Nests are made in large diameter dead trees with cavities. Vegetative cover of the 150 acre IBC area is sagebrush with few ponderosa pines and Douglas fir.
- Spotted Bat - The bat has been seen in both Muddy and Box Canyons. These canyons are in close proximity to the 150 acre IBC but no populations have been found within the 150 acre IBC area. The spotted bat usually roosts in rock crevices high on steep cliff faces but will inhabit Ponderosa pine, desert shrub, and pinyon-juniper stands. Few steep cliff faces are located within the 150 acres but are adjacent to the area. The 150 acres is part of a plateau and the vegetation is mainly Ponderosa pine, desert shrub, and pinyon-juniper stands.

**Link Canyon Mine Portals**. A few of the Sensitive species listed in Table 3-3 may be found within the portal area. The disturbed area associated with the re-opened portal is less than one acre and is included in an area previously disturbed by mining activities. No sensitive plants species were found in the area by Zobell (2000) or Mt. Nebo Scientific (2002) nor have mammals included in Table 3-3 been found in the portal area. Previous bat surveys indicated Spotted Bats are not present in the portal area. No access to the mines appear to be available to bats as the portals were completely closed by rubble in the 1980's. No Bald Eagle nests are known to occur in the area. A Peregrine Falcon eyrie was reported two miles to the east of the site in 1998 and 2001 but the eyrie was inactive in 1999, 2000 and 2002. Because the flow of water from the portals is minimal (one gallon per minute or less), fish are not found at this location. A survey specifically conducted for endangered mollusks was conducted in the portal area in June 2002. It is unlikely any endangered

The riparian vegetation within upper Box Canyon adjacent to the 150 acre lease modification is of special concern to the permitting agencies and the permittee. Because of this concern, SUFCO commits to monitoring the effects of subsidence on the riparian vegetation within the upper Box Canyon by including this area within the color infrared photography monitoring program described in the preceding paragraph. Previous infrared surveys have included most of the 150 acre lease modification area and upper Box Canyon. These previous surveys will be used to provide baseline data for the monitoring of subsidence effects, if they occur, on the riparian vegetation within the area. This data will be reviewed by qualified personnel to make determinations concerning the effects of subsidence on the riparian vegetation.

A survey will be conducted to locate representative populations of vegetation growing within bedding planes and fractures in the walls of Box Canyon. The location of the populations will be recorded using a topographic map and a GPS survey will be used to verify the coordinates. Photographs of the vegetation will be taken during the survey. The survey will be conducted during the growing season through 2013, when the survey was discontinued. This survey may coincide with the survey for the Link Trail Columbine as discussed previously in this chapter. A report of this survey will be included in the SUFCO annual report through 2012, a summary of the reports including the information gathered in 2013 is located in Appendix 3-10.

The applicant has implemented a program to monitor surface flowing water to determine diminished flows resulting from mine-related subsidence. The plan is incorporated as part of the over all surface water monitoring program. Monitoring with respect to wildlife watering sources has been discussed in Appendix 7-2. The applicant will cooperate with regulatory agencies to develop and provide alternative water sources for wildlife if mine-related subsidence disturbs the present sources.

In areas where wetlands and habitats of unusually high value for fish and wildlife exist, more intensive water and subsidence monitoring may occur when deemed necessary by the permittee, Division, and/or landowner/manager. This type of monitoring has already taken place in the East Fork of Box Canyon in the Pines Tract area and is described in detail in Chapter 5 Section 5.2.5.1 and Chapter 7 Section 7.3.1.2. Only two short segments of Cowboy Creek are within the SITLA Muddy Tract. Both segments are located on the eastern portion of the tract. One segment is located in the northeast 1/4 of Section 7, T21 S, R 5 E and the other is in the eastern 1/4 of Section 5 Section 7, T 21 S, R 5 E. Both of these segments of stream are perennial and contain riparian vegetation in the

channel bottom and on the banks of the channel. Additionally, there are several low flow springs within the SITLA Muddy Tract supporting riparian vegetation. The locations of these springs are identified on Plate 7-3. The riparian vegetation associated with Cowboy Creek and the springs is identified on Plate 3-1.

As discussed in the SITLA Muddy Tract PHC (Appendix 7-20), springs in the area occur within the North Horn and Price River Formations. The springs typically occur on the down gradient end of a perched aquifer where the beds containing the water are truncated by surface topography. Most of the springs occur in areas where overburden depths are approximately 1500 feet or greater. Sufco has undermined a few springs where the cover was greater than 800 feet, most of them occurring in the East Fork of Box Canyon. A few of the springs that discharged at or near the Blackhawk Formation - Castlegate Sandstone contact moved down-gradient. The remainder that discharge from the Castlegate Sandstone where the overburden is greater than 800 feet do not appear to have been significantly impacted by subsidence (PHC Appendix 7- 20 and personal communication with Erik Petersen of Petersen Hydrologic, Inc., Lehi, Utah, October 2005). Based on this experience, Sufco believes undermining the springs supporting associated riparian vegetation in the SITLA Muddy Tract will not significantly impact the vegetation.

Sufco has undermined a portion of the East Fork of Box Canyon where the flow is perennial. In the segment of the stream supported the Blackhawk Formation, subsidence related cracking of the brittle sandstone and silty sandstone beds did result in a temporary diversion of surface water into the subsurface. However, it was observed the water resurfaced down-gradient where the channel down cut through the brittle sandstone layers and encountered more plastic siltstones and shales. Mine personnel successfully repaired the channel floor with bentonite and native soils and restored the flow to the surface. Subsequent spring runoff also appears to have aided in natural repairing of the channel floor. Initial annual monitoring of the vegetation in the lower East Fork of the Box Canyon, begun in late 2003 and early 2004, has indicated the riparian vegetation adjacent to the stream channel does not appear to have been significantly impacted by subsidence.

Based on the experience to date (Fall 2005) of undermining the East Fork of Box Canyon, subsidence of the short segments of Cowboy Creek present in the SITLA Muddy tract is not anticipated to adversely impact the perennial vegetation associated with the creek. The overburden between the coal seam to be mined and the stream channel in the tract is between 1100 and 1600 feet. The

underlying formations contain rock types that would be expected to easily heal surface cracks that form beneath the stream channel. Additionally, the alluvium within the stream channel supporting riparian vegetation is derived from the fine-grained rocks of the Price River and North Horn formations. This alluvium is expected to naturally readily fill fractures that may occur in the channel substrate thus limiting the loss of flow, if any, supporting the riparian vegetation.

Though not anticipated, short segments of Cowboy Creek could be subsided in the SITLA Muddy Tract. If this is anticipated to occur, Sufco, with the approval of the Division and concurrence of the Forest, will instigate a vegetation monitoring and mitigation plan similar to the plan implemented prior to the undermining of the East Fork of Box Canyon. If mitigation of surface cracks is required, methods similar to those proposed and implemented in the East Fork of Box Canyon as described in Chapter 5 Section 5.2.5.1 and Chapter 7 Section 7.3.1.8 will be used.

The monitoring and mitigation plan for undermining the South Fork of Quitchupah 2R2S Block "A" and 3R2S Block "B" is located in Appendix 3-14. Appendix 3-14 contains a Threatened, Endangered and Sensitive survey prepared by Mt. Nebo Scientific and an assessment of the macroinvertebrates in the South Fork of Quitchupah Creek. The macroinvertebrate assessment was prepared by Dennis K. Shiozawa, Ph.D., which contains the results of a series of benthic samples taken to determine the diversity of the invertebrate community in the South Fork of Quitchupah Creek.

The applicant will request that future power lines on the SUFCO Mine site be constructed per OSM and UDOGM regulations or with alternative guidelines approved by the regulatory authority. Additional information referencing power lines is located in Section 3.5.8.5.

Efforts will be taken to regulate the use of pesticides when needed. Before a pesticide is used, the type and concentration will be approved by the Regulatory Authority.

# APPENDIX 3-14

## Monitoring and Mitigation Plan for Undermining the South Fork of Quitchupah 2R2S Block "A" and 3R2S Block "B"

# AN ASSESSMENT OF THE MACROINVERTEBRATES OF THE SOUTH FORK OF QUITCHUPAH CREEK EMERY COUNTY, UTAH

IN

JULY-AUGUST 2012

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# Introduction

Sufco Mine in Salina Canyon is extending its mining operations under the South Fork of Quitchupah Canyon in Emery County, Utah. This report gives the results of series of benthic samples taken to determine the diversity or the benthic invertebrate community in that portion of the stream.

# Methods

Sample placement was determined by examination of the stream system with guidance as to where the mine expansion would be located. Five stations were established, with the lowest being within Quitchupah Canyon and the highest being on the plateau upstream of the mining boundary (Table 1). An upstream transect of eight locations, each being three meters apart, were sampled within each station. Because of the dominance of sandy substrates, no habitats directly analogous to riffles were found. Two benthic samples were bulked together at each of the eight sample locations within each station. Physical characteristics for each reach were recorded (Table 2). These included conductivity, in micro-Siemens/cm (uS/cm), alkalinity, and hardness. Alkalinity and hardness were measured with a Hach water chemistry kit.

**Table 1. Sampling station locations**

| Date sampled | Reach | GPS coordinates | Elevation |
|---|---|---|---|
| August 1, 2012 | Above | N 38° 57' 57.58" W 111° 25' 38.71" | 2533 m (8310 ft ) |
| August 1, 2012 | Upper | N 38° 57' 58.30" W 111° 25' 24.56" | 2520 m (8267 ft) |
| August 1, 2012 | Middle | N 38° 57' 55.89' W 111° 25' 12.32" | 2512 m (8241 ft) |
| August 1, 2012 | Lower | N 38° 57' 57.04" W 111° 24' 56.56" | 2501 m (8206 ft) |
| July 29, 2012 | Canyon | N 38° 57' 54.45" W 111° 24' 36.53" | 2462 m (8077 ft) |

**Table 2. Physical Characterization of South Fork of Quitchupah Creek, 2012**

| Station | Alkalinity mg/L $CaCO_3$ equivalents | Hardness mg/L $CaCO_3$ equivalents | Conductivity (uS/cm) | Slope cm/m | Depth (cm) | width (cm) | velocity (m/s) | pH |
|---|---|---|---|---|---|---|---|---|
| Above | 120 | 320 | 550 | 1.58 | 8.67 | 49.1 | 0.360 | --- |
| Upper | 120 | 300 | 500 | 1.46 | 7.93 | 53.9 | 0.310 | --- |
| Middle | 140 | 340 | 560 | 1.04 | 6.96 | 45.6 | 0.320 | 10.9 |
| Lower | 140 | 320 | 574 | 1.33 | 6.33 | 58.9 | 0.292 | 9.50 |
| Canyon | 140 | 320 | 540 | 8.19 | 4.42 | 112.3 | 0.168 | 9.35 |

Chemical data were obtained from Sufco because our chemical data did not include sulfate concentrations and the samples were taken for just one point in time, which can significantly bias the water chemistry estimates. When we sampled, late July to early August of 2012, the Arizonal monsoon storms had begun. These storms likely increased stream flow and resulted in the dilution of chemical concentrations.

**Table 3.**

| Alkalinity | 6-2012 | 9-2012 | 10-2012 | 6-2013 | 9-2013 | Average |
|---|---|---|---|---|---|---|
| 006A | 421 | 206 | 213 | -- | -- | 280 |
| 006 | 355 | 209 | 223 | 243 | 289 | 263.8 |
| 006B | -- | 210 | 230 | -- | -- | 220 |
| 006C | -- | 217 | 231 | -- | -- | 224 |
| 006D | -- | 223 | 233 | 221 | 274 | 231 |
| Amanda Spring | -- | 189 | 188 | 0 | 211 | 147 |
| Robert Spring | 407 | 397 | 411 | 467 | 417 | 419.8 |

**Table 4.**

| Sulfate | 6-2012 | 9-2012 | 10-2012 | 6-2013 | 9-2013 | Average |
|---|---|---|---|---|---|---|
| 006A | 183 | 103 | 101 | -- | -- | 129 |
| 006 | 135 | 105 | 102 | 119 | 111 | 114.4 |
| 006B | -- | 104 | 107 | -- | -- | 105.5 |
| 006C | -- | 102 | 106 | -- | -- | 104 |
| 006D | -- | 105 | 111 | 121 | 117 | 113.3 |
| Amanda Spring | -- | 67 | 68 | 72 | -- | 69 |
| Robert Spring | 145 | 145 | 143 | 154 | 289 | 175.2 |

Quantitative invertebrate samples were taken with a modified box sampler (Shiozawa 1986) using a capture net with a net mesh of 253 microns. The sampler measured 20cmX16.5 cm and the total sample area per station was0.528 square meters. Samples were concentrated in the field in sieves with 63 micron mesh and were preserved with ethyl alcohol. In the laboratory the samples were washed to eliminate sediments, sorted in an illuminated pan and organisms were removed. After the visual sorting, the sample was subsampled and the subsamples were examined under magnification. All organisms were re-examined under magnification and were identified to the lowest taxonomic unit possible. Identification was based on the keys of Merritt, Cummins, and Berg (2008) and in some cases additional keys were utilized to clarify structures and identification. The taxon-specific density estimates from the subsamples were calculated and the projected numbers of organisms missed in the visual sorting were added to the total for the sample. The mean values for each taxon were used to determine the density of invertebrates per square meter.

The USFS Biotic Condition Index (Winget and Mangum 1979) was calculated with the community tolerance quotient (CTQa). The predicted community tolerance quotient (CTQp), based on water chemistry data provided by V. Miller, Sufco Mine and data colledted during sampling in 2012. Diversity was calculated for each reach using the Shannon-Weiner index (Pielou 1977). Diversity indices take the number of taxa and their individual densities into account, generating a single value for each station. The greater the number of species or taxa and generally the more even the distribution of densities between taxa, the higher the diversity index value.

Cluster analysis was run with NTSYS-pc (Rolf 2000), using the Bray-Curtis dissimilarity index with the UPGM clustering algorithm. Data from all bulked samples were included in the cluster analysis.

Correspondence analysis, an ordination technique (Braak and Smilauer 2002), was run on the data set to generate a graphical view of relationships among the stations sampled in the South Fork of Quitchupah Creek. A plot of the station ordinations will show the 2012 associations among bulked samples in the analyses. For simplicity only the first two canonical axes are examined. These two axes only carry a portion of the total variation being explained by the procedure, but they are sufficient for illustrating associations between and within stations. Since these samples are to be used to establish pre-mining base-line information, the most important information for future assessment will be the actual densities and taxa lists. The CTQa, diversity indices, and cluster analysis will serve to help understand relative associations between the sampling stations.

## Results and Discussion

### Physical Characterization

Because the upstream sample stations are on the Wasatch Plateau and the downstream-most sample is in the downcut canyon, the stream channel slope is shallow in the upstream sites and the downstream-most station (Canyon) has the highest gradient (Table 2). Generally one expects channel depth and width to increase downstream, with the inflow of seeps and side-streams from the watershed. However in this reach of the South Fork of Quitchupah Creek the distance between the sample stations is too short for significant inflow from side streams. In fact the surrounding porous sandy soil substrate likely allows significant movement of water away (an exfluent system) from the channel in the upstream reaches in the summer since the general climate of the region is relatively arid. Once in the canyon the stream will tend to retain and gain water from the surrounding riparian area because of the extehnsive bedrock substrate. In the canyon station, the stream width increased and the mean velocity decreased. This is most likely the result of increased riparian input into the stream channel. The canyon station riparian is thickly wooded with conifers and significantly more woody debris accumulates in the stream than in the more open willow-aspen canopy of the upstream riparian systems. The debris dams

block water flow, slowing velocity and widening the channel. In addition, the stream is flowing over shallow bedrock, which reduces its ability to deeply incise the channel into loose sediments beyond that which is cut during spates.

The chemical characteristics of the streams appear typical for high desert systems draining exposed sedimentary bedrock. Alkalinity, hardness, and conductivity slightly increased downstream (Table 2) suggesting some exchange with ground water and leaching of salts from the sediments. Alkalinity is generally a measure of carbonate concentration, while hardness is a measure of divalent cations (mainly Ca and Mg). In this stream section the total hardness was double the alkalinity. If the ions in the systems were purely due to carbonates of calcium and magnesium, we would expect alkalinity to equal hardness. However higher hardness readings indicate that the remaining anions in the system are chlorides, sulfates, silicates, or nitrates (Boyd 1990). Given the origin of the bedrock it is likely that the major anions are sulfates and chlorides.

Conductivity readings so not indicate any longitudinal trends in the stream. The pH recorded on this sampling series was unreliable. We obtained some readings that appeared valid, but the probe failed to give consistent reading in the uppers station. The pH was at the high end of the normal scale for natural waters (about 8.5; Hem 1971), but because of the extreme variability in our pH readings, they will not be interpreted.

## Biological Characterization

### Number of Taxa

A total of 36 taxa were collected from the South Fork of Quitchupah Creek in this study (Table 5). The most abundant order was Diptera. The highest number of taxa were collected in the upper three stations. The total number of taxa in the South Fork of Quitchupah Creek, when compared to rocky substrate streams farther north on the Wasatch Plateau, are about 30 to 50% lower per station per sampling date, although the collective total number of taxa collected, in all orders, is much greater in the northern Wasatch Plateau streams where samples have been taken over multiple years (Shiozawa 2013).

### Total Densities

Total invertebrate densities ranges from 6600 to 28,300 per square meter (Table 6). These numbers are comparable to the low range estimates for the rocky substrate streams in the Northern Wasatch Plateau region (Shiozawa 2013).

## Taxa Specific Densities

Four taxa, baetid mayflies, chironomids, water mites, and oligochaetes, numerically dominated the density estimates in the South Fork of Quitchupah Creek (Table 6).

**Table 5. Number of Taxa collected from South Fork Quitchupah Canyon**

| Station | Plecoptera | Trichoptera | Coleoptera | Diptera | Total Taxa |
|---|---|---|---|---|---|
| Above | 1 | 5 | 2 | 13 | 28 |
| Upper | 1 | 2 | 2 | 13 | 24 |
| Middle | 2 | 1 | 1 | 11 | 22 |
| Lower | 1 | 4 | 2 | 9 | 21 |
| Canyon | 1 | 2 | 1 | 10 | 20 |
| Total taxa | 2 | 5 | 3 | 18 | 36 |

The Above Station, which is outside of the mining boundary, had almost 1000 baetid mayflies per square meter. The stonefly Zapada was collected at almost 900 per square meter and chironomids at 4000 per square meter. Mites comprised approximately 2000 of the invertebrates per square meter at this station and oligochaetes were found at levels over 9000 per square meter. Other taxa were much less abundant.

Baetid mayflies in the Upper Station had densities at about 850 per square meter. The chironomids were extremely abundant at over 23,000 per square meter. Simuliids were present at 1300 per square meter. Mites comprised approximately 2000 per square meter and oligochaetes were about 1800 per square meter. Other taxa were much less abundant.

The Middle Station was dominated by just two taxa. Chironomids, estimated at about 3500 per square meter, and oligochaetes, at almost at 3000 per square meter, were the two dominant taxa at this station. Other taxa were much less abundant.

The Lower Station had baetid mayflies at about 1600 per square meter and chironomids at almost 18,000 per square meter. Simuliids were found at about 750 per square meter and mites at about 700 per square meter. Other taxa were much less abundant.

The Canyon Station had baetid mayflies at 1500 per square meter, chironomids at about 4000 per square meter, and oligochaetes at about 700 per square meter. Other taxa were much less abundant.

Three taxa tended to dominate at most stations, baetid mayflies, chironomids, and oligochaetes. Simuliids were also found in high abundance in several stations, but their occurrence is likely a

function of sample locations falling in a position where samples included woody debris, hard substrates, exposed roots, or submerged grasses. Simullids require a hard substrate for attachment. These taxa are often characteristic of harsher conditions because they tend to be relatively vagrant (baetids and simuliids), or capable of living in sandy substrates (oligochaetes, chironomids) (Jordan et al 1999). However the chironomids were relatively vermiform, which is characteristic for taxa adapted to living interstitially (Shiozawa 1986). This indicates that the midges in the South Fork of Quitchupah Creek include species that are adapted to the sandy stream bed. The chironomids were not identified beyond the family level because of the time required to prepare each specimen for keying, but their presence suggests that the sandy substrate in the stream may have significant interstitial oxygen present.

**Table 6. Densities, in number per square meter, for the South Fork of Quitchupah Creek.**

| Taxa | Above | Upper | Middle | Lower | Canyon | Average density |
|---|---|---|---|---|---|---|
| Ephemeroptera: Baetidae: Baetis sp. | 979.17 | 861.74 | 51.14 | 1589.02 | 1511.36 | 998.49 |
| Plecoptera: Chloroperlidae: Paraperla frontalis | 0 | 0 | 1.89 | 0 | 0 | 0.38 |
| Plecoptera: Nemouridae: Zapada | 880.68 | 1.89 | 81.44 | 64.39 | 18.94 | 209.47 |
| Trichoptera: general | 22.73 | 7.58 | 0 | 39.77 | 1.89 | 14.39 |
| Trichoptera: Brachycentridae: Brachycentrus | 9.47 | 0 | 0 | 1.89 | 68.18 | 15.91 |
| Trichoptera: Limnephilidae: Hesperophylax | 1.89 | 5.68 | 11.36 | 7.58 | 0 | 5.30 |
| Trichoptera: Hydroptilidae: Ochrotricha | 115.53 | 0 | 0 | 0 | 0 | 23.11 |
| Trichoptera: Rhyacophilidae: Rhyacophila | 3.79 | 0 | 0 | 1.89 | 0 | 1.14 |
| Coleoptera: Dryopidae: Helichus | 0 | 0 | 5.68 | 7.58 | 66.28 | 15.91 |
| Coleoptera: Dytiscidae: Agabus | 3.79 | 1.89 | 0 | 20.83 | 0 | 5.30 |
| Coleoptera: Elmidae: Optioservus | 26.52 | 1.89 | 0 | 0 | 0 | 5.68 |
| Diptera: Ceratopogonidae:Probezzia | 32.20 | 7.58 | 223.48 | 0 | 1.89 | 53.03 |
| Diptera: Ceratopogonidae:Stizobezzia | 1.89 | 15.15 | 0 | 9.47 | 1.89 | 5.68 |
| Diptera: Chironomidae | 3962.12 | 23390.16 | 3539.77 | 17748.11 | 3962.12 | 10825.76 |
| Diptera: Dixidae: Dixa | 5.68 | 24.62 | 15.15 | 0 | 0 | 9.09 |
| Diptera: Empididae: Hemerodromia | 1.89 | 5.68 | 3.79 | 3.79 | 7.58 | 4.55 |
| Diptera: Empididae: Neoplasta | 0 | 0 | 0 | 0 | 3.78 | 0.76 |
| Diptera: Empididae: Oreogeton | 1.89 | 1.89 | 0 | 0 | 0 | 0.76 |
| Diptera: Muscidae: Limnophora | 0 | 1.89 | 0 | 13.26 | 0 | 3.03 |
| Diptera: Psychodidae: Pericoma | 7.58 | 1.89 | 115.53 | 0 | 0 | 25.00 |
| Diptera: Simuliidae: Simulium | 35.98 | 1299.24 | 392.04 | 755.68 | 3.79 | 479.35 |
| Diptera: Stratiomyidae: Caloparyphus | 7.58 | 11.36 | 18.94 | 5.68 | 1.89 | 9.09 |
| Diptera: Tabanidae: Chyrsops | 0 | 0 | 1.89 | 0 | 0 | 0.38 |
| Diptera: Tipulidae: Antocha | 30.30 | 0 | 17.05 | 0 | 0 | 9.47 |
| Diptera: Tipulidae: Dicranota | 51.14 | 5.68 | 32.20 | 1.89 | 20.83 | 22.35 |
| Diptera: Tipulidae: Hexatoma | 15.15 | 1.89 | 87.12 | 5.68 | 5.68 | 23.11 |
| Diptera: Tipulidae: Limnophila | 0 | 3.78 | 0 | 0 | 0 | 0.78 |
| Diptera: Tipulidae:Oromosa | 0 | 0 | 0 | 0 | 1.89 | 0.38 |
| Diptera: Tipulidae: Tipula | 1.89 | 0 | 0 | 1.89 | 0 | 0.78 |
| Crustacea: Ostracoda | 79.55 | 378.79 | 53.03 | 64.39 | 41.67 | 123.48 |
| Arachnida: Hydracarina | 2329.55 | 106.06 | 37.88 | 678.03 | 0 | 630.30 |
| Mollusca: Physa | 0 | 0 | 1.89 | 0 | 0 | 0.38 |
| Mollusca: Sphaeriidae: Sphaerium | 119.31 | 1.89 | 259.46 | 0 | 41.67 | 83.33 |
| Annelida: Oligochaeta | 9532.20 | 1840.91 | 2922.35 | 435.61 | 679.92 | 3082.20 |
| Collembola | 85.22 | 0 | 0 | 0 | 130.68 | 41.18 |
| Nematoda * | 149.62 | 388.26 | 333.33 | 49.24 | 66.29 | 197.35 |
| Total | 18482.94 | 28367.39 | 8155.27 | 21503.78 | 6638.22 | 16925.89 |
| N | 28 | 24 | 22 | 21 | 20 | 36 |

## Individual Tolerance Quotients of Aquatic Invertebrates

The Individual Tolerance Quotients were obtained from the tolerance scores provided in Winget and Mangum (1979). Since these are based on the presence-absence of taxa, neither the actual or relative abundances are considered in this index. Thus a single individual per square meter is of equal weight to another taxa represented by thousands of individuals in the same area. These individual indices do give some insight into the type of water conditions the various taxa are able to tolerate. Those with a tolerace score of 108 are able to survive in a wide range of conditions, while low tolerance values indicate taxa that require much more specific stream conditions to survive.

**Table 7. Tolerance Quotients for South Fork Quitchupah Creek invertebrates.**

| Taxa | Above | Upper | Middle | Lower | Canyon | Total stream |
|---|---|---|---|---|---|---|
| Ephemeroptera: Baetidae: Baetis sp. | 72 | 72 | 72 | 72 | 72 | 72 |
| Plecoptera: Chloroperlidae: Paraperla frontalis | | | 24 | | | 24 |
| Plecoptera: Nemouridae: Zapada | 16 | 16 | 16 | 16 | 16 | 16 |
| Trichoptera: general | 18 | 18 | | 18 | 18 | 18 |
| Trichoptera: Brachycentridae: Brachycentrus | 24 | | | 24 | 24 | 24 |
| Trichoptera: Limnephilidae: Hesperophylax | 108 | 108 | 108 | 108 | | 108 |
| Trichoptera: Hydroptilidae: Ochrotricha | 108 | | | | | 108 |
| Trichoptera: Rhyacophilidae: Rhyacophila | 18 | | | 18 | | 18 |
| Coleoptera: Dryopidae: Helichus | | | 54 | 54 | 54 | 54 |
| Coleoptera: Dytiscidae: Agabus | 72 | 72 | | 72 | | 72 |
| Coleoptera: Elmidae: Optioservus | 108 | 108 | | | | 108 |
| Diptera: Ceratopogonidae:Probezzia | 108 | 108 | 108 | | 108 | 108 |
| Diptera: Ceratopogonidae:Stizobezzia | 108 | 108 | | 108 | 108 | 108 |
| Diptera: Chironomidae | 108 | 108 | 108 | 108 | 108 | 108 |
| Diptera: Dixidae: Dixa | 108 | 108 | 108 | | | 108 |
| Diptera: Empididae: Hemerodromia | 108 | 108 | 108 | 108 | 108 | 108 |
| Diptera: Empididae: Neoplasta | | | | | 108 | 108 |
| Diptera: Empididae: Oreogeton | 108 | 108 | | | | 108 |
| Diptera: Muscidae: Limnophora | | 108 | | 108 | | 108 |
| Diptera: Psychodidae: Pericoma | 36 | 36 | 36 | | | 36 |
| Diptera: Simuliidae: Simulium | 108 | 108 | 108 | 108 | 108 | 108 |
| Diptera: Stratiomyidae: Caloparyphus | 108 | 108 | 108 | 108 | 108 | 108 |
| Diptera: Tabanidae: Chyrsops | | | 108 | | | 108 |
| Diptera: Tipulidae: Antocha | 24 | | 24 | | | 24 |
| Diptera: Tipulidae: Dicranota | 24 | 24 | 24 | 24 | 24 | 24 |
| Diptera: Tipulidae: Hexatoma | 36 | 36 | 36 | 36 | 36 | 36 |
| Diptera: Tipulidae: Limnophila | | 72 | | | | 72 |
| Diptera: Tipulidae:Oromosa | | | | | 72 | 72 |
| Diptera: Tipulidae: Tipula | 36 | | | 36 | | 36 |
| Crustacea: Ostracoda | 108 | 108 | 108 | 108 | 108 | 108 |
| Arachnida: Hydracarina | 108 | 108 | 108 | 108 | | 108 |
| Mollusca: Physa | | | 108 | | | 108 |
| Mollusca: Sphaeriidae: Sphaerium | 108 | 108 | 108 | | 108 | 108 |
| Annelida: Oligochaeta | 108 | 108 | 108 | 108 | 108 | 108 |
| Collembola | 108 | | | | 108 | 108 |
| Nematoda * | 108 | 108 | 108 | 108 | 108 | 108 |
| Total | 2212 | 2074 | 1798 | 1558 | 1612 | 2866 |
| N | 28 | 24 | 22 | 21 | 20 | 36 |

## Community Tolerance Quotient and Biotic Condition Indices

The Individual Tolerance Quotients for the taxa at a given station are summed and then divided by the number of taxa in the sum (Table 7). This generates the Community Tolerance Quotient for the actual station being sampled (CTQa: Table 8). An ideal Community Tolerance is predicted (CTQp) for a given stream location based on slope, substrate, alkalinity, and sulfate concentrations. These data are run through a key provided by Winget and Mangum (1979) which will give the expected CTQp (Table 8) for the given station. We used the water chemistry data for the Station 0006 A, 006, 006B, 006C, and 006D (Tables 3 and 4) for our chemical estimates because these data cover multiple years and multiple seasons within years. This provides a more robust estimate of these conditions when determining the average concentration of sulfates and alkalinity in the stream.

**Table 8. CTQa and BCI values for the South Fork of Quitchupah Creek**

| Station | CTQa | CTQp | BCI |
|---|---|---|---|
| Above | 79.0 | 65 | 82.3 |
| Upper | 86.4 | 65 | 75.2 |
| Middle | 81.7 | 60 | 73.4 |
| Lower | 74.2 | 65 | 87.6 |
| Canyon | 80.6 | 80 | 99.3 |
| Total | 79.6 | -- | -- |

The Predicted Community Tolerance Quotient (CTQp) for the stream is divided by the actual Community Tolerance Quotient (CTQa) to generate a proportional ratio of the two. This ratio is multiplied by 100 to generate the Biotic Condition Index (Table 8). This ratio effectively reverses the reading of the relationships in the CTQa, so that instead of low values being indicative of higher quality waters, high BCI values indicate better water quality. The ideal is a BCI of 100 or higher, meaning that the station meets or exceeds the predicted level.

None of the five stations have a BCI over 100, but the Canyon station essentially meets the predicted CTQp, and the Lower station is also close. The BCI for these stations, given that they do not contain rubble substrate suggests that the streams are still in reasonably good condition. A number of taxa associated with good water quality occur in the stream system including several stoneflies and a number of dipterans (tipulids).

## Diversity Indices

Diversity indices combine both number of taxa and relative densities into a single measurement.

High diversity index values indicate more taxa and an even number of individuals per taxon. Low diversity values generally reflect a depauperate fauna in species and a very skewed distribution in numbers per taxon. Usually a low diversity community will be dominated by just a few taxa with other taxa being rare and in low density.

The five stations on the South Fork of Quitchupah Creek all had relatively low diversity index values (Table 9) when compared to streams such as Woods and Winter Quarters Canyons located farther north on the Wasatch Plateau (Shiozawa 2013) where the values are generally above 2.0. However even those relatively diverse streams have occasional declines in diversity. In July of 2008 and again in July of 2011, one station on Winter Quarters Canyon had diversity index values (1.208 and 1.464 respectively), lower than those in two of the Quitchupah stations in this study. The South Fork of Quitchupah stations were in coarse sand, occasionally with a small portion of fine pea gravel present. Yet two of the four South Fork of Quitchupah stations had higher diversity than was recorded in two July samples in Winter Quarters Canyon. The Winter Quarters samples were taken in riffles with rubble habitat. Sandy stream bottoms are very harsh on invertebrates because sand is easily eroded by flowing water and thus is very abrasive to invertebrates living in that habitat. In addition, when the sand is not actively moving, its interstitial spaces tend to fill with silt and clays, generating anoxic conditions. Both factors reduce the number of taxa that can survive in the system. Therefore the diversity recorded in the stream is surprising and suggests that the community is likely comprised of taxa well adapted to shifting sand substrates.

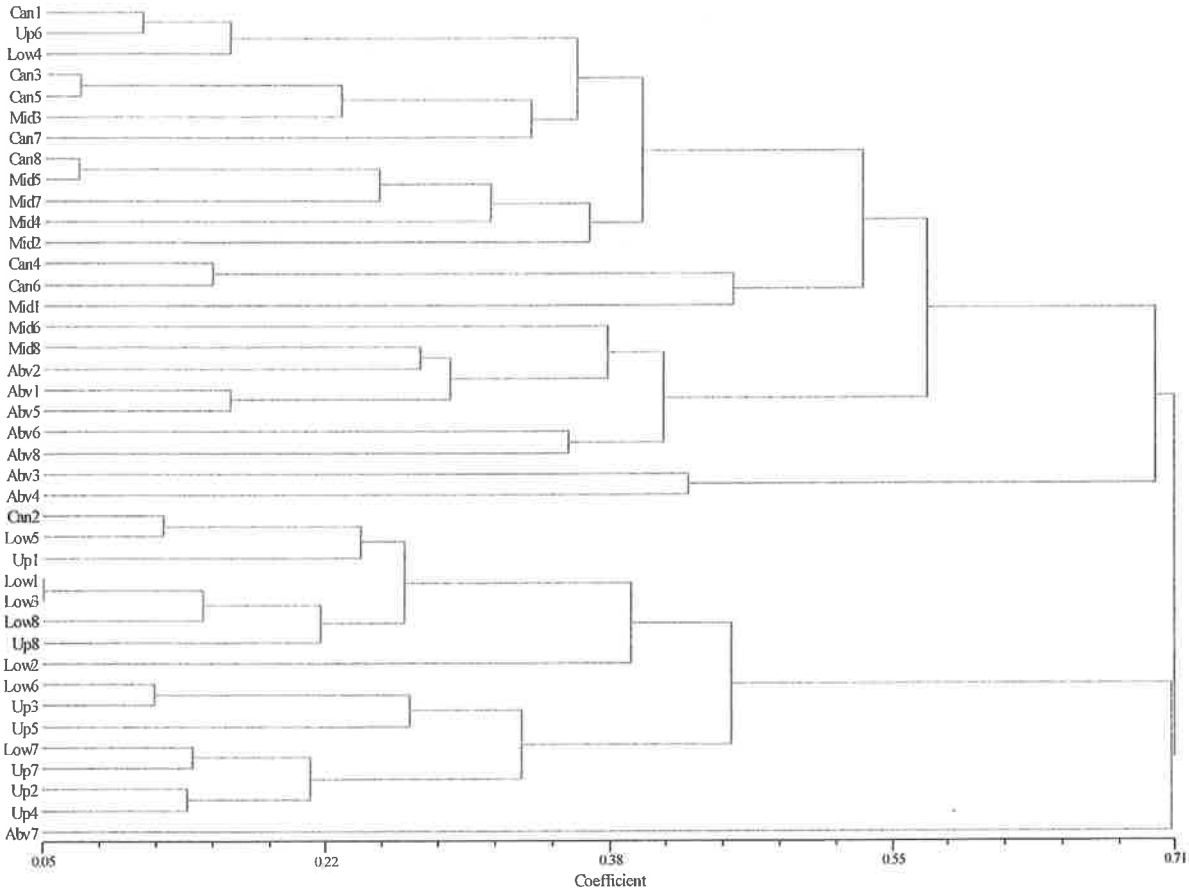
**Table 9. Diversity indices, based on natural logs, for the South Fork of Quitchupah Canyon**

| | Above | Upper | Middle | Lower | Canyon |
|---|---|---|---|---|---|
| Diversity Index | 1.47902 | 0.75031 | 1.53993 | 0.74642 | 1.07908 |

## Cluster Analysis

The cluster analysis of the data utilizes the Bray-Curtis dissimilarity index (Poole 1974, Krebs 1989) with the unweighted pairs group averaging algorithm (UPGMA) (NTSYS; Rolf 2000). The analysis (Figure 1) resulted in four principle clusters separating at a dissimilarity value of approximately 0.60. The top cluster, Cluster 1 for reference, contained the Middle Station and all but one of the Canyon Station samples. Recall that the samples in this analysis represent two samples bulked together at each sample site along the stream transect. Five Above Station samples also fell into this cluster. The second cluster, Cluster 2, consisted of just two of the Above Station samples. Cluster 3 consisted of the Lower and Upper station samples with the exception of a single sample each from the Lower and Upper stations, which fell into Cluster 1. The Lower and Upper stations were similar to one another in composition, showing no obvious segregation within Cluster 3, and interestingly, even the representatives of the two stations in Cluster 1 were very similar to one another. Cluster 4 consisted of a single Above Station sample.

**Figure 1. UPGMA Cluster dendrogram of relationships among communities from the South Fork of Quitchupah Canyon.**



It appears that the Above Station has the highest heterogeneity, with three individual sample locations (Cluster 2 and Cluster 4) at that station being highly divergent. The remaining five samples were in Cluster 1, but within that cluster they were clearly more similar to one another than to the other stations in the Cluster 1.

**Conical correspondence analyses**

The Canonical Correspondence Analysis allows a visualization of both the distribution of the individual bulked sample data relative to the taxa collected in those samples (Figure 2) and the location of centroids of distribution of the taxa included in the analysis (Figure 3). The Samples –based plot (Figure 2) separates the Middle Station samples (in yellow) from the other sample stations. The Above Station samples (in black) form a scatter of points that runs horizontally across the ordination plot, suggesting a wider range in taxa than occurred in the Middle Station. The Above Station in the cluster analysis is also somewhat separated from the other stations. The other three stations, the Upper, Lower, and Canyon were greatly overlapping in their plots. The overlap between the Lower and Upper Stations is also detected in the cluster analysis (Figure 1). But the Canyon Station sites, widely dispersed among the Middle Station samples in the cluster analysis were quite distinct from the Middle Station samples in the ordination plot. These differences likely relate to the differences in the indices used, since the Bray-Curtis relied on raw counts while the canonical correspondence analyses used a log (x+1) transformation to reduce the impact of extremely high numbers of some taxa relative to the others.

The ordination of the relationship among taxa (Figure 3) is based on the densities of the different taxa collected in the samples. The plotted points (Figure 3, triangles) represent the centroids (means) for each of these taxa in first two canonical axes. This plot corresponds with the placement of the samples in Figure 2 and can be interpreted as showing which taxa are most important in various regions of the first two canonical axes. Thus the Middle Station samples (Figure 2) are strongly influenced by.Hexatoma, Physa, Sphaerium, Chrysops, and Pericoma. This relationship is verified by examining the densities of these taxa in Table 6.

## Conclusions

The stream stations sampled in the South Fork of Quitchupah Creek were similar to one-another in having sandy substrates with no classical riffle habitats. Occasionally woody debris, riparian root masses, and grass stems were found in sample quadrants. The Canyon site had a much steeper gradient but also had a wider stream channel and much slower flow. These characteristics were likely associated with the debris dams in the channel because of the narrow canyon bordering the riparian.

The domination of the invertebrate community by baetid mayflies, simuliids, chironomids and oligochaetes results in lower diversity values than is found in rocky streams. That in itself does not indicate that the stream is heavily impacted by anthropogenic factors. In fact the community

**Figure 2. Sample-based ordination plot indicating sample centroids.**

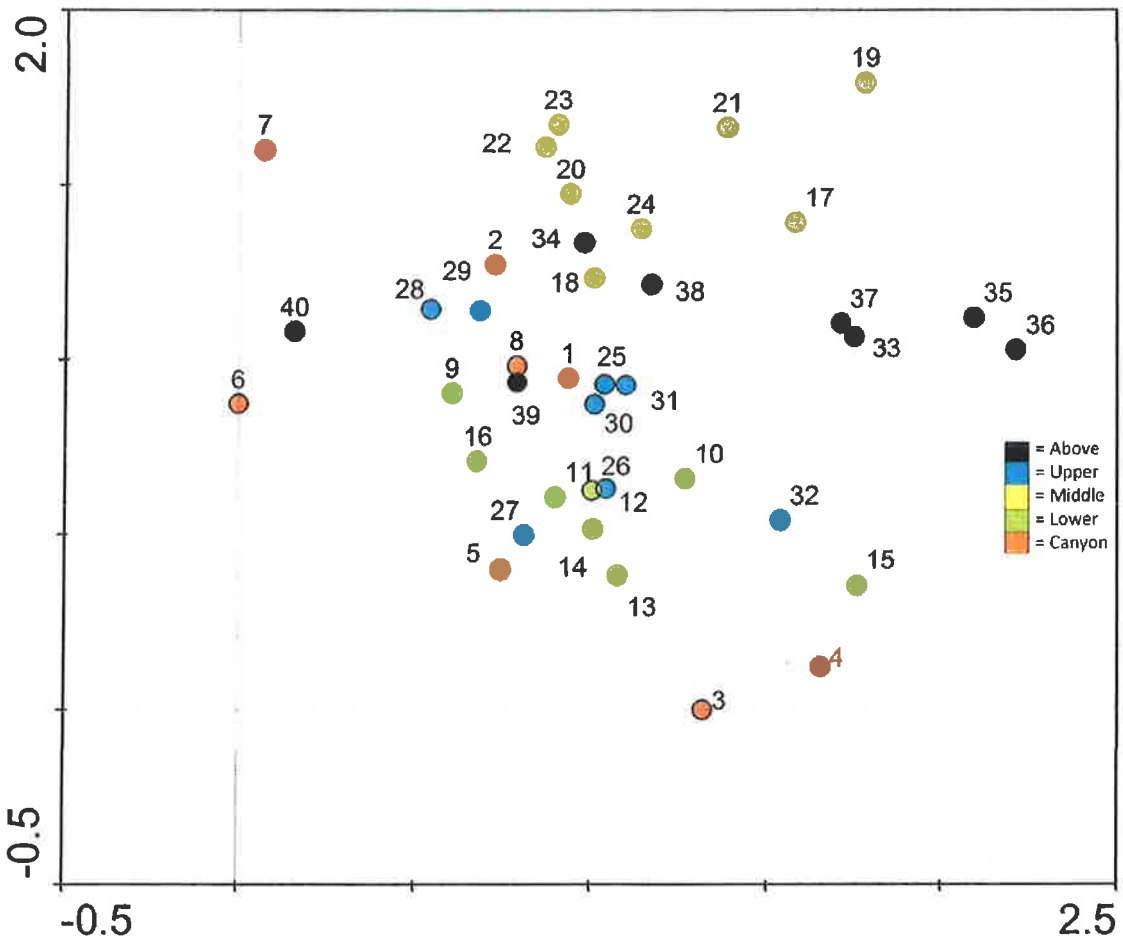
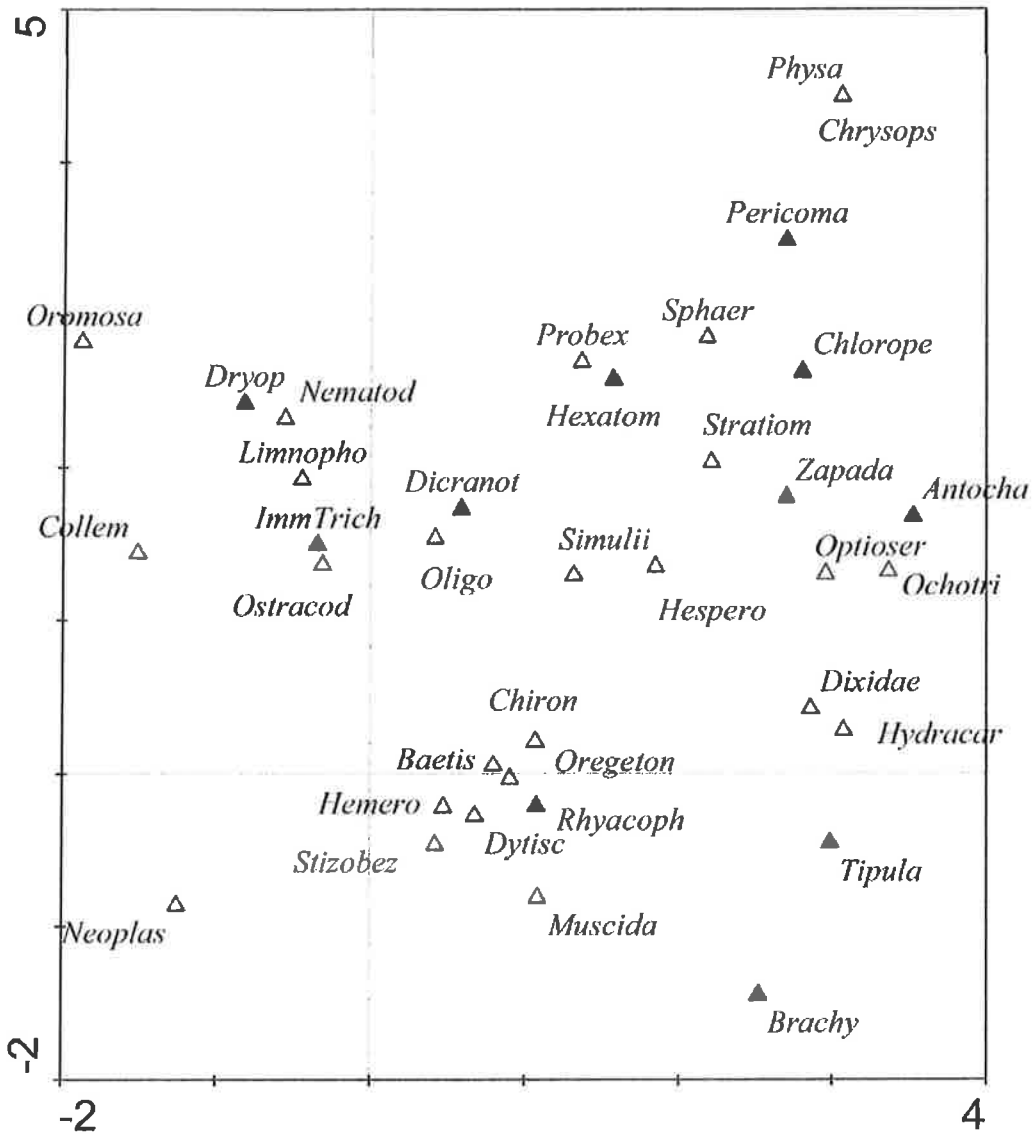


**Figure 3. Taxa ordination plot indicating taxon-specific centroids. Red = taxa with low Tolerance Quotients.**



structure is similar to those documented in sandy river systems (Palmer 1990, Wolz and Shiozawa 1995, Jordan et al 1999). Further the diversity values are within the low range occasionally detected in Woods and Winter Quarters Canyon (Shiozawa 2013). Of course similar diversity indices can be obtained with widely differing community types so that alone is not sufficient to indicate whether this system is either in good condition or degraded. Likewise the Community Tolerance Quotient and Biotic Condition Index resulted in somewhat equivocal information. The CTQa indicated that a number of taxa in the communities sampled were characteristic of higher quality systems while the BCI showed the Canyon Station met the predicted community structure. The other stations were mostly within 25% of the ideal BCI value and clearly that index was developed without including sandy substrate streams. That bias strongly suggests that this stream more closely meets the ideal given the slope and water chemistry parameters.

The lack of rubble and gravel in the stream suggest that the sandstone in the area surrounding the South Fork of Quitchupah Creek may be too soft to produce coarse substrates, or that sand resting on the top of the plateau in that region is so thick that very little larger material is present to enter the stream channel. In either case, the abundance of sand in the channel would restrict the invertebrate community to taxa adapted to living in sandy stream beds. Several facts support this. First the chironomids present in the stream were dominated by a larva that is much more streamlined than those usually found in rocky streams. While this taxon was not identified, its dominance in the South Fork of Quitchupah suggests that the environment has favored the success of an adaptive body shape. If the midges were a residual from a preexisting community adapted to rubble communities, they would be expected to have the predominant body for of midges in other rocky stream systems on the Wasatch Plateau. Second, a number of tipilid larvae were collected, including one specimen which we were unable to identify in our larval keys. The presence of many members of this single dipteran family indicates that this canyon has a unique environment favorable to this group. That environment is likely the canyon habitat with its thick riparian cover and high detrital content. Even if this system is subject to large spates, recolonization by dipterans from the surrounding metapopulation would be relatively rapid.

The cluster analysis and the canonical correspondence analysis both detected some differences between sample stations. However no definite upstream-downstream pattern was detected with either approach. The taxa having low Tolerance Coefficients (Table 7) thus indicating high water quality were not concentrated together in the Taxa Ordination plot (red triangles Figure 3), also indicating that the stations were not separating in any particular region (stations) of the first two canonical axes. It is possible that, had additional canyon stations been examined, we would have been able to identify differences in the upstream and canyon communities due to the shift in riparian habitat. The canyon provides a protected environment which likely has higher humidity and weaker winds that the exposed reaches on the top of the plateau. These factors may favor a higher diversity in weaker fliers, such as the tipulids.

## Literature Cited


Braak, C. J. F. and P. Smilauer. 2002. CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (Version 4.5). Microcomputer Power. Icatha, NY. 500 pp.

Boyd, C. E. 1990. Water quality in ponds for aquaculture. Birmingham Publishing Co. Birmingham, AL. 482 pp.

Hem, J. D. 1971. Study and interpretation of the chemical characteristics of natural water. U. S. Geological Survey Water-Supply Paper No. 1473. 363 pp.

Jordan, S., D. K. Shiozawa, and J. M. Schmid-Araya. 1999. Benthic invertebrates of a large sandy river system: The Green and Colorado Rivers of Canyonlands National Park, Utah. Arch. Hydrobiol. 147:91-127.

Merritt, R. W., K. W. Cummins, and M. B. Berg. (eds.) 2008. An Introduction to the Aquatic Insects of North America. 4th Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa. 1158 pp

Palmer, M. A. 1990. Temporal and spatial dynamics of meiofauna within the hyporheic zone of Goose Creek, Virginia. J. North Amer. Benthological Soc. 9: 17-25.

Pielou, E. C. 1977. Mathematical Ecology. John Wiley and Sons. NY, NY. 385 pp.

Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill, Inc. 532pp.

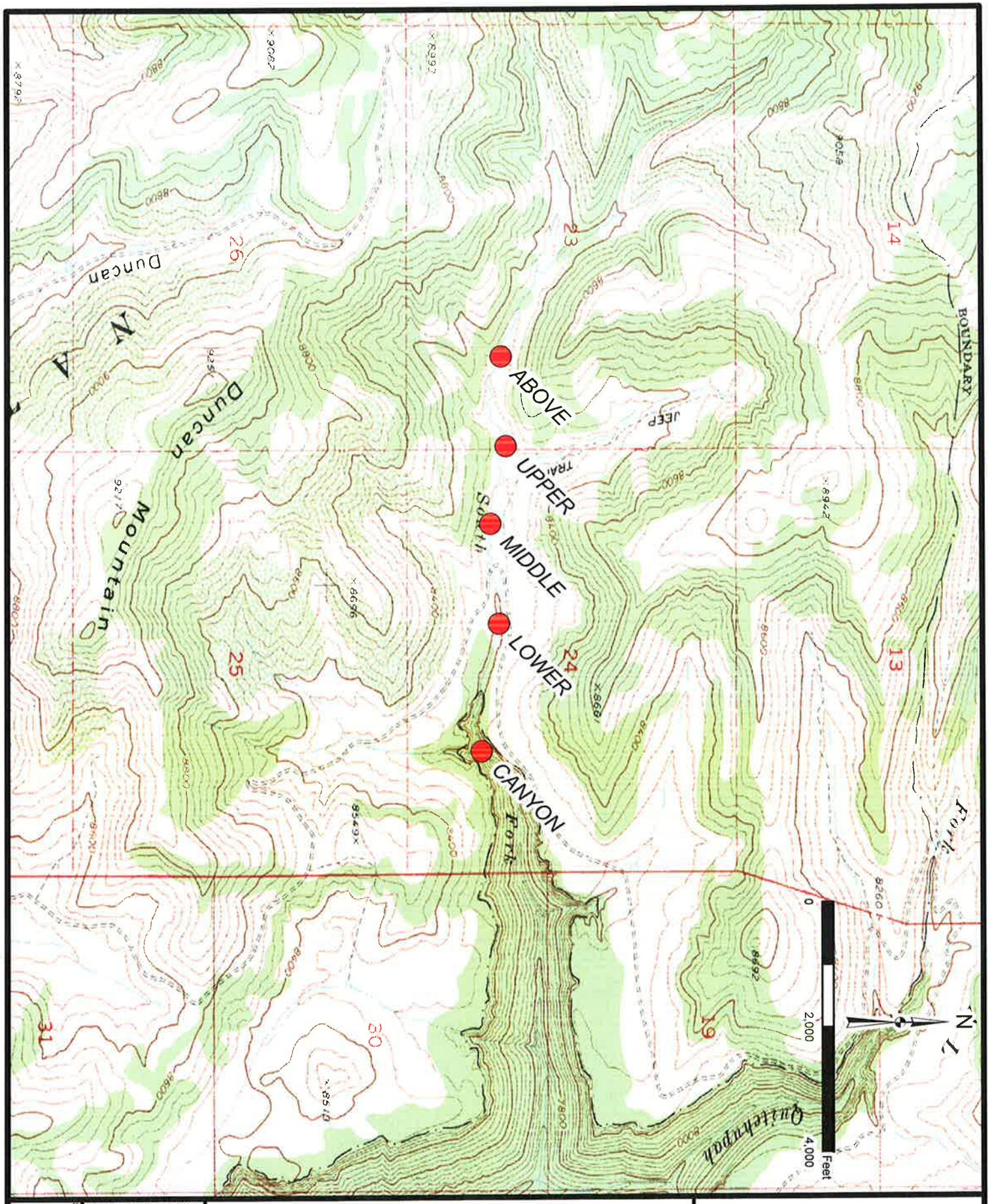
Rolf, F. J. 2000. NTSpc: Numerical taxonomy and multivariate analysis system. Version 2.1. Exeter Software. Setauket, NY.

Shiozawa, D. K. 1986. The seasonal community structure and drift of microcrustaceans in Valley Creek, Minnesota. Canadian Journal of Zoology 64: 1655-1664.

Shiozawa, D. K. 2013. An assessment of the macroinvertebrates of Woods Canyon Creek and Winter Quarters Creek, Sevier County, Utah in July 2011. Report to Canyon Fuel Co, LLC. Skyline Mines. March, 2013.

Winget, R. N. and F. A. Mangum. 1979. Biotic condition index: integrated biological, physical, and chemical stream parameters for management. U. S. Forest Service Intermountain Region. Ogden, UT.

Woltz, E. R. and D. K. Shiozawa. 1995. Soft sediment macroinvertebrate communities of the Green River at Ouray National Wildlife Refuge, Uinta County, Utah. Great Basin naturalist 55: 213-224.




| | | |
|---|---|---|
| SHEET NO. 1 | SCALE: 1 " = 2,000 ' | SUFCO MINE |
| | DATE: 4/16/2014 | SOUTH FORK |
| | DRAWN BY: T.R.B. | SAMPLING STATION LOCATIONS |
| | CHECKED BY: V.L.M. | |
| | ENGINEER: . | |
| | PROJ: . | FILE NAME: E:\GIS\MAPS\SURFACE\WATER SAMPLING STATIONS.mxd |


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

# APPENDIX 3-10

## Monitoring and Mitigation Plan for Mining Under the East Fork of Box Canyon

**LINK TRAIL COLUMBINE (Aguilegia flavenscens var rubicunda) SURVEY 1999 thru 2013**

USDA-FS Region 4 Sensitive Species

Found by Forest Service in 1999 at Upper end of the Main Fork of Box Canyon in Grotto Area

| Photo Locations No. & Description | Condition/Vigor | | | | |
|---|---|---|---|---|---|
| | 1999 | 2000 | 2001 | 2002 | 2003 |
| 1A - Grotto Area Plant in Crack | F | P | F to G | P to F | P to F |
| 1B - Grotto Area Plant in Crack | F | P | F to G | P to F | P to F |
| 1C - Grotto Area Plant in Crack | F | P | F to G | P to F | P to F |
| 2 - Gotto Area Multiple Plants in Cracks - 3 Plants | F | P | F to G | P to F | P to F |
| 3A - Grotto Area Base of Rocks | F | P | F to G | P to F | P to F |
| 3B - Grotto Area Base of Rocks | F | P | F to G | P to F | P to F |
| 4 - Halfway Down Box Canyon, Limited Water | G | NA | G | G | P to F |
| 5W - Riparian Areas in Bottom of Box Canyon | G | P | G | P | F |
| 5T - Columbine Photo | G | P | G | NA | NA |
| 6W & 6T - Riparian Area - No Columbine | NA | NA | G | P | F |
| 7 - Columbine(s) - No Plants after 2001 | G | P | F | P | P |
| 8 - Hanging Ferns | NA | P | P | P | P |
| 9A- Hanging Ferns and Moss | NA | P | P | P to F | P |
| 9B - Hanging Ferns and Moss | NA | P | P | P to F | P |
| 10W - Riparian Vegetation | NA | NA | G | P | G |
| 10T - Riparian Vegetation | NA | NA | G | P | P |
| Grazing Impacts | No | Yes | No | Yes | No |

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| 1A - Grotto Area Plant in Crack | F | G | G | G | F |
| 1B - Grotto Area Plant in Crack - 2 Plants | F to G | G | G | G | G |
| 1C - Grotto Area Plant in Crack | F | G | G | G | Dead? |
| 2 - Gotto Area Plants in Cracks - 2 to 3 Plants | F | G | G | F | F |
| 3A & 3B - Grotto Area Base of Rocks - 2 Plants | F | F | F to G | F | F |
| 4 - Halfway Down Box Canyon, Limited Water | F to G | G | G | P | F |
| 5W - Riparian Areas in Bottom of Box Canyon | F to G | G+ | P to F | F | P |
| 6W & 6T - Riparian Area - No Columbine | P | G | P to F | P to F | P |
| 7 - No Columbine Plants after 2001 | P | P | P | P | P |
| 8 - Hanging Ferns | F | G | G | F | F to G |
| 9A- Hanging Ferns and Moss | F | G | G | G | G |
| 9B - Hanging Ferns and Moss | F | G | G | G | G |
| 10W - Riparian Vegetation | P | G | F | P | P |
| 10T - Riparian Vegetation | P | G | F to G | G | G |
| Grazing Impacts | Yes | No | Yes | No | Yes |

| | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| 1A - Grotto Area Plant in Crack | F | F | G | F | F |
| 1B - Grotto Area Plant in Crack | F to G | G | F to G | F | F |
| 1C - Grotto Area Plant in Crack | Dead ? | Dead | Dead | Dead | NA |

| | | | | | |
|---|---|---|---|---|---|
| 2 - Gotto Area 1 to 2 Plants | F | P | F to G | F | F |
| 3A & 3B - Grotto Area Base of Rocks - 2 Plants | F | F | G | G | G |
| 4 - Halfway Down Box Canyon, Limited Water | P | P | F to G | F | F |
| 5W - Riparian Areas in Bottom of Box Canyon | P | P to F | G | P | F to G |
| 6W & 6T - Riparian Area - No Columbine | <P | <P | G | P to F | G |
| 7 - No Columbine Plants after 2001 | <P | <P | G | F | G |
| 8 - Hanging Ferns | F | P | F | F | F |
| 9A- Hanging Ferns and Moss | F | P | G | F | F |
| 9B - Hanging Ferns and Moss | F | F | G | F | F |
| 10W - Riparian Vegetation | <P | <P | P to F | <P | F |
| 10T - Riparian Vegetation | G | G | G+ | G+ | G |
| Grazing Impacts | Yes | Light | No | Yes | No |

**Legend - Condition/Vigor**

P - Poor F - Fair G- Good

< Less Than + Better Than

**DOGM required the following:**

Stake Location of some plants

Make photographic record of the species

Revisit plot locations annually until the area has been subsided

Determine if mining has any affect on the plants

Include riparian and hanging fern garden areas, starting in 2000

**Conclusions**

The location of the plants did not seem to be associated with moisutre draining to the surface.

The columbine grows in or adjacent to the Castlegate formation and not in close association to other plants.

Survey suggests they do not compete well in the established phase of growth cycle with other plants.

Some columbines will grow in well drained sandy soils within a flood plain, likely establishing following a flood carrying seed.

Columbine does not necessarily need moist soil climate to survive.

Columbine survival is dependent on growing in protected areas, not easily accessible to grazing.

During survey no impacts attributed to mining.

Impacts likely due to drought conditions and grazing.

The Box Canyon area was under-mined in Late December 2005 and Early January 2006.

Survey/Study reports included in annual reports 1999 thru 2012

Photo Point 1A and 2

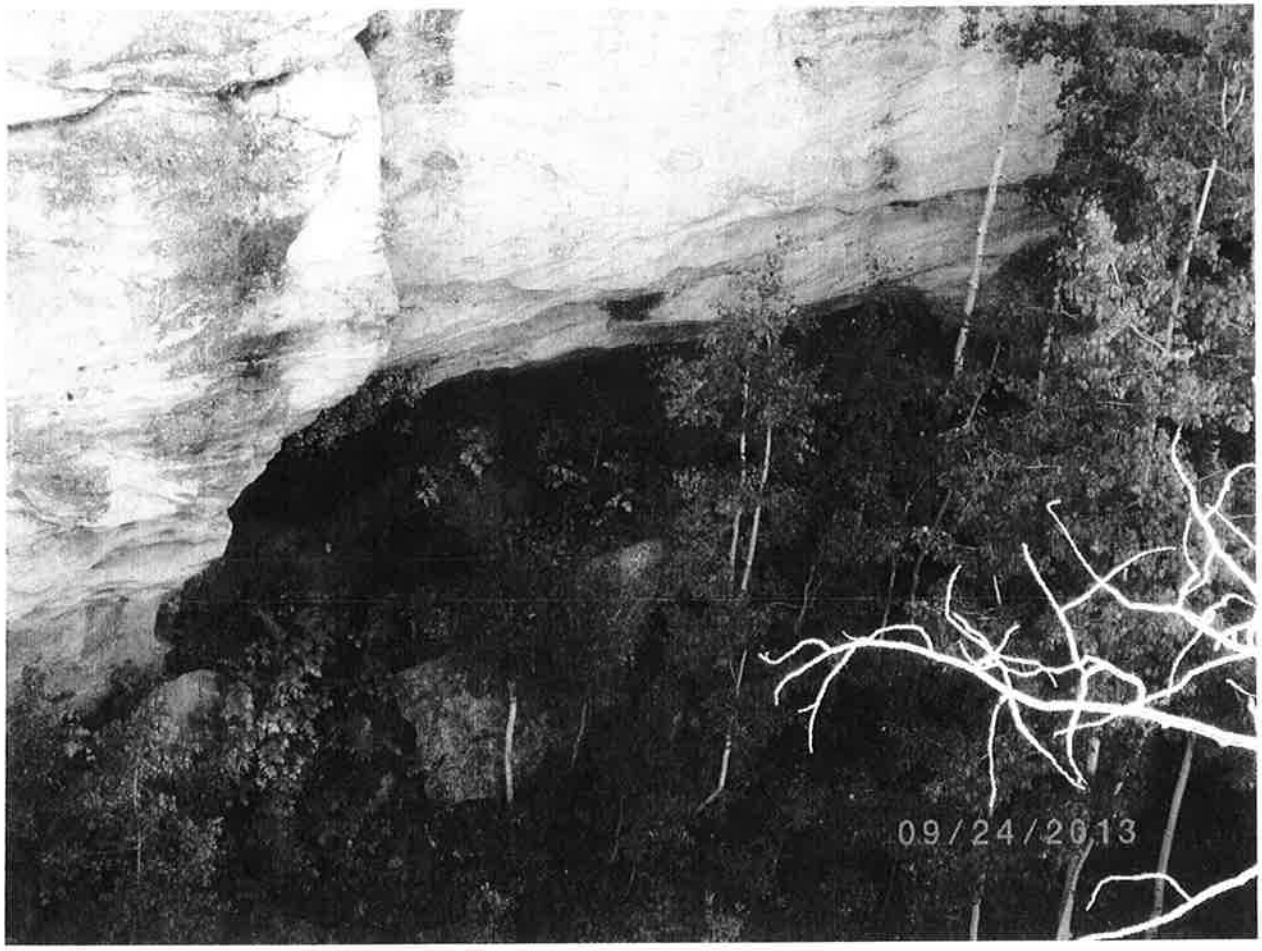
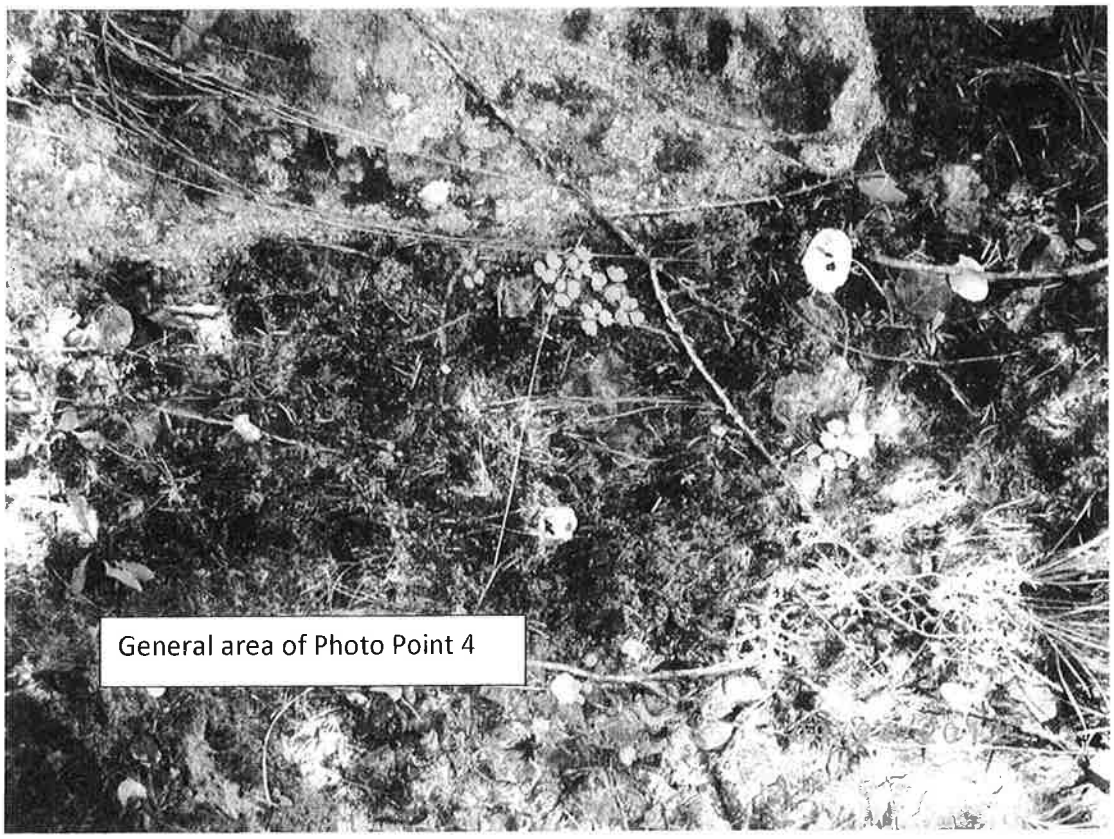



Photo Point 1B

Photo Point 3

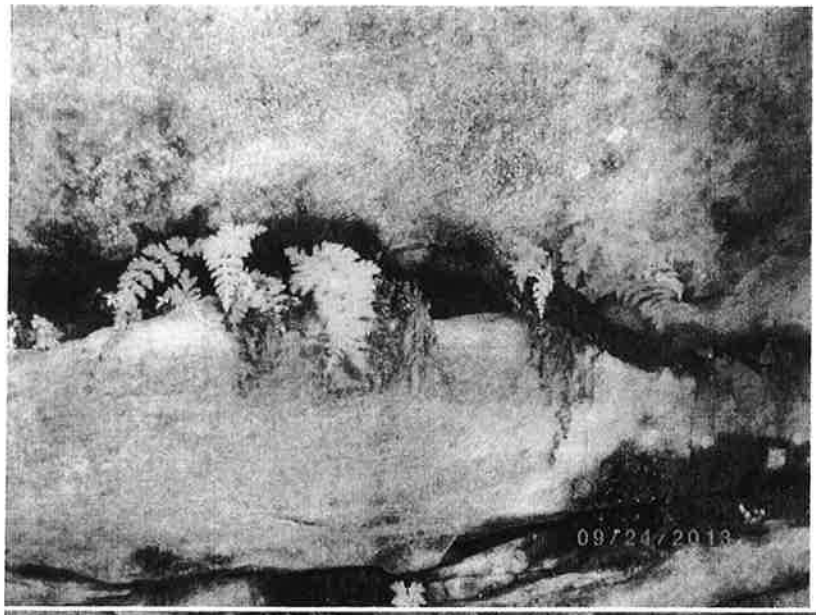


General area of Photo Point 4

Photo Point 5

General Area of Photo Point 6

Photo Point 7



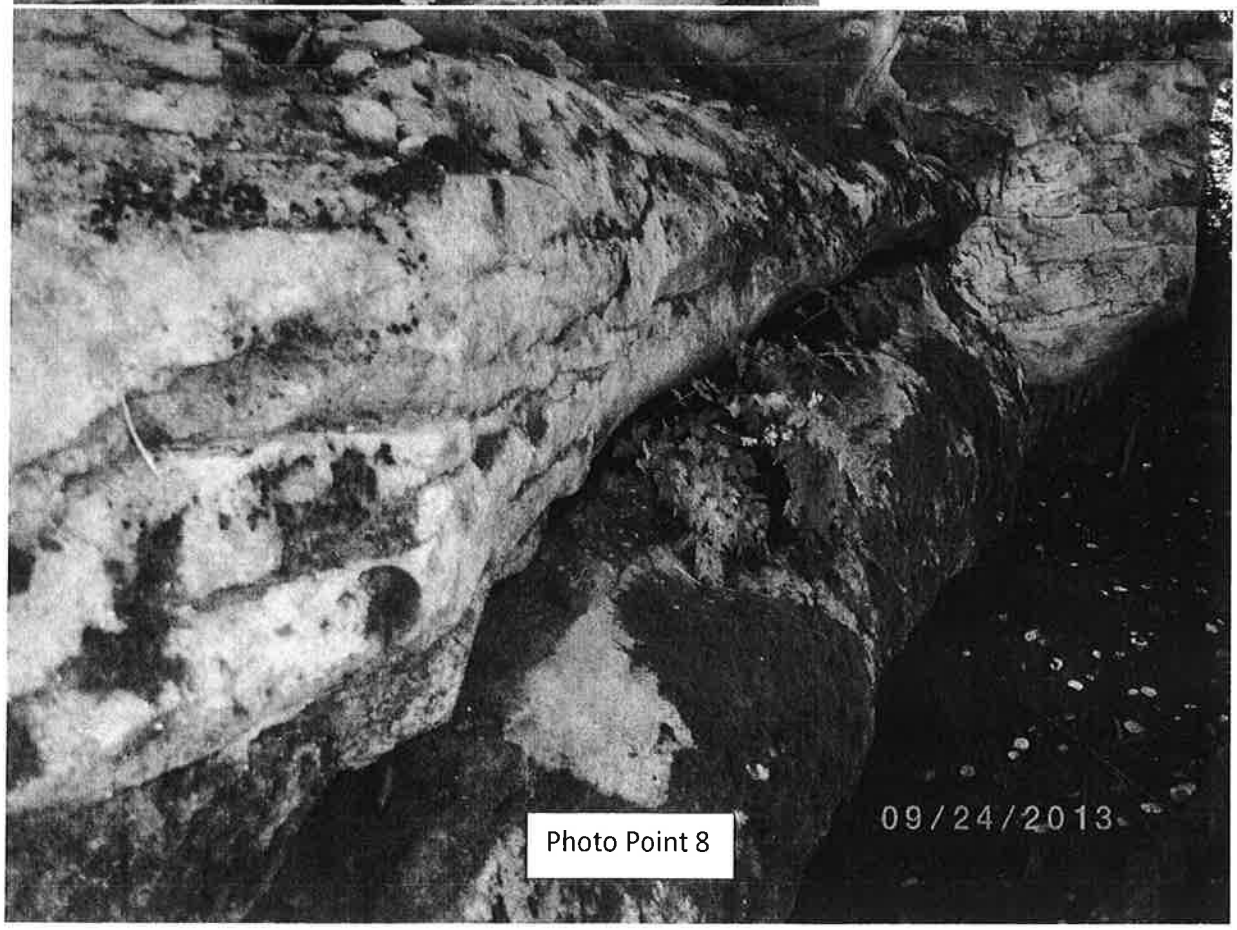




Photo Point 8

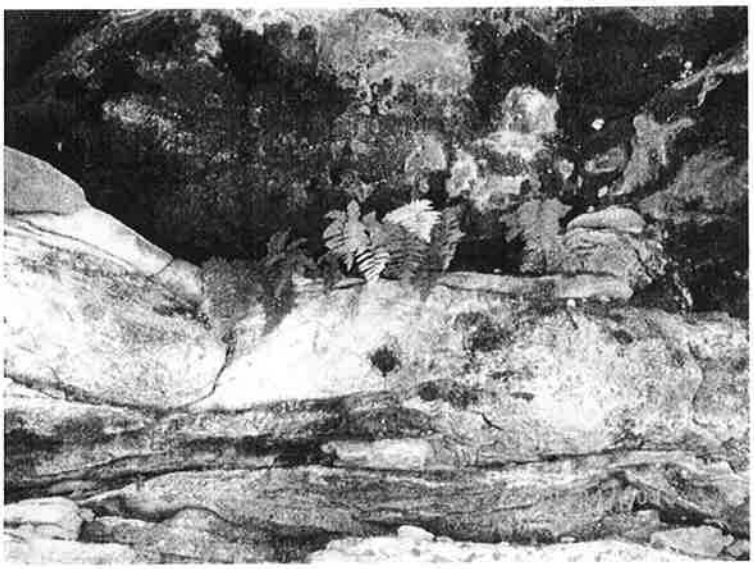


Photo Point 9A

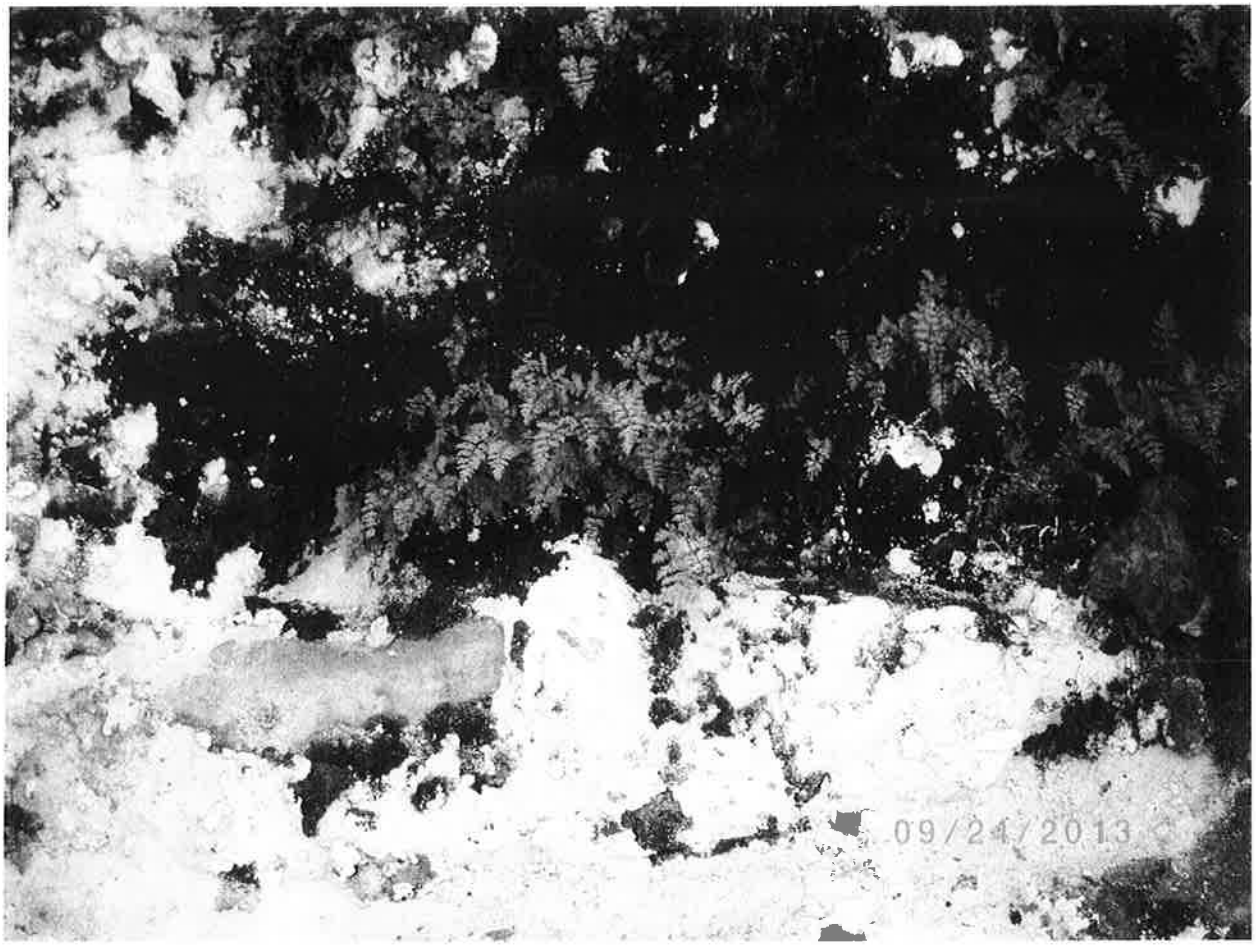



Photo Point 9B

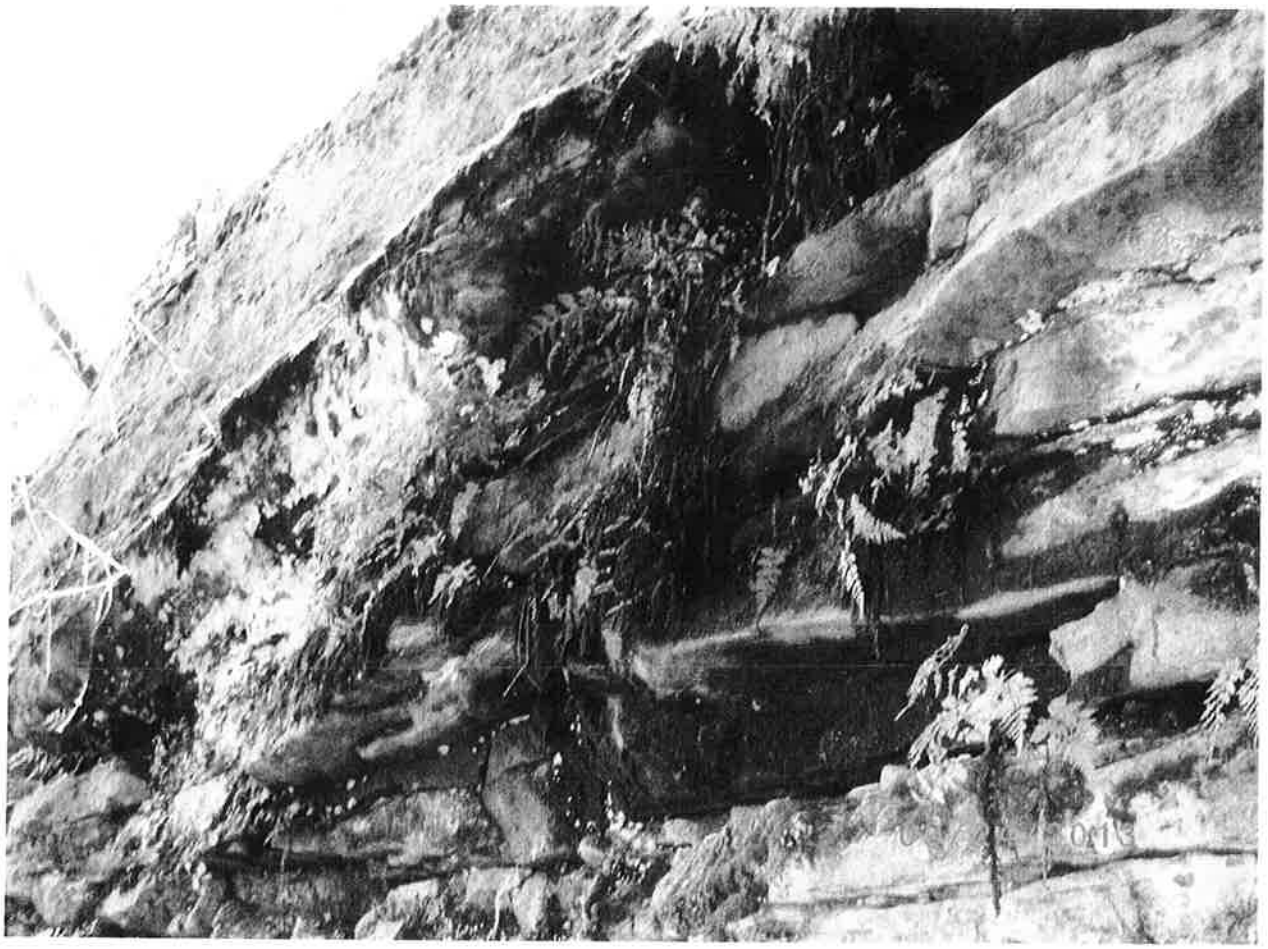
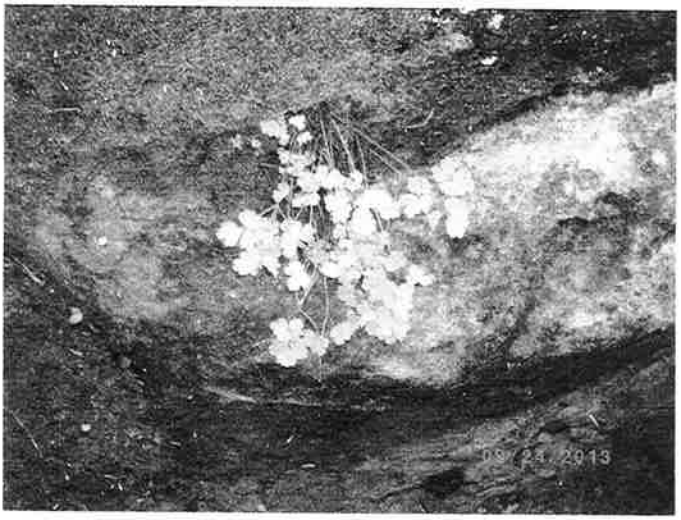
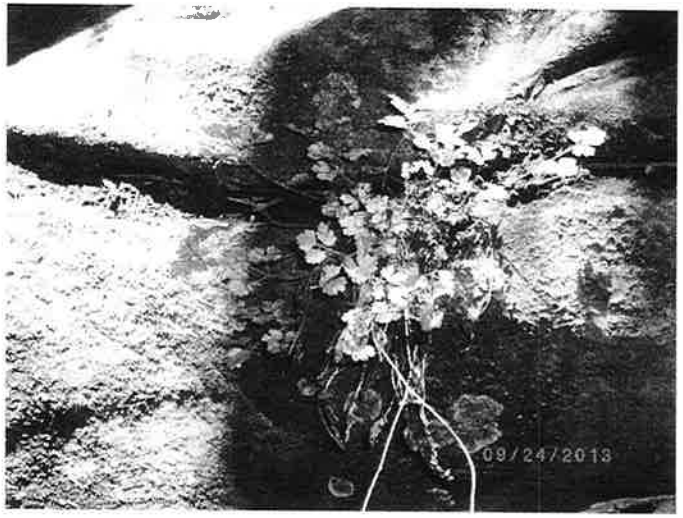


Photo Point 9B

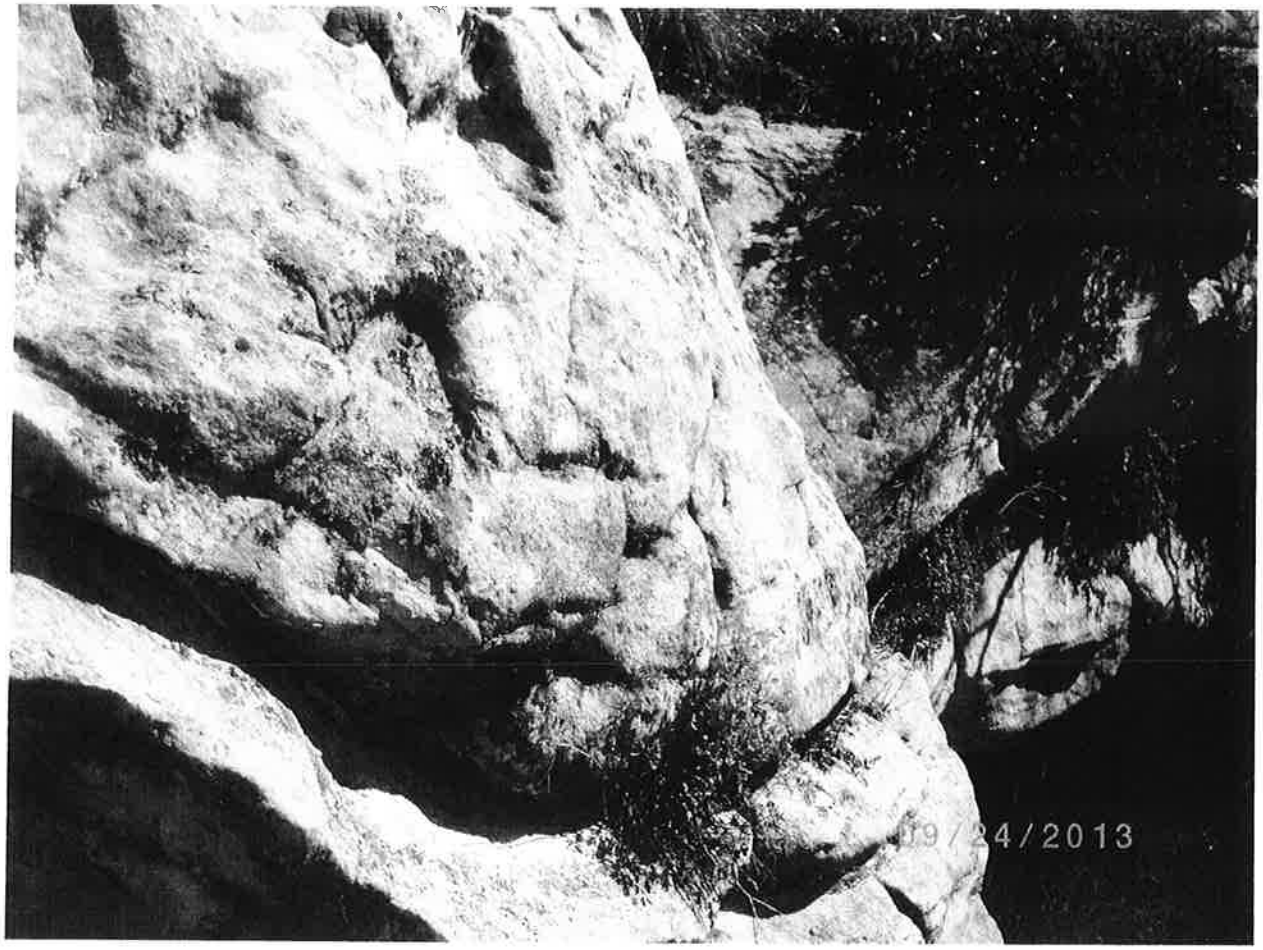
General Area of Photo 10

General Area of Photo 10, Note signs of flooding due to storms in September.

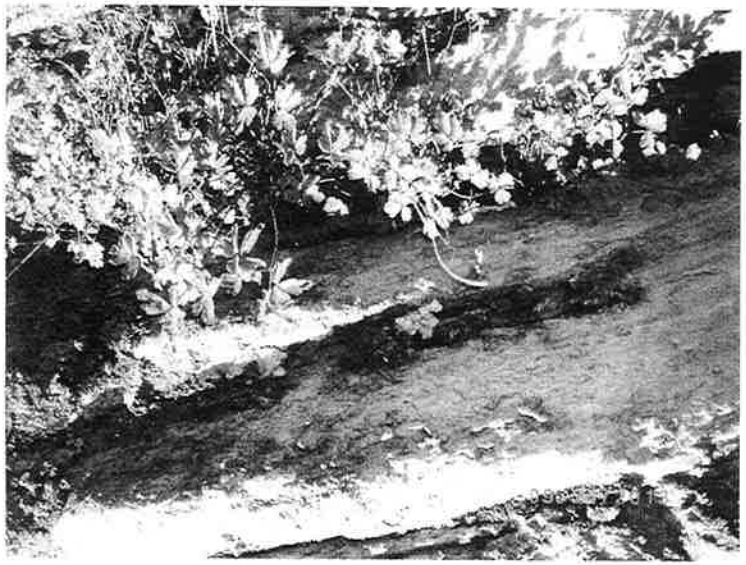


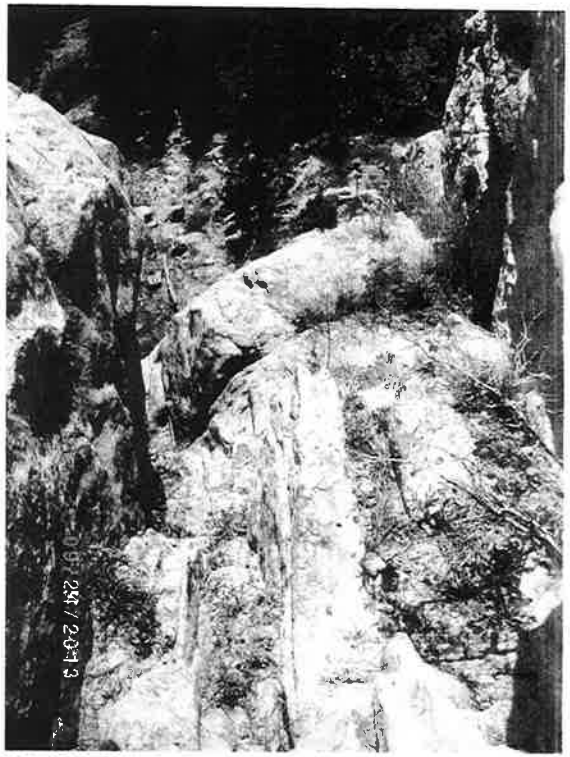



Various Columbines in Box Canyon




Columbine Growing in Box Canyon Walls

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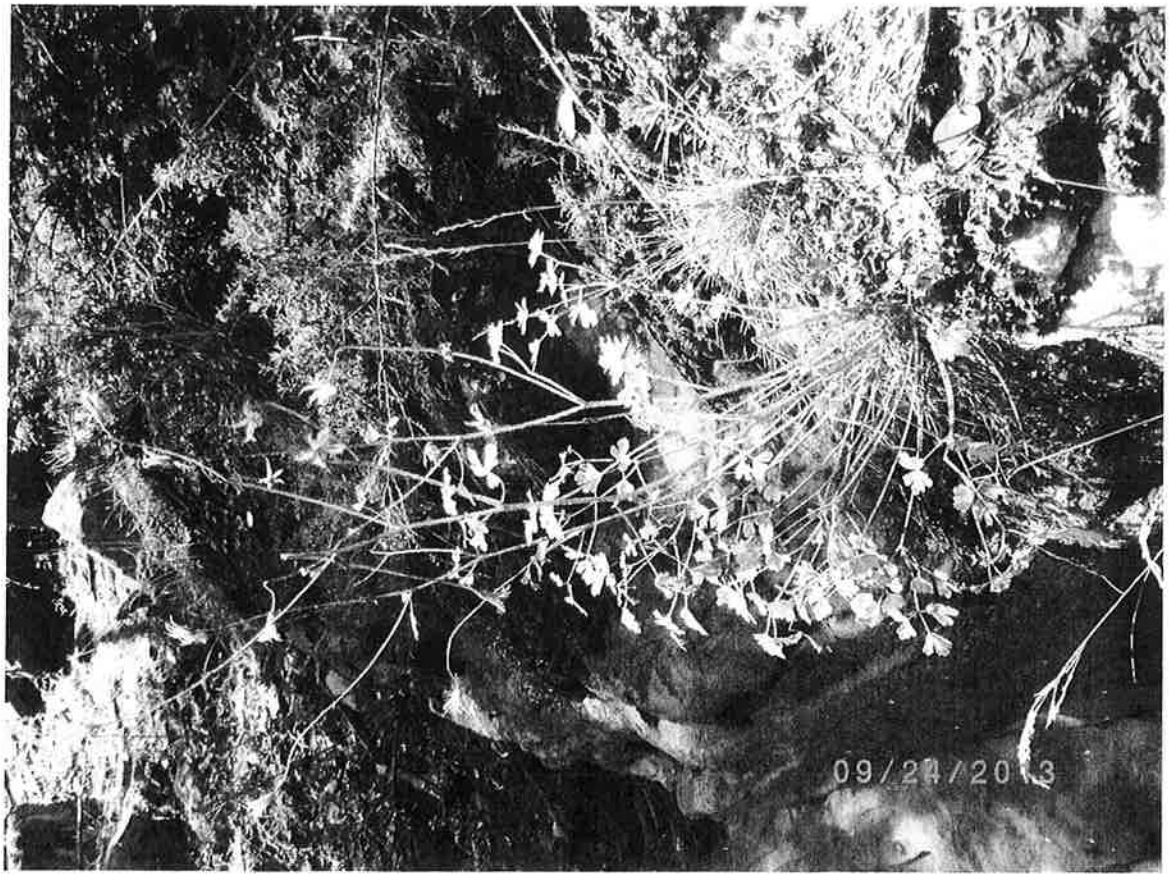
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# CHAPTER 7

# HYDROLOGY

intermittent stream under the R645 rules as a result of its drainage area size, the stream functions primarily as an ephemeral stream (Thiros and Cordy, 1991). As described in Section 7.2.4.2 of this chapter, the majority of the stream's reaches typically only flow as a result of runoff from significant precipitation events and during brief periods of snow melt runoff. The two surface water sites, Link 001 and Link 002 which are located above and below the portals (Plate 7-3), did not have measurable or monitorable flows during quarterly monitoring episodes from 1999 through 2002 (Erik Petersen, personnel communication, November 2002). Observable surface flows in the stream are generally limited to just below the developed springs *(Pines 100 and GW-21)* near the head of the canyon and just below and adjacent to the Link Canyon Portals. In both locations water flow or moist soils have been observable for only a few hundred feet below the source. Table 7-1A details the dates, flows, and monitoring personnel for sites Link 001, Link 002, Link Portal West and Link Portal East.

Vegetation in the Link Canyon channel below the mine will be photographically monitored on a quarterly basis, except in the winter months, to determine what, if any, impacts the reduction of discharge from the western portal has on the vegetative community. The vegetation monitoring was started in the summer of 2005 and will continue through 2013 ~~the reclamation of the portals~~. The general health of the willows, Woods Rose, clematis, and wire grasses present in the vegetative community will be observed and the observations reported in the mine's annual report (2005 - 2012) and in Appendix 2-9. If significant changes occur in the vegetation monitored, these changes will be reported to the Division and the Forest Service. A plan may be developed and instigated at that time to mitigate any damages to the vegetation as a result of mining activities. Refer to Section 3.2.2.2 for addition vegetation information.

Flows from the Link Canyon portals have been measured periodically since 1977 with discharges ranging from 5 gpm (estimated by Hydrometrics, 1977) to no discharge (Petersen 2002). Samples of the water discharged from the west portal have been obtained and analyzed by Thiros and Cordy (1991), Mayo and Associates during the Pines Tract EIS process (1998), and recently by Petersen (2002, Appendix 7-4).