C/015/018 Incoming
CC: Keenan
Steve C.

United States Department of the Interior

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

IN REPLY REFER TO:
3800
UT9223

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DIV. OF OIL, GAS & MINING

Memorandum

To: Russell J. Riley District Manager
District 9 – Coal Mine Safety and Health

From: Roger Bankert, Chief, Branch of Minerals

Subject: Meeting of May 28, 2015 – Deer Creek Mine Closure – Proposed Bulkheads

Thank you for the meeting regarding the Deer Creek Mine closure. The Bureau of Land Management (BLM) continues to fully support the MSHA efforts to ensure a safe and secure closure of the Deer Creek Mine.

The BLM's role[1] is to ensure the protection of Federal coal resources by proper closure of mine access points.

Informal Suggestions

During the meeting several possible approaches were discussed regarding proper handling and the removal of excess water from the closed mine workings. Here are a few suggestions:

1. Install surface boreholes to pump water over to the Deer Creek portal area for mixing to achieve proper discharge attainment. Of course evaluation would be needed to assess qualities and results of mixing.

---

[1] **43 CFR § 3484.1 Performance standards for exploration and surface and underground mining.**

(c) *Performance standards for underground mines* – (1) *Underground resource recovery.* Underground mining operations shall be conducted so as to prevent wasting of coal and to conserve recoverable coal reserves consistent with the protection and use of other resources. No entry, room, or panel workings in which the pillars have not been completely mined within safe limits shall be permanently abandoned or rendered inaccessible, except with the prior written approval of the authorized officer.

Potential Water Storage/Resource of Abandoned Long Wall Coal Mines

David Merrell P.E.
Ryan Egbert
Dr. Rollin Hotchkiss Ph.D., P.E., D.WRE, F.ASCE
Department of Civil and Environmental Engineering

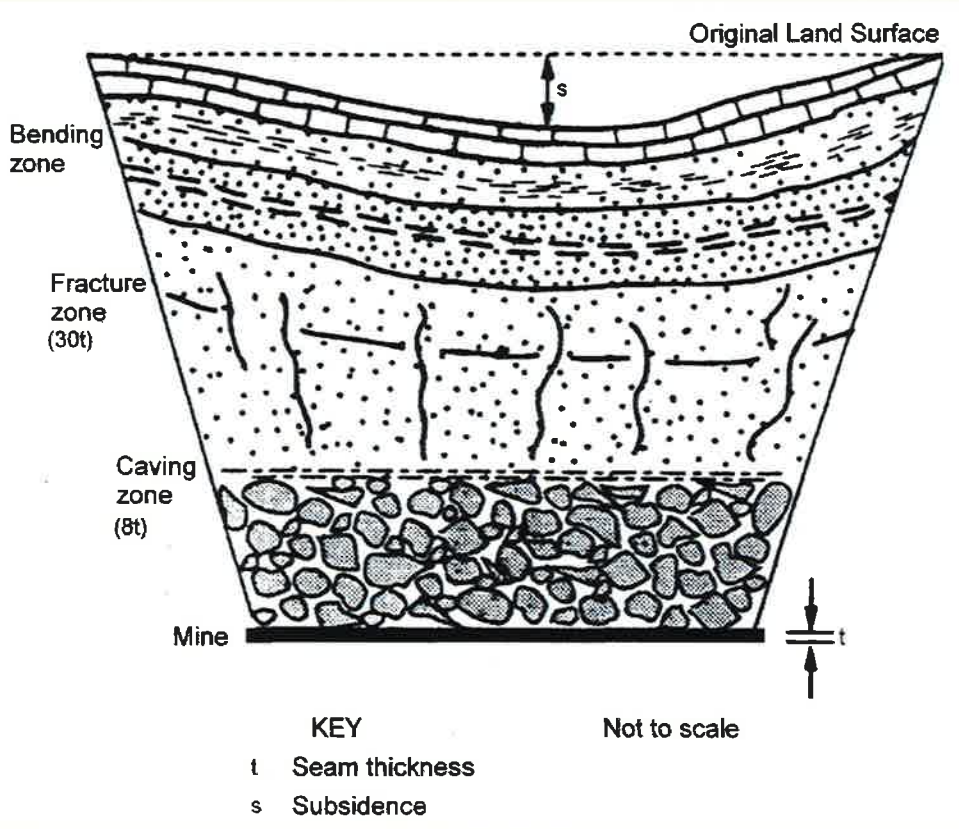
Potential Water Storage/Resource of Abandoned Long Wall Coal Mines

- **Investigate Long Wall Mine Void Reservoirs and Examine Development Risk for Town of Emery Utah**
- Motivations for Additional Sources
- Existing Mine Reservoirs
- Available Groundwater
- Head Limit and Storage Curves
- DOGM Data for Flow and Quality
- Water Rights
- Hydraulics
- Water Treatment

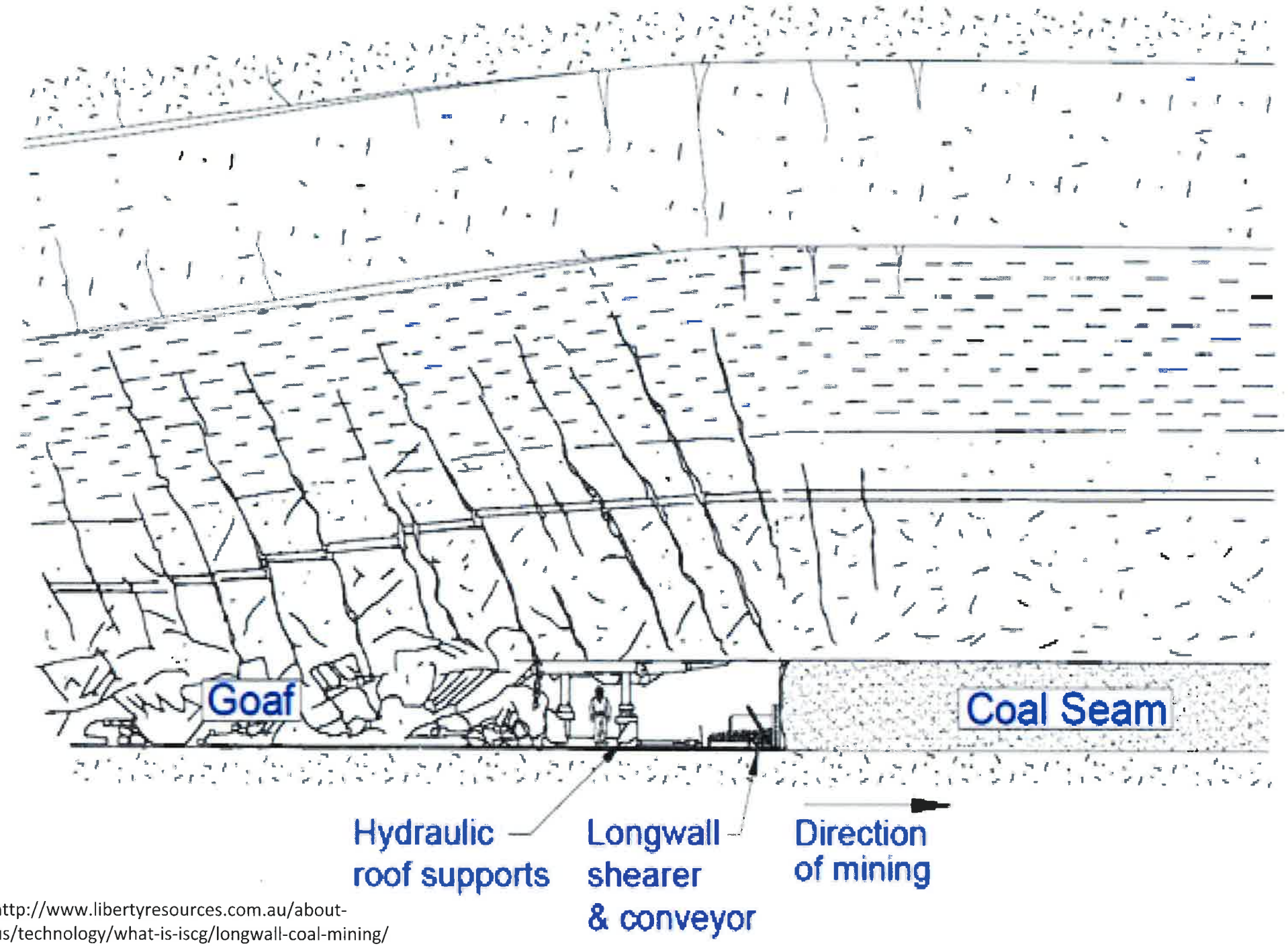
Long Wall Mining Void Reservoirs

http://www.asxvalue.com/2012/01/20/delta-sbd-a-recent-float-with-promise-and-a-macro-tailwind-dsb/

Vertical propagation of voids maintains approximately 80% of original mined volume

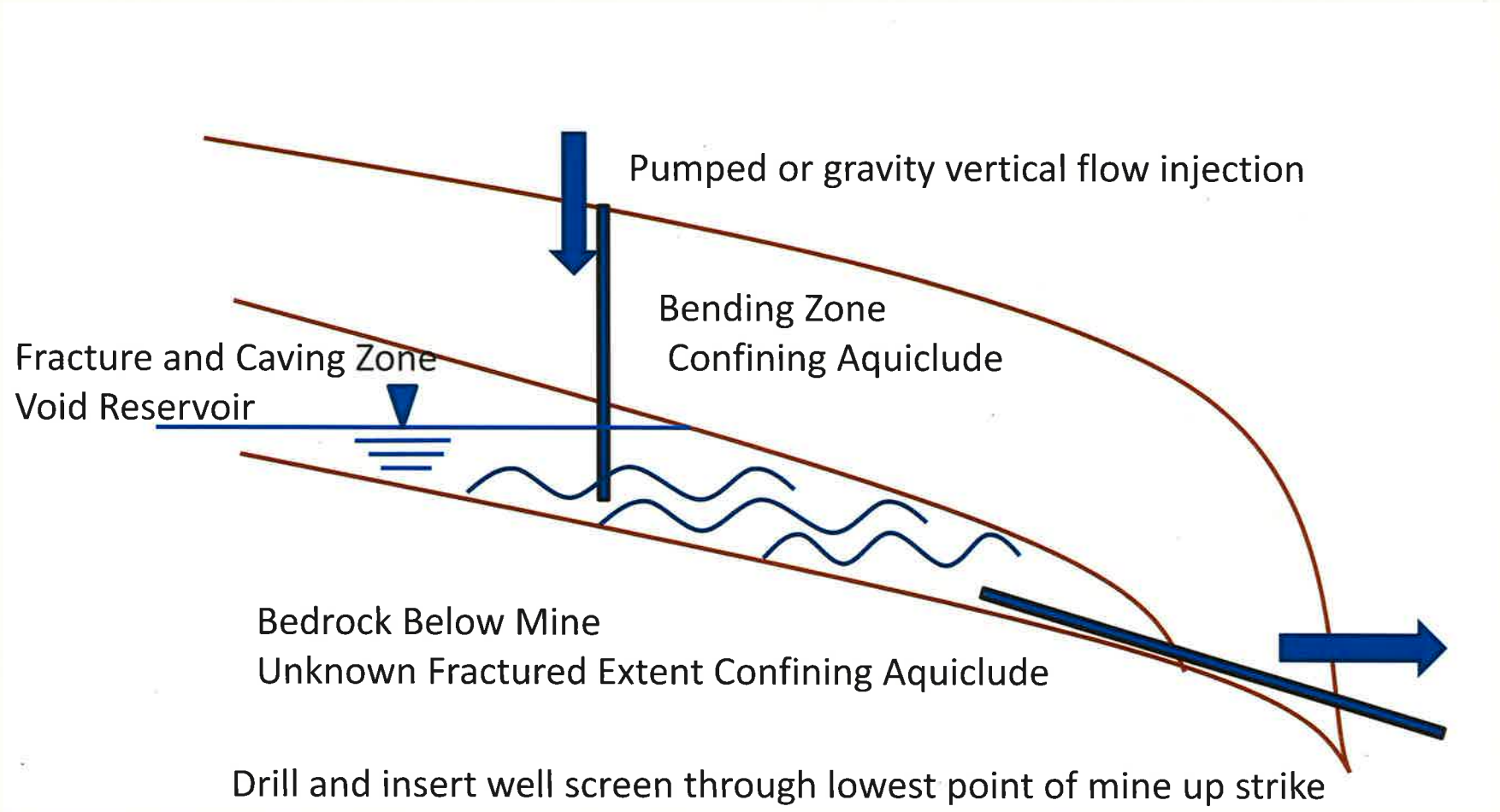


Potential for Water Storage in Abandoned Mine Workings in the Castlegate Area, Carbon County, Utah



ıttp://www.libertyresources.com.au/about-
ıs/technology/what-is-iscg/longwall-coal-mining/

Desired Gravity Storage Reservoir Requires Vertical and Horizontal Confinement



Benefits

- Relatively low costs of development compared to surface storage
- Sedimentation and Algae growth are not an issue
- No evaporation losses
- Relatively constant and reliable water temperature from storage
- High water heads are available from the plateau coal seams
- Thousands of acre*ft of storage are available within the abandoned coal mines of the Wasatch Plateau and Book Cliffs.

Hotchkiss, Israelsen, and Riley; 1980; Management of the Hydrologic System in Areas Subject to Coal Mining Activities

Groundwater Development Risk

http://www.merchantmaverick.com/articles-tips-and-advice/highrisk-merchant/

- Any groundwater development project involves a higher degree of risk due to less data available (many municipalities drill groundwater wells which are unproductive)
- Water in mine is not an additional water resource to be tapped beyond the existing water rights

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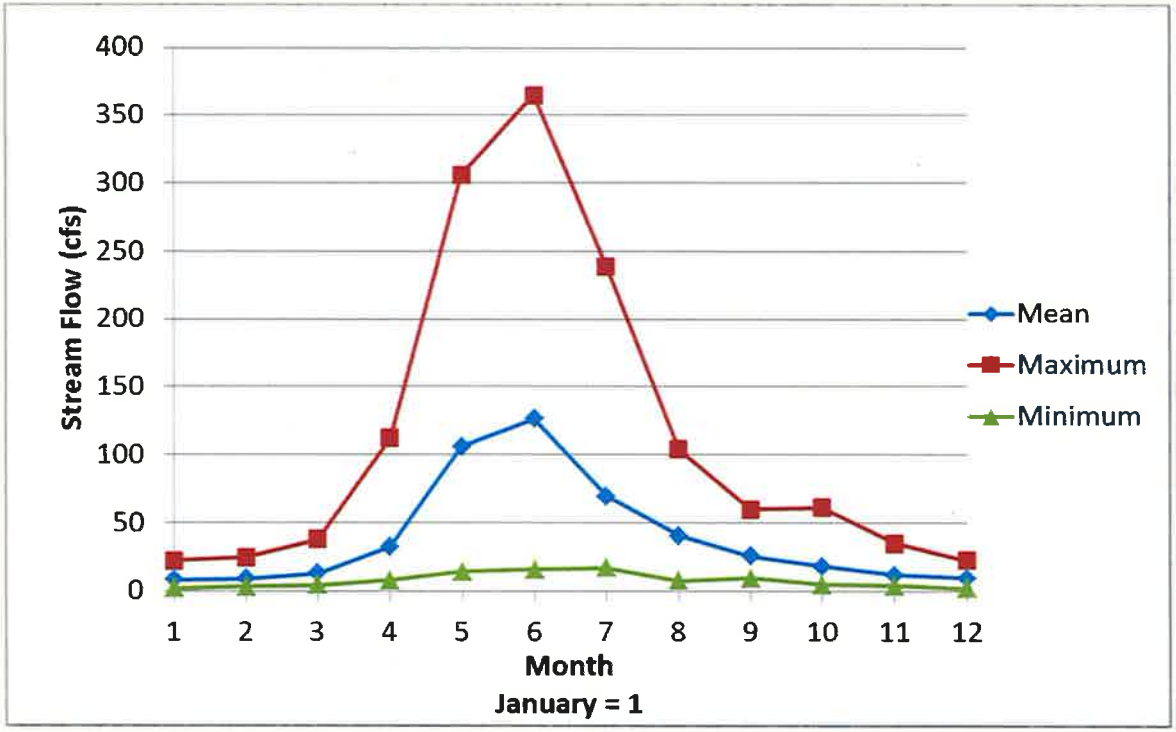
Motivations of Town of Emery for Additional Sources

- Expectation of growth and increased demand
- Potential freeze of overland supply during low flow winter months
- Reliable source during times of drought

Low Flows and Velocities During Winter Freeze

Peak Hourly Demand (PHD) = 1.04 cfs

UAC R309-510-9(2)



Month	Mean	Max	Min
Jan	8.29	22	2
Feb	8.89	24.6	3.09
Mar	12.9	37.7	4.15
Apr	32.6	112	7.84
May	106	306	14.2
Jun	126	365	15.7
Jul	69.1	239	17.1
Aug	40.6	104	7.55
Sep	25.9	59.7	9.58
oct	18.1	60.9	4.78
Nov	12	34.8	3.73
Dec	9.28	22.6	2

For the foreseeable future there is enough water available within the overland supply

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Existing Abandoned Coal Mine Water Reservoirs

– Alta Mine

(Little Cottonwood Canyon, Utah)

– Eastern Kentucky

Photo and table via Kentucky Geological Survey

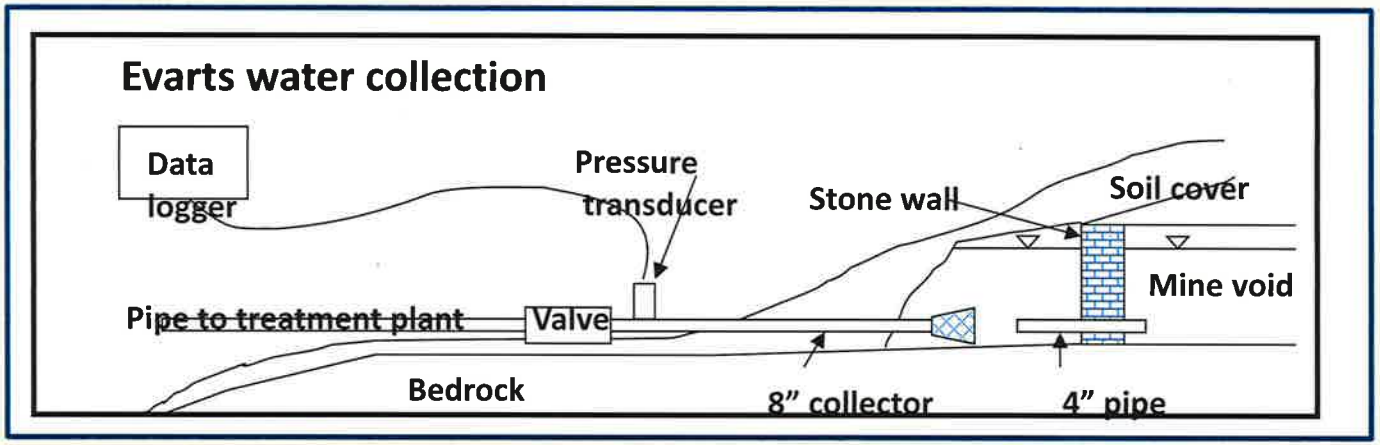
Estimated Storage Volumes and Recharge Rates for Selected Underground Mines in the Kentucky River Headwaters		
Mine	County	Volume (Mgal)
Polly No. 4 Mine at Sand Lick	Letcher	114
Polly No. 4 Mine at Cow Branch	Letcher	260
BE No. 22 at Craft's Colly	Letcher	220
Leatherwood/Blue Diamond mines	Perry	550
BenCo Mine	Perry	100
Yocum Creek Coal Co. Mines	Harlan	260
LeeCo No. 47 at Manchester	Clay	450

Photos via Kentucky Geological Survey

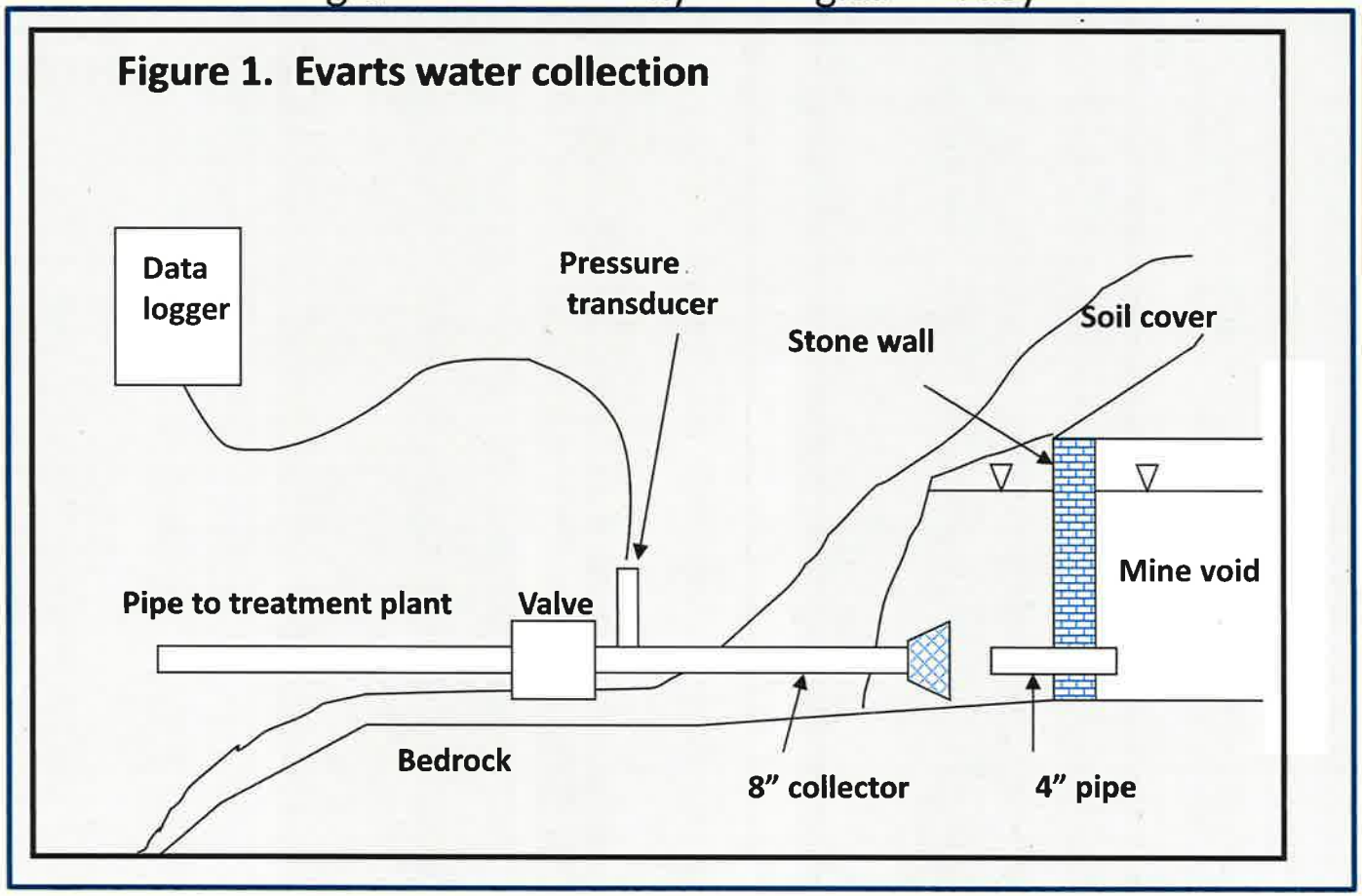
Opening to the mine in Evarts Kentucky where discharge pipes carry the water from the mine to the water plant using gravity.

Opening to the mine in Evarts Kentucky where discharge pipes carry the water from the mine to the water plant using gravity.

Installed flume at Leatherwood mine to measure discharge with a pressure transducer.



Diagrams via Kentucky Geological Survey



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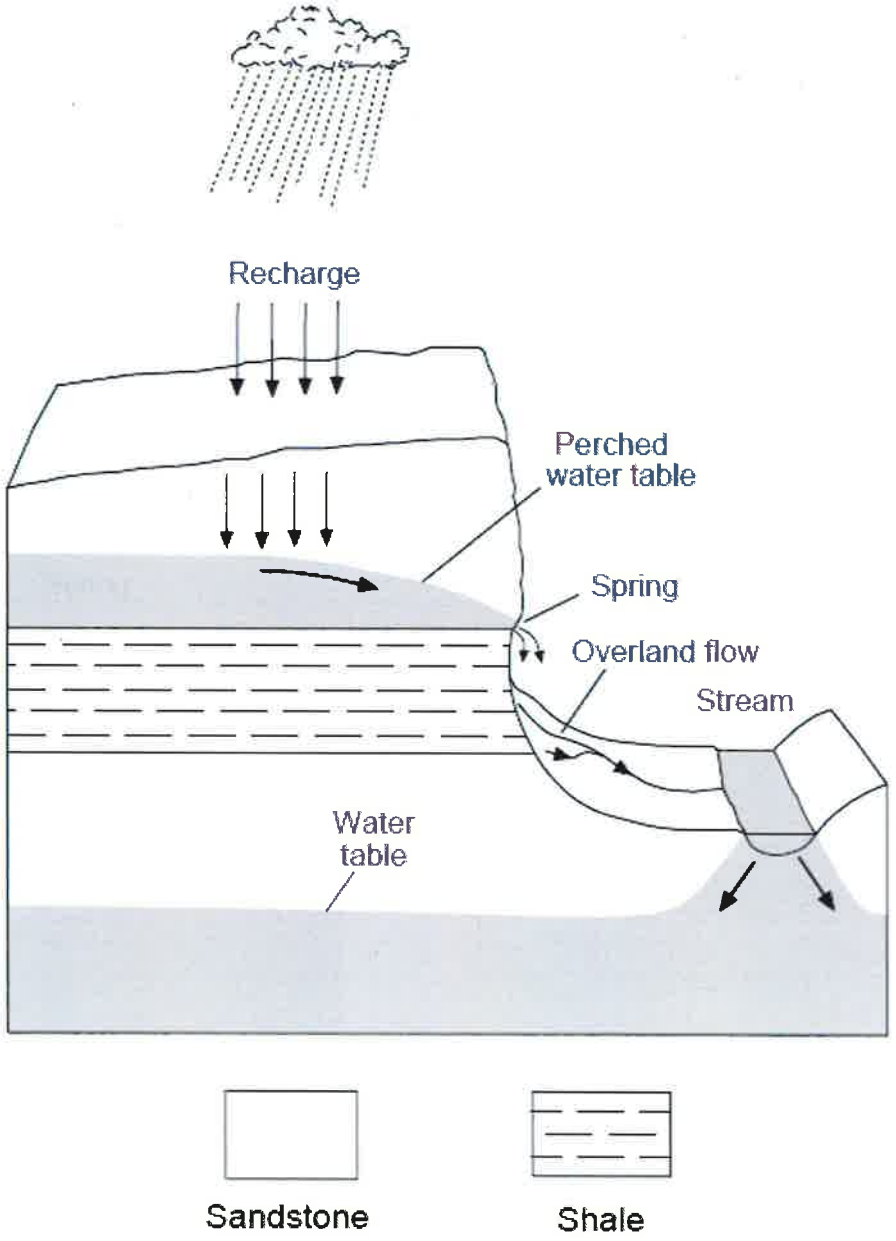
Available Groundwater

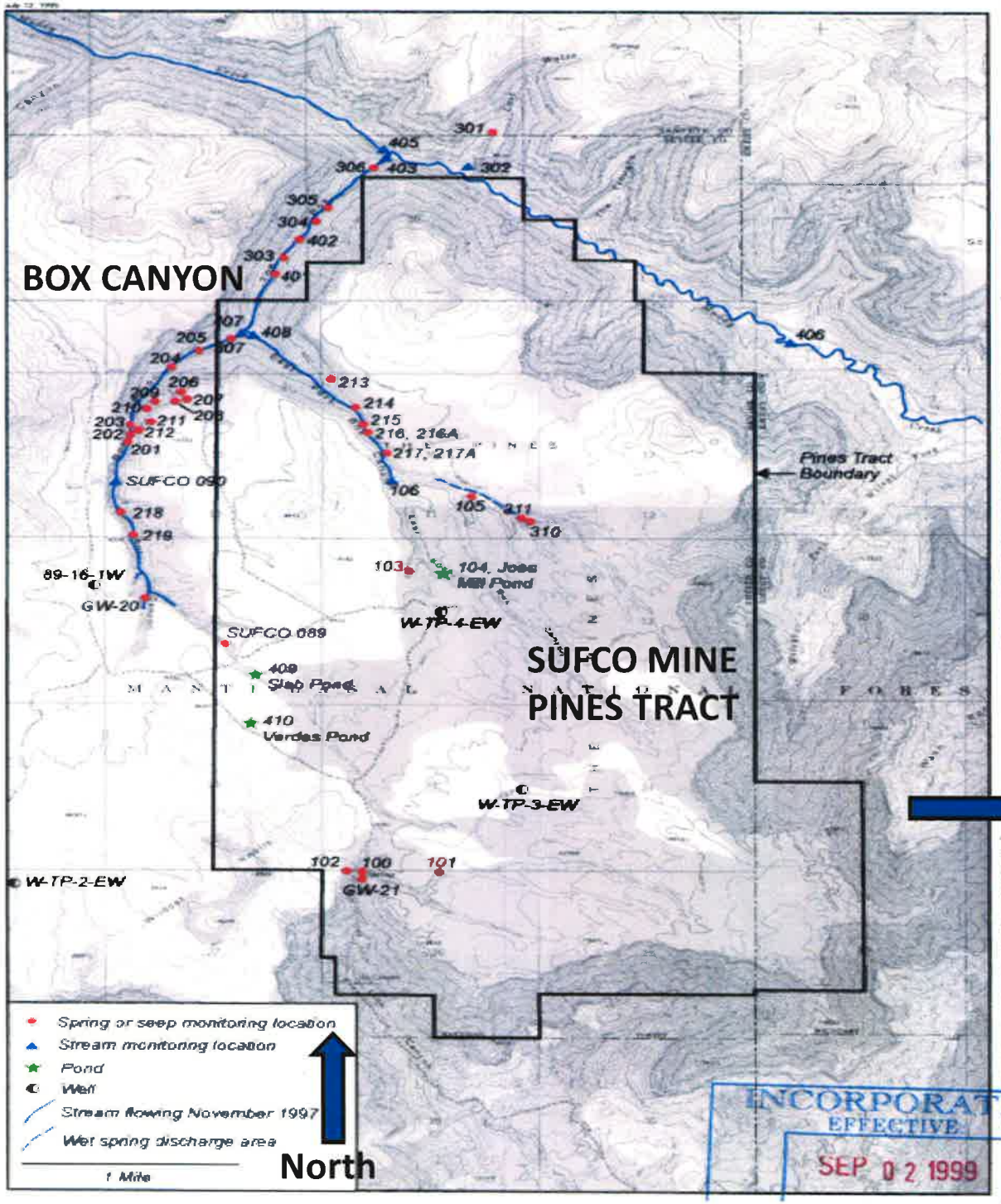


Longterm recharge is small percentage of annual rain which requires a large surface area to generate a useful recharge

Average age of water within mine was estimated as 70 yrs old based on stable isotope studies (Thiros and Cody, 1991)

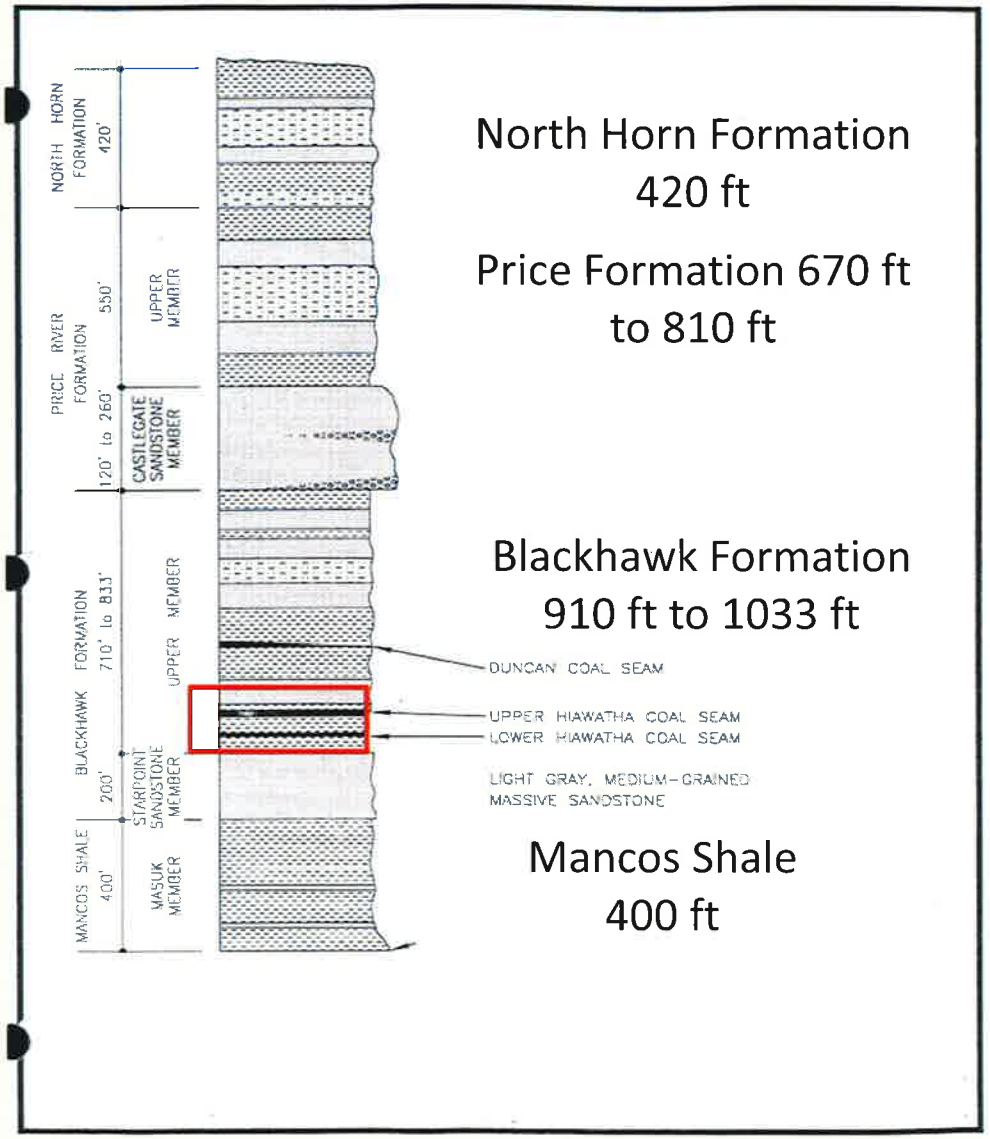
Energy Mineral and Groundwater Resources of Carbon and Emery Counties, Bulletin 132 Utah Geological Society

Mapped Springs and Seeps



(per MRP, Appendix 7-18, 2.3)

Vertical Stratigraphy



North Horn Formation
420 ft

Price Formation 670 ft
to 810 ft

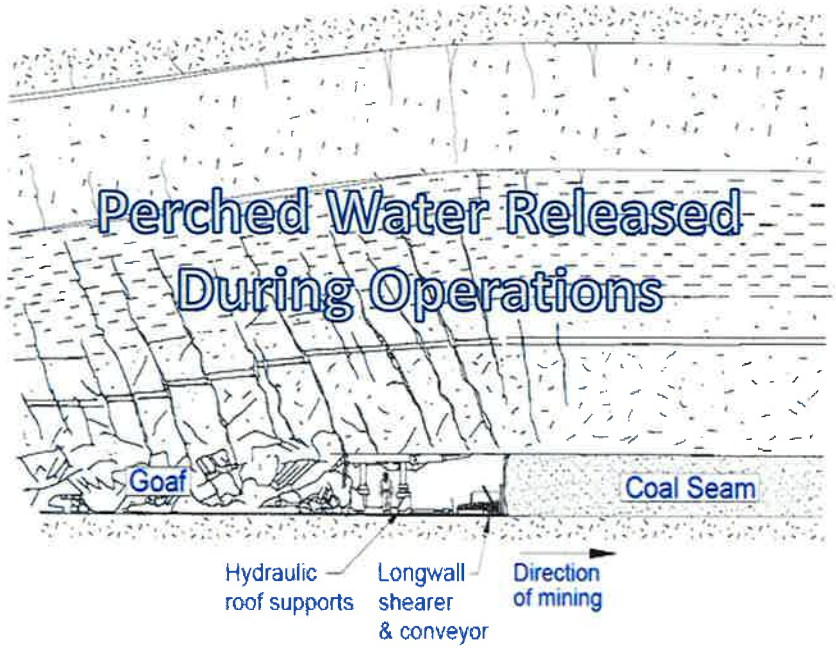
Blackhawk Formation
910 ft to 1033 ft

Mancos Shale
400 ft

(per SUFCO MRP, 1991, Section 6.2.2)

Mine water recharge is estimated as 10% of groundwater recharge which is 1.2% of annual precipitation equaling 0.12% of annual precipitation or 6 gpm

Majority of recorded discharges is assumed as perched groundwater in immediate vertical horizon above mine



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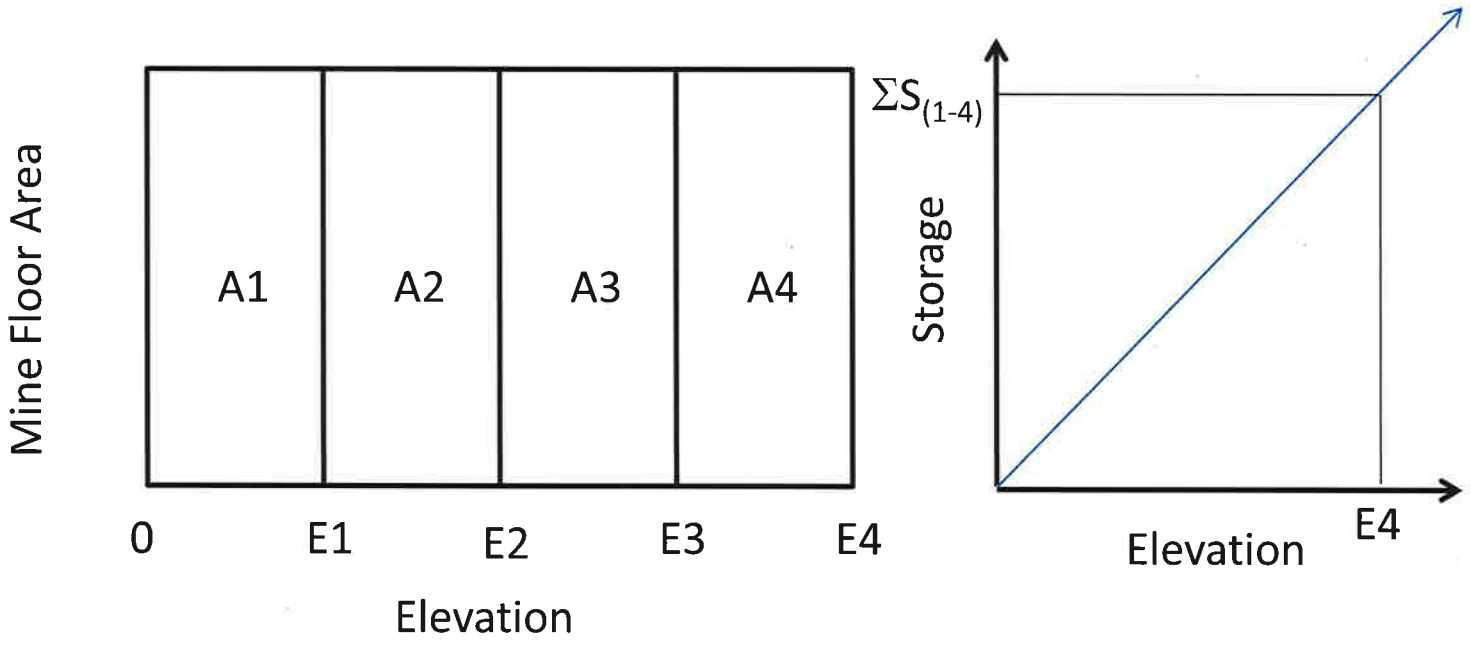
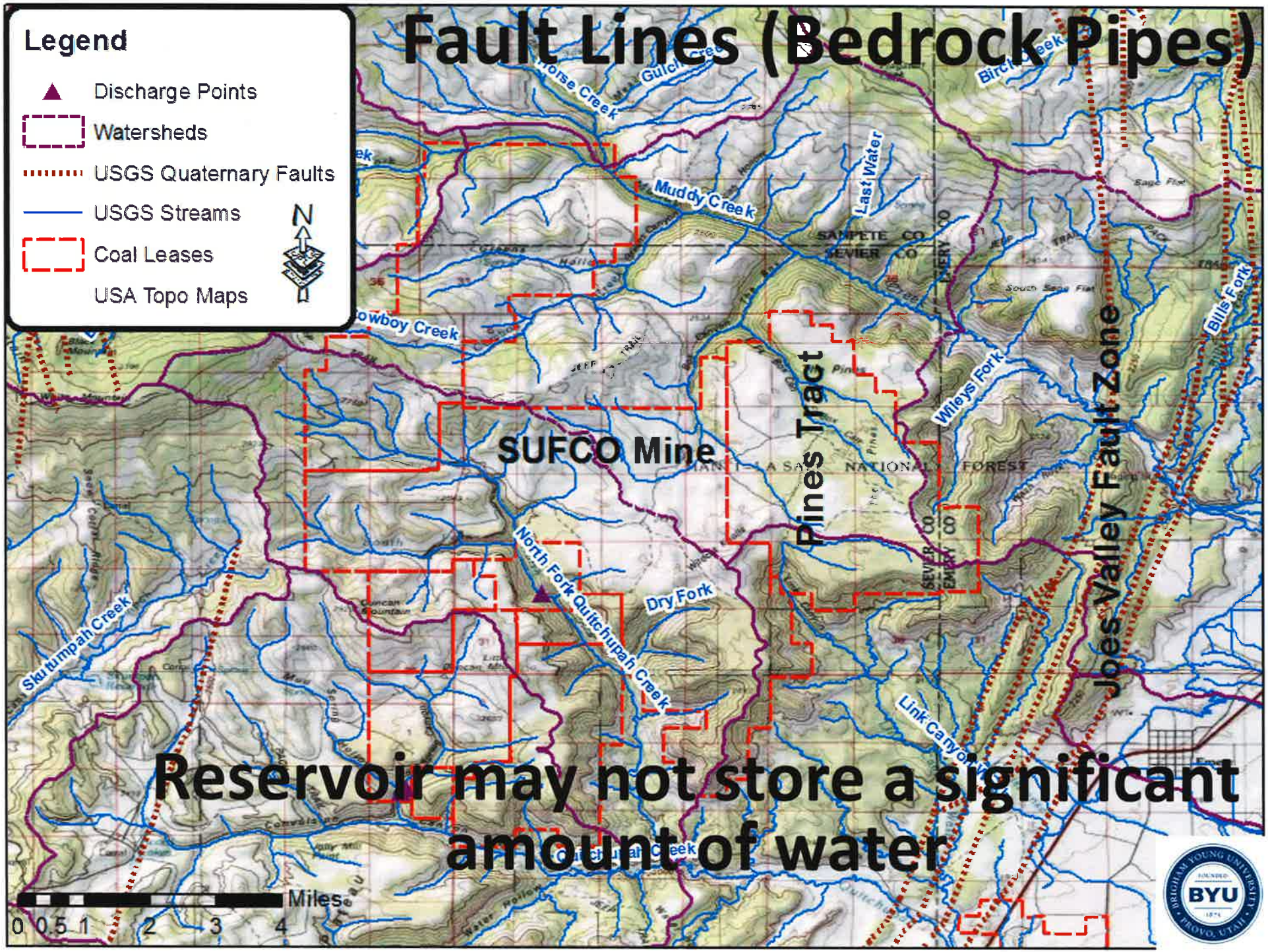
Storage Estimation and Dead Storage

Storage(i) = Mine Floor Area (i) * Mine Thickness (i) * 0.8



SUFCO Mine Pines Tract was measured at 25 ft elevation intervals


Fault Lines (Bedrock Pipes)
Legend
Discharge Points
Watersheds
USGS Quaternary Faults
USGS Streams
Coal Leases
USA Topo Maps
N
Horse Creek
Muddy Creek
Last Water
Birch Creek
Bills Fork
Wileys Fork
Cowboy Creek
SUFCO Mine
Pines Tract
Joes Valley Fault Zone
North Fork Quitchupah Creek
Dry Fork
Skumpah Creek
Link Canyon
SANPETE CO
SEVIER CO
EMERY CO
NATIONAL FOREST
Reservoir may not store a significant amount of water
Miles
0 0.5 1 2 3 4
BYU

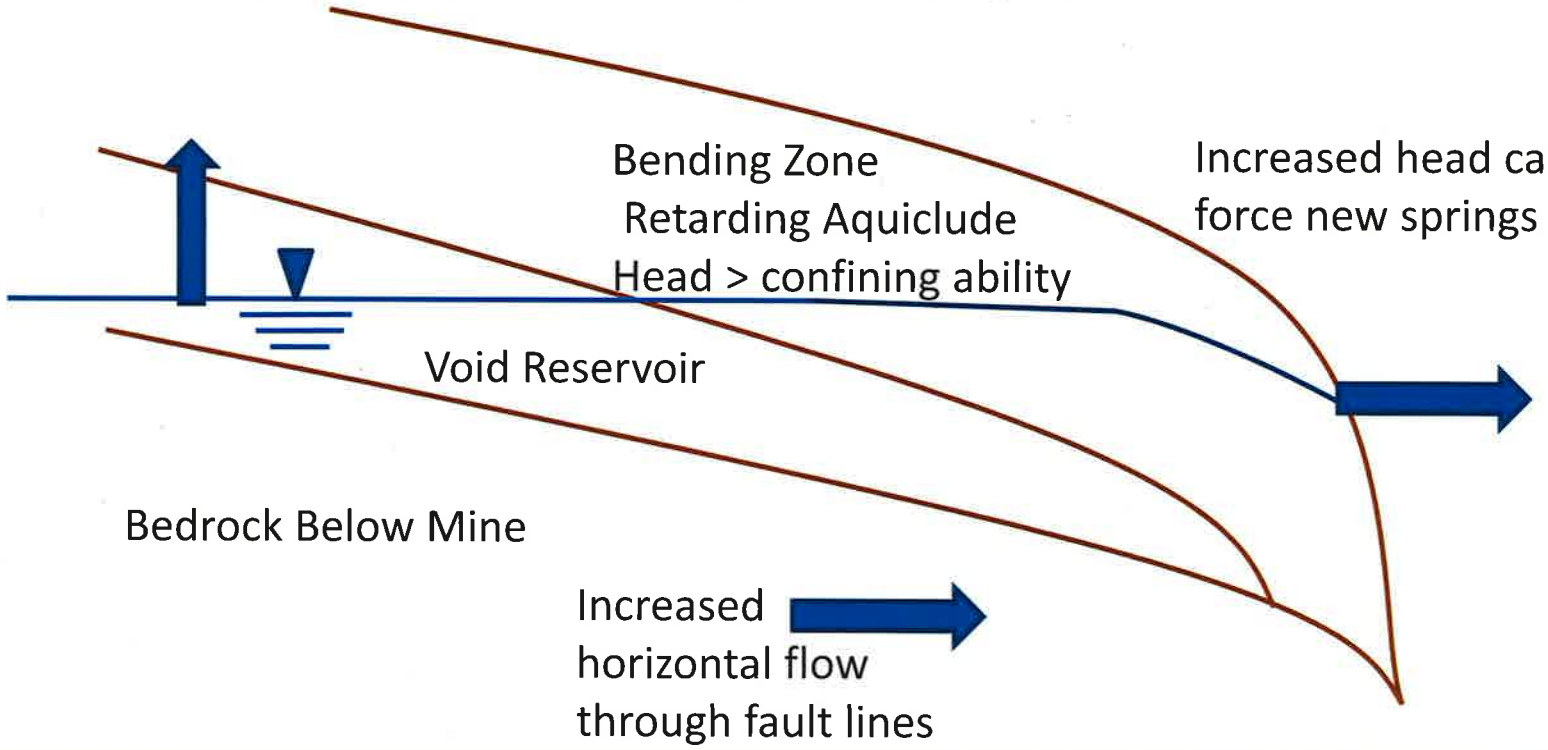
Void Reservoir Head Limit

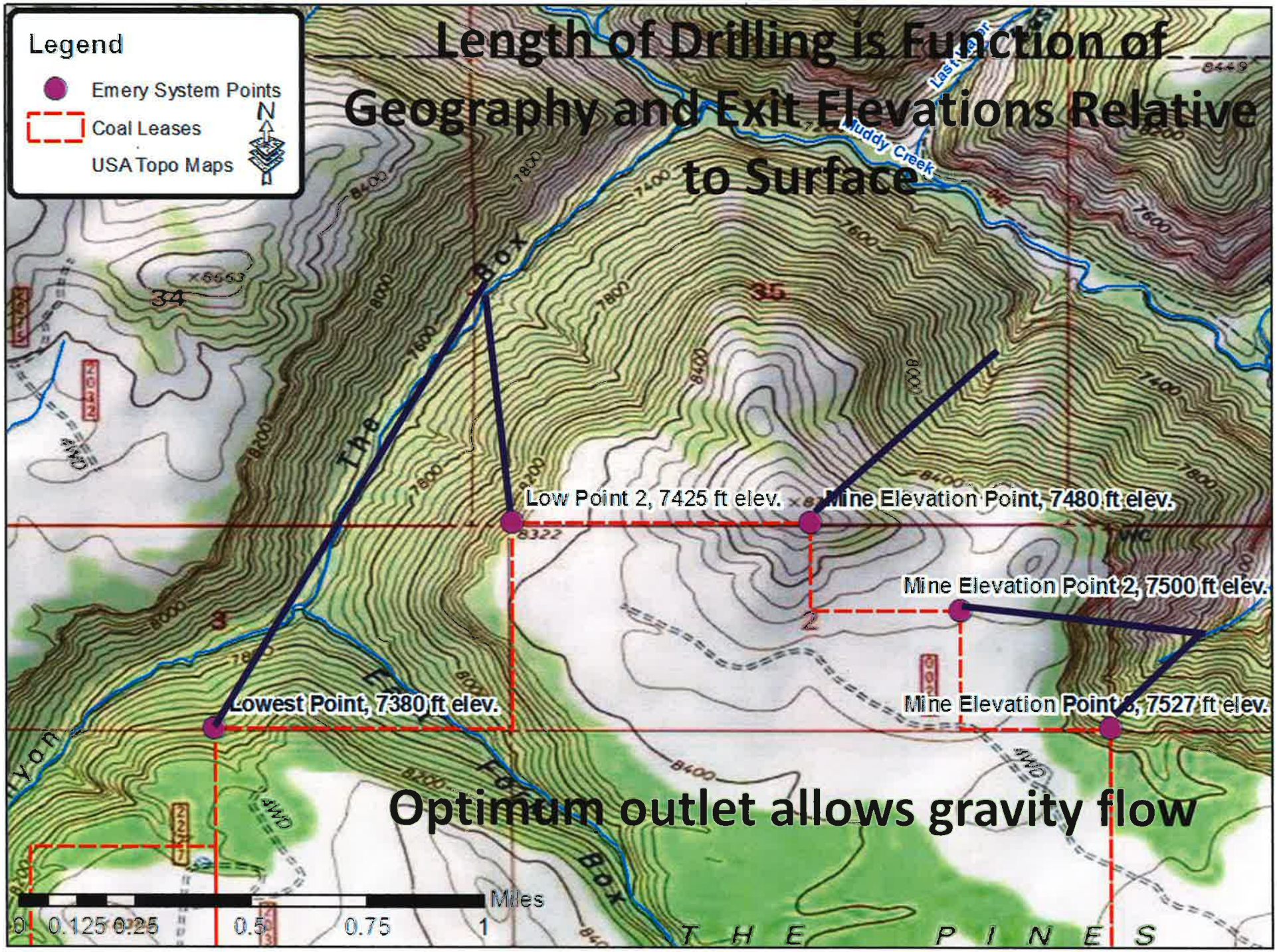
Alta Mine, an abandoned silver mine, has produced 50 MGY for Little Cottonwood Canyon since 1985

Mine reservoir was built to hold 1600 ft of head but is limited to 300 ft

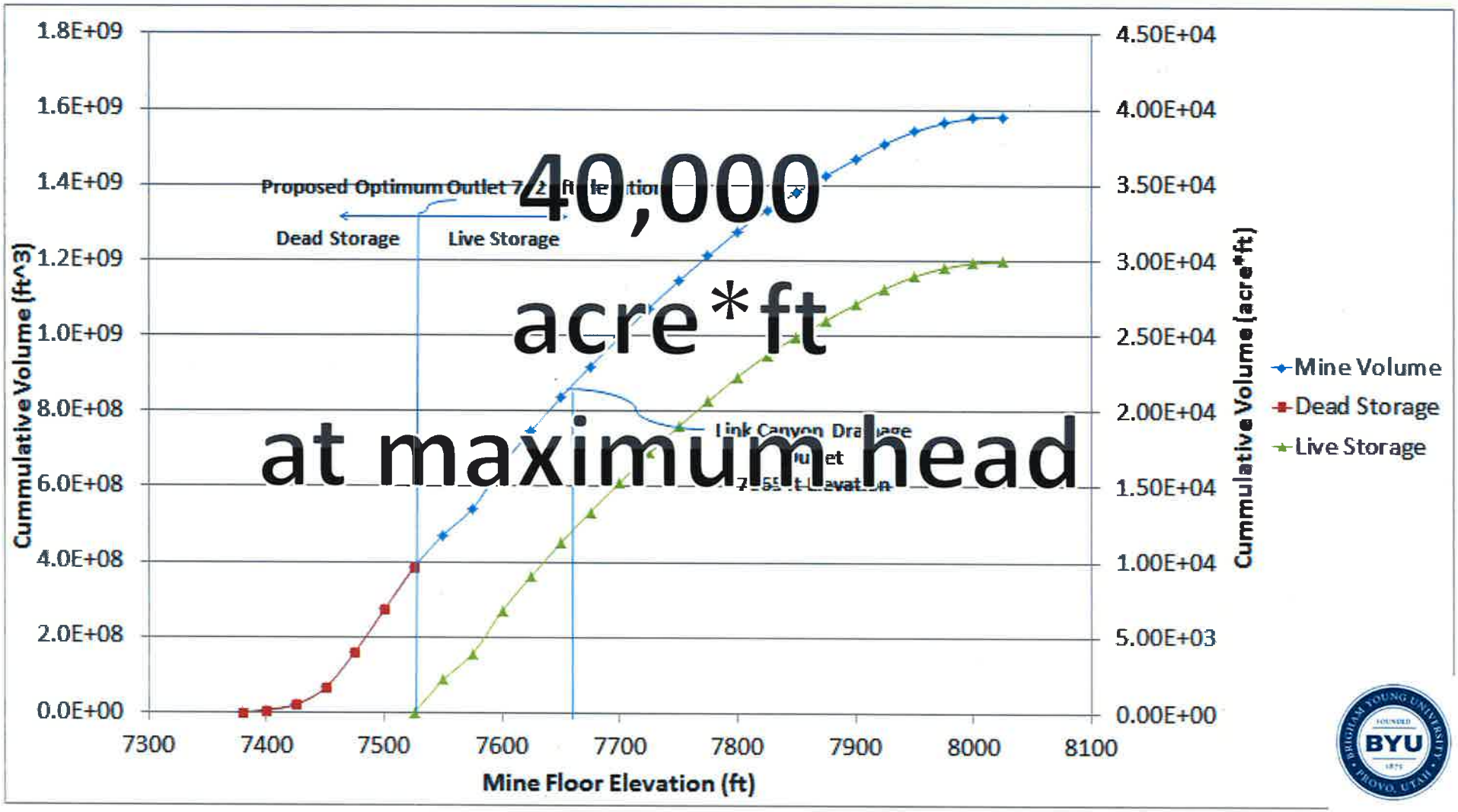
Increased Head in Mine Reservoir Can Generate Unwanted Seeps and Springs

- At some point the forced exit flow from increased head will neutralize inflow




Legend
Emery System Points
Coal Leases
USA Topo Maps
N
Length of Drilling is Function of Geography and Exit Elevations Relative to Surface
Low Point 2, 7425 ft elev.
Mine Elevation Point, 7480 ft elev.
Mine Elevation Point 2, 7500 ft elev.
Lowest Point, 7380 ft elev.
Mine Elevation Point 3, 7527 ft elev.
Optimum outlet allows gravity flow
Miles
0
0.125
0.25
0.5
0.75
1
THE PINES

Dead Storage Situation for Gravity Storage Reservoir



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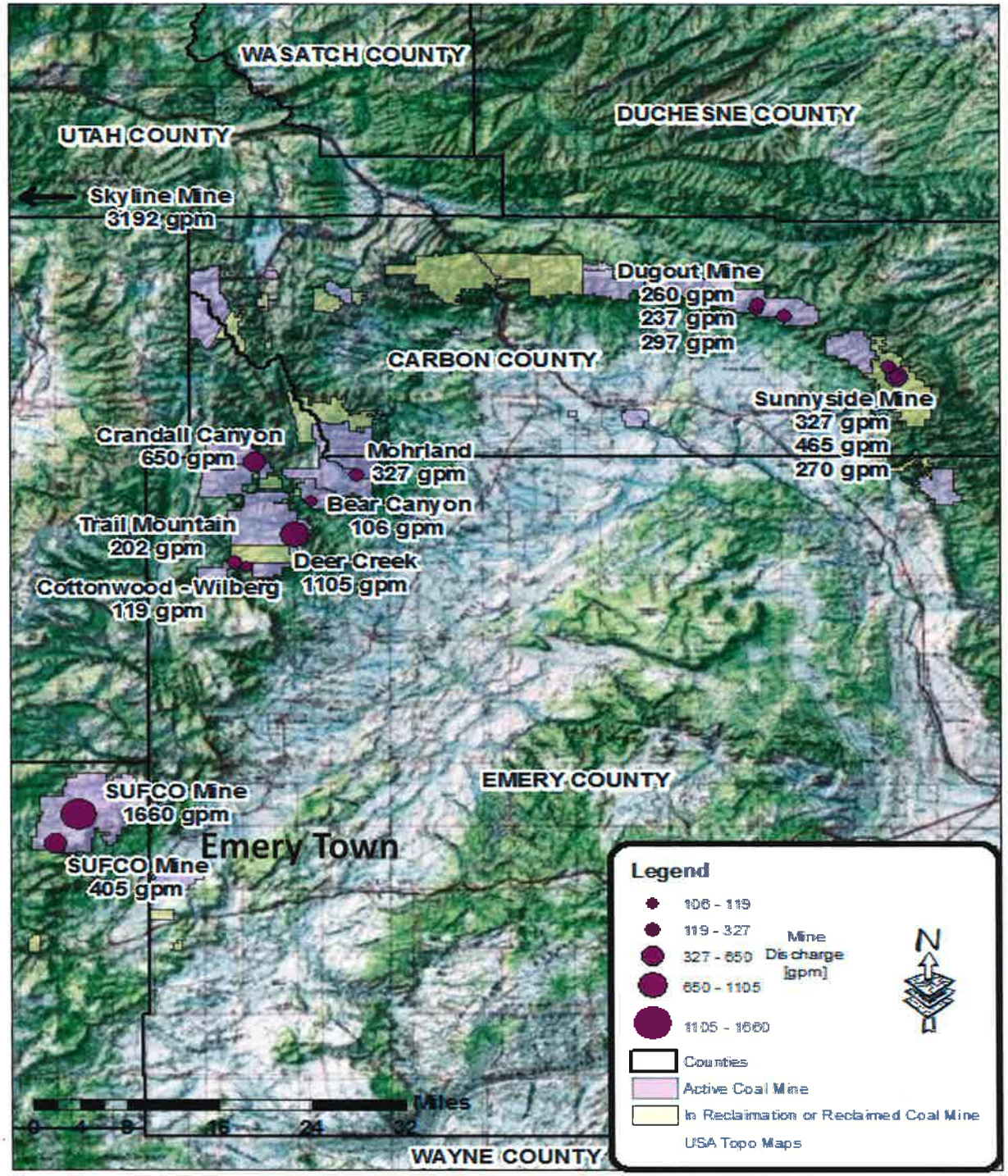
DOGM Data for Flow and Quality

DOGM data is not reflective of information needed for active mines and/or treated discharge.

Flow data will generally reflect operations freeing perched groundwater above the mine ceiling.

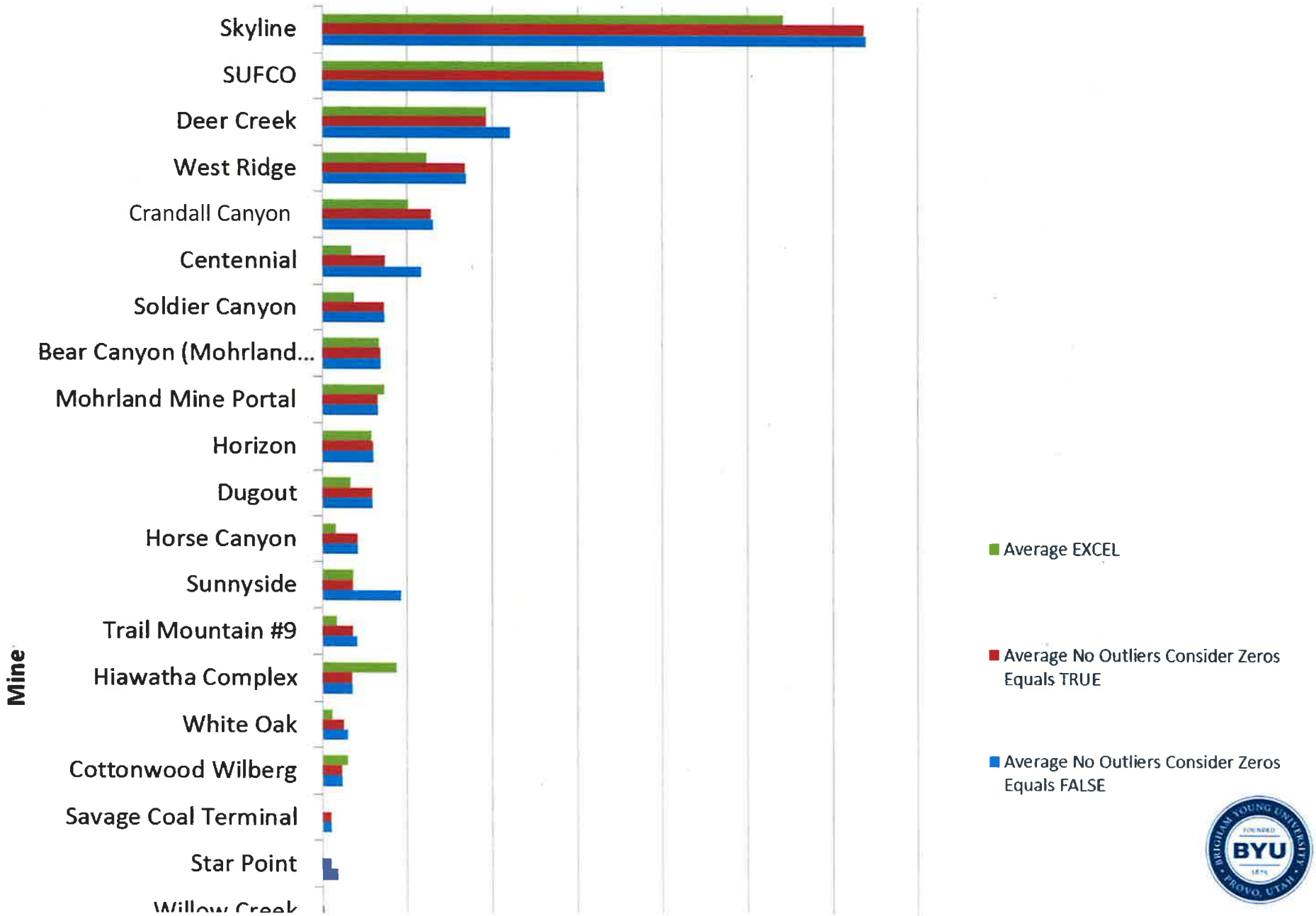
Water quality data is recorded after treatment.

Data is reflective of information needed for mines which are not active and/or receive no treatment



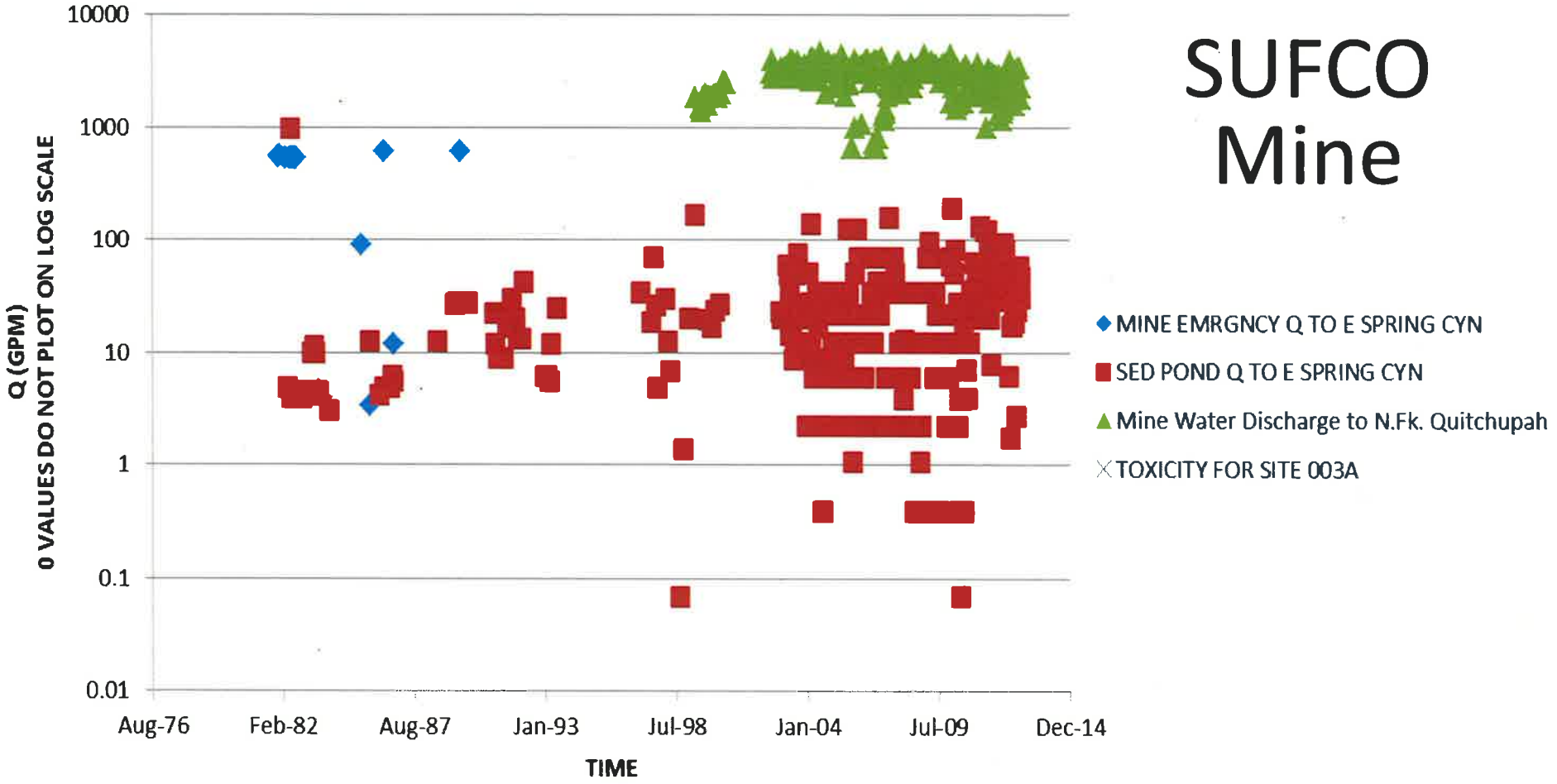
Coal Mines in the Wasatch Plateau and Book Cliffs Area

Mine Average Discharges



Mine Average Discharges

Almost continuous 3000 gpm discharge since 1998



Water Quality

Highly variant by mine

Mohrland and SUFCO mines are known to discharge without treatment

Crandall mine is known to require treatment. Current trend is improved iron content over time towards quality goal.

(coloration reflects treatment agent precipitating metals)

DOGM water quality database only records after discharge
Crandall Mine Data is Acceptable to Permit Requirements

PARAMTER	UNITS	Based on Average No Outliers custom EXCEL VBA function (Appendix B)				PERMIT REQUIREMENTS
		Average IGNORING ZEROS	Average INCLUDING ZEROS	Average IGNORING ZEROS	Average INCLUDING ZEROS	
		Mine Q	Mine Q	Sediment Pond	Sediment Pond	UT0024368-002 and 001
pH min DMR	pH units				6.5	6.5
pH max DMR	pH units			7.5	6.7	9
TSS-30 DAv	mg/l			5.3	4.7	25
TSS-7 DAv	mg/l			5.6	5.0	35
T-Fe	mg/l	0.54	0.54			1.24
TSS	mg/l	56	56			70
TDS	mg/l	716	716			1200

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Water Rights

- Muddy Creek watershed is 100% claimed by water rights
- Additional water available is not valid water right for an average flow year
- Change application would required processing to move water right diversion
- Water from mine is not required to discharge over time even if claimed on as the flows would be considered higher than average flows

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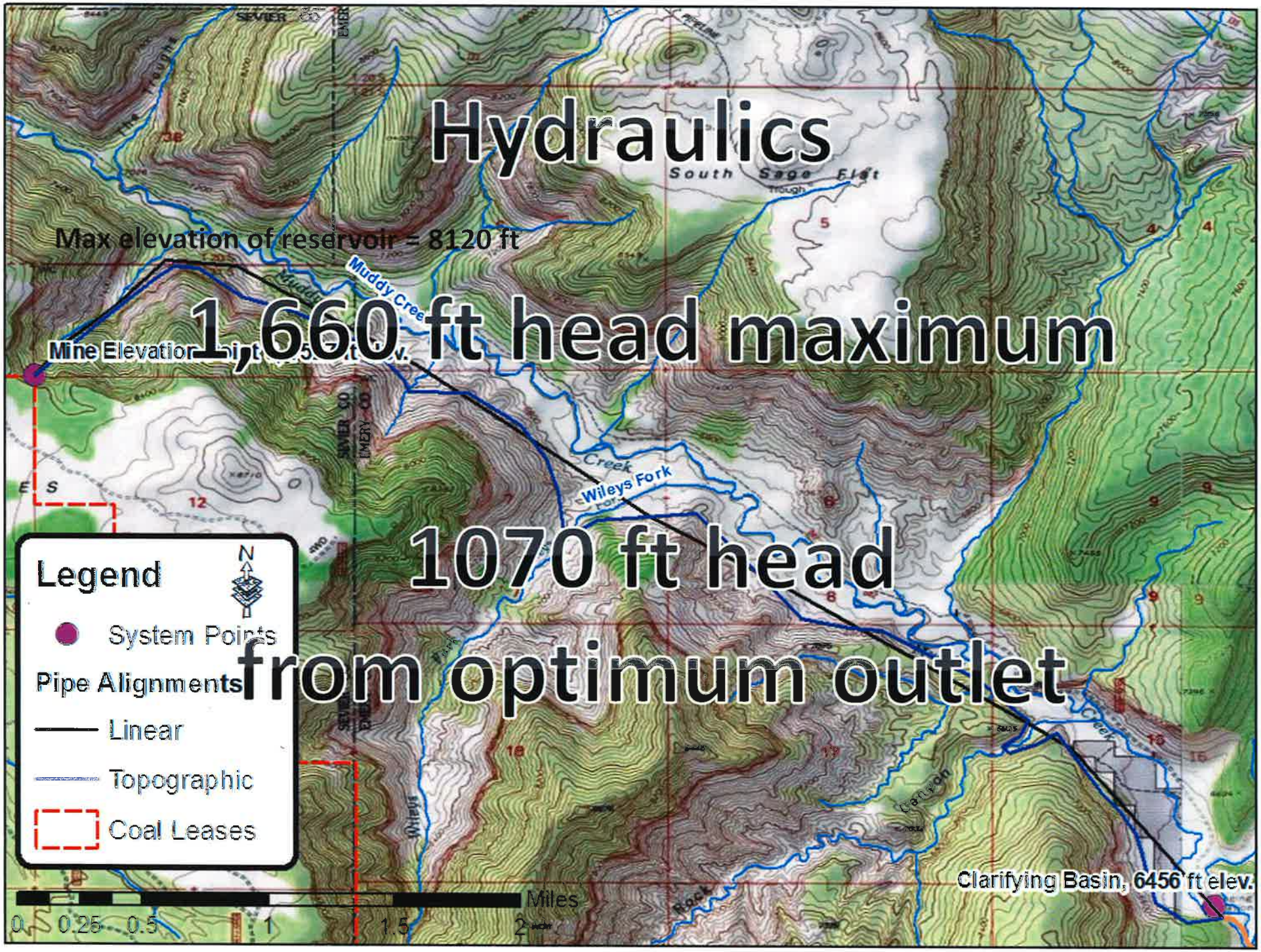
Hydraulics
Max elevation of reservoir = 8120 ft
1,660 ft head maximum
Mine Elevation
1070 ft head
from optimum outlet
Clarifying Basin, 6456 ft elev.
Legend
System Points
Pipe Alignments
Linear
Topographic
Coal Leases
Miles
0
0.25
0.5
1
1.5
2
Muddy Creek
Wilseys Fork
South Sage Flat
Canyon

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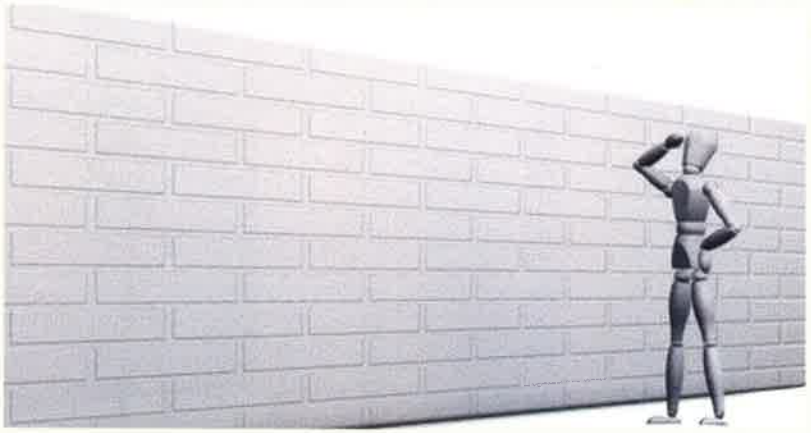
Water Treatment

Alta Mine Treatment Facility (50 MGY) Constructed in 1985 at a cost of $2.9 M in 2013 dollars

Obstacles



http://www.techinasia.com/3-main-obstacles-to-implementing-a-social-media-strategy/

- High Risk
- Low Recharge Yields and discharge does not increase water rights
- Possible inability to hold significant amounts of water
- Difficult locations for construction
- High heads/pressure require high cost materials

Conclusions

- Using long wall mines is a feasible means of storing water
  - Plenty of head and storage volume avialable
- Development of groundwater is high risk, on site tests must be performed to determine if site can hold water
- More research and data is needed for specific cases
- Mine reservoirs in the Wasatch Plateau and Book Cliffs region could provide high quality water and plentiful storage

Potential for Water Storage in Abandoned Mine Workings in the Castlegate Area, Carbon County, Utah

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Cyprus Plateau Mining Corporation, Price, Utah

15 June 1999

Mayo and Associates, LC
Consultants in Hydrogeology

Potential for Water Storage in Abandoned Mine Workings in the Castlegate Area, Carbon County, Utah

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Cyprus Plateau Mining Corporation, Price, Utah

15 June 1999

Prepared by:

David A. Herron
Staff Hydrogeologist

Erik C. Petersen, P.G.
Senior Hydrogeologist

Alan L. Mayo, Ph.D.
Principal

Mayo and Associates, LC
710 East 100 North
Lindon, Utah 84042
801-796-0211

Mayo and Associates, LC
Consultants in Hydrogeology

Potential for Water Storage in Abandoned Mine Workings in the Castlegate Area, Carbon County, Utah

Executive Summary

For mining in Cyprus Plateau Mining Corporation's Willow Creek Mine to be successfully completed, it will be necessary to pump and dispose of an estimated 1.5 billion gallons of water from abandoned mine workings underlying the Willow Creek Mine. The purpose of this investigation is to estimate the potential for storage of this water in abandoned mine workings in the Castlegate area west of Highway 6.

The information required to make calculations of available open mine volumes includes an accurate description of the mine geometry (i.e., the mined area and the extracted coal thickness), the interconnectedness of mined areas, the changes which may occur in mine workings through time after mining is completed (i.e., caving and subsidence), and the presence or absence of water in the abandoned mine workings prior to any potential injection. Most of this information was obtained from old mine working maps obtained from CPMC. In many instances, information essential for mine volume calculations was not available. In these instances, required parameters were estimated based on discussions with CPMC personnel, knowledge of commonly utilized mining practices, and extrapolation of data from nearby locations where data are available. Because of the limited and incomplete nature of the data, it is not possible to determine with certainty the mine volumes available for water storage. The values presented here should, therefore, be considered as best estimates and should not be taken as absolute values.

The results of the mine volume calculations suggest that between 0.720 and 2.490 billion gallons of water can be stored in the abandoned mine workings west of Highway 6. To inject this volume of water into the abandoned mine workings, more than one injection site will be necessary. It is estimated that between 0.720 and 1.930 billion gallons of water can be injected into the old workings at a single injection site. To accommodate this water, the abandoned mine workings will be filled to an elevation of 6,300 feet.

Much of the uncertainty in these calculations results from the lack of information regarding the amount of water already in the old mine workings prior to any injection. It is recommended that a monitoring well be constructed in Bear Canyon which will allow the determination of the existing water level in the Royal/New Peerless Mine complex. This well may also be used to monitor water levels as injection activities progress and as a means to measure water quality. Monitoring of the Crandall Canyon Shaft is also recommended to provide water quality and water level information.

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1.0 INTRODUCTION

Cyprus Plateau Mining Corporation (CPMC) operates the Willow Creek Mine which is located near Helper, Utah (Figure 1). CPMC holds additional coal leases west of Highway 6 in Price Canyon and plans to mine these leases in the future. Shortly after coal mining in the Willow Creek Mine commenced, it was determined that the old Castlegate #2 Mine workings are flooded with an estimated 1.5 billion gallons of water. These workings are located in the K-Seam, which lies approximately 80 feet below the Willow Creek Mine workings in the D-Seam. The water in the Castlegate #2 Mine must be removed and disposed of before mining in the Willow Creek Mine can be safely completed. Several methods for disposal of the old mine waters have been investigated by CPMC. These include 1) treatment of the water and discharging it into the Price River drainage, and 2) pumping the water into one or several of the abandoned mine workings west of Highway 6 (Figure 2). The feasibility of the latter method is the topic if this investigation.

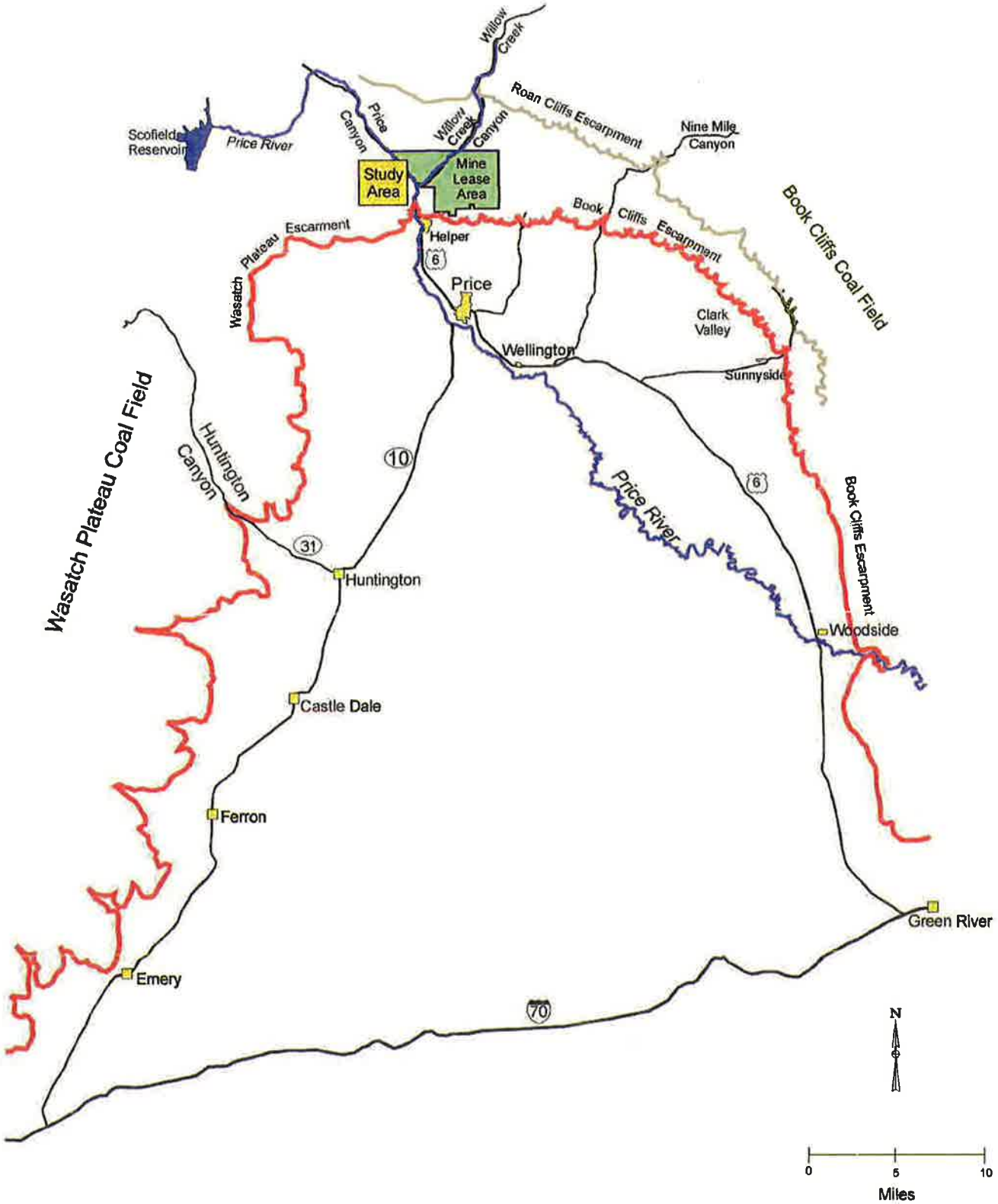


Figure 1 Regional Map for Willow Creek Study Area

Figure-1-Regional-Map-B.cdr
Mayo and Associates, LC
June 7, 1999

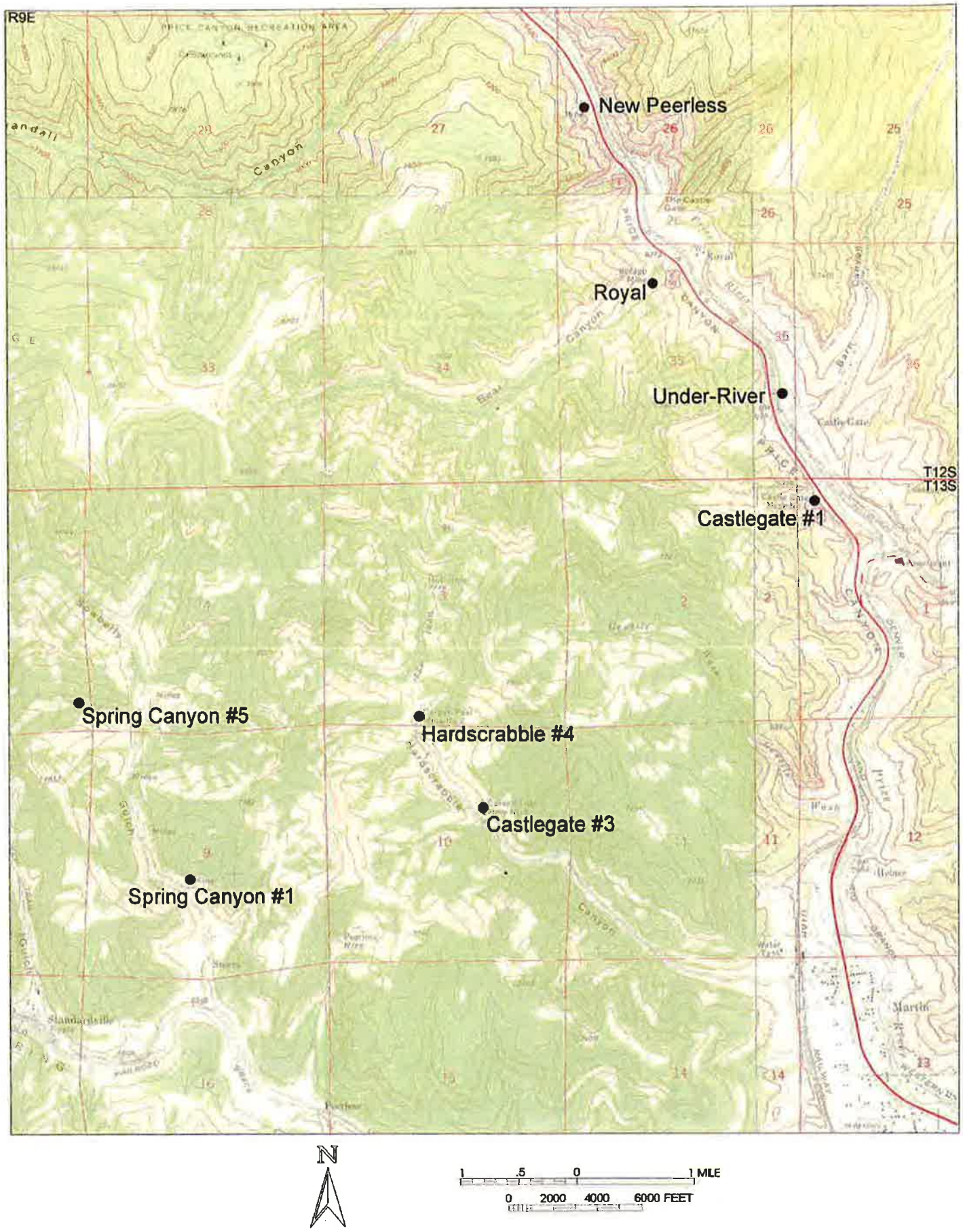


Figure 2 Location of portals of abandoned mines considered for water storage.

Figure-2-Mine Locations cdr
Mayo and Associates, LC
June 7, 1999

2.0 PROJECT OVERVIEW

2.1 Purpose of investigation

The purpose of this investigation is to examine the feasibility of injecting waters from the de-watering of the Castlegate #2 Mine workings beneath the Willow Creek Mine into abandoned mine workings west of the Price River. This investigation includes 1) the evaluation of the potentially open mine volumes available to receive injected water, and 2) the likely fate of the water after it has been pumped into the abandoned mine workings.

2.2 Methods of investigation

2.2.1 Mine Maps

All available maps of old mine workings in the Willow Creek and adjacent areas were obtained from CPMC and reviewed. The original mine working maps used in this investigation were 1 inch = 2,000 feet scale or greater. Many of the original mine maps are nearly 100 years old and many were hand drawn. The mine-working maps were used to determine the geometry of the old mine workings, the elevations of the mine workings, and the thickness of the coal seams and/or height of coal extracted in the old mines. Calculations of mine volumes available for injection were conducted using the various mine maps provided from CPMC. Mine workings shown on the old maps were digitized into electronic AutoCAD™ file format.

2.2.2 Volume Calculations

Electronic maps of each mine were carefully analyzed to determine the potential available open volume of each mine and the locations of potential spillover points. Individual mines

were divided into small blocks based on proximity and apparent mining style. Care was taken to digitize blocks according to the apparent style of mining, because several distinct mining styles were apparent from the maps and the style of mining affects the percentage of the total coal that was recovered in any given area.

To simplify the volume calculations, the various mining styles were grouped together into several categories and given the following arbitrary names: LONG (for longwall mining), SECO (for secondary mining), DRP (for dense room & pillar), TRP (for typical room & pillar), and LRP (for ladder-like room & pillar). Each mining style was then assigned a value for approximate coal recovery, as well as a value for volume loss from subsidence. The determination of these values is based on professional expertise and on conversations with Willow Creek Mine staff.

Each digitized mine block was then assigned a mining style, a mining height, and a total area in square feet. The total area for each digitized block was determined by having AutoCAD™ determine the area of the digitized polygon outlining the block. The mined height for each block was determined by averaging coal thickness information shown on the mine maps within or near the block. Where coal thickness information was sparse or unavailable, mined heights were estimated based on interpolation between the nearest locations where data are available. The volume for each digitized mine block was then calculated by multiplying the total area of the block, the percentage of coal recovery within that area, the mined height, and the percentage of mined height not lost to surface subsidence. This information was tabulated for each mine using an interactive spreadsheet.

3.0 DESCRIPTION OF THE LEASE AREA

The area of interest, located west of Highway 6 and north of Spring Canyon (Figure 2), contains a series of deeply incised, narrow-bottom canyons separated by Ford Ridge. This narrow ridge trends diagonally through the area and separates the Price River drainage from the Spring Canyon drainage. Important canyons in the Price Canyon drainage include, from south to north, Hardscrabble Canyon, Gentile Wash, Bear Canyon, and Crandall Canyon. In the Spring Canyon drainage, the main canyons include Sowbelly Gulch and Robinson Gulch. These canyons are generally steep walled, with moderate to low soil cover. Rocky cliffs commonly occur where the Castlegate Sandstone outcrops on hillsides. The vegetation cover in most areas is relatively sparse, with sagebrush and deciduous brush covering the south facing slopes, and isolated stands of conifer trees occurring on north facing slopes.

The old mine workings considered for potential injection in this investigation are shown on Plates 1 through 4, and include the Royal, New Peerless, Spring Canyon #5, Spring Canyon #1, Hardscrabble #4, Castlegate #3, and Castlegate #1 Mines. Each of these mines is located west of Highway 6 between Spring Canyon on the south and Crandall Canyon on the north (Figure 2). In addition to the Castlegate #3 Mine listed above, another abandoned mine is shown on old maps as being called the Castlegate #3 Mine. This second and smaller Castlegate #3 passes underneath the Price River at shallow levels, is already flooded with water, and cannot be used for storage of additional water. To eliminate possible confusion between these two mines, the mine passing underneath the Price River will be referred to in this report as the Under-River Mine.

4.0 GEOLOGIC SETTING

4.1.1 Blackhawk Formation

All of the mine workings evaluated as potential sumps for the storage of mine water are in the lower portion of the Blackhawk Formation. The Blackhawk Formation consists primarily of interbedded sandstone, mudstone, shale, and coal with a total thickness of about 1,100 to 1,300 feet in the Willow Creek area. Individual rock layers in the formation are generally lenticular in nature and it is not possible to trace individual layers over significant lateral distances. Several thicker, massive, sandstone units, which are more continuous in nature, occur in the lower portion of the Blackhawk Formation.

Most of the coal reserve in the lease area lies in the lower half of the Blackhawk Formation, above the Spring Canyon Sandstone. Important coal seams in the Willow Creek area are the A-Seam, the Kenilworth Seam (K-Seam), the D-Seam (which is currently being mined at the Willow Creek Mine) and the Sub 3-Seam.

In many locations, the coal seams in the Blackhawk Formation have experienced natural coal burns along the outcrop. The coal burn commonly results in intense fracturing of the rocks immediately above and below the coal seam and may extend several hundred feet laterally into the mountain.

4.1.2 Mancos Shale

The marine Mancos Shale underlies the Blackhawk Formation in the study area (in the adjacent Wasatch Plateau coal district, the lower, massive-sandstone tongues of the

Blackhawk Formation are designated as the Star Point Sandstone). The Mancos Shale consists of highly erodeable calcareous, gypsiferous, and carbonaceous dark gray shale. The Mancos Shale is generally considered mostly impermeable to groundwater flow.

4.1.3 Structure

The study area lies in the Book Cliffs Coal Field in a three-way transition zone between the Colorado Plateau, Uinta Basin, and the Wasatch Plateau physiographic provinces. The rocks in the lease area were protected from major tectonic stresses by stress release along the Fish Creek Graben. There is a lack of major structural features in the area, such as major faulting and strong jointing. Where minor fracturing and jointing do occur, they primarily trend approximately 60° W with dips of about 5° to 7° from vertical. Fracture densities are greatest in thin-bedded or fine-grained strata. Thicker-bedded rocks and homogeneous sandstones commonly have lower fracture densities. Rock layers in the region generally dip about 8° north to northeast, although in localized areas the rocks may dip as steeply as 15° where differential compaction of the coal seams has occurred.

5.0 VOLUME ASSUMPTIONS AND MINE INTERCONNECTIONS

5.1 Assumptions Used in Mine Volume Calculations

The calculation of mine volumes available for water injection requires making several assumptions, which are listed and discussed below. Assumptions used in calculating estimated fillable mine volumes include 1) the thickness of the coal seams and the percentage of coal recovered, as opposed to coal left in place, 2) the extent to which the mined volume has been lost to surface subsidence, 3) the amount of water existing in the mines before injection, and 4) whether seals constructed in the mine will leak sufficiently to allow flooding of sealed passages. The ambiguity involved in determining many of these parameters results in considerable uncertainty in the results of the mine volume calculations. Even so, using reasonable estimates allows a determination as to whether or not the abandoned mines can potentially hold the water CPMC proposes to discharge.

Coal seam thickness and mined height

A determination of the height of coal that was extracted during mining is required to calculate the volume of mine voids. In many locations, this parameter is unknown. In these areas, an assumption of mined height has been made based on the thickness of the coal seam in that location, and judgements regarding the percentage of the coal seam height commonly extracted by the mining technique used in that area. Based on examination of the mine working maps, it is apparent that variations in coal seam thicknesses generally occur in a relatively gradual and uniform manner. This suggests that interpolation of coal thicknesses between data points, where such data are sparse, should yield reasonably accurate estimates of actual coal thickness. Different styles of coal mining have different coal recovery

percentages (i.e. leave different percentages of unmined coal after mining). The differences in the percentage of coal extracted by different mining styles are significant. The coal recovery parameters used in making the volume calculations are listed in Table 1. These estimated recovery percentages are based on discussions with CPMC personnel and graphical analysis of the mine working maps and are believed to be reasonably accurate. The mine volume calculation equations are incorporated into the volume calculation spreadsheet in a manner that is conducive to doing sensitivity analyses by varying the value of the coal recovery parameter.

Table 1 – Coal Recovery and Volume Loss

Mining Style	Coal Removed	Loss to Surface Subsidence
Longwall	100%	20%
Secondary	80%	20%
Dense Room & Pillar	60%	0%
Typical Room & Pillar	50%	0%
Ladder-Like	45%	0%

Mine volume lost to surface subsidence

After mining in an area is complete, settling of the rock overburden can result in surface subsidence and a diminished open mine volume. Although longwall and secondary mining techniques commonly result in partial collapse of the initial open voids, the volume of open space is not lessened, rather it is redistributed upward (except for the volume lost to surface subsidence). Room and Pillar mining (without secondary recovery) commonly results in

little or no surface subsidence. If longwall or secondary mining takes place under shallow cover or beneath relatively flexible rocks, then up to 70% of the original void space can be lost to the ground surface as subsidence. If the mining takes place under considerable cover or beneath strong, rigid rocks, most of the mining volume stays within the caving zone, within and immediately above the original void. Widely used and generally accepted equations governing the predicted height of the caving and fracture zones above longwall mined areas have been developed. The application of these equations to coal mining in the Wasatch Plateau coal district is summarized in Kadanuk (1994). Generally, the caving zone is predicted to propagate upward for a distance of 8 times the mined height. The fracture zone is predicted to propagate upward for a distance of 30 times the mined height. Thus, using a conservative estimate of 10 feet for the mining height, the caving zone is predicted to extend upward approximately 80 feet, and the fracture zone should extend approximately 300 feet. Most of the redistributed open space remaining in an area after longwall mining is contained in the caving zone as shown in Figure 3.

Examination of mine, structure, and topographic maps reveals that most of the mine areas being considered for water storage are situated under considerable cover, ranging from 500 to over 2,400 feet. Assuming a mine height of 10 feet, this corresponds to a cover thickness ranging from 50 to 240 times the mine height. Rocks overlying the mines also contain numerous thick and rigid sandstone lenses (CPMC Mining and Reclamation Plan). Because of these factors, and after discussions with CPMC personnel, it was decided that subsidence in the areas being considered was probably minimal. With surface subsidence estimates ranging from 0% to about 30% of the mine height, a possibly conservative value of 20% was

selected for the estimate of mine volume lost to subsidence in areas of longwall and secondary mining. For areas of room and pillar mining with no secondary recovery, it is assumed that there is no volume loss. The assumed values for coal recovery and volume loss due to subsidence are summarized in Table 1.

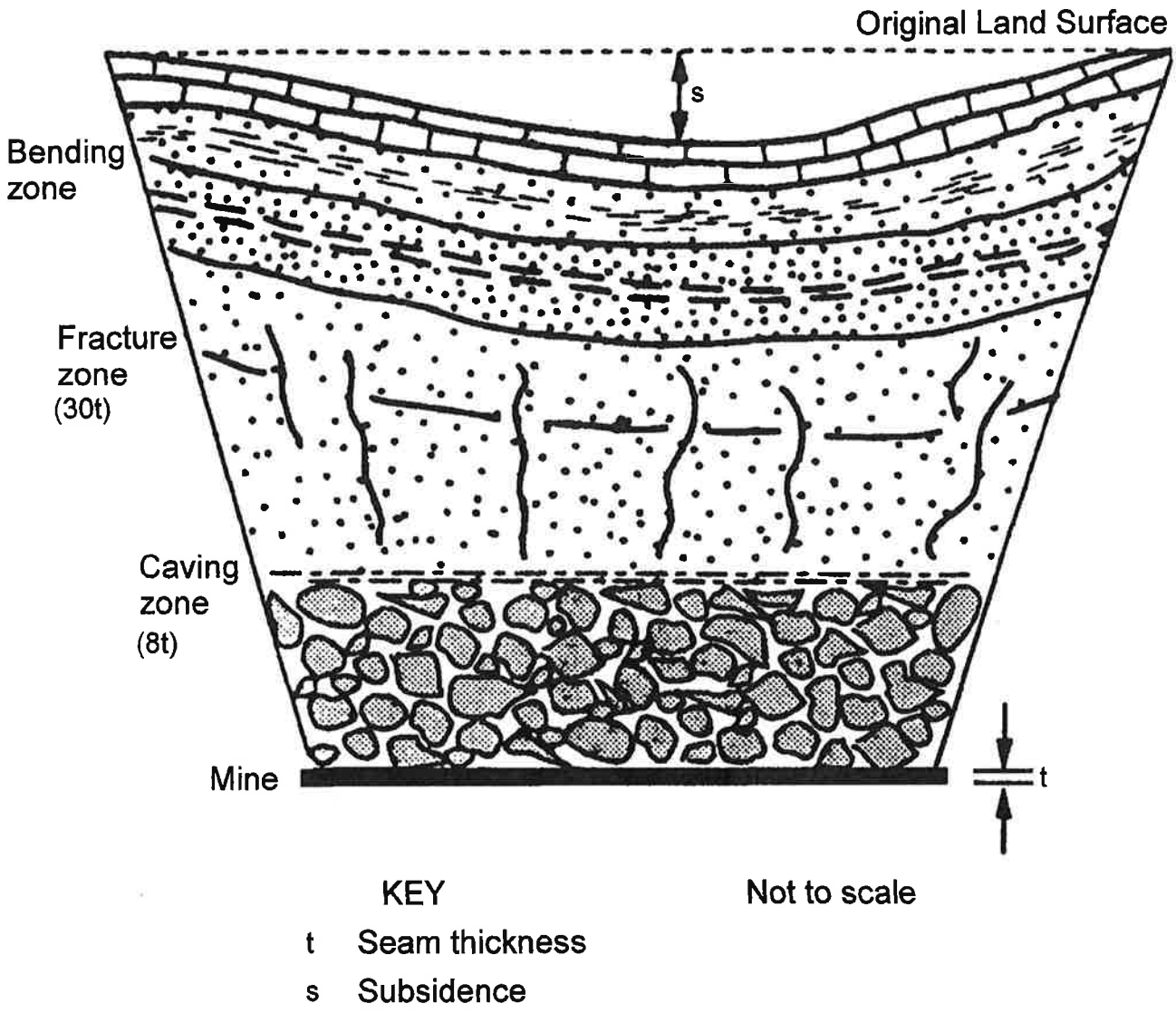


Figure 3 Fracturing and Subsidence Above Longwall Panel

Figure-3-Subsidence cdr
Mayo and Associates, LC
April 28, 1999

Existing volumes of water in mine workings

The mine volume calculations also require an assumption as to the amount of water already present in the various mines. The water level measured in the Crandall Canyon ventilation shaft (Plates 1 and 2) appears to represent the elevation of impounded water in the Castlegate #3 and Spring Canyon #5 mines. Although these mines appear to presently contain some water, there is likely considerable volume available for the storage of additional water. No recent water level information is available for the Royal and New Peerless Mines, but old maps indicate that some water was present during mining operations. The water level shown on the old mine maps is therefore interpreted as the minimum amount likely to be present. The quantity of water currently contained in the Royal and New Peerless Mine complex remains problematic at this time.

The dip of the coal seam in the Spring Canyon #1 Mine is such that these mine workings have the potential to be useful in storing additional water, but nothing is known about how much water may already be present. The Castlegate #1 Mine slopes upward away from the portal and thus cannot be used to store water. The Hardscrabble #4 Mine cannot be used to store water because its workings are higher than the overflow point of the mines connected to it. Water put into the Hardscrabble #4 mine would migrate downward into the other mines to which it is interconnected. If these other mines were already filled to their recommended limits, the excess water could cause the other mines to overflow.

Hydraulic integrity of mine seals

After mining in a portion of a coal mine is completed, these areas are commonly sealed. Information about the location of seals in many of the old workings is very incomplete. Seals in the mine workings are intended to prevent airflow to or from certain portions of the mines. This prevents explosive gasses or oxygen deficient atmospheres in abandoned portions of a mine from reaching active mining areas, and also allows more efficient ventilation of active mining areas. Currently, mine seals are commonly constructed of block, with grout being used to seal the margins of the wall to the surrounding rock material. Historically, these seals may have been created using other techniques and with other materials. Since mine seals are intended to be air-tight, it is possible that they are also water-tight, which would interfere with injection of water into the old mine workings. After discussions with CPMC staff, it was concluded that the mine seals would almost certainly leak water, but that the rate of leakage is not known. It is possible that mine seals will eventually implode, as water pressure from impounded water increases until the pressure exceeds the strength of the seal. It seems more likely that the seals would continuously leak water and the hydraulic head on both sides of the seal would remain near equilibrium. For this investigation, it has been assumed that seals in the old mine workings will leak, and that they will leak at a rate fast enough to not interfere with the injection of water into the old workings.

5.2 Mine Interconnections and Overflows

The mine volume available for injection with water is limited by the lowest overflow point for each mine, as well as by the amount of water already present in the mines. In order to determine the overflow point for the various mines, each map was carefully examined to

locate mine portals and connections to other mines. The old workings that were considered for water storage were found to fall into three distinct groups, each with a different overflow location and elevation. These groups include 1) the Royal and New Peerless Mines, 2) the Castlegate #3, Castlegate #1, Spring Canyon #5, and Hardscrabble #4 Mines, and 3) the Spring Canyon #1 Mine. The locations of the mine portals are shown on Figure 2, while the mine workings are shown on Plates 1-4.

The Royal and New Peerless Mines appear to be parts of the same mine complex, and are connected in multiple locations. The spillover point for this group of mines is the rock-slope portal of the Royal Mine, located in Bear Canyon just above an elevation of 6,300 feet (Figure 2).

The Castlegate #1, Castlegate #3, Hardscrabble #4, and Spring Canyon #5 Mines also appear to be connected. The Hardscrabble #4 and Spring Canyon #5 Mines are simply separate portals to the same mine complex, which are then connected to the Castlegate #3 Mine via the Crandall Canyon ventilation shafts (Plates 1 and 2). This mine complex is then connected to the Castlegate #1 Mine by a rock-slope from the Castlegate #3 Mine (Plates 2 and 3). The overflow point for this group of mines is the top of the rock-slope in the Castlegate #1 Mine, at an elevation of 6,405 feet. Water overflowing this point would flow to and out of the Castlegate #1 portal, located above the highway in Price Canyon (Figure 2). Although connected to the other mines, the Hardscrabble #4 Mine is higher than the 6,405 elevation of the spillover point for the connected mines, and thus has no useable storage volume.

The third group of mines consists of only the Spring Canyon #1 Mine, which does not appear to connect to the other mines (Figure 2 and Plate 2). The mine maps suggest that this mine would not overflow until filled to an elevation of approximately 6,900 feet, at which point water would spill from one of its many portals in Sowbelly Gulch.

The known interconnections between the various mines are not the only significant pathways between mines. Exploration drillholes and overlapping longwall or secondary mining areas complicate the determination of mine interconnections by creating the potential for significant leakage between mines vertically. Parts of the Spring Canyon #5 Mine directly overlie large secondary mined portions of the Spring Canyon #1 Mine, with the lowest area of significant overlap being the 6,600-foot elevation of the #5 Mine (Plate 4). Filling the Spring Canyon #1 Mine above this point could result in leakage into the overlying mine through drillholes and fractures created by secondary mining. Because of the possibility of leakage into overlying workings, the recommended injection elevation of the Spring Canyon #1 Mine is lowered from 6,900 feet to 6,600 feet. In a similar manner, the Royal Mine directly overlies significant portions of the Castlegate #3 Mine (Plate 4). Here, longwall panels of the #3 Mine are overlain by secondary mining areas of the Royal Mine. Although the rock between the two mines is approximately 400 feet thick, suggesting that leakage may not be significant, there are likely to be exploration drillholes in the area which may facilitate interconnections between these two mines. Therefore, the recommended injection elevation of the Castlegate #3 Mine, and mines connected to it, is lowered from 6,400 feet to the spillover elevation of the Royal Mine at 6,300 feet. Lowering the recommended injection

elevation, so that these mines would be filled to the same level, also allows injection of both groups of mines from a single injection site.

6.0 MINE VOLUME RESULTS

6.1 Mine Volume Results

Mine volumes were calculated for those parts of the various mines that appear to have volume available for water injection and storage. Results of these calculations are summarized in Table 2. The full calculations are shown on plates 5-8. The elevations listed in Table 2 represent recommended elevations to which the data indicate that water can be injected and stored in the mines. Below these elevations, overflow or significant leakage of water from the mine workings would not be expected. Maximum and minimum volumes listed for each mine include only the volume existing below recommended injection elevations, and available for storage of additional water. The difference between maximum and minimum volumes for each mine represents uncertainty in the volume of water already present in the workings considered for water injection.

From Table 2, it is clear that a more accurate estimate of the available volume depends greatly on the determination of the current water levels in the Royal / New Peerless and Spring Canyon #1 Mines. A total volume available for water injection excluding the Spring Canyon #1 Mine was listed because all of the other mines could theoretically be filled from a single injection site located in Bear Canyon. Storing water in the Spring Canyon #1 Mine would require additional piping to a separate injection site in Sowbelly Gulch.

Table 2 - Summary of Volume Calculation Results

Name of Mine Considered for Water Storage	Recommended Injection Elevation (feet)	Volume Below Injection Elevation	Current Water Elevation (feet)	Current Water Volume Present In Mine Workings		Potential Volume Available for Storage of Additional Water		Comments
				Min. (Gallons)	Max. (Gallons)	Min. (Gallons)	Max. (Gallons)	
Royal Mine	6,300	1,166 million	Unknown	228 million	1,166 million	0	938 million	May already be flooded
New Peerless	6,300	-	-	-	-	-	-	Included with Royal Mine
Castlegate #3	6,300	941 million	5,770	92 million	364 million	577 million	849 million	
Spring Canyon #5	6,300	144 million	5,770	1 million	1 million	143 million	143 million	
Spring Canyon #1	6,600	560 million	Unknown	0	560 million	0	560 million	May already be flooded
Hardscrabble #4	-	-	-	-	-	0	0	Above spillover point
Castlegate #1	-	-	-	-	-	0	0	Above spillover point
Under-River Mine	-	-	-	-	-	0	0	Already flooded
Total Potential Volume for Additional Water						**720 million**	**2,490 million**	
Total Potential Volume Using a Single Injection Well[1]						**720 million**	**1,930 million**	

1 The Spring Canyon #1 workings are not believed to be interconnected with the other workings

Table-2-Volume Results xls
Mayo and Associates
February 23,1999

7.0 IMPACTS OF STORING WATER IN OLD WORKINGS

This section describes the likely fate of mine water stored in abandoned mine workings and the potential hydrologic impacts which might occur as a result of the storage of this water. Potential problems resulting from the injection of water include 1) the overflow of injected water from mine portals, 2) the creation of new springs or degradation of water quality at existing springs by leakage of mine water to the surface, and 3) degradation of the quality of the water presently contained in the mine workings or the quality of water in bedrock groundwater systems surrounding the mine workings.

Fate of injected water

Accidental discharge of injected water to the surface from mine portals is unlikely if the water levels in the mines receiving the water are monitored to ensure that the water levels in the old workings do not exceed the recommended elevations. The only mine portals that might experience overflow are those for the Under-River Mine which crosses under the Price River. This mine, and the potential for overflow from it, is discussed in more detail at the end of this section.

Seepage of impounded water to the surface

Assuming that the elevation of the water injected into the old mine workings does not exceed recommended levels, the potential for the creation of new springs at the surface is low. This is because very little of the surrounding topography is lower than the recommended maximum elevation for water injection. As can be seen on Plate 9, only small portions of Price Canyon are topographically lower than 6,300 feet. In addition, most of the mine

workings to be flooded are several thousand feet or more, horizontally, from the canyon walls at these elevations. The rocks between the mine workings and the canyon walls are composed predominantly of interbedded layers of sandstone, mudstone, and shale. Although some of the sandstone units have the ability to transmit water, the lenticular nature of sandstone units precludes significant lateral migration of groundwater because the sandstone units pinch-out and interfinger with shale or mudstone units that are nearly impermeable (Mayo and Associates, 1998). Permeability studies on the sandstones of the lower Blackhawk Formation (and Star Point Sandstone) suggest that the ability of these units to transmit water is poor (Lines, 1985). Hydraulic conductivities for the Blackhawk Formation reported by Lines (1985) ranged from impermeable to 1.1×10^{-8} feet/day for the shales, and from 1.1×10^{-2} to 9.3×10^{-8} feet/day for the interbedded sandstones and siltstones. Lines (1985) noted that some of the shales tested were impermeable to water, even when tested under a pressure of 5,000 pounds per square inch.

That groundwater encountered during mining operations in the Book Cliffs and Wasatch Plateau coal districts is commonly several thousand years old supports the supposition that groundwater does not readily move through the lower Blackhawk Formation. If new springs were created as a result of seepage of injected water through the sandstones, such springs would be limited to elevations below 6,300 feet. Only the river bottom and lowest 200 feet (in elevation) of the Price Canyon and the very lowest portions of several side canyons (Plate 9) are below this elevation. The long seepage distances and poor water transmission potential would probably limit the discharge of any new springs to small seeps.

In evaluating specific locations where there is potential for discharge of impounded mine waters to the surface, three regions with differing leakage potentials have been delineated. In each region the potential for leakage to the surface is limited to the area below 6,300 feet elevation (the maximum hydraulic head of the impounded water). Differences in geology, and topographic and stratigraphic gradients result in differing potentials for seepage in each of these three regions. These regions have been designated as Zones A, B, and C. These zones are plotted on Plate 9. Annotated photographs showing the land surface in Zones A, B, and C are presented in Figure 4. Additional annotated photographs depicting the land surface in Zones A, B, and C below 6,300 feet are presented in the appendix.

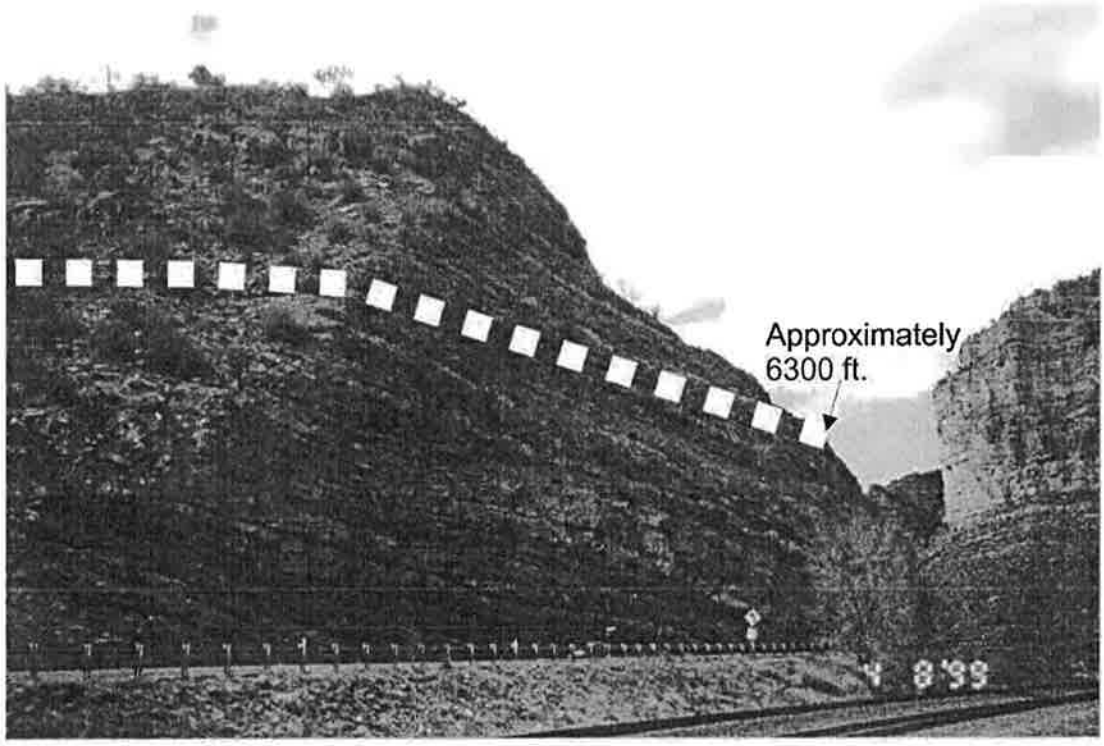
Zone A

Zone A extends from the intersection of the 6,300 foot elevation contour with the bottom of Price Canyon in the northwest quarter-section of Section 26, T. 12 S., R. 9 E. to the approximate contact of the top of the coal-bearing horizons of the Blackhawk Formation in Price Canyon in east-central Section 35, T. 12 S., R. 9 E. (Plate 9). Within this zone, only the lowermost canyon walls immediately adjacent to the Price River are below 6,300 feet in elevation.

The potential for seepage of impounded waters to the surface in Zone A, and the potential for related slope failures, is minimal. The rocks exposed in Zone A are part of the upper Blackhawk Formation and consist of interbedded and discontinuous mudstones, shales, and sandstone channels. The sandstone channels are generally isolated from each other both laterally and vertically by low permeability rocks (Mayo and Associates, 1998). More

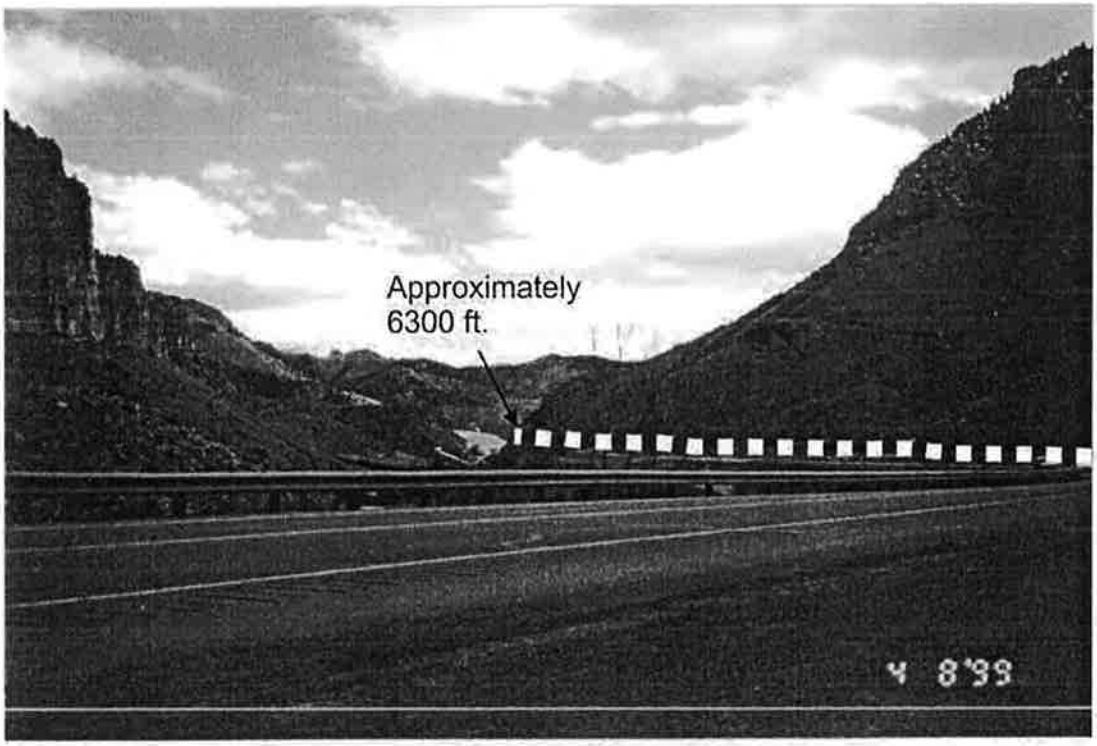
Zone A.cdr
Mayo and Associates, LC
April 22, 1999

A)



Zone A Coal Burn in Price Canyon located in NE ¼, SE ¼, Sec. 35, T12S, R9E.

B)



Zone A View looking southwest down Price Canyon from the Center of SW ¼ Sec. 26, T12S, R9E.

Figure 4 Zones of potential water seepage

Zone B cdr
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April 22, 1999

C)

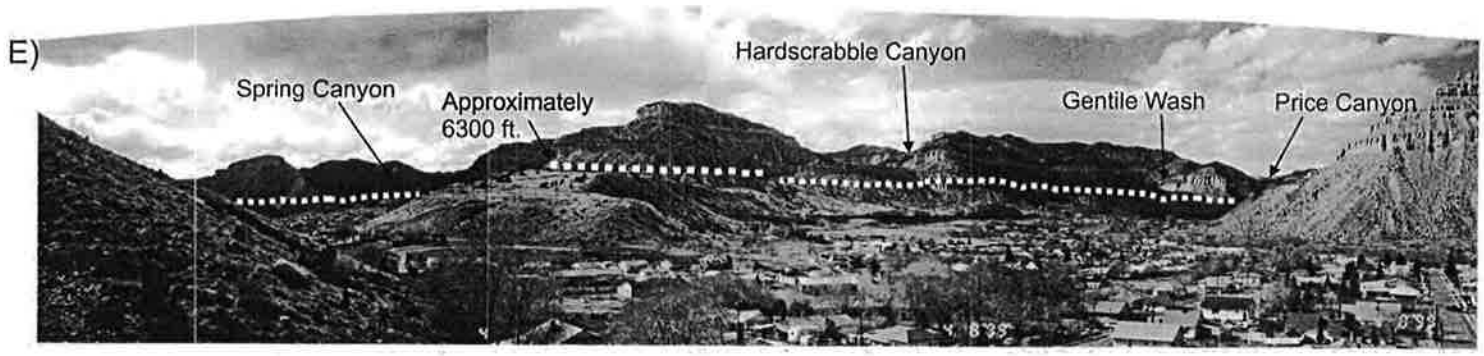
Zone B Bedding in Blackhawk Formation on Highway 6 located at junction of sections 1,2, T13S, R9E and sections 35, 36, T12S, R9E.

D)

Zone B North of roadcut on Highway 6 in Price Canyon 1/8 mile northwest of Power Plant located in the Center of NW ¼, Sec. 1, T13S, R9E.

Figure 4 Continued

Zone C.cdr
Mayo and Associates, LC
April 22, 1999



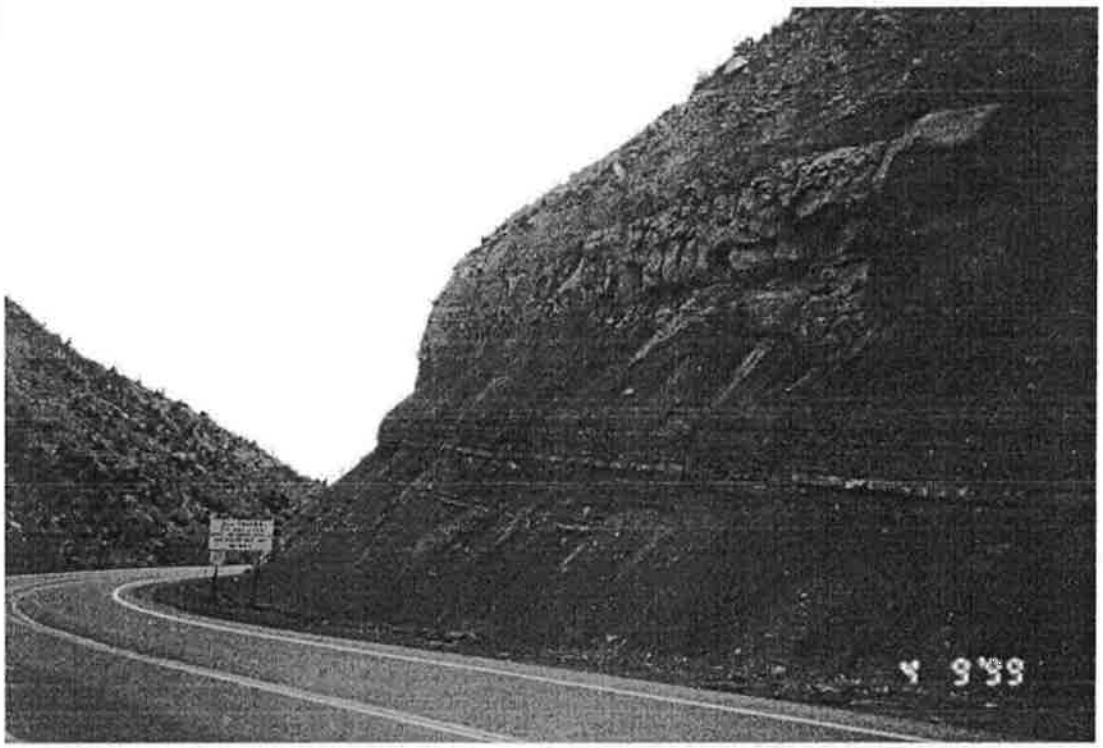
Zone C View from Helper looking northwest into study area.

Zone C Looking northwest in Price Canyon from Highway 6 below the check station located in SW ¼, SW ¼, Sec. 1 and in the North of NW ¼, Sec. 12, T13S, R9E.

Figure 4 Continued

Zone C1.cdr
Mayo and Associates, LC
April 22, 1999

G)



Zone C Mancos Shale tongues in Price Canyon just above check station located in the Center of SW ¼, Sec. 1, T13S, R9E.

Figure 4 Continued

continuous, massive sandstone units, which are present in the lower Blackhawk Formation are absent in the rocks of Zone A. Additionally, because the coal seams and the abandoned mine workings are in the lower part of the Blackhawk Formation, water must flow across bedding planes upward in the geologic section (i.e. it must successively flow from one horizon in the Blackhawk Formation into and through the next horizon stratigraphically above it) in order to seep to the surface in Zone A. This is unlikely to occur because in stratified rocks the vertical permeability is commonly only a fraction of the horizontal permeability. Thus, because of the discontinuity of the rock strata in this zone and the limited potential for lateral or vertical migration of the water, the risk of impounded water migrating to the surface in Zone A is very low.

If water were to seep to the surface in Zone A, because the region below 6,300 feet is limited almost entirely to areas which are less than 100 feet above the canyon floor, the potential for major slope failure as a result of saturated sediments on steep slopes is minimal.

Zone B

Zone B consists of the region in Price Canyon below 6,300 feet in elevation that is approximately on strike with the lower Blackhawk Formation. The area extends for approximately one mile along Highway 6 between the east-central portion of Section 35, T. 12 S., R. 9 E., and the west-central portion of Section 1, T. 13 S., R. 9 E., just below the intersection of Highway 6 and Highway 33 (Plate 9). Each of the major coal seams crops out in the canyon bottom in Zone B. The potential for leakage of impounded waters to the surface, and the related potential for slope failure in Area B is low. However, of the three

zones of potential leakage discussed in this report, the potential for leakage in Zone B is much greater than it is in either Zones A or C. Because the same stratigraphic horizons that contain the old mine workings crop out at the surface in Zone B, water may seep laterally to the surface without flowing across bedding planes.

Generally, the rocks of the lower Blackhawk Formation are discontinuous and lenticular in nature. Individual sandstone lenses are encased both vertically and horizontally in low permeability shale and mudstone (Mayo and Associates, 1998). Thus, the potential for lateral migration of water through these sediments is low. Likewise, the sandstone paleochannels, which are commonly known to conduct water when they are encountered in the mine environment, are lenticular and somewhat discontinuous in nature. However, several massive, more continuous sandstone units occur in the lower Blackhawk Formation in the Castlegate area. These include the Kenilworth, Aberdeen, and Spring Canyon Sandstones. These massive sandstone units may transmit water laterally over greater distances than do other rock units of the lower Blackhawk Formation. However, aquifer testing data obtained from massive sandstone units of the lower Blackhawk Formation elsewhere in the Book Cliffs and Wasatch Plateau coal fields indicate that the hydraulic conductivity of these rocks are generally very low. If any of the flooded mine workings are in direct contact with these massive sandstone units, there is the potential for some leakage of mine water to the surface through these rocks, although the rate would likely be low. Fracturing in the massive sandstone units could potentially increase the transmissivity of these rocks, which could result in a greater likelihood of seepage at the surface.

In many locations, the coal seams in the Blackhawk Formation have experienced natural coal burns along the outcrop. The coal burn commonly results in intense fracturing and mineralogical alteration of the rocks immediately above and below the coal seam. The coal burn commonly extends several hundred feet laterally into the mountain. As a result of the coal burn, large aperture fractures and void spaces exist that appear to be well interconnected. Where extensive coal burns have occurred in Zone A, there is therefore an increased potential for seepage of impounded mine workings to the surface. However, the major areas of coal burn exposed in Price Canyon (Figure 4) are not associated with the massive sandstone units of the lower Blackhawk Formation. Because the coal burned area is primarily associated with lenticular, discontinuous strata (which do not conduct water laterally), it would be difficult to provide recharge to these coal burns deeper within the mountain where the rocks are not burned.

Most of the rock strata exposed in Price Canyon along Zone B are well consolidated, competent rock. Soil development appears to be minimal in these areas. Therefore, if slow seepage of mine water to the surface were to occur in Zone B, it seems more likely that the water would discharge to the surface as a spring or seep and would not result in major slope failure. Naturally occurring slope failures are not common in this area, suggesting that the near surface sediments are relatively stable.

Zone C

Zone C includes the region below 6,300 feet in elevation where rocks that are stratigraphically below the lower Blackhawk Formation are exposed at the surface. This area

includes all of the lower reach of Price Canyon below the west-central portion of Section 1, T. 13 S., R. 9 E. (Plate 9). It also includes a small area in the mouth of Hardscrabble Canyon and the lowest elevations on the north side of Spring Canyon below the center of Section 22, T. 13 S., R. 9 E. In order for impounded water to migrate to the surface in Zone C, water must move down through the geologic section across bedding planes. The strata exposed in Zone C consist primarily of rocks of the Star Point Sandstone and the interbedded Mancos Shale. The Mancos Shale is known regionally as an extremely poor transmitter of water. Additionally, the old mine workings to be filled are located at substantial distances from the land surface in Zone C (most areas are greater than one mile away from the nearest filled mine area). Therefore, the potential for leakage of impounded mine waters to the surface in Zone C is considered to be remote.

In locations where the mine workings to be injected are located directly under the canyon bottom, most of the mine workings are under relatively deep cover. Workings of the New Peerless Mine, for example, go directly under the Price River at a depth of nearly 1,000 feet (Plate 1). Similarly, workings of the Royal Mine lie beneath the mouth of Bear Canyon, at a depth of approximately 500 feet below the surface. In these locations, water would have to pass vertically upward through the bedrock, almost directly across bedding. The numerous thick shale and mudstone beds in the bedrock make this scenario very unlikely unless the rock is highly fractured. Since mining in these areas was predominantly by room and pillar methods (without secondary recovery), significant mining induced fracturing of the overlying bedrock is unlikely.

A potentially serious problem that could reasonably occur as a result of water injection is overflow or upward leakage from workings of the Under-River Mine. Although available maps show that this mine is not connected to the mines proposed for water injection and storage, a barrier of only 50 to 100 feet separates it from workings of Royal Mine (Plate 1), which is proposed for injection. Workings of the Under-River Mine are shown on maps to pass underneath the Price River at very shallow levels. Although it is not clear from the mine maps, portions of this mine may be separated from the overlying Price River channel by less than 200 feet of overburden, and from the bottom of Barn Canyon by less than 50 feet of overburden. Some of this overburden is composed of alluvial deposits that readily transmit water. If the abandoned mine workings are filled to an elevation of 6,300 feet, there would be approximately 150 feet of differential in hydraulic head between the mine workings and the overlying Price River, which is at an elevation of 6,150 feet. Therefore, there is the potential for upward leakage of water from this mine to the surface.

Previous work (Mayo and Associates, 1998) has suggested a likely connection between waters of the Under-River Mine and shallow alluvial groundwater systems or surface waters in the vicinity of the river. Even if water in this mine could not leak upward through the roof, however, the portals of the mine are topographically below the recommended water injection elevation for the adjacent Royal Mine. Even if water injected into the Royal Mine was able to leak into the Under-River Mine and it did *not* leak upward into the river bottom, it would likely overflow the adjacent portals of the Under-River Mine and flow over the land surface into the Price River. It seems clear that if water injected into other nearby mines is able to leak into the Under-River Mine, it will then enter the shallow alluvial groundwater system or

overflow to the river. It is unknown whether water injected into the Royal Mine will leak into the Under-River Mine, and if so, whether the rate of leakage will be significant. After the commencement of water injection, this determination can be made by monitoring water levels in the Under-River Mine (Plant Recovery Well and Plant Injection Well; Plate 10). Water levels in these wells may then be correlated with water levels in the Crandall Canyon Shaft and the new monitoring well in Bear Canyon.

Although mine maps show a barrier between the Under-River and Royal mines, it is not known whether this barrier remains intact, or if the 50-foot barrier can effectively hold back water. It is possible that the integrity of the barrier may have been compromised as a result of an accidental mining error.

Degradation of the quality of water currently existing in the mine workings

Another potential consequence of the proposed water injection is that the quality of waters already existing in the old mine workings may be lessened. If existing waters in the old mine workings are of a higher quality than the injected waters, then the quality of that water would be lessened. The magnitude of the potential impact will be proportional to the magnitude of the difference in the water quality between the two water bodies, and the volume of water injected relative to the amount that was present prior to the injection. However, water already in the workings to be injected may be similar in TDS and chemistry to the water being injected, as the Castlegate #2 Mine being dewatered is only a few miles from the proposed receiving mines. Under these conditions, there would be no detrimental impact on water quality.

Because UIC requirements preclude the degradation of water sources, it will be necessary to monitor the water quality of both the receiving waters and the water being injected.

8.0 CONCLUSIONS

1) Based on the available data and the assumptions listed previously, it appears that the investigated mine workings do have the potential for storing considerable volumes of water. The calculated volumes potentially available for the storage of additional water in each of the investigated mines are listed in Table 3, along with overall and single-injection site totals.

Table 3 – Potential Volume for Storage of Additional Water

Mine Name	Potential for Storage of Additional Water
Royal / New Peerless Mines	Between 0 million and 938 million gallons
Castlegate #3 Mine	Between 577 million and 849 million gallons
Spring Canyon #5 Mine	Approximately 143 million gallons
Spring Canyon #1 Mine	Between 0 million and 560 million gallons
Hardscrabble #4 Mine	None
Castlegate #1 Mine	None
Under-River Mine	None
Potential additional storage	**Between 720 million and 2,490 million gallons**
Potential using 1 injection site	**Between 720 million and 1,930 million gallons**

2) Mine maps suggest that the Castlegate #3 and Spring Canyon #5 Mines are connected via the ventilation shafts in Crandall Canyon, and that the Royal and New Peerless Mines are also connected to each other. Mine Map information also suggests that the Spring

Canyon #1 Mine is not connected to the other mines. Because the Royal Mine appears to overlie the Castlegate #3 Mine locally, it is possible that water could be injected into the Royal, New Peerless, Castlegate #3, and Spring Canyon #5 Mines from a pipeline to a single well-placed injection well. One possible location for such an injection well would be in Bear Canyon, with the specific coordinates listed in Table 4 and the general location shown on Plate 10. Such a well would need to be carefully drilled and inspected prior to injection, to ensure that it fully penetrated and is open to both sets of mine workings. It is also important to note the exact elevation at which workings of the Royal Mine are intersected by this well, as these workings are very close to the maximum injection elevation of 6,300 feet. Should workings of the Royal Mine be intersected above the injection elevation of 6,300 feet, water levels in the different workings will not be able to equilibrate during injection. Under these conditions it may be preferable to have two injection wells, located at essentially the same injection site, allowing the different workings to be injected independently.

3) Based on available data and the assumptions listed in sections above, calculations suggest that such a single injection well may be able to inject somewhere between 684 million and 1,962 million gallons of water before overflow or significant leakage would occur. The only potentially fillable mine workings which do not appear to be accessible from this injection well are those of the Spring Canyon #1 Mine.

4) Storing water in workings of the Spring Canyon #1 Mine, if they are not already full of water, would require an additional injection site.

Table 4 - Proposed locations for monitoring and injection wells

Monitoring Well	East*	North*	Township and Range Location
Proposed Monitoring Well	2,174,790	515,070	North 1/4 Section 35, T12S R9E
Monitoring NW Limit	2,174,720	515,170	
Monitoring NE Limit	2,174,860	515,140	
Monitoring SE Limit	2,174,840	514,310	
Monitoring SW Limit	2,174,720	514,330	

Monitoring Well target is on the south side of the mouth of Bear Canyon

Surface elevation of the monitoring well site is approximately 6,320 feet

Depth to D-Seam workings of the Royal Mine is estimated at 450 feet

Elevation of the D-Seam workings at this location is estimated at 5,870 feet

Injection Well	East*	North*	Township and Range Location
Proposed Injection Well	2,170,730	511,820	SE 1/4 Section 34, T12S R9E
Injection NW Limit	2,170,270	511,925	
Injection NE Limit	2,171,115	512,160	
Injection SE Limit	2,171,100	511,700	
Injection SW Limit	2,170,420	511,510	

Injection Well target is in the bottom of Bear Canyon, at the mouth of a side canyon

Injection Well target is essentially the same location as drillhole MC-1

Surface elevation of the injection well site is approximately 6,630 feet

Depth to D-Seam workings of the Royal Mine is estimated at 330 feet

Elevation of the D-Seam workings at this location is estimated at 6,300 feet

Depth to Sub-3 workings of the Castlegate #3 Mine is estimated at 770 feet

Elevation of the Sub-3 workings at this location is estimated at 5,860 feet

* These locations based on the coordinant system of mine maps provided by CPMC

Table-4-Proposed Wells xls
Mayo and Associates
April 23,1999

5) The barrier shown on mine maps between the Royal and Under-River Mines may not be intact or may leak. If so, water injected into the Royal and New Peerless Mines could leak into the Under-River Mine. Such waters could then enter a shallow alluvial groundwater system in Price Canyon or overflow the surface to the Price River. Monitoring of water levels in the Under-River Mine during injection will reveal whether this barrier will leak water at a significant rate.

6) Large uncertainties in the amount of water already existing in several of the mine workings, particularly the Royal, New Peerless, and Spring Canyon #1 Mines, preclude a more accurate calculation of the volume available for storage of additional waters.

9.0 RECOMMENDATIONS

1) Because of the importance of determining how much water is currently present in the Royal and New Peerless Mines, the primary recommendation of this report is to drill a monitoring well near the mouth of Bear Canyon. The proposed location of this monitoring well is shown on Plate 10, with specific coordinates listed in Table 4. This monitoring well would allow the level of impounded water in the Royal and New Peerless Mines complex to be determined. This will allow a better estimate of the volume available in these mines for injection of additional water. It will also allow water levels and water chemistry in the Royal Mine and Under-River Mine to be compared. This may be helpful in determining whether the barrier between the Royal and Under-River Mines will actually prevent significant leakage between the two mines. It is important that this well be drilled from an elevation above 6,300 feet, to prevent leakage of injected water through the monitoring well. The elevation of the proposed drilling site should be checked prior to drilling, and the drill site adjusted uphill to the south if needed, as the proposed location is very close to the critical elevation of 6,300 feet.

   If large amounts of water are found in the Royal Mine, particularly if that water resembles river water with a low TDS, high tritium content, and a recent radiocarbon age, then it is likely that the barrier between the mines has leaked. In that case, injection of the Royal Mine would not be recommended, as the injected water would likely leak from the Royal Mine to the Under-River Mine, and then subsequently to the Price River or shallow alluvial groundwater systems which eventually enter the Price River. If the recommended well did not reveal large quantities of lower TDS, modern water in the

Royal Mine, or water levels similar to those in the Price River and the Under-River Mine, it can probably be assumed that the mine barrier will likely not transmit significant quantities of water. The well would then provide an ideal location to monitor water levels and quality in the Royal Mine during future injection activities.

2) Waters in the Crandall Canyon Shaft should be re-sampled, with care taken to obtain samples from the bottom, middle, and top of the water column. This would allow a better determination of the baseline water quality parameters of the water currently impounded in the Castlegate #3 and Spring Canyon #5 Mines. This will allow a determination of the potential for degradation of water quality of existing waters in the mines. Periodic measurements of water levels in the shaft are also recommended to better determine current water levels in the mines, and to establish baseline water level data prior to any future injection activities in these mines. Monitoring of water levels in both the Crandall Canyon Shaft and in the proposed monitoring well is recommended because the shaft and proposed well will intersect different mine workings. Since the various mine workings will likely fill at different rates, prior to reaching equilibrium at the recommended injection level, independent monitoring of each set of interconnected workings is recommended.

3) An injection well should be drilled, if and when injection and long term water storage proves feasible. This well should be drilled at a location where it can penetrate both the Royal and Castlegate #3 workings, such as the location in Bear Canyon shown on Plate

10. Should the Royal and New Peerless Mines prove to be already filled with water, other injection sites and additional options may be recommended.

10.0 REFERENCES CITED

Cyprus Plateau Mining Corporation, Mining and reclamation permit, Willow Creek Mine.

Kadanuk, L.L.M, 1994, Response of springs to longwall coal mining at the Deer Creek and Cottonwood Mines, Wasatch Plateau, UT. USBM Information Circular 9405, 21p.

Lines, G.C., 1985, The ground-water system and possible effects of underground coal mining in the Trail Mountain Area, Central Utah, U.S. Geological Survey Water-Supply Paper 1159.

Mayo and Associates, 1998, Intercepted groundwater investigation, Willow Creek Mine, Carbon County, Utah, unpublished consulting report for Cyprus Plateau Mining Corporation, Price, Utah.

Appendix

Annotated photographs of Zones A, B, and C

Photo 1,2 cdr
Mayo and Associates, LC
April 21, 1999

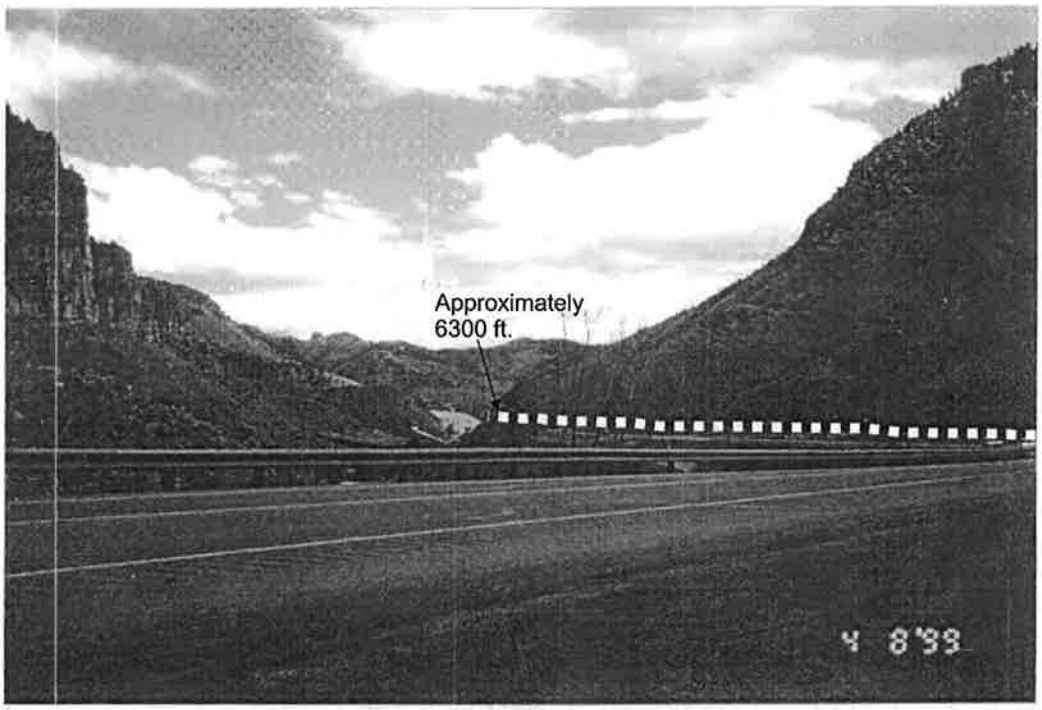


Photo 1 View looking southwest down Price Canyon from the Center of the SW ¼ , Sec. 26, T12S, R9E.

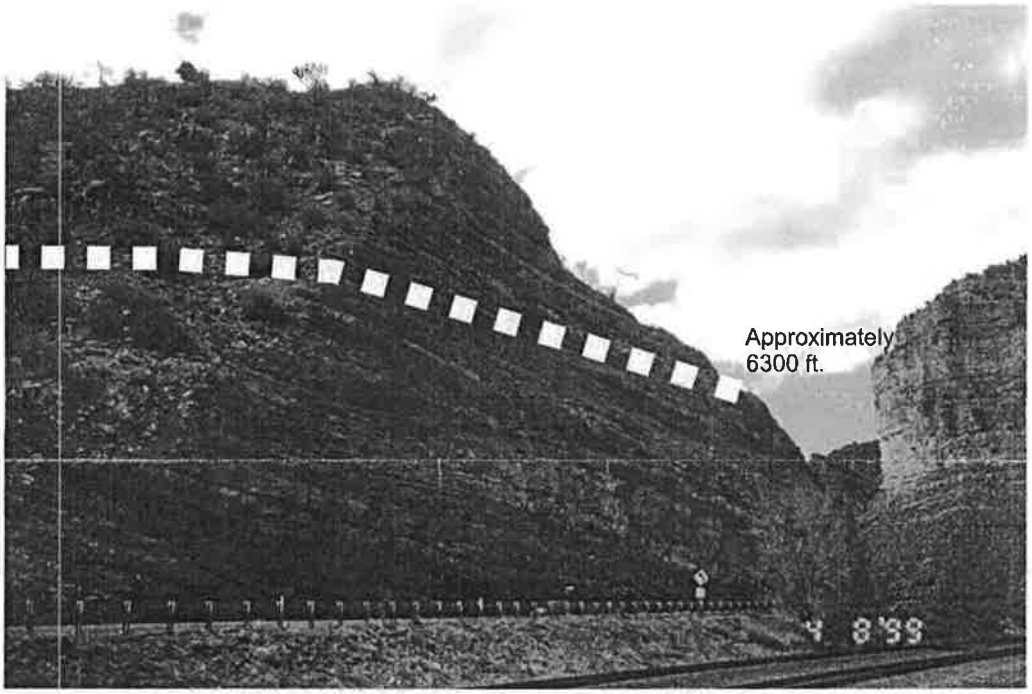


Photo 2 Coal Burn in Price Canyon located in NE ¼, SE ¼ , Sec. 35, T12S, R9E.

Photo 3,4.cdr
Mayo and Associates, LC
April 21, 1998

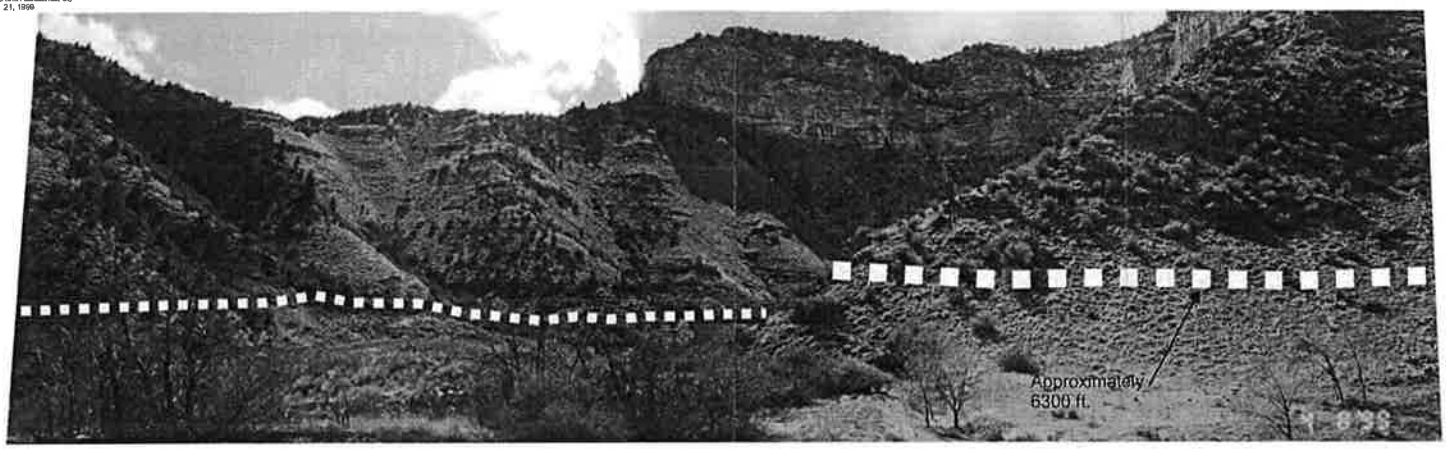


Photo 3 View looking southwest up Gravel Canyon from Highway 6 opposite of Barn Canyon located in SE ¼, SE ¼, Sec. 35, T12S, R9E.

Photo 4 Bedding in Blackhawk Formation on Highway 6 located on junction of sections 1,2, T13S, R9E and sections 35, 36, T12S, R9E.

Photo 5,6 cdr
Mayo and Associates, LC
April 21, 1999

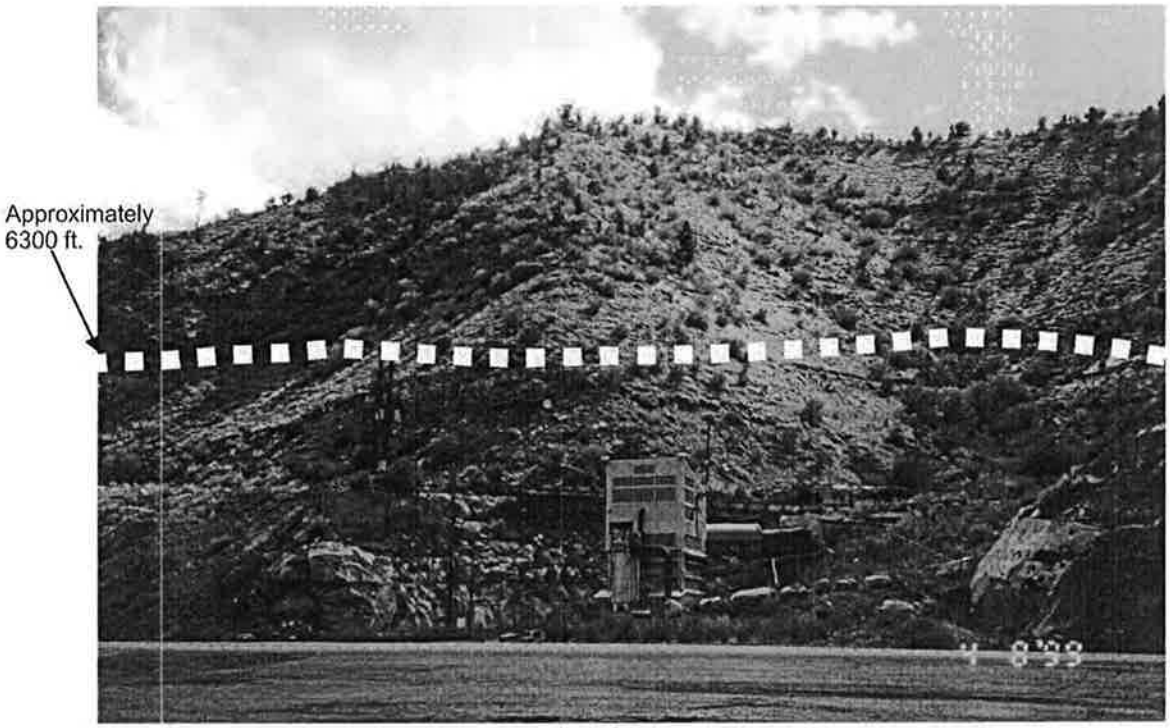


Photo 5 Price Canyon looking west at Castle Gate Mine No. 1 located in NW ¼, NW ¼, Sec. 1, T13S, R9E.

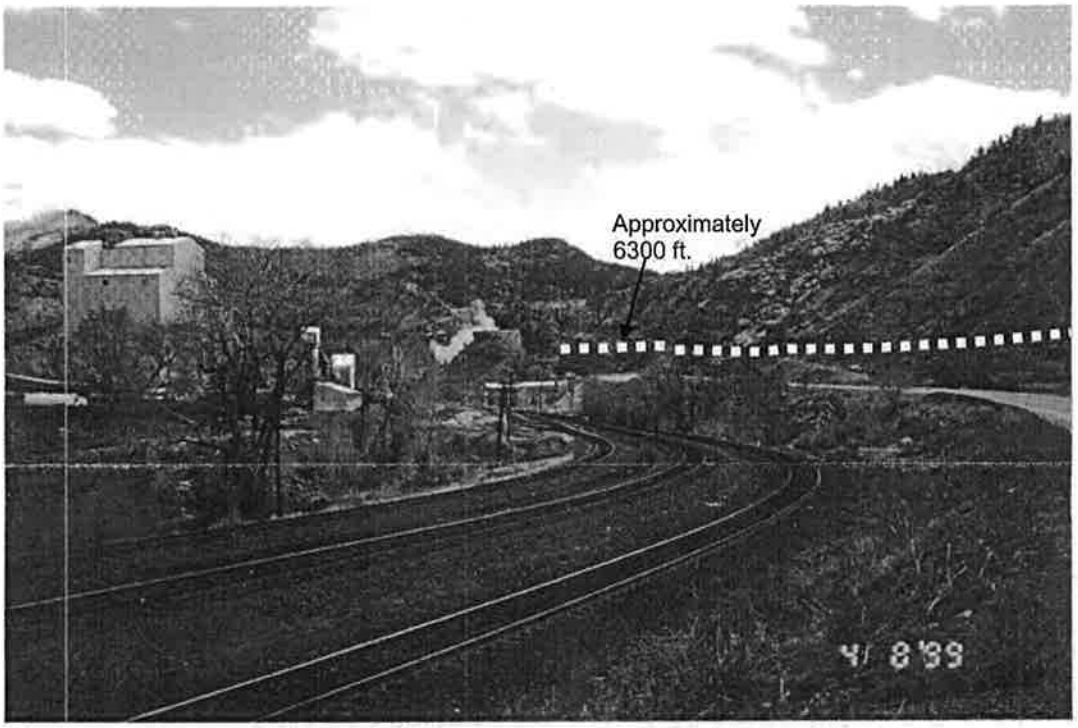


Photo 6 View looking southeast from Highway 6 near loadout facility..

Photo 7.cdr
Mayo and Associates, LC
April 21, 1999

Photo 7 North of roadcut on Highway 6 in Price Canyon 1/8 mile northwest of Power Plant located in the Center of the NW ¼, Sec. 1, T13S, R9E.

Photo 8,9 cdr
Maya and Associates, LC
April 21, 1999

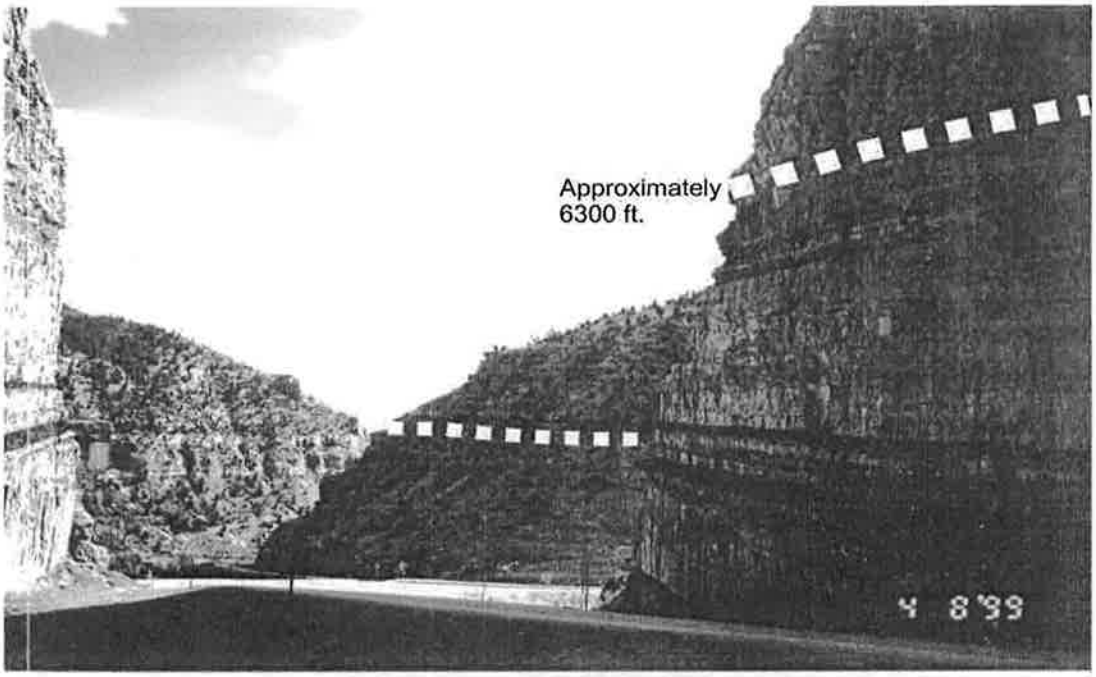


Photo 8 Roadcut on Highway 6 in Price Canyon 1/8 mile northwest of Power Plant near junction of Highway 191 located in Center of the NW ¼, Sec. 1, T13S, R9E.

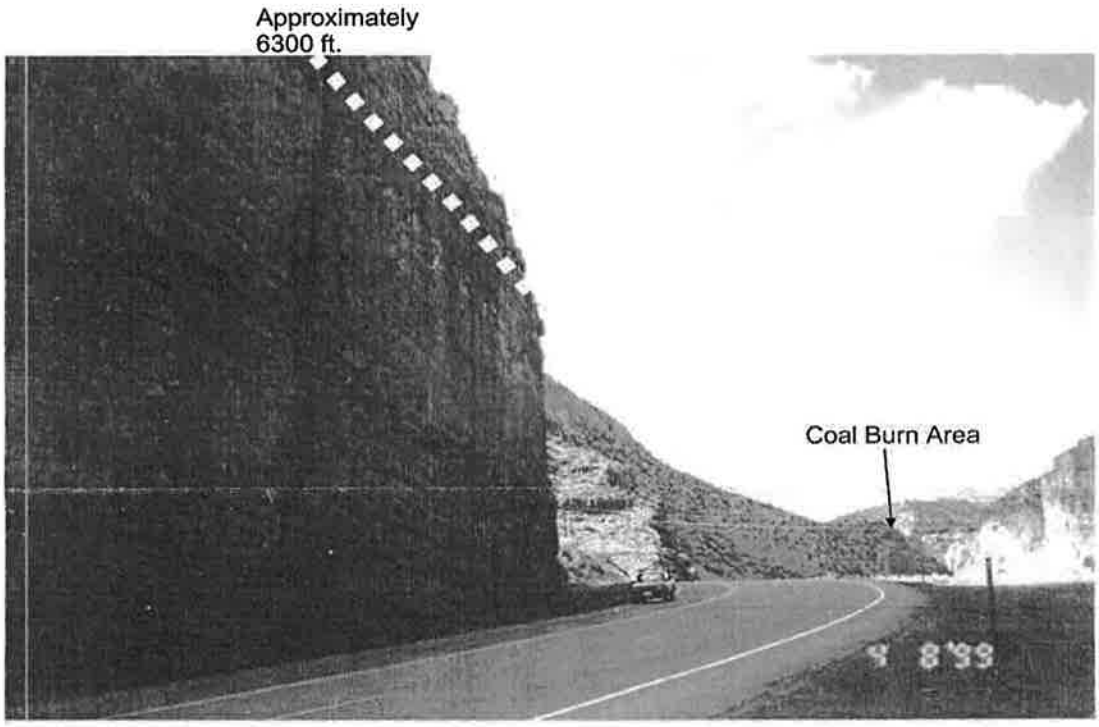


Photo 9 Roadcut on Highway 6 in Price Canyon 1/8 mile northwest of Power Plant near junction of Highway 191 located in Center of the NW ¼, Sec. 1, T13S, R9E.

Photo 10,11.cdr
Mayo and Associates, LC
April 21, 1999

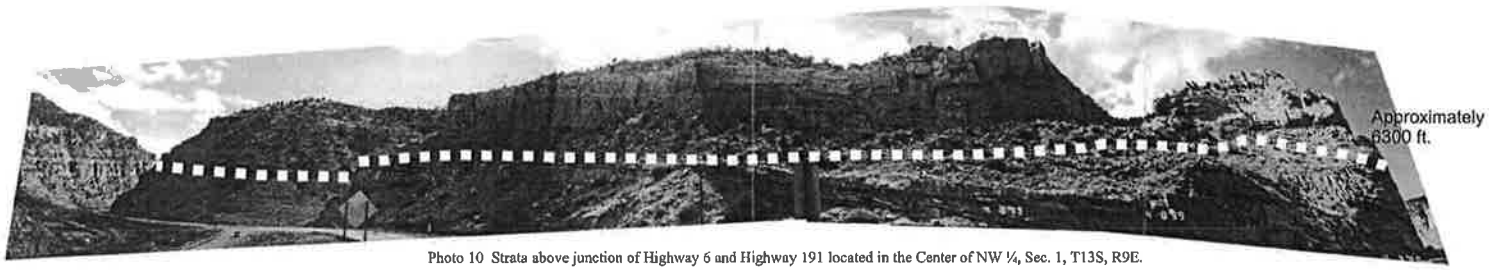


Photo 10 Strata above junction of Highway 6 and Highway 191 located in the Center of NW ¼, Sec. 1, T13S, R9E.

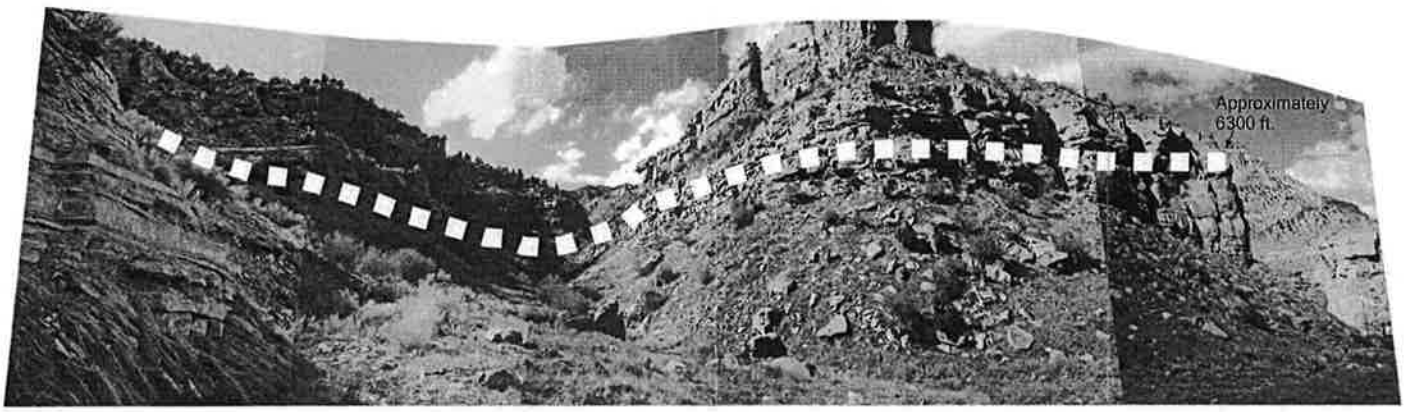


Photo 11 Drainage at junction of Highway 6 and Highway 191 located in SW ¼, NW ¼, Sec. 1, T13S, R9E.

Photo 12.cdr
Mayo and Associates, LC
April 22, 1999

Approximately
6300 ft.

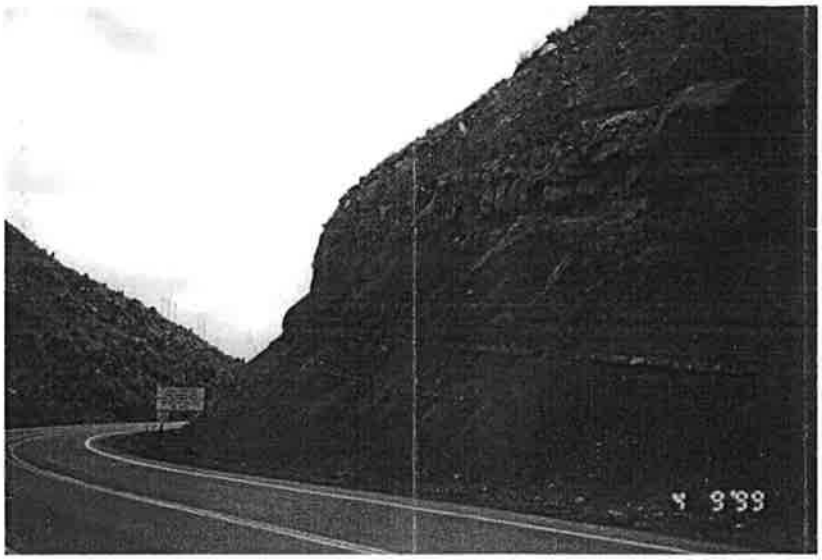


Photo 12 Mancos Shale tongues in Price Canyon just above check station located in the Center of SW ¼, Sec. 1, T13S, R9E.

Photo 13,14 cdr
Mayo and Associates, LC
April 22, 1999

Photo 13 Looking northwest in Price Canyon from Highway 6 below the check station located in SW ¼, SW ¼, Sec. 1 and N ¼, NW ¼, Sec. 12, T13S, R9E.

Photo 14 Spring Canyon looking north located in the South of SW ¼, Sec. 14, T13S, R9E.

Photo 15.tif.cdr
Mayo and Associates, LC
April 21, 1999

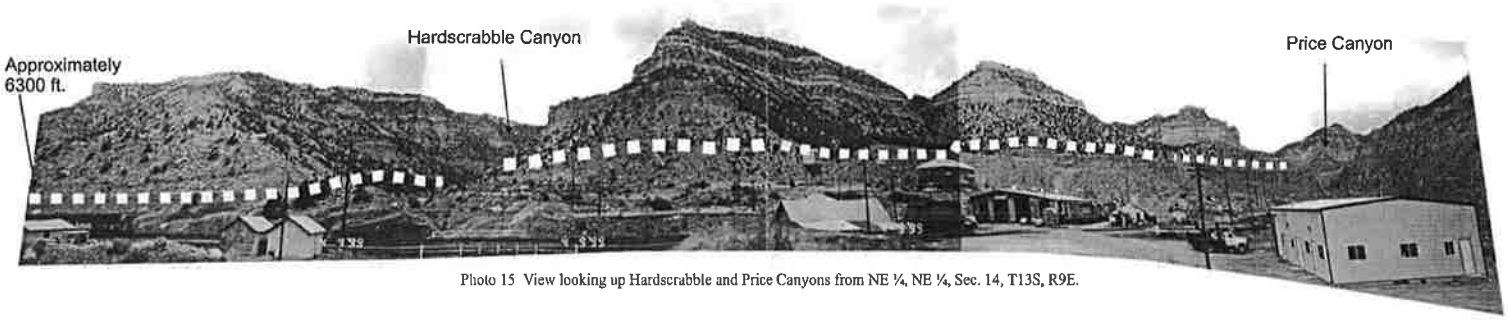
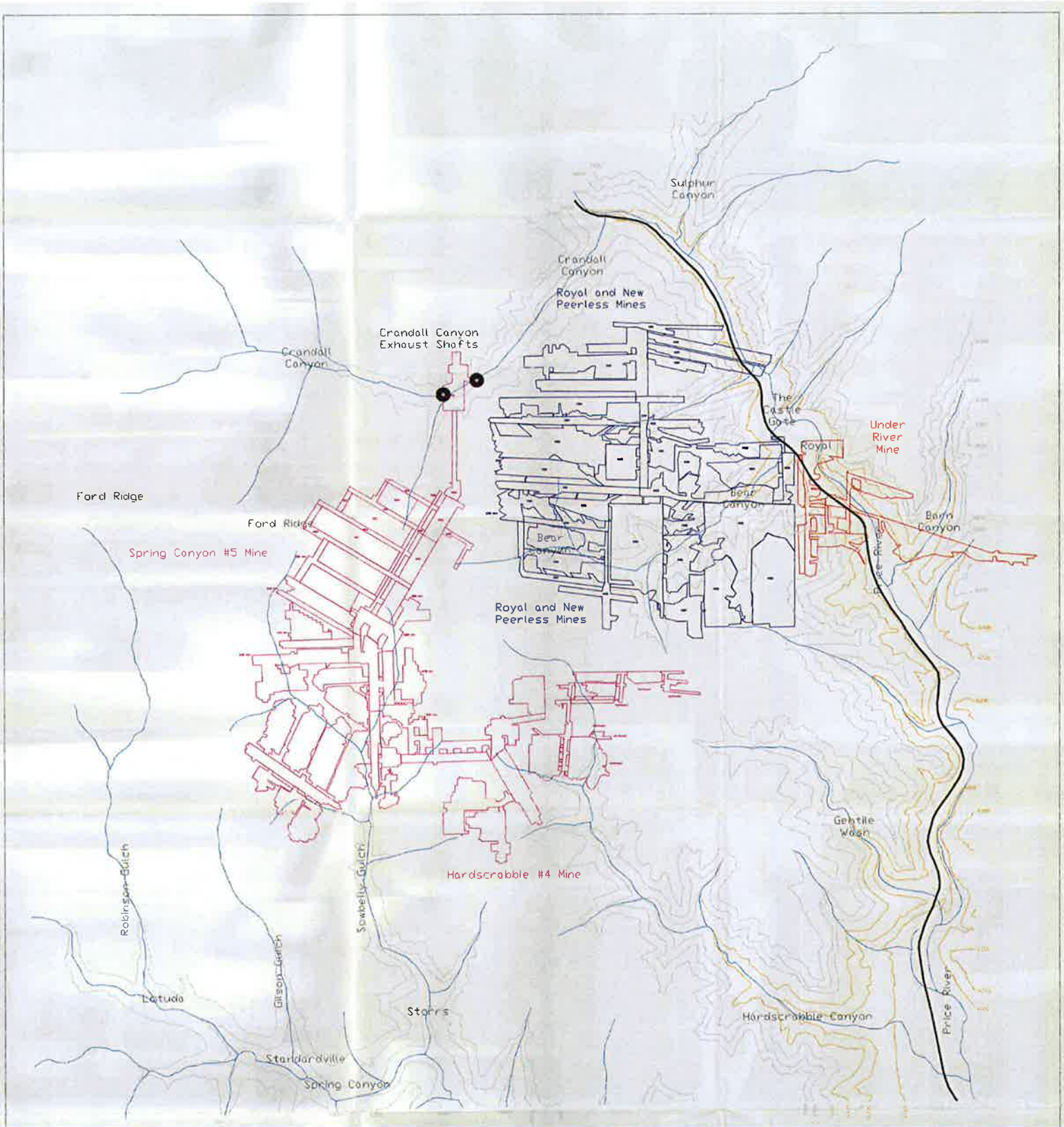
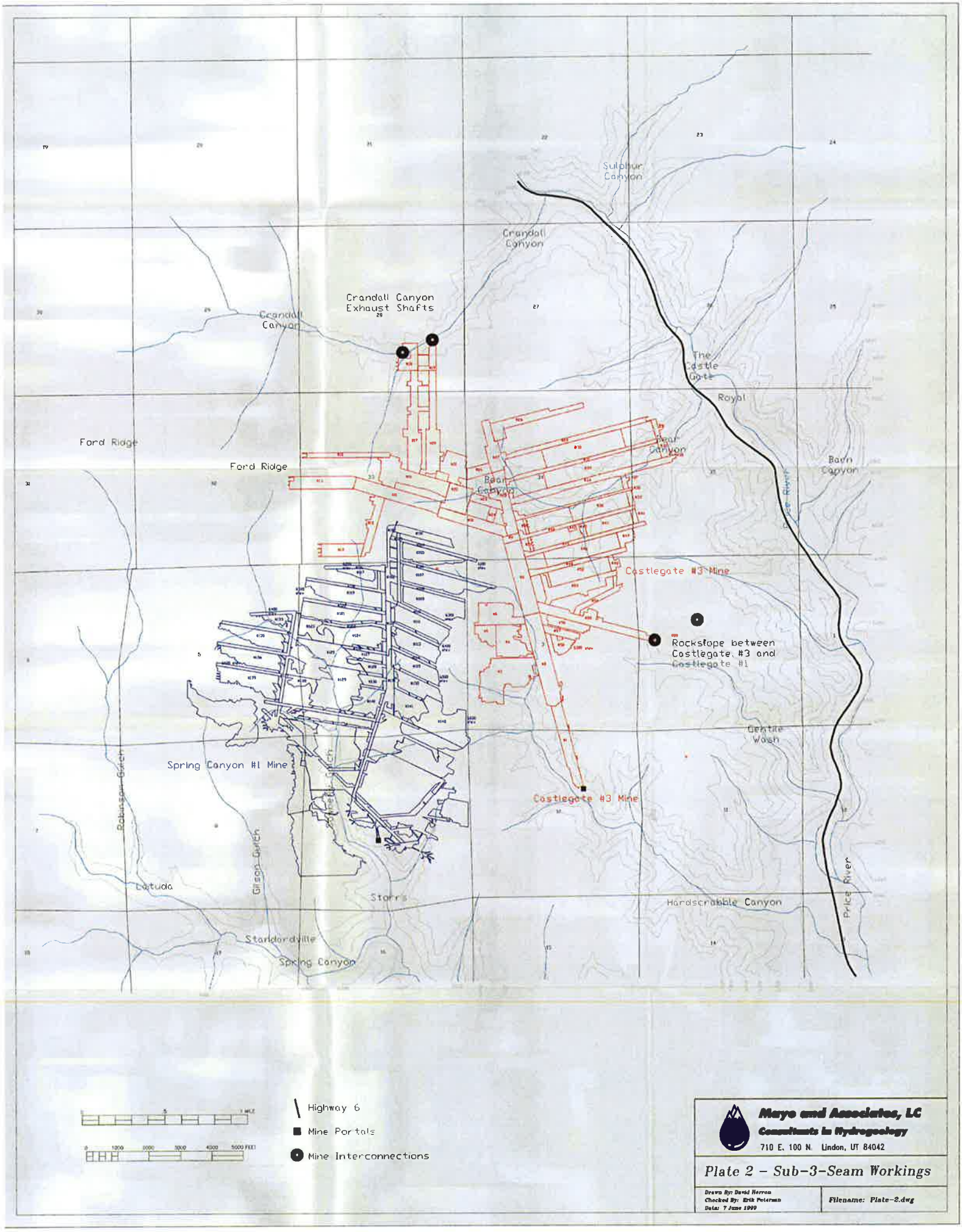


Photo 15 View looking up Hardscrabble and Price Canyons from NE ¼, NE ¼, Sec. 14, T13S, R9E.

Photo 16 View from Helper looking northwest into study area.


Sulphur Canyon
Crandall Canyon
Royal and New Peerless Mines
Crandall Canyon Exhoust Shafts
Crandall Canyon
The Castle Gate
Under River Mine
Royal
Bear Canyon
Barn Canyon
Ford Ridge
Ford Ridge
Spring Canyon #5 Mine
Bear Canyon
Royal and New Peerless Mines
Gentile Wash
Hardscrabble #4 Mine
Robinson Gulch
Sowbelly Gulch
Gibson Gulch
Latuda
Storrs
Hardscrabble Canyon
Price River
Standardville
Spring Canyon
Highway 6
Mine Portals
Mine Interconnections
Mayo and Associates, LC
Consultants in Hydrogeology
710 E. 100 N. Lindon, UT 84042
Plate 1 - D-Seam Workings
Drawn By: David Herrin
Checked By: Erik Peterson
Date: 7 June 1999
Filename: Plate-1.dwg


Sulphur Canyon
Crandall Canyon
Crandall Canyon Exhaust Shafts
Crandall Canyon
The Castle Gate
Royal
Ford Ridge
Ford Ridge
Bear Canyon
Bear Canyon
Barn Canyon
Castlegate #3 Mine
Rocksfope between Castlegate #3 and Castlegate #1
Gentile Wash
Spring Canyon #1 Mine
Robinson Gulch
Green Gulch
Castlegate #3 Mine
Latuda
Storrs
Hardscrabble Canyon
Price River
Standardville
Spring Canyon
Highway 6
Mine Portals
Mine Interconnections
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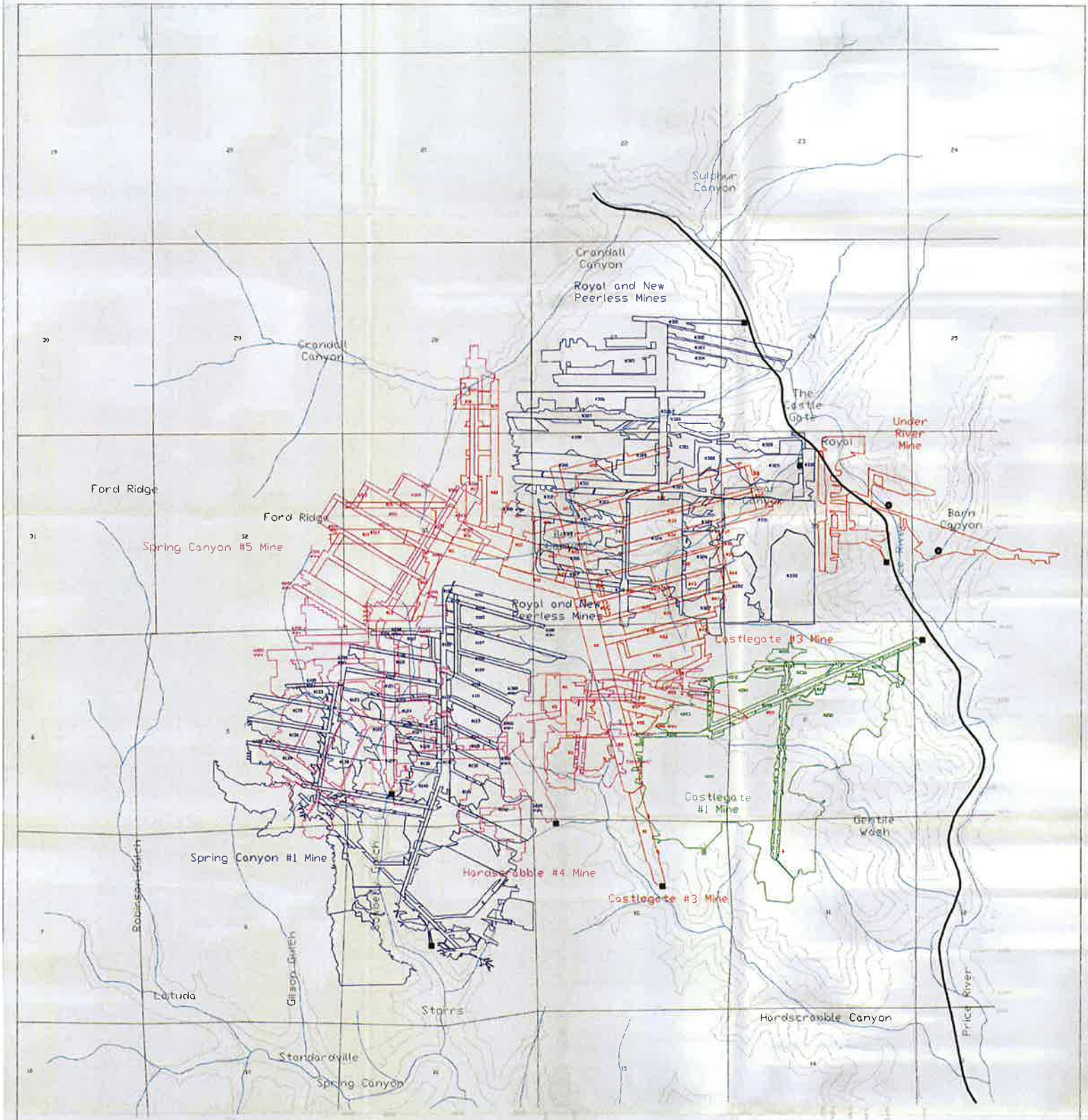
710 E. 100 N. Lindon, UT 84042
Plate 2 – Sub-3-Seam Workings
Drawn By: David Herron
Checked By: Erik Petersen
Date: 7 June 1999
Filename: Plate-2.dwg



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710 E. 100 N. Lindon, UT 84042

Plate 4 – All Mine Workings

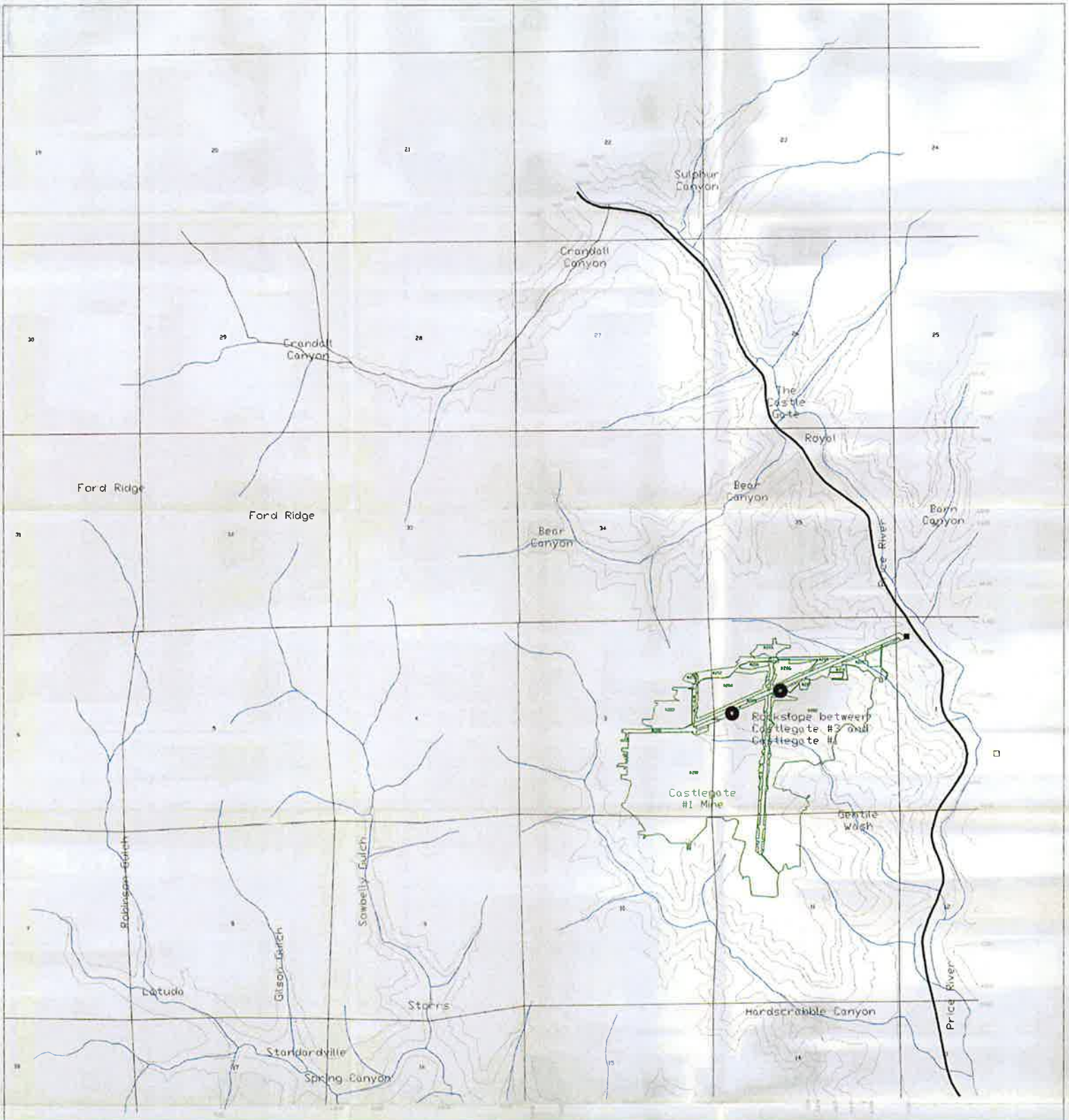
Drawn By: David Herron
Checked By: Erik Petersen
Date: 7 June 1999

Filename: Plate-4.dwg

Plate 5 - Royal / New Peerless Volume Spreadsheet

Mine	Block	Area (ft^2)	Type	% Mined	% Pores	Coal Min.	Coal Max.	Coal-Avg	Guess Ht.	Block Volume (Feet ^ 3)	Block Volume (Gallons)	Elevation Minimum	Elevation Maximum	Elevation Average	Water Volume Below Level (unknown) Flooded?	Existing Minimum Gallons	Existing Maximum Gallons	Water Volume Below Level 6300 Can Hold?	Minimum Gallons	Maximum Gallons
Royal and	301	440063	DRP	60%	100%	?	?	?	6	2,112,302	15,800,022	?	?	?	Yes	15,800,022	15,800,022	Yes	15,800,022	15,800,022
New Peerless	302	934938	DRP	60%	100%	?	?	?	6	4,467,702	33,568,014	?	?	?	Yes	33,568,014	33,568,014	Yes	33,568,014	33,568,014
In Coal Seam D	303	862116	DRP	60%	100%	?	?	?	6	4,136,157	30,953,413	?	?	?	Yes	30,953,413	30,953,413	Yes	30,953,413	30,953,413
	304	436958	DRP	60%	100%	?	?	?	6	2,097,398	15,688,540	?	?	?	Yes	15,688,540	15,688,540	Yes	15,688,540	15,688,540
	305	3692114	DRP	60%	100%	?	?	?	6	17,722,147	132,561,661	?	?	?	Yes	132,561,661	132,561,661	Yes	132,561,661	132,561,661
	306	1400869	DRP	60%	100%	?	?	?	6	6,724,267	50,297,519	?	?	?	Maybe	0	50,297,519	Yes	50,297,519	50,297,519
	307	766746	DRP	60%	100%	?	?	?	6	3,680,381	27,529,248	?	?	?	Maybe	0	27,529,248	Yes	27,529,248	27,529,248
	308	2890812	DRP	60%	100%	?	?	?	6	13,875,898	103,791,714	?	?	?	Maybe	0	103,791,714	Yes	103,791,714	103,791,714
	309	882513	SECO	60%	60%	?	?	?	6	4,518,467	33,798,130	?	?	?	Maybe	0	33,798,130	Yes	33,798,130	33,798,130
	310	1192249	DRP	60%	100%	?	?	?	6	5,722,795	42,806,508	?	?	?	Maybe	0	42,806,508	Yes	42,806,508	42,806,508
	311	965105	DRP	60%	100%	?	?	?	6	4,632,504	34,651,130	?	?	?	Maybe	0	34,651,130	Yes	34,651,130	34,651,130
	312	867449	DRP	60%	100%	?	?	?	6	4,163,755	31,144,889	?	?	?	Maybe	0	31,144,889	Yes	31,144,889	31,144,889
	313	736358	DRP	60%	100%	?	?	?	6	3,534,516	26,438,198	?	?	?	Maybe	0	26,438,198	Yes	26,438,198	26,438,198
	314	545901	DRP	60%	100%	?	?	?	6	2,620,325	19,600,030	?	?	?	Maybe	0	19,600,030	Yes	19,600,030	19,600,030
	315	943886	DRP	60%	100%	?	?	?	6	4,530,648	33,889,247	?	?	?	Maybe	0	33,889,247	Yes	33,889,247	33,889,247
	316	842549	DRP	60%	100%	?	?	?	6	4,044,235	30,250,879	?	?	?	Maybe	0	30,250,879	No	0	0
	317	621108	DRP	60%	100%	?	?	?	6	2,981,318	22,300,262	?	?	?	Maybe	0	22,300,262	No	0	0
	318	661110	DRP	60%	100%	?	?	?	6	4,133,328	30,917,293	?	?	?	Maybe	0	30,917,293	No	0	0
	319	760776	DRP	60%	100%	?	?	?	6	3,747,726	28,032,982	?	?	?	Maybe	0	28,032,982	Yes	28,032,982	28,032,982
	320	657455	DRP	60%	100%	?	?	?	6	3,155,784	23,605,264	?	?	?	Maybe	0	23,605,264	Yes	23,605,264	23,605,264
	321	828997	SECO	60%	60%	?	?	?	6	3,220,465	24,089,076	?	?	?	Maybe	0	24,089,076	Yes	24,089,076	24,089,076
	322	366787	SECO	60%	60%	?	?	?	6	1,877,949	14,047,062	?	?	?	Maybe	0	14,047,062	Yes	14,047,062	14,047,062
	323	1453978	DRP	60%	100%	?	?	?	6	6,979,094	52,203,626	?	?	?	Maybe	0	52,203,626	Yes	52,203,626	52,203,626
	324	3679674	SECO	60%	60%	?	?	?	6	18,839,931	140,922,683	?	?	?	Maybe	0	140,922,683	3/4?	105,692,012	105,692,012
	325	777844	DRP	60%	100%	?	?	?	6	3,732,211	27,916,940	?	?	?	Maybe	0	27,916,940	Yes	27,916,940	27,916,940
	326	1190281	DRP	60%	100%	?	?	?	6	5,713,349	42,735,849	?	?	?	Maybe	0	42,735,849	2/3 ?	28,633,019	28,633,019
	327	853607	DRP	60%	100%	?	?	?	6	4,097,314	30,647,906	?	?	?	Maybe	0	30,647,906	No	0	0
	328	566249	DRP	60%	100%	?	?	?	6	2,717,995	20,330,604	?	?	?	Maybe	0	20,330,604	Yes	20,330,604	20,330,604
	329	1278562	DRP	60%	100%	?	?	?	6	6,137,194	45,906,208	?	?	?	Maybe	0	45,906,208	Yes	45,906,208	45,906,208
	330	416741	DRP	60%	100%	?	?	?	6	2,000,357	14,962,669	?	?	?	Maybe	0	14,962,669	Yes	14,962,669	14,962,669
	331	4130038	DRP	60%	100%	?	?	?	6	19,824,182	148,284,884	?	?	?	Maybe	0	148,284,884	Yes	148,284,884	148,284,884
	332	1566824	SECO	60%	60%	?	?	?	6	8,021,115	59,997,939	?	?	?	Maybe	0	59,997,939	No	0	0
	333	2929708	SECO	60%	60%	?	?	?	6	15,000,105	112,200,785	?	?	?	Maybe	0	112,200,785	1/2 ?	?	?
								Avgerage Height (ft)=	6.0						Min. Gallons	228,571,650		Min. Gallons	1,166,222,607	
								Total Mine Volume (feet^3) ----> =		200,784,916					Max. Gallons ---->		1,501,871,173	Max. Gallons ---->		1,166,222,607
								Total Mine Volume (Gallons) ---->		---->	1,501,871,173									
															Volume below (unknown)			Volume below	6300	

Use These Values--->		Mined%	Pores%
Longwall --->	LONG	100%	80%
Secondary --->	SECO	60%	60%
Room And Pillar Mining			
Dense	DRP	60%	100%
Typical	TRP	50%	100%
Ladder	LRP	45%	100%



Mayo and Associates, LC
Consultants in Hydrogeology
710 E. 100 N. Lindon, UT 84042

Plate 3 – A-Seam Workings

Drawn By: David Herron
Checked By: Erik Petersen
Date: 7 June 1999

Filename: Plate-3.dwg

Plate 6 - Castlegate #3 Volume Spreadsheet

Mine	Block	Area (ft^2)	Type	% Mined	% Pores	Coal Min.	Coal Max.	Coal-Avg	Guess Ht	Block Volume (Feet ^ 3)	Block Volume (Gallons)	Elevation Minimum	Elevation Maximum	Elevation Average	Water Volume Below Level 5770 Flooded?	Existing Minimum Gallons	Existing Maximum Gallons	Water Volume Below Level 6400 Can Hold?	Minimum Gallons	Maximum Gallons	Water Volume Below Level 6300 Can Hold?	Minimum Gallons	Maximum Gallons
Castlegate #3	1	898053	TRP	50%	100%	4.1	5.4	4.4	4.4	1,975,717	14,778,360	6488	6665	6565	No	0	0	No	0	0	No	0	0
(Carbon Fuel #3)	2	1549789	TRP	50%	100%	4.9	7.0	6.0	6.0	4,649,367	34,778,816	6220	6458	6340	No	0	0	3/4?	28,082,612	28,082,612	1/4	6,694,204	6,694,204
in Sub-Seam 3	3	1790363	DRP	50%	100%	?	?	5.0	5.0	5,371,089	40,175,746	?	?	6440	No	0	0	No	0	0	No	0	0
	4	860406	DRP	80%	100%	?	?	5.5	5.5	2,839,340	21,238,262	?	?	6280	No	0	0	Yes	21,238,262	21,238,262	No	0	0
	5	360110	DRP	80%	100%	?	?	?	6.0	1,296,396	9,697,042	?	?	6260	No	0	0	Yes	9,697,042	9,697,042	No	0	0
	6	873518	DRP	80%	100%	?	?	7.0	7.0	3,668,776	27,442,441	?	?	6220	No	0	0	Yes	27,442,441	27,442,441	Yes	27,442,441	27,442,441
	8	1256663	TRP	50%	100%	6.7	8.3	7.2	7.2	4,524,058	33,839,960	5935	6220	6070	No	0	0	Yes	33,839,960	33,839,960	Yes	33,839,960	33,839,960
	9	119709	TRP	50%	100%	?	?	?	7.0	418,982	3,133,982	?	?	5935	No	0	0	Yes	3,133,982	3,133,982	Yes	3,133,982	3,133,982
	10	733371	TRP	50%	100%	6.7	7.8	7.3	7.3	2,676,804	20,022,495	?	?	5980	No	0	0	Yes	20,022,495	20,022,495	Yes	20,022,495	20,022,495
	11	1061544	LRP	45%	100%	10.2	8.0	9.0	9.0	4,360,253	32,764,294	5920	5950	5930	No	0	0	Yes	32,764,294	32,764,294	Yes	32,764,294	32,764,294
	12	527915	LRP	45%	100%	7.8	10.1	8.9	8.9	2,114,300	15,814,961	5955	6103	6030	No	0	0	Maybe	0	15,814,961	Maybe	0	15,814,961
	13	539388	LRP	45%	100%	8.5	10.1	9.2	9.2	2,233,098	16,703,338	6115	6180	6150	No	0	0	Maybe	0	16,703,338	Maybe	0	16,703,338
	14	818341	LRP	45%	100%	7.0	10.2	8.8	8.8	3,277,456	24,515,389	5917	5990	5950	No	0	0	Yes	24,515,389	24,515,389	Yes	24,515,389	24,515,389
	15	425075	LRP	45%	100%	7.4	9.4	8.4	8.4	1,606,784	12,018,741	5790	5860	5825	No	0	0	Yes	12,018,741	12,018,741	Yes	12,018,741	12,018,741
	16	1318068	LRP	45%	100%	4.3	9.5	7.4	7.4	4,391,184	32,845,910	5790	?	5850	No	0	0	Yes	32,845,910	32,845,910	Yes	32,845,910	32,845,910
	17	1212842	LRP	45%	100%	7.1	9.4	8.4	8.4	4,583,787	34,286,725	5475	5830	5690	Yes	34,286,725	34,286,725	Yes	34,286,725	34,286,725	Yes	34,286,725	34,286,725
	18	412594	LRP	45%	100%	7.2	9.6	8.4	8.4	1,559,605	11,665,848	5360	5477	5420	Yes	11,665,848	11,665,848	Yes	11,665,848	11,665,848	Yes	11,665,848	11,665,848
	19	241781	LRP	45%	100%	6.7	7.8	7.0	7.0	761,810	5,696,844	5324	5450	5390	Yes	5,696,844	5,696,844	Yes	5,696,844	5,696,844	Yes	5,696,844	5,696,844
	20	1131889	LRP	45%	100%	6.9	8.4	7.6	7.6	3,971,060	28,955,532	5460	5810	5635	Yes	28,955,532	28,955,532	Yes	28,955,532	28,955,532	Yes	28,955,532	28,955,532
	21	672971	LRP	45%	100%	6.0	9.8	7.2	7.2	2,180,426	16,309,587	5740	?	5780	1/2?	8,154,793	8,154,793	Yes	16,309,587	16,309,587	Yes	16,309,587	16,309,587
	22	667030	LRP	45%	100%	6.9	8.4	7.5	7.5	2,251,226	16,839,172	?	?	5960	No	0	0	Yes	16,839,172	16,839,172	Yes	16,839,172	16,839,172
	23	274883	LRP	45%	100%	6.3	7.2	6.6	6.6	816,700	6,108,912	?	?	5870	No	0	0	Yes	6,108,912	6,108,912	Yes	6,108,912	6,108,912
	24	151150	LRP	45%	100%	6.9	7.0	7.0	7.0	350,125	2,618,916	?	?	5890	No	0	0	Yes	2,618,916	2,618,916	Yes	2,618,916	2,618,916
	25	824868	TRP	50%	100%	6.1	7.1	6.6	6.6	2,722,064	20,361,042	5780	5990	5885	No	0	0	Yes	20,361,042	20,361,042	Yes	20,361,042	20,361,042
	26	285761	LRP	45%	100%	6.3	8.0	7.2	7.2	861,086	6,440,771	?	?	5770	1/2?	3,220,385	3,220,385	Yes	6,440,771	6,440,771	Yes	6,440,771	6,440,771
	27	948085	LRP	45%	100%	6.2	7.4	6.8	6.8	1,983,140	14,833,888	?	?	5690	Maybe	0	14,833,888	Yes	14,833,888	14,833,888	Yes	14,833,888	14,833,888
	28	619620	LRP	45%	100%	?	?	?	6.8	2,508,649	18,764,696	?	?	5630	Maybe	0	18,764,696	Yes	18,764,696	18,764,696	Yes	18,764,696	18,764,696
	29	723724	LRP	45%	100%	6.6	9.4	7.9	7.9	2,572,839	19,244,834	5510	5725	5620	Maybe	0	19,244,834	Yes	19,244,834	19,244,834	Yes	19,244,834	19,244,834
	30	1590850	LONG	100%	80%	6.7	10.4	8.5	8.5	10,818,420	80,906,822	5561	5739	5650	Maybe	0	80,906,822	Yes	80,906,822	80,906,822	Yes	80,906,822	80,906,822
	31	807380	LRP	45%	100%	6.4	7.4	6.9	6.9	1,865,934	14,106,783	5590	5808	5700	Maybe	0	14,106,783	Yes	14,106,783	14,106,783	Yes	14,106,783	14,106,783
	32	269813	TRP	50%	100%	6.2	9.9	7.2	7.2	1,043,327	7,804,084	?	?	5590	Maybe	0	7,804,084	Yes	7,804,084	7,804,084	Yes	7,804,084	7,804,084
	33	1942692	LONG	100%	80%	6.4	9.8	7.5	7.5	11,656,152	87,188,017	5598	5814	5706	Maybe	0	87,188,017	Yes	87,188,017	87,188,017	Yes	87,188,017	87,188,017
	34	1159331	TRP	50%	100%	6.1	8.3	6.8	6.8	3,928,505	29,387,464	5650	5687	5770	Maybe	0	29,387,464	Yes	29,387,464	29,387,464	Yes	29,387,464	29,387,464
	35	17770	TRP	50%	100%	6.5	8.5	8.5	8.5	57,753	431,969	?	?	5620	Maybe	0	431,969	Yes	431,969	431,969	Yes	431,969	431,969
	36	324361	TRP	50%	100%	6.0	7.5	6.7	6.7	1,086,609	8,127,838	5780	5950	5865	No	0	0	Yes	8,127,838	8,127,838	Yes	8,127,838	8,127,838
	37	79093	TRP	50%	100%	6.5	8.7	7.5	7.5	296,599	2,218,559	5730	5780	5755	No	0	0	Yes	2,218,559	2,218,559	Yes	2,218,559	2,218,559
	38	939654	LONG	100%	80%	4.9	8.0	6.2	6.2	4,860,884	34,861,915	?	?	5880	No	0	0	Yes	34,861,915	34,861,915	Yes	34,861,915	34,861,915
	39	80892	TRP	50%	100%	5.5	7.1	6.3	6.3	254,810	1,905,977	?	?	5820	No	0	0	Yes	1,905,977	1,905,977	Yes	1,905,977	1,905,977
	40	467231	TRP	50%	100%	5.3	7.7	6.5	6.5	1,583,501	11,844,586	?	?	5880	No	0	0	Yes	11,844,586	11,844,586	Yes	11,844,586	11,844,586
	41	41278	TRP	50%	100%	7.1	10.7	8.7	8.7	179,546	1,343,006	?	?	5930	No	0	0	Yes	1,343,006	1,343,006	Yes	1,343,006	1,343,006
	42	71291	TRP	50%	100%	7.2	8.2	7.8	7.8	270,906	2,026,375	?	?	5925	No	0	0	Yes	2,026,375	2,026,375	Yes	2,026,375	2,026,375
	43	698852	LONG	100%	80%	5.1	8.7	6.4	6.4	3,577,098	26,756,695	?	?	5920	No	0	0	Yes	26,756,695	26,756,695	Yes	26,756,695	26,756,695
	44	75483	TRP	50%	100%	6.0	6.5	6.3	6.3	237,771	1,778,530	?	?	5910	No	0	0	Yes	1,778,530	1,778,530	Yes	1,778,530	1,778,530
	45	495108	TRP	50%	100%	5.9	8.9	8.3	8.3	1,559,590	11,665,735	6052	?	5970	No	0	0	Yes	11,665,735	11,665,735	Yes	11,665,735	11,665,735
	46	1207810	LONG	100%	80%	6.3	7.0	6.7	6.7	8,472,790	48,416,466	6090	?	6000	No	0	0	Yes	48,416,466	48,416,466	Yes	48,416,466	48,416,466
	47	219298	TRP	50%	100%	6.4	8.7	8.5	8.5	712,719	5,331,134	?	?	5940	No	0	0	Yes	5,331,134	5,331,134	Yes	5,331,134	5,331,134
	48	479599	TRP	50%	100%	6.9	7.0	6.4	6.4	1,534,717	11,479,682	?	?	6040	No	0	0	Yes	11,479,682	11,479,682	Yes	11,479,682	11,479,682
	49	119526	TRP	50%	100%	6.5	7.4	7.0	7.0	418,341	3,129,191	?	?	6040	No	0	0	Yes	3,129,191	3,129,191	Yes	3,129,191	3,129,191
	50	47658	TRP	50%	100%	7.0	8.5	7.5	7.5	178,718	1,336,807	5929	?	5950	No	0	0	Yes	1,336,807	1,336,807	Yes	1,336,807	1,336,807
	51	42072	TRP	50%	100%	7.0	8.3	7.7	7.7	161,977	1,211,589	?	?	5990	No	0	0	Yes	1,211,589	1,211,589	Yes	1,211,589	1,211,589
	52	985690	LONG	100%	80%	6.4	6.6	6.5	6.5	5,125,588	38,339,398	?	?	6050	No	0	0	Yes	38,339,398	38,339,398	Yes	38,339,398	38,339,398
	53	1002832	TRP	50%	100%	6.0	7.0	6.5	6.5	3,258,204	24,378,848	?	?	6090	No	0	0	Yes	24,378,848	24,378,848	Yes	24,378,848	24,378,848
	54	327791	TRP	50%	100%	?	?	6.0	6.0	983,373	7,355,630	?	?	6090	No	0	0	Yes	7,355,630	7,355,630	Yes	7,355,630	7,355,630
	55	1062628	TRP	50%	100%	?	?	?	6.5	3,454,518	25,839,780	?	?	6250	No	0	0	Yes	25,839,780	25,839,780	Yes	25,839,780	25,839,780
	56	383700	DRP	60%	100%	?	?	6.6	6.6	1,519,452	11,365,501	?	?	6280	No	0	0	Yes	11,365,501	11,365,501	Yes	11,365,501	11,365,501
	57	266890	TRP	50%	100%	?	?	?	6.3	873,993	6,536,716	?	?	6290	No	0	0	Yes	6,536,716	6,536,716	Yes	6,536,716	6,536,716
	58	286663	DRP	60%	100%	?	?	?	6.5	1,118,786	8,368,367	?	?	6320	No	0	0	Yes	8,368,367	8,368,367	1/2?	4,184,184	4,184,184
	59	136773	Single	100%	100%	0.0	0.0	0.0	0.0	0	0	?	?	6300	No	0	0	No	0	0	No	0	0
								Avgerage Height (ft)=		6.9												
								Total Mine Volume (Feet^3) ----> =			141,355,343												
								Total Mine Volume (Gallons) ---->			---->	1,057,337,964											

				Min. Gallons	81,980,127		Min. Gallons	981,171,357		Min. Gallons	908,863,481	
				Max. Gallons	---->	384,648,704	Max. Gallons	---->	993,689,654	Max. Gallons	---->	941,181,758
				Volume below	5770		Volume below	6400		Volume below	6300	

Use These Values--->		Mined%	Pores%
Longwall --->	LONG	100%	80%
Secondary --->	SECO	80%	80%
Room And Pillar Mining			
Dense	DRP	60%	100%
Typical	TRP	50%	100%
Ladder	LRP	45%	100%

Plate 7 - Spring Canyon #8 Volume Spreadsheet

Mine	Block	Area (ft^2)	Type	% Mined	% Pores	Coal Min.	Coal Max.	Coal-Avg	Guess Ht.	Block Volume (Feet ^ 3)	Block Volume (Gallons)	Elevation Minimum	Elevation Maximum	Elevation Average
Spring Canyon #8 (in the D-Seam)	501	817705	LRP	45%	100%	7.7	10.0	8.8	8.8	3,236,112	24,221,076	5720.0	5610.0	5900.0
	502	414270	LRP	45%	100%	6.0	9.0	7.5	7.3	1,350,877	10,179,360	5980.0	5190.0	6080.0
	503	594764	LRP	45%	100%	7.5	9.8	8.8	8.8	2,355,348	17,617,978	6180.0	6330.0	6250.0
	504	814120	LRP	45%	100%	7.0	9.1	8.0	8.0	2,210,832	16,537,923	6330.0	6470.0	6400.0
	505	184358	LRP	45%	100%	8.4	8.9	8.1	8.1	671,958	5,026,447	?	?	6300.0
	506	36134	LRP	45%	100%	?	?	7.5	7.5	126,830	948,691	?	?	6200.0
	507	174089	LRP	45%	100%	8.5	9.4	9.0	9.0	705,060	5,273,852	6176.0	6240.0	6200.0
	508	259931	LRP	45%	100%	8.3	10.9	9.2	9.2	1,076,114	8,049,335	6170.0	6440.0	6305.0
	509	630143	LONG	100%	80%	8.7	9.8	9.2	9.2	4,637,852	34,691,137	6184.0	6296.0	6240.0
	510	352453	LRP	45%	100%	8.3	9.6	8.9	8.9	1,411,974	10,558,576	6180.0	6300.0	6240.0
	511	1247375	LONG	100%	80%	8.2	9.8	9.0	9.0	8,981,100	67,178,628	6254.0	6375.0	6315.0
	512	99394	LRP	45%	100%	8.8	10.8	7.0	7.0	313,091	2,341,921	6254.0	6320.0	6290.0
	513	354827	LRP	45%	100%	8.2	8.6	7.4	7.4	1,180,908	8,833,191	6310.0	6390.0	6350.0
	514	1632012	LONG	100%	80%	8.1	10.4	7.5	7.8	9,792,072	73,244,599	6320.0	6450.0	6385.0
	515	598582	LRP	45%	100%	8.2	7.1	6.7	6.7	1,805,629	13,506,107	6399.0	6480.0	6430.0
							Averaged Height (ft)=		8.3					
							Total Mine Volume (feet^3) ----> =			38,987,382				
							Total Mine Volume (Gallons) ---->			---->	298,208,020			

Water Volume Below Level 5770			Water Volume Below Level 6400			Water Volume Below Level 6300		
Flooded?	Existing Minimum Gallons	Existing Maximum Gallons	Can Hold?	Minimum Gallons	Maximum Gallons	Can Hold?	Minimum Gallons	Maximum Gallons
1/3?	316,230	316,230	Yes	24,221,076	24,221,076	Yes	24,221,076	24,221,076
No	0	0	Yes	10,179,360	10,179,360	Yes	10,179,360	10,179,360
No	0	0	Yes	17,617,978	17,617,978	Yes	17,617,978	17,617,978
No	0	0	1/2?	8,268,512	8,268,512	No	0	0
No	0	0	Yes	5,026,447	5,026,447	1/2 ?	2,513,224	2,513,224
Yes	948,691	948,691	Yes	948,691	948,691	Yes	948,691	948,691
No	0	0	Yes	5,273,852	5,273,852	Yes	5,273,852	5,273,852
No	0	0	Yes	8,049,335	8,049,335	1/2 ?	4,024,668	4,024,668
No	0	0	Yes	34,691,137	34,691,137	Yes	34,691,137	34,691,137
No	0	0	Yes	10,558,576	10,558,576	Yes	10,558,576	10,558,576
No	0	0	Yes	67,178,628	67,178,628	1/2?	33,589,314	33,589,314
No	0	0	Yes	2,341,921	2,341,921	1/2?	1,170,961	1,170,961
No	0	0	Yes	8,833,191	8,833,191	No	0	0
No	0	0	1/4?	54,933,524	54,933,524	No	0	0
No	0	0	No	0	0	No	0	0
Min. Gallons	1,264,921		Min. Gallons	258,122,228		Min. Gallons	144,788,835	
Max. Gallons ---->		1,264,921	Max. Gallons ---->		258,122,228	Max. Gallons ---->		144,788,835
Volume below	5770		Volume below	6400		Volume below	6300	

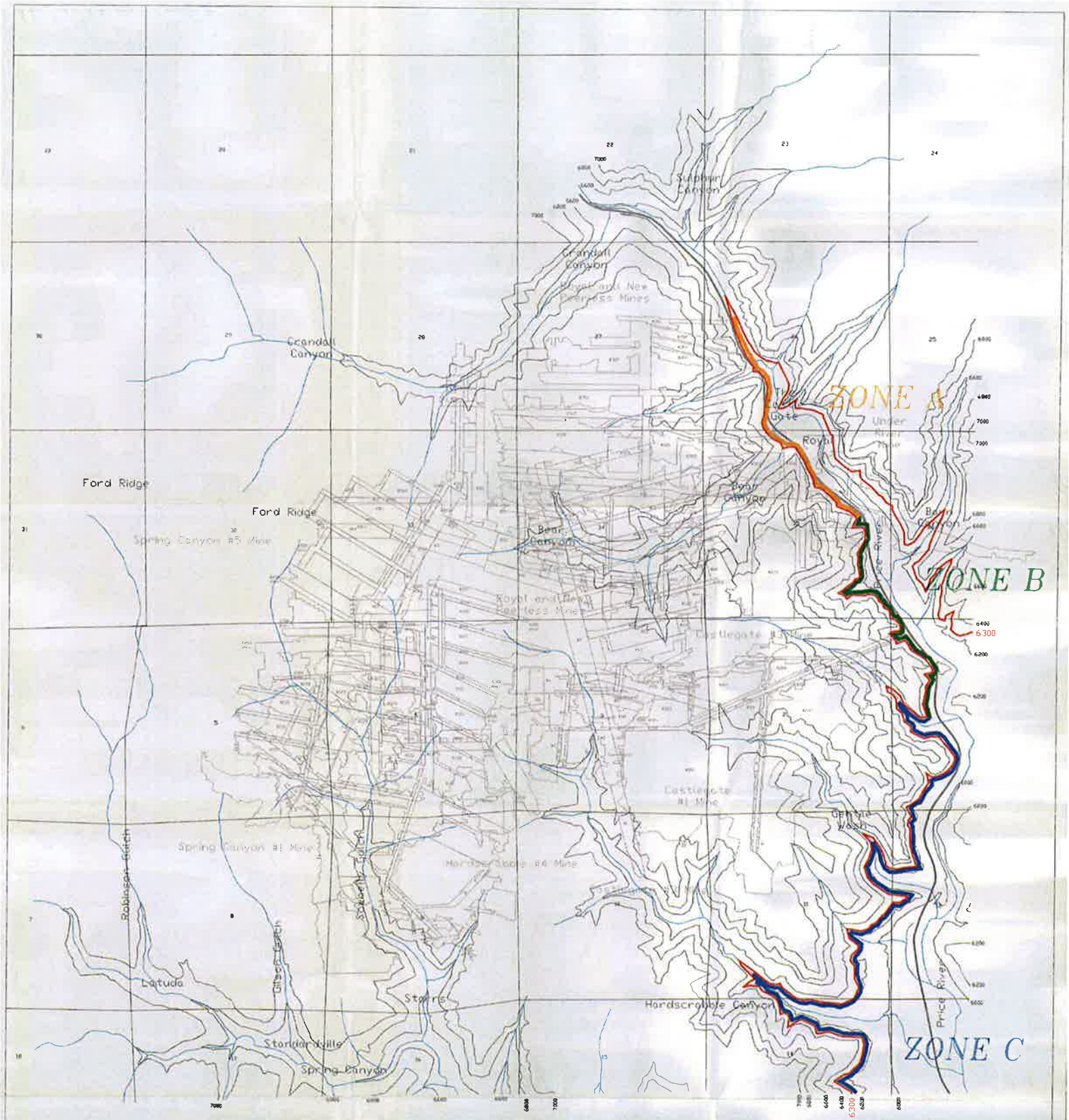
Use These Values---->		Mined%	Pores%
Longwall --->	LONG	100%	80%
Secondary --->	SECO	60%	80%
Room And Pillar Mining			
Dense	DRP	60%	100%
Typical	TRP	50%	100%
Ladder	LRP	45%	100%

Plate 8 - Spring Canyon #1 Volume Spreadsheet

Mine	Block	Area (ft^2)	Type	% Mined	% Pores	Coal Min.	Coal Max.	Coal-Avg	Gueas Ht	Block Volume (Feet ^ 3)	Block Volume (Gallons)	Elevation Minimum	Elevation Maximum	Elevation Average
Spring Can. #1	101	462617	OE	50%	100%	?	?	?	7.0	1,619,160	12,111,313	?	?	<6300
(Bowbelly #17)	102	445400	OE	50%	100%	?	?	?	7.0	1,568,900	11,660,572	?	?	<6300
in Sub-Seam 3	103	340113	OE	50%	100%	?	?	?	7.0	840,366	6,286,158	?	?	<6300
	104	234337	OE	50%	100%	?	?	?	7.0	820,180	6,134,943	?	?	<6300
	105	768775	ORP	53%	100%	?	?	?	7.0	2,852,155	21,334,121	?	?	<6300
	106	311460	OE	50%	100%	?	?	?	7.0	1,090,075	8,153,761	?	?	<6300
	107	1175998	ORP	53%	100%	?	?	?	7.0	4,361,469	32,623,785	?	?	<6300
	108	181718	OE	50%	100%	?	?	?	7.0	671,013	5,018,177	?	?	<6300
	109	1242389	ORP	53%	100%	?	?	?	7.0	4,609,189	34,478,734	?	?	<6300
	110	180735	OE	50%	100%	?	?	?	7.0	632,573	4,731,642	?	?	<6400
	111	884237	ORP	53%	100%	?	?	?	7.0	3,280,819	24,538,284	?	?	<6400
	112	422900	OE	50%	100%	?	?	?	7.0	1,480,150	11,071,522	?	?	6400
	113	793801	ORP	53%	100%	?	?	?	7.0	2,833,702	21,196,089	?	?	<6500
	114	146014	OE	50%	100%	?	?	?	7.0	514,199	3,846,209	?	?	6450
	115	991845	ORP	53%	100%	?	?	?	7.0	2,466,445	18,366,728	?	?	6500
	116	226811	OE	50%	100%	?	?	?	7.0	799,289	5,903,878	?	?	<6300
	117	262150	ORP	53%	100%	?	?	?	7.0	1,046,777	7,829,668	?	?	<6300
	118	295330	OE	50%	100%	?	?	?	7.0	1,033,655	7,731,739	?	?	<6300
	119	1153074	ORP	53%	100%	?	?	?	7.0	4,203,705	31,443,710	?	?	6300
	120	265830	OE	50%	100%	?	?	?	7.0	929,705	6,954,193	?	?	<6400
	121	1044804	ORP	53%	100%	?	?	?	7.0	3,810,594	28,996,922	?	?	<6400
	122	153480	OE	50%	100%	?	?	?	7.0	642,110	4,802,983	?	?	<6400
	123	527998	SECO?	80%	80%	?	?	?	7.0	2,365,431	17,693,424	?	?	<6500
	124	1057134	ORP	53%	100%	?	?	?	7.0	3,921,967	29,330,314	?	?	<6500
	125	958532	SECO?	80%	80%	?	?	?	7.0	4,294,223	32,120,791	?	?	6500
	126	193869	OE	50%	100%	?	?	?	7.0	466,612	3,805,214	?	?	6450
	127	297499	ORP	53%	100%	?	?	?	7.0	992,421	7,423,311	?	?	<6500
	128	291877	ORP	53%	100%	?	?	?	7.0	1,048,784	7,822,312	?	?	<6600
	129	1674823	SECO?	80%	80%	?	?	?	7.0	7,505,855	56,127,340	?	?	6600
	130	244987	ORP	53%	100%	?	?	?	7.0	908,790	6,797,753	?	?	<6600
	131	473783	OE	50%	100%	?	?	?	7.0	1,656,241	12,403,639	?	?	6600
	132	669760	ORP	53%	100%	?	?	?	7.0	2,559,010	19,141,392	?	?	<6600
	133	208290	ORP	53%	100%	?	?	?	7.0	772,788	5,780,214	?	?	<6500
	134	706370	OE	50%	100%	?	?	?	7.0	2,472,295	18,492,767	?	?	6500
	135	812683	ORP	53%	100%	?	?	?	7.0	3,016,054	22,562,603	?	?	6500
	136	861804	ORP	53%	100%	?	?	?	7.0	3,197,664	23,918,526	?	?	<6600
	137	803532	OE	50%	100%	?	?	?	7.0	1,762,362	13,182,464	?	?	6600
	138	274398	OE	50%	100%	?	?	?	7.0	960,393	7,183,740	?	?	<6600
	139	1072712	ORP	53%	100%	?	?	?	7.0	3,979,782	29,766,816	?	?	<6700
	140	639408	ORP	53%	100%	?	?	?	7.0	2,372,193	17,744,000	?	?	<6700
	141	696733	ORP	53%	100%	?	?	?	7.0	2,547,779	19,057,396	?	?	<6700
	142	1559260	SECO	80%	80%	?	?	?	7.0	6,959,560	52,050,029	?	?	6650
								Avgerage Height (ft)=	7.0					
								Total Mine Volume (feet^3) ----> =		98,897,687				
								Total Mine Volume (Gallons) ---->		---->	717,316,194			

Use These Values--->		Mined%	Pores%
Longwall --->	LONG	100%	80%
Secondary --->	SECO	80%	80%
Room And Pillar Mining			
Dense	DRP	60%	100%
Typical	TRP	50%	100%
Ladder	LRP	45%	100%
Old Entry	OE	50%	100%	(Measured on Block 103)
Old R+P	ORP	53%	100%	(Measured on Block 105)

Water Volume Below Level	Existing Minimum Gallons	Existing Maximum Gallons	Water Volume Below Level 6400			Water Volume Below Level 6600		
Flooded?			Can Hold?	Minimum Gallons	Maximum Gallons	Can Hold?	Minimum Gallons	Maximum Gallons
Maybe	0	12,111,313	Yes	12,111,313	12,111,313	Yes	12,111,313	12,111,313
Maybe	0	11,660,572	Yes	11,660,572	11,660,572	Yes	11,660,572	11,660,572
Maybe	0	6,286,158	Yes	6,286,158	6,286,158	Yes	6,286,158	6,286,158
Maybe	0	6,134,943	Yes	6,134,943	6,134,943	Yes	6,134,943	6,134,943
Maybe	0	21,334,121	Yes	21,334,121	21,334,121	Yes	21,334,121	21,334,121
Maybe	0	8,153,761	Yes	8,153,761	8,153,761	Yes	8,153,761	8,153,761
Maybe	0	32,623,785	Yes	32,623,785	32,623,785	Yes	32,623,785	32,623,785
Maybe	0	5,018,177	Yes	5,018,177	5,018,177	Yes	5,018,177	5,018,177
Maybe	0	34,478,734	Yes	34,478,734	34,478,734	Yes	34,478,734	34,478,734
Maybe	0	4,731,642	Yes	4,731,642	4,731,642	Yes	4,731,642	4,731,642
Maybe	0	24,538,284	Yes	24,538,284	24,538,284	Yes	24,538,284	24,538,284
Maybe	0	11,071,522	Half	5,535,761	5,535,761	Yes	11,071,522	11,071,522
Maybe	0	21,196,089	No	0	0	Yes	21,196,089	21,196,089
Maybe	0	3,846,209	No	0	0	Yes	3,846,209	3,846,209
Maybe	0	18,366,728	No	0	0	Yes	18,366,728	18,366,728
Maybe	0	5,903,878	Yes	5,903,878	5,903,878	Yes	5,903,878	5,903,878
Maybe	0	7,829,668	Yes	7,829,668	7,829,668	Yes	7,829,668	7,829,668
Maybe	0	7,731,739	Yes	7,731,739	7,731,739	Yes	7,731,739	7,731,739
Maybe	0	31,443,710	Yes	31,443,710	31,443,710	Yes	31,443,710	31,443,710
Maybe	0	6,954,193	Yes	6,954,193	6,954,193	Yes	6,954,193	6,954,193
Maybe	0	28,996,922	Yes	28,996,922	28,996,922	Yes	28,996,922	28,996,922
Maybe	0	4,802,983	Yes	4,802,983	4,802,983	Yes	4,802,983	4,802,983
Maybe	0	17,693,424	No	0	0	Yes	17,693,424	17,693,424
Maybe	0	29,330,314	No	0	0	Yes	29,330,314	29,330,314
Maybe	0	32,120,791	No	0	0	Yes	32,120,791	32,120,791
Maybe	0	3,805,214	No	0	0	Yes	3,805,214	3,805,214
Maybe	0	7,423,311	No	0	0	Yes	7,423,311	7,423,311
Maybe	0	7,822,312	No	0	0	Yes	7,822,312	7,822,312
Maybe	0	56,127,340	No	0	0	Half	28,063,670	28,063,670
Maybe	0	6,797,753	No	0	0	Yes	6,797,753	6,797,753
Maybe	0	12,403,639	No	0	0	Half	6,201,819	6,201,819
Maybe	0	19,141,392	No	0	0	Yes	19,141,392	19,141,392
Maybe	0	5,780,214	No	0	0	Yes	5,780,214	5,780,214
Maybe	0	18,492,767	No	0	0	Yes	18,492,767	18,492,767
Maybe	0	22,562,603	No	0	0	Yes	22,562,603	22,562,603
Maybe	0	23,918,526	No	0	0	Yes	23,918,526	23,918,526
Maybe	0	13,182,464	No	0	0	2/3	8,832,253	8,832,253
Maybe	0	7,183,740	No	0	0	Yes	7,183,740	7,183,740
Maybe	0	29,766,816	No	0	0	No	0	0
Maybe	0	17,744,000	No	0	0	No	0	0
Maybe	0	19,057,396	No	0	0	No	0	0
Maybe	0	52,050,029	No	0	0	No	0	0
Min. Gallons	0		Min. Gallons	259,209,565		Min. Gallons	560,080,455	
Max. Gallons ---->		717,316,194	Max. Gallons ---->		259,209,565	Max. Gallons ---->		560,080,455
Volume below (unknown)			Volume below	6400		Volume below	6600	



Zones A, B, and C designate areas of differing potential for leakage of impounded mine waters to the surface.

Zone A includes the region below 6,300 feet elevation that is stratigraphically above the horizons which contain mine workings to potentially be filled

Zone B includes the region below 6,300 feet elevation that is approximately on strike with the stratigraphic horizons that contain mine workings to potentially be filled

Zone C includes the region below 6,300 feet elevation that is stratigraphically below the mine workings to potentially be filled.

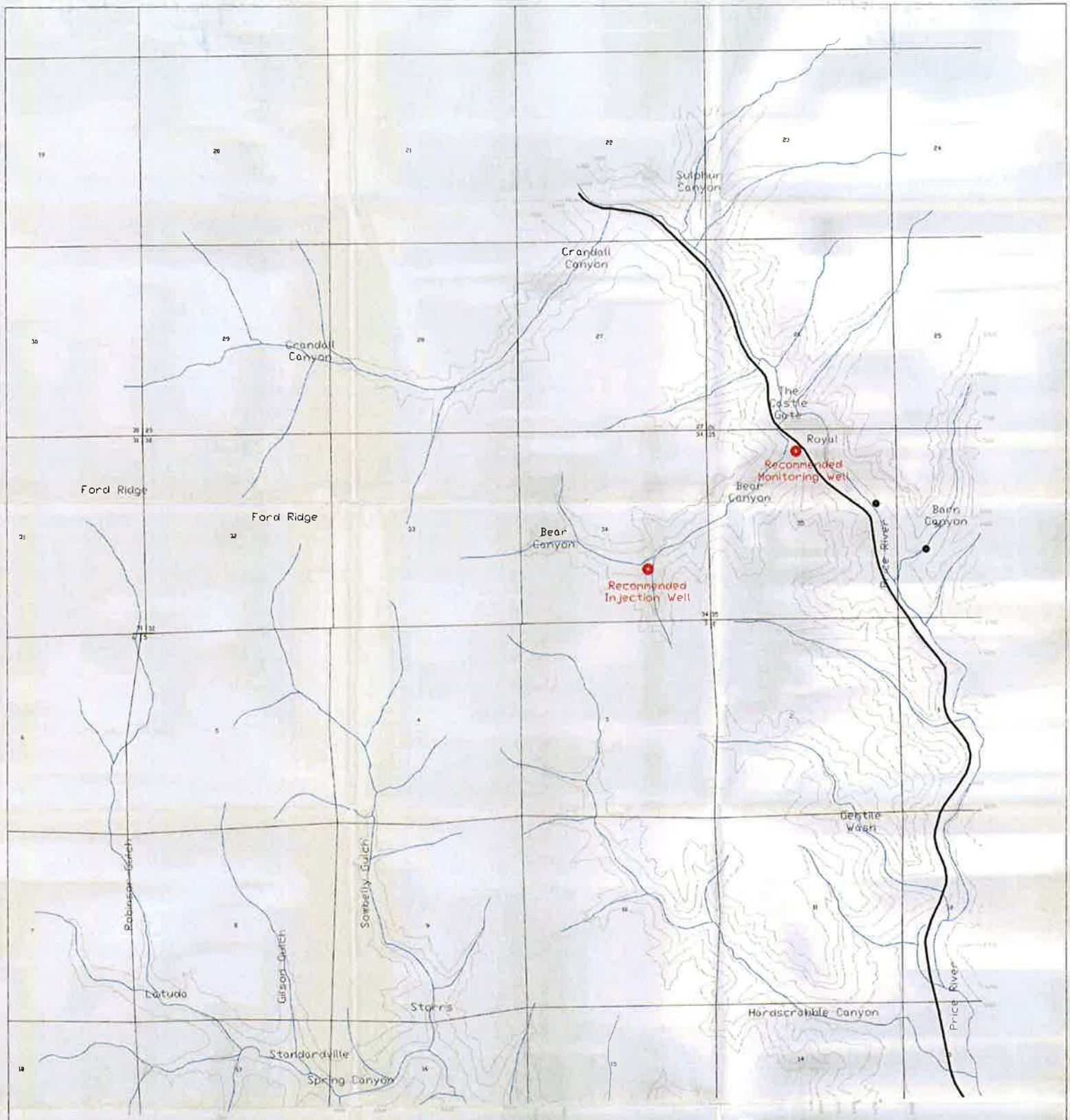
Highway 6

Mayo and Associates, LC
Consultants in Hydrogeology
710 E. 100 N. Lindon, UT 84042

Plate 9 – Topography Below 6,300

Drawn By: Dave Herron
Checked By: Erik Petersen
Date: 14 June 1999

Filename: Plate-9.dwg



Mayo and Associates, LC
Consultants in Hydrogeology
710 E. 100 N. Lindon, UT 84042

Plate 10 – Recommendations

Drawn By: Dave Herron
Checked By: Erik Petersen
Date: 8 June 1999

Filename: Plate-10.dwg