INTERWEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

Interwest Mining Company
Huntington Office
P. O. Box 310
15 North Main Street
Huntington, UT 84528

May 9, 2016

Utah Coal Program
Utah Division of Oil, Gas, and Mining
1594 West North Temple, Suite 1210
P.O. Box 145801
Salt Lake City, Utah 84114-5801

Subj: Amendment for a Post Mining Land Use Change and Include a Post Mining Water Discharge for Rilda Canyon Portals, PacifiCorp, Deer Creek Mine, C/015/0018, Emery County, Utah.

PacifiCorp, by and through its wholly-owned subsidiary, Interwest Mining Company, as mine manager, hereby submits an amendment to include a permanent water discharge from the Rilda Canyon Portals of the Deer Creek Mine.

Interwest Mining Company proposed several alternatives to the Mine Safety and Health Administration to handle intercepted mine water underground and prevent discharge at Rilda Canyon. Plans included retaining the water through the construction of underground bulkheads, retaining and diverting intercepted mine water using parallel plugs routing water to a 12" diversion through an unmined portion connecting the Mill Fork Area to the southern area of the Deer Creek Mine. This diversion would have allowed all water produced in the Mill Fork Area to be diverted and discharged from the Deer Creek Mine portals in Deer Canyon. Interwest Mining Company currently possesses an approved UPDES discharge point at this location. However, the Mine Safety and Health Administration has denied all plans for retaining or diverting intercepted mine water using dam type structures underground. The only alternative left to handle the intercepted mine water is to discharge from the Rilda Canyon Portals in Rilda Canyon.

In this alternative, PacifiCorp is proposing to install a permanent mine water discharge in each of the two (2) portals of the Rilda Canyon Portal facility. Each portal will include two (2) HDPE pipes, a 25 foot thick solid concrete plug, and at least 25 feet of non-combustible backfill immediately outby the concrete portal plug. Each of the pipes will be perforated inby the plug and covered with 3 feet of gravel to filter out any solids that has the potential to cause clogging in the pipe line.

Because of the anti-degradation policy adopted by the United States Forest Service and the Utah Department of Water Quality, intercepted mine water cannot be discharged into the stream of the Rilda Canyon Creek. The pipelines from the portals will therefore, report to an 8" HDPE collection line that will be routed down the canyon adjacent to the mine site's primary access road. At the boundary of the Deer Creek Mine disturbed area, PacifiCorp's Huntington Power Plant will extend the line adjacent to Emery County Road #306. The pipe will extend to Huntington Canyon and cross under State Highway 31. From this point, the line will be buried on the north and west side of Hwy 31 within the highway's recorded Right of Way. At the Huntington Plant water diversion structure, the line will again be routed under Hwy 31 to the power plant's sediment pond.

The water will discharge into the Plant's sediment pond. Huntington Power Plant is planning to consume the water in its generation of electrical power. Interwest Mining expects that once the water begins to discharge from the mine (timing is unknown), the plant should realize anywhere from 200 to 600 gallons per minute.

As part of this alternative use of the mined lands, Interwest Mining is proposing to revise its Post Mining Land Use to add Industrial/Commercial to the list of land uses. Currently, the Deer Creek Mine's PMLU is Fish and Wildlife, Grazing, and Recreation. This PMLU change adds a fourth use to the list.

This permitting action complies with R645-301-413-300. Therefore, attached to this application is a draft public notice for the PMLU change. Once the Division approves the draft public notification, Interwest Mining will submit to publish in the Emery County Progress for 4 consecutive weeks.

C1/C2 forms are included with this submittal. A Redline/Strike-out copy of the revised text in Volume 11 and Volume 12 of the Deer Creek MRP is included for your review as well as the associated revised maps that show detailed designs of the discharge plan.

If there are any questions or concerns with the submittal, please contact me at 435-687-4712, Chuck Semborski at 435-687-4720, or Dennis Oakley at 435-687-4825.

Sincerely,

Kenneth S. Fleck

Kenneth Fleck
Geology and Environmental Affairs Manager

Enclosures

Cc File
Scott Child

APPLICATION FOR COAL PERMIT PROCESSING

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

Permittee: PacifiCorp

Mine: Deer Creek Mine **Permit Number:** C/015/0018

Title: Amendment for a Post Mining Land Use Change and Include a Post Mining Water Discharge for Rilda Canyon Portals, PacifiCorp, Deer Creek Mine, C/015/0018, Emery County, Utah.

Description, Include reason for application and timing required to implement:

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

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

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

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

Kenneth Fleck — Kenneth S. Fleck — Manager of Environmental Affairs MAY 9, 2016
Print Name — Sign Name, Position, Date

Subscribed and sworn to before me this 9th day of May, 2016

Chris M Christensen
Notary Public

My commission Expires: April 24, 2019

Attest: State of Utah } ss:
County of Emery

NOTARY PUBLIC
CHRIS M CHRISTENSEN
Commission No. 682810
Commission Expires
APRIL 24, 2019
STATE OF UTAH

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

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

Permittee: PacifiCorp
Mine: Deer Creek Mine **Permit Number:** C/019/0018
Title: Amendment for a Post Mining Land Use Change and Include a Post Mining Water Discharge for Rilda Canyon Portals, PacifiCorp, Deer Creek Mine, C/015/0018, Emery County, Utah.

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

Add	Replace	Remove	DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☐	☒	☐	Volume 11, R645-301-400: Land Use and Air Quality, replace page 3-4, highlighted text.
☐	☒	☐	Volume 11, R645-301-500: Engineering, replace page 40, highlighted text.
☐	☒	☐	Volume 11, R645-301-700: Hydrology, replace five pages, see highlighted text.
☐	☒	☐	Volume 11, R645-301-400: Land Use and Air Quality, replace Plate 400-1
☐	☒	☐	Volume 11, R645-301-500: Engineering, Figures Section, replace Figure R645-301-500d
☐	☒	☐	Volume 11, R645-301-500: Engineering, replace Plate 500-4 (1 of 4 and 2 of 4)
☐	☒	☐	Volume 11, R645-301-500: Engineering, replace Plate 500-5
☐	☒	☐	Volume 12, R645-301-700: Hydrology, replace entire chapter. see highlighted text.
☒	☐	☐	Volume 12, R645-301-700, Appendix D
☐	☐	☒	Volume 12, R645-301-700, Maps Section, MFS1831D-East Mountain Property - Mill Fork Area Spring Map
☐	☐	☒	Volume 12, R645-301-700, Maps Section, MFS1832D-East Mountain Property - Water Rights Map
☒	☐	☐	Volume 12, R645-301-700, Maps Section, MFU1901D-Deer Creek Mine Debris Control Screens Water Diversion Structures
☒	☐	☐	Volume 12, R645-301-700, Maps Section, MFU1902D-Deer Creek Mine Closure Sequencing
☒	☐	☐	Volume 12, R645-301-700, MMFU1903D-Deer Creek Mine Hydrology Map
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Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan. Note: Page numbers may not be identical to existing MRP. Reviewer should compare chapter sections and not page numbers.	Received by Oil, Gas & Mining

PacifiCorp
Deer Creek Mine
C/015/0018

Post Mining Land Use Change Application

Interwest Mining Company
PO Box 310
Huntington, Utah 84528

PacifiCorp, by and through its wholly-owned subsidiary, Interwest Mining Company, hereby submits and application to amend the post mining land use for the Deer Creek Mine. The main mine facility is located approximately 10 miles northwest of the town of Huntington, Utah on State Hwy 31. Operations at this facility have been suspended and portals sealed.

The Deer Creek Mine's Rilda Canyon Portal facilities, located 3 miles northwest of the Huntington Power Plant, remain operational. Efforts are ongoing to plan and prepare for a post mining water discharge from the two Rilda canyon portals. Preliminary calculations estimate a discharge of approximately 200-600 gallons per minute. PacifiCorp is planning to collect this discharged water from the mine through pipes from each of the two portals. An 8" pipeline will be constructed and buried from the Rilda Canyon Portal facilities to the Huntington Power Plant settling pond. The discharge water will be consumed in the electrical power generation operations. The Company proposes to bury the line adjacent to the Emery County Road #306 and State Highway 31. As required by the Utah State coal mining regulations, a post mining land use change must be approved by the Division of Oil, Gas, and Mining since the current mining permit does not specify "Industrial/Commercial" land use activities within its plan.

Currently, the post mining land uses are Fish and Wildlife Habitat, Grazing, and Recreation. Interwest Mining Company proposes to add Industrial/Commerical to its list of post mining land uses.

This application is submitted for approval to allow for higher and better uses that are consistent with the criteria regarding alternative post mining land uses. The consumptive use of the mine discharge water at the Huntington Power Plant is a practical and achievable use.

A copy of the Post Mining Land Use change application may be examined at 1) office of the Division of Oil, Gas, and Mining, 1594 West North Temple, Suite 1210, Salt Lake City, Utah 84114-5801, or 2) Emery County Recorder's Office in Castle Dale, Utah. Written comments, objections, or requests for a public hearing and informal conference may be submitted to the Salt Lake City address. This notice is being published to comply with the Surface Mining Control and Reclamation Act of 1977, and the State and Federal regulations promulgated pursuant to said Act.

Published in the Emery County Progress for four consecutive weeks beginning May XX, 2016.

R645-301-550 RECLAMATION DESIGN CRITERIA AND PLANS

Reclamation activities at the Rilda Canyon Portal Facility will include plans and designs for 1) Casing and sealing of portals, 2) Permanent features, and 3) Backfilling and grading. These plans and designs are outlined below.

R645-301-551 Casing and Sealing Underground Openings

The Rilda Canyon Portal Facility has a total of two (2) portals of which one (1) is a blowing fan installation. These portals are located on the surface facility map, Map 500-3. The plan for sealing these portals consists of a 25 foot permanent ~~MSHA approved, plug-type seal~~ solid concrete plug with at least 25 feet of non-combustible material compacted, to the extent possible, to form an earthen plug (see Figure R645-301-500d in the Figures Section). Two (2) 100 foot perforated HDPE pipes will be installed through the concrete and earth plug to transfer post mining water discharge from the mine to an 8" central collection pipe. The collection pipe will extend from the Rilda Canyon facilities to the Huntington Power Plant where the water will be consumed in electrical power generation operations.

The earthen plug will extend out of the portal and graded to match the topography that existed prior to mining and reclamation activities in this area. Since the portals have been developed post-SMCRA, the associated highwalls will be completely eliminated by the reclamation activities. All concrete materials that are crushed and removed from the pad areas, storage bunkers, etc. will be ~~permanently disposed of within the two portals facility portals~~ used as fill to cover the highwalls, permanently disposed of in the mine, or disposed of off-site. ~~Compliance to MSHA requirements for ventilation will be followed during this backfilling activity.~~ Backfilling and grading of the portals and mine site is detailed below.

R645-301-552 Permanent Features

As noted above, PacifiCorp is planning for a permanent post mining water discharge. Pipes will be installed through the concrete portal plugs to facilitate the discharge of water from the mine. Although the water line will be buried outside of the mine, a access vault will be constructed within the reclaimed area. This vault will be utilized for access into the line to monitor flow and discharge water quality. The location of the vault is shown on Plate 500-5. Plate 500-4 shows the location of the buried pipeline in respect to the drawn cross-sections. Figure R645-301-500d illustrates the design for the French drain system installed in each portal.

Small depressions (pocks) will be constructed to retain moisture, minimize erosion, create and enhance wildlife habitat, and assist revegetation. The pocks will be constructed with a track-hoe or similar machinery and placed in random order. The pocks will measure

The referenced 15 degree angle of draw is an industry/agency accepted standard used for delineation of surface influence protection from mining areas considered for full extraction mining. Mining experience at Energy West's Deer Creek, Cottonwood, and Trail Mountain mines has provided a sound, scientific basis for using the 15° angle of draw mentioned above (refer to Annual Subsidence Reports of the Deer Creek MRP).

The angle of draw of subsidence produced by full-extraction mining can be influenced by many factors. These include the size of the area mined, number of seams mined, fractures or faults in the overburden, adjacent mine workings, and adjacent areas of burned coal and clinker. If mine workings extend to an area of burned coal, experience has shown that the overburden stresses above the mined area can be transferred to the adjacent burned coal and clinkers which can cause the clinkered areas to fail. In this case, the angle of draw may appear to be very shallow, when the crushing of the clinkered areas are the source of subsidence outside the normal area of influence.

Faults can also influence the angle of draw. If mining occurs adjacent to an existing fault, the area of subsidence will follow the natural plane of weakness formed by the fault. In this case, the angle of draw will be the same as the dip of the fault.

Based on data collected by the U.S. Bureau of Mines and eighteen years of subsidence data collection on East and Trail mountains, the angle of draw is found to be between 0 and 15 degrees from vertical. In some limited areas, the angle of draw is greater than 15 degrees, but in every case, the angle is greater due to the influence of one of the other factors mentioned above.

For planning purposes, any barrier of protection left in the mine to protect surface features should use a 15 degree angle of draw unless one of the factors mentioned above is known to exist in the immediate area.

In the majority of cases, cracking due to subsidence is not anticipated to extend to the surface; therefore, surface runoff patterns will not be significantly affected. Data collected by PacifiCorp over a eighteen-year period concerning subsidence and surface drainages has not detected any surface stream impacts. Consequently, subsidence should not cause significant impacts to the surface water system.

Underground coal mines in the Wasatch Plateau coal field typically intersect groundwater from strata surrounding the coal seams. Both Deer Creek and Wilberg/Cottonwood mines have intersected quantities of water in excess of operational needs and therefore have discharged intercepted groundwater. Dewatering of Deer Creek has had only a minor impact on surface quality and quantity on a regional basis; however, on a site specific basis the flow in Deer Creek has increased from pre-mining conditions (refer to Volume 12 Mill Fork Area for details related to the hydrology of this area including post mine discharge). During periods of high runoff changes in quality are insignificant; however, in low flow conditions some degradation is likely due to the fact that the mine discharge waters are higher in TDS than the surface waters. It is difficult to assess the degradation because it is not known from

D. INCREASED FLOW TO RILDA CREEK - MINE WATER DISCHARGE

All mine discharge water is will be routed through a buried pipeline from the Rilda Canyon 1st Right portals to the Huntington Power Plant Settling Pond (refer to Volume 12 Hydrologic Section for details related to post mine discharge from Mill Fork Area including North Rilda).the underground reservoirs in the old workings or specialized sump areas and discharged at the Deer Creek Mine portals located in Deer Creek Canyon. Monitoring will be in accordance with UPDES permit standards and state and federal regulations.

E. INTERFERENCE TO RILDA SPRINGS (QUALITY)

Site development related to the Rilda Canyon Portal Facilities is up gradient of the Rilda Canyon Springs. The site has been graded and paved to allow construction of the mine entries, facilities pad, and ancillary facilities on relatively flat areas. All grading and paving has been sloped away from the receiving stream/Rilda Canyon Springs and drains to a drop drain and culvert system that is diverted to a sediment basin minimizing potential impacts.

As stated previously, two separate drainage systems are provided at the Rilda Canyon portal facility site and are classified as "undisturbed" and "disturbed" collection systems. The "undisturbed" system collects overland runoff water above the portal site and from side slopes adjacent to the site and conveys it past the disturbed area into the natural channel of Rilda Canyon Creek. The "disturbed" collection system collects runoff from the portal and storage areas and conveys it to a temporary sedimentation basin east of the facilities pad. Flows that exceed the holding capacity of the sediment basin is diverted to the sediment pond.

Development plans for the Rilda Canyon Portal Facilities include construction of single sedimentation pond located at the eastern extent of the disturbed area (refer to R645-301-500 Engineering Section Map 500-2). Analysis utilized to determine the size and hydraulics related to the construction and operation of the sedimentation pond is included Volume 11 Appendix Volume - Hydrology: Appendix B: Drainage and Sediment Control Plan. The sediment pond was strategically located below Rilda Canyon Springs to minimize the effects to the springs and collection system.

F. ALTERATION TO THE BIOLOGIC COMMUNITIES

PacifiCorp developed a Drainage and Sediment Control Plan to protect the surface (Rilda Creek) and groundwater resources (Rilda Canyon Springs) in the area of the Rilda Canyon Portal Facilities. The Drainage and Sediment Plan will ensure protection of water resources by handling soil, overbuden and refuse from previous mining activities in such a manner to minimize discharge of pollutants to the hydrologic regime. Refer to Volume 11 Appendix Volume - Hydrology: Appendix B: Drainage and Sediment Control Plan for complete details related to development of the Rilda Canyon Portal Facilities. As stated reclamation methods and sediment control practices. Sediment control methods include, but are not limited to:

- a. Retaining sediment within disturbed areas;
- b. Diverting runoff away from disturbed areas;
- c. Diverting runoff using protected channels or pipes through disturbed areas so as not to cause additional erosion;
- d. Using straw dikes, riprap, check dams, mulches, vegetative sediment filters, dugout ponds and other measures that reduce overland flow velocities, reduce runoff volumes or trap sediment.
- e. Paving.

PacifiCorp and governmental agencies have conducted several baseline studies of Rilda Creek to establish existing surface and groundwater characteristics. These studies included; quality and quantity monitoring of Rilda Creek, Rilda Canyon Springs, installation of groundwater wells and pump testing, geomorphology investigation and biological organisms assessments. Baseline data has been compared to hydrologic monitoring results to evaluate the effectiveness of the drainage and sediment control plan. The results indicate that there has been no conclusive evidence that shows construction activities of the Rilda Portal facilities having a negative impact on the hydrologic regime of Rilda Creek. The results of the biological assessment study are included in Volume 11 Appendix Volume - Biology: Appendix C.

Mitigation and Control Plans

To minimize potential effects to Rilda Creek, all mine discharge water will be routed through a buried pipeline from the Rilda Canyon 1st Right portals to the Huntington Power Plant Settling Pond (refer to Volume 12 Hydrologic Section for details related to post mine discharge from Mill Fork Area including North Rilda)~~the underground reservoirs in the old workings or specialized sump areas and discharged at the Deer Creek Mine portals located in Deer Creek Canyon~~. Monitoring will be in accordance with UPDES permit standards and state and federal regulations. (refer to Volume 9 - Hydrologic Section: Appendix B for UPDES permit information.) As described previously and in the Drainage and Sediment Control Plan (refer to Volume 11 Appendix Volume - Hydrology: Appendix B) the site development in Rilda Canyon has been designed to minimize the potential effects to the hydrologic balance. Baseline studies have been conducted to assess the quality, quantity, geomorphology and biologic resources of Rilda Canyon.

The effects of the mining operation on the surface water system will continue to be analyzed through the surface water monitoring plan described below. In the event that monitoring shows that the surface water system is being adversely affected by mining activities, additional steps will be taken to rectify said impacts in cooperation with local, state, and federal regulatory agencies.

Surface Monitoring Plan

The mines in the coal fields of the Wasatch Plateau tend to act as interceptor drains. The groundwater that is brought to the surface has a lower dissolved solids content than would have existed were the water to continue its downward movement through shale layers, dissolving increased amounts of salt with distance (Southeastern Utah Association of Governments, 1977; Vaughn Hansen Associates, 1979; Danielson et al., 1981). The quality also decreases vertically because of the influence of marine sediments as well as along the trend of decreasing quality from north to south.

Post Mining

The monitoring of in-mine water sources has shown that the long-term water flow from a given area is much less than ten percent (10%) of the initial flow from the area. Most of the current inflow into the mine workings is from areas where water storage has not been depleted. After the storage has been depleted, the flow will reduce to roughly equal the recharge rate which is expected to be less than ten percent (10%) (data presented earlier in this report) of the current discharge rate.

Post mining discharge from the North Rilda Area ~~is~~ was not anticipated due to the limited extent of the groundwater resources. As discussed in section 721: GENERAL REQUIREMENTS - EXISTING GROUNDWATER RESOURCES: PERMIT AND ADJACENT AREA GROUNDWATER CHARACTERISTICS groundwater resources in the the North Rilda Area ~~is~~ are limited due to several factors including; stratigraphic controls, limited surface area for infiltration, topographic configuration of the area (incised canyons), and outcropping of the Star Point Sandstone Formation around the entire North Rilda Ridge. Mining conditions encountered in the North Rilda Ridge area were generally dry, and there is no flow from the area. Measures taken during the underground mine closure will prevent any flows into this area. ~~If intercepted perched aquifers are encountered in the North Rilda Area, water will migrate downdip to the south/southeast, (refer to Volume 8 - Geologic Section of the Deer Creek MRP for structual contour maps of the Blind Canyon and Hiawatha seams). If the impounded water exceeds the capacity of the abandoned workings, water from the North Rilda Area will migrate to the northern portion of 3rd North and eventually flow to the south/southwest.~~

R645-301-729 Cumulative Hydrologic Impact Assessment (CHIA)

The Division provides an assessment of the probable cumulative hydrologic impacts of the coal mining and reclamation operation and all anticipated coal mining and reclamation operations upon surface and groundwater systems in the cumulative impact area. The CHIA can be reviewed at the Division's offices in Salt Lake City.

R645-301-730 OPERATION PLAN

Water Monitoring Location Map: refer to Volume 9 - Hydrologic Section: Map HM-1.

has occurred in the Hiawatha coal seam or the Starpoint Sandstone just beneath it. During the development of the Rilda Canyon Portal Facilities two separate surface breakouts were constructed; 1) Mine Fan; and 2) Intake Access (refer to R645-301-500 Engineering Section). Both portals were developed from underground as rocks slopes developed through the upper member of the Star Point Sandstone (Spring Canyon Member). The slopes extend from the portal facility area to an interception point in the Hiawatha Coal Seam. ~~Inclination (dip) of the Hiawatha seam prevents water from discharging at the portal facilities.~~ No groundwater ~~is~~ was intercepted during the development of the intake rock slope therefore, the portal area itself will be dry post-closure. ~~and no post mining gravity discharge from the Rilda Portal is expected.~~

R645-301-731.530 State-appropriated Water Supply

PacifiCorp will promptly replace any State-appropriated water supply that is contaminated, diminished or interrupted by UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES conducted after October 24, 1992, if the affected water supply was in existence before the date the Division received the permit application for the activities causing the loss, contamination or interruption. The baseline hydrologic and geologic information required in R645-301-700 will be used to determine the impact of mining activities upon the water supply.

R645-301-731.600 Stream Buffer Zones

Mining related activities will not occur within 100 feet of a perennial or intermittent stream unless the Division authorizes such activities.

As mentioned in the PROBABLE HYDROLOGIC CONSEQUENCES DETERMINATION section, (728: Hydrologic Balance - Surface Water System), the drainages conveying runoff away from the mine plan areas are streams in Rilda, and Mill Fork canyons. Second mining (ie. longwall extraction, room & pillar, of the North Rilda area) will be limited to the ridge separating Rilda and Mill Fork canyons and subsidence will not occur beneath the stream channels of these canyons. First mining (ie. mainline, gateroad development) will occur below the right fork of Rilda Canyon. For a complete analysis of the proposed "no subsidence" design of the 4/5th North Mains development within the Right Fork of Rilda and the long-term stability analysis, refer to the Volume 11 Appendix Volume - Engineering: Appendix A. To protect the alluvial/colluvial system of the Right Fork of Right Fork of Rilda Canyon, a stream buffer zone was established based on the extent of the riparian zone and the angle of draw from the Hiawatha Seam, the lowest seam to be mined. The riparian zone within the right fork of Rilda Canyon was delineated by field observation, aerial photography, and map contour analysis. The extent of the identified zone is based on the contact of the alluvial/colluvial fill with the canyon's side slopes. The angle of draw was calculated from the Hiawatha Seam horizon/elevation @ 15 degrees to the point of intersection on the surface. The stream buffer zone delineates the area restricted from full extraction mining. The referenced 15 degree angle of draw is an industry/agency accepted standard used for

R645-301-412 Reclamation Plan

In areas where surface disturbances result from coal mining and reclamation operations, regrading and revegetation will be conducted to restore the areas to their premining conditions which they were capable of supporting prior to mining. Because such a small surface disturbance is planned for the North Rilda Area, little or no effect to the past or future land use is anticipated. The land will be reclaimed to the original land use practices of grazing and wildlife habitats.

A detailed reclamation plan has been developed for the ~~North~~ Rilda Canyon Portal Facilities area and included in Section R645-301-200 thru R645-301-700 of this volume. The reclamation plan for the Left Fork Fan Facilities is found in Volume 2, Chapter R645-301-500: Engineering, Appendix R645-301-500-B.

R645-301-412.300 Suitability and Compatibility

The reclamation soil sampling will identify any soil that is not suitable. All unsuitable soils will be placed at least 4 feet below the final grade surface. This will ensure suitable growth material for vegetation. All fills will be graded at slopes compatible with the surrounding areas.

R645-301-413 Performance Standards

All disturbed areas will be restored in a timely manner to conditions they were capable of supporting before mining. Liability will be for the duration of the coal mining and reclamation operations and for the period of extended responsibility for achieving successful revegetation. All post mining land use criteria will be satisfied before the bond is fully released.

R645-301-413.100 Post-mining Land Use

The post-mining land uses of the North Rilda Portal Area are dictated by its pre-mining uses which include Fish and Wildlife Habitat, Grazing, and Recreation. However, at closure of the Rilda Canyon Portal Facility, the permittee will add Industrial/Commercial to the list as an alternative post-mining land use.

At closure, PacifiCorp is proposing to install mine discharge water drainage lines in each of the two portals of the Rilda Canyon Portal Facility. The discharge line from each portal will tee into a 8" HDPE line that will transfer water through the disturbed area (refer to Plate 400-1)). The line will be buried and final reclamation will be conducted to the surface over the line. As shown on Plate 400-1, an inspection vault will be placed within the disturbed area where flow and quality of the discharging water can be monitored.

From the boundary of the disturbed area, PacifiCorp's Huntington Power Plant will collect the water for use in its power plant operations. The Huntington Plant will extend the buried line down Rilda Canyon to Huntington Canyon. The 8" HDPE line will pass across State Highway 31 to the North and East side of the highway. The trenched line will be constructed parallel to Hwy 31 within its ROW to a point near the Huntington Power Plant. The line will again be trenched under Hwy 31 and routed to the Huntington Plant's sediment pond where the line will terminate.

Reclamation of the small area of disturbance at the Rilda Canyon Portal Facility to comply with the postmining land use will take place soon after closure of the facilities. Because of the small area needing to be reclaimed, the process can take place in one construction season. Vegetation performance standards will be met by comparison to undisturbed vegetation reference areas.

R645-301-420 AIR QUALITY

Air pollution control measures are described in the "Approval Order DAQE-AN0239003-02" issued by the Division of Air Quality. This order has conditions that the operator must comply with to reduce emissions that may affect the air quality. Because processing or coal transport will not be conducted at the Rilda Canyon Portal Facilities, the controlled emissions will only include fugitive dust emissions. Those emissions will be controlled by typical dust suppressant measures. The Division of Air Quality requires that the Approval Order be in place and complied with by the operator for the life of the facilities operation. Periodic inspections, by the Division of Air Quality, are conducted at the site to verify compliance. This air quality Approval Order is filed at the Energy West Mining offices in Huntington, Utah.

Some of the dust suppressant measures typically taken are: asphalt surfaces, wetting or sweeping of surfaces, restricted speeds for vehicular traffic, limitations for travel on service roads.

All areas adjacent to roads or travelways have been planted for revegetation. Reseeding is repeated until vegetation is adequately established. Revegetation has been applied on all disturbed surfaces and regraded areas.

R645-301-421 Clean Air Act

Coal mining and reclamation operations will be conducted in compliance with the requirements of the Clean Air Act (42 U.S.C. Sec. 7401 et seq.) and any other applicable Utah or federal statutes and regulations containing air quality standards.

R645-301-422 Utah Division of Air Quality

The operator has coordinated compliance efforts with the State of Utah, Division of Air Quality. The current Approval Order (AO) issued to the operator is DAQE-AN0239003-02 and is dated June 14, 2002. Refer to R645-301-420.

R645-301-700 HYDROLOGIC SECTION

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

LIST OF REFERENCES

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R645-301-700: HYDROLOGY

R645-301-710. INTRODUCTION

This application provides a detailed description of the hydrology, including groundwater and surface water quality and quantity, of the land within the Mill Fork ~~State Lease~~ Area (including UTU-88554/UTU-84285 and adjacent areas (refer to Figure MFHF-1)). The Mill Fork ~~Lease (ML-48258)~~ Area consists of approximately 5,563 acres (UTU-88554 - 5522.8 acres, UTU-84285 - 213.57 acres) located northwest of the existing Deer Creek Mine workings.

Detailed data on the hydrology of the land within the ~~permit~~ Mill Fork Area and surrounding area have been collected, compiled, and analyzed by PacifiCorp, hydrologic consultants and several government agencies. Information collected by PacifiCorp is the result of exploratory drilling, field investigations, geologic mapping, aerial photography, spring surveys, groundwater tests, monitoring of numerous wells and stream stations, climatological monitoring, and investigations by independent consultants.

PacifiCorp has a policy of close cooperation with many agencies and has invited, encouraged, and permitted numerous agencies to conduct investigations and experiments within and adjacent to the ~~permit~~ Mill Fork Area. The resulting information produced by these investigations is quite extensive and has been utilized throughout this application.

R645-301-711. GENERAL REQUIREMENTS

711.100 Existing hydrologic resources as given under R645-301-720

711.200 Proposed operations and potential impacts to the hydrologic balance as given under R645-301-730

711.300 The methods and calculations utilized to achieve compliance with hydrologic design criteria and plans given under R645-301-740

711.400 Applicable hydrologic performance standards as given under R645-301-750

711.500 Reclamation activities as given under R645-301-750

R645-301-712. CERTIFICATION

All cross sections, maps, and plans required by R645-301-722 as appropriate and R645-301-731.700 will be prepared and certified according to R645-301-512.

R645-301-713. INSPECTION

No impoundments are planned for the Mill Fork Area.

R645-301-720. ENVIRONMENTAL DESCRIPTION

R645-301-721. GENERAL REQUIREMENTS

The existing pre-mining hydrologic resources of the East Mountain - Mill Fork Area are subdivided into the following sections.

A. Existing Groundwater Resources

1. Regional and ~~Permit~~ Mine Area Groundwater Hydrology
2. Regional and ~~Permit~~ Mine Area Geology
3. Regional and ~~Permit~~ Mine Area Groundwater Characteristics
4. Springs and Seeps
5. Groundwater Quality

6. Chemical Evolution of Groundwater
7. Solute and Isotope Chemistry
8. Active and Inactive Groundwater Zones
9. Mine Dewatering
10. Groundwater Rights and Users
11. North Emery Water Users ~~Association~~ Special Services District (NEWU~~A~~SSD)
12. Castle Valley Special Service District (CVSSD)
    Little Bear Springs

B. Existing Surface Resources

1. Regional and ~~Permit~~ Mine Area Surface Water Hydrology
2. Surface Water Quality
3. Soil Loss and Sediment Yield

A. EXISTING GROUNDWATER RESOURCES

1. Regional Groundwater Hydrology

The characteristics and usefulness of a groundwater resource are dependent upon the geology of the water bearing strata and on the geology and hydrology of the recharge area. Groundwater movement and storage characteristics are dependent on the characteristics of the substratum. To facilitate an understanding of groundwater of the Mill Fork Area, a discussion of pertinent regional geologic features is presented below.

2. Regional Geology

The Mill Fork Area is located in the central portion of the Wasatch Plateau Coal Field in Emery County, Utah. Generally, this area is a flat-topped mesa surrounded by heavily vegetated slopes which extend to precipitous cliffs dropping steeply to the valley below. Relief of up to 5,000 feet is measured from Castle Valley lowland to the plateau above. The following discussion summarizes the structural geology and stratigraphy of the region and the ~~permit~~ mining areas located within the Mill Fork Area.

The regional geology of the Colorado Plateau in which the Wasatch Plateau coal field is situated is fairly simple. Sedimentary rocks have been accumulating in this region since Permian time. A broad, high, flat region that encompasses southeastern Utah, southwestern Colorado, northwestern New Mexico, and northern Arizona, the Colorado Plateau has been an area of relative stability while mountain-building episodes have occurred in surrounding regions. The thick accumulations of sedimentary rocks in this region are being deeply dissected by erosion, leaving the most recent coal reserves in the higher plateaus, where they are now being mined. The ~~Energy West permit~~ PacifiCorp mining area covers portions of East Mountain and Trail Mountain, which are separated by Cottonwood Canyon, a deep, partially glaciated valley.

The geologic formations exposed in the ~~Energy West permit~~PacifiCorp mining area range from Upper Cretaceous (100 million years old) to Tertiary and Recent in age. These formations, in ascending order from oldest to youngest, are the Masuk Shale member of the Mancos Shale, the Star Point Sandstone, the Blackhawk Formation, the Castlegate Sandstone, the Upper Price River Formation (all Cretaceous), and the North Horn Formation, and the Flagstaff Limestone (Tertiary). The coal deposits are restricted to the lower portion of the Blackhawk Formation, about 2,500 feet below the top of the Plateau. Recent geologic deposits include numerous stream terrace gravels along streams and rivers, glacial till deposits in the upper reaches of Cottonwood Canyon, and alluvial and colluvial fills in all of the significant drainages.

The Masuk Shale is the upper member of the Mancos Shale and consists of light to medium gray marine mudstones. The marine Masuk Member of the Mancos Shale was deposited in an open marine environment (Mayo and Peterson, 2001). The Masuk Member is a highly erodeable calcareous, gypsiferous, and carbonaceous dark gray colored shale. It is continuously exposed along the eastern edge of the Wasatch Plateau, but is not exposed in the Mill Fork ~~permit~~ Area. The Masuk Member is approximately 1,300 feet thick. Westward thinning wedges of the Masuk inter-finger with tongues of the Star Point Sandstone. Usually this formation weathers readily, forming slopes which are often covered by debris. It is generally devoid of water.

Overlying and intertonguing with the Masuk Shale is the Star Point Sandstone. In the East Mountain area the Star Point Sandstone consists of three or more massive sandstones totaling about 400 feet in thickness.

The Star Point Sandstone forms massive cliffs where exposed at the surface. The sandstone was deposited as seaward thinning (east), marine, shoreface blanket sands that are laterally continuous (Mayo and Peterson, 2001). Landward (west), these sandstones terminate abruptly into the mud- and organic-rich backshore facies (Van Wagoner and others, 1990). Because many of the organic-rich facies are now mineable quality coal, locally the Star Point Sandstone has immediate contact with coal seams. Elsewhere sandstone bodies of the Star Point Sandstone are overlain and underlain by lower shoreface and open marine shales of the Mancos Formation. What this means is that the marine shoreface sandstones are three dimensionally encased by low-permeability marine shales and fine-grained carbonaceous backshore coal-bearing facies (Mayo and Peterson, 2001).

The Star Point Sandstone thins eastward and merges with the underlying Masuk Member of the Mancos Shale. Three prominent tongues of the Star Point Sandstone inter-finger with the Mancos Shale. These three sandstone members, from top to bottom, are the

Spring Canyon, Storrs, and Panther Sandstones (refer to Figure 6, Mayo & Associates report in Appendix B). In the Mill Fork ~~permit~~ Area, the Spring Canyon tongue is approximately 100 feet thick, lies about 80 feet above the Storrs tongue, and consists of massive, fine- to medium-grained sandstone. The Storrs tongue lies about 120 feet above the Panther tongue and consists of 50 feet of soft, friable sandstone. The basal Panther tongue is approximately 100 feet thick and consists of massive, cross-bedded delta front sandstones Mayo and Peterson, 2001).

Even though the Star Point ~~Formation~~ Sandstone exists throughout the entire East Mountain property, the low permeability and lack of recharge limit its usefulness as a water producing aquifer. Permeability and the limiting factors of recharge, i.e., very little outcrop exposure and limited vertical groundwater migration caused by the mudstone layers of the North Horn and Blackhawk formations, will be discussed in detail in the section entitled REGIONAL GROUNDWATER CHARACTERISTICS. Locally, the Star Point Sandstone exhibits aquifer characteristics. These are isolated occurrences where regional faults have created secondary permeability and have been intersected by major canyons with perennial streams. An example is Little Bear spring located in Huntington Canyon.

The Blackhawk Formation consists of alternating mudstones, siltstones, sandstones, and coal. Although coal is generally found throughout the Blackhawk Formation, the economic seams are restricted to the lower 150 feet of the formation. The total thickness of the Blackhawk Formation in the East Mountain area is about 750 feet.

The upper portion of the Blackhawk Formation was deposited in an alluvial-plain/suspended-load fluvial channel environment (Mayo and Peterson, 2001). In these delta and flood-plain environments layers of mud are more abundant than channel sands. Sandstone channels are generally isolated from each other both laterally and vertically by mud-rich overbank and inter-fluvial rocks (Galloway, 1977). The upper portion of the Blackhawk Formation also contains some thin carbonaceous shale layers and thin coal seams that are not of economic interest.

The lower portion of the Blackhawk Formation contains the mineable coal deposits and consists of more thinly bedded sandstone and shale layers (Johnson, 1978). The coal-bearing units of the lower Blackhawk Formation overlie and are laterally juxtaposed to marine shoreface sandstones of the Blackhawk Formation and Star Point Sandstone (Mayo and Peterson, 2001). On a large scale, these sandstone bodies are laterally continuous but terminate abruptly into the mud- and organic-rich backshore faces in a landward direction (Van Wagoner and others, 1990). However, individual rock layers are lenticular and discontinuous, with abundant shaley interbeds. The fine to medium grained sandstones occur as thin- to massively-bedded paleochannel deposits. The paleochannels increase in frequency, thickness, and lateral extent upward in the formation. There is also a vertical repetition of erosional scours within the upper sandstones (Marley, 1979).

The Castlegate Sandstone , the lower member of the Price River Formation, generally caps the escarpment which surrounds the eastern limit of the property. The Castlegate Sandstone consists of approximately 250 to 350 feet of coarse-grained, light gray, fluvial sandstones; pebble conglomerates; and subordinate zones of mudstones.

The formation was deposited from bed-load fluvial channel systems (Appendix B Figure 8; Chan and Pfaff, 1991). The Castlegate Sandstone is made up of coarse-grained, often conglomeratic, fluvial sandstone. Thin interbeds of siltstone and claystone occur in lower portion the formation. Sandstone dominates over mudstone and individual sand channels may be thin, wide, or interpenetrating. Although the primary porosity is high, the existence of mudstone drapes and pervasive carbonate and silica cement greatly reduces the overall porosity (Mayo and Peterson, 2001, Appendix B).

The Upper Price River Formation, which overlies the Castlegate Sandstone, is about 350 feet thick and forms steep slopes which extend upward from the Castlegate Sandstone.

The Price River Formation was deposited from mixed-load fluvial channel systems that have sandstone/mudstone ratios intermediate between bed-load and suspended-load channel systems (Mayo and Peterson, 2001, Appendix B). Sandstones and mudstones occur in about equal proportions. Point bars that develop in this type of system are larger than those in suspended-load channel systems. Mudstone drapes created during low flow stages of the active fluvial system separate the sandstones from each other both horizontally and vertically (Mayo and Peterson, 2001, Appendix B).

The North Horn Formation forms the cap rock for much of East and Trail mountains where the Flagstaff Limestone has been eroded away. Mudstones dominate the rock types present and are generally gray, light brown, to purple in color. Localized, lenticular sandstone channels are present throughout the formation. The sandstone beds are more common near the upper and lower contacts of the formation. The North Horn Formation is approximately 850 to 1,000 feet thick in the Mill Fork Area.

The North Horn Formation was deposited in an alluvial-plain/suspended-load fluvial channel environment (Mayo and Peterson, 2001, Appendix B). In such environments layers of mud are more abundant than sands, which occur in sandstone channels. The sandstone channels are generally isolated from each other, both laterally and vertically, by mud-rich overbank and inter-fluvial rocks (refer to reference list in Appendix B: Galloway, 1977). In the study area the formation consists primarily of shale with discontinuous sandstone channels, minor lenses of limestone, and conglomerate. Highly bentonitic mudstones, which swell when wetted, are common in the lower two-thirds of the formation.

The Flagstaff Limestone caps the uppermost portions of East Mountain is the youngest formation exposed in the Mill Fork ~~permit~~ Area. It typically forms small exposures on top of the plateau (refer to Geologic Section, Geologic Formation Map). A thickness of 105 feet was measured on Trail Mountain immediately south of the study area (refer to reference list in Appendix B: Davis and Doelling, 1977). Maximum thickness in the Mill Fork ~~permit~~ Area is approximately 80-100 feet.

The Flagstaff Limestone consists of carbonates, marls, and some thin sandstone stringers deposited in lacustrine, marginal lacustrine, and alluvial plain depositional environments (refer to reference list in Appendix B: Garner and Morris, 1996). It primarily consists of light- to medium-gray colored limestone containing abundant secondary fractures produced during uplift and subaerial exposure (Mayo and Peterson, 2001, Appendix B).

3. Regional Groundwater Characteristics

Waters entering the groundwater system are mostly from snow melt. The amount of water which enters the groundwater system is highly variable from one site to another. The low surface relief on the top of East Mountain encourages the infiltration of melting snow. Conversely, the many areas with steep slopes have a much more limited infiltration opportunity. All of the geologic formations which surface in the area have relatively low permeability which further reduces the amount of water entering the groundwater system. Probably less than five percent of the annual precipitation recharges the groundwater supply (Price and Arnow, 1974; U. S. Geological Survey, 1979).

Geology controls the movement of groundwater. Because of the low permeability of the consolidated sedimentary rocks in the East Mountain area, groundwater movement is primarily "through fractures, through openings between beds, and, in the case of the Flagstaff Limestone, through solution openings" (Danielson et al., 1981, p. 25).

The majority of the groundwater which infiltrates the Flagstaff Limestone flows down vertical fractures which intersect sandstone channel systems in the North Horn Formation. The majority of the groundwater reaching this point intersects the surface in springs located in the North Horn Formation. Very little recharge intersects the Price River Formation and Castlegate Sandstone; consequently, they are not water saturated where intersected in the numerous drill holes penetrating those units. The remaining water then flows downdip (to the southeast) from the northern reaches of East Mountain until it discharges in the form of springs.

Data have been collected from numerous coal exploration drill holes, from within the adjacent mine workings, from surface drainages, and from the springs in the area. The data have identified two separate isolated aquifer systems on the East Mountain property; the first is localized perched water tables in the North Horn and the Price River formations, and the second is a combination of localized perched water tables in the Blackhawk Formation and the Star Point Sandstone which exhibits some limited potential as a regional aquifer. Stratigraphy is the main controlling factor restricting groundwater movement and development of regional and perched aquifer systems within the East Mountain property. The following is a description of the various formations and how they influence the groundwater systems. The description is in descending order, which parallels the general groundwater flow (refer to Figure MFHF-3).

Flagstaff Limestone

This formation displays a strong joint pattern which permits good groundwater movement both vertically and horizontally through the formation. Exposures of the Flagstaff Limestone ~~is~~ are limited to a narrow north-south trending ridge located in the western half of the Mill Fork ~~permit~~ Area.

a. North Horn Formation

This formation is comprised of a variety of rock types which range from highly calcareous sandstone to mudstone. Its permeability is variable.

Lenticular sandstone channels are oftentimes present in the upper and lower portions of the formation. Water which percolates down fractures from the overlying Flagstaff Limestone works its way into the sandstones, forming the perched water tables. The actual lateral extent, or correlation, between the perched water tables has not been identified; and it is not practical to do so because the tables are limited in extent and variable in stratigraphic location. Many springs have been identified where the sandstone channels intersect the land surface.

The lower two thirds (upper Cretaceous in age) of the formation is generally highly bentonitic mudstone which is impermeable. It is likely that this material is acting as an aquiclude, preventing adequate recharge from reaching the Upper Price River Formation or Castlegate Sandstone below (bentonitic mudstone will be discussed in detail in the PHC.) The mudstones present swell when they come in contact with water. Therefore, vertical migration of water along fractures through this material is limited because the fractures are sealed by the swelling clays.

The depth of the aquifers in the North Horn Formation is variable due to the rugged topography. The localized perched water tables may either intersect the surface of the ground or be covered by as much as 1,000 feet of overburden. They are located at least 1,400 feet above the coal seam to be mined. Communication of water between the perched aquifers in the North Horn Formation and the water flowing into the mine is limited in quantity and occurs very slowly. The monitoring of the numerous springs located on East Mountain gives PacifiCorp the ability to assess any effects that mining might have on the North Horn Formation perched aquifers.

With the data available it is not possible to compile a piezometric map of the waterbearing strata in the North Horn Formation because the channels are discontinuous and not interconnected.

b. Upper Price River Formation

The Upper Price River Formation is comprised predominantly of sandstone but commonly contains mudstone beds between the point bar deposits. It is generally devoid of water because it lacks adequate recharge.

c. Castlegate Sandstone

The formation is thought to be fairly permeable but, where it has been intersected by drill holes, has never been found to be water saturated. It is often dry or slightly damp in some zones. It is devoid of significant water because it lacks adequate recharge.

d. Blackhawk Formation

The Blackhawk Formation contains only perched or limited aquifers which exist within the strata overlying the coal seams and the upper portion of the Star Point Sandstone Formation. The perched aquifers exist as fluvial channels (ancient river systems) which overlie and scour into the underlying strata (refer to Volume 9 Hydrologic Section Maps HM2 and HM3 for examples of mapped channels systems within the adjacent Cottonwood and Deer Creek mines). Channel systems were part of a deltaic depositional setting active during and after the coal forming peat accumulation. The largest influx of water encountered during the mining process occurs beneath the fluvial channels. The sandstone channels are mainly composed of a fine to medium grained sand with similar characteristics to the Star Point Sandstone Formation. The semi-permeable and porous nature of the channels allows an effective route for water transport. Other constituents of the Blackhawk Formation (i.e., non-permeable mudstone, carbonaceous mudstone, coal seams, and inter-bedded mudstones/siltstones and sandstones) generally act as aquicludes which impede vertical groundwater flow to the lower stratigraphic units. In areas other than where faulting and fracturing have created secondary permeability, the migration of water from the perched aquifers-sandstone channel systems of the Blackhawk Formation to the Star Point Sandstone Formation is limited. Extensive mining in the Cottonwood/Wilberg complex, which produces coal from the Hiawatha seam, is stratigraphically located directly on top of the upper member of the Star Point ~~Formation~~ Sandstone. Only minor quantities of groundwater have been produced from the Star Point Sandstone ~~Formation~~. The coal seams of the Blackhawk Formation are effective in impeding vertical groundwater movement. In many areas in the adjacent mines where roof coal was left in place because of abundant thickness or as an additional effort to support the immediate roof, production of groundwater occurred only when roof support was installed or when a roof failure occurred exposing the overlying sandstone channel systems. Listed below are hydrologic characteristics of individual rock types reported by the USGS, Open File 84067.

Lithology: Sh, shale; Slt, siltstone; Ss, sandstone; f, fine grained; m, medium grained.
Hydraulic Conductivity: I, impermeable to water even at pressures of 5,000 pounds per square inch (psi).

				Hydraulic Conductivity (feet per day)	
Geologic Unit	Lithology	Depth below land surface	Porosity %	Horizontal	Vertical
Blackhawk	Ss, f	1,521	14	$1.5x10^{-2}$	3.7x10-3
Formation	Slt	1,545	3	$9.3x10^{-8}$	1.2x10-7
	Sh	1,786	2	I	I
	Ss, f	1,792	14	$1.1x10^{-2}$	3.9x10-3
	Sh	2,170	4	$1.1x10^{-8}$	---
	Slt	2,265	2	$2.0x10^{-7}$	2.2x10-6
Star Point	Ss, m	2,466	17	3.1x10-2	1.1x10-2
Sandstone	Ss,	2,493	11	1.5x10-2	6.6x10-3

In the adjacent Cottonwood and Deer Creek mines, the majority of the water flowing into the mines comes from within the limited fluvial channel aquifers; however, water is also transmitted into the mine workings by way of faults, joints or fractures, and in-mine drill holes. Historical monitoring locations in the Deer Creek Mine are shown on Map HM2, in the Wilberg/Cottonwood Mine on Map HM3 (refer to Volume 9 Hydrologic Section). Many locations within the mines have been monitored in the past, but a limited number of accessible long term water monitoring locations now exists because most water-producing areas of the mines are dewatered and stop flowing shortly after initial mining in the area.

In several locations in the Deer Creek and Wilberg/Cottonwood mines, such as retreated longwall panels, water is being produced but cannot be measured because the workings are inaccessible. The water entering these areas flows into numerous low areas in the mine which act as temporary sumps. The water is then pumped to the main sump located near the mine portal. Because the pumping system in the mine is ever changing (i.e., portable pumps being moved to various locations within the mine as the need arises), it is not possible to collect meaningful data from specific areas of the mine that can be compared with data collected from years or even months past.

Based on data from the adjacent mines, several observations have been made concerning the Blackhawk water-bearing strata. The sandstone, which is semi-permeable and porous, affords an effective route of water transport; while relatively impervious shale in the Blackhawk Formation prevents significant downward movement of the percolating water. Of the water-producing areas, those closest to the active mining face exhibit the greatest flows. As mining advances the area adjacent to the active face continues to be excessively wet, and previously mined wet areas experience a decrease in flow. It appears that the water source is being dewatered since mined out areas of the mine do not continue to produce water indefinitely. The water source must be either of limited extent, e.g., a perched aquifer, or have a limited recharge capacity. In an attempt to quantitatively evaluate saturated sandstone channels, a dripping channel in the 6th West area of the Deer Creek Mine was investigated (site 6W X 20; Figure 10, refer to Mayo & Associates report, Volume 9 Hydrologic Section: Hydrologic Support Information No. 11). The channel, located near a minor fault with very limited displacement, has the dimensions of >2,000 feet in length, 150 feet in width and a maximum thickness of 25 feet. An array of uphole monitoring wells was installed across the width of the channel. The wells were 15 to 25 feet deep and were open along their entire depth. Each well was equipped with a shutoff valve and pressure gauge. The idea was to conduct a pump test by letting selected wells gravity drain and simultaneously measuring pressure change in nearby wells. Because a maximum of about 2 psi was recorded in the well (i.e. (5 feet of water) we were unable to conduct the test. What the well did demonstrate was that the sandstone channel was not fully saturated and it was a perched, unconfined groundwater system.

Although much of the water transfer within the Blackhawk Formation is through fractures or faults, data indicate that recharge to the Blackhawk is limited because of the above confining formations and many of the fractures become sealed by swelling bentonitic clays which stop or limit the water transfer, confirmation of which exists along the numerous faults and fractures over the area. A measurable flow of water along a fault existed at only one location in the Wilberg/Cottonwood Mine - along the Pleasant Valley Fault in Main West, Wilberg. This location produced an estimated average flow of 5 gpm from the time it was encountered to 1980 when the flow stopped. The fractures sealed readily because of the ability of the shaley layers to swell and decompose to form an impervious clay, preventing significant downward percolation, collection, or conveyance of water along faults in the Blackhawk Formation.

Significant quantities of groundwater were also encountered in the Deer Creek Mine, 4th South area, where development entries intersected fractures/faults associated with the Roans Canyon Fault system. As with other areas where groundwater has been intercepted, the flow from the 4th South/2nd Right area has decreased rapidly, from approximately 2000 gpm in March 1990 to approximately 120 gpm in December 1990. Exploratory drilling was utilized in the development entries to locate and map the extent of the water producing fracture. The water producing zone was isolated utilizing an inflatable packer and a pressure gauge was installed to monitor the head differential. Pressure readings recorded were similar to those of Roans Canyon Fault crossing at 3rd North, with readings varying from 80-90 pounds per inch. This calculates out to approximately 200 feet of head. The amount of overburden in the area where the water producing fracture was encountered is approximately 1800-2000 feet. In reviewing the dewatering curve and the initial head differential, groundwater produced from the interception of the water producing fracture was a function of storage and recharge to the fault is limited. To monitor the potential impact of mine dewatering, PacifiCorp installed a series of wells in both the Deer Creek and Cottonwood/Wilberg mines (refer to Volume 9 Hydrologic Section Maps HM-2 and HM-3). These wells were incorporated in the hydrologic monitoring program in 1989. Well development information was detailed in the 1989 Annual Hydrologic Monitoring Report and in Volume 9 - Hydrologic Support Information).

Only the wells in the Deer Creek Mine along the axis of the Straight Canyon Syncline revealed a change which could possibly be related to mine dewatering. In addition to the in-mine monitoring PacifiCorp installed a series of surface wells to monitor the potential impacts in Cottonwood Canyon located to the south of Mill Fork and in Rilda Canyon located to the east of Mill Fork. To evaluate the effects on the surface springs and surface drainage systems PacifiCorp maintains an extensive monitoring program. Data collected will be reported annually in the Hydrologic Monitoring reports.

Long-term water producing areas do exist within the current mine workings. Four types of occurrences have been recognized and will be monitored by the applicant (refer to Volume 9 Hydrologic Section: Figure HF4) and include 1) structural rolls with overlying fluvial channels, 2) Pleasant Valley and Roans Canyon Fault systems, 3) fractures and joints (lineaments), and 4) surface and in-mine drill holes.

e. Star Point Sandstone

The Star Point Sandstone overlies and inter-tongues with the Masuk Shale. The formation is approximately 350 to 400 feet in thickness and consists of at least three upward coarsening sandstone units. Mudstone units of the Masuk Shale are present above the lower two sandstone members of the Star Point Sandstone due to the inter-fingering nature of the contact between the two units.

The Star Point Sandstone, which immediately underlies the Hiawatha Coal Seam, exhibits some characteristics of an aquifer but experiences little recharge. Studies conducted by the USGS indicate that the Star Point Sandstone is of low permeability, thus limiting its usefulness as a water-producing aquifer. Most of the water discharge from the Star Point Sandstone is where it has been intersected by the major canyons in the plateau or where faulting has caused secondary permeability. This, plus the fact that the Star Point Sandstone is only slightly to moderately permeable, allows only limited flow of groundwater through the formation. Drill holes completed in the Deer Creek, Wilberg/Cottonwood and Genwal mines have defined the piezometric gradient in the lower Blackhawk/Star Point Sandstone system in isolated areas and confirmed the groundwater flow conforms with the topographic relief and structural features, i.e., regional dip, Straight Canyon Syncline, and regional faulting (refer to Volume 9, figures HF-5A and HF-5B for gradient information related to

Deer Creek and Wilberg/Cottonwood mines and figure MFHF-6 for potentiometric gradient data for the Spring Canyon Member of the Star Point Sandstone for the Mill Fork Area).

The overall pattern of groundwater flow and surface water-groundwater interactions in the Mill Fork ~~permit~~ Area and adjacent areas can be described by a fairly simple conceptual model involving both active and inactive groundwater flow regimes (Mayo and Morris, 2000 Appendix B). The model is illustrated in Appendix B Figure 27. Inactive zone groundwater systems contain old groundwater (i.e. 2,000 to 19,000 radiocarbon years, Appendix B Table 5), have very limited hydraulic communication with the surface and with other active groundwater flow systems, and are not influenced by either annual recharge events or short term climatic variability as evidenced by the decline in roof drip rates (Appendix B Figure 15) and lack of fluctuations of in-mine monitoring wells.

Solute chemistry in the Spring Canyon Member is not uniform beneath existing mines suggesting that there is a partitioning of groundwater systems in the member (refer to Appendix B - Mill Fork Hydrologic Investigation). This condition is likely the result of inter-bedded lower-permeability layers in the Star Point Sandstone which partition individual sandstone bodies. These findings are substantiated by monitoring well data from 6 wells in the Trail and East Mountain areas (Appendix B Section 7.3) and are significant in that they strongly suggest that the Spring Canyon Member does not act as a single regionally continuous aquifer, but rather it supports a series of smaller, discrete groundwater systems.

Water in most of the Blackhawk/Star Point aquifer is confined under pressure between shale and siltstone beds within the aquifer (USGS, Lines, Open File Report 84067). Water is released from storage from confined aquifers mainly by compression of the sandstones and less permeable, confining beds as pressure in the aquifer declines. The quantity of water that can be released from storage is dependent on the storage coefficient, which is about $1x10^{-6}$ per foot of thickness for most confined aquifers (USGS Lines, Open File Report 84067). Data collected by PacifiCorp on the Roans Canyon Fault System in 1988, 3rd North fault crossing, confirmed the USGS storage coefficient estimations, with values ranging from $1.6x10^{-4}$ to $7.0x10^{-6}$. Transmissivity values computed for pump tests conducted by the USGS on Trail Mountain on ~~nonfully~~ semi-penetrating wells in the Blackhawk/Star Point aquifer ranged from 0.7 to 100 ft^2 /day with a majority of the two results ranging from 1 to 10 ft^2 /day. The computed transmissivity of 100 ft^2 /day was greater than the laboratory data (listed early in this section) and was believed to be due to secondary permeability in the form of fractures. Transmissivity results ranging from 0.7 to 10 ft^2 /day are indicative of the low permeability rock in most of the Cretaceous and Tertiary strata within the Wasatch Plateau.

f. Structural Hydrologic Features

Several important structural features, the Straight Canyon Syncline, Flat Canyon Anticline and Huntington Anticline, the Roans Canyon Fault Graben, Mill Fork Fault Graben, Left Fork Fault Graben, Pleasant Valley Fault, and the Deer Creek Fault, have been identified adjacent to and within the Mill Fork ~~permit~~ Area (refer to Hydrologic Map MFS1830D).

Folding:

Strata in the Mill Fork area are gently folded in two broad structural features. The Flat Canyon Anticline crosses the southeastern portion of the ~~permit~~ lease area (refer to Hydrologic Map MFS1830D). This anticline trends southwest to northeast, and plunges to the southwest. Dips in the anticline range from two to six degrees with the south limb dipping the steepest.

To the north, the north limb of the Flat Canyon Anticline becomes the south limb of the Crandall Canyon Syncline, a flat-bottomed syncline. This syncline also trends southwest to northeast. Dips on the northwest side are much steeper than on the southeast side.

Faulting:

The only known fault within the Mill Fork ~~permit~~ Area is the Joes Valley Fault, which forms the western limit of the coal reserves in this ~~permit~~ area. The Joes Valley Fault is the largest and most prominent of several north south trending fault zones within the Wasatch Plateau coal field. Displacement of the fault is approximately 1,500 feet, downthrown on the western side. The fault creates a continuous north-south escarpment on the east side of Joes Valley. Several side canyons are cut into this escarpment on the western side of the ~~permit~~ lease area, all of which drain into Joes Valley. The fault zone itself is not visible along this escarpment, but the fault has been intercepted underground in the Genwal Mine to the north.

Where the fault has been intercepted in the Genwal mine workings, a drag fold is present, indicated by a gentle downward folding of the strata along the fault zone, extending for a few hundred feet to the east of the fault.

The nearest known faulting outside of the ~~permit~~ lease area is the Mill Fork fault graben. The Mill Fork fault graben passes to the southeast of the ~~permit~~ lease area (refer to Hydrologic Map MFS1830D). This fault graben was crossed in ARCO's Huntington Canyon #4 Mine in Mill Fork Canyon and has a displacement of about twenty five (25) feet on the each side. The trend of this fault zone is approximately N 40^{o} E. Based on projections from maps of #4 Mine, this graben should pass by the southeast corner of the ~~permit~~ lease area, between the Mill Fork lease and the existing Deer Creek Mine. Where it crosses the northern end of East Mountain, the fault has been mapped to have a displacement of thirty (30) feet down on the northwest side. Deer Creek mine workings have not intercepted this fault zone and exploration drilling in the right fork of Rilda canyon does not show any displacement, indicating that the displacement of the fault zone is too small to measure with exploration drilling, or that it has disappeared in this area. This fault zone does not appear in any surface outcrops.

g. Alluvial Aquifers

Utah Regulations require that the presence of alluvial valley floors in or adjacent to the mine project area be identified. The regulations define an alluvial valley floor as "unconsolidated stream laden deposits holding streams with water availability sufficient for sub-irrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by un-concentrated runoff or slope wash together with talus, or other mass movement accumulations, and windblown deposits." The alluvial valley floor is therefore determined to exist if:

1. Unconsolidated stream-laid deposits holding streams are present, and,
2. There is sufficient water to support agricultural activities as evidenced by:
    a. The existence of flood irrigation in the area in question or its historical use;

b. The capability of an area to be flood irrigated, based on stream flow, water yield, soils, water quality, topography, and regional practices; or
c. Sub-irrigation of the lands in question, derived from the groundwater system of the valley floor.

Scope: The purpose of this section of the report is to examine the potential existence of alluvial valley floors in and adjacent to the areas to be affected by surface operations associated with the permit areas. It is divided into three parts. First, a general description of the surface operations and site disturbances associated with the permit areas is presented. Next, discussions of the characteristics of geomorphology and irrigation are presented. Finally, the conclusions of the alluvial valley floor determination are summarized.

Site Description: Surface facilities associated with the permit area will consist of the portal area and associated facilities for Deer Creek Mine.

The climate of the general area is semi-arid to arid and continental. Daily minimum temperatures recorded at the East Mountain weather station in winter range from the average low of -6.3^{o} F to the maximum record low of -15.2^{o} F, and daily maximum temperatures in summer range from the average high of 84.7^{o} F to the maximum record high of 89.3^{o} F.

Temperatures in the region tend to be inversely related to elevation. Average annual precipitation recorded for a 20 year period (1981-00) at the East Mountain weather station averaged 13.59 inches. Approximately fifty percent of the annual precipitation falls during the winter as snow with most of the remainder coming as summer thunderstorms.

Alluvial Valley Floor Characteristics: In this section of the report the various criteria for determining the existence of an alluvial valley floor are examined in relation to the overall ~~permit~~ Mill Fork and adjacent areas.

Geomorphic Criteria: Alluvial deposits in and adjacent to the ~~mine permit~~ Mill Fork Area have been mapped and reported in Doelling's "Wasatch Plateau Coal Fields, 1972." The report indicated that alluvia in the area are found solely along Huntington Creek below the Rilda Canyon confluence in the Huntington drainage system, in the Cottonwood drainage system along lower Cottonwood Creek and at the mouth of the North Fork of Cottonwood Creek, and in the Joe's Valley drainage.

Flood Irrigation: Flood irrigation near the project area is currently (and has historically been) confined to the alluvial areas of Huntington Creek approximately one mile below the confluence of Deer Creek and Huntington Creek. In the Cottonwood drainage system flood irrigation is currently, and historically, confined to the alluvial areas of lower Cottonwood Creek. No flood irrigation has historically been practiced on the narrow alluvium land upstream in the canyons opening to lower Cottonwood and Huntington Canyon creeks. The historic lack of flood irrigation in these steep, narrow canyons suggests that such activities are not feasible in the region. In addition, the topography is very steep and consequently not conducive to agricultural activities.

Water quality of Cottonwood and Huntington creeks is good. A detailed review of the surface water quality has been presented previously in this report and is updated each year in the annual Hydrologic Monitoring Report.

Sub-irrigation: Some sub-irrigation of vegetation does occur on the alluvial valley floors. The sub-irrigated species (mainly cottonwoods and willows) are found along the channels of Cottonwood Creek and in the Joes Valley drainage above the reservoir and along the channels of Rilda Canyon and Huntington Creek. This suggests that sub-irrigation is confined to the channel areas where the water table is near the surface.

Alluvial Valley Floor Identification: Based on the foregoing analysis, the narrow canyons associated with the ~~permit~~ Mill Fork Area cannot be considered to have an alluvial valley floor due to insufficient alluvium and the very limited area for supporting an agriculturally useful crop. The valley floor of Huntington Creek below the confluence with Deer Creek, however, can be classified as an alluvial valley floor due to the presence of both flood irrigation and limited sub-irrigation on the alluvium.

Potential Impacts of Alluvial Valley Floors: Very little potential exists for the mine operations to impact the Cottonwood and Huntington Creek alluvial valley floor due to the location of the operations in comparison to the alluvial deposits. All surface disturbances in the portal area will be protected by sediment control facilities and have been designed and constructed according to R645 standards in an environmentally sound manner.

The hydrologic monitoring program will help determine the actual impact of surface activities and aid in selecting mitigating measures, if necessary; however, it is believed that the overall ~~permit~~ lease area and associated activities will have no significant hydrologic impacts on the alluvial valley floor along Cottonwood and Huntington creeks. Details concerning the monitoring program are outlined in section R645-301-731.

4. Springs and Seeps

Prior to coal leasing, lands administrated by the United States Forest Service require sufficient environmental baseline data to be analyzed during the National Environmental Protection Act (NEPA) analysis process. In preparation for coal leasing through the lease-by-application process, Genwal Resources conducted baseline spring and seep surveys from 1994-1996 (northern portions of the lease were surveyed in 1989-90). Data collected by Genwal Resources was determined by the Forest Service to meet the requirements of the Data Adequacy Standards (refer to Appendix C). Information submitted to the Forest Service included: location, flow and quality (data indicates general trends, date of collection generalized and quality limited to field data). With PacifiCorp's acquisition of the Mill Fork State Coal Lease (reverted to the BLM on August 1, 2011 and designated as federal lease UTU-88554), a complete re-evaluation of groundwater resources was initiated in 2000 and continued through 2002. Evaluation of the data revealed similar geologic occurrences to the southern portion of East Mountain, (majority of the groundwater resources discharge from the North Horn Formation in a down-dip configuration), which has been monitored by PacifiCorp for more than ~~twenty~~ thirty years. The water reconnaissance program of the Mill Fork Area was initiated with an aerial survey via helicopter. During the reconnaissance survey, previous baseline survey data was evaluated for field location accuracy. Based upon initial observations, PacifiCorp commenced a field program in 2000 to completely map, field mark and photograph each groundwater source. Previous baseline studies were utilized as a guide of potential groundwater resources. The entire area of the Mill Fork ~~State Lease/UTU-84285~~ Area (including leases UTU-88554 and UTU-84285) and adjacent area was traversed. During the field reconnaissance process, when water resources were encountered, they were tracked to the source. At the sources, the sites were located utilizing GPS surveying techniques (GPS - equipment: Trimble Asset Surveyor, differentially corrected, horizontal accuracy sub-meter), digitally photographed, field marked with a brass tag and measurements were taken of flow and temperature (refer to Appendix C). PacifiCorp retained identification system established during the previous surveys, except for the Joes Valley area and Mill Fork Ridge. In these two areas, several springs were labeled with multiple tags of different numbers and separate springs were labeled the same identification. In addition to the field measurements, PacifiCorp collected baseline water quality samples. Not all sites were sampled, collection of water quality samples were restricted to sites where representative samples could be obtained. At selected sites, springs were also sampled for isotopic data. These sites were selected based on geographic location, geologic formation, and occurrence (refer to Appendix C).

During the 2000-2002 baseline evaluation, a total of 198 springs were identified within and adjacent to the ~~permit~~ Mill Fork Area. Each spring site on East Mountain has been studied to determine the geologic circumstances that cause the springs to occur. The mode of occurrence for each spring has been tabulated on the "Springs Geologic Conditions Inventory" sheets located in the compact disk in the Appendix C. The springs on East Mountain originate in several different ways (see Table MFHT-1 and Mill Fork ~~Spring~~ Hydrologic Map MFS1831~~1~~0D); however, many springs share the same mode of occurrence and, in some cases, are related.

The most frequent occurrences of springs are those located about 150 to 350 feet below the top of the North Horn Formation (refer to Figure MFHF-4). Field observations along with drill hole data show a predominance of fluvial siltstone and sandstone at that stratigraphic interval. These sedimentary rocks represent many isolated fluvial systems which are water-bearing. The springs are formed where the fluvial channels intersect the land surface. Because the fluvial channels within this zone are generally not interconnected, the springs are not interrelated but share the same mode of occurrence.

Numerous springs located in the lower portion of the North Horn Formation occur when water flowing through fluvial sandstones which are underlain by a thin zone of impervious mudstone at the base of the North Horn Formation intersects the land surface. Field observations along with drill hole data indicate that impervious mudstone units occur at the upper and lower portion of the North Horn Formation. Even though these individual mudstone layers are discontinuous, the occurrence of this type of strata exists throughout the East Mountain Property. The springs related to this mode of occurrence are not generally interrelated because they are fed by waters flowing through isolated fluvial channel sandstones and siltstones.

Numerous springs are located along and within the Joes Valley Graben. Generally, the springs are located within the North Horn Formation (Bald Mountain Ridge located west of the ~~permit~~ Mill Fork Area) along the fault zone and the alluvial valley deposits. Many of the largest springs surveyed for the Mill Fork ~~permit~~ Area are located along this fault system west of the Mill Fork ~~permit~~ Area. The springs located along this fault zone are generally interrelated.

A few springs are located within both the Flagstaff and Price River formations; however, their occurrence is insignificant in comparison to springs located in the North Horn Formation.

Generally springs with discharges exceeding 50 gpm are associated with faulting where permeability has been increased by fracturing (example: Bald Ridge area). The discharge of the springs varies directly with the amount of precipitation and also varies seasonally. Discharge is greatest during the snow melt period, normally from late April through the month of June. Following periods of groundwater recharge the discharge recedes fairly rapidly at first, then gradually, indicating a double porosity effect. At the end of the water year, the remaining discharge is only twenty to thirty percent (20-30%) of the peak discharge (refer to Tables MFHT-3 and -4 for historical data for the southern portion of East Mountain compared to the Mill Fork Area. Seasonal flow variation collected for the Mill Fork ~~permit~~ Area compares directly to the data collected for the southern portion of East Mountain and data collected by Genwal resources to the north. Table MFHT-4 compares the data collected from the southern portion of East Mountain to the Mill Fork Area.

The following table provides a breakdown of spring locations by geologic formation and surface drainage:

MILL FORK ~~PERMIT~~ AREA (Energy West 2000-2002 Surveys) **SPRINGS by GEOLOGIC FORMATION and SURFACE DRAINAGE**						
Drainage System	***Geologic Formation***					
	Alluvium	***Flagstaff***	***North Horn***	***Upper Price River***	***Castle Gate***	***Blackhawk***
Huntington Drainage						
Crandall Canyon	0	0	0	7	1	0
Mill Fork Canyon	0	0	44	10	1	5
Right Fork of Rilda Canyon	0	1	39	1	0	0
Cottonwood Drainage						
Un-Named Drainages of Joes Valley	35		29	19	6	0
Total Number of Springs = 198						

5. Groundwater Quality

Groundwater chemical quality is very good in strata above the Mancos Shale. The USGS reported a range in dissolved solids from 50 to 750 mg/l for samples from 140 springs in the region issuing from the Star Point Sandstone Formation and overlying formations (Danielson et al., 1981). During the Energy West 2000 - 2002 seep and spring surveys, a total of one hundred twenty-nine (129) samples were collected with a range of dissolved solids from 207 to 390 mg/l (refer to Appendix C). Danielson et al. (1981) identified the regional trends of decreasing water quality from north to south and west to east across the Wasatch Plateau. Waters percolating through the underlying Mancos Shale quickly deteriorate, with total dissolved solids concentrations frequently exceeding 3000 mg/l.

Additional studies by PacifiCorp have confirmed the primary findings of the USGS concerning regional trends in quality. Originally, decreasing quality from north to south was believed to depict the groundwater flow direction, and the quality decreased as a function of the time it traveled through the strata. Although the time travel component is probably an important factor, in 1985 a surface exploration program identified the existence of an area of residual heat from an ancient burn on the outcrop throughout the southern extreme of East Mountain. The high temperature was also explored within the mine and a portion of reserves were lost because of the situation. It is now theorized that the high temperature water dissolved the mineral constituents of the formations, thereby altering the water chemistry. The quality also decreases vertically downward because of the influence of marine sediments along with the trend of decreasing quality from north to south.

An examination of Figure MFHF-5 indicates that a relationship exists between elevation and the total dissolved solids concentration of the springs. The data indicate that concentrations of dissolved materials increase with diminishing elevation for both surface streams and springs. The change in quality is a function of the differences in the chemical character of geologic formations which outcrop at different elevations.

To more closely identify springs which are related, water samples are analyzed to determine the percentage of cations and anions in solution. These percentages have been graphically represented as cation-anion diagrams (refer to Appendix B, Table 2, Figure 22 and Appendix C: Water Quality tab). The purpose of the diagrams is to identify groups of related springs by water chemistry. The diagrams clearly show the similarity of water quality of springs originating in the same geologic formation. Historical data from PacifiCorp's on-going East Mountain Hydrologic Program has demonstrated is that, even though the quality varies slightly from individual sites as well as from different formations, seasonal variations do not exist (refer to Annual Hydrologic Reports for yearly comparisons and Volume 9 Hydrologic Section Hydrologic Support Information No. 11, page 36: paired t-test analysis). Along with the data referenced above, Table MFHT-5 compares the seasonal water quality data collected during 2000-2001 field seasons for the Mill Fork Area. Data collected in 2000-2001 confirms the trends historical in data collected for southern East Mountain, i.e., despite the seasonal variability in discharge rates, the solute concentrations of active region ground waters do not exhibit significant seasonal variability (refer to Appendix C: Water Quality tab and Table MFHT-5).

PacifiCorp began in-mine quality monitoring in 1977 (Cottonwood/Wilberg and Deer Creek mines). With the collection of numerous samples throughout the extent of the mine workings, the quality has remained relatively constant (see Volume 9 Hydrologic Section Maps HM2 and HM3). As with the springs the quality varies from individual sites, but quality from the individual sites remains constant versus time (see Volume 9 Hydrologic Section Figure HF8).

The predominant dissolved chemical constituents of the groundwater from both surface springs and samples collected in the mine are calcium, bicarbonate, magnesium, and sulfate. Concentrations of magnesium are normally about one-half the concentration of calcium. Sulfate concentrations are typically higher in water from springs issuing from the Star Point Sandstone-Blackhawk aquifer zone or confined aquifers intersected by mine workings. As mentioned earlier, water quality degrades from the north to the south and also vertically.

PacifiCorp contracted Mayo & Associates in 1996 to conduct comprehensive study to characterize the hydrology and hydrogeology of the East and Trail M~~m~~ountains (refer to Volume 9 - Hydrologic Support Information No.11). The hydrogeology of the PacifiCorp leases were evaluated by analyzing: 1) solute and isotopic composition of surface and ground waters, 2) surface and groundwater discharge data, 3) piezometric data, and 4) geologic information. The following lists the key points and conclusions from the 1996 study:

Conclusions from the 1996 Mayo & Associates Hydrologic Investigation

1. The δ^{2}H and δ^{18}O compositions demonstrate that all ground waters are of meteoric origin (i.e. snow and rain).
2. Active and inactive groundwater regimes occur in the mine lease area.
3. The active regime includes alluvial groundwater, groundwater in the Flagstaff Formation, and all near surface exposures of the other bedrock formations except, perhaps, the Mancos Shale. The near surface extends about 500 to 1,000 feet into cliff faces. Ground waters in the active regime contain abundant ^{3}H and anthropogenic ^{14}C.
4. Comparison of long-term discharge hydrographs with precipitation records demonstrates that active regime ground waters: 1) are in direct hydraulic communication with the surface, 2) are recharged by modern precipitation, and 3) have large fluctuations in spring discharge rates which can be attributed to seasonal and climatic variability. High-flow/low-flow discharge rates vary as greatly as 600 gpm to nearly dry; however, most high flow rates are less than 50 gpm.
5. Despite the seasonal variability in discharge rates, the solute concentrations of active region ground waters do not exhibit significant seasonal variability.
6. The inactive regime includes groundwater in sandstone channels in the North Horn, Price River, and Blackhawk Formations which are not in direct hydraulic communication with the surface (i.e. greater than about 500 to 1,000 feet from cliff faces). Mine workings are largely part of the inactive regime. The sandstone channels are vertically and horizontally isolated from each other and when encountered in mine workings are usually drained quickly. Coal seams are hydraulic barriers to groundwater flow. The blanket sands of the Star Point Sandstone are also largely in the inactive zone. Except where exposed near cliff faces, faults encountered in mine workings are part of the inactive regime. Except near cliff faces, faults are not conduits for vertical hydraulic communication between otherwise hydraulically isolated pockets of groundwater.
7. Inactive region groundwater systems contain old groundwater (i.e. 2,000 to 12,000 years), and are not influenced by annual recharge events or short term climatic variability.

8. In-mine inactive regime ground waters occur in nearly stagnant, isolated zones which have extremely limited hydraulic communication with other inactive regime ground waters in the vicinity of mine workings and with near-surface active regime ground waters as evidenced by the following:

   a) Ground waters discharging into mine openings have ^{14}C ages ranging from 2,000 to 12,000 years
   b) Roof drip rates rapidly decline when water is encountered in the mine indicating that the saturated zone above the coal seam is not hydraulically continuous and has a limited vertical and horizontal extent.
   c) Unsaturated conditions have been identified in boreholes drilled vertically into sandstone channels located above coal seams.

9. The fact that inactive region ground waters encountered in mine openings do not have an infinite age means that, at some time, there has been some hydraulic communication with the surface. This communication is extremely limited as illustrated by calculated steady state recharge-discharge rates of faults and sandstone channels in the inactive zone which range from 0.001 to 1.23 gpm.
10. Groundwater in the Star Point Sandstone is part of the inactive regime as evidenced by the 6,000 year ^{14}C age of the sample from well TM-3. In the down dip direction along the axis of the Straight Canyon Syncline, potentiometric pressures in the Spring Canyon member results in upwelling of groundwater into Hiawatha seam mine openings. Such upwelling may locally reduce the pressure in the Spring Canyon member.
11. Aerially extensive groundwater regimes in the lower Blackhawk Formation and Star Point Sandstone do not exist within the lease area. Therefore, it is not meaningful to create piezometric surface maps of these systems.
12. Stream flow is dependent on snow melt, precipitation and thunderstorm activity. There is no apparent hydraulic communication between stream flow and groundwater encountered in mine openings.
13. The groundwater discharging into the Rilda Canyon alluvial collection system is of modern origin and is closely tied to seasonal recharge. This is evidenced by its modern radiocarbon and ^{3}H contents and by the discharge hydrographs. The alluvial groundwater is not related to the groundwater encountered in the mines.
14. The groundwater discharging in Cottonwood Canyon near Cottonwood Spring and Roans Spring discharges from glacial deposits and is of modern origin. The radiocarbon and ^{3}H contents of this water indicate a modern origin. The water in the shallow glacial deposits is not related to the groundwater encountered in the mines.

In addition to the study conducted in 1996, Mayo & Associates were retained in 2000 to investigate hydrologic resources of the Mill Fork ~~permit~~ Area and adjacent areas. The purpose of this investigation is to 1) characterize the groundwater and surface water systems in the Mill Fork ~~permit~~ Area, and 2) determine the probable hydrologic consequences of underground coal mining to surface waters and ground waters within the Mill Fork ~~permit~~ Area. The hydrology and hydrogeology of the Mill Fork ~~permit~~ Area area have been evaluated by analyzing: 1) solute and isotopic compositions of surface waters and ground waters, 2) surface water and groundwater discharge data, 3) piezometric data, and 4) geologic information (refer to Appendix B for complete details).

6. Chemical Evolution of Groundwater (excerpt from Mayo & Associates Study - Appendix B)

a. Chemical Reactions

Solute compositions of groundwaters are the result of interactions between groundwater and bedrock lithology and between groundwater and atmospheric and soil gases. The general reactions responsible for the chemical evolution of groundwaters in the vicinity of the study area and inside the coal mines are described below:

Groundwater acquires most of its $CO_{2(g)}$ in the soil zone where the partial pressure of CO_2 greatly exceeds atmospheric levels. This CO_2 combines with water to form carbonic acid according to

$$CO_{2(g)} + H_2O = H_2CO_3 \quad (1)$$

Carbonic acid dissociates into H^+ and HCO_3^- as

$$H_2CO_3 = HCO_3^- + H^+ \quad (2)$$

The H^+ ions temporarily decrease the pH of the water but are quickly consumed by the dissolution of carbonate minerals that are abundant in the soil zone and in most aquifers. Carbonate mineral dissolution is represented as

$$2H^+ + \underset{\text{(dolomite)}}{CaMg(CO_3)_2} = Ca^{2+} + Mg^{2+} + 2HCO_3^-, \text{ and} \quad (3)$$

$$H^+ + \underset{\text{(calcite)}}{CaCO_3} = Ca^{2+} + HCO_3^- \quad (4)$$

The net effect of reactions 2 through 4 is to increase the pH and the Ca^{2+}, Mg^{2+}, and HCO_3^- contents of waters. Dissolution of gypsum, which is present in minor amounts in many formations in the region, can elevate the

Ca^{2+} and SO_4^{2-} contents in the absence of additional $CO_{2(g)}$ and H^+ according to

$$CaSO_4 \cdot 2H_2O = Ca^{2+} + SO_4^{2-} + 2H_2O \quad (5)$$
(gypsum)

Elevated Na^+ concentrations may result from either the dissolution of halite or from ion exchange on clay particles or on sodium zeolites (Mayo and others, 2000). Halite dissolution will increase the overall solute concentration (i.e. TDS) and will yield equal Na^+ and Cl^- contents when the solute compositions are reported in the meq/l units. Halite is not abundant in the study area. Ion exchange will not directly elevate the overall solute content, but will result in increased Na^+ concentrations with corresponding decreases in Ca^{2+} and/or Mg^{2+} concentrations. Halite dissolution may be represented as

$$NaCl = Na^+ + Cl^- \quad (6)$$

And the ion exchange may be represented by reactions involving the sodium zeolite analcime,

$$2NaAlSi_2O_6 \cdot H_2O + Ca^{2+} = Ca(AlSi_2O_6)_2 \cdot H_2O + 2Na^+, \quad (7)$$

$$2NaAlSi_2O_6 \cdot H_2O + Mg^{2+} = Mg(AlSi_2O_6)_2 \cdot H_2O + 2Na^+, \quad (8)$$

or clay mineral exchange which may be represented as

$$Ca^{2+} + Na\text{-}clay = 2Na^+ + Ca\text{-}clay \quad (9)$$

$$Mg^{2+} + Na\text{-}clay = 2Na^+ + Mg\text{-}clay \quad (10)$$

7. Solute Compositions

Stiff (1951) diagrams representing mean solute compositions of groundwater, streams, and springs at the surface are shown in Appendix B Figure 22. Mean solute compositions of each spring and geologic formation are listed in Appendix B Table 2. The solute compositions of ground waters and surface waters in the study area are shown graphically on a Piper plot in Appendix B Figure 23. Calculated mineral saturation indices are listed in Appendix B Table 3.

a. Streams

(1) Crandall Canyon Drainage

Water quality samples taken below the confluence of the north and south forks of Mill Fork Creek have a mean TDS of about 300 mg/l and are of the Ca^{2+}-Mg^{2+}-HCO_3^- type with lesser amounts of SO_4^{2-} (Appendix B Table 2). This water includes drainage from the Mill Fork ~~permit~~ Area as well as the area to the north.

(2) Mill Fork Canyon Drainage

Water quality samples taken below the confluence of the north and south forks of Crandall Creek have a mean TDS of about 480 mg/l and are of the Ca^{2+}-Mg^{2+}-HCO_3^- type with lesser amounts of SO_4^{2-} (Appendix B Table 2). Most of this water originates in the Mill Fork ~~permit~~ Area.

(3) Rilda Canyon Drainage

Water quality samples taken below the confluence of the north and south forks of Rilda Creek have a mean TDS of about 400 mg/l and are of the Ca^{2+}-Mg^{2+}-HCO_3^- type (Appendix B Table 2). This water is mostly drainage from the Mill Fork ~~permit~~ Area.

b. Springs

The solute compositions of ground waters from nearly all of the springs in the Mill Fork ~~permit~~ Area are of similar chemical type (Appendix B Table 2). This is seen in the similarity of the shapes of the Stiff diagrams in Appendix B Figure 22, and the clustering of the data points on the Piper plot in Appendix B Figure 18. All of the springs in the Mill Fork ~~permit~~ Area for which chemical analyses are available are of the Ca^{2+}-Mg^{2+}-HCO_3^- type with variable amounts of SO_4^{2-}. This chemical type is consistent with the dissolution of carbonate minerals in the presence of soil zone $CO_{2(gas)}$ according to equations 1-4 above.

Mineral saturation calculations indicate that most of the springs and streams in the study area are at or above saturation with respect to the carbonate minerals calcite and dolomite (Appendix B Table 3). What this means is that the chemistry of the spring water is near equilibrium with respect to these minerals, and thus there is not a thermodynamic tendency to dissolve additional carbonate minerals if these are encountered in the groundwater system. Waters with saturation indices less than log = -0.1 have a thermodynamic tendency to dissolve the mineral species should they be encountered in the groundwater system and waters with a saturation indices greater than log = 0.1 have a thermodynamic tendency to precipitate the mineral species.

For additional dissolution of carbonate minerals to occur, an influx of CO_2(g) into the groundwater system must occur. Common sources of CO_2(g) in this environment include CO_2 produced by root respiration and organic decay in the soil zone and bacteriological processes resulting in the oxidation of CH_4 (methane). No surface or groundwater in the study area is near saturation with respect to gypsum. What this indicates is that, if gypsum is encountered along a waters flow path, dissolution of the gypsum will occur, resulting in elevated Ca^{2+} and SO_4^{2-} concentrations. Groundwater from the Blackhawk Formation and Star Point Sandstone encountered in nearby mine environments is supersaturated with respect to both calcite and dolomite (Appendix B Table 3) indicating that the water has the thermodynamic tendency to precipitate these minerals.

TDS concentrations of springs in the study area fall in the narrow range of 207 to 390 mg/l. A probability plot of the ordered ranking of the TDS of ground waters collected during the 2000-2001 spring and seep survey (Appendix B Figure 24) indicate a single population with a normal distribution. The fact that all of the Mill Fork ~~permit~~ Area springs discharging from alluvial systems, the North Horn Formation, Price River Formation, Castlegate Sandstone, and Blackhawk Formation have the same chemical character (Appendix B Table 2; Figures 22 and 23) is of particular significance. In other areas in the Wasatch Plateau, bedrock springs commonly have a broader range of TDS and chemical type, which is related to the bedrock formation from which the springs discharge (Danielson and others, 1981; Mayo and Associates, 1997d; Mayo and Morris, 2000).

The mean TDS for each geologic formation ranges from 253 mg/l in the North Horn Formation to 322 mg/l in the Price River Formation. That there is not a greater variability in TDS, or a greater number of groundwater types represented in the springs in the study area implies that there is not a great deal of variation in the soil zone processes or mineralogy of the matrix of the groundwater systems from which these springs emanate. We believe that the lack of variability in groundwater solute chemistry occurs because the groundwater systems that support springs in the area flush large quantities of groundwater through the thick soil zone and shallow fractured bedrock. Over thousands of years, some of the soluble minerals which were once present in the shallow bedrock and in the soil have been leached away. Because these groundwater systems do not come into contact with rocks deeper in the geologic formations (which vary substantially in their soluble mineral contents) there is little variation in the chemical type of groundwater.

Although there is little variability in the chemical type and TDS of groundwater discharging from springs in the Mill Fork ~~permit~~ Area, there is considerable variability in the TDS and solute compositions of spring discharge waters and the solute composition of spring discharging from the Blackhawk Formation in the nearby Trail and Cottonwood Mine areas (Appendix B Table 2, Figure 23). We interpret the overall greater TDS and degree of chemical variability in the Blackhawk Formation in the Trail and Cottonwood Mine waters as a result of great precipitation variability in the Trail and Cottonwood Mine areas. Except for Joes Valley Alluvium, Mill Fork ~~permit~~ Area ground waters recharge and discharge from very wet upland areas. Trail and Cottonwood Mine groundwater recharge and discharge from a variety of elevations and recharge domains.

c. In-Mine Groundwater

Because the Mill Fork State Lease (now UTU-88554) was a new lease area that did not have existing underground workings, the solute compositions of in-mine groundwater can only be inferred from compositions of in-mine waters in nearby mines. Extensive in-mine samples of Blackhawk Formation roof drip water are available from Energy West's mines which include Cottonwood, Wilberg, Trail Mountain, and Deer Creek (Appendix B Table 2). A limited number of in-mine samples (Table 2) from the Star Point Sandstone are also available from the Deer Creek and Cottonwood Mines (Mayo and Associates, 1997d) and from public documents for the Crandall Canyon Mine (Mayo and Associates, 1997a).

(1) Blackhawk Formation

In-mine roof drips from the Blackhawk Formation are of the Ca^{2+}-Mg^{2+} -HCO_3^- -SO_4^{2-} type with appreciable amounts of Na^+ (Appendix B Table 2). These ground waters have elevated TDS contents relative to Blackhawk spring waters in the Mill Fork ~~permit~~ Area and are generally chemically dissimilar to springs in the Mill Fork ~~permit~~ Area (Appendix B Figure 23). The two spring samples from the Deer Creek and Cottonwood Mine areas (Appendix B Table 2) have similar solute contents as the in-mine samples. Mayo and others (2000) found the elevated TDS in coal mine roof drip water to be the result of a cascading series of chemical reactions involving the oxidation of pyrite which increases the SO_4^{2-} concentration and releases H^+ ions. The H^+ ions are consumed by dissolution of additional carbonate minerals (i.e., calcite and dolomite) elevating the Ca^{2+} and Mg^{2+} contents. In the process acid mine drainage (AMD) is prevented. Ion exchange of Ca^{2+} and

Mg^{2+} on the sodium zeolite analcime increases the Na^{+} contents. We anticipate similar in-mine processes will occur in the Mill Fork ~~permit~~ Area.

(2) Spring Canyon Member

The solute chemical composition of groundwater in the Spring Canyon Member beneath existing mine workings is highly variable (Appendix B Table 4). Conductivities range from 500 to 2,287 µS/cm. Ca^{2+} concentrations range from 5.5 to 64 mg/l and Mg^{2+} concentrations range from 5.1to 41 mg/l. Na^{+} concentrations range from 14 to 550.6 mg/l and Cl^{-} concentrations range from 5.0 to 221.3 mg/l. The large spatial variations in solute chemistry are attributed to the influence of inter-bedded Mancos Shale tongues which are present in some locations and not in others and are known to contain soluble minerals. The variations in Na^{+} are likely the result of the presence or absence of clays with ion exchange capacity. Ion exchange commonly results in elevated Na^{+} concentrations at the expense of decreased Ca^{2+} or Mg^{2+} concentrations.

That the solute chemistry in the Spring Canyon Member is not uniform beneath existing mines suggests that there is a partitioning of groundwater systems in the member. This condition is likely the result of inter-bedded lower-permeability layers in the Star Point Sandstone which partition individual sandstone bodies. These findings are substantiated by monitoring well data from 6 wells in the Trail and East Mountain areas (Appendix B Section 7.3) and are significant in that they strongly suggest that the Spring Canyon Member does not act as a single regionally continuous aquifer, but rather it supports a series of smaller, discrete groundwater systems.

(3) Joes Valley Fault System

Ground waters in the Joes Valley Fault system and associated synthetic faults and fractures have been observed in the Crandall Canyon Mine. Data from a public domain document (Mayo and Associates, 1997a, c) indicate the water is of the Ca^{2+} -Mg^{2+} -HCO_3^- type. This water type is consistent with the dissolution of carbonate minerals in the presence of soil zone $CO_{2\ (gas)}$. Slightly elevated SO_4^{2-} concentrations are consistent with dissolution of minor amounts of gypsum. The relatively low mean Na^+ concentration (3.7 mg/l; 0.17 meq/l) indicates that appreciable ion exchange has not occurred. Na^+ and Cl^- contents, in meq/l, are essentially the same, indicating halite dissolution as the Na^+ source.

8. $\delta\ ^2H$ and $\delta\ ^{18}O$

The $\delta\ ^2H$ and $\delta\ ^{18}O$ composition of a water molecule falling as precipitation is determined by the temperature at which nucleation of the water droplet occurs. However, other effects related to the bulk composition of the water vapor phase, such as cloud rainout and orographic effects, also can affect the isotopic composition of precipitation.

The stable isotopic compositions of waters are usually analyzed relative to the Meteoric Water Line (MWL). The MWL is empirically derived from the worldwide plotting locations of coastal zone precipitation and is defined by the equation $\delta\ ^2H = 8\ \delta\ ^{18}O + 10$ ‰ (See Appendix B for further discussion of the MWL). Precipitation that forms under cooler conditions will plot lower (i.e. more negatively) along the MWL than will precipitation that forms under warmer conditions.

Except for unusual conditions such as geothermal heating above about 100°C, the $\delta\ ^2H$ and $\delta\ ^{18}O$ composition of a groundwater is set at the time of recharge and is not affected by subsurface conditions such as groundwater residence time and mineral dissolution and precipitation reactions. In other words, the recharge and flow history of a groundwater can be evaluated independently of the solute content of the water using stable isotopic compositions.

The $\delta\ ^2H$ and $\delta\ ^{18}O$ composition of both in-mine ground waters and ground waters from springs, streams, and wells in the study area are listed in Appendix B Table 5 and are plotted on Appendix B Figure 25. Laboratory reporting sheets are presented in Appendix B. All ground waters in the study area plot near the meteoric water line indicating a meteoric recharge origin (i.e. rain and snow).

Based on their stable isotopic compositions, ground waters from within both the Energy West and Crandall Canyon Mines are readily distinguishable from each other and from springs and creeks in the Mill Fork ~~permit~~ Area. These three populations are statistically different from each other at the 95% confidence level. The Mill Fork Spring samples tend to plot more positively relative to the meteoric water line than do the in-mine waters, indicating that the near-surface ground waters recharged under different climatic conditions. The more negative composition of the in-mine ground waters is probably the result of paleo-recharge during cooler, wetter times. The stable isotopic composition of water seldom changes significantly after infiltration into the groundwater system. What this suggests is that modern groundwater systems in the upland areas overlying the mine area are not the primary source of recharge to the groundwater systems encountered in the mines.

9. Groundwater Ages (^{3}H and ^{14}C)

The concept of groundwater age is difficult to define because water arriving at a well or spring seldom travels via pure piston flow. Instead it is usually a mixture of water molecules that recharged at different locations and at different times, thus water has no unique age. It is therefore best to think of a groundwater "age" as the *mean residence time* of the water sampled at the well or spring.

In this investigation, two unstable isotopes, tritium (^{3}H) and carbon-14 (^{14}C) have been used to evaluate mean residence times. Tritium is a qualitative tool indicating if groundwater has a component of water that recharged since about 1954. Groundwater that recharged prior to about 1954 will contain essentially no tritium (Appendix B). Carbon-14 provides information regarding the number of years that have elapsed since the groundwater became isolated from soil zone gases and near-surface waters. Like tritium, ^{14}C can indicate if groundwater has a component that recharged since the 1950s. Ground waters with ^{14}C contents greater than about 50 percent modern carbon (pmc) contain anthropogenic (i.e., human-induced) carbon associated with atmospheric nuclear weapons testing. It is not uncommon for groundwater issuing from a spring or occurring in a well to be a mixture of old (i.e. containing no ^{3}H) and modern water.

Groundwater ages have been calculated for 27 springs, 14 in-mine locations, and 6 Star Point Sandstone wells (Appendix B Table 5, Figure 26). All spring waters, except for spring 18-4-1 which is located in the southwestern portion of Trail Mountain, contain anthropogenic carbon and appreciable amounts of ^{3}H and are, therefore, modern. These springs issue from alluvial systems, the North Horn Formation, the Price River Formation, the Castlegate Sandstone, and Blackhawk Formation.

Spring 18-4-1 issues from the Blackhawk Formation-Castlegate Sandstone contact at the down plunge end of the Straight Canyon Syncline (Appendix B Plate 1) and is not in the

Mill Fork ~~permit~~ Area. The spring water does not contain water that recharged since 1954; however, the water was likely recharged less than a few hundred years ago as is indicated by its ^{14}C content.

Most groundwaters collected inside the Cottonwood/Wilberg and Deer Creek Mines contain essentially no tritium (Appendix B Table 5) and have mean ^{14}C ages ranging from 2,000 to 12,000 years. Roof drip waters associated with faults (i.e., 1.5N X 29, 6W X 20, and MN-ME) contain waters 2,000 to 7,000 years old and are not in hydraulic communication with the surface (Appendix B Table 5). Both roof drip (i.e. Blackhawk Formation) and wells in the Spring Canyon Member of the Star Point Sandstone in the Crandall Canyon Mine generally have groundwater ages of 13,000 – 19,000 years. These waters contain essentially no tritium and thus represent groundwater systems that are essentially hydraulically isolated from modern near surface hydrologic phenomena.

As discussed in Appendix B Section 7.2.3, two in-mine roof drip samples associated with faults, TW-10 (Roans Canyon) in the Deer Creek Mine and 5th West (Joes Valley Fault) in the Crandall Canyon mine, have ^{3}H contents indicating a component of modern recharge.

Two wells completed in the Star Point Sandstone, CCCW-1S and TM-3, have mean groundwater residence times of 1,000 and 6,000 years, respectively. These two wells are both completed in the Spring Canyon tongue and appear to be located on approximately the same flow line. CCCW-1S is up gradient and near the recharge area as evidenced by the young ^{14}C age and the ^{3}H content. TM-3 is down gradient. Assuming that the two wells intercept groundwater along the same flow line, travel times can be calculated using the method described by Mooke (1980):

$$\Delta T = 8270 \ln (a_{k+1}^{14}/a_k^{14}) \qquad (11)$$

$$\Delta T = 5{,}300 \text{ years}$$

where:

ΔT = travel time (in years)
a_{k+1}^{14} = ^{14}C activity of up-gradient sample
a_k^{14} = ^{14}C activity of down-gradient sample

Assuming the travel time of 5,300 years and a distance of 4 miles, the calculated flow velocity is approximately 0.25 feet per year.

10. Active and ~~In-Active~~Inactive Groundwater Zones

The overall pattern of groundwater flow and surface water-groundwater interactions in the Mill Fork ~~permit~~ Area and adjacent areas can be described by a fairly simple conceptual model involving both active and inactive groundwater flow regimes (Mayo and Morris, 2000 Appendix B). The model is illustrated in Appendix B Figure 27.

Active zone groundwater flow systems contain abundant ^{3}H, have excellent hydraulic communication with the surface, are dependent on annual recharge events, and are affected by short term climatic variability. Tritium and carbon-14 "age" dating of spring waters in the study area demonstrate that all springs, except 18-4-1, issue from active zone groundwater systems and are of modern origin (Appendix B Table 5, Figure 26). Groundwater in the active zone generally circulates shallowly and has short flow paths. Because the springs in the Mill Fork ~~permit~~ Area and adjacent areas are not part of large, regional groundwater systems, hydrographs of their discharge rates show both seasonal and climatic fluctuations (Appendix B Figure 12). During drought cycles, it is not uncommon for discharge from some springs in the active zone to completely cease.

The $\delta\,^{2}$H and $\delta\,^{18}$O compositions of Mill Fork ~~permit~~ Area springs relative to in-mine ground waters demonstrate that the Mill Fork ~~permit~~ Area springs are not part of the same groundwater systems that discharge in the mines (Appendix B Figure 25).

The active regime includes alluvial groundwater, all of the Flagstaff Limestone, and the near-surface exposures of all other bedrock formations. The "near surface" extends a few hundred feet vertically into the subsurface, about 500 to 1,000 feet into cliff faces and is controlled by fracturing, weathering, and the surface exposures of fluvial channel sands. Further into the cliff faces the discontinuous character of the channel sands prevents active groundwater flow.

Except for mountain fronts and cliff faces, the coal bearing lower Blackhawk Formation and the Star Point Sandstone are generally not exposed at the surface in the Mill Fork ~~permit~~ Area and are not part of the active zone. In Cottonwood Canyon, located south of Mill Fork ~~permit~~ Area, the Star Point Sandstone is within a few hundred feet of land surface and is part of the active zone as evidenced by the tritium content, 1.10 TU, in Well CCCW-1S (Appendix B Table 5). Elsewhere Star Point Sandstone samples have groundwater ages of 6,000 to 19,000 years. In the Mill Fork ~~permit~~ Area the lower Blackhawk Formation and Star Point Sandstone are not exposed near the land surface, except at cliff faces, and are not in the active zone.

Except for mining operations near cliff faces, the in-mine environment is generally not part of the active zone. However, in-mine groundwater containing tritium (i.e., 1 TU or more, Appendix B Table 5) in TW-10 (Roans Canyon Fault) and 5th West Fault (Joes Valley Fault-Genwal Mine) indicate that locally the inactive zone extends into the mine environment where fracture zones, that are associated with major faulting, are currently under tensional stress. The extension of the active zone into the mine environment along fractures is localized as evidenced by the absences of tritium and old ^{14}C ages in in-mine groundwater collected elsewhere along the fracture zone (Appendix B Table 5).

Inactive zone groundwater systems contain old groundwater (i.e. 2,000 to 19,000 radiocarbon years, Appendix B Table 5), have very limited hydraulic communication with the surface and with other active groundwater flow systems, and are not influenced by either annual recharge events or short term climatic variability as evidenced by the decline in roof drip rates (Appendix B Figure 15). Groundwater in these systems tends to occur in sandstone channels in the North Horn, Price River, and Blackhawk Formations which are not in direct hydraulic communication with the surface (i.e. greater than about 500 to 1,000 feet from cliff faces). These sandstone channels are vertically and horizontally isolated from each other and when encountered in mine workings are usually drained quickly. The blanket sands of the Star Point Sandstone are also largely in the inactive zone.

Except for the immediate vicinity of Joes Valley Fault, we believe that groundwater intercepted in the Mill Fork ~~permit~~ Area will be part of the inactive zone and will not be in hydraulic communication with either near surface groundwater or surface water systems. Mining within 200 to 300 feet of Joes Valley Fault is problematic in that the area is under tension and deep groundwater may be part of the active zone.

Two fundamentally different groundwater regimes, active (near surface) and inactive (deep subsurface and in-mine) that occur in the vicinity of the Mill Fork ~~permit~~ Area and elsewhere in the Utah Coal District are due to the vertical and horizontal heterogeneity of the bedrock (Appendix B Section 5.3). The rock formations consist primarily of alternating and interpenetrating layers of somewhat permeable sandstone and impermeable shale and mudstone. Individual rock layers are generally not continuous over great horizontal distances. Rather, one rock facies commonly grades horizontally into another facies. Fluvial deposits consisting of sandstone channels, which locally support groundwater systems, typically interpenetrate with shale and mudstone units. Thus, layers of shale or claystone that have very low permeabilities encase individual sandstone layers both horizontally and vertically. Although the permeability of individual sandstone bodies may locally be relatively high, the ability of these rocks to transmit water horizontally over great distances is low because of the discontinuous nature of the sandstones. Due to the pervasiveness of low permeability shales and mudstones, the potential for vertical groundwater flow is minimal.

Because of the limited potential for groundwater to migrate vertically through the stratigraphic section, active zone recharge waters commonly infiltrate only into the soil zone and shallow, fractured bedrock. Most groundwater moves downward through the shallow subsurface until the first impermeable layer is encountered where it migrates laterally and is discharged at the surface as a spring or seep.

11. Regional Groundwater Systems

A report by the U.S. Geological Survey (Lines, 1985) states that there exists a regional aquifer in the lower Blackhawk Formation and Star Point Sandstone in the Wasatch Plateau. Lines also postulates that the regional aquifer is recharged by the downward migration of ground waters from overlying perched groundwater systems in the North Horn and Price River Formations. This idea is not correct. Ground waters encountered within mine openings in the lowermost Blackhawk Formation occur primarily within discontinuous sandstone channels. It is not uncommon for some of these channels to be completely dry, while others are partially or completely filled with water. Between these sandstone channels, the surrounding shales and claystones of the Blackhawk Formation are usually dry. The discontinuous nature of the saturated sediments in the lowermost Blackhawk Formation, and the unconfined conditions under which these ground waters exist do not support the idea of a deep, regional system with groundwater flowing from areas of recharge to areas of discharge.

Additionally, radiocarbon and tritium groundwater age dating indicates that groundwater in the shallow perched groundwater systems are modern (post-1954) and in-mine groundwater in the Blackhawk Formation and Star Point Sandstone are thousands of years old.

We believe that the presence of swelling clays and impermeable shales in the rocks in the unsaturated zone between the overlying perched systems and the Blackhawk Formation effectively prohibit downward vertical migration of waters from the perched systems. Lines (1985) analyzed cores taken from well (D-17-6) 27bda-1 and found the hydraulic conductivities of the shales and siltstones to be very low (i.e. 10^{-7} to 10^{-8} ft/day). One shale sample was found to be effectively impermeable even when a hydraulic pressure of 5,000 psi was applied.

Because there are no regionally extensive groundwater regimes in the lower Blackhawk Formation or Star Point Sandstone within the lease area, it is not possible to draw meaningful potentiometric surface maps of these systems.

Lines (1985) also reported that water was likely leaking from the Joes Valley Reservoir downward into the “lower Blackhawk / Star Point aquifer” in Straight Canyon. We believe that this is incorrect. Groundwater collected from well TM-3, which is completed in the Star Point Sandstone in Straight Canyon just below the reservoir, has a radiocarbon age of 6,000 years, while water in Joes Valley Reservoir is of modern origin. Water levels in TM-3 do not respond to seasonal fluctuations in the water level in Joes Valley Reservoir, indicating that there is little or no hydraulic communication between the reservoir and water in the Star Point Sandstone. Groundwater was sampled at UG-3 in the lower

Blackhawk Formation in the Trail Mountain Mine. This water has a radiocarbon age of 5,500 years, which is likewise not consistent with water from the reservoir.

12. Summary of 2001 Mayo & Associates Study

In summary, all groundwater encountered in springs monitored in the Mill Fork ~~permit~~ Area discharge from active, shallow groundwater systems. No evidence exists that suggests a large, regional-type aquifer occurs in the area. All of the springs analyzed in the study area exhibit large-scale fluctuations in discharge rates in response to the annual snowmelt event. The springs are also sensitive to longer-term variations in climate. Carbon-14 and tritium dating of spring and stream waters indicate that the springs contain anthropogenic (human-induced) carbon and levels of tritium consistent with recharge in the past 50 years. Stable isotopic $\delta\,^{2}H$ and $\delta\,^{18}O$ data from springs and streams at the surface indicate that the recharge sources for these groundwater systems are different from those that recharged the groundwater systems encountered in the mine environment.

Almost all groundwater encountered in in-mine environments is not related to shallow, active zone groundwater systems from which springs and streams discharge. ^{14}C dating indicates that groundwater entering the underground workings in most locations is thousands of years old. When groundwater is encountered in the mine, inflow rates commonly decrease rapidly and most inflows eventually dry up completely. This indicates that the groundwater systems encountered in the mine are not part of large regional groundwater systems. There is no relationship between groundwater inflow rates measured in the mine and the annual snowmelt event or long term climatic trends. This demonstrates a lack of hydraulic communication between the groundwater systems encountered in the mine and active zone groundwater systems near the surface.

13. Conclusions from 2001 Mayo & Associates Study

- Ground waters discharging from springs are part of active zone groundwater systems. Isotopic analysis indicates that groundwater from the active zone is of modern origin (recharged less than 50 years ago). Seasonal variations in discharge rates from active zone springs indicate that flowpath lengths are short and that groundwater travel times from recharge areas to discharge areas are generally less than one year. The abundance of shale and claystone units in the geologic section prohibits significant downward migration of active zone ground waters into deeper horizons.

- Analysis of the solute chemistry of ground waters discharging from springs and seeps indicate that depths of circulation in these systems are shallow. The modern groundwater ages of shallow ground waters in the study area support this conclusion.

- Groundwater encountered in most locations in the mines is many thousands of years old. Groundwater in the Star Point Sandstone ranges from approximately 1,000 to 19,000 years old. Groundwater in the Blackhawk Formation within the mines ranges in age from about 2,000 to 14,000 years, whereas groundwater in the Joes Valley Fault system ranges in age between about 2,500 and 5,000 years. None of these groundwaters have appreciable tritium concentrations, indicating that no recharge has occurred in the past 50 years.

- Groundwater encountered in the northwest corner of the Crandall Canyon Mine discharges from a series of fractures located near the Joes Valley Fault. Tritium data indicate that a component of this water recharged in the past 50 years, whereas ^{14}C data indicate that another component recharged more than 3,500 years ago. This groundwater appears to originate from a sandstone channel in the mine roof.

- More than two-thirds of all non-alluvial springs in the Mill Fork ~~permit~~ Area discharge from the North Horn Formation. The abundance of springs in the North Horn Formation is the result of the large area of exposed North Horn in the upland areas where precipitation is greatest, and the presence of the abundant claystone and shale layers which inhibit significant downward migration of precipitation into the formation.

- The fact that Little Bear Spring discharges modern water and has large variations in discharge rates suggests that it is the discharge location of an active zone groundwater system. Because inactive zone groundwater systems in the Star Point Sandstone beneath the mine are tens of thousands of years old and do not exhibit seasonal variations in discharge, these groundwater systems are precluded as potential contributors to the discharge from Little Bear Spring. The very low permeability in the Star Point Sandstone beneath the mine indicates that diffuse flow through the Star Point Sandstone beneath the mine cannot contribute significant groundwater to the discharge from the spring.

- Limited data suggest the possibility that Little Bear Spring may receive significant recharge where the fracture system from which it emanates crosses streams and active zone groundwater systems in drainages south of Little Bear Canyon. The conditions in Mill Fork Canyon seem favorable for recharge to the spring.

14. Mine Dewatering

Water encountered within the Deer Creek and Wilberg/Cottonwood mines (Des-Bee-Dove was a dry mine) has generally been confined to the perched aquifer systems and fractures-faults associated with the Blackhawk Formation as discussed earlier. Water enters the mines through various avenues including roof leakers (drippers) from overlying fluvial sandstone channels, bolt holes, tension cracks in the overlying strata, longwall caved areas, and where fractures or faults have been intersected by the mine workings. Excess water not utilized in the mining operation or for domestic use in the Mill Fork ~~permit~~ Area will be either pumped to storage areas or discharged from the Deer Creek Mine under approved UPDES permits (see Volume 9 Hydrologic Section: Appendix B for UPDES permit information). A complete description of the quality and quantity is reported in the annual Hydrologic Monitoring reports and also in the PHC section (R645-301-728).

15. Groundwater Rights and Users

Nine springs have been developed in Huntington Canyon to provide for domestic, industrial, and commercial water needs. Currently, Huntington City utilizes two springs in Huntington Canyon, Big Bear Canyon Spring and Little Bear Canyon Spring. The North Emery Water Users ~~Association~~ Special Services District also utilizes springs in Huntington Canyon to provide for domestic and industrial water needs in areas outside of Huntington City. The ~~Association~~ NEWUSSD is currently utilizing water from three springs in Rilda Canyon as well as from four other springs in the general area (refer to Volume 9 Hydrologic Section: Map HM1).

Some of the springs on East Mountain/Mill Fork Area have been developed for watering livestock by installing troughs, and JV-36 (located approximately 1 mile west of ~~the Mill Fork State Lease~~ UTU-88554) has been developed as a culinary water source for a cabin in the area. See Table MFHT-3 for a summary of the springs within the ~~permit~~ Mill Fork Area, their location, and any claims placed on the water they produce.

a. North Emery Water Users ~~Association~~ Special Services District

Of concern to PacifiCorp is the proximity of proposed mining activities in Rilda Canyon to the Rilda Canyon Springs which currently serve as a culinary water source to the North Emery Water Users ~~Association~~ Special Services District (NEWU~~A~~SSD) serving some 410 connections. Due to the importance of these springs, a separate discussion is provided in Volume 9 Hydrologic Section.

b. Little Bear Spring

A second spring system which has been developed for culinary purposes referred to as Little Bear Spring occurs east of the Mill Fork ~~permit~~ Area. Little Bear Spring is a large spring (average flow of approximately 300 gpm) which issues from the lowest member of the Star Point Sandstone (Panther Member) located approximately one and one half (1 ½) miles to the east of the Mill Fork ~~permit~~ Area boundary in Section 9, Township 16 South, Range 7 East. The spring was developed in 1960 by Huntington City and is currently maintained by Castle Valley Special Service District

(CVSSD). Little Bear Spring provides sixty five (65) percent of the culinary water for the cities of Huntington, Cleveland and Elmo.

As stated in the Mill Fork environmental assessment (EA) competed in 1997, Little Bear Spring flows continuously, with average monthly discharge ranging from two hundred (200) to four hundred forty (440) gpm (CVSSD, 1997). Flow varies seasonally, with a typical increase of twenty (20) to forty (40) percent in response to spring runoff. The lowest average monthly baseflow recently measured was one hundred ninety eight (198) gpm in April 1995 (refer to Appendix C: Little Bear Spring - for historical quality and quantity). Isotopic analyses performed to evaluate the age of water indicated that the spring discharges modern water, and has very similar composition to water in both Crandall and Huntington Creeks (Mayo and Associates, 1997). Further chemical analyses show that water from Little Bear is very similar to surface water in both Little Bear and Huntington Creeks. Water quality in the spring is good, requiring only chlorine treatment before it is suitable for consumptive use.

Based on previous reports and field observations (refer to Little Bear Spring reference list), the spring emanates from western fault of the Mill Fork graben. The graben is approximately one thousand (1,000) feet wide and trends from the southwest to the northeast at approximately north thirty (30) degrees east. Much of the geologic and hydrologic detail concerning the fault system was derive from the mining history of the Arco #4 mine located in Mill Fork Canyon. Mining in the #4 mine encountered the eastern fault (down thrown approximately thirty (30) feet on the west) of a small graben as entries were driven northwest from the portals in Mill Fork Canyon. Rock slopes were developed through the fault system down to the coal seam level. Mining proceeded across the graben to the western fault up thrown fault (up thrown approximately twenty nine (29) feet on the west). A second set of rock slopes were developed to access coal reserves to the west of the graben. Coal reserves diminished rapidly to the west and the mine was eventually closed and reclaimed. Mining across and within the graben encountered only minor quantities of groundwater and flow of Little Bear Spring was not impacted.

Isotopic sampling of water from Little Bear Spring indicates modern water (Appendix B Table 5), shows marked seasonal discharge variations and responds to short term climatic cycles indicates that it is supported by shallowly circulating groundwater. The groundwater that supports Little

Bear Spring is not related to the deep, old groundwater encountered in area coal mines (refer to Appendix B Groundwater Section).

Results of in-mine slug testing of the Star Point Sandstone beneath the Crandall Canyon Mine conducted by Genwal Resources (Mayo and Associates, 1997b) indicate that diffuse, matrix flow of groundwater through the Star Point Sandstone cannot be an important source of recharge to Little Bear Spring. Flow calculations using the hydraulic conductivities obtained from the slug testing and the approximate hydraulic gradient indicate that diffuse flow through the Star Point Sandstone is capable of yielding at most only a few gpm of groundwater discharge, which would represent only a very small percentage of the spring discharge. The ancient age of groundwater encountered in the Star Point Sandstone beneath the Crandall Canyon Mine adjacent to Little Bear Spring (19,000 years; Mayo and Associates, 1997a) supports this conclusion.

Mayo and Associates (Appendix B Reference List Mayo 1997a,b) suggested that Little Bear Spring is primarily recharged from surface water losses and alluvial groundwater losses in Mill Fork Canyon east of the Mill Fork ~~permit~~ Area (refer to Little Bear Spring reference list, Mayo & Associates studies June 1999 through November 2001 and AquaTrack Surveys December 1998 through November 2001).

(1) Groundwater Flow Mechanisms

The Mill Fork environmental assessment described three (3) mechanisms controlling flow to Little Bear Spring:

1. Water flowing through the Star Point Sandstone emerges at the spring location. Recharge for the spring is coming from the north and west, possibly supported by the Joes Valley Fault.

2. Recharge to the spring comes from the flow through the Star Point Sandstone from the north and northwest, and surfaces through fractures in the formation.

3. The trend of Huntington Creek follows a series of straight segments that are evident on topographic maps. The portion of Huntington Creek approximately two (2) miles north of the lease tract follows a north-south lineation. It has been suggested the trend of the creek in this area is controlled by a north-south

anomaly (possibly an unmapped fault) that runs south, through the northeast portion of the lease area (proposed lease delineation including the Little Bear drainage area) in Little Bear Canyon. Water from Huntington, Crandall Creeks and maybe Little Bear creeks enters this anomaly, and travels through it until it is intercepted by the Mill Fork Graben, where it is redirected to the northeast and emerges where the Mill Fork Graben fault zone intersects Little Bear Canyon. Comparison of the flow hydrographs for the spring and Huntington Creek show a strong correlation, suggesting that the water from the spring is derived from surface water sources. Spring flow has an apparent time lag of two (2) to four (4) years against flow in Huntington Creek. Additional flow may reach the spring by surface water seeping into the exposed outcrop of the Star Point Sandstone at nearby upgradient locations, or through direct infiltration of precipitation close to the spring source.

Additional studies completed after the publication of the Mill Fork EA (AquaTek, 1998 and 1999) have developed a fourth mechanism controlling flow:

4. Surface water from the upper reaches of Mill Fork Canyon flows down canyon recharging the alluvial deposits is intercepted by the southern extension of the Mill Fork graben, and then flows north along the fault and emerges in Little Bear Canyon. This flow mechanism was confirmed by a study conducted jointly by Mayo & Associates and the Forest Service (Little Bear Spring reference list: Mayo & Associates, November 2001)

As stated in the EA, given the most recent studies that indicate water from Little Bear spring is modern, chemically similar to surface waters in the area, and given the high discharge rates, it appears that the spring is supported by a system of faults and/or fractures that transmit surface water from the north and the south *(AquaTek Studies).* The hydraulic conductivity of the Star Point Sandstone is low, and gives rise to slow groundwater movement. As demonstrated by Hansen, Allen and Luce, assuming a five thousand (5,000) foot capture zone along the Mill Fork graben, a velocity of 0.013 ft/day through the Star Point, and aquifer height of forty five (45) feet, the potential discharge amount through the

Star Point for the spring would only be fifteen point two (15.2) gpm. This demonstrates that flow through the Star Point Sandstone itself cannot support the flow emanating from Little Bear spring.

(2) *Mill Fork Leasing Process*

As stated in the Mill Fork EA, on February 4, 1993, Genwal Resources, Inc. submitted Coal Lease Application UTU-71307 to the Bureau of Land Management (BLM), Utah State Office, to lease Federal Lands in the vicinity of Mill Fork Canyon.

The Mill Fork tract lies within the Huntington Canyon-Gentry Mountain and the Ferron Canyon, Cottonwood-Trail Mountain Multiple-Use Evaluation Areas as described in the Manti-La Sal National Forest Land and Resource Management Plan (Forest Plan). The Forest Plan Environmental Impact Statement (EIS) and Record of Decision make these areas available for consideration for coal leasing.

The first step in the leasing evaluation process was to delineate a tract. Tract delineation was completed by the BLM on October 2, 1996. Named the Mill Fork Tract, the area encompassed approximately six thousand four hundred forty (6,440) acres.

A no action alternative and three action alternatives were developed to provide a full range of reasonable alternatives that sharply define the significant issues.

A. Alternative 1 - No Action

Forest Service would not consent to, and the BLM would not approve leasing.

B. Alternative 2 - Offer for lease with standard BLM Lease Terms, Conditions and Stipulations

Forest Service would consent to, and the BLM would approve, offering six thousand four hundred forty (6,440) acres, as delineated for competitive leasing. The lease *would only have the standard BLM terms, conditions and stipulations that are included on the BLM coal form.*

C. Alternative 3 - Offer for lease with application of Special Coal Leasing Stipulations for Protection of Non-Coal Resources

Forest Service would consent to, and the BLM would approve, offering six thousand four hundred forty (6,440) acres, as delineated for competitive leasing. The lease would have the standard BLM terms, conditions and stipulations that are included on the BLM coal form along with eighteen (18) Special Coal Lease Stipulations from Appendix B of the Forest Plan and two (2) additional tract specific stipulations.

D. Alternative 4 - Offer a modified tract for lease with application of Special Coal Lease Stipulations for Protection of Non-Coal Resources

In addition to those activities addressed in Alternative 3, Alternative 4 specifically focuses on concerns identified as water issues. The portion of the lease tract east of the northeast quarter of Section 7 is removed from the leasing offering, to protect the water quality and quantity of Little Bear watershed and spring, reducing the overall tract by eight hundred eighty (880) acres.

Based on the USFS Record of Decision, the BLM offered for lease the Mill Fork Tract excluding the eight hundred eighty (880) acres (total tract approximately five thousand six hundred sixty (5,660) acres). The modified lease excluded the northeastern portion of the lease tract which encompasses the Little Bear Canyon watershed (designated as a Municipal Water Supply [MWS]). Exclusion of the eight hundred eighty (880) acres will protect the Little Bear MWS and minimize potential disruption or degradation to surface and groundwater resources.

On June 6, 2000, Genwal Resources Inc. re-applied for the eight hundred eighty (880) acres which were excluded during the 1997 Environmental Assessment for the Mill Fork Tract. Bureau of

Land Management and United States Forest Service evaluated the Lease-By-Application (LBA U-78593) referred to as the South Crandall Canyon Tract and issued the FONSI on February 18, 2003. Genwal Resources acquired the South Crandall coal lease on June 12, 2003.

PacifiCorp cooperated with Huntington City, Elmo City, Cleveland City and CVSSD in developing a comprehensive mitigation plan. The agreement was signed on July, 2004. As part of the agreement, PacifiCorp constructed a water treatment plant in 2005 located near at the existing Huntington City plant in Huntington Canyon. The mitigation agreement information is found in Appendix D of Volume 9.

B. EXISTING SURFACE RESOURCES

Presented within this section of the report is the regional hydrologic setting as well as the site specific description of hydrologic surface water characteristics of the ~~permit~~ Mill Fork Area.

1. Regional and ~~Permit~~ Mining Area Surface Water Hydrology

The PacifiCorp ~~permit~~ lease area is located in the headwater region of the San Rafael River Basin. The surface drainage system of the ~~permit~~ lease area is divided into two major drainages. The southwest portion forms part of the Cottonwood Creek drainage and the northeast portion contributes to the Huntington Creek drainage (see Hydrologic Map MFS1830D). The Huntington Creek drainage covers approximately seventy percent (70%) of the East Mountain leases held by PacifiCorp; the remaining thirty percent (30%) is within the Cottonwood drainage system.

Huntington and Cottonwood creeks drain about 300 square miles of the Wasatch Plateau in central Utah. Altitude changes rapidly across the Wasatch Plateau with steep canyon sides and high mountain peaks. Altitudes range from 6,000 to 10,700 feet. Average precipitation generally increases with altitude and ranges from ten (10) inches near the town of Huntington to thirty (30) inches in the upper reaches of Huntington and Cottonwood creeks. Most of the precipitation occurs during winter months in the form of snow.

Water use upstream from Castle Valley (the monoclinal valley containing most of the agricultural land) is primarily for stock watering and industrial purposes (coal mining and electrical power generation). Within Castle Valley, agriculture and power production utilize nearly all of the inflowing water (Mundorff, 1972) with minimum flows in the gaged streams occasionally approaching zero. Transbasin diversions occur throughout the area.

In general, the chemical quality of water in the headwaters of the San Rafael River Basin is excellent, with these watersheds providing most of the domestic water needs to the people below; however, quality rapidly deteriorates downstream as the streams cross shale formations (particularly the Mancos Shale in and adjacent to Castle Valley) and receive irrigation return flows from lands situated on Mancos derived soils (Price and Waddell, 1973). Dissolved solids concentrations range from about 100 to 600 mg/l in the mountain regions and from 600 to 6000 mg/l in Castle Valley.

Huntington Creek above the USGS stream gaging station (0318000) near the town of Huntington drains approximately 190 square miles. Storage reservoirs regulate runoff from fifty four square miles in the upper part of Huntington Creek. The average channel gradient of Huntington Creek above Huntington is about 100 feet per mile (1.9 percent). Danielson et al. (1981) estimate the average annual precipitation on the Huntington Creek drainage to be on the order of twenty six (26) inches. The average discharge at the USGS gage near Huntington is approximately ninety six (96) cubic feet per second (70,000 acre feet per year). The USGS estimates that "during most years, about 65 percent of the annual discharge at the Huntington Creek station (09318000) occurs during the snowmelt period (April-July)" (Danielson et al., 1981, p. 110). While the majority of stream flows are due to snow melt, thunderstorms of high intensity are common in the area during the summer months. The largest annual peak flows have been caused by thunderstorms. Of the measured annual peak flows on Huntington Creek near Huntington, eight annual events have been greater than 1600 cfs (about a 10 year return period), all of which occurred during July, August, or September. The peak discharge of record was 2500 cfs on August 2 or 3, 1930.

Cottonwood Creek above Straight Canyon drains approximately 21.9 square miles. The average channel gradient of Cottonwood Creek above Straight Canyon is 300 feet/mile (5.7 percent). Only a short period of record (October 1978 to present) is available for the USGS stream gaging station (09324200) on Cottonwood Creek above Straight Canyon. Danielson et al. (1981) estimate the average annual precipitation to be on the order of twenty-two (22) inches, or 26,000 acre feet, on the Cottonwood Creek drainage above Straight Canyon. Danielson et al. (1981) also estimate that only two percent of the precipitation on Cottonwood Creek above Straight Canyon leaves the basin as stream flow compared to thirty percent for Huntington Creek above Huntington. The suggested reasons for the wide difference in percent of precipitation contributing to stream flow are: 1) Cottonwood Creek Basin has a greater proportion of area with southern exposure with more gradual slopes than Huntington Creek Basin and 2) possible subsurface movement of water through fractures associated with the Joe's Valley Fault. About seventy percent of the total discharge at the Cottonwood Creek station above Straight Canyon for the water year 1979 occurred during the snow melt period (April-July).

Sixty years of data are available for the gaging station on Cottonwood Creek near Orangeville (09324500). The drainage area above Orangeville contributing to Cottonwood Creek is approximately 208 square miles. Cottonwood Creek has an average discharge near Orangeville of about ninety-five (95) cfs, or 69,000 acre feet per year. The maximum and minimum discharges of record on Cottonwood Creek near Orangeville are 7,220 cfs (August 1, 1964) and 1.2 cfs (April 8, 1966), respectively.

Surface drainages within and adjacent to the Mill Fork ~~State Lease\UTU-84285~~ Area include portions of Crandall, Mill Fork, Right Fork of Rilda, and un-named tributaries of Indian Creek. Crandall, Mill Fork and the Right Fork of Rilda drain the east slope of East Mountain and generally flow in an east-west direction from the headwaters to Huntington Creek located east of the ~~permit~~ Mill Fork Area. Un-named drainages associated with Indian Creek drain the western slope of East Mountain. Indian Creek flows to Lowry Water and then to Joes Valley.

State of Utah designated standards for water quality in the Huntington Canyon and Indian Creek are 1C, 2B, 3A and 4, corresponding to domestic, recreation, cold water fisheries and irrigation beneficial uses.

a. ~~Permit~~ Lease Area Watershed Characteristics

Water sources within the mine plan area include springs and seeps, which were discussed earlier in the Existing Groundwater Resources section of this report. There are no major water bodies located within or immediately adjacent to the mine plan area.

All of the streams within the Mill Fork ~~permit~~ Area are ephemeral or intermittent except for a portion of Crandall Creek (see table below). Elevations in the Mill Fork ~~permit~~ Area range from approximately 7880 feet in Crandall Canyon to 10,728 feet at Bald Mountain peak. General land slopes in the ~~permit~~ Mill Fork Area range from near vertical along the Castlegate Sandstone escarpment to less than four percent. Vegetative cover consists of sagebrush, juniper, and grasses on the south-facing slopes and dense conifer and aspen complexes on the north facing slopes. The following table outlines the stream classifications for the individual drainage systems:

MILL FORK ~~PERMIT~~ AREA DRAINAGE SYSTEM Stream Drainage Area and Classification				
Major Drainage	**Sub-Drainage**	**Drainage Area (acres)**		**Stream Classification**
		Total	**Within ~~Permit~~ Lease/Right-of-Entry Boundary**	
*Huntington Creek**	Crandall Creek	4000	1770	Perennial
	Mill Fork Creek	4020	1195	Intermittent
	Right Fork Rilda Canyon	5460	810	Intermittent
Cottonwood Creek	Un-Named Drainages associated with Indian Creek	NA	2047	Ephemeral
* Little Bear Canyon is not included within the boundaries of the lease and will not be included in the analysis. The Mill Fork EA completed in 1997 excluded 880 acres for protection of the Little Bear watershed.				

(1) Huntington Creek Drainage System

(a) Crandall Creek

Crandall Creek is a perennial stream and is the northern most surface drainage system within the ~~permit~~ Mill Fork Area. (Refer to Hydrologic Map: MFS1830D). The drainage area encompasses approximately 4,000 acres of which 1,770 is within the ~~permit~~ right-of-entry area. Surface facilities of the Genwal Resources coal mine are located in Crandall Canyon in Section 5, Township 16 South, Range 7 East. Genwal's coal leases are located generally to the west and north of the Mill Fork ~~permit~~ Area. The Crandall Creek drainage system has been extensively undermined by the Crandall Canyon Mine.

According to the United States Geological Survey (USGS), discharge from Crandall Creek ranged from a minimum of 0.24 cubic feet per second (cfs) to 97 cfs from 1979 to 1984 (Danielson, 1981). Based on the unit hydrographs developed for Crandall Canyon, approximately eighty (80) percent of the streamflow occurs between April and July. Suspended sediment loads in Crandall Canyon were measured in 1978 and 1979 and were found to range between 0.08 to 0.41 tons/day based on flow variations (Danielson 1981). Crandall Creek immediately below the Genwal Mine was designated as a class A1 channel type (steeper than 4% with boulder or bedrock channel) by Raleigh Consultants in a 1992 survey of drainages in the Huntington watershed.

Crandall Canyon is extensively monitored by Genwal Resources including ground and surface water resources.

(b) Mill Fork Canyon

Mill Fork Creek is an intermittent stream centrally located within the ~~permit~~ Mill Fork Area. (Refer Hydrologic Map MFS1830D). The drainage area encompasses approximately 4,020 acres of which 1,195 is within the ~~permit~~ right-of-entry area. Numerous springs are located in the headwaters of Mill Fork in Sections 11, 12, 13 and 14. Based upon field observations, flow exists in upper reaches during base flow conditions from the headwaters in Section 11 to the lower contact of the Castle Gate Formation. From this point the drainage is dry except for short reaches due to the contributions of springs MF-7 and MF-8A. The drainage is again dry below spring MF-8A until the confluence of the two forks in Section 17. Due to the contribution of flow from spring MF-213, flow in the drainage exists below the forks for approximately one quarter mile. Again, the drainage is dry from this point in Section 17 to where the flow reemerges in Section 21 below the reclaimed Beaver Creek #4 Mine. Flow below the mine exists for approximately one half (½) mile. Mining in the Beaver Creek #4 was restricted to the lower portions of the Mill Fork drainage system in Sections 16 and 17 (refer to Hydrologic Map MFS1830D). During the operational and reclamation phase of the #4 Mine, Beaver Creek monitored stream characteristics (quantity and quality) above and below the mine. As part of the North Rilda extension of the Deer Creek Mine, PacifiCorp incorporated these two points within the surface hydrologic monitoring plan in 1996 (refer to Volume 9 and Annual Hydrologic Reports for unit hydrographs of Mill Fork Canyon). At the request of the Forest Service, an additional surface monitoring point (MFU03) was incorporated into PacifiCorp's hydrologic monitoring program during 2002. Surface monitoring point MFU03 is located in Section 17, Township 16 South, Range 6 East, above the projected intersection of the Mill Fork Graben with Mill Fork Creek (refer to hydrologic map MFS1851D).

(c) Right Fork of Rilda Canyon

Right Fork of Rilda Canyon is an intermittent stream located on the southeastern boundary of the Mill Fork ~~permit~~ Area (Refer to Hydrologic Map MFS1830D). The drainage area encompasses approximately 5460 acres of which 810 are within the ~~permit~~ right-of-entry area. Numerous springs are located in the headwaters of the Right Fork in Sections 14, 23 and 24. Based upon field observations, flow exists in upper reaches during base flow conditions from the headwaters in Section 14 to the confluence to the two forks in Section 29. PacifiCorp has maintained an extensive network of surface and groundwater resources of Rilda Canyon since 1989, including a flume located in the Right Fork of Rilda Canyon in Section 29 (refer to Volume 9 Hydrologic Section and Annual Hydrologic Reports for unit hydrographs of Rilda Canyon).

(2) Cottonwood Creek Drainage System

(a) Un-Named Tributaries to Indian Creek

The un-named tributaries of Indian Creek which drain the western slope of East Mountain are ephemeral. Indian Creek itself is located approximately one half (½) mile to the west of the ~~permit~~ UTU-84285 boundary. As stated in the Mill Fork EA and confirmed with field observations, Indian Creek is perennial from the southeastern quarter of Section 34, Township 15 South, Range 6 East, approximately one mile north of the ~~permit~~ lease boundary. Most of the flow originates from the canyons on East Mountain as either surface flow or from springs at the base of the colluvial/alluvial toe in the valley floor. Additional contribution comes from a series of large springs located on the east side of Bald Mountain located within the Joes Valley graben. Indian Creek progressively gains flow from headwaters to below the ~~Mill Fork State Lease~~ lease boundary due to the contribution of groundwater. A portion of Indian Creek is diverted at a structure located in Section 15, and flows in a ditch roughly parallel to Indian Creek along the western base of East Mountain. Flow records collected by the Forest Service from 1972 to 1975 ranged between 1 to 30 cfs. Seven relatively small ephemeral drainages flow from the western slope of East Mountain within the ~~permit~~ lease areas. (Refer to Hydrologic Map MFS1830D). The total drainage area ~~within the permit area~~ encompasses approximately 2,047 acres.

b. Water Quality and Quantity

PacifiCorp maintains an extensive surface monitoring program to evaluate both quantity and quality of the two major drainage systems which incorporate the ~~permit~~ Mill Fork Area. The following will be divided by major drainage systems.

(1). Huntington Creek Drainage System

(a) Huntington Creek

Huntington Creek is comprised of many smaller tributary systems that feed the main stream. Crandall Creek, Mill Fork Creek, and Right Fork of Rilda Canyon, are the only tributaries to Huntington Creek that emanate from within the Mill Fork ~~permit~~ Area.

Huntington Creek flow data are recorded on a continuous basis by ~~Utah Power~~ PacifiCorp Energy at two locations; one station is located near the Huntington Power Plant, the other below Electric Lake which is about twenty-two miles upstream from the Huntington Plant. Flow records are maintained by ~~Utah Power~~ PacifiCorp Energy in order to determine water entitlements and reservoir storage allocation for the various users on the river.

The ~~Utah Power~~ PacifiCorp Energy station near the Huntington plant was established in the fall of 1973. Prior flow records were obtained from the USGS station located about one mile downstream from ~~Utah Power's~~ PacifiCorp Energy's existing station. The USGS station was established in 1909 and discontinued in 1970 after determination of available water supply for the Electric Lake Dam. The dam was completed in December 1973, and water storage commenced shortly afterward.

The calculated natural flow rates, which consider actual flow recorded at the plant, plant diversions, Electric Lake storage, and lake evaporation along with yearly comparisons, are reported annually in the Hydrologic Monitoring Report.

In addition to the sites monitored by Huntington Plant Environmental ~~Service~~ staff (refer to Volume 9 Hydrologic Section), three sites were added on Huntington Creek near the Deer Creek confluence in conjunction with the Deer Creek discharge permit (refer to Volume 9).

Specific water quality data as well as yearly comparisons are reported annually in the Hydrologic Monitoring Report. This practice will continue throughout the life of the permit. In general, the water shows a gradual increase in concentration of dissolved minerals as the flow proceeds down Huntington Canyon. The values at the station below Electric Lake do not express the actual natural drainage water quality characteristics because of the lake effect, but it appears that the surface flow in Huntington Canyon is of very high quality in the upper reaches with some natural degradation occurring as the flow proceeds to the canyon mouth. Predominant dissolved chemical constituents in surface waters area calcium, magnesium and bicarbonate. Sediment yields in the Upper Huntington Canyon drainage were estimated at 0.1 ace-feet per square mile by Wadell, et. al, 1981.

(b) Crandall Creek

As stated earlier, only a small portion of the ~~permit~~ right-of-entry area is within the Crandall Canyon drainage area, and stream characteristics are extensively monitored by Genwal Resources. To reduce redundant information, monitoring of Crandall Creek will not be included as part of the Mill Fork permit application unless Genwal Resources terminates monitoring.

Water quality samples taken below the confluence of the north and south forks of Crandall Canyon Creek have a mean TDS of about 300 mg/l and are of the Ca^{2+}-Mg^{2+}-HCO_3^- type with lesser amounts of SO_4^{2-} (Appendix B Table 2). This water includes drainage from the Mill Fork ~~permit~~ Area as well as the area to the north.

(c) Mill Fork Canyon Creek

Mill Fork Canyon Creek is a tributary of Huntington Creek and was included in PacifiCorp's monitoring program starting in 1997. Monitoring of Mill Fork will be conducted according to the following schedule (see Hydrologic Monitoring Schedule in Volume 9 Hydrologic Section).

a.) Locations:

(1) Above old mines – MFA01
(2) Mill Fork Canyon Culvert – MFB02
(3) Above projected Mill Fork Graben crossing - MFU03 (refer to Hydologic Monitoring Map MFS1851D).

b.) Flow information is collected during the first or second week of each month.

c.) Water samples will be collected and analyzed quarterly (one sample at low flow and high flow) during the first or second week of the quarter. Parameters analyzed are those listed in the DOGM Guidelines for

Surface Water Operational Quality. The program was initiated in 1997, except for MFU03 which was added in 2002. Field measurements, including pH, specific conductivity, and temperature will be performed quarterly in conjunction with quantity measurements. Data regarding flow in Mill Fork Canyon Creek is presented in the annual Hydrologic Monitoring Report.

As stated above, flow information is collected monthly throughout the year. Hydrographs comparing annual flows are reported in the annual Hydrologic Monitoring Report.

Historical monitoring data collected by ARCo's Beaver Creek Coal Company - #4 Mine and the United States Geological Survey (site No. 76 Open File Report 81-539) has been incorporated in PacifiCorp's hydrologic database. Operational water quality monitoring was conducted during 1997 and 1998 (refer to Quarterly Hydrologic submittals). Baseline quality analysis was conducted from November 1998 through the fourth quarter 2000 (refer to respective Annual Hydrologic reports and Appendix C: Water Quality tab). Thereafter, baseline analysis will be repeated once every five- (5) years.

Water quality samples taken below the confluence of the north and south forks of Mill Fork Creek have a mean TDS of about 480 mg/l and are of the Ca^{2+}-Mg^{2+}-HCO_3^- type with lesser amounts of SO_4^{2-} (Appendix B Table 2). Most of this water originates in the Mill Fork ~~permit~~ Area .

(d) Rilda Canyon Creek

Rilda Canyon Creek is a tributary of Huntington Creek and is monitored according to the following schedule (see Hydrologic Monitoring Schedule included herein).

a.) Locations:

(1) Right Fork of Rilda - RCF1*
(2) Left Fork of Rilda - RCLF1 (Field data only)
(3) Left Fork of Rilda - RCLF2 (Field data only)
(4) Rilda Canyon - RCF2 (Field data only)
(5) Rilda Canyon - RCF3
(6) Rilda Canyon - RCW4 (refer to Volume 9 Map HM1).

*During mining of the North Rilda Leases, an additional site has been added upstream of RCF1 (adjacent to drill hole EM-163) to monitor surface/groundwater flow relationships. Flow will be measured yearly during base flow conditions.

b.) Flow information is collected during the first or second week of each month.

c.) Water samples will be collected and analyzed quarterly (one sample at low flow and high flow) during the first or second week of the quarter. Parameters analyzed are those listed in the DOGM Guidelines for Surface Water Operational Quality. The program was initiated in June 1989. Field measurements, including pH, specific conductivity, temperature, and dissolved oxygen, will be performed at the perennial stream locations, i.e., RCF3 and RCW4, monthly in conjunction with quantity measurements. Data regarding flow in Rilda Canyon Creek is presented in the annual Hydrologic Monitoring Report.

As stated above, flow information is collected monthly throughout the year with the use of three Parshall flumes and one V-notch weir (refer to Volume 9 Map HM1). Hydrographs comparing yearly flows are reported in the annual Hydrologic Monitoring Report and also as Figure HF33 in Volume 9 Hydrologic Section.

In accordance with the Hydrologic Monitoring Plan baseline quality analysis was conducted for a two year period; 1989-90, (refer to the respective Annual Hydrologic reports). Baseline analysis will be repeated once every five (5) years. Quality sampling was initiated in 1989; results of the samples collected are presented in Volume 9 Table HT7 and in the Annual Hydrologic Monitoring Reports.

Water quality samples taken below the confluence of the north and south forks of Rilda Creek have a mean TDS of about 400 mg/l and are of the Ca^{2+}-Mg^{2+}-HCO_3^- type (Appendix B Table 2). This water is mostly drainage from the Mill Fork ~~permit~~ Area. Water quality of Rilda Canyon deteriorates slightly from the upper reaches to the confluence with Huntington Canyon.

(2) Cottonwood Creek Drainage System

The western portion of East Mountain is intersected by Cottonwood Creek and its associated tributaries, including Cottonwood Canyon

Creek and Indian Creek. The Cottonwood Creek drainage is about equal in size to the Huntington drainage, with total discharge from each drainage about 70,000 acre feet per year. The major cultural feature on Cottonwood Creek is the Joes Valley Reservoir, located about twelve miles west of the town of Orangeville. The 63,000 acre foot reservoir was constructed by the U.S. Bureau of Reclamation and provides storage water for irrigation, industrial, and municipal needs in the Emery County area.

(a) Cottonwood Canyon Creek

An extensive baseline study conducted on Cottonwood Canyon Creek to determine water characteristics prior to mining at the proposed Cottonwood Mine began in 1979. A property acquisition in 1981 resulted in mine plan changes; therefore, the baseline study was terminated as of January 1, 1984. As agreed upon with DOGM, PacifiCorp will continue to monitor the flow and water quality field measurements at the USGS flume location on monthly basis (see Volume 9 Figure HF34).

The Cottonwood Canyon located south of the Mill Fork ~~permit~~ Area is a major drainage system where evidence of glaciation exists. From the headwaters to Section 24, Township 17 South, Range 6 East, the canyon is characterized by U-shaped valleys with associated lateral and terminal moraine deposits. Lateral moraine deposits most commonly occur at the intersection with side canyons. Terminal moraine deposits occur at the northwest corner of Section 24 and from this point to near the confluence with Straight Canyon the canyon can be characterized as a V-shaped valley with little evidence of glaciation. For a complete discussion on Cottonwood Canyon Creek drainage refer to Volume 9.

(b) Indian Creek

Indian Creek is a tributary of ~~Lowery~~ Lowry Water located in upper Joes Valley. Four permanent runoff sampling sites were established in 2000 and are sampled as listed below (see Hydrologic Monitoring Schedule included herein).

a.) Locations:

(1) Indian Creek Above - ICA
(2) Indian Creek Flume - ICF (Installed by Genwal Resources)
(3) Indian Creek Below - ICB

(4) Indian Creek Ditch - ICD (refer to Hydrologic Map MFS1851D)

b.) Flow information will be collected during base flow conditions at ICA, ICF, ICB and ICD.

c.) Water samples will be collected and analyzed during base flow sampling. Parameters analyzed are those listed in the DOGM Guidelines for Surface Water Operational Quality. Field measurements, including pH, specific conductivity, dissolved oxygen and temperature, will be performed in conjunction with quantity measurements.

As stated above, flow information will be collected during base flow conditions with the use of Parshall flume and a portable v-notch weir (see Hydrologic Map MFS1851D for locations). Hydrographs comparing yearly base flows will be shown in the Hydrologic Monitoring Reports.

Historical flow monitoring data collected by Genwal Resources at Indian Creek Flume (ICF) has been incorporated in PacifiCorp's hydrologic database and is included in Appendix C: Water Quality tab). In accordance with the hydrologic monitoring guidelines, baseline quality analysis was conducted for a two year period (2000 and 2001). Information from the baseline sampling is included in Appendix C: Water Quality tab. After the initial baseline period, additional baseline analysis will be repeated once every five (5) years.

Quality of Indian Creek is similar to the data collected in the Huntington Drainage. Quality remains relatively constant throughout the upper Joes Valley area. Indian Creek has mean TDS of about 270 mg/l and are Ca^{2+}-Mg^{2+}-HCO_3^- type with lesser amounts of SO_4^{2-} (refer to Appendix C: Water Quality tab and Table MFHT-5). Water quality of Indian Creek Ditch (ICD) is influenced by groundwater discharge from a series of springs throughout the length of the ditch and is slightly higher in TDS (average of about 410 mg/l) than Indian Creek.

2. Soil Loss - Sediment Yield

Sediment load concentrations in the area of the ~~permit~~ mine leases vary dramatically depending on the percentage of disturbed areas, ruggedness of the terrain, geologic formations present, the amount of precipitation the area receives, and stream flow volume.

Stream	Site No.	Date	Suspended Sediment	
			Concentration (mg/L)	Load (tons per day)
Huntington Creek (gaging station 09318000)	88	8-13-78	104	27
		11-17-78	72	2.5
		6-13-79	114	66
		8-7-79	44	15
Crandall Canyon (gaging station 09317919)	51	8-12-78	49	0.14
		11-18-78	60	0.08
		6-14-79	15	0.41
		8-6-79	56	0.15
Tie Fork Canyon (gaging station 09317920	67	8-13-78	12	0.03
		11-18-78	57	0.12
		6-14-79	38	0.68
		8-6-79	66	0.17
Bear Creek	81	10-25-78	8,860	1.90
Deer Creek	87	6-14-79	609	3.10
Cottonwood (gaging station 0932400)	104	8-15-78	5	0.003
		11-19-78	130	0.2
		8-5-79	63	0.09

As part of the U.S. Geological Survey water monitoring program in Utah coal fields (Open File Report #81359), fourteen water samples associated with the ~~permit~~ Mill Fork and Deer Creek mining areas were collected between August 1978 and September 1979 at gaging station 09318000 on Huntington Creek to determine suspended-sediment concentrations and loads. Three samples each were collected at gaging stations 09317919, 09317920, and 09324200 in Crandall and Tie Fork canyons and on Cottonwood Creek. Five additional samples were collected by project personnel from these and other streams in the study area. Representative suspended-sediment concentrations and loads of streams in the study area are listed below.

As indicated from the samples collected by the USGS, the suspended-sediment concentrations varied widely among the drainages analyzed. The relatively low concentrations of suspended sediment were attributed to well established channels, low flow periods, and a scarcity of roads. Higher concentrations appeared to be associated with the activities of man and erosion of large exposures of the Mancos Shale formation in the lower reaches of the drainages. Sediment concentrations generally increased with increased stream discharge. Note that the highest values at all of the locations occurred during the spring runoff period, but not enough data were available to compute daily sediment discharge.

PacifiCorp has collected samples on a quarterly basis from the streams within and adjacent to the ~~permit~~ Mill Fork Area. Samples taken at periods of both high and low flow have been tested for total suspended solids (TSS) to identify stream stability and are reported annually in the Hydrologic Monitoring Report.

Runoff from disturbed areas is diverted through sediment control facilities or protected from abnormal erosion. Each sediment control facility is sized according to calculated annual sediment accumulations (see Operational section of the individual permit applications for specific information on sediment yields from disturbed areas). Water discharged from the sediment pond facilities is monitored according to the stipulations set forth in the UPDES permits (refer Volume 9 Hydrologic Section Appendix B).

R645-301-723. SAMPLING AND ANALYSIS

Water quality sampling and analysis of samples collected by PacifiCorp will be done according to the "Standard Methods for the Examination of Water and Wastewater." Refer to Volume 9 Hydrologic Section Appendix A for sample documentation and analytical methods and detection limits.

R645-301-724. BASELINE INFORMATION

PacifiCorp maintains an extensive groundwater and surface monitoring program to characterize premining and any mining related impacts both to quality and quantity. As an integral part of the permit application, an annual Hydrologic Monitoring Report is prepared by PacifiCorp and submitted to appropriate government agencies. Baseline information for the East Mountain property will be divided into the following categories: 1) Groundwater and 2) Surface Water.

1. Groundwater

The characteristics of the groundwater resource are dependent upon the geology of the water-bearing strata and on the geology and hydrology of the recharge area. Groundwater movement and storage characteristics are dependent on the characteristics of the substratum. To characterize the baseline quality and to document the existence of seasonal variations, PacifiCorp developed a groundwater monitoring program which includes sampling both surface springs and in-mine groundwater sources. The program was initiated during a period from 1977 through 1979 for majority of East Mountain and during the year 2000 for the Mill Fork area. Routine monitoring continues to support the quality data collected during the initial phase. In general, data from the springs and in-mine sources are representative of the groundwater quality in the geologic strata from which the groundwater sources issue. Cation-anion diagrams have been utilized to depict the groundwater characteristics and to monitor quality trends (refer to Appendix C: Water Quality tab for cation-anion diagrams for the Mill Fork Area). Results of the data collected have shown that in both the surface springs and in-mine groundwater sources variations in quality from individual sources do exist, but the quality from the individual sources remains consistent with time. Spring water is mostly calcium-bicarbonate with some magnesium and sulfate. As discussed in the General Requirement Section - R645-301-711, quality decreases with increasing downward vertical movement and from north to south with sulfate becoming a major constituent. Cation-anion diagrams have been included in the Annual Hydrologic Reports to support the lack of seasonal variation.

2. Surface Water

The Mill Fork ~~permit~~ Area is drained by four major drainage systems: Crandall Canyon Creek, Mill Fork Creek, Right Fork of Rilda Canyon, ~~and~~ a series of un-named drainages in Joes Valley. PacifiCorp and Genwal Resources along with government agencies have documented that all of the streams emanating from within the ~~permit~~ lease area with the exception of Crandall Creek and the lower portion of Rilda Canyon cease flowing in the fall or winter, suggesting that they are not perennial but ephemeral. Flow in the drainage is a combination of snow melt and springs. Most of the runoff occurs during the months of April through July. Even though the drainage systems are ephemeral, except for Crandall Canyon and the lower portion of Rilda Canyon, variations in quality do exist. Total dissolved solids increase gradually in concentration as flow proceeds from the upper plateau areas to the confluence of the major drainages of Huntington and Cottonwood Canyons. Surface waters in the mine ~~permit~~ area are predominantly bicarbonate, calcium, and magnesium in the upper reaches with sulfate becoming a major constituent in the lower reaches. The increase in sulfate concentration is due to the influence of the Mancos Shale, a marine shale, which outcrops in the lower reach of each of the drainage systems. Seasonal total suspended solids variations also occur with the highest concentrations occurring during the initial runoff period.

R645-301-724.100. GROUNDWATER INFORMATION

A detailed description of the ownership of existing wells, springs, and other groundwater resources, including seasonal quality and quantity of groundwater and usage, is given in sections R645-301-721 and 722.

R645-301-724.200. SURFACE WATER INFORMATION

A detailed description of all surface water bodies, i.e., streams and lakes, including quality, quantity, and usage is given in section R645-301-722.

R645-301-724.300. GEOLOGIC INFORMATION
Applicable geologic information can be referenced in the Geologic Section of this Volume.

R645-301-724.400. CLIMATOLOGICAL INFORMATION
PacifiCorp operates a network of weather stations, including two at low elevations (Hunter and Huntington power plants) and two at high elevations (Electric Lake and East Mountain).

A. PRECIPITATION
The climate of the ~~permit~~ area has been described by the U.S. Geological Survey, which states that it is semi-arid to sub-humid and that precipitation generally increases with altitude. The average annual precipitation ranges from about ten (10) inches in the lowest parts of the ~~permit~~ mine plan area (southeast) to more than twenty-five (25) inches in the highest parts (northwest). PacifiCorp's weather station, located in Section 26, Township 17 South, Range 7 East, has provided data which shows that the summer precipitation in the form of thundershowers averages about the same as the winter precipitation in the form of snowfall. Because much of the summer precipitation runs off without infiltration, the winter precipitation has the greatest impact on groundwater.

Precipitation amounts have been and will continue to be recorded at the Hunter and Huntington power plants, at Electric Lake Dam, and on East Mountain. Precipitation data can be found in the annual Hydrologic Monitoring Report.

B. TEMPERATURES
Air temperatures vary considerably both diurnally and annually throughout the ~~permit~~ Mill Fork Area. Midsummer daytime temperatures in lower areas commonly exceed 100^{o} F, and midwinter nighttime temperatures throughout the area commonly are well below 0^{o} F. The summer temperatures are accompanied by large evaporation rates. Although not recorded, there probably also is significant sublimation of the winter snowpack, particularly in the higher plateaus which are unprotected from dry winds common to the region. Temperature information is collected at the PacifiCorp weather stations at each power plant, at Electric Lake, and on East Mountain. These data will continue to be included in the annual Hydrologic Monitoring Report.

C. WINDS
The winds in the area are generally variable. The wind rose presented in Volume 9 Figure HF36 displays the variability for the Meetinghouse Ridge area for January to December 1978.

R645-301-724.600. SURVEY OF RENEWABLE RESOURCES LANDS

Information describing the existing groundwater resources, including descriptions of ~~permit~~ local area aquifers and areas of recharge can be found in section R645-301-721. Impacts related to mine subsidence can be found in section R645-301-728.

R645-301-724.700. ALLUVIAL VALLEY FLOORS

Utah Regulations require that the presence of alluvial valley floors in or adjacent to the mine project area be identified. The regulations define an alluvial valley floor as "unconsolidated stream-laid deposits holding streams with water availability sufficient for sub-irrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by unconcentrated runoff or slope wash together with talus, or other mass movement accumulations, and windblown deposits." The alluvial valley floor is therefore determined to exist if:

1. Unconsolidated stream-laid deposits holding streams are present, and
2. There is sufficient water to support agricultural activities as evidenced by:
    a. The existence of flood irrigation in the area in question or its historical use;
    b. The capability of an area to be flood irrigated, based on streamflow, water yield, soils, water quality, topography, and regional practices; or
    c. Subirrigation of the lands in question, derived from the groundwater system of the valley floor.

A. SCOPE

The purpose of this section of the report is to examine the potential existence of alluvial valley floors in and adjacent to the areas to be affected by surface operations associated with the permit areas. It is divided into three parts. First, a general description of the surface operations and site disturbances associated with the permit areas is presented. Next, discussions of the characteristics of geomorphology and irrigation are presented. Finally, the conclusions of the alluvial valley floor determination are summarized.

B. SITE DESCRIPTION

Surface facilities associated with the permit area will consist of the portal area and associated facilities: for Deer Creek Mine - Deer Creek and Rilda canyons.

The climate of the general area is semi-arid to arid and continental. Daily minimum temperatures recorded at the East Mountain weather station in winter range from the average low of -6.3^{o} F to the maximum record low of -15.2° F, and daily maximum temperatures in summer range from the average high of 84.7° F to the maximum record high of 89.3° F.

Temperatures in the region tend to be inversely related to elevation. Average annual precipitation recorded for a 20 year period (1981-00) at the East Mountain weather station averaged 13.59 inches. Approximately fifty percent of the annual precipitation falls during the winter as snow with most of the remainder coming as summer thunderstorms.

C. ALLUVIAL VALLEY FLOOR CHARACTERISTICS

In this section of the report the various criteria for determining the existence of an alluvial valley floor are examined in relation to the overall ~~permit~~ mine plan and adjacent areas.

D. GEOMORPHIC CRITERIA

Alluvial deposits in and adjacent to the mine ~~permit~~ plan area have been mapped and reported in Doelling's "Wasatch Plateau Coal Fields, 1972." The report indicated that alluvia in the area are found solely along Huntington Creek below the Rilda Canyon confluence in the Huntington drainage system, in the Cottonwood drainage system along lower Cottonwood Creek and at the mouth of the North Fork of Cottonwood Creek, and in the Joes Valley drainage.

E. FLOOD IRRIGATION

Flood irrigation near the ~~permit~~ mine plan area is currently (and has historically been) confined to the alluvial areas of Huntington Creek approximately one mile below the confluence of Deer Creek and Huntington Creek. In the Cottonwood drainage system flood irrigation is currently, and historically, confined to the alluvial areas of lower Cottonwood Creek. No flood irrigation has historically been practiced on the narrow alluvium land upstream in the canyons opening to lower Cottonwood and Huntington Canyon creeks. The historic lack of flood irrigation in these steep, narrow canyons suggests that such activities are not feasible in the region. In addition, the topography is very steep and consequently not conducive to agricultural activities.

Water quality of Cottonwood and Huntington creeks is good. A detailed review of the surface water quality has been presented previously in this report and is updated each year in the annual Hydrologic Monitoring Report.

F. SUB-IRRIGATION

Some sub-irrigation of vegetation does occur on the alluvial valley floors. The sub-irrigated species (mainly cottonwoods and willows) are found along the channels of Cottonwood Creek and in the Joes Valley drainage above the reservoir and along the channels of Rilda Canyon and

Huntington Creek. This suggests that sub-irrigation is confined to the channel areas where the water table is near the surface.

G. ALLUVIAL VALLEY FLOOR IDENTIFICATION

Based on the foregoing analysis, the narrow canyons associated with the ~~permit~~ mine plan area cannot be considered to have an alluvial valley floor due to insufficient alluvium and the very limited area for supporting an agriculturally useful crop. The valley floor of Huntington Creek below the confluence with Deer Creek, however, can be classified as an alluvial valley floor due to the presence of both flood irrigation and limited sub-irrigation on the alluvium.

H. POTENTIAL IMPACTS OF ALLUVIAL VALLEY FLOORS

Very little potential exists for the mine operations to impact the Cottonwood and Huntington Creek alluvial valley floor due to the location of the operations in comparison to the alluvial deposits. All surface disturbances in the portal area will be protected by sediment control facilities and have been designed and constructed according to R645 standards in an environmentally sound manner.

The hydrologic monitoring program will help determine the actual impact of surface activities and aid in selecting mitigating measures, if necessary; however, it is believed that the overall ~~permit~~ mine plan area and associated activities will have no significant hydrologic impacts on the alluvial valley floor along Cottonwood and Huntington creeks. Details concerning the monitoring program are outlined in section R645-301-731.

R645-301-725. BASELINE CUMULATIVE IMPACT AREA INFORMATION

Hydrologic and geologic data required assessing the probable cumulative impacts of the coal mining and reclamation activities are presented in the Hydrologic (including the Annual Hydrologic Reports), Operational, and Reclamation sections of the Deer Creek permit application.

R645-301-728. PROBABLE HYDROLOGIC CONSEQUENCES (PHC) DETERMINATION

Probable hydrologic consequence determinations are based on extensive investigations conducted to determine existing groundwater and surface water resources along with ongoing hydrologic research and comprehensive monitoring programs including hydrologic and subsidence. Data utilized to arrive at the conclusions presented in this section were discussed earlier (see Section R645-301-721), and specific information pertaining to impacts to the hydrologic balance will be discussed under the appropriate section.

A. DESCRIPTION OF THE MINING OPERATION

The PacifiCorp mine ~~permit areas~~ operations are located in the central portion of the Wasatch Plateau Coal Field in Emery County, Utah. Generally, this area is a flat-topped mesa surrounded by heavily vegetated slopes which extend to precipitous cliffs leading to the valley below. Much data has been collected regarding the geology and the hydrology of the East Mountain property including the Mill Fork ~~permit~~ Area. In all, approximately ~~150~~ 232 drill holes have been completed from the surface, over 500 from within the mines; and a comprehensive hydrologic data collection program is ongoing, all of which have provided data used in this PHC. The most applicable data have been included in this document. For a review of additional data it is suggested that the reader refer to the annual Hydrologic Monitoring Report.

B. GEOLOGY

A detailed description of the geology (structure and stratigraphy) has been presented in a previous section and will not be duplicated here. (Refer to R645-301-600 Geologic Section of this Volume).

C. MINING METHODS

Mining of the Mill Fork Area was ~~be~~ conducted entirely by underground mining methods consisting of continuous miner and longwall techniques. Production from the Mill Fork Area ceased on January 7, 2015. Two mineable coal seams existed within the property. In ascending order they are the Hiawatha and Blind Canyon (refer to the Engineering Section). Inter-burden between the two seams ranges from approximately eighty (80) to one hundred twenty (120) feet. Based on the proposed mine plan, there ~~will be~~ were areas in each seam where one seam ~~will be~~ was mined, and an isolated area mainly within UTU-88554 where both seams ~~will be~~ were extracted. Thin coal ~~prohibits~~ prohibited mining in the southwestern portion of Sections 22 and 23 (T. 16 S., R 6 E.), and eastern half of Section 13 (T. 16 S., R 6 E.) and 18 (T. 16 S., R 7 E.). Multiple-seam mining ~~is projected to occur~~ has occurred in Sections 11, 12, 13 and 14 (T. 16 S., R 6 E.).

The chemical and physical properties of the overburden have been identified and described in the Geologic section of the permit application.

Because mining was ~~is~~ limited to underground mining techniques, only minor amounts of overburden directly in contact with the seam, either roof or floor, were ~~will be~~ removed during mining operations.

D. SURFACE WATER SYSTEM

A detailed description of the regional and ~~permit~~ mine plan area surface water resources have been presented in previous sections and will not be duplicated here. (Refer to R645-301-722). In general, the surface drainage system on East Mountain is divided into two major drainages; the southwest portion forms part of the Cottonwood Creek drainage, and the northeast portion contributes to the Huntington Creek drainage. The Huntington Creek drainage covers seventy percent (70%) of the East Mountain leases held by PacifiCorp. Both of these perennial streams are located adjacent to but not within the ~~permit~~ lease boundaries. PacifiCorp has observed that all of the streams emanating from within the Mill Fork ~~permit~~ boundary, with the exception of Crandall Canyon Creek, are either intermittent or ephemeral. Most of the streams are spring fed. PacifiCorp has monitored all of the surface waters since 1979 (except for Rilda Canyon, Mill Fork Canyon and Indian Creek, 1989, 1997 and 2000 respectfully) and will continue to monitor them in the future. The data collected is included in each annual Hydrologic Monitoring Report.

Impacts to surface water due to the underground operations of Deer Creek are minor, both in terms of quality and quantity. Due to the type of mining and relatively small areas of surface disturbance, surface water impacts are limited. Through the use of sedimentation ponds and the diversion of runoff from undisturbed areas around the surface facilities, impacts to surface waters are negligible. (See Volume 9 Appendix B for UPDES permit information.) One impact associated with the Deer Creek operations is mine dewatering. A detailed analysis of the associated impacts is described in the Hydrologic Balance section below.

E. HYDROLOGIC BALANCE - SURFACE WATER SYSTEM

As mentioned previously in this report, the major drainages conveying runoff away from the mine ~~permit~~ areas are streams in Crandall, Mill Fork, Rilda Canyons and un-named drainages in Joes Valley. With the exception of the very headwater regions of these drainage basins, mining and, therefore, subsidence will not occur beneath the major stream channels of these canyons. In the majority of cases, cracking due to subsidence is not anticipated to extend to the surface; therefore, surface runoff patterns will not be significantly affected. Data collected by PacifiCorp over a ~~twenty~~ thirty (~~2~~30) year period concerning subsidence and surface drainages has not detected any surface stream impacts. Consequently, subsidence should not cause significant impacts to the surface water system. Surface facilities are located in the following canyons:

Deer Creek Mine:	Deer Creek Canyon
	Rilda Canyon

Natural tributary flows are diverted around surface facilities. Surface runoff from disturbed areas is detained in sedimentation ponds prior to release. All discharge from the sedimentation ponds is sampled in accordance with the stipulations in the UPDES permits (see Volume 9 Appendix B).

Underground coal mines in the Wasatch Plateau Coal Field typically intersect groundwater from strata surrounding the coal seam. Mines operated by PacifiCorp; including Deer Creek, Wilberg/Cottonwood, and Trail Mountain mines have intersected quantities of water in excess of operational needs and therefore have discharged intercepted groundwater. Dewatering of Deer Creek, Wilberg/Cottonwood and Trail Mountain has had only a minor impact on surface quality and quantity on a regional basis; however, on a site specific basis the flow in Deer Creek and Grimes Wash has increased from premining conditions. During periods of high runoff changes in quality are insignificant; however, in low flow conditions some degradation is likely due to the fact that the mine discharge waters are higher in TDS than the surface waters. ~~It~~ The degradation is difficult to assess ~~the degradation~~ because it is not known from where or how much of the water discharged from the mine would naturally have been discharged into the receiving streams by natural groundwater flow. It is anticipated that mining in the Mill Fork ~~permit~~ Area will intercept groundwater similar adjacent operations (Deer Creek and Genwal Resources). The section below will describe the dewatering of Deer Creek and related surface impacts.

Deer Creek Mine

Excess water not utilized in the mining operation or for domestic use is either pumped to storage areas or discharged from the mine. (Quality and quantity is reported in the Annual Hydrologic Report.) The locations of the sump areas within the mine are shown in the Annual Hydrologic Report.

Inline flow meters are utilized to record the amount of water discharged from the mine, after which it passes through underground sedimentation sumps. Prior to December 1990 all of the water discharged from Deer Creek was piped directly to PacifiCorp's Huntington Power Plant. As of November 16, 1990, the State of Utah-Department of Health granted PacifiCorp a temporary discharge permit under a bypass agreement. On June 1, 1994, Department of Health granted PacifiCorp a site specific permit which included discharge from the Deer Creek Mine. Excess water not utilized in the mining operation or for domestic use is either pumped to storage areas or discharged to the Huntington Plant or Deer Creek drainage in accordance with stipulations of UPDES Permit Number UT0023604-02 (refer Volume 9 Appendix B for UPDES permit information).

F. MITIGATION AND CONTROL PLANS

Runoff from disturbed areas is diverted through sediment control facilities or protected from abnormal erosion. Any mine discharge will be routed through the underground sediment pond and reservoir in the old workings or specialized sump areas and will be monitored in accordance with UPDES permit standards and state and federal regulations. (See Appendix B for UPDES permit information.)

The effects of the mining operation on the surface water system will be analyzed through the surface water monitoring plan described below. In the event that monitoring shows that the surface water system is being adversely affected by mining activities, additional steps will be taken to rectify said impacts in cooperation with local, state, and federal regulatory agencies.

G. SURFACE MONITORING PLAN

A hydrologic surface monitoring program, initiated in 1979 (except for Rilda Canyon, Mill Fork Canyon and Indian Creek, 1989, 1997 and 2000 respectfully), has been underway at each of the surface monitoring stations shown on Hydrologic Map MFS1830D. Stations were established to monitor water quality and quantity above and below the mine ~~permit~~ areas. The parameters for laboratory analyses are those established by DOGM in "Guidelines for Surface Water Quality" (see Appendix A). Once baseline data have been collected (two year period), the surface sites described in the hydrologic monitoring schedule in Volume 9 Appendix A will continue to be monitored quarterly (when accessible) throughout the operational phase of the mine. The quarterly monitoring during the mine operational phase will include flow and quality to delineate seasonal variation and assess changes in water quality.

Future data may show that modifications of the monitoring schedule are justified. Any changes to the monitoring schedule (frequency or parameters) will be made only with the approval of DOGM. Results of all water quality data will be submitted to that agency quarterly, with an annual summary.

Postmining monitoring of surface water will continue at representative stations determined with the aid and approval of DOGM. Representative surface water stations will be monitored biannually during high and low flow conditions. Monitoring will continue until the release of the reclamation bond or until an earlier date to be determined after appropriate consultation with local, state, and federal agencies.

H. GROUNDWATER SYSTEM

Detailed descriptions of the regional and ~~permit~~ local area groundwater resources have been presented in previous sections and will not be duplicated here (refer to R645-301-722). In general, the majority of all natural groundwater discharge points located on the East Mountain property (including the Mill Fork ~~State Lease/UTU-84285~~ Area) are in the form of seeps and springs. PacifiCorp has mapped approximately one hundred ninety-eight (198) springs within and adjacent to the Mill Fork ~~permit~~ Area ranging in discharge from <1 gpm to as high as 145 gpm (see Spring Map MFS1831 and Appendix C).

PacifiCorp has collected an extensive database of information pertaining to the groundwater quality and quantities of the East Mountain region and adjacent areas. Included in the database is longterm quality and flow information both for springs and for groundwater intercepted by mining. In addition to the studies completed by PacifiCorp, Mayo & Associates was contracted in 1996 and 2000 to conduct comprehensive study to characterize the hydrology and hydrogeology of the East and Trail ~~m~~Mountains (refer to Volume 9 - Hydrologic Support Information No.11 and Appendix B of this section). The hydrogeology of the PacifiCorp leases were ~~elevated~~evaluated by analyzing: 1) solute and isotopic composition of surface and groundwaters, 2) surface and groundwater discharge data, 3) piezometric data, and 4) geologic information. The following is summary of the conclusion of this study (refer to Volume 9 Hydrologic Support Information No. 11 and Appendix B of this section for complete details):

Conclusions from Mayo & Associates Hydrologic Investigation

1. The δ^2H and δ^{18}O compositions demonstrate that all groundwaters are of meteoric origin (i.e. snow and rain).
2. Active and inactive groundwater regimes occur in the mine lease area.
3. The active regime includes alluvial groundwater, groundwater in the Flagstaff Formation, and all near surface exposures of the other bedrock formations except, perhaps, the Mancos Shale. The near surface extends about 500 to 1,000 feet into cliff faces. Groundwaters in the active regime contain abundant ^{3}H and anthropogenic ^{14}C.
4. Comparison of long-term discharge hydrographs with precipitation records demonstrates that active regime groundwaters: 1) are in direct hydraulic communication with the surface, 2) are recharged by modern precipitation, and 3) have large fluctuations in spring discharge rates which can be attributed to seasonal and climatic variability. High-flow/low-flow discharge rates vary as greatly as 600 gpm to nearly dry; however, most high flow rates are less than 50 gpm.
5. Despite the seasonal variability in discharge rates, the solute concentrations of active region groundwaters do not exhibit significant seasonal variability.
6. The inactive regime includes groundwater in sandstone channels in the North Horn, Price River, and Blackhawk Formations which are not in direct hydraulic communication with the surface (i.e. greater than about 500 to 1,000 feet from cliff faces). Mine workings are largely part of the inactive regime. The sandstone channels are vertically and horizontally isolated from each other and when encountered in mine workings are usually drained quickly. Coal seams are hydraulic barriers to groundwater flow. The blanket sands of the Star Point Sandstone are also largely in the inactive zone. Except where exposed near cliff faces, faults encountered in mine workings are part of the inactive regime. Except near cliff faces, faults are not conduits for vertical hydraulic communication between otherwise hydraulically isolated pockets of groundwater.
7. Inactive region groundwater systems contain old groundwater (i.e. 2,000 to 12,000 years), and are not influenced by annual recharge events or short term climatic

variability.

8. In-mine inactive regime groundwaters occur in nearly stagnant, isolated zones which have extremely limited hydraulic communication with other inactive regime groundwaters in the vicinity of mine workings and with near-surface active regime groundwaters as evidenced by the following:

a) Groundwaters discharging into mine openings have ^{14}C ages ranging from 2,000 to 12,000 years

b) Roof drip rates rapidly decline when water is encountered in the mine indicating that the saturated zone above the coal seam is not hydraulically continuous and has a limited vertical and horizontal extent.

c) Unsaturated conditions have been identified in boreholes drilled vertically into sandstone channels located above coal seams.

9. The fact that inactive region groundwaters encountered in mine openings do not have an infinite age means that, at some time, there has been some hydraulic communication with the surface. This communication is extremely limited as illustrated by calculated steady state recharge-discharge rates of faults and sandstone channels in the inactive zone which range from 0.001 to 1.23 gpm.

10. Groundwater in the Star Point Sandstone is part of the inactive regime as evidenced by the 6,000 year ^{14}C age of the sample from well TM-3. In the down dip direction along the axis of the Straight Canyon Syncline, potentiometric pressures in the Spring Canyon member results in upwelling of groundwater into Hiawatha seam mine openings. Such upwelling may locally reduce the pressure in the Spring Canyon member.

11. Areally extensive groundwater regimes in the lower Blackhawk Formation and Star Point Sandstone do not exist within the lease area. Therefore, it is not meaningful to create piezometric surface maps of these systems.

12. Streamflow is dependent on snow melt, precipitation and thunderstorm activity. There is no apparent hydraulic communication between streamflow and groundwater encountered in mine openings.

13. The groundwater discharging into the Rilda Canyon alluvial collection system is of modern origin and is closely tied to seasonal recharge. This is evidenced by its modern radiocarbon and ^{3}H contents and by the discharge hydrographs. The alluvial groundwater is not related to the groundwater encountered in the mines.

14. The groundwater discharging in Cottonwood Canyon near Cottonwood Spring and Roans Spring discharges from glacial deposits and is of modern origin. The radiocarbon and ^{3}H contents of this water indicate a modern origin. The water in the shallow glacial deposits is not related to the groundwater encountered in the mines.

The USGS has conducted extensive studies to determine the regional groundwater system for the central Wasatch Plateau Coal Field. The studies indicate a regional aquifer exists in the coal-bearing sequence of the Blackhawk and the underlying Star Point Sandstone formations. The studies have also concluded that several isolated or perched aquifers existed above the Blackhawk/Star Point Sandstone aquifer. PacifiCorp agrees with conclusions of the USGS studies concerning the perched aquifers above the coal-bearing sequence of the Blackhawk Formation but has some reservations about the significance of the Blackhawk/Star Point Sandstone aquifer which will be discussed below. The majority of the groundwater is discharged from the perched aquifers which occur along the base of the North Horn Formation in the form of seeps and springs (refer to ~~Spring~~ ~~Hydrologic~~ Map MFS183~~1~~0D). Several other perched aquifers exist mainly along the formational contacts with the North Horn Formation, including the upper contact with the Flagstaff Limestone and the lower contact with the Price River Formation.

The majority of the groundwater recharge on East Mountain comes from the winter snowpack which melts and infiltrates into the surface of East Mountain. The water flows down vertical fractures which intersect sandstone channel systems in the North Horn and Blackhawk formations. The majority of the groundwater reaching this point intersects the surface in springs located in the North Horn Formation. Very little recharge intersects the Price River Formation and Castlegate Sandstone sandstones; consequently, they are not water saturated where intersected in the numerous drill holes penetrating those units.

The hydrogeologic characteristics of the coal-bearing Blackhawk and overlying formations effectively limit the extent of impacts to the hydrologic system. Impacts to water quality are negligible and may be slightly beneficial. As discussed previously, two separate aquifers-water bearing zones occur on the East Mountain property: 1) perched aquifers associated mainly with the North Horn Formation, and 2) Blackhawk-Star Point Formation, which exhibits limited potential as a property wide, water saturated zone. The following hydrologic balance section will segregate the two zones and describe the significance and possible impacts to each zone.

I. HYDROLOGIC BALANCE - GROUNDWATER

Mining within the Mill Fork ~~permit~~ Area will have negligible impact on the regional hydrologic balance, but there could be some possible local impact. This section discusses the possible mining-related impact on the hydrologic balance due to 1) subsidence - perched aquifer systems, 2) mining in the Rilda Canyon area - NEWU~~A~~SSD springs, 3) mining in the Mill Fork area - Little Bear Spring, and 4) interception of groundwater by mine workings.

1. Subsidence: Perched Aquifer Systems above the Mine Horizon

As discussed earlier, most of the groundwater in the ~~permit~~ mine plan area discharges in the form of seeps and springs. Springs issuing from the perched groundwater in the Flagstaff Limestone throughout the Blackhawk formations will only be impacted by mining activities if fracturing from subsidence reaches upward into these formations and is not sealed by swelling or fracture filling from plastic mudstones. As discussed earlier, the majority of springs on the East Mountain property (including the Mill Fork area) are associated with the North Horn Formation. As discussed in the regional groundwater characteristics section, the North Horn Formation is comprised of a variety of rock types which range from highly calcareous sandstone to mudstone. Lenticular sandstone channels are often present in the upper and lower portion of the formation. Water which percolates down fractures from the overlying Flagstaff Limestone works its way into the sandstones, forming the perched water tables. The actual lateral extent, or correlation, between the perched water tables has not been identified; and it is not practical to do so because the tables are limited in extent and variable in stratigraphic location. Many springs have been identified where sandstone channels intersect the land surface. A Spring Geologic Conditions Inventory sheet has been completed for each spring inventoried on the East Mountain Property and can be found in Appendix C.

The lower two thirds (upper Cretaceous in age) of the formation is generally highly bentonitic mudstone which is impermeable. It is likely that this material is acting as an aquiclude, preventing adequate recharge from reaching the Price River Formation or Castlegate Sandstone Sandstone below. The mudstones present appear to swell when they come in contact with water; therefore, vertical migration of water along fractures through this material is limited because the fractures are sealed by the swelling clays. To identify and verify the existence of these bentonitic-plastic type mudstones, PacifiCorp conducted a special surface drilling program in 1989 to determine the rock strength and lithologic characteristics of the overburden on the East Mountain property. The entire sequence of the formations which are present on the East Mountain property, from the Flagstaff through the Star Point Sandstone Formation, was penetrated using two drill holes, identified as EM136C and EM137C. Drill hole EM136C penetrated the Flagstaff Limestone and the upper 200 feet of the North Horn Formation. Hole EM137C penetrated the lower portion of the North Horn Formation through the upper Star Point Sandstone Formation (refer to Volume 9 Hydrologic Support Information: No.8). Previous East Mountain surface exploration programs have experienced swelling and caving problems associated with plastic mudstone zones located in the upper and lower portions of the North Horn Formation. Regional as well as property wide drilling, along with limited accessible outcrop data, has shown that even though projecting the lateral extent of individual lithologic units is not practical, the basic lithologic characteristics of the North Horn Formation are consistent on regional and ~~permit~~ local area bases. Drilling of EM136C and 137C confirmed existence of soft, plastic type mudstones which form an aquiclude, preventing significant recharge to the lithologic units below the North Horn Formation. Field investigations have shown that even along major fault systems, i.e., Pleasant Valley and Roans Canyon, vertical migration is interrupted by the lithologic characteristics of the North Horn Formation, forming springs along the fault traces. Examples of springs of this type are shown on Volume 9 Table HT1 and Map HM4.

The depth of the aquifers in the North Horn Formation is variable due to the rugged topography.

The localized perched water tables may either intersect the surface of the ground or be covered by as much as 1,000 feet of overburden. They are located at least 1,400 feet above the coal seam to be mined. Communication of water between the perched aquifers in the North Horn Formation and the water flowing into the Deer Creek Mine is limited in quantity and occurs very slowly.

Studies conducted by PacifiCorp, along with independent governmental research have concluded that impacts to the perched aquifers have been negligible (refer to 1). Annual Hydrologic Monitoring Reports, 2). Supplemental Volume 1, Phase I, II, and III Lease Relinquishment Information for the Cottonwood/Wilberg Mine, C/015/019, Deer Creek Mine, C/015/018, and Des Bee Dove Mine C/015/017, Emery County, Utah, and 3). United States Department of Interior: Bureau of Mine Information Circular 9405). As stated in IC9405; the Bureau of Mines evaluated the hydrologic and overburden failure data to assess the response of local ground water to underground coal mining in single- and multiple-seam conditions. Surface subsidence did not appear to play a major role in response of springs at this site. The lack of observed responses was attributed to geologically driven site-specific conditions that buffered the effects of mining. These conditions included thickness of overburden, presence of hydrophilic clays and estimated elevation of fracturing.

To identify any mining related impacts to the perched aquifer systems above the mine horizon PacifiCorp monitors a significant number of springs which have been undermined or will be undermined within the next five years (see Hydrologic Monitoring Schedule in Appendix A and Hydrologic Monitoring Map MFS1851D). A field verification meeting will be held each year with the government agencies involved to determine if changes in the springs monitored are required. Each year in the annual Hydrologic Monitoring Report spring flow rates will be compared to East Mountain climatology as to how closely spring discharge follows local annual precipitation or to verify any mining related impacts.

2. Mining in the Rilda Canyon Area-NEWUA~~A~~SSD Springs

As discussed in R645-301-721, North Emery Water Users ~~Association~~ Special Services District (NEWU~~A~~SSD), a major concern to PacifiCorp is the proximity of proposed mining activities in Rilda Canyon to the Rilda Canyon springs. Probable hydrologic consequences of mining in the vicinity of the Rilda Canyon Springs is described in Volume 9 Hydrologic Section and will not be repeated here. Mitigation alternative information for Rilda Canyon Springs can be found in Volume 9 Appendix D.

3. Mining in the Mill Fork Area - Little Bear Spring

The potential for mining activities to impact Little Bear Spring is believed to be minimal for several reasons. First, the spring is located one and one half (1½) miles from the Mill Fork ~~permit area~~ lease UTU-88554 and more than two miles from the nearest proposed mining activities (refer to Hydrologic Monitoring Map MFS1851D). Second, Little Bear Spring discharges from an active zone groundwater system that is in good communication with shallow recharge sources. These types of groundwater systems are isolated from the deep, inactive zone groundwater systems encountered in area coal mines.

Although the headwaters of the Mill Fork drainage ~~is~~are within the Mill Fork ~~permit~~ Area, the potential for adversely affecting surface waters in the drainage is remote. In those areas in the headwaters region that are proposed for full extraction mining, the stream channel resides primarily on the North Horn and Price River Formations (Appendix B Figure 5). The thick sequence of relatively low permeability rock that separates the mined horizon from the stream channel effectively prohibits the downward migration of surface water and groundwater into deeper horizons. Thus, the potential for diminished flow in Mill Fork Creek, and corresponding decreases in the recharge to Little Bear Spring, is minimal (for alternative mitigation information related to Little Bear Spring refer to R645-301-731.530).

PacifiCorp cooperated with Huntington City, Elmo City, Cleveland City and CVSSD in developing a comprehensive mitigation plan. The agreement was signed on July, 2004. As part of the agreement, PacifiCorp constructed a water treatment plant in 2005 located near at the existing Huntington City plant in Huntington Canyon. The mitigation agreement information is found in Appendix D of Volume 9.

4. Interception of Groundwater by Mine Workings

As previously discussed in this section, the Blackhawk Formation consists of inter-bedded layers of sandstone and mudstone separated by various mineable and non-mineable coal seams. The sandstone beds-fluvial channel systems are generally massive while the mudstone layers are fine textured and have a tendency to swell when wet and decompose into an impervious clay. Because of the aquiclude formed by mudstone layers in the North Horn Formation, recharge to the Blackhawk Formation is limited, even along major fault systems. Due to the lithologic characteristics of the Blackhawk, both vertical and horizontal migration is constricted.

The interception of groundwater varies and is dependent on several factors. One of the most significant is that when the mine enters virgin country, a significant amount of water is liberated. In virtually all cases the amount of water which flows into the mine exceeds the recharge and, in time, the water inflow decreases in volume. If new areas are not mined, the discharge from the mine will decrease accordingly. As reported in the annual Hydrologic Monitoring reports, flow rates for individual areas including fault zones normally decrease to less than ten percent of the initial flow rate. (Historical information can be found in the annual Hydrologic Monitoring reports.)

Long term monitoring of water producing zones in both Deer Creek and Wilberg/Cottonwood mines has established that once base flow has been reached, the flow is consistent over time. Monitoring has not indicated any seasonal or yearly variations (see annual Hydrologic Monitoring reports for in-mine long term flow information).

As pointed out by Theis (1957, p. 3), water discharged from a well or, in this case, underground mines, must be balanced by 1) an increase in recharge to the groundwater system, 2) a decrease in natural discharge from the system, or 3) a decrease of groundwater in storage, or by a combination of all of these. As hydrologic studies have shown and monitoring of intercepted groundwater has verified, recharge into the underground workings is limited even in areas of faults and fractures. Based on the hydrologic characteristics of the Blackhawk and the underlying Star Point Formation (low porosity and hydraulic conductivities) and data from surface hydrologic monitoring, decrease in the natural discharge of the system is considered to be only a minor factor; therefore, groundwater intercepted in the ~~permit~~ mine plan area is believed to be from storage. One factor which verifies this conclusion is rapid dewatering of intercepted groundwater with no apparent change in the surface hydrological system. As the USGS pointed out in Open File 81539 and monitoring by PacifiCorp has shown, the majority of surface flow is due to the runoff from the winter snowpack and not from groundwater recharge. It is possible that over a long period of time the groundwater system of the Cottonwood and Huntington Creek drainage systems could be impacted from a slight reduction in recharge; but this is more than offset by the interception of the groundwater, especially in terms of quality, which will be discussed later.

a. Depletion Of Storage

Two main areas-types of groundwater depletion are projected to occur within the Mill Fork ~~permit~~ Area and will be discussed separately, 1) fluvial sandstone channel systems, and 2) geologic structures; including folding, faults and fractures.

(1) Fluvial Sandstone Channel Systems

In the Deer Creek Mine sandstone channels (ancient river systems) overlie and scour into the underlying strata (refer to Volume 9 Maps HM2 and HM3 updated annually in the Hydrologic Monitoring Reports). Based upon drilling results, similar geologic conditions are projected to occur in the Mill Fork ~~permit~~ Area. These channel systems were part of a deltaic depositional setting active during and after the coal forming peat accumulation. The largest influx of water originates from the roof when mining advances beneath sandstone top. The sandstone, which is semipermeable and porous, affords an effective route of water transport. Mudstone, siltstone, and interbedded materials generally act as aquicludes which impede water flow unless fracturing of the formation has allowed for secondary permeability. Of the water producing areas, those closest to the active mining face exhibit the greatest flows. As mining advances, the area adjacent to the active face continues to be excessively wet and previously mined wet areas experience a decrease in flow. Data collected by PacifiCorp indicates a ninety percent reduction in water flows from roof sampling sites over a five month period (or less) as the mining face is advanced (review annual Hydrologic Monitoring reports). It has also been noted that the outermost entries of a multiple entry system remain wet for a longer period of time than the inner entries. It appears that the water source is being dewatered since excavated areas of the mine do not continue to produce water indefinitely. The water source must be either of limited extent, i.e., a perched aquifer, or have a limited recharge capacity, i.e., poor horizontal and vertical permeability (refer to Volume 9 Figure HF42 depicting an idealized view of the dewatering process).

As documented in Appendix B, in-mine groundwater occurs in isolated, inactive systems as demonstrated by the small ^{3}H content and radiocarbon ages of mine waters which range from 2,000 to 19,000 years (Appendix B Table 5), with the exception of two sites which are discussed below. This indicates that in-mine waters are not in hydraulic connection with near-surface spring waters that respond to seasonal and climatic changes and contain anthropogenic carbon and appreciable amounts of ^{3}H.

(2) Geologic Structures Including Folding, Faults And Fractures

Folding: Strata in the Mill Fork Area are gently folded in two broad structural features. The Flat Canyon Anticline crosses the southeastern portion of the ~~permit~~ lease area. This anticline trends southwest to northeast, and plunges to the southwest. Dips in the anticline range from two to six degrees with the south limb dipping the steepest. To the north, the north limb of the Flat Canyon Anticline becomes the south limb of the Crandall Canyon Syncline, a flat-bottomed syncline. This syncline also trends southwest to northeast. Dips on the northwest side are much steeper than on the southeast side.

Groundwater inflow related to folding has been minimal in the vicinity of the Mill Fork ~~permit~~ Area, except for the western portion of the Trail Mountain Mine located approximately nine miles to the south of the Mill Fork ~~permit~~ Area. A major geologic structure known as the Straight Canyon Syncline bisects the Trail Mountain Mine area. Gradient from the portal area to western portion of the mine was in excess of nine hundred feet in a distance of approximately three miles. The trough of the Straight Canyon Syncline can be observed at the Joes Valley Dam. Drilling along the trough of the syncline intercepted artesian flow (refer to Trail Mountain Permit: Hydrologic Section for discussion of well TM-3 located in Section 3, Township 18 South, Range 6 East). As mining progressed to the west in the Trail Mountain Mine, groundwater inflow was encountered related to depressurization of the Star Point Sandstone.

As stated above, the strata in the Mill Fork area are gently folded in two broad structural features with overall gradients across the lease of approximately one hundred feet in a distance of approximately three miles. Exploration drilling has been conducted along the trough of the

Crandall Canyon Syncline on the eastern and western boundaries of the lease (refer to map MFU1828D). Drilling conducted by PacifiCorp has not detected measurable groundwater inflow from the lower Blackhawk/Star Point formations (refer to R645-301-600 Appendix B). Personnel communications with representatives of Genwal, hydrologic studies conducted at the Genwal Mine (refer to Genwal MRP: Hydologic Section) and observations of the mine verify that interception of groundwater related to the depressurization of the Star Point Sandstone is minimal.

As stated earlier, Little Bear Spring is located in Little Bear Canyon along the base of the Crandall Canyon Syncline. Little Bear Spring discharges from active zone groundwater system that is in communication with shallow recharge sources. These types of groundwater systems are isolated from the deep, inactive zone groundwater systems encountered in the coal mines. PacifiCorp's Hydrologic Monitoring Program has been specifically designed to monitor potential impacts to the lower Blackhawk and Star Point Sandstone formations with the inclusion of springs MF-213 and Little Bear Spring (refer to map MFU1851D and Appendix A).

Faults and Fractures: Groundwater inflows associated with the Roans Canyon Fault system have occurred in the Deer Creek Mine and the Joes Valley Fault in the Crandall Canyon Mine. Hydrologic concerns regarding fault inflows are; 1) the capture of water supplying baseflow to creeks or springs, and 2) the discharge of fault-related water to creeks. In general, we do not believe that fault-discharge waters are tied to active, modern groundwater systems. However, locally fault related groundwater inflows, associated with the Roans Canyon and Joes Valley faults, have hydraulic communication with the surface as evidenced by their ^{3}H contents. Wells drilled into and near the fault systems demonstrate that there is limited lateral communication along the fault system and the radiocarbon age most fault-discharge waters are 2,500 or more years. Mining within 200 to 300 feet of the Joes Valley Fault could intercept appreciable quantities modern near surface water. For a complete discussion of faults and fractures of the Deer Creek Mine southeast of the Mill Fork ~~permit~~ Area refer to Volume 9 Hydrologic Section - PHC).

To prevent interception of groundwater from the Joes Valley Fault, the Forest Service included Stipulation #19 to the Special Coal Lease Stipulations. It states, " *Except at specifically approved locations, mining that would cause subsidence will not be permitted within a zone along the Joes Valley Fault determined by projecting a 22 degree angle of draw (from vertical) eastward from the surface expression of the Joes Valley Fault"* . A buffer zone entitled "Joes Valley Fault Buffer Zone", (22 degree angle of draw from the lowest coal seam - Hiawatha), is indicated on all maps associated with the Mill Fork ~~permit~~ Area.

On January 25 (revised March 20), 2006, PacifiCorp filed an application for a federal coal lease by application (LBA) for access to unleased federal coal adjacent to ~~the Mill Fork State Lease~~ UTU-88554. The serial number assigned to this LBA is UTU-84285.

Leasing of the Mill Fork West Extension Tract, serial number UTU-84285, would encourage and enable the greatest ultimate recovery and conservation of this natural resource, while promoting full development of the economically recoverable coal located between the western lease line of ~~the Mill Fork State Lease ML-84258~~ UTU-88554 and the Joes Valley Fault zone which would otherwise become subject to bypass. This would be accomplished by allowing westward mine development and extraction beyond the existing Mill Fork western lease boundary until mining advancement is terminated due to the actual location of the Joes Valley Fault (refer to R645-301-600 Geology Section for a complete discussion of the location of the Joes Valley Fault).

Mining in the Federal Lease UTU-84285 area ~~will~~ consisted of longwall gateroads, setup and bleeder entries. First mining ~~will be~~ was conducted with continuous miners. Longwall gateroads were ~~will be~~ extended to the west but in no case did ~~will~~ second/full extraction mining occur within the Joes Valley buffer zone. The Joes Valley buffer zone was established during the NEPA process to prevent interception of groundwater from the Joes Valley Fault. No pillars were ~~will be~~ removed within the Joe Valley buffer zone during mining within the UTU-84285 area, and therefore no subsidence ~~will~~ occurred.

In an effort to minimize interception of groundwater from the Joes Valley Fault, as mining in the longwall gateroads approaches within 200 feet of the projected location of the fault, an underground drill ~~will be~~ was set up in the western extent of each continuous miner section development and exploration holes were drilled roughly perpendicular to the known fault trend until they intersect the fault zone. ~~The holes will be drilled slightly upward at the start to aid circulation. The holes will be roughly 3" in diameter.~~ Drilling results were ~~will be~~ examined by a professional geologist for evidence of faulting, fracturing, and water influence (weathering). Presence of faulting was ~~be~~ determined by fault gouge, weathering, and/or sudden lithologic change. This is a large displacement fault, fault gouge should ~~be~~ have been significant.

Precautions against water inflow ~~will~~ included cementing at least 10 feet of "surface" casing with a full flow valve, through which the hole was ~~ill be~~ drilled. ~~This will allow shutting the valve in the event of large water inflows.~~ No~~If~~ significant water ~~is flowing at the time of completion of the hole, the hole will be cemented to prevent continued~~ inflows ~~of water~~ were observed.

If faulting ~~is~~ was encountered prior to reaching the planned bleeder entries, mining ~~will~~ was to be terminated and the bleeder entries ~~will be~~ relocated. At least 50 feet of solid coal ~~will be~~ was left between the bleeder entry and the fault. ~~Energy West~~ PacifiCorp would have ~~will~~ notified ~~y~~ DOGM and the surface management agency immediately if substantial water (greater than 50 gpm) ~~is~~ was produced from the drill holes, entries or the Joes Valley Fault. Horizontal drilling has delineated the fault along its entirety on the west side of the UTU-88554 area. Gateroad entries and bleeder developments were completed adjacent to the fault according to the permit stipulations as of August, 2013. No fault intercepts were made by mine workings, and no significant groundwater inflows were encountered.

Mining in the Genwal Mine located to adjacent to ~~the Mill Fork State Lease~~ UTU-88554 provided hydrologic information related to the Joes Valley Fault. Minor quantities of groundwater were intercepted in entries which penetrated the fault (Genwal Main West -Mine visit by Chuck Semborski and Ken Fleck) and in drill holes within UTU-77975 (personal communication with John Lewis - Genwal Mine engineer). ~~Although significant groundwater has not been intercepted by mining near the Joes Valley Fault, Energy West has developed an emergency plan contend with interception of groundwater as a preventative measure. The plan consists of the following:~~

1) ~~Notify governmental agencies.~~
2) ~~Remove all mining equipment.~~
3) ~~Erect two solid concrete block seals at least 2 feet apart with appropriately sized de-watering pipe with valve at the bottom of the seal.~~
4) ~~Quick dying cement will be pumped into the space between the two seals.~~
5) ~~After the cement has cured, the de-watering valve will be closed.~~

b. Quality

The mines in the coal fields of the Wasatch Plateau tend to act as interceptor drains. The groundwater that is brought to the surface has a lower dissolved solids content than would have existed were the water to continue its downward movement through shale layers, dissolving increased amounts of salt with distance (Southeastern Utah Association of Governments, 1977; Vaughn Hansen Associates, 1979; Danielson et al., 1981).

Additional studies by PacifiCorp have confirmed the primary findings of the USGS concerning regional trends in quality. Originally, ~~decreasing~~ deteriorating quality from north to south was believed to depict the groundwater flow direction, and the quality ~~decreased~~ deteriorated as a function of the time it traveled through the strata. The time travel component is probably an important factor. But in 1985 a surface exploration program identified the existence of an area of residual heat from an ancient burn on the outcrop throughout the southern portion of East Mountain. The high temperature was also explored within the mine and a portion of reserves were lost because of the situation. It is now theorized that the high temperature water dissolved the mineral constituents of the formations, thereby altering the water chemistry. The quality also ~~decreases~~ deteriorates vertically downward because of the influence of marine sediments as well as along the trend of decreasing quality from north to south.

c. Quantity

As stated earlier, interception of groundwater varies and is dependent on several factors. One of the most significant is that when the mine enters virgin country, in some areas significant amounts of water are liberated. Mining quickly dewaters the saturated horizon immediately above the mined horizon and this water is not replaced as evidenced by the rapid decline and often complete drying of roof drips. In-mine groundwater occurs in isolated, inactive systems as demonstrated by the small ^{3}H content and radiocarbon ages of mine waters which range from 2,000 to 19,000 years (refer to Appendix C: Table 5). This indicates that in-mine waters are not in hydraulic connection with near-surface spring waters that respond to seasonal and climatic changes and contain anthropogenic carbon and appreciable amounts of ^{3}H.~~s~~

Based on data collected by PacifiCorp, discharge of intercepted groundwater from the Mill Fork Area was ~~has~~ been similar to that of the Deer Creek Mine and adjacent Genwal Mine. Discharge from the these ~~to~~ mines range from ~~650~~ 500 to 1,500 gpm (Deer Creek Mine average discharge ranged from 1,000 to 1,500 gpm [Energy West Mining Company ~~2001~~ Annual Reports], discharge from the Genwal Mine ~~averages~~ averaged approximately ~~650~~ 900 gpm [~~Genwal 2000 Annual Report~~ data received from UtahAmerican Energy - Crandall Canyon Mine Flows]). All of the intercepted groundwater from the southern portion of the Deer Creek Mine will be ~~discharge~~ discharged to the Deer Creek drainage system. Intercepted groundwater from the Mill Fork Area will be routed to the Rilda Canyon 1st Right Portals and piped directly to the Huntington Power Plant Settling Pond. Discharge from the Deer Creek Mine will be monitored as specified in the UPDES permit (refer to Volume 9, Appendix B).

d. Post Mining

The monitoring of in-mine water sources has shown that the long term water flow from a given area is much less than ten percent (10%) of the initial flow from the area. Most of the current inflow into the mine workings is from areas where water storage has not been depleted. After the storage has been depleted, the flow will reduce to roughly equal the recharge rate which is expected to be less than ten percent (10%) (data presented earlier in this report) of the current discharge rate. Prior to the termination of production (January 7, 2015), ~~The current~~ discharge rate from the Deer Creek Mine averaged approximately 1000 to 1500 gpm; therefore, the postmining discharge rate is expected to ~~be approximately~~ diminish to 100 to 150 gpm. For verification purposes, PacifiCorp has monitored selected areas of the mine to formulate discharge recession curves over time, enabling a better understanding of the ratio of initial discharge rates and long-term post mining discharge values (discharge recession curves from long-term in-mine water sources can be found in Volume 9 - Hydrologic Support Information, In-Mine Discharge Recession Curves).

Deer Creek Mine portals were sealed April 17, 2015 as a facet of the Deer Creek mine closure process. All mining equipment including the mine dewatering system was removed from the mine prior to sealing. Withdrawal of all mining equipment inby the parallel plug locations commenced upon completion of mining (refer to Map DS1902D for mine closure sequencing, Comprehensive Environmental Response, Compensation, and Liability Act inspections [equipment removal] and areas of belt structure removal). PacifiCorp coordinated removal of the mining equipment, including conducting environmental inspections, with the subsurface management agency and State of Utah regulators. A double redundant French drain system (two separate well screen intake setups installed in two separate portals) was installed in the two lowest elevation portals at the Deer Creek Mine site to allow for a permanent post mine gravity discharge of groundwater from the southern portion of the mine. Intercepted groundwater from the Mill Fork Area will be diverted to the Rilda Canyon 1st Right portals. Similar to the structures at the Deer Creek portals, a double redundant French drain system (two separate well screen intake setups installed in two separate portals) are proposed for the Rilda Canyon 1st Right portals. Gravity discharge from the Deer Creek and Rilda Canyon portals will resume after the mine floods to the elevation of the portals discharge structures (refer to Volume 12 Engineering Section, Figures R645-301-500D). ~~There is no reason to assume the~~ Postmining discharge water quality ~~will differ from that currently being discharged~~ is predicted to be consistent with pre-closure analysis, except for Total Iron which will be detailed below (see Groundwater Quality section for pre-closure analysis). The cumulative effect of discharge water on the receiving stream will be insignificant based on data collected from Deer Creek and in comparison to flow differential.

Post Mining Water Quality Analysis – Total Iron:

PacifiCorp is aware of the elevated iron content of the mine water discharge from the adjacent sealed Genwal Mine. Based on published reports and testimony before the Board of Oil, Gas and Mining (December 2011, Docket No. 2010-026), the elevated iron concentrations are attributed to the oxidation of pyrite or sulfide minerals in the flooded portions of the mine.

PacifiCorp agrees with Peterson Hydrologic that the situation encountered in Genwal and a portion of the Deer Creek Mine is unique geologic occurrence and is spatially isolated to a narrow band bisecting the Mill Fork area. In addition, as pointed out by Peterson Hydrologic, long term discharges from the Blackhawk Formation from surrounding mines have not produced mine discharge waters with elevated total iron. PacifiCorp currently monitors the sealed Cottonwood Mine (UPDES-001) mine discharge water and has not recorded total iron values exceeding minimum detection limit of 0.05 mg/l.

PacifiCorp evaluated the hydrologic monitoring data received from UtahAmerican Energy on the trend of total iron discharge from the Crandall Canyon mine to assess long term potential occurrence of elevated mine discharge water from Deer Creek. The occurrence at the Genwal facility was complicated given the fact that the discharge was uncontrolled and not anticipated.

Structures such as hydrologic bulkheads/parallel plugs were proposed to be installed in strategic locations in the Deer Creek Mine to control groundwater movement.

Identified Hydrologic Concerns of the Mill Fork Lease Area:

In the Mill Fork Area, all longwall panels trend east - west. On the west side of these panels is the Joes Valley Fault system. The north is restricted by the Crandall Canyon mine workings. A barrier of unmined coal separates the longwall panels from both the Joes Valley Fault and the Crandall Canyon mine workings. The northwestern portion of the Mill Fork Area dips toward the Joes Valley Fault. The eastern portion of the Mill Fork Area dips toward the east.

Groundwater from the Mill Fork mining area and the eastern portions of the lease flows to the east and is currently collected at the heading of 17th West and directed into the 7th North sump (refer to Map DU1901D). Groundwater from the northwest panels will eventually drain through the seals at 7th North XC-39, and would be collected in the 7N sump if the mine is still operating. Groundwater collected in this sump has contact with the zones of coal that contain the elevated sulfur concentrations and the discharge water from the sumps has elevated concentrations of total iron. Because the eastern portion of the Mill Fork Area dips downward to the east, Interwest projects that these waters will discharge from the Rilda Canyon 1st Right portals if not contained within the mine.

PacifiCorp initiated an underground hydrologic monitoring program in May 2012 to assess the potential impacts of groundwater with elevated iron from sealed areas in the Hiawatha seam. Water samples were collected from the 11th and 17th West seals in the Hiawatha seam and 10th North drain (no longer accessible) from the Blind Canyon seam (refer to Map DU1903D). Elevated iron in excess of the State of Utah Department of Environmental Health - Utah Pollutant Discharge Elimination (UPDES) limitation of 1.0 mg/l has been detected from the Hiawatha sampling sites. The values are similar to those recorded during the high-iron discharge situation recently experienced at the adjacent Crandall Canyon Mine.

Water Chemistry Assessment of the Mill Fork Area:

Mayo and Associates LLC was contracted by PacifiCorp to conduct a geochemical investigation of the elevated concentrations of sulfur in the coal and the elevated total iron concentrations found in the discharge from the Mill Fork Area of the mine. PacifiCorp has concerns that the high iron concentrations in the mine water from the Mill Fork Area would not comply with the effluent limitations of the Utah Pollution Discharge Elimination System (UPDES) for total iron should this water discharge to the surface.

The Mayo Report concludes the following (refer to Appendix D):

1. Zones of elevated sulfur and iron occur in the Hiawatha seam coal in the Mill Fork Area workings.
2. Several factors suggest that gypsum and $MgSO_4$ dissolution are the primary sources of the elevated concentrations of SO_4^{2-} in both the Hiawatha 17th West seals and the Blind Canyon borehole groundwaters. The factors are: 1) the very positive $\delta^{34}S$ values of all sampled groundwaters, 2) the SO_4^{2-} concentrations in mine water greatly exceed the concentration available from iron sulfide oxidation, and 3) laboratory leaching experiments demonstrate that almost all of the SO_4^{2-} is from the dissolution of oxidized sulfate minerals.
3. Groundwaters discharged from the Hiawatha seam mine workings in the Mill Fork Area contain elevated concentrations of total iron which makes the water rust colored when oxygenated. This elevated total iron is associated with groundwater that has contact with the elevated sulfur zone Hiawatha seam coal.
4. Based on a 1st order calculation, approximately 958 tons of iron sulfide minerals (pyrite and marcasite) will be potentially available in the elevated sulfur zones to interact with in-mine groundwater at the time of projected mine closure.
5. Approximately 600 tons of iron would also be available for oxidization from the conveyor belt components if the beltlines are abandoned and left in the mine workings.
6. Chemical interaction between incoming groundwater containing oxygen and the elevated sulfur zone results in iron sulfide oxidization and is responsible for the formation of rust colored iron hydroxide which is reported as total iron in laboratory analysis.
7. Assuming that all of the potentially available iron sulfide mineralization will have contact with oxygen rich water it would take about 75 years to exhaust the total supply of iron sulfide. If the beltline iron is included the time to exhaustion would exceed 100 years. When realistic in-mine conditions are considered it is likely that supply of readily available iron sulfide would be exhausted in a few to tens of years under present conditions.
8. Water quality associated with two future mine closure options have been evaluated:
   a) The first condition, call herein the Open System, envisions groundwater discharging to the surface from the Rilda Canyon Portals via Mill Fork Access workings. This discharge water would be continually oxidized and would contain elevated concentrations of total iron for an indefinite period of time. Total iron concentration in the range of 1-3.5 mg/l would continue for several years. The water will also contain elevated SO_4^{2-}.
   b) The second condition, called herein the Closed System, envisions no surface groundwater discharge at Rilda Canyon due to the construction of bulkheads in the Mill Fork Access workings. The water impounded in the workings behind the bulkheads would become reducing and would attain elevated and steady state concentrations of total ion and SO_4^{2-}.

For the full description of the water chemistry of the Mill Fork Area, refer to the geochemical evaluation conducted by Mayo and Associates for Energy West Mining in 2014. This document is found in Appendix D Final Closure Plan - Appendix A.

Remedial Approaches to Containing Potentially Elevated Iron Water

In an effort to maintain acceptable compliance quality discharge water from the Deer Creek Mine, PacifiCorp is proposing the construction of water diversion pipeline from the Rilda Canyon 1st Right Portals to the Huntington Power Plant Settling pond. PacifiCorp will sub-contract the installation of the pipeline to a reputable contractor with experience to assure quality control and quality assurance of the project.

Groundwater intercepted in the mine, including groundwater with potentially elevated iron from the Mill Fork Area, will gravity flow to the Deer Creek portals (southern portion of the mine will discharge at the Deer Creek portals – Deer Canyon, Mill Fork Area will discharge at the Rilda Canyon 1st Right portals). Final sealing of the Deer Creek portals completed April 17, 2015 included installing a French drain system approved by MSHA and the BLM. PacifiCorp has developed a strategy to control the mine water discharge depending on water quality (concentration of Total Iron) to comply with the UPDES stipulations. Prior to the interception of the pyritic split in the Mill Fork Area, post mine gravity discharge water quality was predicted to be in compliance with UPDES permit limitations. PacifiCorp has revised the final reclamation plans to accommodate a buried pipeline from the Rilda Canyon 1st Right portals routing groundwater from the Mill Fork Area with potentially non-compliant water (elevated total iron concentrations exceeding 1 mg/L [UPDES limitation]) to the Huntington Power Plant Settling Pond. Predicting post mine gravity discharge quality of the Mill Fork Area will depend on a number of factors including:

- Combined discharge rates from Mill Fork Area (non-elevated and elevated iron sources)
- Concentration of Total Iron from the areas influenced by the pyritic split in the Mill Fork Area compared to the historic water quality from non-affected areas
  - Mill Fork Area – Elevated Iron Affected Areas
    - Predicted Total Iron peak concentration - 3.0 to 4.0 mg/L (based on in-mine sampling data and monitoring history of the adjacent Genwal Mine)
      - Finite amount of available of free iron from pyritic split
      - Total Iron concentration is time dependent with concentration dissipating over time
        - Genwal Mine (adjacent to the Mill Fork Area) with similar geologic occurrence experienced elevated Total Iron values ranging from approximately 4.0 mg/L slowly dissipating to UPDES compliance level of 1.2 mg/L.
  - Mill Fork Area – Non-Affected Area
    - Intercepted groundwater Total Iron concentration - ND (not detected), reported as <0.05 mg/L
- Timing of discharge sequence and water quality blending ratios

- Gravity inflow of water from Mill Fork Area, both from the non-affected and affected areas, will slowly migrate to the south eventually blending and discharging at the Rilda Canyon 1st Right Portals. Overall total iron concentration of the mine discharge will depend upon inflow rates from the respective areas and diluted total iron concentration from the Mill Fork Area.

Final reclamation plans for Deer Creek will include a buried pipeline from the Rilda Canyon 1st Right portals to the Huntington Plant Settling Pond (see Volume 11 Engineering Figure R645-500 D for details of the Rilda Canyon 1st Right portal structures). Hydrologic monitoring of the mine discharge will include the gravity outfalls at Deer Canyon (UPDES Permit #UT0023064-002) and mine water diverted through pipeline to the Huntington Power Plant Settling Pond. Water diverted to the Huntington Power Plant will be used in plant operations and will not require reporting through the UPDES system . The following table outlines the strategies and action plan to protect the hydrologic balance and limit potential offset impacts related to discharging groundwater with potentially elevated total iron from the Deer Creek Mine – Rilda Canyon 1st Right portals to the receiving stream (Huntington Creek):

Deer Creek Mine Final Mine Closure Mine Water Discharge Monitoring Water Quality Parameter of Concern – Total Iron (UPDES permit limitation, 1.0 mg/L)			
Concentration (mg/L)	**Trend of Analysis**	**Monitoring Frequency**	**Location of Discharge**
> 1.00	▼▲	Monthly	Huntington Plant
< 1.00 to 0.50	▼	Monthly	Huntington Plant
<0.50	▼	Monthly See Note 1	Huntington Plant
Trend Analysis **▼► - Decreasing to Stable** **▼ – Decreasing**			
Notes **1. – After one year of monitoring, results of <0.5 (or UPDES limitations on Total Fe), PacifiCorp evaluate potential discharge options; 1) continue discharging to the plant, 2) divert discharge to receiving stream at the Huntington Plant location – Division of Water Quality approval required**			

Because the ~~permit~~ lease area is divided between the Huntington Creek Drainage Basin and the Cottonwood Creek Drainage Basin, seventy percent and thirty-percent, respectively, the amount of interbasin water transfer that occurs must be considered. PacifiCorp ~~will~~ installed seals as a mitigation effort to minimize interbasin transfer. The average annual flows of Huntington and Cottonwood creeks are 96.3 and 95.1 cfs, respectively (USGS Open File reports #81539 and #81141). The historical ~~current~~ discharge rate from PacifiCorp's ~~total permit areas~~ Utah mines range~~s~~ from 1000 to 1500 gpm, less than three and one half percent of either of the creeks' average flows. Because a limited portion of the projected Mill Fork ~~permit~~ Area mine workings (less than thirty percent) intersects water that would normally migrate toward the Cottonwood Basin but is discharged out Deer Creek Canyon, the interbasin water transfer from the Cottonwood drainage to Huntington Creek will probably never exceed one percent (<1%) of the average annual discharge of either system.

R645-301-729 CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

The Division will provide an assessment of the probable cumulative hydrologic impacts of the proposed coal mining and reclamation operation and all anticipated coal mining and reclamation operations upon surface and groundwater systems in the cumulative impact area.

R645-301-730 OPERATION PLAN

R645-301-731. GENERAL REQUIREMENTS

PacifiCorp has submitted a plan to minimize disturbance to the hydrologic balance, to prevent material damage, and to support approved postmining land use (see Operational and Reclamation plan for the Deer Creek Mine).

R645-301-731.100. HYDROLOGIC BALANCE PROTECTION

A. GROUNDWATER PROTECTION

Although the analysis of the overburden samples tested has shown that no toxic or hazardous materials are present, groundwater quality will be protected by handling earth materials and runoff in a manner that minimizes infiltration to the groundwater system.

B. SURFACE WATER PROTECTION

Surface water quality will be protected by handling earth materials, groundwater discharges, and runoff in a manner that minimizes the potential for pollution.

R645-301-731.200. WATER MONITORING

A. GROUNDWATER

Groundwater within the Mill Fork ~~permit~~ Area will be monitored according to the schedules in Appendix A. PacifiCorp has conducted baseline and operational monitoring of spring sources in and adjacent to the ~~permit~~ lease area. ~~The springs located within or immediately adjacent to areas overlying coal to be mined in the next five (5) years or areas overlying previously mined areas will be monitored.~~ The data collected have provided information useful in the understanding of potential hydrologic consequence of mining.

1. East Mountain Springs - Mill Fork

In preparation for coal leasing, Genwal Resources conducted baseline spring and seep surveys from 1994-1996 (northern portions of the lease were surveyed in 1989-90). With PacifiCorp's acquisition of the Mill Fork State Coal Lease (reverted to the BLM on August 1, 2011 designated as federal lease UTU-88554), a complete re-evaluation of groundwater resources was initiated in 2000 and continued through 2001. During the 2000-2002 baseline evaluation, a total of 198 springs were identified within and adjacent to the ~~permit~~ lease plan area. Each spring site on East Mountain has been studied to determine the geologic circumstances that cause the springs to occur. The mode of occurrence for each spring has been tabulated on the "Springs Geologic Conditions Inventory" sheets located in Appendix C. The springs on East Mountain originate in several different ways (see Table MFHT-1 and Mill Fork Spring Map MFS1830D); however, many springs share the same mode of occurrence and, in some cases, are related.

The ground water monitoring plan in Appendix A includes a selection of springs based on the following criteria:

- Stratigraphic position
- Area of potential influence from subsidence
- Aerial distribution
- Established water rights
- Measurable flow based on historical surveys
- Reliable measuring point(s)

The following table outlines the rationale for springs selected for long term monitoring. Selection of the springs to be monitored was based upon the factors listed along with discussions with the water users (CVSSD, Emery Conservancy District, NEWU~~A~~SSD) and the surface management agency.

MILL FORK GROUNDWATER MONITORING PLAN - SPRINGS							
Spring	**Stratigraphic Position**	**Projected Subsidence Zone**	**Regional Location**	**Water Rights**	**Historical Measurable Flow**	**Reliable Measuring Point**	**Comment**
EM-216	✓		✓	✓	✓	✓	Located outside projected zone of subsidence
EMPOND					✓	✓	Added to the spring monitoring program at the request of the USFS
GRANTS SPRING					✓	✓	Added to the spring monitoring program at the request of the USFS
LITTLE BEAR SPRING	✓		✓	✓	✓	✓	Located outside projected zone of subsidence. Added to the spring monitoring program at the request of the DOGM
JV-9	✓		✓			✓	Located outside projected zone of subsidence. Monitored to detect impacts to the Joes Valley alluvium
JV-34	✓		✓			✓	Located outside projected zone of subsidence. Monitored to detect impacts to the Joes Valley alluvium
MF-7	✓		✓		✓	✓	Located outside projected zone of subsidence
MF-10	✓	✓	✓	✓	✓	✓	
MF-19B	✓		✓	✓	✓	✓	
MF-213	✓		✓	✓	✓	✓	Large spring located in the Blackhawk Formation downdip from projected mining
MF-219	✓	✓	✓	✓	✓	✓	
MFR-10	✓	✓	✓		✓	✓	Large spring denoted by USGS
MFR-30	✓	✓	✓		✓	✓	
RR-5	✓	✓	✓	✓	✓	✓	
RR-15	✓	✓	✓		✓	✓	
RR-23A	✓		✓		✓	✓	Large spring within a series of springs located downdip from projected mining
SP1-26	✓	✓	✓	✓	✓	✓	
SP1-29	✓	✓	✓		✓	✓	
UJV-101	✓		✓		✓	✓	
UJV-206	✓	✓	✓	✓	✓	✓	

Water samples will be collected and analyzed during the months of July and October. Parameters analyzed are those listed in the "DOGM Guidelines for Groundwater Water Quality" (see Appendix A – Monitoring Locations – Groundwater – East Mountain Springs – Mill Fork Area). Monitoring of groundwater sites will continue for a minimum of three years after the last date of mining (date of last mining - January 2015). PacifiCorp will submit a formal application to reduce hydrologic monitoring after the three year minimal time frame.

2. In-Mine

Monitoring of in-mine water sources was terminated after mine sealing completed April 2015. Historically, intercepted groundwater sampling sites, (either roof drippers or contribution from the floor), ~~will~~ were ~~be~~ established according to the Special Condition Stipulation in the Deer Creek permit renewal, (February 6, 1996); "*If during entry development, sustained quantities of groundwater are encountered which are greater than 5 gpm from a single source in an individual entry, and which continue after operational activities progress beyond the area of groundwater production, PacifiCorp must monitor these flows for quality and quantity under the approved monitoring plan"*. ~~In addition to the standard plan described above, if mining encountered significant quantities of groundwater which issues from a fault zone, PacifiCorp will; quantify the volume, sample for water quality according to the approved monitoring plan (baseline parameters for two year period), conduct isotopic sampling using a systematic approach (phase 1: tritium analysis, phase 2: depending the results of the tritium sampling, perform carbon age dating). Parameters analyzed are those listed in the "DOGM Guidelines for Groundwater Water Quality" (see Appendix A).~~

B. SURFACE WATER

PacifiCorp has conducted baseline monitoring of surface waters within and adjacent to the Mill Fork ~~permit~~ Area. Water samples will be collected and analyzed as outlined in Appendix A. Parameters analyzed are those listed in the "DOGM Guidelines for Surface Water Quality." Locations of all surface monitoring sites and sampling schedules can be found in Appendix A.

R645-301-731.500. DISCHARGES

Refer to Mine Dewatering R645-301-721 and UPDES information in Volume 9 Appendix B.

R645-301-731.300. ACID AND TOXIC-FORMING MATERIALS

Acid-forming materials in western coal mines generally consist of sulfide minerals, which, when exposed to air and water, are oxidized causing the production of H^+ ions (acid). The sulfide mineral pyrite (FeS_2) has been identified in the PacifiCorp mines. Although the oxidation of pyrite occurs in the mine, acidic waters are not observed in the mine. The acid is quickly consumed by dissolution of abundant, naturally occurring carbonate minerals (refer to Appendix B Eqs. 3 and 4). Iron is readily precipitated as iron-hydroxide and excess iron is not observed in the mine discharge water.

R645-301-731.530. State Appropriated Water Supply

PacifiCorp commits to comply with R645-301-731.530, which states: "The permittee will promptly replace any State-appropriated water supply that is contaminated, diminished or interrupted by UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES conducted after October 24, 1992, if the affected water supply was in existence before the date the Division received the permit application for the activities causing the loss, contamination or interruption. The baseline hydrologic and geologic information required in R645-301-700. will be used to determine the impact of mining activities upon the water supply". PacifiCorp has conducted baseline hydrologic monitoring to determine pre-mining hydrologic resources (refer to Appendix C). Ground and surface water monitoring programs have been designed to specifically to monitor potential impacts associated with mining in the Mill Fork ~~permit~~ Area. Table MFHT-2 list the ground and surface water rights within and adjacent to the Mill Fork ~~permit~~ Area. In addition, Table MFHT-2 list the quantity of the water rights within the projected affected area, and the observed flows collected during the baseline surveys and mitigation alternatives. Quality of the State Appropriated Water Supplies are reported in Appendix C.

R645-301-731.600. STREAM BUFFER ZONES

Mining related activities will not occur within 100 feet of a perennial or intermittent streams unless the Division authorizes such activities.

R645-301-731.700. CROSS SECTION AND MAPS

731.710-720 and 750: A water supply intake system known as "North Emery Water Users Association Special Services District - Rilda Canyon Springs" is located in Section 28, Township 16 South, Range 7 East (refer to Volume 9 Map HM-9, a detailed drawing of the collection system is provided in Volume 9 - Hydrologic Section Map HM-8). The intake system consists of a series of French drains collecting near surface alluvial water as a supply source for culinary water (for complete description of the NWEUASSD system refer to Volume 9 R645-721 "Existing Groundwater Resources").

Mine Sites: All disturbed area drainage will flow into an approved sediment control device. Maps showing water diversion, collection, conveyance, treatment, storage, and discharge can be found in the Operational section of the Deer Creek Mine PAP.

730: Water Monitoring Location Map - Refer to Hydrologic Map MFS1851D.

R645-301-731.800. WATER RIGHTS AND REPLACEMENT

In order to fulfill the requirements to restore the land affected by applicant's mining operations to a condition capable of supporting the current and postmining land uses stated herein, the applicant will replace water determined to have been lost or adversely affected as a result of applicant's mining operations if such loss or adverse impact occurs prior to final bond release. The water will be replaced from an alternate source in sufficient quantity and quality to maintain the current and postmining land uses (refer to Table MFHT-2 for a list of State Appropriated Water Supplies; including; type, quantity (water right and baseline observations) and quality references.

Nine springs have been developed in Huntington Canyon to provide for domestic, industrial, and commercial water needs. Currently, Huntington City utilizes two springs in Huntington Canyon, Big Bear Canyon Spring and Little Bear Canyon Spring. The North Emery Water Users ~~Association~~ Special Services District also utilizes springs in Huntington Canyon to provide for domestic and industrial water needs in areas outside of Huntington City. The ~~Association~~ NEWUSSD is currently utilizing water from three springs in Rilda Canyon as well as from four other springs in the general area (refer to Volume 9 Hydrologic Section: Map HM1).

1. North Emery Water Users ~~Association~~ Special Services District

Of concern to PacifiCorp is the proximity of proposed mining activities in Rilda Canyon to the Rilda Canyon Springs which currently serve as a culinary water source to the North Emery Water Users ~~Association~~ Special Services District (NEWU~~A~~SSD) serving some 410 connections. Due to the importance of these springs, a separate discussion is provided in Volume 9 Hydrologic Section.

2. Little Bear Spring

A second spring system which has been developed for culinary purposes referred to as Little Bear Spring occurs east of the Mill Fork ~~permit~~ Area. Little Bear Spring is a large spring (average flow of approximately 300 gpm) which issues from the lowest member of the Star Point Sandstone (Panther Member) located approximately one and one half (1 ½) miles to the east of the Mill Fork ~~permit~~ Area boundary in Section 9, Township 16 South, Range 7 East (refer to Groundwater Rights and Users for complete hydrologic characteristics related to Little Bear Spring). PacifiCorp cooperated with Huntington City, Elmo City, Cleveland City and CVSSD in developing a comprehensive mitigation plan. The agreement was signed on July, 2004. As part of the agreement, PacifiCorp constructed a water treatment plant in 2005 located near at the existing Huntington City plant in Huntington Canyon. The mitigation agreement information is found in Appendix D of Volume 9.

R645-301-732 - 764. SEDIMENT CONTROL

Information pertaining to sediment control can be found in the Operational plan of the Deer Creek Mine PAP.

R645-301-748, 755, 765. CASING AND SEALING OF WELLS

Each water well will be cased, sealed, or otherwise managed, as approved by the Division.

R645-301-751. WATER QUALITY STANDARDS AND EFFLUENT LIMITATIONS

Discharges of water from areas disturbed by coal mining and reclamation operations will be made in compliance with all Utah and federal water quality laws and regulations and with effluent imitations for coal mining promulgated by the EPA set forth in 40CFR Part 434 (refer Volume 9 Appendix B for UPDES permit information).

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Consultants in Hydrogeology

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Deer Creek Mine – Mill Fork Area

Geochemical Evaluation of Groundwater with Elevated Iron

April 26, 2014

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Table of Contents

List of Figures

List of Tables

Deer Creek Mine – Mill Fork Area

Geochemical Evaluation of Groundwater with Elevated Iron

1. Introduction

Energy West Mining Company (Energy West) anticipates closing the Deer Creek Mine as early as November 2014. Hiawatha Seam workings in the Mill Fork Area have encountered a north-south trending zone of coal that contains elevated sulfur concentrations. Groundwater discharges at a rate of about 1,000 gallons per minute (gpm) from the Mill Fork area and this water has elevated concentrations of total iron in the form of ferric hydroxide (goethite) which is observable as a yellow precipitate. This groundwater is used for in mine process purposes, however upon mine closure the water will discharge to the surface via the Rilda Canyon portals unless corrective actions are taken.

The North Emery Water Users Special Services District (NEWUSSD) collects culinary water from three springs in the portals area. The discharge of mine water containing ferric hydroxide precipitate will have a negative impact on the NEWUSSD water supply as well as surface water in Rilda Canyon. Energy West has requested Mayo and Associates to undertake a chemical evaluation of the fate of the groundwater containing elevated iron. Specifically we have been tasked to:

1. Review hydrologic data from the adjacent Crandall Canyon Mine.
2. Assess the geochemical evolution of intercepted groundwater and the chemical alteration of groundwater within sealed areas in the Hiawatha Seam – Mill Fork Area.
3. Project geochemical long term trends of groundwater from sealed areas during mining, and after mining and sealing are complete.
4. Evaluate mitigation options to control elevated iron groundwater discharge.

2. Setting

Coal is mined from the Hiawatha and the overlying Blind Canyon seams in the Deer Creek Mine. The mine consists of several separate mining areas. Of interest to this investigation is the Mill Fork Area (Figure 1). The Mill Fork Area is connected to other Deer Creek mining areas via the 2.6 mile long Mill Fork Access and Rilda Canyon break-out portals both of which are completed in the Hiawatha seam. In the Mill Fork Area the longwall panels trend east-west and are bounded to the west by the Joes Valley Fault and to the north by the Crandall Canyon mine workings. Barriers of unmined coal separate the longwall panels from both the Joes Valley Fault and the Crandall Canyon mine workings. A northeast trending anticlinal structure with gentle dips causes the western portion of the mine floor to slope toward the Joes Valley Fault and the eastern portion to slope toward the east.

Active mining is occurring in the Hiawatha seam in the northern portion of the Mill Fork Area. In the tract, the western most portions of the mined out 12th to 17th West and the 21st to 23rd West longwall panels are flooded due to the slight westward dip of the bedrock. Groundwater from the active mining area and the eastern portions of the tract flow to the east and are collected at the 10th North, 17th West, and 11th West sumps (Figure 1). Groundwaters collected in the sumps have contact with the zones of coal that contain elevated sulfur concentrations and the discharge water has elevated concentrations of total iron (Table 1).

3. High Sulfur Zones

In the Mill Fork Area the primary elevated sulfur zone in the Hiawatha seam is 1,500 to 2,000 feet wide, 2 miles long and trends approximately north-south (Figure 2). Much of the coal in this zone has been removed by mining of the 12th to 23rd West panels; however, coal containing elevated sulfur remains in the mine floor, unmined supporting pillars, and in the unmined portions 24th to 27th West panels. A smaller high sulfur zone occurs in the mostly flooded portion of the mined 12th to 23rd West panels area (Figure 2). This high sulfur zone extends into the adjacent Crandall Canyon mine, which since early 2008 has discharged about 500 gpm of groundwater containing total iron concentrations in excess of 1 mg/L (Peterson Hydrologic, 2011).

The percentage of sulfur in the coal in the high sulfur zone ranges between 0.5 and 10% and has an average value of 5.75%. This compares with the average Deer Creek mine sulfur content of 0.5%. Sulfur in coal may be in oxidized, reduced, and native forms. Oxidized sulfur includes minerals such as gypsum ($CaSO_4 \cdot nH_2O$) and anhydrite ($CaSO_4$) which form in evaporative environments and as secondary mineralization. Sulfur can also be the results of precipitation from sea water that flooded peat swamps (Chou, 1997). Such sulfur may be in a highly soluble form such as $MgSO_4 \cdot 7H_20$ (epsomite). Reduced forms include iron sulfide minerals such as pyrite and marcasite (FeS_2). Native sulfur (S) has also been report in some coals. The concentration of oxidized and reduced sulfur minerals in the high sulfur zones are described below.

The calculated total sulfur in the high sulfur zones that may potentially interact with groundwater is 31,961 tons (Table 2). The total sulfur in the high sulfur zones exceeds 50,000 tons (Figures 2 and 3). The calculated amount of sulfur that may potentially react with groundwater is based on the following assumptions:

1. The average sulfur concentration in the high sulfur zones is 5.75%.
2. Groundwater may interact with sulfur in mine areas to a depth of 2 feet from exposed mine floor and vertical surfaces. Unmined coal beyond the 2 foot exposed surfaces contains non-available sulfur.
3. Calculations of total sulfur do not include potential sulfur that occurs in collapsed gob coal and other rocks from the mine roof.

Separate calculations have been made for the amount of available sulfur in the mine floor and in the mine vertical surfaces (Table 2; Figures 2 and 3, respectively). In the table, calculated amounts are summarized for both the flooded and non-flooded portions of the Mill Fork Area that may interact with groundwater. About 77% of the available sulfur is in non-flooded portions of the Mill Fork Area.

4. Groundwater Discharge

Groundwater flows into the Mill Fork Area mine workings from both mine roof and floor sources and the general direction of groundwater flow in the mine workings are shown on Figure 1. Because of the approximate 3 % westerly slope of the mine floor, groundwater has flooded the western portion of the 12th to 17th West mined panels and the western portion of the 21st to 23rd West mined panels. Elsewhere the mine floor slopes gently to the east and groundwater flow is captured in one of three sumps which from south to north are the 11th West, the 17th West, and the 10th North. These sumps are located just outside of the longwall panel seals. Quasi steady state flow to the sumps are about 5 gpm at the 11th West, 100 gpm at the 17th West, and 50 gpm at the 10th North. Water collected at the sumps is currently used as in-mine process water or is discharged at the Deer Creek Portals. After mine closure this and other Mill Fork Area mine water will flow across the floor of mined out areas, along the Mill Fork access workings, and will discharge to Rilda Canyon (Figure 1). The current total groundwater discharge rate to the in-mine workings is about 1,000 gpm. The long-term groundwater discharge rate from the Mill Fork Area will likely decline after the end of mining activities.

5. Geochemistry of Mill Fork Area Groundwater

Since May 1, 2012, water quality samples have been collected monthly from the Hiawatha 11th and 17th West sumps and from the Blind Canyon 10th North XC-5 borehole for analysis. Sulfate, pH, and total and dissolved iron concentrations are shown in Table 1. Analysis of groundwater samples for major ions from the Hiawatha seam 11th and 17th West sumps and the Blind Canyon seam borehole collected on December 18, 2013 and January 1, 2014 are shown in Table 3. On

November 6, 2013 samples were collected for analysis of the stable isotope $\delta^{34}S$ on dissolved SO_4^{2-} and for the stable isotopes $\delta^{18}O$ and $\delta^{2}H$ of the water (Table 4). The $\delta^{18}O$ and $\delta^{2}H$ data did not provide significant information regarding iron and sulfate and are not discussed herein.

Both the 11th and 17th West collection locations drain the eastern dipping portion of the Mill Fork Area Hiawatha seam workings and the Blind Canyon borehole represents groundwater in the overlying Blind Canyon seam.

5.1 Dissolved and Total Iron

The dissolved iron contents in most samples are less than the laboratory detection limit of 0.03 mg/L, however concentrations as great as 1.19 mg/L have been reported in Hiawatha seam groundwaters (Table 1). The total iron concentrations in both Hiawatha seam locations are typically greater than 1 mg/L and the average total iron concentrations in the 11th and 17th West sump samples are 1.6 and 3.47 mg/L, respectively (Table 1).

Although there is considerable scatter in the plot of total iron data, there is an apparent general trend of decreasing concentrations over the 18 months of record (Figure 4a). Assuming a linear decay function and projecting best fit linear regression lines through the data, the total iron concentrations would intercept the 0 mg/L concentration in 2016 and 2019 for the 11th and 17th West sumps, respectively. The r^2 (i.e. goodness of fit for linear regression) values of the best fit lines are less than 0.3, which means the regression lines are not a good predictor of future outcomes and considerably more temporal data are need to validate a decreasing trend in the data. An r^2 value of 1 means that all of the data fall on the regression line and a value of 0 means that the data are completely random. Typically an r^2 value greater than 0.5 is needed to assume a linear data fit.

Both the dissolved and total iron concentrations of all Blind Canyon borehole samples were below the detection limits and iron is not an issue.

5.2 Dissolved Sulfate (SO_4^{2-})

The most recent SO_4^{2-} concentrations in the Blind Canyon Borehole and the 17th West sump groundwaters average 132.5 and 181.1 mg/L, respectively (Table 3). These values are considerably greater than the average concentrations of about 70 mg/L for in-mine groundwaters in the Wasatch Plateau and the Book Cliffs (Mayo et al., 2003). The average value for the 11th West sump is only 36.7 mg/L (Table 1) which may represent quasi-steady state conditions for low sulfur areas.

A plot of the monthly SO_4^{2-} analysis (May 2012 to February 2014 data; Figure 4b) are better behaved than are the total iron data. Linear regressions of all of the SO_4^{2-} data have decreasing concentration trends that approach 0 mg/L in about the year 2025. The r^2 values associated with the Blind Canyon Borehole, 17th West sump, and 11th West sump are 0.62, 0.90, and 0.80, respectively. Although it is unlikely that SO_4^{2-} concentration will ever reach 0 mg/L, substantial decreases in SO_4^{2-} concentrations in the Blind Canyon borehole and the 17th West sump are likely.

5.3 Iron Hydroxide Precipitate

Mine personnel have observed rust colored iron precipitate in the Mill Fork Area underground outflows and a rust coloration of some in-mine groundwater. Rust colored precipitate was collected from outby of the 17th West seal and iron was precipitated from water samples collected at the 17th West seal during both in-mine and laboratory experiments.

In the mine, the rapid conversion from dissolved iron to iron precipitate is illustrated in Figure 5 where 2.5 gallons of water was poured 10 times between two clean 5 gallon buckets at the 17th West seal. Pouring between the buckets oxygenated the groundwater and the dissolved iron quickly converted to a rust colored precipitate. In the figure, a non-agitated control sample is shown for comparison.

X-ray diffraction (XRD) scans of the in-mine and laboratory precipitate indicates that the precipitate is amorphous and does not have an x-ray pattern (Appendix A). Based on the XRD analysis and the physical properties David Tingey (BYU Laboratory of Isotope Geochemistry) concluded that the precipitate is either goethite (FeOOH) or its hydrated form limonite ($FeOOH \bullet nH_2O$).

5.4 Sulfur Isotopes

In an attempt to better understand the origin of the total iron and the elevated SO_4^{2-} concentrations, the SO_4^{2-} has been analyzed for sulfur isotopes (Table 4). Pyrite typically has a $\delta^{34}S$ value of about 0 ± 3 ‰. Mayo et al., (2000) found a value of +3.4 ‰ for a pyrite sample in the SUFCO coal mine in Utah. Data for pyrite in the Deer Creek mine are not available. Oxidized sources of sulfur, such as marine gypsum and other marine sedimentary minerals, have values of +10 to +40 ‰ (Thode, 1991). All of the Mill Fork Area samples have very positive $\delta^{34}S$ values (i.e., +8.3 to +35.5 ‰) which suggest marine sedimentary or marine evaporative minerals as the primary source of dissolved sulfur.

5.5 Chemical Reactions

All of the groundwater samples, including the monthly sampling of the Hiawatha Seam 11th and 17th West sumps, and the Blind Canyon Seam borehole (Tables 1 and 3), have near neutral to mildly basic pH values indicating that acid drainage is not an issue. Groundwaters discharging from Utah coal mine environments are typically basic due to the abundance of carbonate minerals associated with the coal deposits (Mayo et al., 2000).

5.5.1 Major Ions

The major ion chemistry and the geochemical evolution of the Hiawatha 11th and 17th West seals and the Blind Canyon borehole water provide additional insight into the origin of both the total iron and the elevated SO_4^{2-} concentrations. In Table 3, the major ion concentrations (mg/L) have been converted to reacting equivalents to better understand chemical reactions. Units of reacting equivalents are milliequivalents per liter (meq/L).

The meq/ L unit allows direct comparison of reacting concentrations of cations and anions. Conversion factors between meq/L and mg/L for major ions follow:

	meq/L	mg/L
Ca^{2+}	1	20.0
Mg^{2+}	1	12.2
Na^{+}	1	23.0
K^{+}	1	39.1
HCO_3^-	1	61.0
SO_4^{2-}	1	48.0
Cl^-	1	35.5

By using reacting equivalents it is easier to evaluate chemical reactions than by using concentrations in mg/L. For example the dissolution of 68 mg of gypsum ($CaSO_4 \bullet H_20$) in a liter of water would yield 1 meq/L of both Ca^{2+} and SO_4^{2-} and 20 and 48 mg/L of Ca^{2+} and SO_4^{2-}, respectively.

Total iron concentrations have been converted to their corresponding dissolved ferric (Fe^{3+}) concentrations and these concentrations have also been converted to reacting equivalents (Table 3). A comparison of the total iron in the Hiawatha 11th and 17th West waters converted to reacting Fe^{3+} equivalents with the SO_4^{2-} reacting equivalents suggests that only a small portion of the SO_4^{2-} is from pyrite or marcasite oxidation. In the 11th and 17th West waters, the SO_4^{2-} reacting equivalents are one to two orders of magnitude greater than their equivalent Fe^{3+} values (Table 3). The average reacting equivalents of SO_4^{2-} in the 11th and 17th West waters are 0.70 and 2.54, respectively, whereas their corresponding reacting equivalents of Fe^{3+} are only 0.02

and 0.08. The ratios of calculated Fe^{3+} reacting equivalents to the measured SO_4^{2-} reacting equivalents are 0.029 and 0.031 for the 11th and 17th West sump samples, respectively. These similar ratios suggest that the sulfate/iron sulfide ratios are similar in the rocks which have contact with mine waters regardless of location. Some of the total iron in the water may have settled out prior to sampling and it is possible that the reported total iron somewhat under measures the total amount. However, it is unlikely that the lost total iron approaches the SO_4^{2-} reacting equivalents. The $\delta^{34}S$ and the Fe^{3+}/SO_4^{2-} ratios of reacting equivalents suggest that the origin of most of the SO_4^{2-} may be explained by non-redox reactions (i.e., pyrite) which are described below.

Major ion solute compositions of groundwaters are the result of interactions between groundwaters and bedrock lithology and between groundwaters and gases. The general reactions responsible for most of the chemical evolution of groundwaters may be described as follows. Groundwater acquires most of its $CO_{2(g)}$ in the soil zone where the partial pressures of CO_2 greatly exceeds atmospheric levels. In the in-mine environment additional $CO_{2(g)}$ is available from the gob atmosphere where the CO_2 content is an order of magnitude greater than the outside air. The Mill Fork Area in-mine gas composition is described below. CO_2 combines with water to form carbonic acid according to

$$CO_{2(g)} + H_2O = \underset{\text{(carbonic acid)}}{H_2CO_3} \quad (1)$$

Carbonic acid dissociates into H^+ and HCO_3^-

$$H_2CO_3 = HCO_3^- + H^+ \quad (2)$$

The H^+ ions temporarily decrease the pH of the water but are quickly consumed by the dissolution of carbonate minerals that are abundant in the mine environment. Carbonate mineral dissolution is represented as

$$2H^+ + \underset{\text{(dolomite)}}{CaMg(CO_3)_2} = Ca^{2+} + Mg^{2+} + 2HCO_3^- \quad (3)$$

and

$$H^+ + CaCO_3 = Ca^{2+} + HCO_3^- \quad (4)$$
(calcite)

The net effect of reactions 3 through 4 is to increase the pH and the Ca^{2+}, Mg^{2+}, and HCO_3^- contents of waters.

Dissolution of gypsum, which is present in many formations in the region, can increase the Ca^{2+} and SO_4^{2-} contents in the absence of $CO_{2(g)}$ and H^+ according to

$$CaSO_4 \bullet 2H_2O = Ca^{2+} + SO_4^{2-} + 2H_2O \quad (5)$$
(gypsum)

Most $CaSO_4$ is in the hydrated form but some occurs without attached water molecules and is known as anhydrite. Anhydrite forms are implicitly included when gypsum is described.

Both Mg^{2+} and SO_4^{-2} can also be released by the dissolution of very soluble minerals such as epsomite which may form in coal environments where the peat was inundated by sea water. Dissolution of epsomite may be represented as

$$MgSO_4 = Mg^{2+} + SO_4^{2-} \quad (6)$$
(epsomite)

Elevated Na^+ concentrations may result from either the dissolution of small amounts of very soluble halite or from ion exchange on clay particles or on sodium zeolites. Halite dissolution will increase the overall solute concentration (i.e. TDS) and will yield equal Na^+ and Cl^- contents when the solute compositions are reported in the meq/L units. Ion exchange will not directly elevate the overall solute content, but will result in increased Na^+ concentrations at the expense of reduced Ca^{2+} and/or Mg^{2+} concentrations.

Halite dissolution may be represented as

$$NaCl = Na^+ + Cl^- \quad (7)$$
(halite)

Ion exchange may be represented by reactions involving the sodium zeolite analcime,

$$2NaAlSi_2O_6 \bullet H_2O + Ca^{2+} = Ca(AlSi_2O_6)_2 \bullet H_2O + 2Na^+ \quad (8)$$

$$2NaAlSi_2O_6 \bullet H_2O + Mg^{2+} = Mg(AlSi_2O_6)_2 \bullet H_2O + 2Na^+ \quad (9)$$

Clay mineral ion exchange which may be represented as

$$Ca^{2+} + \text{Na-clay} = 2Na^+ + \text{Ca-clay} \quad (10)$$

$$Mg^{2+} + \text{Na-clay} = 2Na^+ + \text{Mg-clay} \quad (11)$$

In all of the mine waters the Na^+ reacting equivalents exceed the Cl^- reacting equivalents by an order of magnitude or more (Table 3) which suggest that ion exchange (Eqs. 8-11) is the primary source of dissolved Na^+ rather than halite dissolution (Eq. 7). Although there are other potential sources of Cl^-, such as silicate mineral dissolution, most of these chemical reactions only yield meager amounts of Cl^- and are not considered further. Ion exchange requires a source of dissolved Ca^{2+} or Mg^{2+}. Calcite, dolomite and gypsum dissolution (Eqs. 3-5) are all potential sources for these cations in the mine environment.

In both the Hiawatha 11th West seals and the Blind Canyon borehole groundwaters the HCO_3^- reacting equivalents exceed the Ca^{2+} plus Mg^{2+} reacting equivalents by 3.03 and 1.51 meq/L, respectively. The Ca^{2+} or Mg^{2+} deficit in the 11th West water can largely be accounted for by carbonate mineral dissolution and less than 1 meq/L of gypsum dissolution is necessary to account for the excess Na^+. This is consistent with the fact that the SO_4^{2-} content is only 0.7 meq/L. In the Blind Canyon borehole samples carbonate mineral dissolution can only account for about 25% of the excess Na^+ and gypsum dissolution is required to provide the additional Ca^{2+} for ion exchange reactions. In these samples the average SO_4^{2-} content is 2.54 meq/L.

All of the groundwaters are supersaturated with respect to carbonate minerals and under saturated with respect to gypsum (Table 3). Saturation is defined as log SI = 0.00 ± 0.1. Values less than 0.01 means that the water is under saturated and can dissolve additional minerals and values greater than 0.01 means the water is supersaturated and has a thermodynamic tendency to precipitate minerals. The saturation condition for carbonate minerals limits the amount of Ca^{2+} and Mg^{2+} that can be supplied by carbonate mineral dissolution and under saturation of gypsum allows for the dissolution of all available gypsum.

5.5.2 Pyrite – Marcasite Dissolution

Ken Fleck (personal communication) indicated that the iron sulfide mineralization occurs in more than one form and one of these is highly reactive when exposed to water. In order to determine the mineralogy of the iron sulfide minerals XRD (x-ray diffraction) analysis was performed on samples from the coal and an igneous dike in the mine by Dave Tingey (BYU Laboratory of Isotope Geochemistry, Appendix A). Samples were collected from a high-sulfur split rock and the cleat in the 17th West submains XC-6, a high-sulfur split rock from the 17th West longwall at about XC-60, and an igneous dike. The igneous dike sample only contained pyrite; however the coal samples contained both pyrite and its pseudomorph marcasite. In the laboratory samples marcasite constitutes as much as much as 45 % of the iron sulfide mineralization (Appendix A).

Both pyrite and marcasite have the same chemical composition (FeS_2) and undergo similar decomposition reactions. The general form of pyrite and marcasite oxidation can be represented as

$$\underset{\text{(pyrite or marcasite)}}{2FeS_{2(s)}} + 7O_2 + H_2O = 2\,Fe^{2+}_{(aq)} + 4SO_4^{2-}{}_{(aq)} + 4H^+ \qquad (12)$$

And the ferrous iron (II) may be oxidized to ferric iron (III)

$$4Fe^{2+}_{(aq)} + 7O_2 + 4H^+ = 4\,Fe^{3+} + 2H_2O \qquad (13)$$

Both reactions (12 and 13) can be catalyzed by microorganisms that derive energy from the oxidation reactions and pyrite oxidation is greatly facilitated by microorganism. Marcasite oxidation may readily occur without such organisms. Pyrite has a cubic structure whereas marcasite has an orthorhombic structure. The difference in crystal structures makes marcasite considerably more soluble than pyrite when in contact with oxygen rich water. Solubility controls are described below.

From equations 12 and 13 it is clear that an abundant supply of oxygen is required for the dissolution of iron sulfide minerals and the subsequent release of iron and sulfate.

Under suitable oxidizing/reducing potential (ORP) and pH conditions the released ferric iron (Fe^{3+}) then combines with water to form amorphous iron hydroxide, which colors the water red/yellow/orange according to.

$$Fe^{3+} + 2H_2O = \underset{\text{(goethite)}}{FeOOH_{(s)}} + 3H^+ \qquad (14)$$

The oxidation of reduced iron minerals such as pyrite and marcasite and the form of the released ion are regulated by both the pH and the ORP of the water (Figure 6). ORP is commonly measured as Eh or pe (in millivolts) where Eh = 0.059pe. Although there are no free electrons in a solution, it is useful to define the electron activity as pe where pe = -log electron activity in a fashion similar to defining pH as –log of the hydrogen ion activity. If the ORP is low (i.e., reducing conditions) there is strong tendency for a solution to donate protons and if the ORP is high (i.e., oxidizing conditions) there is a strong tendency for a solution to accept protons. Dissolved oxygen is a strong electron acceptor and thus the presence of O_2 in groundwater facilitates the oxidation of pyrite and marcasite.

In reduced, low pH water the dissolved iron is often in the form of Fe^{2+} (Eq. 12), but may be in the form Fe^{3+} in more oxidized water (Figure 6). In neutral to basic oxidized water, which is typical of mine floor water in Utah coal mines and in the Deer Creek mine, both ferrous and ferric iron combine with water to form rust colored iron hydroxide precipitate (Eqs. 13-14). This iron hydroxide precipitate is amorphous and may not readily settle from moving water.

In many mining environments reactions 12-13 result in acid mine drainage (AMD), however the abundance of carbonate minerals in Utah coal mines neutralizes the acid generated as shown in equations 1-3 (Mayo et al., 2000).

5.5.3 Solubility Controls

As described above, factors including OPR and/or pH control the conditions necessary for the dissolution of some minerals including carbonates and pyrite and marcasite. Other minerals such as halite and gypsum and $MgSO_4$ can dissolve independently of these controls. The concentrations of ions released by chemical reactions are regulated by the solubility of each mineral species and there is a very wide range of mineral solubility. The maximum solubility can be defined by the equilibrium constant (Keq) for each mineral. Keq is temperature and for some minerals pH and or pe dependent. The equilibrium constant is sometimes known as the Ksp (solubility product) and is defined as

$$\text{Keq} = \frac{concentrations\ of\ products}{concentrations\ of\ reatants}$$

Using calcite as an example

$$\text{Keq Calcite} = \frac{Ca^{2+} \quad HCO_3^-}{CaCO3}$$

where ( ) are the chemical activities which are similar to the concentrations. The activity of a solid has a value of 1.

The equilibrium constants and solubility for reactions of interest are listed in Table 5. From the table it is apparent that the dissolution of gypsum and $MgSO_4$ can release considerably more SO_4^{2-} than pyrite and that iron hydroxide precipitate is essentially insoluble. These differences in solubility may partially explain why the trends of SO_4^{2-} concentrations in Mill Fork Area waters are declining over time and there is no measurable decline in total iron (Figure 4a, b). The high equilibrium constants of gypsum and minerals such as epsomite mean that the available gypsum and epsomite will more readily leach out whereas it will take considerably longer for the available pyrite/marcasite to leach.

5.6 In-Mine Factors Controlling SO_4^{2-} and Iron Concentrations Due To Oxidizing/Reducing Conditions and Dissolved Oxygen

The average Eh of water collected on March 6, 2014 by David Tingey at the 17th West seal was -150 mv, whereas the well oxygenated groundwater in the mine had an Eh of about +300 mv.

The negative Eh of the water accumulating behind the 17th West seal reflects reducing conditions, whereas the positive value of the well oxygenated groundwater measured after the 10 bucket pours during the in-mine experiment reflects oxidizing conditions. Because groundwater collected at the 17th West seal has had contact with mine atmosphere behind the seal, the groundwater had been partially oxygenated and the groundwater entering the mine environment is more reduced than indicated by the measured value of the 17th West discharge.

Eh is difficult to measure accurately and hard to quantify, therefore the dissolved oxygen (DO) content is usually a better measure of a waters ORP. There is no direct relationship between ORP and the concentration of dissolved oxygen as the concentration of a dissolved gas is inversely proportional to water temperature and numerous other factors and reactions can affect ORP.

The measured gas composition of the atmospheric environment behind the 17th West seal indicates that the non-ventilated in-mine atmosphere is enriched in both CO_2 and methane (CH_4) relative to the outside atmosphere (Table 6). It is assumed that the in-mine ventilated atmosphere has a similar composition as the outside non-mine atmosphere. Although the sealed 17th West mine gob area atmosphere is somewhat depleted in oxygen relative to the outside atmosphere, there is abundant O_2 to oxygenate groundwater behind the seal.

Field and laboratory measurements of DO in groundwater samples were conducted to evaluate the potential oxygen content of in-mine groundwater (Table 7, Appendix A). In-mine analysis of DO in groundwater collected from the 17th and 11th West sumps and the TW-10 borehole had low oxygen concentrations of 2.44, 4.03, and 4.72 mg/L, respectively. Although there is abundant O_2 behind the seals the low DO contents of the waters suggest that there is little agitation of the water. The laboratory analysis of the two sump samples collected at the same time is consistent with the low Eh of the in-mine analysis. The TW-10 borehole sample had been exposed to O_2 prior to the laboratory analysis or during sampling.

Three laboratory flow though cell experiments were performed by David Tingey on 17th West sump groundwater to further evaluate the impact of O_2 on behind the seal groundwater that would flow on the mine floor if permitted to discharge at the Rilda Canyon portals. The groundwater samples were collected in large containers without air space and when water was removed from the containers in the laboratory the displaced water was replaced with nitrogen gas to prevent oxygenation of the raw water. In each experiment water was transferred to a flow through cell and readings were made every 2 minutes for 6 minutes. In the first experiment the flowing water was allowed to equilibrate with the laboratory atmosphere and the DO increased to 6.28 mg/L. When the water was injected with laboratory air the DO increased to 7.35 mg/L. After letting the samples equilibrate over two days the measured DO dropped 5.77 mg/L on March 11, 2014. The increased conductivity and pH associated with the March 11 flow through cell data may be due to evaporation of the water as it was open to evaporation in the laboratory.

Results of the laboratory experiments suggest that groundwater flowing on the mine floor will likely acquire additional O_2 and the dissolved Fe^{2+} may oxidize to Fe^{3+} (Eq. 13) and the Fe^{3+} would likely be converted to ferric hydroxide (Eq. 14) turning the water rust colored.

5.7 Oxidized Sulfur and Elevated Mg Concentrations

Although much of the excess SO_4^{-2} concentrations in the discharge waters may be the result of gypsum dissolution it is unlikely that most of the elevated Mg^{2+} concentrations (Table 3) are due to dolomite dissolution. Dolomite has not been reported as a common mineral in the Utah coal district and pure dolomite is rare. The dissolution of pure dolomite would yield equal reacting equivalents of both Ca^{2+} and Mg^{2+}. In two sampling locations, 17th West Seals and Blind Canyon Borehole, the Mg^{2+} reacting equivalents exceed the Ca^{2+} reacting equivalents.

In an attempt to better understand the source of the elevated Mg^{2+} and its relationship to the elevated SO_4^{-2}, dissolution experiments were conducted on coal and parting shale samples. The samples were crushed and allowed to equilibrate with CO_2 and oxygen free water (i.e., reducing condition) in an oxygen free environment (Appendix A). The purpose of the CO_2-oxygen free environment was to evaluate the potential dissolution of oxidized sulfur bearing minerals and to reduce the effects of pyrite oxidization and acid driven carbonate mineral dissolution. Some oxygenation may have occurred during liquid transferring procedures.

Results of the leaching experiments are shown in Table 8. Although only two samples were leached and the results do not represent a systematic sampling of the in-mine environment, the results provide valuable insight into in-mine chemical reactions. In the absence of CO_2 and oxygen only minor mineral dissolution occurred in the coal sample. In the parting shale sample it appears as if appreciable dissolution of both reduced and oxidized sulfur minerals occurred. Sulfate was the dominant anion (97.9%) and dominant anions include Ca^{2+} (35.3%), Mg^{2+} (42.5%), and Fe^{3+} (19.4%). The small amounts of HCO_3^- (2.1%) and Na^+ (1.8%) means that carbonate mineral dissolution and ion exchange were negligable reactions and that gypsum and $MgSO_4$ dissolution were responsible for the elevated Ca^{2+} and Mg^{2+} and for most of the SO_4^{-2}. In the parting sample, pyrite or other reduced iron species dissolution accounts for 19.8% of the dissolved SO_4^{-2}. The factors responsible for the release of dissolved iron were not investigated.

6 Estimated soluble iron sulfide in the Mill Fork Area

Although most of the dissolved SO_4^{-2} in the 11th and 17th West sump waters is likely derived from the dissolution of oxidized sulfur (gypsum and epsomite) in the elevated sulfur zone, the total iron concentrations in discharge water clearly demonstrate that pyrite and marcasite oxidation provides some SO_4^{-2} and releases iron which is converted to rust colored iron hydroxide.

Although the sulfur content in the elevated sulfur zones is known, the concentration of iron sulfide mineralization is unknown. Using the calculated Fe^{3+} concentrations and the measured SO_4^{2-} concentrations it is possible to make a 1st order estimate of the iron sulfide concentration in the high sulfur zones. Assuming the calculated Fe^{3+} reacting equivalents represent the SO_4^{2-} reacting equivalents due to iron sulfide oxidation and that both oxidized sulfate minerals (gypsum and $MgSO_4$) and pyrite contribute SO_4^{2-} proportionally to their concentrations in water in the high sulfur zones, approximately 3% of the total sulfur in the high sulfur zones is from of iron sulfide. Assuming 55% of the iron hydroxide is pyrite and 45% is the very reactive marcasite, pyrite and marcasite constitute 1.65 and 1.35% of the total sulfur content in the high sulfur zones, respectively. Based on these assumptions the calculated potentially reactive total pyrite and marcasite in the Mill Fork Area is 958 tons of which 775 tons are on the floor of the mine workings and 183 tons are in the vertical surfaces (Table 2).

In Table 2, the amounts of iron sulfide mineralization has been calculated for both pyrite and marcasite and these calculations include mine floors and vertical surfaces for both flooded and non-flooded portions of the Mill Fork Area. Total amounts are listed in both tons and in kg. Kilogram units are useful for evaluating the long-term impact of iron sulfide dissolution on in-mine water quality. When reviewing the calculated amounts in Table 2 it is important to keep in mind that the calculations are based on numerous assumptions and the results should only be considered as a 1^{st} order approximation.

7 Other Potential Sources of Iron

Approximately 1,200 tons of beltline components, located up gradient of the proposed bulkhead location Mill Fork Access #2 XC-62.5 to 27^{th} West, may be abandoned in the mine workings after mine closure. An unknown but large portion of the beltline components consists of iron that will be subject to iron oxidization (i.e., rusting). Assuming 50% of the total beltline components are iron, the total available iron for oxidation would become about 1,500 tons (600 beltline tons + 958 iron sulfide tons). Such oxidization will incrementally add to the dissolved and total iron in in-mine waters and the fate of this iron will be similar to the fate of iron from the oxidization of iron sulfide as described below.

8 Long-term Impacts of Iron Sulfide Mineral Dissolution on In-mine Water

Total oxidation and conversion to iron hydroxide (i.e., total iron) of the calculated iron sulfide in the Mill Fork Area would require about 75 years. If the beltline iron is abandoned in the mine total iron oxidation would require more than 100 years. The calculation assumes: 1) the total available iron sulfide is 958 tons, 2) all of the iron sulfide has and will continue to have contact with oxygenated water, 3) the groundwater flow rate will remain at about 1,000 gpm, and 4) the steady state iron hydroxide concentration will be about 3.5 mg/L. Clearly these are assumptions are unreasonable and the experience of declining total iron concentrations in groundwater discharging from the adjacent Crandall Canyon Mine (Peterson Hydrologic, 2011) suggest that the total iron concentrations in Mill Fork Area discharge water will also decrease over time. Additionally, after the cessation of mining activities the discharge rate will likely decline substantially from the current 1,000 gpm. Several factors will regulate the long-term total iron concentrations in Mill Fork Area water. These factors are discussed below.

8.1 Open System Conditions

Open system conditions means that after mine closure Mill Fork Area groundwater will discharge to the surface at the Rilda Canyon portals and that this water will flow across the floor of the Mill Fork Area long wall panels area and the Mill Fork Access workings. Under open system conditions the current flooded and non-flooded portions of the workings will behave chemically differently.

Water in the flooded portions has low oxygen concentrations, reducing conditions prevail, and the turnover rate of water from the flooded to non-flooded portions is very slow. Gypsum and $MgSO_4$ dissolution is not ORP regulated and the SO_4^{2-} concentration may become quite large. The elevated SO_4^{2-} concentrations in the Blind Canyon borehole (Table 3) provide evidence for increasing SO_4^{2-} concentrations in water that is not actively flushed from the system. Flooded region water has contact with both vertical surfaces and the mine floor and likely interacts with minerals to full saturation in the coal to a depth of 2 feet or more. Because water in the flooded portions has a very low turnover rate and reducing conditions will prevail the water will reach pyrite and marcasite saturation and the rate of additional iron sulfide oxidation will be slow. This means that most of the available iron sulfide mineralization will not react with in mine water, but would become reactive if the impounded water were drained from the mine.

The flooded regions of the Mill Fork workings are separated from the Joes Valley Graben by coal barriers. To date there is no evidence that this water leaks into the damage zone of the Joes Valley Fault or discharges into the Joes Valley Graben.

Water in the non-flooded portions of the Mill Fork Area workings will flow along the floor of the 7th North Mains, the Mill Fork Access Mains #1 and #2, and ultimately discharge to the surface via the Rilda Canyon portals. This water will have limited access to vertical surfaces and will only have contact with part of the mine floor. Elsewhere the mine floor may remain relatively dry, but the portion of mine floor that will be either wet or dry is unknown. Because the water will flow along the mine floor, the water will have ample opportunity to acquire mine atmosphere oxygen in both the non-flooded portions of the Mill Fork workings and the Mill Fork Access workings. In other words, oxidizing conditions will prevail and the water will be able to continually oxidize available iron sulfide minerals until the supply of iron sulfide mineralization is exhausted. Marcasite oxidation will occur rapidly and pyrite oxidation will require additional time. Bacteria in the water will aid in the oxidization of pyrite. Iron oxide exhaustion in the mine discharge water will occur over time but this will likely require years to tens of years. Water discharge from the portals will also have elevated SO_4^{-2} concentrations.

8.2 Closed System Conditions

Closed system conditions means that after mine closure Mill Fork Area groundwater will not discharge to the surface at the Rilda Canyon portals and that this water will not flow across the floor of the Mill Fork Access workings. Construction of bulkheads in the Mill Fork access workings are proposed to seal the Mill Fork Area. One proposed location is near the down gradient end of the access workings (1st Right Sub-Mains XC-27.5) at an elevation of 7,793.9 feet and the other is located closer to the Mill Fork Area at Mill Fork Access #2 Mains XC-62.5, elevation 7,977 feet.

The net effect of the bulkheads will be to flood the most or all of the Mill Fork Area workings. Until the workings are completely flooded additional groundwater inflows will be oxygenated and this water will react with oxidized sulfate, iron sulfide minerals, and belt line iron. The net effect will be an increase in both SO_4^{2-} and total iron concentrations. After flooding is complete, the impounded water will become reducing which will ultimately result in steady state SO_4^{2-} and total iron concentrations.

9 Not Included In This Investigation

An analysis of future groundwater flow rates and potential impacts of in-mine water leakage to the damage zone of the Joes Valley Fault and the Joes Valley Graben are beyond the scope of this investigation. Under closed systems conditions the impounded water in the Mill Fork Area will fully saturate the Hiawatha seam gob areas and may saturate the overlying rock, via fractures, to the aquifer system(s) that are draining into the Mill Fork Area workings. Analyses of chemical and hydrodynamic conditions associated with saturating overlying bed rock are also beyond the scope of this investigation.

Also not included in this investigation are the analyses of impacts of water leakage at the proposed bulkhead or other down gradient locations and the potential for catastrophic failure of the bulkhead.

Over time the water discharge rate from the Mill Fork Area will likely decline. The impact of such a decline relative to either total iron or SO_4^{-2} concentrations has not been evaluated. Also not analyzed is the spatial distribution of belt line components and the impact of roof drip and mine floor water on the iron portion of the components on total iron and SO_4^{-2} concentrations.

10 **Conclusions**

1. Zones of elevated sulfur and iron occur in the Hiawatha seam coal in the Mill Fork Area workings.

2. Several factors suggest that gypsum and $MgSO_4$ dissolution are the primary sources of the

elevated concentrations of SO_4^{2-} in both the Hiawatha 17th West seals and the Blind Canyon borehole groundwaters. The factors are: 1) the very positive $\delta^{34}S$ values of all sampled groundwaters, 2) the SO_4^{2-} concentrations in mine water greatly exceed the concentration available from iron sulfide oxidation, and 3) laboratory leaching experiments demonstrate that almost all of the SO_4^{2-} is from the dissolution of oxidized sulfate minerals.

3. Hiawatha seam groundwaters in the Mill Fork Area contain elevated concentrations of total iron which makes the water rust colored when oxygenated. This elevated total iron is associated with groundwater that has contact with the elevated sulfur zone Hiawatha seam coal.

4. Based on a 1st order calculation, approximately 958 tons of iron sulfide minerals (pyrite and marcasite) will be potentially available in the elevated sulfur zones to interact with in-mine groundwater at the time of projected mine closure.

5. Approximately 600 tons of iron would also be available for oxidization from the beltline components if the beltline is abandoned in the mine workings.

6. Chemical interaction with oxygen containing water results in iron sulfide oxidization and is responsible for the formation of rust colored iron hydroxide which is reported as total iron in laboratory analysis.

7. Assuming that all of the potentially available iron sulfide mineralization will have contact with oxygen rich water it would take about 75 years to exhaust the total supply of iron sulfide. If the beltline iron is included the time to exhaustion would exceed 100 years. When realistic in-mine conditions are considered it is likely that supply of readily available iron sulfide would be exhausted in a few to tens of years under present conditions.

8. Water quality associated with two future mine closure options have been evaluated:

   a) The first condition, call herein the Open System, envision groundwater discharging to the surface from the Rilda Canyon Portals via Mill Fork Access workings. This discharge water would be continually oxidized and would contain elevated concentrations of total iron for an indefinite period of time. Total iron concentration in the range of 1-3.5 mg/l would continue for several years. The water will also contain elevated SO_4^{2-}.

b) The second condition, called herein the Closed System, envisions no surface groundwater discharge due to the construction of bulkheads in the Mill Fork Access workings. The water impounded in the workings behind the bulkheads would become reducing and will attain elevated and steady state concentrations of total ion and SO_4^{2-}.

9. Water impounded behind Mill Fork bulkheads water would not discharge to the surface via the Rilda Canyon Portals. It is unlikely that the ensuing closed system water would leak out via the damage zone of the Joes Valley Fault or into Joes Valley, but analysis of this condition is beyond the scope of this investigation.

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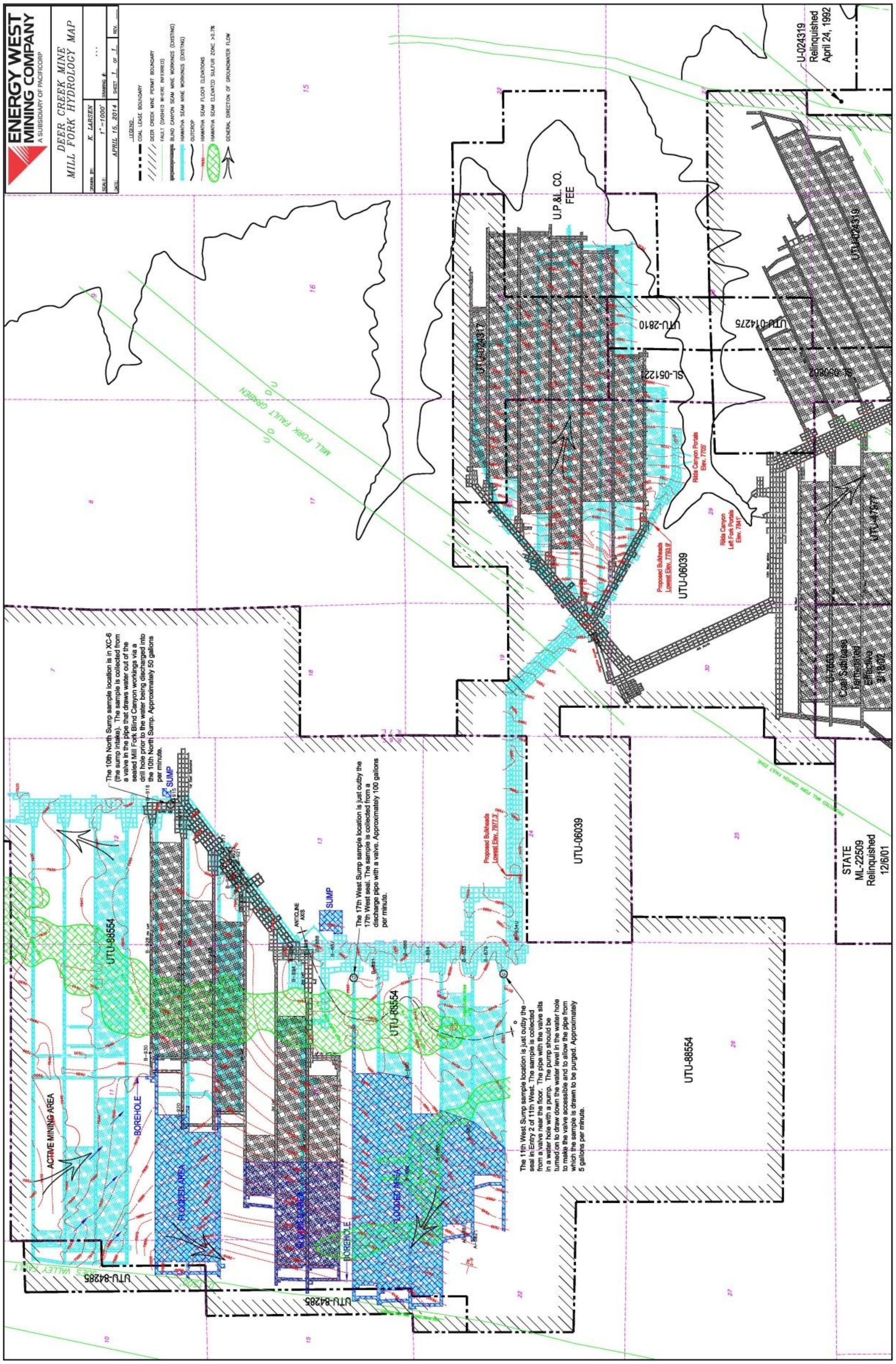


Figure 1 Deer Creek Mine hydrogeologic map. The Mill Fork Area is to the left.

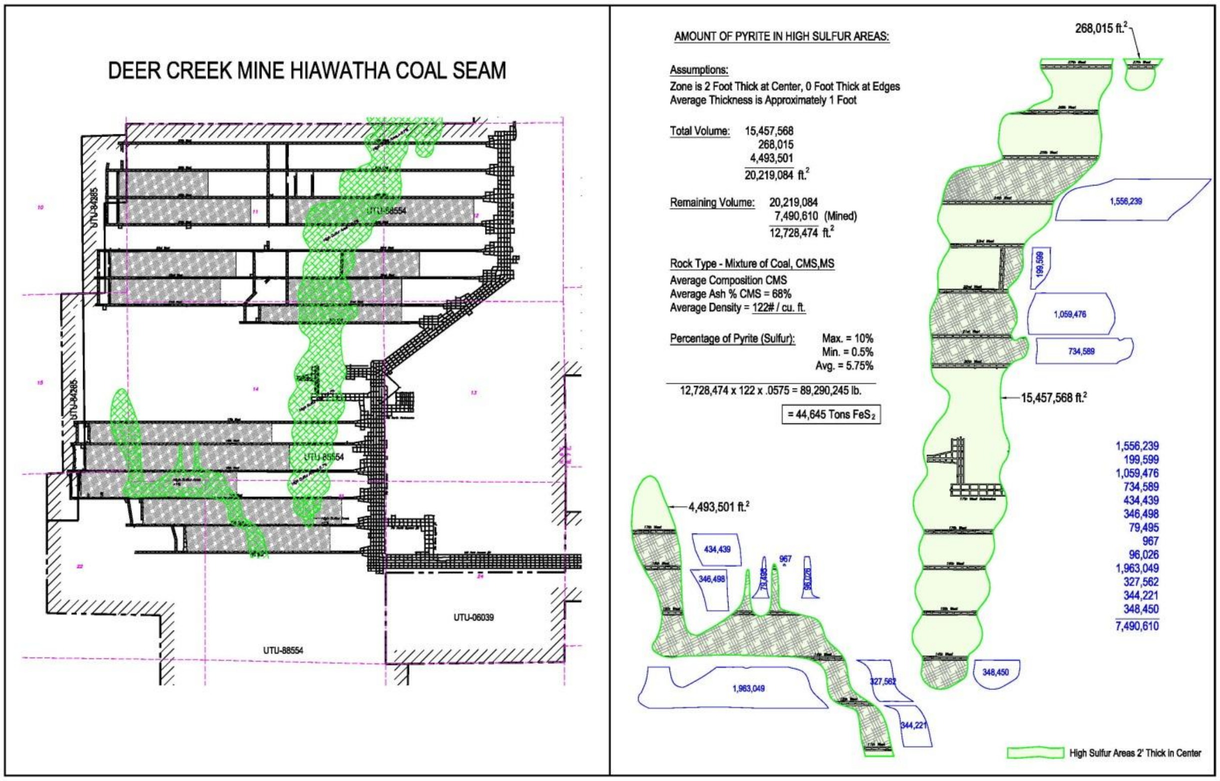


Figure 2 Distribution of iron-sulfide mineralization in Hiawatha seam mine floor workings in the Mill Fork Area. Calculated tons of iron sulfide mineralization is shown in blue.

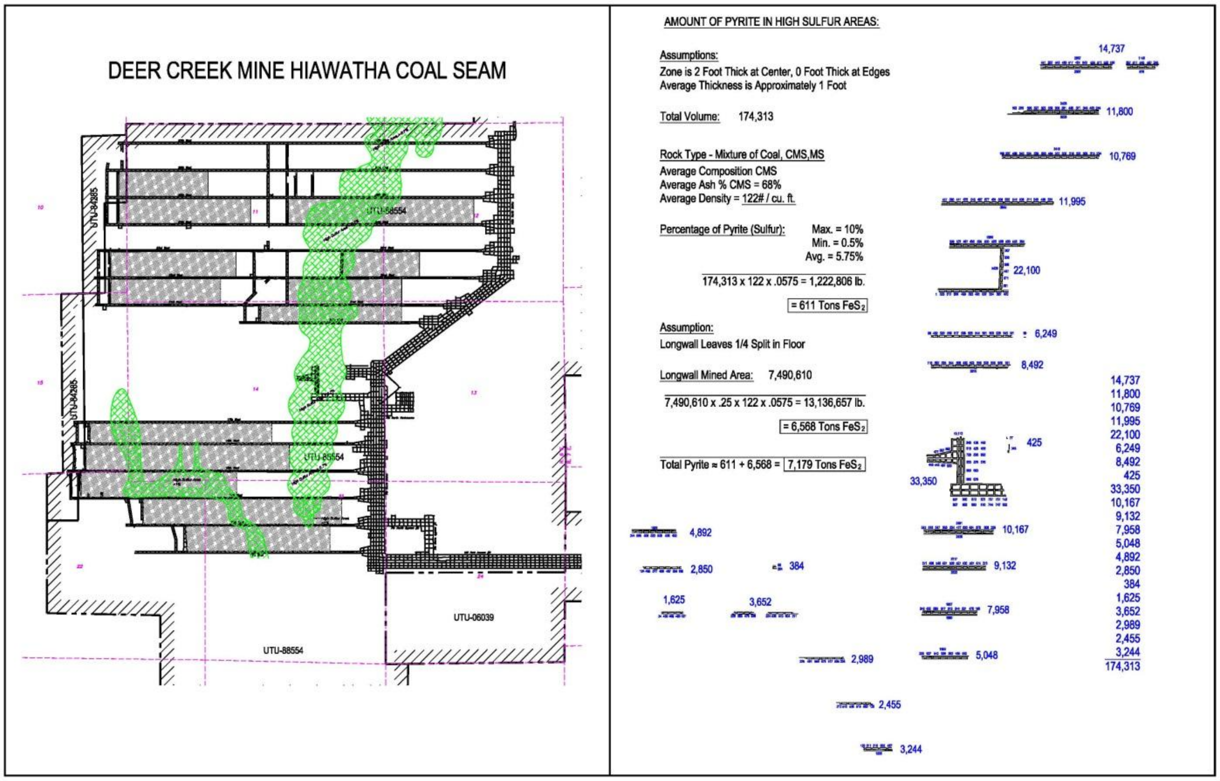


Figure 3 Distribution of iron-sulfide mineralization in Hiawatha seam vertical surfaces in the Mill Fork Area. Calculated tons of iron sulfide mineralization is shown in blue.

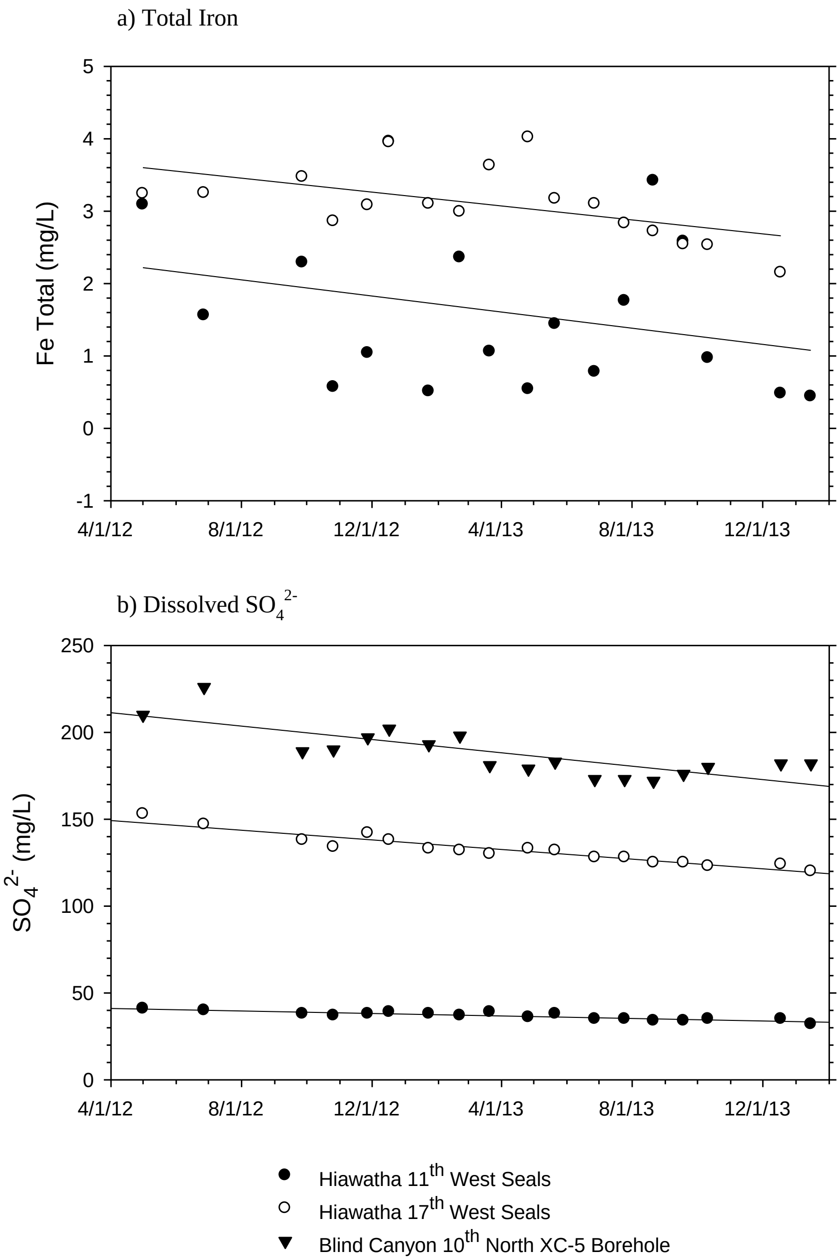


Figure 4 Temporal variation in: a) total iron and b) SO_4^{2-} concentrations in Mill Fork Area groundwater discharges.

Figure 5 Results of in mine oxidation experiment of 17^{th} West seals groundwater. Iron oxide precipitate is clearly visible in the left bucket water which was oxidized by transferring back and forth into an empty bucket. The clear water in the left bucket is the control 17^{th} West seals water which was not oxidized and contains dissolved iron.

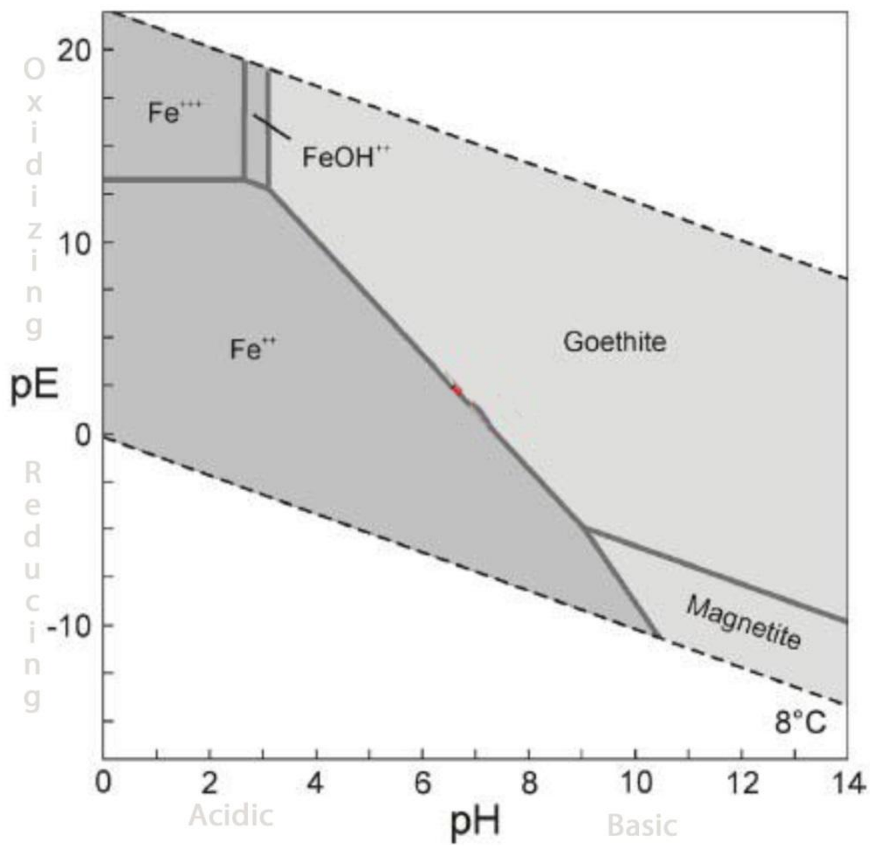


Figure 6 Stability diagram showing the relationship between dissolved ferric and ferris iron and iron hydroxide precipitate (goethite).

Table 1 Results of periodic sampling of Mill Fork area solute compositions.

	5/1/12	6/27/12	9/27/12	10/26/12	11/27/12	12/17/12	1/23/13	2/21/13	3/21/13	4/26/13	5/21/13	6/27/13	7/25/13	8/21/13	9/18/13	10/11/13	12/18/13	1/15/14
Hiawatha 11th West Seals																		
pH, units	7.15	7.19	7.13	7.53	7.2	7.12	7.24	7.12	7.14	7.48	7.18	7.5	7.12	7.13	7.17	7.17	7.28	7.62
Sulfate mg/L	41	40	38	37	38	39	38	37	39	36	38	35	35	34	34	35	35	32
Iron, Fe Total mg/l	3.09	1.56	2.29	0.57	1.04	3.96	0.51	2.36	1.06	0.54	1.44	0.78	1.76	3.42	2.58	0.97	0.48	0.44
Iron, Fe Dissolved mg/l	1.19	<0.03	0.44	<0.03	<0.03	0.11	<0.03	<0.03	0.11	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.3	<0.03	<0.03
Hiawatha 17th West Seals																		
pH, units	7.45	7.47	7.52	7.43	7.26	7.36	7.26	7.34	7.47	7.4	7.34	7.3	7.25	7.51	7.49	7.33	7.48	7.33
Sulfate mg/L	153	147	138	134	142	138	133	132	130	133	132	128	128	125	125	123	124	120
Iron, Fe Total mg/l	3.24	3.25	3.47	2.86	3.08	3.95	3.10	2.99	3.63	4.02	3.17	3.1	9.79	2.83	2.72	2.54	2.53	2.15
Iron, Fe Dissolved mg/l	<0.03	<0.03	<0.03	<0.03	0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.14	<0.03	<0.03	<0.03	<0.3	<0.03	<0.03
Blind Canyon 10th North XC-5 Borehole																		
pH, units	7.61	7.62	7.6	7.55	7.47	7.51	7.37	7.39	7.42	7.46	7.37	7.32	7.34	7.36	7.41	7.46	7.35	7.3
Sulfate mg/L	210	226	189	190	197	202	193	198	181	179	183	173	173	172	176	180	182	182
Iron, Fe Total mg/l	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, Fe Dissolved mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.3	<0.03	<0.03

Table 2 Calculated tons of sulfur and iron sulfide minerals in the high sulfur zones that may have contact groundwater. Only mineralization within two feet of exposed surfaces are included in the calculations.

	Mine Floor[1]				Vertical Surfaces[1]			
Area	Mined Area (ft^2)	Reactive Mined Area (ft^3)[1]	Reactive Area Coal in Floor[2] (tons)	Sulfur (tons)[3]	Vertical Surfaces (ft^2)	Vertical Surfaces (ft^3)[1]	Reactive Vertical Surfaces[2] (tons)	Sulfur (tons)[3]
Non-flooded areas								
20th - 25th west panels	3,558,903	3,558,903	217,093	12,266				
11th to 14th west panels	1,020,233	1,020,233	62,234	3,516				
20th to 27th gate roads					86,142	86,142	5,255	3,021
18th-19th gate roads					33,775	33,775	2,060	1,185
11th -27th gate roads					40,993	40,993	2,501	1,438
Flooded areas								
14th -17th west panels	2,920,474	2,920,474	178,149	10,065				
14th -17th gate roads					13,403	13,403	818	470
total	7,499,610	7,499,610	457,476	25,847	174,313	174,313	10,633	6,114

	Mine Floor[1]						Vertical Surfaces[1]					
	Iron Sulfide[4] (tons)	Pyrite[5] (tons)	Marcasite[6] (tons)	Iron Sulfide (kg)	Pyrite[5] (kg)	Marcasite[6] (kg)	Iron Sulfide[1] (tons)	Pyrite[5] (tons)	Marcasite[6] (tons)	Iron Sulfide (kg)	Pyrite[5] (kg)	Marcasite[6] (kg)
Non-flooded areas												
20th - 25th west panels	368	202	166	333,820	183,601	300,437						
11th to 14th west panels	105	58	47	95,696	52,633	86,127						
20th to 27th gate roads							91	50	82	82,230	90,453	37,003
18th-19th gate roads							36	20	32	32,241	35,465	14,509
11th -27th gate roads							43	24	39	39,131	43,044	17,609
Flooded areas												
14th -17th west panels	302	166	136	273,936	150,665	246,542						
14th -17th gate roads							14	8	13	12,794	14,074	5,757
total	775	426	349	703,452	386,899	633,106	183	101	165	166,397	183,036	74,878

1 Assumes thicness of active reactive zone is 1 ft from exposed surface

2 Average density = 122 lbs/ft^3

3 Assumes 5.75% average sulfur content

4 Assumes 3% of total sulfur

5 Assumes 1.65% of total sulfur

6 Assumes 1.35% of total sulfur

Table 3 Major iron compositions of and saturation Indices (SI) of Mill Fork areak groundwaters.

							mg/L									
Sample Location	date	Q (gpm)	oC	pH	cond µmhos /cm	TDS	Ca	Mg	Na	K	HCO_3	Cl	SO_4	Fe dissolved	Fe total	Fe^{+3} equivalent
Hiawatha 11th West Seals	12/18/13	4.3	15.7	7.28	900	499	73.3	24.4	90.2	9.9	538.9	8	35	<0.3	0.48	0.302
	1/15/14	4.6	15.7	7.62	913	525	75.9	25.8	88.5	9.8	536.5	8	32	<0.3	0.44	0.277
	average		15.7	7.45	907	512	74.6	25.1	89.3	9.9	537.7	8	34	<0.3	0.46	0.290
															0.35	
Hiawatha 17th West Seals	12/18/13	~100	12.5	7.48	928	536	64.4	42.5	64.8	11.2	388.9	12	124	<0.3	2.53	1.594
	1/15/14	~100	12.6	7.33	921	542	65.4	43.2	62.6	10.6	421.9	12	120	<0.3	2.15	1.355
	average		12.6	7.41	925	539	64.9	42.8	63.7	10.9	405.4	12	122	<0.3	2.34	1.474
Blind Canyon 10th North XC-5 Borehole	12/18/13	50	11.6	7.35	1206	733	75.8	46.7	134.7	11.4	554.7	7	182	<0.3	<0.05	
	1/15/14	50	11.6	7.30	1216	749	76.8	48.5	128.9	10.9	571.8	7	182	<0.3	<0.05	
	average		11.6	7.33	1211	741	76.3	47.6	131.8	11.1	563.3	7	182	<0.3	<0.05	

					meq/L						
		Ca	Mg	Na	K	HCO_3	Cl	SO_4	Fe^{+3}	sum cation	sum anion
Hiawatha 11th West Seals	12/18/13	3.66	2.00	3.92	0.25	8.83	0.23	0.73	0.02	9.84	9.79
	1/15/14	3.79	2.12	3.85	0.25	8.79	0.23	0.67	0.01	10.01	9.69
	average	3.72	2.06	3.89	0.25	8.81	0.23	0.70	0.02	9.92	9.74
Hiawatha 17th West Seals	12/18/13	3.21	3.49	2.82	0.29	6.37	0.34	2.58	0.09	9.81	9.29
	1/15/14	3.26	3.55	2.72	0.27	6.91	0.34	2.50	0.07	9.81	9.75
	average	3.24	3.52	2.77	0.28	6.64	0.34	2.54	0.08	9.81	9.52
Blind Canyon 10th North XC-5 Borehole	12/18/13	3.78	3.84	5.86	0.29	9.09	0.20	3.79		13.77	13.08
	1/15/14	3.83	3.99	5.61	0.28	9.37	0.20	3.79		13.70	13.36
		3.81	3.91	5.73	0.28	9.23	0.20	3.79		13.74	13.22

	Log Saturation Indicies (SI)[1]			
	Calcite	Dolomite	Gypsum	Halite
Hiawatha 11th West Seals	0.43	0.56	-2.1	-7.7
Hiawatha 17th West Seals	0.19	0.36	-1.63	-1.7
Blind Canyon 10th North XC-5 Borehole	0.26	0.46	-1.44	-7.6

[1] Saturation = 0.00 ± 0.1; positive values incidate super saturation and negative values indicate under saturation

Table 4 Stable isotopic compositions of dissolved sulfur and water collected on November 6, 2013.

	$\delta^{18}O$ ‰	+/-	$\delta^{2}H$ ‰	+/-	$\delta^{34}S$ ‰	+/-
Hiawatha 11th West Seals	-17.18	0.40	-129.5	1.0	35.5	0.2
Hiawatha 17th West Seals	-17.07	0.40	-128.3	1.0	22.8	0.2
Blind Canyon 10th North XC-5 Borehole	-17.10	0.40	-127.1	1.0	13.8	0.2
Hiawatha 8w xc-25 #2	-16.85	0.40	-125.9	1.0	24.5	0.2
Hiawatha11 N xc-9 #2	-16.93	0.40	-126.2	1.0	20.4	0.2
Hiawatha 27 W outby sc-37 Ent 2	-16.83	0.40	-126.5	1.0	27.7	0.2
Hiawatha 27 W Inby xc-70 Ent 2	-16.94	0.40	-126.9	1.0	8.3	0.2

Table 5 Equilibrium constants and solubility of selected minerals of interest.

Mineral	Keq	Solubility @ 25 ^{o}C (mg/L)
Gypsum	$10^{-4.5}$	2100
Calcite	$10^{-8.4}$	100-500*
Dolomite	10-17	90-480**
Pyrite	10-18	***1-10
Geothite	10-37	Essentially insoluble

*CO_2 dependent

** pure dolomite is rare, most contains more Ca than Mg

*** value depend on the availability of O_2; rapidly oxidizes and precipitates

Table 6 Gas composition of the atmosphere behind the 17th west seal and the average composition of the atmospere.

	Non-mine atmospheric average (%)	In-mine non-ventilated atmosphere behind 17^{th} west seal (%)
Nitrogen	78.084	81.17
Oxygen	20.946	13.65
CO2	0.397	5.15
Methane	0.00018	0.04

Table 7 Summary of field and laboratory dissolved oxygen

	Field DO (mg/L)	Laboratory DO (mg/L)	Laboratory conductivity (µm/cm)	Laboratory pH	Comments
17th West #2 seal					
2/26/2014	2.44	3.80			
3/7/2014		6.28	788	7.18	Average of 3 measurements over 6 minutes
3/7/2014		7.35	856	7.82	Average of 3 measurements over 6 minutes with injection of laboratory air
3/11/2014		5.77	928	8.30	Average of 3 measurements over 6 minutes after 2 day slow bubbling of laboratory air
MN-ME					
2/26/2014	9.34	8.00			
TW-10					Borehole
2/26/2014	4.72	6.50			
11th West #2 Seal					
2/26/2014	4.03	4.20			

Table 8 Summary of leaching experiments

	mg/L							
	Ca	Mg	Na	K	HCO_3	Cl	SO_4	Fe^{+3}
Parting Shale	317.1	232.0	18.11	15.74	56	<0.01	2107.8	242.9
Coal	7.27	4.19	3.05	1.93	18	14.52	8.91	0.04

	meq/L							
	Ca	Mg	Na	K	HCO_3	Cl	SO_4	Fe^{+3}
Parting Shale	15.82	19.09	0.79	0.40	0.92	<0.01	43.88	8.70
Coal	0.36	0.34	0.13	0.05	0.30	0.41	0.09	0.001

Appendix A

Laboratory Reports

BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Mayo and Associates
710 East 100 North
Lindon, UT 84042

Reporting Date: March 11, 2014
Analysis Date: March 7-11, 2014

Project: Deer Creek Mine—Mill Fork Area

Water Parameter Experiments Collected from Flow-Through Cell

3/7/2014 Raw Water

	DO %	DO mg/L	Cond uS/cm	pH	ORP mV
2 min	57.6	6.23	786	7.16	57.9
4 min	58.5	6.30	788	7.19	66.4
6 min	58.9	6.32	790	7.19	69.3

3/7/2014 After Oxygenation (using lab air)

2 min	72.9	7.32	855	7.82	97.4
4 min	73.0	7.31	856	7.82	97.7
6 min	74.3	7.42	858	7.81	98.0

3/11/2014 After slow bubbling all weekend using lab air

2 min	67.4	5.81	931	8.29	93.8
4 min	66.9	5.77	929	8.29	92.7
6 min	66.5	5.73	928	8.30	91.3

Eh Measurement

Jug #1	Jug #2
-190	-109

DO—Dissolved Oxygen
Cond—Conductivity
ORP—Oxidation Reduction Potential
Eh—Oxidation-Reduction measured in volts

David G. Tingey
Research Professor

BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Mayo and Associates
710 East 100 North
Lindon, UT 84042

Reporting Date: March 19, 2014
Analysis Date: March 17, 2014

Project: Deer Creek Mine—Mill Fork Area

XRD results

- Iron Precipitate is composed of Geothite and/or Limonite
  - Chemical Formula of Geothite is $FeO(OH)$
  - Chemical Formula of Limonite is $FeO(OH) \cdot nH_20$
- Parting Shale FeS_2 is composed of 55% Pyrite and 45% Marcasite
- Igneous Dike Fes_2 is Pyrite
- Coal Cleat Faces FeS_2 is Pyrite

Analysis by Scintag Inc. Model 2000 XRD instrument.

David G. Tingey
Research Professor

BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Mayo and Associates
710 East 100 North
Lindon, UT 84042

Reporting Date: April 11, 2014
Analysis Date: April 9, 2014

Project: Deer Creek Mine—Mill Fork Area

Leach Experiment Procedure

1. Water processing: Approximately 500 milliliters of ultrapure distilled water was boiled in a glass apparatus under an Argon atmosphere with Argon bubbling through the samples. This process was used to remove all dissolved Oxygen and to lower the Eh potential.
2. A sample from the parting collected by David Tingey was first washed to remove the mining rock dust ($CaCO3$) and dried. The shale material was coarse-crushed to a size which would pass through a screen with a ½ inch opening (12.7 mm).
3. The procedure described in item 2 was done for the coal sample collected in the same location above the parting.
4. Both the crushed parting and coal samples (150 mg) where placed in 1 liter wide mouth polypropylene bottles. The atmosphere was purged from the bottle with Argon gas and the bottle was sealed.
5. After the leach water had boiled for 10 minutes, it was allowed to cool to room temperature while being maintained under an Argon atmosphere to prevent the introduction of Oxygen.
6. The leach water (150 milliliters) was quickly transferred into each 1 liter bottle. The bottles where again purged with Argon and sealed.
7. The 2 sample bottles where refrigerated so the reaction could happen at mine temperatures. The leaching experiment lasted for 48 hours after which the samples were filtered and analyzed for both anions and cations.

David G. Tingey
Research Professor

BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Mayo and Associates
710 East 100 North
Lindon, UT 84042

Reporting Date: April 11, 2014
Analysis Date: April 9, 2014

Project: Deer Creek Mine—Mill Fork Area

Leach Experiments continued: Parting Shale sample

Cations	mg/L	meq/L	
Calcium (Ca^{++})	317.1	15.82	EPA Method: 215.1
Magnesium (Mg^{++})	232.0	19.09	EPA Method: 242.1
Sodium (Na^{+})	18.11	0.79	EPA Method: 273.1
Potassium(K^{+})	15.74	0.40	EPA Method: 258.1
Iron (Fe^{++})	242.9	8.70	
Anions			
Bicarbonate (HCO_3^-)	56.0	0.92	
Fluoride (F^-)	< 0.01	0.00	EPA Method: 300.0
Chloride (Cl^-)	< 0.01	0.00	EPA Method: 300.0
Nitrate (NO_3^-)	< 0.01	0.00	EPA Method: 300.0
Bromide (Br^-)	< 0.01	0.00	EPA Method: 300.0
O-Phosphate (HPO_4^{--})	< 0.01	0.00	EPA Method: 300.0
Sulfate (SO_4^{--})	2107.8	43.88	EPA Method: 300.0
Cation/Anion Balance			ASTM: D 596-83
Total cations		44.80	
Total anions		44.80	
Percentage error (%)		0%	

Cations were analyzed using Atomic Absorption and the EPA Methods listed above.
Anions were analyzed using Ion Chromatography and following EPA Method 300.0.
Bicarbonate was estimated as the difference.

David G. Tingey
Research Professor

BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Mayo and Associates
710 East 100 North
Lindon, UT 84042

Reporting Date: April 11, 2014
Analysis Date: April 9, 2014

Project: Deer Creek Mine—Mill Fork Area

Leach Experiments continued: Coal sample

Cations	mg/L	meq/L	
Calcium (Ca^{++})	7.27	0.36	EPA Method: 215.1
Magnesium (Mg^{++})	4.19	0.34	EPA Method: 242.1
Sodium (Na^{+})	3.05	0.13	EPA Method: 273.1
Potassium(K^{+})	1.93	0.05	EPA Method: 258.1
Iron (Fe^{++})	0.04	0.00	
Anions			
Bicarbonate (HCO_3^-)	18	0.30	EPA Method: 310.1
Fluoride (F^-)	< 0.01	0.00	EPA Method: 300.0
Chloride (Cl^-)	14.52	0.41	EPA Method: 300.0
Nitrate (NO_3^-)	< 0.01	0.00	EPA Method: 300.0
Bromide (Br^-)	0.05	0.00	EPA Method: 300.0
O-Phosphate (HPO_4^{--})	< 0.01	0.00	EPA Method: 300.0
Sulfate (SO_4^{--})	8.91	0.19	EPA Method: 300.0
Cation/Anion Balance			ASTM: D 596-83
Total cations		0.89	
Total anions		0.89	
Percentage error (%)		0.01%	

Cations were analyzed using Atomic Absorption and the EPA Methods listed above.
Anions were analyzed using Ion Chromatography and following EPA Method 300.0.
Bicarbonate was estimated as the difference.

David G. Tingey
Research Professor

LEGEND

FEDERAL COAL LEASE

PRE-DISTURBED AREA (AML RECLAIMED 1988)

DATE	REVISION	BY	CHK
5/9/2016	ADDED POST MINING LAND USE, WILDLFE HABITAT, GRAZING, INDUSTRIAL, RECREATION	KJL	
2/4/2010	ADDED AS-BUILT DISTURBED AREA BOUNDARY AND NORTH RILDA CANYON PORTAL FACILITIES	KJL	

CAD FILE NAME/DISK#: 500-5 AS-BUILT

400-1

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

DEER CREEK MINE
RILDA CANYON HISTORICAL MINING
POST MINING LAND USE

DRAWN BY: K. LARSEN
SCALE: 1"=200'
DRAWING #: 400-1
DATE: MAY 9, 2016
SHEET 1 OF 1
REV. 2

NOTES

1. CROSS SECTIONS REFERENCE FROM 500-3
2. REFER TO VOLUME 11 APPENDIX VOLUME ENGINEERING APPENDIX F FOR SLOPE STABILITY ANALYSIS

LEGEND

PRE-EXISTING LINE

POST CONSTRUCTION LINE

FINAL RECLAMATION LINE

DATE	REVISION	BY	CHK
2/19/2010	REVISED TO REFLECT THE AS-BUILT CONDITIONS	KJL	

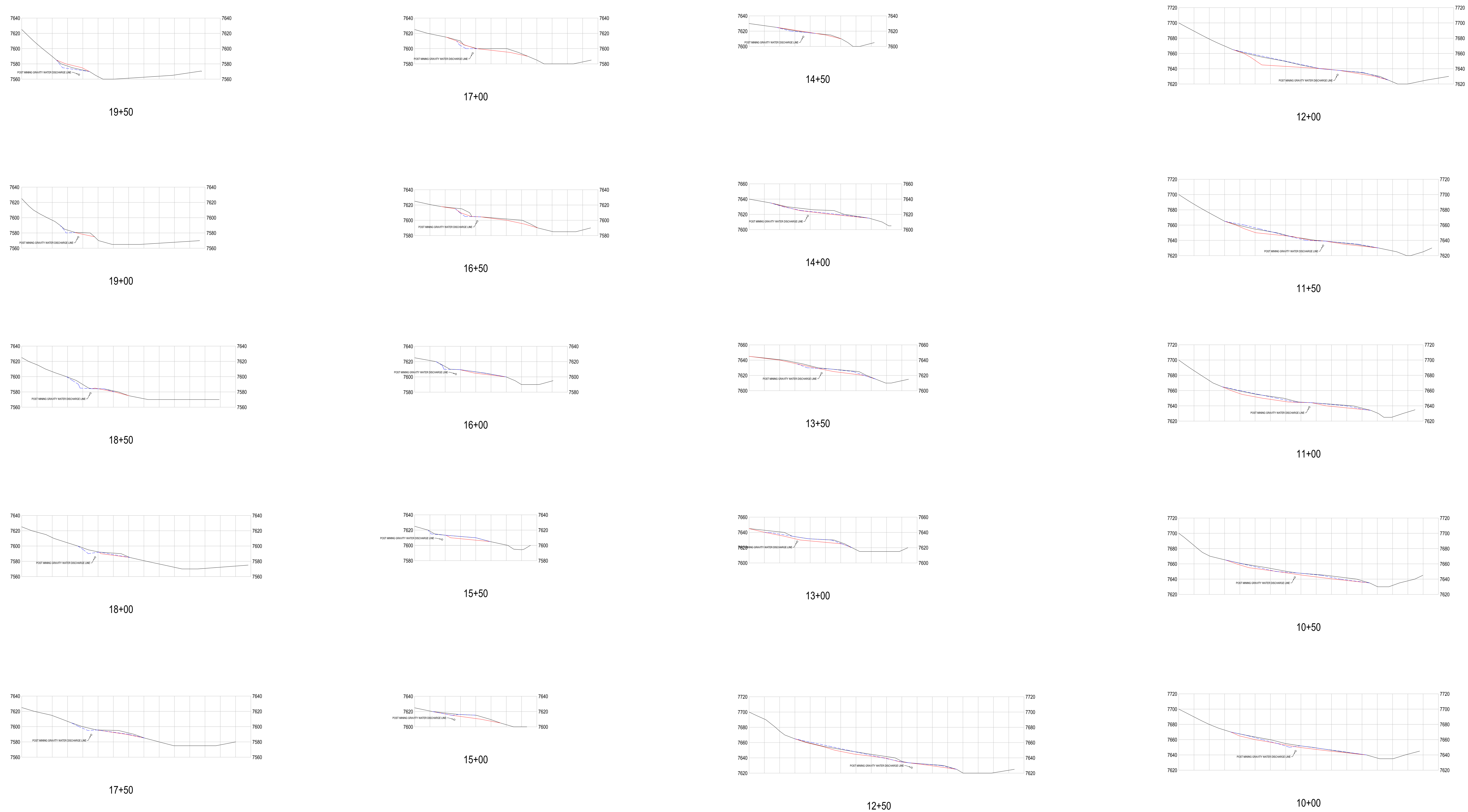
500-4

CAD FILE NAME/DISK#: 500-4 AS-BUILT

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

DEER CREEK MINE
RILDA CANYON FACILITIES
CROSS SECTIONS

DRAWN BY: K. LARSEN
SCALE: 1" =60'
DATE: MAY 9, 2016
DRAWING #: 500-4
SHEET 1 OF 4
REV. 2



NOTES

1. CROSS SECTIONS REFERENCE FROM 500-3
2. REFER TO VOLUME 11 APPENDIX VOLUME ENGINEERING APPENDIX F FOR SLOPE STABILITY ANALYSIS

LEGEND

PRE-EXISTING LINE
POST CONSTRUCTION LINE
FINAL RECLAMATION LINE

DATE	REVISION	BY	CHK
2/19/2010	REVISED TO REFLECT THE AS-BUILT CONDITIONS	KJL	

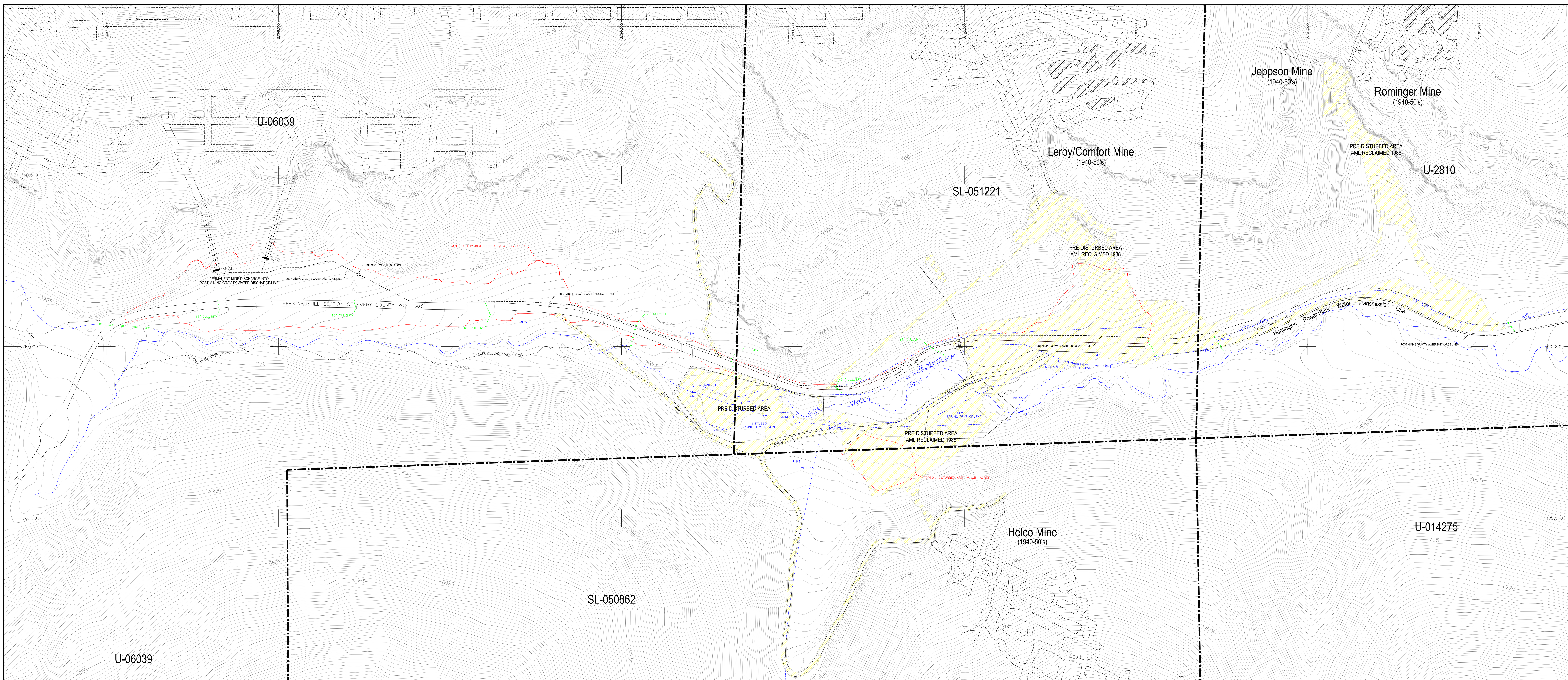
CAD FILE NAME/DISK#: 500-4 AS-BUILT

500-4

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

DEER CREEK MINE
RILDA CANYON FACILITIES
CROSS SECTIONS

DRAWN BY: K. LARSEN	DRAWING #: 500-4
SCALE: 1" =60'	
DATE: MAY 9, 2016	SHEET 2 OF 4 REV. 2



LEGEND

PRE-DISTURBED AREA (AML RECLAIMED 1988)
OF THE 7.28 TOTAL DISTURBED ACRES, 1.79 ACRES ARE ON LAND PRE-DISTURBED BY HISTORICAL MINE SITES. THE PRE-DISTURBED LAND IS 24.6% OF THE TOTAL DISTURBED AT THE RILDA CANYON PORTAL FACILITIES.

CAD FILE NAME/DISK#: 500-5 AS-BUILT

500-5

DATE	REVISION	BY	CHK
5-9-16	ADDED POST MINING GRAVITY WATER DISCHARGE LINE & NOTATIONS	KJL	
3-23-10	REVISED DISTURBED AREA BOUNDARIES, AND FINAL RECLAMATION TOPOGRAPHY	KJL	
5-23-05	ADDED FOREST DEVELOPMENT ROAD 024	KJL	

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

DEER CREEK MINE
RILDA CANYON FACILITIES
FINAL RECLAMATION TOPOGRAPHY

DRAWN BY: K. LARSEN	DRAWING #: 500-5
SCALE: 1"=100'	
DATE: MAY 9, 2016	SHEET 1 OF 1 — REV. 3

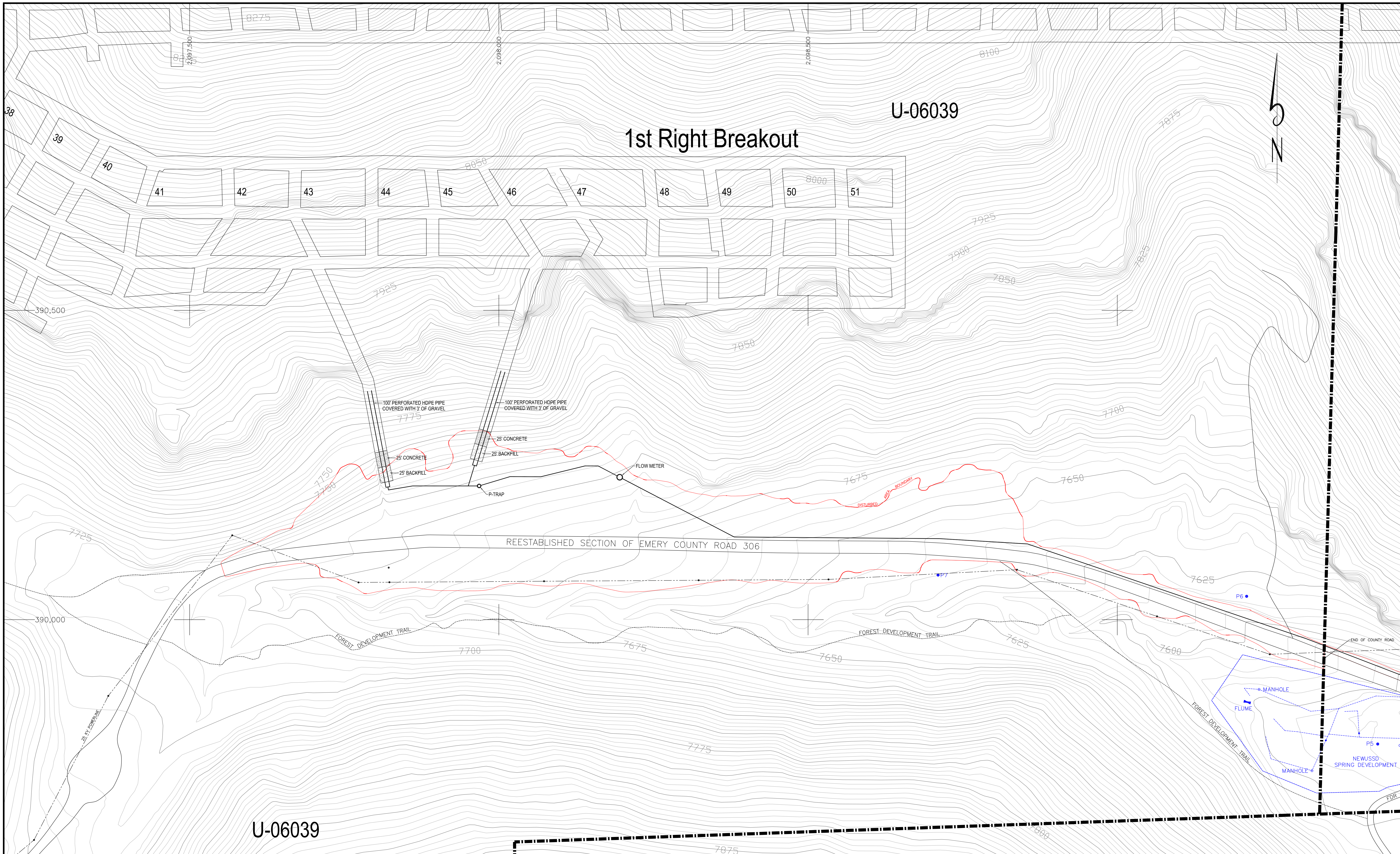
PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

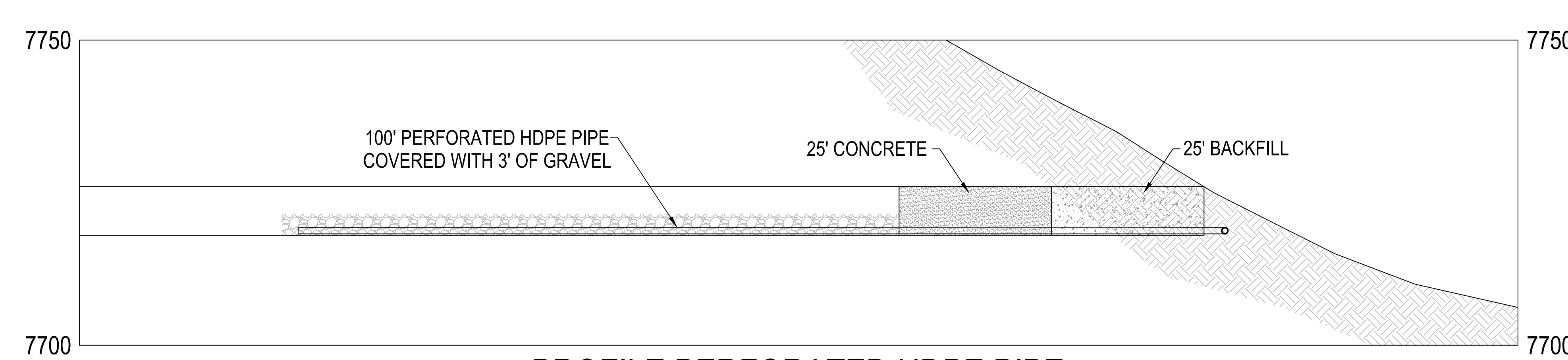
DEER CREEK MINE
DEBRIS CONTROL SCREENS
WATER DIVERSION STRUCTURES

DRAWN BY:	K. LARSEN		MFU1901D
SCALE:	1" =600'	DRAWING #:	
DATE:	MAY 3, 2016	SHEET 1 OF 1	REV.


DEER CREEK MINE
HIAWATHA SEAM
N
PHASE 1 PROJECT COMPLETE
PHASE 2 PROJECT COMPLETE
PHASE 3 PROJECT COMPLETE
AREA OF BELT STRUCTURE REMOVED
DATE OF INITIAL CERCLA REVIEW
OCTOBER 3, 2014
DATE OF LAST MINING
JANUARY 7, 2015
DATE OF INITIAL CERCLA REVIEW
FEBRUARY 13, 2015
DATE OF INITIAL CERCLA REVIEW
FEBRUARY 20, 2015
PHASE 1
SEAL/VENTILATION PLAN
SUBMITTED TO MSHA
DECEMBER 30, 2014
Ventilation Plan Approved January 30, 2015
Seal Plan Approved February 4, 2015
PROJECT COMPLETE (3-2-15)
PHASE 1
RECOVERY SEALS
DATE OF INITIAL CERCLA REVIEW
MARCH 27, 2015
AREA OF BELT
STRUCTURE REMOVED
PHASE 2
SEAL/VENTILATION PLAN
SUBMITTED TO MSHA
February 11, 2015
Ventilation Plan Approved March 6, 2015
PROJECT COMPLETE (3-9-15)
(1st Right Fan OFF)
HYDROLOGIC
PARALLEL PLUG
HYDROLOGIC
PARALLEL PLUG
HYDROLOGIC
PARALLEL PLUG
RILDA CANYON PORTALS
RIGHT FORK
AREA OF OVERLAY
HIAWATHA SEAM
AREA OF OVERLAY
BLIND CANYON SEAM
PHASE 3
SEAL/VENTILATION PLAN
SUBMITTED TO MSHA
March 19, 2015
Approved April 1, 2015
PROJECT COMPLETE (4-12-15)
DATE OF INITIAL CERCLA
REVIEW MARCH 27, 2015
RILDA CANYON PORTALS
RIGHT FORK
FINAL PHASE RECOVERY SEALS
RILDA CANYON PORTALS
LEFT FORK
3rd North B
MINE SEPARATION
SEALS
DEER CREEK MINE
BLIND CANYON SEAM
MINE CLOSURE PROCESS
PHASE 3 PROJECT COMPLETE
PHASE 4 PROJECT COMPLETE
AREA OF BELT STRUCTURE REMOVED
3rd NORTH B
AREA OF BELT STRUCTURE REMOVED
SEALS
MEETINGHOUSE CANYON
BREAKOUTS
SEALED 4/14/2015
DATE OF INITIAL CERCLA REVIEW
MARCH 19, 2015
3rd NORTH
AREA OF BELT STRUCTURE REMOVED
DATE OF INITIAL CERCLA REVIEW
FEBRUARY 13, 2015
DEER CREEK MINE
PORTALS SEALED 4/17/2015
PHASE 4
RECOVERY SEALS
PHASE 3
SEAL/VENTILATION PLAN
SUBMITTED TO MSHA
March 19, 2015
Approved April 1, 2015
PROJECT COMPLETE (4-17-15)
9TH EAST
BREAKOUTS
SEALED & RECLAIMED
CAD FILE NAME/DISK#: MFU1902D
PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY
DEER CREEK MINE
MINE CLOSURE
SEQUENCING
DRAWN BY: K. LARSEN
MFU1902D
SCALE: 1"=1500'
DRAWING #:
DATE: MAY 9, 2016
SHEET 1 OF 1
REV.


PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY
DEER CREEK MINE
MILL FORK HYDROLOGY MAP
DRAWN BY: K. LARSEN
SCALE: 1" =1000'
DATE: MAY 9, 2016
DRAWING #: MFU1903D
SHEET 1 OF 1
REV.
LEGEND
COAL LEASE BOUNDARY
DEER CREEK MINE PERMIT BOUNDARY
FAULT (DASHED WHERE INFERRED)
BLIND CANYON SEAM MINE WORKINGS (EXISTING)
HIAWATHA SEAM MINE WORKINGS (EXISTING)
OUTCROP
HIAWATHA SEAM FLOOR ELEVATIONS
HIAWATHA SEAM ELEVATED SULFUR ZONE >0.7%
GENERAL DIRECTION OF GROUNDWATER FLOW
SEALS 50 PSI
SEALS 120 PSI
ACTIVE MINING AREA
UTU-84285
UTU-88554
BOREHOLE
FLOODED AREA
SUMP
ANTICLINE AXIS
Seals
The 10th North Sump sample location is in XC-6 (the sump intake). The sample is collected from a valve in the pipe that draws water out of the sealed Mill Fork Blind Canyon workings via a drill hole prior to the water being discharged into the 10th North Sump. Approximately 50 gallons per minute.
The 17th West Sump sample location is just outby the 17th West seal. The sample is collected from a discharge pipe with a valve. Approximately 100 gallons per minute.
The 11th West Sump sample location is just outby the seal in Entry 2 of 11th West. The sample is collected from a valve near the floor. The pipe with the valve sits in a water hole with a pump. The pump should be turned on to draw down the water level in the water hole to make the valve accessible and to allow the pipe from which the sample is drawn to be purged. Approximately 5 gallons per minute.
MILL FORK FAULT GRABEN
Top of 4th North Slopes Elev. 8010'
UTU-024317
U.P.&L. CO. FEE
Directional Water Drain Not Used
Rilda Canyon Portals Elev. 7705'
Rilda Canyon Left Fork Portals Elev. 7841'
3rd North X-Cut 138 Mine Separation Seals
UTU-06039
SL-051221
UTU-2810
UTU-014275
SL-050862
UTU-024319
U-024319 Relinquished April 24, 1992
STATE ML-22509 Relinquished 12/6/01
U-7653 Coal Sublease Terminated Effective 3/18/02
UTU-47977





PROFILE PERFORATED HDPE PIPE

Not to Scale

CAD FILE NAME/DISK#: R645-301-500D

PACIFICORP

A BERKSHIRE HATHAWAY ENERGY COMPANY

DEER CREEK MINE

FINAL RECLAMATION PLAN & PROFILE

POST MINING GRAVITY WATER DISCHARGE LINE

DRAWN BY:	K. LARSEN	R645-301-500D	
SCALE:	1"=100'	DRAWING #:	
DATE:	MAY 9, 2016	SHEET 1 OF 1	REV.