Lower Quitchupah Creek Watershed
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

For
EMERY DEEP MINE
C/015/0015

In
EMERY COUNTY, UTAH

March 16, 2007
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I. INTRODUCTION

The Lower Quitchupah Creek Cumulative Impact Area (CIA) is located in Emery County, Utah approximately 10 miles south of the town of Emery. There is currently one active mine in the Lower Quitchupah Creek CIA- Consolidation Coal Company’s Emery Deep Mine. A 160 acre incidental boundary change (IBC) expansion of the Emery Deep Mine facilitated this review and update of the Lower Quitchupah Creek Cumulative Hydrologic Impact Assessment (CHIA).

The Division has the responsibility to assess the potential for mining impacts both inside and outside permit areas. The CHIA is a findings document prepared by the Division that assesses whether existing, proposed and anticipated coal mining and reclamation operations have been designed to prevent material damage to the hydrologic balance outside the permit areas. The Division cannot issue a permit to a proposed coal mining operation if the probable, anticipated hydrologic impacts will create material damage to the hydrologic balance outside the permit area. The CHIA is not only a determination if coal mining operations are designed to prevent material damage beyond their respective permit boundaries when considered individually, but also if there will be material damage resulting from effects that may be acceptable when each operation is considered individually but are unacceptable when the cumulative impact is assessed.

The objective of the CHIA document is to:

1. Identify the Cumulative Impact Area (CIA) (Part II)
2. Describe baseline conditions in the CIA; Identify hydrologic systems, resources and uses; and document baseline conditions of surface and ground water quality and quantity (Part III)
3. Identify hydrologic concerns (Part IV)
4. Identify relevant standards against which predicted impacts can be compared (Part V)
5. Estimate probable future impacts of mining activity with respect to the parameters identified in Part IV (Part VI)
6. Assess probable material damage (Part VII)
7. Make a statement of findings (Part VIII)

This CHIA complies with the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA) and subsequent federal regulatory programs under 30 CFR 784.14(f), and with
Utah regulatory programs established under Utah Code Annotated 40-10-et seq. and the attendant State Program rules under R645-301-729.
II. CUMALTIVE IMPACT AREA (CIA)

Reviewing Permit Application Packages (PAP’s) and Mining and Reclamation Plans (MRP’s) alone is not sufficient to assess impacts to the geologic and hydrologic regimes. Specific knowledge of the geology and hydrology is crucial in assessing the dynamics and interactions of chemistry, surface- and groundwater movement and surface disturbance and subsidence impacts associated with the mine sites. The Division uses pertinent information from many sources including federal and state agencies; geological and hydrological reports; textbooks and other publications; site visits; and a knowledge base built on experience and training.

Plate 2 delineates the CIA for current and projected mining in the Lower Quitchupah Creek watershed area. The CIA for the current and projected mining in the Lower Quitchupah Creek is approximately 11,003.2 acres. The Emery underground mine is located in the Quitchupah Creek watershed, approximately 10 miles south of Emery, Utah. The surface facility for the mine is located at the confluence of two perennial streams, Quitchupah Creek and its tributary, Christiansen Wash. Quitchupah Creek, with a drainage area of 430 square miles, flows to the southeast from the mine complex, converging with Ivie Creek, immediately above the confluence of Ivie Creek and Muddy Creek at Highway 1-70. Muddy Creek, with a drainage area of 1,450 square miles, is one of the major streams in the Dirty Devil River watershed, a tributary to the Upper Colorado River. Flows in Quitchupah Creek and Christiansen Wash derive from three sources: direct runoff; baseflow from the Upper and lower Ferron Sandstone aquifers; and returning irrigation flows that are diverted out of Muddy Creek. Quitchupah Creek is also directly impacted by discharge from the mine as all mine-inflow pumped from the underground workings is directed to a single treatment pond that discharges into a small tributary of that stream.

The Lower Quitchupah Creek CHIA (Emery Deep CIA) encompasses watersheds contained within the Quitchupah-Muddy Creek CHIA (Sufco CIA). The Sufco Mine’s permit and CIA include portions of the Christiansen Wash and Quitchupah Creek watersheds. The Sufco Mine complex is located within the Wasatch Plateau approximately 12 miles northwest of the Emery Deep facility. The Sufco Mine is considered sufficiently removed hydrologically that it will not adversely impact surface and ground water quality and quantity of the permit area and CIA. Therefore, it is not viewed as a factor in the cumulative impact assessment. This assumption is made on the basis of geologic and hydrostratigraphic. At the Sufco complex, mining will take place within the Blackhawk Formation. The areal aquifer to be affected at the Sufco Mine consists of sandstone units within the Blackhawk; at the Emery Mine, the Blackhawk Formation is not present. The Bluegate Shale comprises the surface geology formation at the Emery Mines and if present, the Blackhawk would be situated several thousand feet stratigraphically above the Bluegate Shale. The Sufco Mine is located in the highlands of the Wasatch Plateau, whereas the Emery complex is located on the outwash plain east of the Wasatch Plateau; there is several thousand feet of elevation difference between the two mines. In regard to surface water concerns, the quality of water being discharged from the Sufco mine is
comparable to the natural outflow from the areal aquifer. As such, measurable increases in downstream total dissolved solids (TDS) levels and the flow in Quitchupah Creek in the vicinity of the Emery Mine are not anticipated.

SCOPE OF MINING

Mining is conducted in the I-J zone coal bed, in the Ferron Sandstone member of the Mancos Shale. Development of the mine is accomplished with seven or eight entry mains with entries on 80 foot centers and crosscuts on 100 foot centers. The submains for panel development typically use a five entry system with similar entry centers. Panels are developed off the mains or submains with a four or five entry system with rooms drivein on either side of the development entries.

The Emery Mine utilized a system of partial secondary extraction where the barrier pillars were split. The Emery Mine did not employ full extraction techniques until the mining of the First South Pannel. Additionally, full extraction techniques were utilized at the 4th East Portal. In order to obtain maximum economic recovery (MER) of the coal resource for the 160 acre incidental boundary change (IBC) permitted by the Division in March of 2007, full extraction techniques were required by the Bureau of Land Management (BLM). During the term of the Emery Mine permit, the planned production is 1.7 million tons per year. The mine will produce this coal with five continuous miner sections. Producing at this rate, the mine will continue operations until 2010 at which time the I-J Zone will be mined out. At that time, final reclamation operations will begin.
III. HYDROLOGIC SYSTEM AND BASELINE CONDITIONS

The elevation range of the permit area and CIA is relatively small (generally between 5,500 feet – 6,100 feet). Soils within the permit area tend to be fine grained, ranging generally from loam to silty clay loam. If irrigated, the soil supports alfalfa and similar crops. Otherwise, the soils mostly support rangeland plants such as shadscale, Indian ricegrass, greasewood, and/or saltgrass.

GEOLOGY INFORMATION

The Emery coal field is located at the western side of the San Rafael Swell. The bedrock dips to the west-north-west at angles of 3-4 degrees. The field is bounded on the west by the Joe’s Valley fault zone, a regional graben structure. No other faults are known. Plates VI-2 and VI-2A depict the surface geology of the area.

Three geologic units are of particular significance in the permit area and CIA: Quarternary colluvium and alluvium, the Bluegate Shale member of the Mancos Shale and the upper portion of the Ferron Sandstone member of the Mancos Shale.

Quarternary colluvium and alluvium occurs on toe slopes, along the drainages and on the high terraces. The colluvium is a bouldery, loamy sand below sandstone outcrops and a silty clay below shale hills. The Quarternary alluvium and terrace deposits are crudely stratified, poorly sorted sands and gravels. Alluvium occurs as unconsolidated deposits of partly stratified silt, sand and gravel deposits in and adjacent to Quitchupah Creek and Christiansen Wash. South of Quitchupah, this material grades into fine silty surficial material which is probably older alluvium. It is difficult to distinguish this older material from weathered Bluegate Shale.

The Bluegate Shale outcrops west of Christiansen Wash and west of Quitchupah Creek south of the mine office. It is a saline, bluish gray, silty mudstone or siltstone. The Bluegate Shale is a unit of marine origina composed of irregularly bedded mudstone and siltstone with rare thin sandstone lenses. Thin sandstone beds occur within the Bluegate Shale. Where the Bluegate Shale is exposed at the surface it forms barren shale hills. The Ferron Sandstone overlies the Bluegate Shale, which acts as a confining bed over the Upper Ferron aquifer. Due to the shale content of this formation, permeability is considered to be very low. Water is contained in the Bluegate Shale; however, it is not considered an aquifer in the regional context. Water is generally thought to exist and move via localized fracturing in the formation. In the area where the Bluegate Shale is exposed, it is highly weathered, allowing for communication between the Christiansen Wash alluvium and the Upper Ferron Sandstone aquifer. The Bluegate Shale ranges in thickness from 0 to 70 feet in the surface mine permit area.

The Ferron Sandstone is the coal bearing unit of the Emery field. The coal beds are described in Part V.A.3 of the approved MRP. The Ferron averages about 400 feet thick and is
composed of interbedded, lenticular layers of sandstone, siltstone, shale, clay and coal. The upper contact is sharp and usually can be easily detected on electric logs. The lower contact is transitional over a thickness of about 60-70 feet. The Ferron Sandstone aquifer has an average saturated thickness of 60 feet, and the alluvium along Christiansen Wash varies from a few feet to 25 feet in thickness. Overburden depths range from 20 to 140 feet over the coal (for further description of the ground water system, see the Ground Water section of this analysis).

Unconsolidated alluvial aquifers also exist at the mine. Alluvial terrace deposits overlying the Bluegate are water bearing, as are the alluvial deposits of Christiansen Wash and Quitchupah Creek.

Hydraulic Conductivity

In sedimentary rocks, there is a wide range of textures or fabrics that determine the hydraulic characteristics of the unfractured medium. These textures or fabrics are related to the mineralogy or composition of the sediments, the range of sizes of the sedimentary particles (sorting), the spatial distribution of different sediment-sizes (grading), the shape and spatial orientation or arrangement of the sediment particles after compaction (packing), cementation and properties acquired or altered as the sediments were lithified.

The Permittee calculated the hydraulic conductivity of the Ferron Sandstone (geologic unit containing the I-J mineable coal seam in the Emery Coal field) in lieu of the 160 IBC proposal submitted to the Division in December 2006. The average hydraulic conductivity of the Ferron Sandstone overlying the coal seam was determined to be 0.20 ft/day. This value compares well with independently produced data from Lines et al in U.S. Geological Survey Water-Supply Paper 2195, Hydrology of the Ferron Sandstone Aquifer and Affects of Proposed Surface Mining in Castle Valley, Utah. Laboratory hydraulic conductivity data provided by Lines et al. (1983) averaged 0.11 ft/day in the horizontal flow direction and 0.076 ft/day in the vertical direction. Hydraulic conductivities derived from field tests summarized by Lines et al. (1983) averaged 0.55 ft/day.

CLIMATE

Summer precipitation generally results from convection-type storms that move into the area from the south. Those storms are generally localized and of short duration; however, they produce torrential rains that often result in flash flooding and associated property damage.

Air temperatures vary considerably both diurnally and annually throughout the CIA. Midsummer daytime temperatures commonly exceed 100 degrees F and midwinter night-time temperatures can reach well below 0 degrees F. Normal annual precipitation in the area is in the range of 8-10 inches/year (USGS, Water Resources Investigations Open-File Report 83-88,1984).

The Palmer Hydrologic Drought Index (PHDI) indicates long-term climatic trends for the
region. The PHDI is a monthly value generated by the National Climatic Data Center (NCDC) that indicates the severity of a wet or dry spell. The PHDI is computed from climatic and hydrologic parameters such as temperature, precipitation, evapotranspiration, soil water recharge, soil water loss and runoff. Because the PHDI takes into account parameters that affect the balance between moisture supply and moisture demand, it is useful for evaluating the longterm relationship between climate and groundwater recharge and discharge. The Lower Quitchupah Creek Watershed lies in Region 7 for the State of Utah. Figure 1 shows the PHDI for 1977 through 2005.

**Figure 1** - Palmer Hydrologic Drought Index, Divisions 4, 5 and 7

**HYDROLOGY**

As part of the Emery Deep mining and reclamation plan (MRP), the Permittee has implemented a baseline and operational surface- and ground water monitoring program for their permit and adjacent areas. The locations of the water monitoring sites are shown on Plates V1-1, Location Map Surface Water Stations and VI-3, Ground Water Monitoring Well and Surface Water Monitoring Site Location Map.
Ground Water

Groundwater within the mine permit and CIA occurs primarily within the Ferron Sandstone. The Ferron Sandstone is situated between the overlying Bluegate Member of the Mancos Shale and the underlying Tununk Member of the Mancos Shale, both of which are relatively impermeable and considered aquicludes. The Ferron Sandstone outcrops in a series of prominent cliffs along the eastern edge of the Emery coal field and dips to the northwest beneath the ground surface. The continuity of the Ferron is broken in the subsurface by the Joe's Valley-Paradise fault zone, which exists immediately northwest of the permit area.

The largest source of recharge to the coal-bearing Ferron Sandstone member in the Emery coal field is subsurface inflow from the Wasatch Plateau to the west (Lines and Morrissey, 1981, p. 58). Much of the water is transmitted in the subsurface along

Several aquifer pump tests have been conducted by the United States Geological Survey. The tests were conducted utilizing the monitoring wells located within and outside the permit area. The drawdown and recovery data obtained from the tests were utilized to calculate storage coefficients and transmissivity values. In addition, the Permittee conducted three pump tests on several stratigraphic sections of the Ferron aquifer. The data for the USGS and Permittee pump tests are tabulated in Table VI-4 of the MRP. The data indicates an average transmissivity of 2,730 gpd/ft and a storage coefficient of $1.59 \times 10^{-3}$.

From static water level data obtained from the monitoring wells in the permit and adjacent areas, it’s apparent from head differences that the groundwater within the CIA has the widespread potential to move downward from the upper Ferron Sandstone into the coal-bearing section of the Ferron and to a lesser degree, upward from the middle Ferron Sandstone. Although the Ferron Sandstone is completely saturated within the existing mine area, historic inflows to the mine have been predominantly from the roof rather than the floor. This suggests that the upper and lower portions of the Ferron Sandstone are hydraulically separated. This hydraulic separation is further evidenced by comparing Plates VI-4, Upper Ferron Potentiometric Surface and VI-5, Lower Ferron Potentiometric Surface, of the MRP. Plate VI-4 clearly depicts a cone of depression within the upper Ferron Sandstone aquifer as a result of mine dewatering operations, while the lower Ferron Sandstone aquifer shows very little potentiometric surface impacts in the mined area. A slight difference in water quality data provides further evidence that there is a separation between the upper and lower Ferron Sandstones. This is further substantiated by examining the head differences depicted on Table VI-5 of the MRP. The data indicates that the upper Ferron Sandstone water levels are stressed as a result of mine water inflow, while those in the lower Ferron Sandstone are not.

Groundwater discharges from the Ferron Sandstone by wells, by dewatering of the Emery Mine, by seepage into Quitchupah Creek and Christiansen Wash and by leakage into the Bluegate and Tununk Shales. Within the immediate vicinity of the permit area, the largest anthropogenic discharge of ground water from the Ferron Sandstone is dewatering of the Emery Mine, which accounts for approximately 0.6 to 1.2 cubic feet per second of water being removed.
HYDROLOGIC SYSTEM AND BASELINE CONDITIONS

from the Ferron Sandstone (See page 8 of Chapter XIII of the MRP).

Recharge to the groundwater body in the CIA is believed to originate from the Joe’s Valley-Paradise fault zone (Morrisey, Lines and Bartholoma, 1980). Relatively higher amounts of precipitation in the recharge zone and the shape and southeastward slope of the potentiometric surface suggest this to be the case.

Although the amount of ground water recharge to the Ferron Sandstone is not well understood, the upper, middle and lower sandstone units within the Ferron Sandstone are known to contribute subsurface outflow to Muddy and Quitchupah Creeks, Christiansen Wash and to Miller Canyon. Based upon USGS estimates (Morrisey, Lines and Bartholoma, 1980) recharge to the Ferron Sandstone aquifer is approximately 2.4 cfs along the Joe’s Valley-Paradise fault zone in the vicinity of the Emery Mine. Bluegate Shale overlies the Ferron Sandstone throughout much of the region. The Bluegate is believed to have very poor permeability because of it’s fine-grained lithology. As a result, vertical percolation of precipitation and applied water in the CIA are probably not major sources of recharge to the Ferron Sandstone.

Potentiometric surface maps (Plate VI-4 and VI-5) for the upper and lower Ferron Sandstone indicate that the ground water moves generally updip and in a southeast direction toward the areas of the mine and toward areas of outcrop. Plate VI-4 clearly shows that the potentiometric surface of the upper Ferron Sandstone aquifer has been affected by mine water inflow.

After migrating to the southeast toward the mine site, groundwater in the Ferron Sandstone discharges into alluvium along the channels of Quitchupah Creek and Christiansen Wash along sandstone outcrops just east of the mine boundary. Based upon USGS estimates (Morrisey, Lines and Bartholoma, 1980), discharge to streams in the area of the Emery Mine is approximately 0.4 cfs from the entire Ferron Sandstone aquifer. Based on it’s relative thickness, the upper Ferron Sandstone would be about 1/5 of this value based on it’s relative thickness. The most significant discharges from the Ferron sandstone aquifer with respect to the potential effects of the Emery mine operation include: mine discharge, discharge to alluvium, discharge at springs and well discharge.

Groundwater of the upper Ferron sandstone aquifer seeps or flows into the mine and is discharged via pumps to sedimentation ponds. Discharge to alluvium occurs from the entire Ferron sandstone aquifer at various locations.

Groundwater Quality

Groundwater samples have been collected regularly from monitoring wells since 1979 at the Emery Mine. Statistical summaries and individual sample reports are found in Table VI-7 and Appendix VI-1 of the MRP. In addition, water quality data can be obtained from the Division of Oil, Gas and Mining’s Utah Coal Mining Water Quality Database-http://www.ogm.utah.gov/coal/edi/wqdb.htm. The primary chemical constituents which
HYDROLOGIC SYSTEM AND BASELINE CONDITIONS

characterize the quality of the upper Ferron Sandstone aquifer waters are primarily bicarbonate (HCO₃), sulfate (SO₄) and sodium (Na). The pH values generally range between 7.0 and 9.5. Natural groundwater quality in the upper Ferron Sandstone is moderately saline, with total dissolved solids (TDS) concentrations in monitoring well and mine roof inflow samples averaging approximately 1,000 to 1,3000 mg/l (See Table VI-9 of the approved MRP). The total dissolved solids concentration of groundwater in the lower Ferron Sandstone tends to be slightly less, averaging approximately 800 mg/l (see previously noted table). The difference in salinity further suggests a hydraulic separation between the upper and lower Ferron Sandstone. Sodium and sulfate are the dominant ions in groundwater occurring in both the upper and lower Ferron Sandstone.

A spring and seep inventory for the Emery Mine was conducted in 1979. Springs and seeps within one mile outside of the permit boundary were located and evaluated. Each of the springs were evaluated for the field parameters of temperature, pH, conductivity, dissolved oxygen and discharge (when possible). Within the study area, 14 springs were identified. Locations and field measurements for each of the sites are exhibited on Plates VI-2 and VI-2A and Table VI-10 respectively. All of the springs were observed to be issuing from pediment gravels overlying the Bluegate Shale. No springs were found to be issuing from the Bluegate Shale. Two springs are known to discharge from the Ferron Sandstone aquifer within the CIA. Spring SP-15 (See Plate 2A) is believed to discharge from the upper Ferron Sandstone aquifer and is appropriated for 0.1 cfs by Consol for stockwatering purposes. The spring is not expected to be affected by underground mining. SP-16 is believed to discharge from the lower Ferron Sandstone and is unappropriated.

Within the CIA, well discharges from the Ferron Sandstone aquifer include the Emery municipal well (approximately 90 gpm) and the Bryant and Lewis wells (approximately 30 gpm each). The Bryant and Lewis well have been impacted by underground mining in that they no longer flow at the land surface. The Permittee has furnished and installed pumps and surface ancillary facilities in order to replace these water supplies.

Plate V1-6 contains the locations of water supply intakes for current users of surface water in and around the mine plan area and also identifies receiving streams, irrigation diversions and water well users. Plate VI-3 identifies surface and ground water monitoring stations. Plate VI-4 and VI-5 show the location and extent of subsurface water within the upper and lower Ferron Sandstone members while Figures VI-5 thru VI-9 show seasonal static water level variations for the upper Ferron Sandstone aquifer.

Predicted mine-water inflow/discharge rates through the period of the mine plan (2013) are summarized in Table VI-23B from the MRP. The rates were calculated based on the Hantush equation (Freeze and Cherry., 1979). Spreadsheets detailing the calculations are provided in Appendix VI-9 of the MRP. Based on these calculations, discharge rates are expected to average 1.50 cfs with a range of 1.2 to 2.0 cfs. Variations are discharge rates are anticipated depending on the depth of mining below the potentiometric surface and the area over which mining will occur. The estimates are based on a hydraulic conductivity of 0.20 ft./day.
The hydraulic conductivity value was calculated utilizing historic discharge rates. The estimates presented in Table VI-23B assume full extraction of the coal.

Table VI-23B: Predicted Mine Water Discharge Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Predicted Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1.29</td>
</tr>
<tr>
<td>2007</td>
<td>1.19</td>
</tr>
<tr>
<td>2008</td>
<td>1.33</td>
</tr>
<tr>
<td>2009</td>
<td>1.77</td>
</tr>
<tr>
<td>2010</td>
<td>1.28</td>
</tr>
<tr>
<td>2011</td>
<td>1.52</td>
</tr>
<tr>
<td>2012</td>
<td>1.63</td>
</tr>
<tr>
<td>2013</td>
<td>1.98</td>
</tr>
<tr>
<td>Average</td>
<td>1.50</td>
</tr>
</tbody>
</table>

Surface Water

The Emery Mine is situated at the confluence of Quitchupah Creek and its tributary, Christiansen Wash. Quitchupah Creek, a perennial stream whose headwaters in the eastern flank of the Wasatch Plateau, are primarily sustained by snowmelt, receives additional flow in the vicinity of the mine from several sources, including:
- Direct irrigation return flows containing mostly water whose source was Muddy Creek.
- Groundwater discharge from the Ferron Sandstone aquifer.
- Irrigation induced seepage from the Quaternary pediment deposit aquifers.
- Discharge from the Emery Mine.
- Overland flow from storm events and spring snowmelt.

Christiansen Wash owes the majority of its flow to irrigation water diverted from Muddy Creek which reaches the stream either as direct return flows or as seepage from Quaternary pediment deposit aquifers. Additionally, groundwater discharge from the Ferron Sandstone aquifer, as well as surface contributions from spring snowmelt and occasional storm events, contribute flow and influence the water quality of Christiansen Wash.

The assortment of influences affecting both Quitchupah Creek and Christiansen Wash creates considerable fluctuations in both streamflow and water quality. Systematic stream gaging in the Emery Mine area has been conducted by the USGS, Angelus Owili-Eger of Conoco and WATEC. Examination of the data indicates that increases in flow occur on Christiansen Wash where a spring fed tributary discharges into the drainage. Quitchupah Creek’s flow is increased by a tributary carrying direct irrigation releases and irrigation return flows. Less consistent fluctuations in flow, including both gains and losses, were measured. These gains and losses may reflect various contributions from ground water and irrigation return
flows, as well as seepage losses to the alluvium. In addition, man induced and natural streamflow fluctuations may account for some of the apparent gains and losses.

In the spring of 1978, the USGS, Water Resources Division, installed a bubble gage type continuous recording monitoring station on Quitchupah Creek and Christiansen Wash. From these records, it is apparent that both streams experience a wide seasonal variation in flow as well as occasional flood events. As would be expected, the peak flows generally occur in May as a result of mountain snowmelt, while low flow is experienced in the fall and winter.

Considerable fluctuation in streamflow is also evident from day to day during the spring and summer months. This can be explained in the spring by fluctuations in temperature as it affects melting of the mountain snowpack. However, by mid-summer, snowmelt is no longer a factor and the hydrograph would be expected to smooth out. The fluctuations in flow during the summer and fall, therefore, can be explained only by man-induced irrigation influences as there is little precipitation during this time period.

In addition to seasonal and man-caused changes in streamflow, both Quitchupah Creek and Christiansen Wash experience flash floods caused by storm events. These flash floods carry a considerable amount of debris and can cause channel changes and damage to recording structures and equipment.

The USGS has conducted seepage studies along Quitchupah Creek and Christiansen Wash. Available data are given in Table VI-14 of the MRP. Within the CIA, the USGS seepage data indicate that a general downstream increase in flow on both Quitchupah Creek and Christiansen Wash.

From all of the streamflow data presented for Quitchupah Creek and Christiansen Wash, some basic conclusions can be made:

1. Streamflow generally increases in the downstream direction on both Christiansen Wash and Quitchupah Creek.
2. Peak runoff occurs in May as a result of snowmelt and low flows occur in fall and winter.
3. Both streams are subject to occasional flash flooding.
4. On both Quitchupah Creek and Christiansen Wash, considerable changes in flow during very short time periods have been observed and documented. These flows result from irrigation practices in the region.

Water is discharged from the mine through sedimentation ponds. Flows at these outfalls are about 370,000 and 250,000 gallons per day at sites 6 and 12 respectively.

Due to the complexity of the surface water hydrology of both Christiansen Wash and
Quitchupah Creek, it is extremely difficult to determine even the relative contributions to streamflow of the various influences such as irrigation return flows and seepage, discharge from the Ferron Sandstone, surface runoff and losses to seepage into alluvium. Only the discharges from the mine sedimentation ponds are readily measured.

**Surface Water Quality**

Within the CIA and adjacent area containing the Quitchupah Creek and Christiansen Wash watersheds, the smallest dissolved-solids concentrations in surface water are at the higher altitudes where concentrations generally are less than 500 milligrams per liter (Lines et al. 1984). Dissolved solids concentrations increase markedly as the streams emerge from the mountains and cross the Mancos Shale. Shales in the Mancos typically contain large quantities of soluble minerals, including gypsum (CaSO\(_4\) . 2H\(_2\)O), mirabilite (Na\(_2\)SO\(_4\) . 10 H\(_2\)O) and thenardite (Na\(_2\)SO\(_4\)). In the lowland areas where the Emery Mine and CIA are located, the dissolved solids concentrations in streams vary from less than 500 to more than 2,000 milligrams per liter (Lines et al., 1984). During most years, the minimum dissolved-solids concentrations occur during high flows resulting from snow-melt. The maximum concentrations generally occur during the late summer, maintained primarily by ground-water discharge. The largest seasonal changes occur in the lowland areas (i.e. Emery Mine CIA). In the lowland streams the dominant ions during high flow are calcium magnesium, and bicarbonate but during low flow, are generally are sodium, calcium and sulfate (Lines et al, 1984).

A considerable amount of site-specific water quality data has been gathered in the vicinity of the Emery Mine by the USGS, Utah Water Resources Division, Consol. Chapter VI of the approved MRP discusses the surface water quality in the region. The data suggests that the concentrations of dissolved constituents generally increase in the downstream direction along Christiansen Wash. This is attributed to irrigation return flow seeping into the stream. The TDS concentration of Christiansen Wash ranges from about 1,000 to 5,000 mg/l and is typically indirectly related to discharge rate. Calcium, sodium and sulfate are the dominant ions. Total suspended solids (TSS) concentrations vary widely in Christiansen Wash (from less than 100 to more than 3,000 mg/l) and tend to be directly related to discharge rate.

The USGS performed a year long study on Quitchupah Creek between July 1975 and September 1976. The USGS collected samples at Site S-18 where Utah State Highway 10 crosses Quitchupah Creek and at site S-29 on Quitchupah Creek where it joins Ivie Creek. Site S-18 is located on the western edge of the permit area. Site S-29 is located approximately 2.5 miles south of the permit area. Between the two sampling sites, Quitchupah Creek’s water increases in concentrations of nearly all constituents: pH increased from 8.1 to 8.3, TDS increased from 939 to 2,496 mg/l and SAR increased from 2.2 to 5.5. At both stations, SO\(_4\) was the dominant anion, but its relative proportion to HCO\(_3\) and Cl greatly increased downstream at site S-29. At site S-18, the specific conductivity of 1,346 umhos/cm at 25 degrees C and SAR of 2.2 classify the water as high salinity, low sodium water. This water may be used for irrigation of plants with good salt tolerance grown in well drained soils. AT site S-29, the specific conductivity of 3,078 umhos/cm at 25 degrees C and SAR of 5.5 classify the water as very high
salinity, medium sodium water. This water is not suitable for irrigation under ordinary conditions.

**Alluvial Valley Floors**

Alluvial valley floors (AVF) have been identified within the Emery Mine permit area and CIA. Volume XI of the MRP discusses the AVF investigations performed relative to the Emery Mine operation. The Upper Quitchupah Creek drainage and associated AVF could be potentially impacted by mining related activity. The other drainages within the CIA (Christiansen Wash, Muddy Creek and Ivie Creek) do not satisfy the federal criteria for AVF designation.

The Upper Quitchupah Creek drainage is defined as that portion of Quitchupah Creek above the confluence with Christiansen Wash. The upper Quitchupah Creek Valley contains unconsolidated stream-laid deposits as shown on Plate 1 of Appendix XI-1 in the MRP. The Upper Quitchupah Creek drainage contains several areas where flood irrigation activities are ongoing. An assessment of the annual runoff in the area indicates that sufficient water could be available from Quitchupah Creek to flood irrigate 300 to 400 acres along the Quitchupah Creek Valley. Presently, the agricultural activities on the north side of Quitchupah Creek are irrigated from Muddy Creek water diverted through the Emery Ditch (See Plate XI-1). The fields south of Quitchupah Creek are irrigated primarily from water diverted from Quitchupah Creek about two miles west of the permit area. The areas presently irrigated in the Upper Quitchupah Creek valley are outlined on Plate XI-1.

The areas outlined in Plate XI-1 (Areas 1-3) meet the criteria for a positive AVF determination. Area 1 is located within a grandfathered area and is therefore exempt from UMC 822.12(a) and (b). Area 2 is presently irrigated by Muddy Creek water but could potentially be irrigated with Quitchupah Creek water. Area 3 is the area presently being irrigated with Quitchupah Creek water. Areas 2 and 3 as depicted on Plate XI-1 are subject to the protection requirements of UMC 822.122(a) which requires that the mining activities will not interrupt, discontinue or preclude farming on AVF’s unless the premining land use is undeveloped rangeland or the affected area is small and provides negligible support for farm production. The possible effect of mining under these areas would be subsidence of the surface. Subsidence could cause changes in the surface drainage patterns and thus interrupt farming operations. In order to prevent subsidence impacts to the farming operations, the Permittee has established a buffer zone around the aforementioned AVF’s. The buffer zones are established taking into account the angle of draw and the amount of overburden in the area. See below Section IV-SUBSIDENCE discussion for further information.
IV. IDENTIFY HYDROLOGIC CONCERNS

General hydrologic concerns include changes of flow rates and chemical composition that could physically affect the off-permit hydrologic balance. Changes to the existing hydrologic regime or balance need to be limited in order to prevent economic loss to existing agricultural and livestock enterprises, prevent significant alteration to the channel size or gradient and maintain adequate capacity for existing fish and wildlife communities. The basis for the limiting value of a parameter may differ according to site specific conditions.

The surface and ground water hydrology in the vicinity of the Emery Mine is complex due in part to the imperfect understanding of the communication of ground waters within the various stratigraphic units above and below the mine and due to the unpredictable anthropogenic caused variations in streamflow and water quality resulting from irrigation practices. Isolating the effects of mining on the surface and ground water systems is somewhat difficult but there are several influences which can be distinguished:

- Contamination from acid- or toxic-forming materials;
- Increased sediment yield from disturbed areas;
- Impacts to groundwater availability;
- Impacts to surface water availability;
- Increased total dissolved solids concentrations in surface and groundwater;
- Flooding or streamflow alteration;
- Hydrocarbon contamination from above ground storage tanks and
- Subsidence related impacts to surface and ground water.

CONTAMINATION FROM ACID- OR TOXIC-FORMING MATERIALS

Information concerning acid-and toxic-forming materials in rock at the Emery Mine is presented in Sections V.A.4 through V.A.6 and Chapter XIII of the MRP. The data presented indicates that the pH of the roof and floor materials of the mine range from 5.0 to 9.1 with the acid-base potential indicating a net base potential. The alkaline nature of the system is further indicated by the fact that the pH of groundwater in the area is typically in the range of 7.0 to 9.5.

Except near outcrops, the electrical conductivity of the rock is generally low. However, naturally occurring sodium adsorption ratios and exchangeable sodium percentages of the rock are moderately high. As a result, sodium adsorption ratios calculated from the data presented in Table VI-9 suggest that groundwater discharged from the mine may have a low to medium sodium hazard if that water is used for irrigation without further treatment. Analyses of rock samples presented in Section V.A.4 indicate that concentrations of trace elements are generally low so that the rock can be considered non-toxic forming. Thus, with the exception of moderate sodium concentrations in some samples, analytical data obtained from the local rock and mine-water discharges indicate that no significant potential exists for the contamination of surface and groundwater in the permit and adjacent areas by acid- or toxic-forming materials.
INCREASED SEDIMENT YIELD FROM DISTURBED AREAS

Mining and reclamation at the Emery Mine has the potential to increase sediment concentrations in the surface waters downstream from disturbed areas. Sediment-control measures such as sedimentation ponds and diversions have been installed to minimize this impact. The facilities have been designed to meet applicable regulatory requirements and are regularly inspected and maintained to ensure that they continue to meet those standards. In over 500 observations, the sediment ponds that receive disturbed area runoff at the mine-site have never recorded a discharge. Thus the potential for increased sediment yield from the disturbed areas producing an impact on the downstream receiving waters is minimal.

IMPACTS TO GROUNDWATER AVAILABILITY

Of significance to the groundwater hydrologic balance is the potential for water level declines in the Ferron Sandstone aquifer resulting from mining. Groundwater has the potential to enter the Emery Mine through both the floor and roof of the mine workings from permeable, saturated sandstones above and below the IJ coal seam. Alteration of the flow pattern within the Ferron Sandstone aquifer could be caused by the creation of mineward gradients induced by inflow of water to the mine. These conditions in turn affect groundwater level declines in the mined area and in the surrounding area. Groundwater has the potential to enter the Emery Mine through both the roof and floor from the permeable, saturated sandstones. Hydrographs of water-level data collected from monitoring wells at the mine show that water level declines have been experienced in all three sections of the Ferron Aquifer and also in the Blue Gate Shale. However, the hydrographs indicate that the primary source of inflow to the mine is primarily from the upper Ferron aquifer. Significant upward leakage from the middle-Ferron is impeded by shales that constitute the floor of the mine.

Morrisey et al. (1980) indicate that recharge to the Ferron aquifer originates in the Wasatch Plateau west of the Emery Mine and discharges to the southeast along the Joes Valley Paradise fault zone. As such, this fault zone effectively acts as a linear source of groundwater recharge to the Ferron Sandstone.

Mining within the Emery Mine has locally changed the pattern of groundwater flow near the mine and part of the upper section of the Ferron Sandstone aquifer has experienced water-level declines. As mining has progressed, the mine has intercepted more and more groundwater and caused a cone of depression near the northwest corner of the mined area. Inflow of water to and discharge of water from the mine will continue to influence the shape of the potentiometric surface in the vicinity of the mine. As a result, it is anticipated that the cone of depression depicted on Plate VI-4 will change as mining continues.

Figure VI-6 of the MRP provides hydrographs of water-level data collected from monitoring wells completed within the Emery Mine permit area in the Bluegate Shale. As indicated, no declines in water levels have occurred during the recorded period of observation.
IDENTIFY HYDROLOGIC CONCERNS

In contrast, hydrographs that were prepared using data collected from wells completed in the Upper Ferron Sandstone (Figure V1-7 of the MRP) show declines in the groundwater levels during the period of record. Similar conditions are expected in the future (i.e. no substantial influence on groundwater levels in the Bluegate Shale but declining water levels in the Upper Ferron Sandstone). Gradual declines in groundwater levels may be occur in the Middle Ferron Sandstone in the future, while no substantial changes in water levels would be anticipated in the Lower Ferron Sandstone.

In Chapter VI, the water rights information shows that the town of Emery maintains two wells developed in different aquifers within the Ferron Sandstone formation. These wells are used as a backup water source to the town’s present water supply system which relies on surface water from Muddy Creek. Emery Town Well No. 1 is developed in the Lower Ferron aquifer, which lies well below current mining activities. Well No. 2 is developed in the Middle and Upper Ferron aquifers which are directly below and above the coal seam to be mined. No adverse impacts to either well are anticipated since the wells are located approximately 3 to 4 miles from the mine and are up-gradient within the regional ground water flow pattern. Static water level readings taken from wells maintained as part of the mine’s ground water monitoring program also indicate that no disruption of the aquifers in the vicinity of the town’s wells has occurred.

IMPACTS TO SURFACE WATER AVAILABILITY

Surface water is not used in the operation of the Emery Mine. As such, there are no depletions of overland flows or surface drainage from the mine’s surface facilities. Water removed from the mine will be discharged to Quitchupah Creek, increasing the flow of this receiving stream. Historical flow data obtained by the USGS from a gaging station on Quitchupah Creek near the mine office produced an average annual flow record of 8.43 cfs. Predicted discharge levels through the year 2013 (as indicated in Table VI-23B of the MRP) are expected to average 1.50 cfs. This discharge represents an 18% increase in the above noted average annual flow of Quitchupah Creek.

Sediment ponds located on the mine site that accept runoff from the disturbed area have never recorded a discharge. Hence, a small quantity of runoff is precluded from reaching Quitchupah Creek that would discharge to this stream if the mine surface facilities were not present. Given the small amount of precipitation in the area and the relatively small area of the surface facilities, this reduction in the streamflow of Quitchupah Creek is likely minimal. Thus, the net effect of mining on the availability of surface water in the immediate area is an increase in the flow of Quitchupah Creek and downstream waters.

The discharge of mine water to Quitchupah Creek probably results in a local increase in flow and not a basin-wide increase. As discussed above, the coal being mined occurs in the Ferron Sandstone member of the Mancos Shale, which is underlain by the Tununk Shale member of the same formation. The shales of this formation have a low permeability, thus forcing groundwater to the surface as streamflow. As a result, although the discharge of water
from the mine results in a local loss of groundwater and gain in surface water, this discharge
does not disrupt the hydrologic balance of the basin. The applicant has presented supportive
calculations to show that flow depletions to Quitchupah Creek and Christiansen Wash, as a result
of intercepted ground water, should not be significant to the drainages. The amount of
intercepted flow (0.2 cfs or less) is about three percent of the mean discharge of the Quitchupah
Creek-Christiansen Wash drainage system above Ivie Creek. Additionally, the water will be
routed through the mine and discharged back to the Quitchupah Creek watershed, albeit at lesser
quality. From a quantity perspective, however, the disturbance is not significant.

Given this condition, the actual loss of groundwater from the hydrologic balance is that
water which is contained in the coal and leaves the basin upon mining or is discharged from the
mine in the ventilation air.

**INCREASED TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN SURFACE AND
GROUNDWATER**

Data summarized in Table VI-9 of this MRP indicate that the average TDS concentration
of water entering the mine (as measured in roof samples) is 1025 mg/l. Assuming that the
equivalent-weight bicarbonate concentration can be calculated by balancing the anions and
cations in that table, the roof inflow is a sodium-bicarbonate water with an average sulfate
concentration of 264 mg/l. The average TDS concentration of water discharging from the mine
to Quitchupah Creek (as measured at Ponds 1 and 6 and reported in Table VI-9) is 2,390 mg/l.
This is a sodium-sulfate water with an average sulfate concentration of 1,340 mg/l.

The data indicates that the TDS concentration of water flowing through the mine
increases by a factor of approximately 2.3. The sulfate concentration of this water increases by a
factor of approximately 5.1. The ratio of calcium to sodium increases as the water flows through
the mine. The increase in TDS and sulfate concentrations is probably the result of dissolution of
rock dust used in the mine.

The impact of the TDS and sulfate concentration increases on surface-water resources in
the permit and adjacent areas is considered minimal for two reasons. First, surface water in the
permit and adjacent areas has been classified in the Utah Division of Water Quality Standards of
Quality for Waters of the State (R317-2) as Class 2B (protected for secondary contact recreation
such as boating, wading or similar uses), Class 3C (protected for non-game fish and other aquatic
life, including the necessary aquatic organisms in their food chain) and Class 4 water (protected
for agricultural uses including irrigation of crops and stock watering). NO sulfate discharge
standard exists for any of these three classifications. The TDS standard for Quitchupah Creek is
2,6000 mg/l, which is greater than the average concentration previously discussed. The
Permittee operates under a UPDEs discharge permit issued by the Utah Division of Water
Quality and controls discharges from the mine to be consistent with that permit.

Second, except where overlain by a thin veneer of alluvial deposits, surface water in
Quitchupah Creek flows across the Tununk Member of the Mancos Shale immediately
downstream from the mine permit area. Since this member is gypsiferous formation, sulfate and TDS concentrations increase naturally in surface water that flows across areas underlain by this unit. Thus, the additional input of these constituents from the mine waters to local streams is considered minimal.

A TMDL study of the Muddy Creek Watershed (MFG, Inc., 2004), of which Quitchupah Creek is a tributary, indicated that Muddy Creek and its major tributaries would not support an agricultural beneficial use classification. This lack of beneficial use support occurs at the location where these streams cross State Highway 10 (i.e. upstream from mine water discharge point). The study concluded that elevated TDS concentrations in areas downstream from Highway 10 are caused predominantly by changes in surficial geology (i.e. outcropping of the saline Mancos Shale) and irrigated agriculture.

According to the U.S. Bureau of Reclamation (U.S. Bureau of Reclamation, 2003), the salt load from the Muddy Creek watershed averages 86,000 tons/yr. The Emery Mine UPDES permit currently allows a maximum salt load of 12 tons/day to be discharged from the mine. Assuming that this load is discharged constantly throughout the year, the annual salt load from the mine to the Muddy Creek watershed would be 4,380 tons/yr (about 5% of the basin-wide salt load). The UPDES permit indicates that the salt-load limit will change to 3,839 tons/yr (rather than 12 tons/day) following EPA approval of the TMDL loading limit. Once this new limit is adopted, the salt load from the Emery mine will represent about 4.5% of the annual salt load of the Muddy Creek watershed.

Section VI.A.4 of the MRP indicates that no surface water rights exist on Quitchupah Creek downstream from the mine-water discharge point, nor do they exist on Ivie Creek between the confluence of Quitchupah Creek and Muddy Creek. Hence, no substantial water-quality impact to downstream water users is anticipated.

In the post-mining situation, there is a potential for water-quality degradation within the Upper Ferron as groundwater flows through previously mined areas and then into adjacent un-mined rock. However, it is expected that this condition will be tempered by the dilution effect of better quality recharge water entering the area from the west. As far as the middle and lower Ferron are concerned, a fairly uniform shale floor impedes downward seepage of mine water to lower zones. Thus, groundwater quality in these lower sections of the Ferron should not be substantially affected either during or after mining.

**FLOODING OR STREAMFLOW ALTERATION**

Runoff from all disturbed areas flows through sedimentation ponds or other sediment control devices prior to discharge to adjacent undisturbed drainages. Three factors indicate that these sediment-control devices minimize or preclude flooding impacts to downstream areas as a result of mining operations:

The sediment control facilities have been designed and constructed to be geotechnically
IDENTIFY HYDROLOGIC CONCERNS

stable. Thus, no substantial potential exists for breaches of the sediment-control devices to occur that could cause downstream flooding. These sediment control devices are sized sufficiently that no discharges have been recorded. This precludes flooding impacts to downstream areas. By retaining sediment on site in the sediment control devices, the bottom elevations of stream channels downstream from the disturbed areas are not artificially raised. Thus, the hydraulic capacity of the streams channels is not altered and flooding potential is further precluded.

Following reclamation stream channels will be returned to a stable state. Interim sediment control measures and maintenance of the reclaimed areas during the post-mining period will serve to minimize the deposition of significant amounts of sediment in downstream channels following reclamation, thus maintaining the hydraulic capacity of the channels and further precluding adverse flooding impacts.

POTENTIAL HYDROCARBON CONTAMINATION

Diesel fuels, oils, greases and other hydrocarbon products are stored and used at the mine site for a variety of purposes. Diesel and oil stored in above ground tanks at the mine facilities may spill onto the ground during filling of the storage tank, leakage of the tank or filling of the vehicle tank.

The probable future extent of the contamination caused by diesel and oil spillage is expected to be minimal and its impact contained within the permit area. The tanks are located above ground, leakage from the tanks can be readily detected and repaired. Spillage during filling of the storage or vehicle tanks is minimized to avoid loss of an economically valuable product. In addition, the mine has a Spill Prevention Control and Countermeasure Plan that provides inspection, training and operation measures to minimize the extent of contamination resulting from the use of hydrocarbons at the site.

SUBSIDENCE

Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. In as much as vertical and lateral migration of water appears to be partially controlled by fracture conduits; readjustment or realignment in the conduit system will inevitably produce changes in the configuration of groundwater flow.

Mining at the Emery Deep Mine has been done by room and pillar methods with partial pillar extraction. With the addition of the 4th-west full extraction and 160 acre incidental boundary change addition, full extraction techniques were implemented in order to meet the Maximum Economic Recovery requirements established by the Federal Mineral Leasing Act enforced by the Bureau of Land Management.

Maximum subsidence at the Emery Mine will be approximately 50% of the extraction height. Given the current mining horizon, this would relate to 3 feet of subsidence in areas of 6 foot extraction to 5 feet of subsidence in areas of 10 foot extraction. The predicted angle of
drdaw will range from approximately 5 degrees at 150 feet of cover, 12 degrees at 350 feet of cover and 15 degrees at 750 feet of cover or greater. Plate V-5 of the MRP (Subsidence Monitoring Points and Buffer Zones) depicts the estimated subsidence isopacs.

**Quitchupah Creek, Christiansen Wash and Alluvial Valley Floor Areas**

In order to prevent subsidence related impacts from affecting Quitchupah Creek, Christiansen Wash and the alluvial valley floor areas on the west side of the permit area (See Plate V-5 of the MRP), the Permittee has established designated buffer zones in these areas based on the angle of draw. Plate V-5 depicts the buffer zone areas associated with the aforementioned hydrologic features. The buffer zones are created by leaving coal pillars of adequate size beneath these areas. The dimensions of the buffer zone were determined by the overburden depth and the angle of draw. With respect to Quitchupah Creek and Christiansen Wash, the buffer zone will include an additional standoff distance of 100 feet on either side of the drainage as required by UMC 817.57. The pillar dimensions are based on established geotechnical information and a factor of safety for long term pillar stability. The partial pillar splitting design data is provided in Chapter V Pages 28A, 28B and 28C.

Subsidence will occur in areas occupied by ephemeral stream channels. Although surface craks that result from subsidence in the permit area are expected to heal with time in areas overlain by unconsolidated deposits and the Bluegate Member of the Mancos Shale, ephemeral stream flows may be partially intercepted prior to completion of the healing process. In addition, the broad depressions created by subsidence may locally retain runoff that would normally discharge from an area. However, the following factors indicate that the impact of subsidence on ephemeral streamflow will be minimal:

Ephemeral streamflow in the area is sporadic, allowing significant periods of time for surface cracks to heal between flow events. Ephemeral streamflow typically carries a high sediment load. This sediment will fill remaining cracks. As the cracks heal, the potential for interception of streamflow is minimized. The depressions created by subsidence are sufficiently broad that changes in slope are not typically of an ample magnitude to cause ponding in anything other than local areas.
V. IDENTIFY RELEVANT STANDARDS

RELEVANT STANDARDS

The CHIA is based on the best currently available data and is a prediction of mining related impacts to the hydrologic balance outside of the specific permitted coal mine areas. To verify that conditions remain within acceptable limits, the mine operator is required to monitor water quality and quantity as part of the permit requirements. The plans for monitoring are set forth in the Mining and Reclamation Plans (MRP) for the Emery Deep Mine and have been determined adequate by the Division to meet regulatory requirements. If monitoring results show significant departures from the values established in the MRP and in this CHIA, or exceed UPDEs discharge requirements, immediate remedial actions are provided for by SMCRA.

Water quality standards for surface waters in the State of Utah are found in R317-2, Utah Administrative Code (UAC). The standards are intended to protect the waters against controllable pollution. Waters, and the applicable standards, are grouped into classes based on beneficial use designations. The Utah Division of Water Quality of the Department of Environmental Quality has classified surface waters in the CIA as:

2B-Protected for secondary contact recreation such as boating, wading or similar uses.

3C-Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.

4-Protected for agricultural uses including irrigation of crops and stock watering.

Flow: There is no standard for flow in the Emery Deep permit nor in Utah water quality standards. At the Emery Deep Mine, UPDES discharge is to be recorded twice monthly. Characteristics such as stream morphology, vertebrate and invertebrate populations, and water chemistry can be affected by changes in flow and therefore can provide an indirect standard for flow.

Oil and Grease: There is no State water quality standard for oil and grease, but the UPDES permit limit for the Emery Deep Mine is a daily maximum of 10 mg/L; only one sample a month, either grab or composite, is required to measure this, but weekly visual monitoring is required.

Total Dissolved Solids (TDS): The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. There is no state water quality standard for TDS for Classes 1, 2, and 3, but 1,200 mg/l is the limit for agricultural use (Class 4). The total amount of dissolved solids discharged from the Emery Mine operation is limited to 12 tons/day from all discharge points determined by two grab samples a month.
**Identify Relevant Standards**

**pH:** Allowable pH ranges are 6.5 to 9.0 under the Emery Mine UPDES permit. The range is based on Utah secondary treatment requirements.

**Total Suspended Solids (TSS) and Settleable Solids:** There is no State water quality standard for suspended solids in the water, but an increase in turbidity is limited to 10 NTU for Class 2A, 2B, 3A, and 3B waters and to 15 NTU for Class 3C and 3D waters. The Emery Mine UPDES permit allows a daily maximum of 70 mg/L TSS, but limits the monthly average to 25 mg/L and the weekly average to (35 mg/L). Two grab samples a month are used to determine TSS. Under the Emery Mine UPDES permit, all samples collected during storm water discharge events are to be analyzed for settleable solids. Samples collected from increased discharge, overflow, or bypass that is the result of precipitation that does not exceed the 10-year, 24-hour precipitation event can comply with a settleable solids standard of 0.5 mL/L daily maximum rather than the TSS standard, although TSS is still to be determined. If the increased discharge, overflow, or bypass is the result of precipitation that exceeds the 10-year, 24-hour precipitation event, then neither the TSS nor settleable solids standard applies.

**Iron and Manganese:** The Emery Mine UPDES permit allows a daily maximum of 1.5 mg/L total iron, which is based on an assumption that total and dissolved iron concentrations are the same. Grab samples are taken twice a month from the UPDES sites to determine iron concentration. State water quality standards allow a maximum of 1,000 mg/L dissolved iron in Class 3A, 3B, 3C, and 3D waters, with no standard for Class 1, 2, and 4 waters.

Monitoring of total manganese is required by SMCRA and the Utah Coal Mining rules, but there is no UPDES or water quality standard for either total or dissolved manganese.

**Macroinvertebrates:** Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support fish and other aquatic life. Baseline studies of invertebrates provide standards against which actual conditions in Box Canyon and Muddy Creeks can be evaluated if desired. Price and Plantz (1987) summarized invertebrate data. There are no current plans to monitor invertebrate populations in the streams of the CIA.

Utah water quality standards exist for numerous parameters other than those already mentioned above, but at this time there is no evidence or reason indicating they are of concern or have a reasonable potential to affect the hydrologic balance of the CIA. However, those parameters that may have a reasonable possibility of affecting the hydrologic systems are included in routine water quality monitoring of the mine operations. Review of monitoring results by the mine operators and the Division will identify concerns or problems and generate revisions of the mine operations to mitigate those problems.

Sediment is a common constituent of ephemeral stream flow in the western United States.
The quantity of sediment in the flows affects stream-channel stability and most uses of the water. Excessive sediment deposition is detrimental to existing aquatic and wildlife communities. Large concentrations of sediment in streamflow may preclude use of the water for irrigating crops because fine sediment tends to reduce infiltration rates in the irrigated fields, and the sediment reduces capacities of storage facilities and damages pumping equipment. Mean sediment load is the indicator parameter for evaluating the sediment hazard to stream-channel stability and irrigation.

The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. The quality of water from underground sources reflects the chemical composition of the rocks it passes through. That quality may be degraded by intrusion of poorer quality water from wells or mines, by leakage from adjoining formations, or by recharge through disturbed materials. Ground water discharging from seeps and springs is used by wildlife and livestock. The state standard for TDS for irrigation of crops and stock watering (Class 4) is 1,200 mg/L. The Utah Department of Environmental Quality, Division of Water Quality can authorize a coal mine to discharge into surface waters under the Utah Pollutant Discharge Elimination System (UPDES).

The Emery Mine UPDES permit contains site-specific limitations on TDS, total suspended solids, total settleable solids (for discharges resulting from precipitation events), total iron, oil and grease, and pH. There is no limit on flow but it is to be measured monthly. Additionally, there can be no more than a trace amount of visible sheen, floating solids, or foam and no discharge of sanitary waste or coal process water.

Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support fish and other aquatic life.

MATERIAL DAMAGE

Material damage to the hydrologic balance would possibly manifest itself as an economic loss to the current and potential water users, would result in quantified reduction of the capability of an area to support fish and wildlife communities, or would cause other adverse change to the hydrologic balance outside the permit area. The basis for determining material damage may be found to differ from site-to-site within the CIA according to specific site conditions. Surface-water and ground-water concerns have been identified for CHIA evaluation.

Parameters for surface-water quantity and quality

The potential material-damage concerns this CHIA focuses on are changes of surface flow rates and chemical composition that would physically affect the off-permit stream channel systems as they presently function and affect aquatic and wildlife communities and agricultural and livestock production. Therefore, criteria are intended to identify changes in the present discharge regime that might be indicators of economic loss to existing agricultural and livestock enterprises; of significant alteration to the channel size, or gradient; and of a loss of capacity to support existing fish and wildlife communities. In order to assess the potential for material-
damage to these elements of the hydrologic system, the following indicator parameters were selected for evaluation at each evaluation site: low-flow discharge rate, TDS, and sediment load.

**Low-Flow Discharge Rate**

Measurements provided by mine operators are generally of instantaneous flow and provide some indication of long-term trends. In the Wasatch Plateau Waddell and others (1981) found that correlating three years of low-flow records (September) at stream sites against corresponding records from long-term monitoring sites would allow the development of a relationship that could be used to estimate future low-flow volumes at the stream sites within a standard deviation of approximately 20%. Ten years of record reduced the standard deviation to 16% to 17%, and 15 years of data to about 15%.

Monitoring of low-flow discharge rates will also provide a means to evaluate effects of mine discharge on the receiving streams. The Emery Mine discharge will be monitored at UPDES discharge points at the sediment pond. The potential for material damage by mine discharge water is tied to the effect on the flow in the receiving streams.

**Total Dissolved Solids (TDS)**

The concentration of dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. Ground water discharging from seeps and springs is used by wildlife and livestock. Because wildlife and livestock use is the designated post-mining land use, established dissolved solids tolerance levels for wildlife and livestock have been adopted as the thresholds beyond which material damage may occur. The state standard for TDS for irrigation of crops and stock watering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L it will be an indication that evaluation for material damage might be needed.

**Sediment Load**

Sediment is a common constituent of ephemeral stream flow in the western United States. The quantity of sediment in the flows affects stream-channel stability and most uses of the water. Excessive sediment deposition is detrimental to existing aquatic and wildlife communities. Large concentrations of sediment in streamflow may preclude use of the water for irrigating crops because fine sediment tends to reduce infiltration rates in the irrigated fields, and the sediment reduces capacities of storage facilities and damages pumping equipment. Sediment load measurement error is, at a minimum, the same as the flow measurement error because sediment load is directly dependent on flow and in practice cannot be measured more accurately than the flow.

TSS is the indicator parameter initially chosen for evaluating the sediment hazard to stream-channel stability and irrigation. Threshold values have initially been set as the greater of 1
standard error above the baseline mean TSS value or 120 % of the baseline mean TSS value (by analogy with the low-flow discharge rate measurement accuracy and assuming that the error in TSS will contribute equally to the error in flow when determining mean sediment load). If TSS concentrations persistently exceed these threshold values it will be an indication that evaluation for material damage from sediment load in the streams might be needed.

Parameters for ground-water quantity and quality

The potential material-damage concerning this CHIA are intended to limit changes in the quantity and chemical composition of water from ground-water sources to magnitudes that: will not cause economic loss to existing or potential agricultural and livestock enterprises and maintain the hydrologic balance.

Seasonal flow from springs

Maintain potentiometric heads that sustain average spring discharge rates, on a seasonal basis, equal or greater than 80 % of the mean seasonal baseline discharge, in other words baseline minus 20 % probable measurement error. The 20 % measurement error is based on analogy with the accuracy of measuring low-flow surface discharge rates. A 20 % decrease in flows, determined on a seasonal basis, will indicate that decreased flows are probably persisting and that an evaluation for material damage is needed.

TDS concentration

The concentration of total dissolved solids is commonly used to indicate general water quality with respect to inorganic constituents. The quality of water from underground sources reflects the chemical composition of the rocks it passes through. Ground-water quality may be degraded by intrusion of poorer quality water from wells or mines, by leakage from adjoining formations, or by recharge through disturbed materials. Ground water discharging from seeps and springs is used by wildlife and livestock, and those are the designated post-mining land uses. There is no water quality standard for TDS for aquatic wildlife. The state standard for TDS for irrigation of crops and stock watering (Class 4) is 1,200 mg/L. If TDS concentrations persistently exceed 1,200 mg/L it will be an indication that evaluation for material damage might be needed.
VI. ESTIMATE PROBABLE FUTURE IMPACTS OF MINING ACTIVITY

GROUNDWATER

Dewatering and subsidence related to mining have the greatest potential for impacting groundwater resources in the CIA.

Dewatering

Underground mining removes the support to overlying rock causing caving and fracturing of the overburden. In most mining areas it is unlikely that fractures will reach shallower perched aquifers because of the thickness of the overburden, but in areas where fracturing is extensive, subsidence induced caving and fracturing can create conduits that allow ground water to flow into the mine. Dewatering caused by fracturing may decrease aquifer storage and ground water flow to streams and springs. Water quality downstream from the mines will be impacted as well.

Predicted mine-water inflow/discharge rates through the period of the mine plan (2013) are summarized in Table VI-23B from the MRP. The rates were calculated based on the Hantush equation (Freeze and Cherry., 1979). Spreadsheets detailing the calculations are provided in Appendix VI-9 of the MRP. Based on these calculations, discharge rates are expected to average 1.50 cfs with a range of 1.2 to 2.0 cfs. Variations are discharge rates are anticipated depending on the depth of mining below the potentiometric surface and the area over which mining will occur. The estimates are based on a hydraulic conductivity of 0.20 ft./day. The hydraulic conductivity value was calculated utilizing historic discharge rates. The estimates presented in Table VI-23B of the MRP assume full extraction of the coal.

Table VI-23B: Predicted Mine Water Discharge Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Predicted Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1.29</td>
</tr>
<tr>
<td>2007</td>
<td>1.19</td>
</tr>
<tr>
<td>2008</td>
<td>1.33</td>
</tr>
<tr>
<td>2009</td>
<td>1.77</td>
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<tr>
<td>2010</td>
<td>1.28</td>
</tr>
<tr>
<td>2011</td>
<td>1.52</td>
</tr>
<tr>
<td>2012</td>
<td>1.63</td>
</tr>
<tr>
<td>2013</td>
<td>1.98</td>
</tr>
<tr>
<td>Average</td>
<td>1.50</td>
</tr>
</tbody>
</table>
SUBSIDENCE

Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. Inasmuch as vertical and lateral migration of water appears to be partially controlled by fracture conduits, readjustment or realignment in the conduit system will inevitably produce changes in the configuration of ground-water flow. Potential changes include decreased flow through existing fractures that close, increased flow rates along existing fractures that open further, and the diverting of ground-water flow along new fractures or within newly accessible permeable lithologies. Subsurface flow diversion may cause the depletion of water in local aquifers and loss of flow to springs that are undermined. Increased flow rates along fractures could potentially improve water quality by reducing ground-water residence time.

Subsidence surveys have been conducted at the Emery Mine. Mine representatives inspect monthly the areas identified on Plate V-5 as full extraction areas. The reports are forwarded to the Division upon their completion. Pre-subsidence surveys are conducted 6 months prior in areas where full extraction mining will take place. The relatively moderate thickness of the overburden and the fracture system are major contributors to the amount of subsidence.

SURFACE WATER

Changes in flow volume and in water quality have the greatest potential for impacting surface water resources in the CIA. The monitoring plan should help identify variations in flow caused by mining. Monitoring is a benefit to both the public and the Permitee because it can identify and separate natural and anthropogenic variations to the environment or ecosystem. A good monitoring plan can provide the necessary data to establish the necessary mitigation or show the variations are following a natural sequence.

Water Quality

The quality of the local surface waters can be affected by two basic processes. First, the runoff from the disturbed lands and waste piles could increase sediment concentrations and alter the distribution and concentration of dissolved solids in the receiving streams. This potential has been shown to be minimized. The second potential cause of surface-water quality changes is related to the location and chemistry of ground-water discharges, both from the mines and from springs and baseflow.

Water Quantity

Water not used in the Emery Mine or lost to evaporation is discharged to Quitchupah Creek as governed by the mines UPDES permit established with the Department of Water Quality. Ongoing monitoring will indicate total groundwater discharge due to mining.
ALLUVIAL VALLEY FLOORS

Alluvial valley floors (AVF) have been identified within the Emery Mine permit area and CIA. Volume XI of the MRP discusses the AVF investigations performed relative to the Emery Mine operation. The Upper Quitchupah Creek drainage and associated AVF could be potentially impacted by mining related activity. The other drainages within the CIA (Christiansen Wash, Muddy Creek and Ivie Creek) do not satisfy the federal criteria for AVF designation.

The Upper Quitchupah Creek drainage is defined as that portion of Quitchupah Creek above the confluence with Christiansen Wash. The upper Quitchupah Creek Valley contains unconsolidated stream-laid deposits as shown on Plate 1 of Appendix XI-1 in the MRP. The Upper Quitchupah Creek drainage contains several areas where flood irrigation activities are ongoing. An assessment of the annual runoff in the area indicates that sufficient water could be available from Quitchupah Creek to flood irrigate 300 to 400 acres along the Quitchupah Creek Valley. Presently, the agricultural activities on the north side of Quitchupah Creek are irrigated from Muddy Creek water diverted through the Emery Ditch (See Plate XI-1). The fields south of Quitchupah Creek are irrigated primarily from water diverted from Quitchupah Creek about two miles west of the permit area. The areas presently irrigated in the Upper Quitchupah Creek valley are outlined on Plate XI-1.

The areas outlined in Plate XI-1 (Areas 1-3) meet the criteria for a positive AVF determination. Area 1 is located within a grandfathered area and is therefore exempt from UMC 822.12(a) and (b). Area 2 is presently irrigated by Muddy Creek water but could potentially be irrigated with Quitchupah Creek water. Area 3 is the area presently being irrigated with Quitchupah Creek water. Areas 2 and 3 as depicted on Plate XI-1 are subject to the protection requirements of UMC 822.122(a) which requires that the mining activities will not interrupt, discontinue or preclude farming on AVF’s unless the premining land use is undeveloped rangeland or the affected area is small and provides negligible support for farm production. The possible effect of mining under these areas would be subsidence of the surface. Subsidence could cause changes in the surface drainage patterns and thus interrupt farming operations. In order to prevent subsidence impacts to the farming operations, the Permittee has established a buffer zone around the aforementioned AVF’s. The buffer zones are established taking into account the angle of draw and the amount of overburden in the area.
VII. ASSESS PROBABLE MATERIAL DAMAGE

The probable hydrologic impacts are summarized below under the headings entitled Next Five Year Permit Term and Future Mining.

NEXT FIVE YEAR PERMIT TERM-EMERY MINE

Planned operational monitoring will document any measurable changes in the surface and groundwater systems. Surface disturbances and UPDES permitted discharges are not expected to degrade surface or groundwater quality. Due to the buffer zones established by the Permittee (based on a calculated angle of draw and overburden amount) impacts to the identified AVF’s and perennial streams are not anticipated.

Dewatering of the Upper Ferron Aquifer will continue. Future monitoring will provide data applicable to documenting change sin the groundwater system.

Surface disturbance and the discharge of Emery Mine water have not significantly degraded water quality in the Quitchupah Creek drainage. Sediment control measures such as those intended for use at the Emery Deep Mine have served to reduce contaminants and stabilize water quality at acceptable discharge levels.

A monitoring and mitigation plan for full extraction mining has been implemented. The Emery Mine has been diligent at following their monitoring plan to date and have applied reasonable and effective mitigation efforts when needed. No material damage within or outside of the permit area is believed to have occurred. Monitoring of the streams, springs and vegetation for significant loss of natural habitat is ongoing.
VIII. STATEMENT OF FINDINGS

Based on the information presented in this CHIA, the Utah Division of Oil, Gas and Mining finds that the proposed coal mining and reclamation operations of the Emery Mine have been designed to prevent material damage to the hydrologic balance outside the permit areas. The possibility of material damage within the CIA exists from the undermining of stockwatering ponds, irrigation ditches and dewatering of the Ferron aquifer. Based on ongoing monitoring and mitigation, no evidence of material damage from actual mining operations in the CIA has been found thus far. No other probability of material damage has been identified from existing and anticipated mining operations in the CIA.

The Permittee has been cooperative in conducting environmental evaluations and operations to lessen impacts to the hydrologic environments.
IX. REFERENCES


PLATES

Plate 1  Location Map
Plate 2  Workings Map
Plate 3  Geology Map
Plate 4  Hydrologic Map

O:\CHIA\CHIAS\LowerQuitchupahCreekWatershed\Final\03_16_2007\Emery_CHIA.doc
Cumulative Impact Area
Lower Quitchupah Creek Watershed

Plate 2 - Workings Map
Mar. 2007

File: N:/gis/coal/aimaps/LowerQuitchupah/Plate02-Workings.pdf