

Sheila Morrison - [Fwd: Final PHC]

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Subject: [Fwd: Final PHC]
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----- Original Message -----

Subject:Final PHC

Date:Tue, 06 Feb 2007 10:05:24 -0700

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Mark

Attached is the final PHC - Please let me know if any additional changes are necessary.

Let's hope this satisfies the agencies.

Alan

Probable Hydrologic Consequences of Coal Mining in the Mohrland Permit Area

C.W. Mining Company, Huntington, Utah

February 7, 2007

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PROBABLE HYDROLOGIC CONSEQUENCES OF MINING

This document describes the probable hydrologic consequences (PHC) of coal mining in the Mohrland Lease area (Mohrland and McCadden Hollow permit expansion areas), as described on page 1 of the June 25, 2001 report "Investigation of groundwater and surface-water systems in the C.W. Mining Company Federal Coal Leases and Fee Lands, Southern Gentry Mountain, Emery and Carbon Counties, Utah" by Mayo and Associates, LC which is referred to herein as the 2001 Report. Chapter 9 of the 2001 Report, which described the probable hydrologic consequences of mining in the Bear Canyon Mine and the Wild Horse Ridge area, was part of the successful permit application for the Wild Horse Ridge mine expansion. Chapter 9 of the 2001 report did not explicitly include expansion of mining into the Mohrland lease area, but chapters 1-8 of the 2001 report described the groundwater and surface water systems in the Mohrland lease expansion area, specifically the mining areas designated as the Mohrland area and the McCadden Hollow area (page 1, Section 1.0, 2001 Report). The purpose of this PHC revision is to explicitly include the Mohrland lease area.

The Bear Canyon Mine permit area includes Bear Canyon mines #1 and #2, whereas the Wild Horse Ridge expansion area includes mines Bear Canyon mines #3 and #4. Mining has been completed in both Bear Canyon #1 and #2 mines. Mine #1 is sealed and BC2 has been reclaimed. Wild Horse Ridge mine #3, which mines coal from the Blind Canyon Seam, opened in 2002 and mine #4, which mines coal from the overlying Tank Seam, was opened in 2004.

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The distinction between the Bear Canyon Mine permit area and the Wild Horse Ridge mine permit area is important because, groundwater systems in these areas are hydraulically isolated from each other by the Bear Canyon Fault. The hydraulic discontinuity between the two areas is documented in Section 4.3 (2001 Report) and is illustrated in Figure 13b (2001 Report).

The Mohrland Lease application area includes two distinct mining areas that are separated from each other by the Bear Canyon Fault. East of the fault the mining permit area is known as the Mohrland area and west of the fault the mining permit area is known as the McCadden Hollow area. As with the Bear Canyon-Wild Horse Ridge mine areas, groundwater systems in the Mohrland –McCadden Hollow areas are hydraulically isolated from each other by the Bear Canyon Fault (Figure 13B, 2001 Report).

Mining in the Mohrland area, which will include the Hiawatha and Tank Seams, is planned to commence immediately after issuance of the Mohrland lease area permit. The Blind Canyon Seam will not be mined in the Mohrland area due to limited coal.

Only the Blind Canyon Seam contains mineable coal in the McCadden Hollow area. The McCadden Hollow Blind Canyon Seam cannot be accessed from the Bear Canyon Mine because the coal seam pinched out between the Bear Canyon and McCadden Hollow mine areas. Access via the Bear Canyon mine will also be impossible because complete

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reclamation is planned for the Bear Canyon mine and an extensive area of low coal separates the Bear Canyon mine from the McCadden Hollow mine. Access to the McCadden Hollow area is currently economically questionable from the Mohrland area due to stratigraphic offset along the Bear Canyon Fault and complications resulting from the faulting.

C.W. Mining does not currently plan to mine coal from the McCadden Hollow area as the most economical access is from the area north of the McCadden Hollow, which will require the acquisition of additional lease permits. Additionally access through the Mohrland area (a less favorable option) would require additional permitting action to add the portal area. The McCadden Hollow Federal Development Leases (U-46484 and U-024316) were acquired before the access problems were known. Because C.W. Mining owns the leases they have been required to include them in the Mohrland Lease mining application. Since additional lease permits would be necessary to mine coal from McCadden Hollow, a PHC revision would be highly recommended prior to mining. Additionally CW Mining has committed to not mine the McCadden Hollow area until additional hydrologic analysis has been undertaken. None-the-less this PHC revision includes a description of the probable hydrologic consequences of actual mining in the McCadden Hollow lease area.

This PHC determination is required by R645-301-728 of the State of Utah Coal Mining Rules and appropriate subsections of the rules. This PHC determination is based on the data and information presented in Sections 1-8 of the 2001 report and is an addendum to the 2001 report. .

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1.1 Possible adverse impacts to the hydrologic balance (728.310)

1.1.1 Groundwater

In general, there are two mechanisms by which mining in the proposed permit area has the potential to adversely impact natural groundwater discharge rates from horizons overlying or underlying mine workings. The first mechanism is the direct interception and dewatering of groundwater contained either in perched systems in horizons directly overlying the mined or groundwater associated with faults or fractures. The second mechanism is the dewatering of perched groundwater higher in the stratigraphic section caused by interruption and deformation of strata above subsided areas. These mechanisms are discussed below.

Included in the discussion are examples of how the groundwater systems have behaved in the existing mine permit area – Bear Canyon and Wild Horse Ridge mines. Such examples are important because they are the best predictors for the likely behavior of groundwater systems in the Mohrland permit expansion area.

Direct interception of perched groundwater

As described in Section 6.3 (2001 Report), most water encountered in the workings of the Bear Canyon Mine discharged from inactive-flow perched groundwater systems. Waters in these systems are not in good hydraulic communication with the recharge and discharge areas. This is indicated by the radiocarbon ages of these waters (500-9,000 years), the lack of tritium in these waters, and the rapid decreases in discharge rate after a source of water is encountered (often days to weeks). Although a significant quantity of water has discharged

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from the large sandstone paleochannel encountered in the northern extent of the Blind Canyon Seam workings in the Bear Canyon Mine area for a longer period of time, this inflow was nevertheless supported by an inactive-flow groundwater system. Discharge from this channel (measured at SBC-9 and SBC-10; Figure 10c and 10d; 2001 Report) took longer to decrease because of the greater length of that particular channel. Both SBC-9 and SBC-10 are now inactive monitoring sites. Since 2002 all Mine 1 water, including discharge from the paleochannel reports to SBC-9A. Because measured discharge at SBC-9A has been as low as 3 gpm, it is likely that the discharge from the channel has essentially ceased.

Calculations of the steady-state flux of groundwater in this channel (Section 8.1; 2001 Report) suggest that the natural pre-mining recharge and discharge rates for this channel is less than 2 gpm. The increasing radiocarbon age of water (Section 5.3; 2001 Report) in this channel suggests that increased groundwater recharge to this channel due to dewatering of this channel is probably not occurring.

The sandstone channel is located at the north end of the Bear Canyon Mine (southern end of the low coal area separating the Bear Canyon and McCadden Hollow areas; Plate 5-1A, MRP). This is significant because it represent potential groundwater conditions in the vicinity of the low coal – high sandstone regions of the Blind Seam. Elsewhere in the Bear Canyon Mine Blind Seam workings only smaller quantities of groundwater were encountered. Groundwater conditions encountered in the Bear Canyon Mine Blind Seam workings are the best indicator of groundwater conditions that may be encountered in the

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Blind Canyon Seam in the McCadden Hollow area. Based on groundwater conditions in the Bear Canyon mine (page 53; 2001 Report) it is reasonable to anticipate that only minimal groundwater inflows (i.e., less than 40 gpm for short time intervals and then drying up, Figures 10a, b; 2001 Report) will be encountered in the Blind Canyon Seam in the McCadden Hollow area unless a large paleochannel is encountered. Such an encounter is most likely to occur in the southern most workings where the coal seam thins. Here groundwater inflows as great as 200 gpm may be encounter for several years (Figure 10c; 2001 Report). In the Bear Canyon Mine we found groundwater in the paleochannel had a mean ^{14}C age in excess of 1,000 years (Table 4; 2001 Report) and it is likely that water in a McCadden Hollow paleochannel would have a similar age. What this implies is that a McCadden Hollow paleochannel groundwater system will have poor hydraulic communication with near surface groundwater system and its dewatering will not impact surface springs or streams. In the Bear Canyon mine we calculated an average natural recharge-discharge rate of the Blind Canyon paleochannel of only 1.6 gpm (Section 8.1 and Figure 21; 2001 Report) and it is likely that a McCadden Hollow paleochannel would have a similar natural flux rate.

The Bear Mine Blind Canyon Seam paleochannel also provides insight into the relationship between Blind Canyon Seam groundwater systems and the Bear Canyon and Blind Canyon Faults. In the Bear Canyon mine the Bear Canyon Fault truncates the east side of the paleochannel and the Blind Canyon Fault truncates the west side of the paleochannel. Because the paleochannel was essentially full when encountered during mining, appreciable

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quantities of groundwater did not naturally drain into either fault from the channel. In other words, near the Blind Canyon Seam the vertical hydraulic conductivity of the fault zones is small, relative to the vertical and horizontal hydraulic conductivity of sandstone channels, thus the Bear and Blind Canyon Faults are not avenues for appreciable downward vertical groundwater movement in the vicinity of the Blind Canyon Seam in the Bear Canyon mine. A similar condition is anticipated in the McCadden Hollow Mine.

Although the Bear Canyon Fault has not been a significant conduit for groundwater flow where it encounters the Blind Canyon Seam, it is a groundwater conduit in the Panther Sandstone as evidenced by discharge from Big Bear spring. Because the fault is a barrier to flow from mining activities west of the fault, as evidenced by large potentiometric surface difference across the fault (Figure 13b; 2001 Report), a critical issue is will the fault be a barrier to vertical groundwater flow when the Blind Canyon Seam is mined in the McCadden Hollow area. Since the stratigraphic and structural relationships between the Bear Canyon Fault and Blind Canyon Seam are similar to those anticipated in the McCadden Hollow area, as described below in detail it is likely that Blind Canyon Seam mining in the McCadden Hollow area will not alter natural groundwater flow conditions associated with the fault. These conditions include groundwater flow in the Panther Sandstone to Big Bear spring. In the Mohrland and McCadden areas there are no known springs that discharge below proposed coal-mining seams, thus no impacts are anticipated. Potential impacts to Birch and Big Bear spring are described below.

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Springs that discharge from horizons below the mined coal seam in the Bear Canyon Mine area include the Panther Sandstone springs (Big Bear, Birch, Defa #1, and Defa #2). Some or all of the water discharging from the Panther Sandstone springs has antiquity, suggesting a possible relationship with waters encountered by mine workings. However, as discussed extensively in Section 8.0 (2001 Report), these springs are hydraulically isolated from the groundwater that has been encountered in the Bear Canyon Mine. Evidence for this hydraulic isolation includes: 1) almost all groundwater encountered during mining activities was from the paleochannel in the Blind Canyon Seam, located several hundred feet above the Panther Sandstone, 2) the calculated rate of natural recharge-discharge in the channel is only 1.6 gpm, which if stopped would not have a measurable impact on Birch or Big Bear Spring discharge (Figure 21; 2001 Report), 3) fault gouge was identified in the Blind Canyon Fault which has approximately 200 feet of offset (Section 8.2; 2001 Report), and 4) groundwater in a sandstone channel near the Blind Canyon Seam inside the Bear Canyon mine has a ^{14}C age of about 5,400 years whereas groundwater located east of the fault has a ^{14}C age of only 1,400 years. Thus the groundwater would have to become about 3,000 years younger by crossing the fault and would have also become younger before discharging at Birch Spring. Without appreciable mixing from modern, non-mine related groundwater this condition is impossible. Because similar stratigraphic and structural conditions are anticipated in the McCadden Hollow area as found in the Bear Canyon Mine, we do not anticipate any impacts from mining activities in the McCadden Hollow area to Panther Sandstone springs including Birch and Big Bear springs.

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As described above the Mohrland and McCadden Hollow areas are separated by the Bear Canyon Fault which likely prevents hydraulic communication from between the west and east side of the fault. That there is a hydraulic disconnect is indicated by the following:

1. The vertical offset of the Bear Canyon Fault is approximately 230 feet. It has been our experience that faults with large displacements in the Blackhawk Formation, Star Point Sandstone, and Mancos Shale almost always contain relatively impermeable fault gouge because of abundant shale and mudstone. This suggests that the plane of the Bear Canyon Fault is in places filled with fault gouge as found in the Blind Canyon Fault in the Bear Canyon Mine (page 122; 2001 Report). Fault gouge is generally not capable of transmitting water as demonstrated by the lack of water in the gouge of the Blind Canyon Fault where encountered by the Bear Canyon Mine (MRP, Appendix 7-J, p. 78).

If the Bear Canyon Fault contains gouge adjacent to the Blind Canyon Seam in the McCadden Hollow area, then the fault will act as a barrier to flow vertically down the fault, laterally along the fault, or perpendicularly across the fault. Because the Bear Canyon Fault will not be encountered in the Mohrland area the fault gouge discussion is only pertinent to the Blind Seam in McCadden Hollow area. Although fault gouge studies have not been conducted for the Bear Canyon and Blind Canyon Faults, there is evidence that the faults adjacent to the Blind Seam contain gouge. For example, in the Bear Canyon mine the Blind Canyon Fault is filled with dry, clay-

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rich gouge opposite the Blind Canyon Seam (p. 78 and 122; 2001 Report). The dry character suggests groundwater does not flow horizontally across the fault. It is reasonable to expect similar conditions to occur elsewhere in light of the large vertical offsets of the faults and the potentiometric differences on opposite sides of the Bear Canyon Fault (Figure 13b; 2001 Report). While, the fault plane itself may not support groundwater or groundwater flow, fault-associated fractures on either side of the fault may support groundwater flow. Consequently, any water-bearing fractures east of the Bear Canyon Fault are not in hydraulic communication with fractures west of the fault that may be supporting groundwater flow to Big Bear Spring.

2. Groundwater recharge to the Panther Sandstone likely occurs where the Panther Sandstone is exposed at or near the surface and the little water recharges the Panther Sandstone from overlying horizons (Section 6.3; 2001 Report). Along the Bear Canyon Fault, adjacent to the Wild Horse Ridge, Mohrland, and McCadden Hollow areas, the Panther Sandstone is juxtaposed against the Blackhawk Formation, because of 230 feet of vertical movement along the Bear Canyon Fault. Consequently there can be no direct hydraulic communication between the Panther Sandstone west of the Bear Canyon Fault where Big Bear Spring is located and the Panther Sandstone east of the fault in Wild Horse Ridge and Mohrland areas.

3. The rocks in the Mohrland area dip to the southeast. Thus, groundwater in bedrock

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formations in these areas would naturally flow to the southeast, away from the Bear Canyon Fault and away from Big Bear Spring. Additionally Mohrland mine workings, in both the Hiawatha and Tank Seams will be at least 500 feet from the Bear Canyon fault (Plates 5-1B and 5-1C: MRP), thus it is unlikely that water encountered in the Mohrland mine will intercept fault water or that water in the mine will interact with the fault.

Blind Seam workings in the McCadden Mine will approach both the Bear Canyon and Blind Canyon Faults. The experience in the Bear Canyon mine, as described above, suggest that this mining will not result in water moving into or out of these faults. McCadden Hollow workings will also cross a small displacement fault area (6 feet of displacement) which is located 600-700 feet west of the Bear Canyon Fault (Plate 5-1A; MRP). In Bear Canyon Mines #1 and #2 a similar small displacement fault was mined without significant groundwater inflows or affect to any know spring and no hydrologic impacts are anticipated in the McCadden Hollow Mine.

When coal mining recommences in the Hiawatha Seam workings, there is a potential for water to up well from the Spring Canyon Sandstone where the elevation of the coal seam is below the elevation of the potentiometric surface of the Spring Canyon Sandstone. This potential exists because the Hiawatha Seam lies directly on the Spring Canyon Sandstone. Two nearby mines provide insight into mining the Hiawatha Seam. In the Crandall Canyon mine, located about 5 miles west of the Bear Canyon Mine, the potentiometric surface of the

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Spring Canyon Sandstone was generally above the base of the Hiawatha Seam. The Joes Valley Fault to the west and a lesser fault to the east truncate the sandstone body. The Joes Valley Fault is a major structural feature with a vertical displacement of about 2,500 feet. During mining groundwater seldom up-welled from the mine floor (Mayo and Associates, 1999). In those locations where minor upwelling occurred the sandstone floor was fractured, due to a roll structure associated with the Joes Valley Fault. The general absence of upwelling, despite the upward gradient, was attributed to shale material often found in contact with the sandstone and the low hydraulic conductivity of the sandstone. Based on slug test results an average hydraulic conductivity (K) of 6×10^{-8} ft/sec and an average linear velocity of 2.6×10^{-8} ft/sec (0.8 ft/yr) was calculated (Mayo and Associates, 1999). Calculations were also made that demonstrated that a 1-mile long, 100-foot wide section of Star point Sandstone would only yield an average discharge of 7 gpm. This significance of these calculations is that unfractured Star Point Sandstone lenses may be under confining pressure but they have K values so small as to yield minuscule amounts of water. Birch and Big Bear Springs demonstrate that the K and storage coefficient of highly fractured Star Point Sandstone can transport and yield appreciable groundwater.

In PacifiCorp's Trail Mountain mine approximately 200-300 gpm (initial inflow rate) up welled from the Spring Canyon Sandstone at the south end of the mine (Mayo and Associates, 1997). As mining progress the sandstone was depressurized and inflow ceased. Here the sandstone had been folded into the Straight Canyon Syncline which resulted in a highly fracture rock body. The sandstone was also cut by numerous faults associated with the

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folding and the hydraulic conductivity of 4.3×10^{-6} ft/sec was calculated from a recovery test on a nearby well (Mayo and Associates, 1997).

Thus two models exist for the potential behavior of the Spring Canyon Sandstone in the proposed Mohrland Mine – the Crandall Canyon model and the Tail Mountain model. Because the bedrock beneath the mine is not part of a major folded structure, which would greatly fracture the rock, it is likely that the Crandall Canyon model is the best analog for Spring Canyon groundwater inflows into the Mohrland Mine. No evidence has been found in either the existing Bear Canyon or Wild Horse Ridge mines to suggest that the damage zone (i.e., region of extensive sandstone fracturing) extends appreciably away from the mapped Bear Canyon Fault.

In the Mohrland Complex (Blackhawk, Mohrland, Hiawatha, and King mines), located immediately north of the Mohrland area, historical inflows as great as 100 gpm were reported when the Bear Canyon Fault was intercepted. Data do not exist which describe where the fault water was encountered or which formations produced the water. In the Bear Canyon Mine inflows associated with the Bear Canyon Fault were typically less than 5 gpm and dried up shortly after initial encounter. A survey of the King 4 mine (Hiawatha Mine PHC, 2003) found the mine was essentially dry and only five points of inflow greater than 1 gpm were observed. Three of the inflows originated from the mine floor via fractures or the Bear Canyon Fault. The PHC concluded the fault zone is not a major source of in-mine water. Inflow rates in the Mohrland area are anticipated to be small, only a few gpm, because it is

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anticipated that the Bear Canyon Fault will not be intercepted by the proposed mining except to access Lease U-46484 (McCadden Hollow). Based on historical inflows in the Bear Canyon Mine from crossing the Bear Canyon Fault, groundwater inflows should be minimal (i.e., only a few gpm) and should dry us shortly after being encountered.

We do not anticipate that partial dewatering of the Spring Canyon Sandstone will be a significant adverse impact to the hydrologic balance because 1) water in the Spring Canyon Sandstone has antiquity (Section 5.3; 2001 Report) indicating that groundwater flow in the sandstone is not active, 2) there are no discernable discharges from the Spring Canyon Sandstone (except the small seep BP-1), and 3) mine floor conditions similar to those encountered in the Crandall Canyon Mine are anticipated.

Mine workings in the permit expansion area will likely not encounter any large groundwater inflows. As in the Bear Canyon Mine, large inflows will only occur if mining encounters a large water-bearing sandstone paleochannel. The location of such features is not readily predictable, but in the existing mine area, channels have only been encountered in the Blind Canyon Seam. No mining will take place in the Blind Canyon Seam within the Mohrland area as mineable coal only exists in the McCadden Hollow area. We anticipate that if a large water-bearing sandstone channel is encountered, groundwater discharging from the channel will have antiquity and not be part of an active flow system that supports discernable discharge to the surface. Such inflows may initially be as great as 200 gpm and large inflows may last for more than a year. We anticipate that this water will not impact the hydrologic

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cycle as it will not drain surface water sources or reduce the flow of springs.

Direct interception of water associated with faults

Although groundwater is not associated with the Bear Canyon Fault in the Bear Canyon Mine area, the information presented above suggest that the fault will not be a source of groundwater inflows when approached in the McCadden Hollow mine area. Although we expect that water associated with the Bear Canyon Fault may be part of an inactive groundwater flow system, we recommend that if any water is encountered an evaluation be made at that time to confirm this supposition.

Groundwater that may be associated with the Bear Canyon Fault was encountered in the Hiawatha Complex approximately 5 miles north of the Bear Canyon Mine. Based on inflows from the Bear Canyon Fault in the Hiawatha Complex (p. 6, Ch. 7, Hiawatha MRP, 1992), the maximum inflow from the Bear Canyon Fault in the Hiawatha Mine was 100 gpm. However, fault intercepts in the Tank, Blind Canyon, Hiawatha Seams in the Bear Canyon Mine, suggests that the Bear Canyon Fault does not convey water from the Hiawatha area to the Bear Canyon area. Although there are technical reasons that demonstrate that Hiawatha mine water does not discharge at Big Bear and Birch Springs via the Bear Canyon or Blind Canyon Faults, the issue has been previously settled by DOGM. During the Hiawatha permit renewal process, the local water users protested the renewal and claimed that U.S. Fuel had impacted Big Bear and Birch springs when mining the Hiawatha mines. DOGM required Hiawatha to update the PHC and prove here was no impact. The case ended up by going to

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the DOGM Board with input from lawyers on each side. Hiawatha won the case and the issue is now settled. Nonetheless the fact that Hiawatha Complex mine water discharges from the Mohrland Portal suggests that the natural flow is to the north away from the springs. The ages of the Hiawatha Complex water, which now discharges from the Mohrland Portal, has a radiocarbon age in excess of 9,000 years, which is considerably older than water in either Big Bear Spring or the Bear Canyon Mine (Section 5.3; 2001 Report) also suggest Hiawatha water is not a major source of Birch or Big Bear Spring water. Mohrland Portal Water has appreciable tritium (5.5 TU; Table 4, 2001 Report) and thus the fault origin portion of the groundwater is likely older than 9,000 years. Big Bear Spring water has 14-17 TU and is too young to have a ^{14}C age (Table 5, 2001 Report). Birch spring has a ^{14}C age of 1,100 to 3,600 years. Based on a simple mixing model it is not possible to derive Big Bear Spring water from Hiawatha fault water and only a small percent of Birch Spring water could be derived from Hiawatha fault water. Other contents of other conservative species such as sulfate (Mohrland Portal 8.7 meq/l vs. Birch and Big Bear Springs 0.44 to 4.16 meq/l) suggest that only a portion of the spring waters could be attributed to Hiawatha water.

Thus, water inflows to the Bear Canyon Mine or water discharging from Big Bear Spring is not the same water that is associated with the Bear Canyon Fault in the Hiawatha Complex.

Based on what is known about the behavior The Bear Canyon and Blind Canyon Faults, as described above, it is unlikely that mining in the Mohrland or McCadden Hollow areas will impact ground water resources as the faults are approached or encountered.

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Subsidence-related fracturing and deformation

The second method whereby natural groundwater discharge rates may be adversely affected results from interruption and deformation of strata above subsided areas. Removal of coal during second mining causes the strata immediately above the mined horizon to cave. Above the zone of caving, bedrock fractures in response to subsidence. The height of the fracturing zone can be related to mining height. A relationship applied at some western coal mines is that subsidence fractures propagate upward to approximately 30 times the height of the extracted coal (Kadnuck, 1994). Rock strata above the fracture zone commonly bend rather than fracture.

In the Bear Canyon Mine, mining has occurred in three seams, the Hiawatha, Blind Canyon, and Tank Seams. At the Bear Canyon Mine second mining occurred in the Blind Canyon Seam prior to mining in the overlying Tank Seam. This unconventional mining sequence (i.e. extraction of the lower seam first) provides a unique opportunity to evaluate the integrity of the strata overlying second mined areas at a height of about 250 feet above the Blind Canyon Seam. Mine personnel report (C. Reynolds, Personal Communication, 1999) that the Tank Seam was intact and that vertical fractures did not extend as high as the Tank Seam. Some existing fractures were opened or loosened. Subsided areas at this height above the Blind Canyon Seam did experience bending as demonstrated by increased aperture along horizontal bedding planes. What this means is that fracturing propagates upward considerably less than 250 feet. That fracturing does not propagate upward further is likely a

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result of the presence of massive sandstones in the Blackhawk Formation.

The effects of second mining in the Tank Seam cannot be as intimately ascertained. Second mining in the Hiawatha, Blind Canyon and the Tank Seams will cause fracturing to propagate upward from the Tank Seam to a greater height than fractures would extend if mining occurred in the Tank Seam alone. However, because of the ameliorating effect of the thick interburden between the Hiawatha, Blind Canyon and Tank Seams, it is unlikely that the height of fracturing above areas of multiple seam removal will be significantly greater than the height of fracturing above second mined areas in the Tank Seam alone. Thus, we do not expect fracturing to extend more than about 300 feet above the Tank Seam. In the Mohrland permit expansion area second mining will occur in the Hiawatha and Tank Seams.

In the Bear Canyon Mine area and permit expansion area, no springs have been identified which discharge from the upper Blackhawk Formation or the Castlegate Sandstone, and only two springs (FBC-9 and FBC-3) discharge from the Price River Formation. FBC-9 is located about 2,500 feet west of McCadden Hollow mine workings and is separated from the proposed working by several faults with a total vertical displacement greater than 200 feet. FBC-3 is located about 1,500 feet south west of McCadden Hollow mine workings (7-4, MRP). FBC-3 has measured 1.5 gpm and FBC-9 has a measured seasonal discharge of 22.4 to 0 gpm (Table A-1; 2001 Report). Because of the distance from potential McCadden Hollow workings and the fact that the Price River Formation springs are seasonal it is anticipated that McCadden Hollow mining will not affect the springs.

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The bulk of the groundwater resources in the area are found in the North Horn Formation and the Flagstaff Limestone. All of the springs with significant discharges identified in the Flagstaff Limestone and North Horn Formation are separated from the Tank Seam by more than 1,000 feet of overburden (Plate 6-10 of the Bear Canyon Mine MRP). In the Mohrland area all springs are separated from the Tank Seam by more than 1,000 feet of overburden. Thus, the groundwater systems from which these springs discharge are well above the zone of potential impact from subsidence fractures that propagate upward from the mine. Abundant clay and mudstone in the North Horn Formation aids the quick healing of any subsidence-related fractures that do occur. Therefore, the potential for these springs to be impacted as a result of mining-related activities is minimal. This is important because Mohrland area springs SBC-16, 16A, 16B, 18, and 21 provide base flow to the left fork of Fish Creek.

1.1.2 Surface water

Execution of the mine plan for the Mohrland and McCadden Hollow area will result in subsidence of a portion of the Left and Right Forks of Fish Creek (Mohrland Mine) and the ephemeral McCadden Hollow drainage (McCadden Hollow Mine). In the Mohrland area depth of overburden is in excess of 700 feet. Maximum predicted subsidence to the Left Fork is about 4 feet and maximum predicted subsidence to the Right Fork is about 10 feet (confidential mine map). In the Mohrland area no impacts are expected from undermining the stream drainages because the streams are ephemeral along most of their reaches in the

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mine area and because the depth of overburden is great. Previous mining in Bear Canyon Mines #1 and #2 support this idea. In Mine #1 full coal extraction was followed by mining in the overlying Mine #2. Despite the fact that only 200 feet of overburden separated Mines #1 and #2, the Mine #2 coal seam and roof were intact when mining commenced in Mine #2. The ephemeral McCadden Hollow drainage traverses in an east-west direction along the southern portion of the McCadden Hollow mine area. Maximum predicted subsidence is about 10 feet (confidential mine map) and the depth of overburden is in excess of 700 feet. Mining workings will not cross either the Bear Canyon or Blind Canyon Faults. Along the boundary separating the mine workings and the faults maximum subsidence will be 3 feet or less and cliff faces are not associated with either fault. The relatively small subsidence combined with the depth of overburden and the lack of cliff faces suggests there will be insignificant surface impacts such as fracturing, which promote the diversion of surface water from the drainage into the bedrock. Also, because the stream is ephemeral there is no base flow component to the stream that could be affected.

About 1,000 feet west of the Bear Canyon Fault a small displacement fault (Double Fault – 6 feet total displacement) will be mined through. This fault also crosses the McCadden Hollow drainage. Because of the depth of overburden and the fact that the stream is ephemeral no impacts to the surface water regime is anticipated due to mining.

The hydrologic balance of Bear Creek below the mine discharge point will be affected by the addition of mine water to the creek. This impact is discussed in Section 1.5 below.

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1.2 Presence of acid-forming or toxic-forming materials (728.320)

Information on acid- and toxic-forming materials is contained in Appendix 6-C of the MRP. Evaluation of these data using *Guidelines for Management of Topsoil and Overburden* (Table 2; Leatherwood and Duce, 1988) revealed that there have been no poor or unacceptable (acid- or toxic-forming) materials encountered in the permit area. Coal and rock strata in the permit expansion area are expected to be identical to those encountered in the Bear Canyon Mine area. However, if any acid- and/or toxic-forming materials are discovered in waste rock in the future, these materials will be disposed of in accordance with the requirements of R645-301-731.300 and as outlined in Chapter 3 of the MRP.

Western coal mines commonly contain sulfide minerals, which, when exposed to air and water, oxidize and release H⁺ ions (acid). The sulfide mineral pyrite (FeS₂) has been identified in the Bear Canyon Mine and is anticipated to occur in the Mohrland and McCadden Hollow areas. Although pyrite oxidation does occur, acidic mine drainage does not. Acid derived from pyrite oxidation is readily consumed by dissolution of carbonate minerals, which are pervasive throughout the rocks in the vicinity of the mines. Iron liberated during pyrite oxidation is readily precipitated as iron-hydroxide and is not observed in the mine discharge water.

1.3 Impact of coal mining on sediment yield from disturbed areas (728.331)

The sediment load of streams can be impacted by increased sediment yield from disturbed

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areas and from subsided landscape above mine workings. Sediment control measures for existing and proposed disturbed areas are described in 7.2.7 and 7.2.8 of the MRP. It is expected that the installation and maintenance of these sediment control structures will prevent any adverse impacts to the sediment load of streams. Also of particular concern is spring SBC-14 which discharges immediately below the proposed portal area in the right fork of Bear Canyon. This spring supports a small riparian area in the canyon. The portal facilities, culverts, and sediment control structures have been specifically designed to prevent impacts from sediment yield to this spring and riparian area.

Subsidence can result in either increased or decreased sediment loading of ephemeral and intermittent streams. Differential subsidence can locally increase stream gradients, causing higher flow velocities in the stream channel and greater sediment loading. However, this impact would likely be localized and short-lived. If there is sufficient water in the drainage, the increased erosion of easily eroded sediments will rapidly bring the channel to equilibrium with the stream. If the altered substrate in the channel is not easily eroded, there will be no increase in sediment loading of the stream. The sediment load of ephemeral and intermittent streams would be decreased where subsidence causes water to be impounded. Here, sediment would be deposited in the subsidence-induced depressions in the stream channel. This occurrence would also be short-lived because sediment deposition in the depressions would gradually bring the channel into equilibrium with the stream.

An escarpment failure study (confidential mine map identified the Left Fork of fish Creek as

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an area that may be impacted by subsidence. Other areas including McCadden Hollow are not anticipated to be affected by escarpment failure, because they do not contain cliff areas. The modeling activity included: 1) the identification of potential instability areas along cliff faces and 2) modeling of potential failure along selected cliff face transects. Two areas within the lease boundaries and a third area outside the lease boundary were modeled for potential cliff face failure. In all areas the study found that escarpment failure would not present a hazardous condition. Locations of the cross-sections (transect lines) of the modeled areas are shown on Plate 5.3 of the Bear Canyon Mining and Reclamation Plan. The areas and potential impacts are summarized below.

Section	Distance to Stream	Maximum Rock Fall Distance
C-C'	2,600 ft	950 feet
D-D'	1,980 ft	650 ft
E-E'	450 ft	450 ft (rock hit bottom of canyon)

Section C-C'

This section is located on Wild Horse Ridge against the left fork of Fish Creek near the southeast end of Federal Lease U-38727. The cross-section was selected where the escarpments are the largest and the slope is the steepest. The model predicts that escarpment failure will occur, but the falling rocks will not reach the stream channel. Therefore no water related impacts would occur.

Section D-D'

The section is located on Wild Horse Ridge against the left fork of Fish Creek near the

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northeast end of Federal Lease U-38727. This section represents the transition area where subsidence contours transition between the cliff face and the upland slope. Modeled escarpment failure debris will not reach the stream channel, thus not stream impact will occur.

Section E-E'

This section is located at the upper end of the right fork of Fish Creek between the two stream segments of Federal Lease U-61049. Here Fish Creek flows through a box canyon and the escarpment failure will impact the streambed. Because stream flows are minimal in this area, typically 10-30 gpm, water quality impacts, primarily sediment loading, will be minimal and short term.

1.4 Impacts to acidity, TDS, and other important water quality parameters (728.332)

There is the potential for surface water and groundwater quality to be affected by mining operations. Potential impacts to the acidity of surface waters and groundwaters resulting from acid mine drainage were discussed in Section 1.2, and the potential impacts of increased suspended solids were discussed in Section 1.3. Other potential impacts from coal mining activity include increasing the concentration of total dissolved solids (TDS) and specific solutes in streams that receive mine discharge water.

As discussed in Section 1.2, pyrite oxidation, which has the potential to cause acid mine drainage, does occur in the mine environment. However, the ubiquitous presence of

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carbonate minerals in the permit area results in the rapid neutralization of produced acid. Therefore, acid mine drainage does not occur. Toxic forming minerals are generally not found in the permit area. Thus, the potential for detrimental impacts to groundwater or surface-water systems as a result of the discharge or seepage of mine discharge water to the surface is minimal. In fact, the quality of water discharged from the Bear Canyon Mine portals has generally better than that of the receiving water (Bear Creek). Bear Creek above the mine discharge (BC-1) has an average TDS concentration of 544 mg/l, while the mine discharge water (NPDES-004) averages 364 mg/l. The mean sulfate concentration of Bear Creek water is 263 mg/l, while the sulfate concentration of the mine discharge water is less than one fifth as great (51 mg/l).

Because the rock packages and mining practices in the Mohrland and McCadden Hollow Mines will be similar to those in the Bear Canyon mine, similar discharge water quality is anticipated. As described above there is no evidence that mining in the vicinity of either the Bear Canyon or Blind Canyon Faults has affected the groundwater regime at either Big Bear or Birch springs. Also as described above, mining in either the Mohrland or McCadden Hollow area will not impact Big Bear and Birch springs (Sections 1.11 and 1.12).

Because the flow regimes of the two springs will not be impacted by the proposed mining, the TDS, solute content, or other water quality parameters of discharge water from the two springs will not be altered by the proposed mining activities.

The practice of using rock dust for the suppression of coal dust in a mine may potentially

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impact the groundwater flowing through the mine by dissolution of the rock dust constituents into the water. Currently, only limestone or dolomite rock dust is used for dust suppression purposes in the Bear Canyon Mine and this practice is expected to continue during mining in the permit expansion area. Hence, it is doubtful that rock dust usage will adversely impact groundwater quality.

Hydrocarbons (in the form of fuels, greases, and oils) are stored and used in the Bear Canyon Mine area and will be used in the permit expansion area. Groundwater contamination could result from spillage of hydrocarbon products during maintenance of equipment during operations, filling of storage tanks and vehicle tanks, or from tank leakage due to the rupture of tanks. The probable future extent of the contamination caused by diesel and oil spillage is expected to be minimal for three reasons:

1. No underground storage tanks will exist in the permit expansion area;
2. Spillage during filling of the storage or vehicle tanks will be minimized to avoid loss of an economically valuable product;
3. The 1997 SPCC Plan provides for (and C.W. Mining has implemented) inspection and operation measures to minimize the extent of contamination resulting from the use of hydrocarbons at the site.

There are no transformers in the current or expanded mine permit areas that contain polychlorinated biphenyls (PCBs). No roads will be constructed by C.W. Mining in the

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Mohrland or McCadden Hollow permit expansion areas. C.W. Mining is not the property owner and has no control on roads that may subsequently be authorized by the property owners.

The springs that discharge above the mined horizons on Gentry Mountain are related to shallow, active zone groundwater systems. These springs, which include but are not limited to SBC 12, 15, 16, 18, 20, 21, and 22, and SCC-1, 2, 5, 6, and 7, are not in hydraulic communication with groundwater systems that will be encountered in the mine. We anticipate no detrimental impacts to water quality to these springs as a result of mining activities. Indeed, it is difficult to imagine a mechanism whereby the water quality of springs that discharge above the mined horizon may be significantly impacted by mining operations.

Groundwater systems from which the springs on Gentry Mountain discharge are not related to the groundwater systems encountered in the mine. The water quality characteristics at each of these springs have been well documented. Generally, the concentrations of individual solute parameters have not changed significantly over time (Appendix A, 2001 Report).

1.5 Flooding or streamflow alteration (728.333)

Flooding is a potential consequence of mine water discharge. In mine water from the Mohrland expansion will be discharged from the existing Mohrland Portal (SCC-3). The portal currently discharges about 250 gpm, although historical flows have exceeded 700 gpm.

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During the initial phase of mining in the Mohrland area approximately 200 gpm of this discharge will be used for in mine process water. As mining progresses in situ mine water will be used as process water and Mohrland Portal discharges will increase. Because significant discharge from the Spring Canyon Sandstone is not anticipated it is reasonable to assume excess mine discharge will be similar to or less than that in the Bear Canyon Mine. Maximum Bear Canyon mine discharges were the result of the paleochannel in the Blind Canyon Seam. The Blind Canyon Seam will not be mined in the Mohrland area. Thus the discharge rate from the Mohrland Portal may conservatively be estimated to increase by about 50 -100 gpm, due to Mohrland mine discharges, creating a maximum flow of 350 gpm based on the current best available data. Prior to encountering the Blind Canyon Seam paleochannel peak discharge from the Bear Canyon Mine was only about 20 gpm (Figure 10a; 2001 Report), which suggest the maximum increase in discharge at the Mohrland Portal could be as small as 20 gpm.

Discharge from the McCadden Hollow mine will also be via the Mohrland Portal. Because a sandstone channel, similar to the one encountered in the Blind Canyon Seam in the Bear Canyon mine may be encountered, peak discharge from the McCadden Hollow mine may be as great as 200 gpm. Such a discharge would increase the Mohrland Portal flow rate to about 450 gpm, which is well below the historical discharge rate of 700 gpm. As the Mohrland Portal drainage creek was stable at 700 gpm inflow from the Mohrland Portal, it is anticipated that an additional 200 gpm discharge from the McCadden Hollow mine will not results in damage or erosion to the channel.

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1.6 Groundwater and surface-water availability (728.334)

As described in Section 1.1 there are no expected impacts to the hydrologic balance of either groundwater or surface water systems. Therefore, there are no probable impacts to groundwater or surface water supply. There are no water supply wells in the permit area that could be damaged by subsidence. As described in Sections 8.1 and 8.2 (2001 Report) and as described herein, mining has not nor should not affect the groundwater systems that support Big Bear and Birch springs. Thus, we expect that Big Bear and Birch springs will continue to be available for culinary use.

1.7 Contamination, diminution, or interruption of water sources (728.340)

Based on the information presented in this document, we anticipate that there should be no contamination, diminution, or interruption of water sources.

Additional References

Mayo and Associates, LC, 1999, Investigation of groundwater and surface-water systems in the vicinity of GENWAL's existing permit area and the Mill Fork Track, Emery County, UT: January 14, 1999, 87 p.

Mayo and Associated, LC, 1997, Investigation of surface-water and groundwater systems in the PacificCorp Lease Area, East and Trail Mountains, Emery County, Utah: Probable hydrologic consequences of coal mining in the Trail Mountain LBA and Recommendations for surface-water groundwater monitoring: October 20, 1997, 127 p.

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PHC of coal mining in the
Mohrland permit area