CHAPTER 7
HYDROLOGY

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CHAPTER 7
HYDROLOGY

710 INTRODUCTION

711 General Requirements

This chapter presents a description of:

- Existing hydrologic resources within the permit and adjacent areas;
- Proposed operations and the potential impacts to the hydrologic balance;
- Methods of compliance with design criteria and the calculations utilized to show compliance;
- Applicable hydrologic performance standards; and
- Hydrologic reclamation plans for the Dugout Canyon Mine.

Additional information can be found in the following amendments: Methane Degassification Amendment (August 2003), Refuse Pile Amendment (February 2003), and the Leachfield Addendum A-1 (March 2001). Refer to Plate 1-2 for the location of the acreage incorporated into the permit boundary.

The probable hydrologic consequences associated with construction of the AMV Access Road are addressed in the Methane Degassification Amendment (July 2006), Wells G-1 through G-19 and G-31.

The remainder of the State Least ML-48435-OBA (SITLA Lease) was incorporated into the Dugout Canyon Mine permit area in 2005. In 2007 acreage (487.57 acres) was added to existing Federal Coal Lease U-07064-027821, 240 acres of this added acreage is already included as part of the Dugout permitted area. Acreage was previously added to the permit area in excess of the Federal leased acreage to act as a subsidence buffer zone (207.57 acres) and to accommodate a revised mine plan (40 acres). In addition, State Lease ML-50582-OBA (320 acres, more or less) was issued to Dugout Canyon Mine in 2007. Future surface disturbance of these leases will be permitted as needed to facilitate mining activities.

712 Certification

All maps, plans, and cross sections presented in this chapter have been certified by a qualified, registered professional engineer.

713 Inspection

Impoundments associated with the mining and reclamation operations will be inspected as described in Section 514.300 of this M&RP.

720 ENVIRONMENTAL DESCRIPTION

721 General Requirements

This section presents a description of the pre-mining hydrologic resources within the permit and adjacent areas that may be affected or impacted by the proposed coal mining and reclamation operation.

722 Cross Sections and Maps

722.100 Location and Extent of Subsurface Water

A generalized hydrostratigraphic cross section of the permit and adjacent areas is presented in Figure 7-1 and in Appendix 7-4, Figure 19. A description of baseline groundwater conditions within the permit and adjacent areas, together with appropriate cross sections and maps as well as a discussion of seasonal variations in water levels, is provided in Section 724.100 of this M&RP.

722.200 Location of Surface Water Bodies

A description of baseline surface-water conditions within the permit and adjacent areas, together with appropriate maps and cross sections, is provided in Section 724.200 of this M&RP. A map showing the location of surface-water bodies and groundwater sources for which water rights exist or for which there are pending water rights applications is provided as Plate 7-2. A listing of water rights is presented in Appendix 7-1.

722.300 Locations of Monitoring Stations

Surface water and groundwater monitoring stations from which data have been collected within the permit and adjacent areas of the Dugout Canyon Mine are located as shown on Plate 7-1. Approximate surface elevations of the monitoring stations are also indicated by the topographic contours provided on Plate 7-1.

722.400 Location and Depth of Water Wells

The Gilson water supply well is located approximately 450 feet southwest of the water tanks along the side of the water tank access road. The well depth is 300 feet and intercepts water collecting in the Gilson seam at the location shown on Plate 7-5. Groundwater monitoring wells in the area are located as shown on Plate 7-1. Depths of these wells and other completion details of the monitoring wells are summarized in Table 7-1. Refer to Appendix 7-9 for details pertaining to the Gilson water well.

722.500 Surface Topography

Surface topographic features in the permit and adjacent areas are shown on the base map used for Plate 7-1.

723 Sampling and Analysis

Where possible, all water samples collected for use in this M&RP have been analyzed according to methods in either the "Standard Methods for the Examination of Water and Wastewater" or 40 CFR parts 136 and 434. Where feasible, these same references have been used as the basis for sample collection.

724 Baseline Information

Surface water, groundwater, and climatic resource information is presented in this section to assist in determining the baseline hydrologic conditions which exist in the permit and adjacent areas. This information provides a basis to determine if mining operations can be expected to have a significant impact on the hydrologic balance of the area.

724.100 Groundwater Information

This section presents a discussion of baseline groundwater conditions in the permit and adjacent areas. The location of wells and springs in the mine area are presented on Plates 7-1 and 7-2. The wells in the mine area are all, water monitoring wells except for the Gilson water well. No additional water supply wells have been identified. Water rights for the mine and adjacent areas are addressed in Section 722.200 of this M&RP. All groundwater use (seeps and springs) within the permit and adjacent areas is confined to wildlife and stock watering.

Table 7-2 provides a summary of the period of record and selected additional information regarding groundwater sources that have been monitored within the permit area and the nearby vicinity. These sources include wells, springs, and mine-water inflows from the Soldier Canyon Mine. The geologic source for the springs presented in Table 7-2 was determined by comparing Plates 6-1 and 7-1. These data have been collected from over 100 locations within the permit and adjacent areas beginning as early as 1976 and extending through the present, as indicated in the data base contained in Appendix 7-2.

The data provided in Appendix 7-2 were obtained from multiple sources, including (but not limited to) the Soldier Creek Coal Company M&RP and annual reports, U.S. Geological Survey publications, the Sage Point-Dugout Canyon permit application filed by Eureka Energy Company in 1980, Appendix 7-3 of this M&RP, and various consultant reports. Since not all monitoring parties were responsible to adhere to UDOGM or SMCRA rules, the laboratory parameters varied between reports. However, the data are still considered valid and appropriate for determining baseline conditions within the permit and adjacent areas. It should be noted that much of the manganese data presented in Appendix 7-3 represent total (as opposed to dissolved) concentrations.

Additional baseline and operational data for sampling sites within the SITLA tract addition to the Dugout Mine permit are also available on the Division's Electronic Water Monitoring Database.

A hydrologic evaluation of the area was published by Mayo and Associates (1996). This evaluation, which is presented in Appendix 7-3 of this M&RP was initially used together with published reports of the area and the extensive data base contained in Appendix 7-2, to prepare this description of baseline hydrologic conditions within the permit and adjacent areas. While the Mayo report does not specifically include the SITLA tract area, the geologic and hydrogeologic conditions within the tract are similar enough to the area studied by Mayo to assume the conclusions reached by Mayo would apply to the SITLA tract. An update to the PHC document originally written by Mayo and Associates and included in Appendix 7-3 was prepared by the mine in October 2007 to address additional baseline data collected for the 240 acre expansion in the northeast portion of the permit area. The update also includes the results of surface and ground water monitoring by the mine since 1998. This information is included in Appendix 7-3 and titled "Update to the Probable Hydrologic Consequences of Coal Mining at the Dugout Canyon Mine".

Groundwater Systems

Geologic conditions in the permit and adjacent areas are described in detail in Chapter 6 of this M&RP. Formal aquifer names have not been applied to any groundwater system in the permit and adjacent areas because the geometry, continuity, boundary conditions, and flow paths of the groundwater systems in the area are not fully understood. However, the data do suggest that groundwater systems in each of the bedrock formations are sufficiently different from each other to justify the informal designation of groundwater systems based on bedrock lithology. Thus, the informal designation of Colton, Flagstaff, North Horn, Price River, Blackhawk, Star Point, and Mancos groundwater systems is adopted herein.

Perched Groundwater Systems in the Colton Formation, Flagstaff Limestone, North Horn Formation, Price River Formation, and the Castlegate Sandstone

The nature and occurrence of groundwater systems in the Wasatch Plateau and Book Cliffs coal fields are described in a Geological Society of America Bulletin publication (Mayo et al., 2003). The Dugout Canyon Mine permit and adjacent area is included in the study area for this publication. This publication describes active and inactive groundwater flow systems in stratified mountainous terrains. Mayo et al. describe groundwater systems in the Dugout Canyon Mine area as occurring in one of two fundamental groundwater flow regimes. These include "active" groundwater flow systems, and "inactive" groundwater flow systems. Active zone groundwater flow paths are continuous, and responsive to annual recharge and climatic variability. Active zone groundwater systems support springs discharging at the surface in the area. Inactive zone groundwater systems have extremely limited or no communication with annual recharge. Inactive zone groundwater systems may be partitioned, occur as discrete bodies, and may occur in hydraulically isolated regions that do not have hydraulic communication with each other (Mayo et al, 2003; See also Mayo and Morris, 2000).

In the vicinity of the Dugout Canyon Mine, discharge of groundwater from geologic formations overlying mining areas occurs primarily from localized perched groundwater systems (See

Appendix 7-3 for further information on shallow groundwater systems). Perched groundwater systems in the near-surface bedrock formations overlying the Dugout Canyon Mine (including the region near the permit expansion area) were noted by Waddell et al. (1986). It is noteworthy that Waddell reports perched groundwater systems encountered in some drill holes, while perched groundwater systems were not encountered in some other nearby drill holes (See Figure 19 in Waddell et al., 1986). This condition demonstrates the lack of lateral continuity in the local perched groundwater systems present in the area and also highlights the fact that meaningful potentiometric surface maps cannot be constructed for these isolated perched groundwater systems.

The presence of local perched groundwater systems overlying unsaturated strata and the hydraulic disconnect between the shallow perched groundwaters and the deep Blackhawk Formation groundwater systems encountered during mining operations is fundamentally the result of the heterogeneity of the rock sequence in the region (Mayo et al, 2003). The flow of bedrock groundwater in quantities sufficient to support discharge to springs occurs primarily within permeable sandstone strata. Groundwater flow along fault planes, bedding planes, and through rocks with fracture-enhanced permeability also occurs locally. In the rock sequence overlying the Dugout Canyon Mine area, the permeable sandstone units commonly exist as discontinuous sandstone paleochannels. Annotated photographs showing sandstone fluvial channels in the Colton Formation near Colton, Utah are presented in Figures X and Y. Also shown on Figures X and Y are the fine-grained sediments with lower hydraulic conductivities that encase the more permeable sandstone rocks in the fluvial channels. Because of the depositional environments in which these rocks were formed, the fluvial sandstone paleochannels are commonly encased both vertically and horizontally by low-permeability rocks (shales, mudstones, and claystones; Mayo et al., 2003). Although the permeability of individual sandstone bodies may be of aquifer quality, the overall ability of these rocks to transmit water horizontally over great distances is low because of the discontinuous nature of the sandstones (Mayo et al., 2003). The surrounding low-permeability rocks impede the outward migration of groundwater from permeable strata both vertically and horizontally. The abundant presence of low-permeability strata in the rock sequence, and the discontinuous character of permeable strata prevent the appreciable downward migration of groundwater from the perched systems into deeper horizons (or into the underground mine environment; Mayo et al., 2003). As indicated in Appendix 7-3 and based on drilling data (Appendix 7-4 and Appendix 6-1, Confidential), large portions of the rock sequence overlying mining areas in the Dugout Canyon Mine area do not appear to be fully saturated in the vicinity of the Dugout Canyon Mine.

Unlike the Colton, Flagstaff, North Horn, and Price River formations, which consist largely of low-permeability rocks with interbedded sandstone strata, the Castlegate Sandstone in composed primarily of sandstone rocks. However, for several reasons, large aquifers do not form in the Castlegate Sandstone. The Castlegate Sandstone is not a uniform sand deposit. Rather, interbedded with the lenticular fluvial braided sandstone horizons are repeating sequences of mudstone drapes or depositional bounding surfaces (Mayo et al., 2003). The permeabilities of the mudstone drapes are typically many times lower than that of the surrounding sandstone. Consequently, although portions of the Castlegate Sandstone are sufficiently permeable to facilitate groundwater flow, the interbedded mudstones drapes partition and isolate these sandstone units such that the overall ability of the formation to transmit water both laterally and vertically over significant distances is poor (Mayo et al., 2003). Where Castlegate Sandstone discharge is present, it is most commonly associated with the presence of fracturing or jointing. Additionally, the potential for recharge to the Castlegate Sandstone is low. The pervasiveness of low-permeability strata in the geologic formations overlying the Castlegate prevents appreciable recharge to the formation from vertical leakage from the overlying formations. Additionally, because of the limited surface exposure of the Castlegate Sandstone in the area, the potential for groundwater recharge directly onto the Castlegate is low. As discussed above, the observation that the Castlegate Sandstone does not support many springs in the region and that much of the formation was dry when drilled supports these conclusions (See Appendix 7-4 and Appendix 6-1, Confidential). Because geologic and hydrogeologic conditions in the Castlegate Sandstone in the proposed expansion area are believed to be very similar to those in surrounding areas in the Book Cliffs coal field, it is considered probable that the hydrogeologic behavior of Castlegate Sandstone groundwater systems in the proposed expansion area will be consistent with the Castlegate Sandstone groundwater flow conditions described regionally by Mayo (2003).

It should be noted that although there appear to be large areas of unsaturated low-permeability rock surrounding the perched groundwater systems, saturated low-permeability strata are likely also present locally in the rock sequence. However, the rate of movement of water in the low permeability strata is commonly several orders of magnitude less than that in the permeable sandstone horizons (Mayo et al., 2003; Waddell, 1986). Consequently, groundwater in these horizons likely exists mostly under relatively stagnant conditions and is not of much consequence to the hydrologic balance.

The shallow, perched groundwater systems in the Dugout Canyon Mine area are likely recharged where the up-dip ends of the sandstone beds or fractured bedrock strata are exposed at the land surface in wet areas, or where the beds are directly overlain by water-bearing alluvial or colluvial sediments. Recharge to the sandstones from overlying saturated shallow fractured bedrock may also occur. Recharge to the sandstone strata via direct vertical leakage from overlying, competent, low-permeability strata is probably low (Waddell, 1986).

Discharge rates from shallow, perched groundwater systems overlying mining areas in the Dugout Canyon Mine generally exhibit both seasonal and climatic variability (see Appendix 7-3 and flow information submitted to the Division's online hydrology database). Most springs discharging from perched systems respond rapidly to the annual snowmelt recharge event, followed by a rapid waning of discharge rates later in the year. These conditions are indicative of shallow groundwater systems that are in good hydraulic communication with shallow, active recharge sources (i.e., active zone groundwater systems). These conditions are not commonly observed in springs discharging from large aquifers with large storage volumes (Waddell, 1986).

Groundwater flow directions in the perched groundwater systems are constrained largely by the geometry of the permeable sandstone strata through which the groundwater is conveyed. In the general sense, it may be stated that perched groundwaters flow from up-dip recharge areas to topographically lower discharge areas. However, because the sinuous geometries and subsurface locations of individual three-dimensional sandstone paleochannels (or other fractured or permeable strata) are difficult to delineate in the subsurface, the determination of concise groundwater flow directions within these bodies is problematic.

Discharge from the perched groundwater systems commonly occurs where the down-dip ends of the permeable sandstones or bedrock fractures or bedding planes intersect the land surface (Waddell, 1986; Mayo et al., 2003). In some localities, the presence of bedrock fracturing or jointing within sandstone channels enhances the hydraulic conductivity locally. It is not uncommon for the spring discharge locations from perched groundwater systems to coincide with the occurrence of local bedrock fracturing (Mayo et al., 2003). Where fracturing of the bedrock is present at groundwater discharge locations, spring discharge locations are commonly focused into discrete spring locations rather than as diffuse seepage through porous rock.

Potentiometric Surface Maps

A fundamental assumption underlying the construction of a potentiometric surface contour map is that there is a continuously saturated, interconnected aquifer that is present over a substantial aerial extent. Because there are no identified aerially extensive groundwater regimes in the strata overlying coal mining areas in the Dugout Canyon Mine area (See Appendix 7-3), and the probable lack of connection between the individual small perched groundwater systems, it is not possible or scientifically correct to draw potentiometric surface contour maps for these groundwater systems at a reasonable scale. While potentiometric surface contour maps of individual small, perched groundwater systems could conceivably be created at a local scale, it would be impractical and of limited value to do so. Consequently, potentiometric surface contour maps depicting groundwater conditions cannot be presented here.

Groundwater in the permit and adjacent areas occurs within perched aquifers overlying the coal-bearing Blackhawk Formation as well as within the Blackhawk Formation and the underlying Star Point Sandstone. Hydrogeologic conditions within the permit and adjacent areas are summarized below.

Colton Formation. The Colton Formation outcrops in the northeast portion of the permit and adjacent areas. This formation consists predominantly of fine-grained calcareous sandstone with occasional basal beds of conglomerates and interbeds of mudstone and siltstone. Data presented in Table 7-2 and Appendix 7-2 indicate that six springs issue from the Colton Formation within the permit and adjacent areas.

Waddell et al. (1986) evaluated the discharge of spring G-96 for the period of June to September 1980. At spring G-96 the measured discharge rate declined from 103 to 6.3 gpm during the 4-month period of evaluation. The slope of the hydrograph recession curve (which provides a relative index of the seasonal variability of discharge) was calculated by Waddell et al. (1986) to be 24 days per log cycle for the initial slope following snowmelt (designated as "S1") and greater than 365 days per log cycle for base-flow conditions (designated as "S2"). This suggests that, at this location, the groundwater system has a good hydraulic connection with surface recharge and that most of the annual recharge quickly drains out of the system.

Groundwater issuing from the Colton Formation has a total dissolved solids ("TDS") concentration of 300 to 500 mg/l (as measured by specific conductance and laboratory analyses of TDS). The pH of this water is slightly alkaline (7.5 to 8.1). Collected data suggests TDS concentrations do not significantly vary seasonally. The pH of the water appears to shift toward becoming more alkaline during periods of drought.

Based on one sample collected from G-96, the water is a calcium-magnesium-bicarbonate type (see Figure 7-2 and Appendix 7-2). This solute composition is consistent with the dissolution of calcite and dolomite in the presence of soil-zone carbon dioxide, together with ion exchange. The G-96 data also indicated a dissolved iron concentration of 0.02 mg/l. No total iron or manganese data are available for this spring. Samples obtained and analyzed from springs SC-65 and 260 support the conclusions the water discharging from the Colton Formation is a calcium-magnesium-bicarbonate type.

Flagstaff Formation. The Flagstaff Formation outcrops across much of the northern portion of the permit area. This formation consists of an interbedded sequence of sandstone, mudstone, marlstone, and limestone. Most springs and a major portion of the volume of groundwater discharging from the permit and adjacent areas issue from the Flagstaff Formation. According to Table 7-2 and Appendix 7-2, more than 40 springs issue from the Flagstaff Formation within the permit and adjacent areas.

Groundwater discharge rates for springs issuing from the Flagstaff Formation are greatly influenced by seasonal variations in precipitation and snowmelt, with most discharge corresponding to the melting of the winter snow pack during the spring months. Some springs in the Flagstaff Formation, which have been found to discharge 100 to 300 gpm following the spring snowmelt, decrease to flows of 15 gpm or less by the fall (Appendix 7-2). Many springs issuing from the Flagstaff Formation have been noted to dry up each year.

In an effort to quantify the seasonal variability of discharge rates of springs issuing from the Flagstaff Formation, Waddell et al. (1986) prepared hydrograph recession curves for several springs in the permit and adjacent areas. The hydrograph data summarized in Table 7-3 show an S1 recession average of 69 days and an average S2 recession 246 days. The longer duration of the S1 recession relative to the data collected from G-96 in the Colton Formation indicate that the storage capacity of the Flagstaff Formation is greater than that of the Colton Formation. Nonetheless, the data indicate that most of the annual recharge to the Flagstaff Formation drains out of the system within about two months, while the remainder of the annual recharge drains out prior to the next snowmelt recharge event. This conclusion was verified by isotopic data collected by Mayo and Associates, 1996, Appendix 7-3.

The groundwater regime in the Flagstaff Formation appears to be influenced predominantly by the combined effects of lithology and topographic expression. Because the Flagstaff Formation forms much of the upland plateau of the permit and adjacent areas, this formation is capable of receiving appreciable groundwater recharge from precipitation and snowmelt.

Waddell et al. (1986) concluded that the Flagstaff groundwater system is perched. They indicate that approximately 9 percent of the average annual precipitation recharges the Flagstaff groundwater system and that recharge water entering the Flagstaff Formation moves downward until it encounters low permeability shale or claystone layers in the North Horn Formation, where almost all of the water is forced to flow horizontally to springs. The hydrograph and isotopic data support this conclusion

Data presented in Appendix 7-2 indicate that groundwater issuing from the Flagstaff Formation has a mean TDS concentration of 335 mg/l. This water tends to be slightly alkaline and, similar to conditions encountered in the Colton Formation, is of the calcium-magnesium-bicarbonate type (Figure 7-3). The solute compositions of these groundwaters appears to be dominated by the dissolution of calcite and dolomite in the presence of soil zone carbon dioxide, together with ion exchange.

The data presented in Appendix 7-2 indicate that the dissolved iron concentration of groundwater discharging from springs in the Flagstaff Formation is generally less than 0.1 mg/l. Total iron concentrations of this water are typically about one order of magnitude higher. Total manganese concentrations in Flagstaff groundwater are generally less than 0.03 mg/l. These data do not exhibit seasonal trends.

North Horn Formation. The North Horn Formation outcrops across the center of the permit and adjacent areas but eventually pinching out in the eastern portions of the permit and adjacent areas. This formation consists of interbedded sandstone and calcareous mudstone.

According to Table 7-2 and Appendix 7-2, 27 springs issue from the North Horn Formation within the permit and adjacent areas. Although the number of reported springs is large, the maximum measured discharge from most of these springs is less than 5 gpm and the total maximum measured discharge is small compared to the total maximum measured discharge from the Flagstaff Formation. Given the gradational nature of the contact between the North Horn Formation and the overlying Flagstaff Formation (see Section 624.100), it is possible that some of the reported North Horn Formation springs may represent discharge from the lower part of the Flagstaff Formation.

Hydraulic and chemical conditions vary widely within the North Horn Formation. This variability caused Waddell et al. (1986) to conclude that water discharging from the North Horn Formation is probably recharged by upward leakage from the underlying formations, including the Blackhawk Formation. This conclusion was based on water levels in wells perforated in the Blackhawk Formation and on the solute chemistry of spring SP-10. However, this conclusion is considered to be in error since the Price River Formation and the Castlegate Sandstone, which are situated between the North Horn Formation and the Black Formation, are not saturated in the vicinity of Soldier Creek just downstream from SP-10. Furthermore, Soldier Creek loses water as it flows across the Price River Formation and the Castlegate Sandstone (see Waddell et al., 1986). Hence, the upward flow from the Blackhawk Formation does not appear to be the primary source of recharge to the North Horn Formation.

Sufficient data have been collected from two springs (SP-8 and SP-10) to provide diagnostic information regarding the groundwater system of the North Horn Formation in the permit and adjacent areas. The discharge from SP-8 is hydraulically and chemically similar to groundwater in the Flagstaff groundwater system. The spring exhibits substantial variability in discharge in response both to spring snowmelt events and to drought and wet years (Figure 7-4). Discharge rates as great as 20 gpm have been recorded from this spring during the high-flow season, and discharge rates as low as 1 gpm are not uncommon during late summer. The effects of the drought occurring in the late 1980s and early 1990s are clearly evident in the hydrograph.

Groundwater issuing from SP-8 typically has a mean TDS concentration that varies from 250 to 300 mg/l with a pH of 8.5 to 8.9. This water is of mixed cation-bicarbonate type (Figure 7-5) and is chemically distinct from most groundwater in the Blackhawk Formation.

Although spring SP-10 issues from the North Horn Formation, the spring may be fracture controlled and contain water from a deeper groundwater system. Although fracture systems have not been mapped on the surface in the vicinity of SP-10, the long-term hydrograph of SP-10 (Figure 7-4) is not consistent with hydrographs of "shallow-source" springs issuing from the Flagstaff, North Horn, or Price River groundwater systems, in that the discharge rate of SP-10 shows only limited seasonal variability.

According to Mayo and Associates (1996), the isotopic and solute compositions of SP-10 discharge water are more similar to groundwater encountered in the Blackhawk Formation. Groundwater discharging from SP-10 is of the sodium-bicarbonate type (Figure 7-5), which suggests that ion exchange of calcium and magnesium has occurred for sodium in a zone containing clay minerals or zeolites. This could occur in the Blackhawk Formation since the zeolite analcime has been identified in coal at the Skyline Mine located approximately 35 miles west of the proposed Dugout Canyon Mine (Mayo and Associates, 1994).

Groundwater issuing from SP-10 has an elevated sulfate content (Appendix 7-2 and Figure 7-5). In fact, this spring has been locally referred to as Sulfur Spring due to the odor of hydrogen sulfide gas which lingers in the air. The source of the gas is likely near-surface sulfate reduction caused by bacterial activity (Appendix 7-3). Sulfate reduction is consistent with the measured reducing potential of the water (Appendix 7-3).

According to information presented in Appendix 7-3, water issuing from SP-10 has a meteoric origin but an old age. Furthermore, the data indicate that water issuing from SP-10 is similar to water encountered in Soldier Canyon Mine, suggesting that the water issuing from the spring is mixed with water from the Blackhawk Formation (Appendix 7-3).

The old age of groundwater issuing from SP-10 relative to water from other springs in the North Horn and overlying formations is confirmed by the mean radiocarbon age of the water which has been calculated as 10,000 years (see Appendix 7-3). As a point of comparison, a mean radiocarbon age of 21,500 years has been calculated for a groundwater sample collected from the Blackhawk Formation in the 3rd West pillar area inside Soldier Canyon Mine (see Appendix 7-3).

It is likely that groundwater discharging at SP-10 flows upward from depth along a fracture. The major water-bearing fracture identified in the Soldier Canyon Mine is approximately coincident with the location of SP-10, validating this conclusion (see Appendix 7-3).

Wahler Associates (1982) indicate that monitoring well GW-19-1 (Plate 7-1) was initially completed within the North Horn Formation. However, according to Waddell et al. (1986), the well was initially unperforated and was then perforated on two separate occasions (first opening the well to the North Horn Formation and then later to the underlying Price River Formation, Castlegate Sandstone, and Blackhawk Formation). As a result, water levels have reportedly varied significantly in the well over very short periods of time due to the various conditions within the well. Due to these changing well conditions and multiple-zone perforations, the data cannot be used to ascertain water-level fluctuations in the North Horn Formation. However, given the decrease in water levels which occurred following the second round of well perforations (a decline in head of about 540 feet), it is apparent that the head in the North Horn Formation is several hundred feet greater than the composite head of the underlying formations. This suggests that groundwater in the North Horn Formation is probably not insignificant hydraulic connection with groundwater in the underlying formations.

The data presented in Appendix 7-2 indicate that the dissolved iron concentration of groundwater issuing from the North Horn Formation is generally less than 0.07 mg/l. Total iron concentrations of this water is slightly higher. Total manganese concentrations in North Horn groundwater are generally less than 0.02 mg/l. These data do not exhibit seasonal trends.

Price River Formation. The Price River Formation consists of interbedded mudstone and siltstone with some fine-grained sandstone and carbonaceous mudstone. Within the permit area, no springs have been found issuing from the Price River Formation, suggesting that it is not a significant aquifer. The absence of springs is of great significance, since this formation is situated between the overlying Flagstaff groundwater system and the underlying coal zone (in the Blackhawk Formation). The absence of springs is most likely the result of two factors: 1) clay horizons in overlying formations inhibit vertical recharge from groundwaters in the Flagstaff and North Horn Formations, and 2) the exposed recharge area of the Price River Formation is limited primarily to areas of steep cliff faces.

Wahler Associates (1982) indicate that monitoring well GW-11-2 (Plate 7-1) is completed within the Price River Formation. Data collected from this well (Appendix 7-4) indicate that water levels varied by approximately 8 feet during the period of December 1979 through November 1982, but showed no consistent trend. A measurement collected in September 1995 indicated that the water level was 1.2 feet lower than the last time it was measured nearly 13 years earlier. Hence, although a slight decline in water levels has occurred during the period of record, this decline is not considered significant. Since 1997, when this well became part of the mine's monitoring program, the water level dropped approximately 8 feet until 2005 when it rose about 12 feet. Mining activities do not appear to be the cause of the rise and fall of the water level within the well nor do cycles between wet and dry periods. The cause for these changes are unknown at this time.

Castlegate Sandstone. The Castlegate Sandstone consists of a fine- to medium-grained sandstone that is cemented with clay and calcium carbonate. The outcrops of this sandstone form prominent cliffs in the area.

Data presented in Table 7-2 and Appendix 7-2 indicate that only two springs (SC-80 and SC-81) have been found issuing from the Castlegate Sandstone within the permit and adjacent areas. The flow of these springs was 1 gpm or less in September 1995, with no measurable flow being observed in October 1995. Based on specific conductance measurements collected from these springs, the TDS concentration of water issuing from the Castlegate Sandstone varies from about 360 to 430 mg/l. The water is slightly alkaline, with a pH of 7.7 to 8.0. Subsequent field studies found another spring, 227, that appeared to discharge from the Castlegate Sandstone. However, since this site was added to the water monitoring program, this spring has not had measurable discharge. Therefore, this formation is not considered to be a significant aquifer.

Wahler Associates (1982) indicate that monitoring wells GW-10-2 and GW-24-1 (Plate 7-1) are completed in the Castlegate Sandstone. With the exception of early measurements which were likely influenced by the presence of drilling fluids prior to perforation of the casing (Waddell et al., 1986), data collected from GW-24-1 indicate that water levels varied by 4.5 feet during the period of March 1980 through November 1982 (Appendix 7-4), but no consistent trend was noted. The cap could not be removed from this well for a water-level measurement in September 1995. During the Winter of 1999-2000, Monitoring Well 24-1 became blocked. The water level in the well has been inaccessible since that time and was permanently removed from monitoring after the 4th Quarter of 2004.

Data collected from GW-10-2 indicate that water levels have declined approximately 30 feet during the 27-year period of record following an initial stabilization of drilling fluids after casing perforation (January 1980 through May 2007). The rate of this decline has been gradual.

The potentiometric surface of groundwater flow in the Castlegate Sandstone is to the north-northwest at an average gradient of 0.024 ft/ft based on measurements reported by Wahler Associates (1982) for November 1982. The datum reported for GW-11-2, under the assumption that the Price River Formation is in hydraulic connection with the Castlegate Sandstone was also used to determine the potentiometric gradient.

Groundwater recharge to the Castlegate Sandstone is from precipitation and snowmelt. However, as evidenced by the fact that the surface exposure of the Castlegate within the permit and adjacent areas is generally limited to steep cliffs within minimal horizontal surface area, total recharge is probably low. Recharge to the Castlegate Sandstone is further limited by the lack of significant developed soil resources over the formation to encourage infiltration and the presence of low-permeability shales in the overlying Price River Formation (see Waddell et al., 1981).

Discharge from the Castlegate Sandstone probably occurs mainly as springs along the outcrop and as through-flow to the underlying Blackhawk Formation. As indicated above, spring flow from the unit is limited in flow and in occurrence. Besides the monitoring wells completed in the Castlegate Sandstone, no known wells are completed in the formation.

Blackhawk Formation. The Blackhawk Formation underlies the Castlegate Sandstone and consists of interbedded sandstone, siltstone, shale, and coal. The Rock Canyon and Gilson coal seams, to be mined by Dugout Canyon Mine, are located in the lower portion of the Blackhawk Formation.

Only three springs have been identified as issuing from the Blackhawk Formation (SC-61, SC-62, and G-100 - see Table 7-2). Springs SC-61 and SC-62 issue near a stream channel in a tributary of Dugout Canyon. Limited data collected from these springs (Appendix 7-2) indicate that flows are typically less than 2 gpm, with a TDS concentration of 700 to 800 mg/l. The pH of this water is slightly alkaline (7.5 to 8.0).

Visits to spring G-100 in September and October 1995 indicated that this spring was dry on one visit and seeping at a sufficiently low rate on the second visit that it could not be sampled. Previous attempts by Mayo and Associates (1996) could not locate this spring. A sample collected by Waddell et al. (1986) indicated that water discharging from G-100 has a TDS concentration of approximately 650 mg/l and a pH of 7.2. The water is of the calcium-magnesium-bicarbonate-sulfate type (Figure 7-6). The solute composition of this water is chemically distinct from all other springs in the area. It has an elevated sulfate content relative to overlying groundwater and may be distinguished from Blackhawk Formation groundwater associated with coal seams inside Soldier Canyon Mine by its relatively low sodium and bicarbonate contents (Appendix 7-3 and Figure 7-6). The solute composition of water issuing from G-100 is consistent with the dissolution of calcite and dolomite in the presence of soil zone carbon dioxide and the dissolution of appreciable amounts of gypsum.

Four monitoring wells (GW-5-1, GW-6-1, GW-32-1, and G-58.5) have been completed in the Blackhawk Formation in areas north and northeast of the permit area (see Plate 7-1). As noted in Table 7-1, well GW-5-1 is perforated opposite the Sunnyside and Rock Canyon Coal seams in the Blackhawk Formation. Early water-level measurements in this well show the residual influence of drilling fluids in the hole immediately following casing perforation. Subsequently, in November 1982, Wahler Associates (1982) conducted a slug test in the well by filling it with water to within about 20 feet of land surface. Hence, early water-level measurements in this well are not indicative of hydraulic heads in the formation.

SCM began monitoring well GW-5-1 in June 1987. Between June 1987 and June 1993, water levels declined at a slow and nearly constant rate of about 0.02 ft/day (Figure 7-7). The initial water level in June 1987 was about the same as the water level prior to the slug test in 1982.

By mid-year 1993, development of the Soldier Canyon Mine, within the Sunnyside seam, had expanded to a point immediately adjacent to well GW-5-1. Well monitoring data show a slight rise in water level elevation between June 3, 1993 and August 24, 1993 which corresponded to mine development in the vicinity of the well. This rise in water level can be explained by the redistribution of vertical stress acting on the nearby coal (see Appendix 7-3). Following completion of the 1993 development, a sustained moist area was identified on the floor of the Soldier Canyon Mine No. 5 entry, adjacent to GW-5-1.

Furthermore, subsequent monitoring of the water level in the well indicated that, between August 24, 1993 and November 1, 1995, the average rate of water level decline increased to approximately 0.09 ft/day (an increase of about 4.5 times the previously observed rate). This decline was likely due to dewatering of the Blackhawk Formation in the immediate vicinity of the monitoring well.

Wahler Associates (1982) calculated a transmissivity of 0.009 gpd/ft ($1.2x10^{-3}$ ft^2/day) from the falling-head slug test which they performed in GW-5-1. Sergent, Hauskins & Beckwith (1986) reported transmissivities of $2.3x10^{-3}$ to $6.7x10^{-4}$ cm^2/s ($2.1x10^{-1}$ to $6.2x10^{-2}$ ft^2/day) for slug tests conducted in holes drilled into the Blackhawk Formation from within the Soldier Canyon Mine. Based on monitored thicknesses of 22 feet in GW-5-1 (Table 7-1) and 120.8 feet in each of the in-mine holes (Sergent, Hauskins & Beckwith, 1986), the hydraulic conductivity of the Blackhawk Formation is calculated to vary from $5.5x10^{-5}$ to $1.7x10^{-3}$ ft/day, with a median of $5.1x10^{-4}$ ft/day.

Well GW-6-1 is perforated over a 200-foot long interval which includes the Sunnyside seam (see Table 7-1). Initial water level measurements collected from this well are believed to be associated with residual water remaining from drilling and casing operations and are, therefore, probably not representative of natural conditions. Water levels declined between November 1989 and August 1991 (Figure 7-7). From August 1991 through August 1993, water levels in GW-6-1 remained relatively stable at a depth of approximately 425 feet. Monitoring on June 3, 1994 found the well to be dry and plugged at a depth of approximately 470 feet. All subsequent attempts to monitor this well have found the plugged/dry condition unchanged.

Monitoring well GW-32-1 is perforated in the Blackhawk Formation immediately above the Sunnyside seam (see Table 7-1) in a location which is down dip of Soldier Canyon Mine workings. Water level monitoring information shows a fairly consistent rise in water elevation.

From November 1994 through August 1995, the water level appears to have stabilized at a depth of approximately 291 feet (Figure 7-7). There is no information at this time that would suggest that underground mining activities in the nearby Soldier Canyon Mine are effecting the water levels observed to date.

Monitoring well G-58.5 was completed by Mountain Fuel Supply Company into the Blackhawk Formation in 1979. Waddell et al. (1986) reported a depth-to-water in March 1980 in this well of 502.8 feet. Waddell et al. (1982) reported depths to water of 501.7 to 502.4 feet in April and September 1880. No additional water-level data are available for this well.

Attempts for this M&RP to construct a potentiometric surface for the Blackhawk Formation in the Soldier Canyon area based on data collected from GW-5-1, GW-6-1, and GW-32-1 proved fruitless. The difficulty in preparing this potentiometric surface may have been due to the influence of outcropping in the adjacent Soldier Canyon, the influence of mining in the nearby Soldier Canyon Mine, and/or varying lengths and stratigraphic locations of the perforated sections of the monitoring wells within the discontinuous strata which comprise most of the Blackhawk Formation. However, based on water-level data collected from one of the existing Dugout Canyon portals and from monitoring wells GW-5-1 and G-58.5, Waddell et al. (1986) concluded that the flow of groundwater in the Blackhawk Formation within the permit and adjacent areas is to the north away from the face of the cliffs (i.e., down dip as generally seen in the Castlegate Sandstone). They estimated the hydraulic gradient in the Blackhawk Formation to be 42 feet per mile (0.008 ft/ft). Waddell et al. (1986) indicate that the coal bearing zone to be mined in the Dugout Canyon operations will probably be saturated in most areas and will require dewatering during mining. However, since mining was initiated at the Dugout Mine, saturated coal zones have not been encountered. The majority of the water encountered during mining both the Rock Canyon and Gilson seams has entered the mine through the roof as discharges from isolated sandstone channels within the Blackhawk Formation and from the roof and floor through fractures and minor faults.

Recharge to the Blackhawk Formation is of limited magnitude, due primarily to the limited area of exposure on steep outcrops and the presence of low-permeability units in overlying formations. Data presented in Appendix 7-3 indicate that Blackhawk Formation groundwater which discharges into the Soldier Canyon Mine is of ancient meteoric origin (greater than 20,000 years), thereby supporting the conclusion that the rate of recharge to the formation is minimal. Mayo and Associates (1996) concluded that the old groundwater age and the isotopic compositions of water encountered in the Soldier Canyon Mine are evidence that the groundwaters are not part of actively flowing, shallow groundwater systems. The groundwater ages also demonstrate that the hydraulic connection between these old groundwaters and the overlying active (and younger) groundwater systems in the Flagstaff and North Horn Formations is very limited or does not exist.

The quality of groundwater in the Blackhawk Formation has been evaluated by Mayo and Associates (1996) based on data collected from leakage into the Soldier Canyon Mine (see Appendix 7-3). These data indicate that Blackhawk Formation groundwater has a mean TDS concentration of about 750 mg/l and is of the sodium-bicarbonate type (Figure 7-6). These waters are chemically distinct from groundwater in overlying groundwater systems. The solute compositions of mine groundwaters suggest a complex series of rock-water and gas-water reactions (Mayo and Associates, 1996).

The dissolved iron concentration of groundwater flowing into the Soldier Canyon Mine has historically been less than 0.5 mg/l and is generally less than 0.1 mg/l (see Appendix 7-2). The total iron concentration of this water has historically been less than 2.0 mg/l and generally less than 0.5 mg/l. The total manganese concentration of Blackhawk Formation water (as measured in the Soldier Canyon Mine) has historically been less than 0.5 mg/l and is typically less than 0.1 mg/l (see Appendix 7-2).

Four exploration holes (DUG0104, 0204, 0101, and 0201) were drilled within or immediately adjacent to the Dugout Canyon Mine SITLA Lease area and completed in the Blackhawk Formation. All holes were completed below the Gilson Coal Seam. No water was encountered in any of the exploration holes per personal communication with Mike Stevenson, Project Geologist, Ark Land Company, November 22, 2004.

Exploration Hole Number	Location (approximate)	Year Drilled
DUG0104	T13S, R13E, Section 20, NW1/4SE1/4	2004
DUG0204	T13S, R13E, Section 19, SE1/4NE1/4	2004
DUG0101	T13S, R13E, Section 30, NE1/4NW1/4	2001
DUG0201	T13S, R13E, Section 19, SE1/4SE1/4	2001

Star Point Sandstone. In those locations where the Star Point Sandstone exists within the permit and adjacent areas, it consists of a fine-grained calcareous sandstone with layers of siltstone and mudstone. In keeping with regional practice (see Lines, 1985), the Star Point Sandstone and Blackhawk Formation are considered to be hydraulically connected. However, only one spring (SC-64) has been discovered issuing from the Star Point Sandstone within the permit and adjacent areas. The near absence of springs in this formation suggests that the Star Point does not receive appreciable annual recharge and that it does not support active groundwater systems in the area.

Recharge to the Star Point Sandstone probably occurs via leakage from the overlying Blackhawk Formation. Hence, this water is likely of ancient origin.

Data collected from SC-64 indicated that the discharge of this spring declined from 2 gpm to 0.5 gpm in the period of September 1995 to October 1995 (see Appendix 7-2). The TDS of this water, as estimated from the specific conductance data, is approximately 700 mg/l, with a pH of about 7.5.

Mancos Shale. The Mancos Shale is exposed south of the permit area. This formation is a relatively impermeable marine shale and is not considered to be a regional or local aquifer. Groundwater samples collected from four monitoring wells located approximately 2 miles south of Soldier Canyon Mine have a mean TDS concentration of approximately 10,000 mg/l and is of the sodium-sulfate-chloride type (Appendix 7-3). Chemical compositions are consistent with the dissolution of halite and gypsum as well as cation exchange.

Recharge and Discharge Relations

Recharge within the permit area occurs primarily on the exposed upland outcrops of the Flagstaff Formation and the North Horn Formation. Waddell et al. (1986) estimated that the annual recharge to the Flagstaff Formation is 9 percent of the total annual precipitation. Recharge is probably greatest where surface fractures intersect the topographic highs where the Colton, Flagstaff, and North Horn Formations outcrop. Recharge to the Blackhawk Formation and the Star Point Sandstone probably occurs primarily from vertical movement of water through the overlying formations. The rate of recharge to the Blackhawk Formation and the Star Point Sandstone is very slow, as evidenced by the ancient age of groundwater within those formations (see Appendix 7-3).

Assuming mass-balance and stable hydrologic conditions, recharge will equal discharge over the long term. The relatively young age of groundwater discharging from the Flagstaff and North Horn Formations as compared with the underlying Blackhawk Formation suggests that the stratigraphically-higher water discharges rapidly and is not hydraulically connected with the Blackhawk Formation. Waddell et al. (1986) conclude that the perched nature of the Flagstaff Formation protects it from the influence of dewatering of the coal-bearing zone unless the upper zone is influenced by subsidence.

Waddell et al. (1986) performed seepage studies in Pine Canyon (located immediately north of the permit area) and found that significant increases in the flow of Pine Canyon occur near the contact of the North Horn Formation and the overlying Flagstaff Formation. They concluded that downward percolation from the Flagstaff Formation is impeded by the claystones and mudstones of the North Horn Formation, forcing the water to move laterally and emerge along the outcrop in the canyon bottom.

Expansion Area (240 acres, Section 17, T13S, R13E) - While it is not possible to precisely delineate the recharge areas for individual springs using the existing hydrogeologic data, a determination of the most probable recharge area is possible using existing geologic, hydrogeologic, and topographic information. A discussion of the most probable recharge areas for springs in the expansion area is presented below.

Two springs (260 and 260A) have been identified within the boundaries of the expansion area that has the possibility of being impacted by subsidence. The Division of Water Rights (DWRi) has indicated two other springs are located in the eastern portion of Section 17, T 13 S R 13 E and within the permit expansion area. However, these springs were not found in the original seep and spring survey or subsequent surveys. Dugout has committed to take the water right owners to the DWR mapped locations to verify whether or not these springs do indeed exist.

A few other springs, 261, 262, 262A, 263, 263A, have been identified in the nearby surrounding areas outside the permit area. These springs are outside the area where subsidence would potentially occur and are separated from the underlying coal seams by more than 2,000 feet of cover. Mining impacts to the recharge area of these springs will only occur in a very small portion of the recharge area and will likely be similar to spring 260. Because of this, the impacts to the springs outside the permit and subsidence area have not been considered individually. The potential for impacting these springs is considered negligible.

Spring 260 is part of the mine's water monitoring program and thus has several years of data that can be analyzed. Spring 260A is not part of the water monitoring program. Both springs appear to discharge from the same shallow groundwater system as they are in close proximity to one another and discharge at similar elevations. Therefore, it is assumed that mining induced impacts to these two springs would be similar in nature.

Spring 260 discharges from the east side of the canyon wall near the bottom of the local surface-water drainage. The spring discharges from the Colton Formation at an elevation of about 8600 feet above sea level. Because groundwater must recharge in an area topographically higher than the spring discharge location in order to provide driving hydraulic head, the recharge area for the spring must lie at an elevation greater than 8600 feet. As shown on Plate 7-1 and Figure 2 (Appendix 7-3), areas higher than 8600 feet in elevation that could potentially be recharge areas for spring 260 are present in the region to the southeast of the spring and also in the region to the northwest of the spring. Both of these areas are situated along the crest of the Book Cliffs escarpment and are truncated on both the north and south by incised drainages and escarpments.

Because of the considerable discharge from spring 260, which averaged 20.0 gpm between 2000 and 2007, it seems unlikely that sufficient recharge to support the spring could occur on the small surface area situated on the very steep slopes of the south-facing Book Cliffs escarpment above an elevation of 8600 feet immediately south of the spring area (see Plate 7-1, Figure 2 and Memorandum from Alex Papp in Appendix 7-3). Rather, it seems more likely that the relatively flat and broad high-elevation plateau surfaces above 8600 feet as depicted could provide recharge in sufficient quantities to support the observed discharge at the spring.

The sedimentary rocks in the vicinity of the Dugout Canyon Mine area dip at about 8 degrees to the north-northeast (Appendix 7-3). The strike of the rock formations in the area is approximately coincident with the trend of the Book Cliffs escarpment. Similarly, most minor fracture orientations in the coal seams and in the adjacent rock formations trend in roughly the same direction as the strike of the Book Cliffs escarpment (Appendix 7-3). Assuming a primarily northerly component to the bedrock dip in the area, the high-elevation area situated to the southeast of the spring (see Plate 7-1, Figure 2 and Memorandum from Alex Papp in Appendix 7-3) seems more likely to be the recharge area for spring 260 than the high-elevation area to the northwest. This conclusion is based on the assumption that most of the northwest area would be stratigraphically down-dip of the spring area. The observation that spring 260 emanates from the east side of the canyon seems to support this conclusion. Consequently, the area to the southeast of spring 260 at an elevation above 8600 feet and stratigraphically up-dip of the spring location is considered the most likely recharge area for the spring. While the maximum lateral extent of the recharge area from the spring discharge location is not known, an arbitrary (and likely conservative) estimate of about 1.6 miles.

It is interesting to note that the maximum possible depth of circulation for the groundwater system that supports spring 260 is less than about 350 feet (maximum topographic elevation in the probable recharge area minus the spring discharge elevation). This observation supports the conclusion that spring 260 originates from a shallow, perched groundwater system and not from a large aquifer of regional extent.

It should be noted that although the spring discharges from the east side of the canyon, it is possible that the sandstone channel or fracture network that focuses discharge to the spring is continuous on both the east and west sides of the canyon near spring 260. Consequently, it is possible that the groundwater recharge area could also include portions of the high-elevation region to the northwest of the spring, although this is considered a less likely scenario.

Spring 261 discharges from near the bottom of the canyon a short distance north of the expansion area boundary. As discussed above, the potential for impact to this spring is considered negligible and consequently a delineation of a most probable recharge area for this spring has not been performed. However, it is likely that this spring, as well as other similar nearby springs, recharge by mechanisms similar to that at spring 260. Like spring 260, the springs further north in the unnamed tributary of Cow Canyon (springs 261 and 262) are likely not recharged from infiltration on the steep slopes of the north facing slopes of the Book Cliffs escarpment. Again, similar to spring 260, these springs probably receive recharge from broad upland areas to the east-southeast.

Surface runoff from the majority of the land surface in Section 16 (T13S R13E) drains to the Cow Canyon drainage. Discharges from the localized perched Colton Formation groundwater systems in the vicinity contribute baseflow discharge to streams in the expansion area and sustain discharges in portions of the drainage during the summer and fall months and during wet years. During the spring snowmelt event and in response to torrential precipitation events, streamflow in the drainages are augmented by surface runoff. After the spring runoff season is complete, there is typically not a sufficient contribution of groundwater to the surface water systems and many reaches of the stream drainages in the expansion area are dry. There is no discharge from a regional type aquifer system to the stream drainages in the Cow Canyon drainage area. Consequently, because impacts to the localized perched Colton Formation groundwater systems are not anticipated, detrimental impacts to baseflow in the stream drainages are likewise not anticipated.

Mining Impacts to Subsurface Water Resources

As presented previously, exploration drilling in the SITLA tract has not encountered significant volume of water in the Gilson seam or overlying strata. As discussed in previous paragraphs, the formations that overlie the coal seams do not include extensive units of rock that would form large aquifers. The Blackhawk Formation can discharges water from isolated channel sandstones in the roof of the mine. However, very few springs have been found on the surface in the Dugout Canyon Mine area that discharge from Blackhawk units. Springs that do discharge from the Blackhawk

Formation typically have very low flows. In-mine flows that are encountered as a result of mining have typically discharged from the roof, are initially much less than 100 gpm, and have flow rates that decrease rapidly as mining progresses. The sandstone channels that hold water in the Blackhawk are typically lenticular, have low to moderately low transmissivity rates, of limited areal extent, and contain waters older than 50 years and typically older than a few thousand years. Since the Blackhawk Formation in the Dugout Canyon Mine area, including the SITLA Tract, is very similar throughout, it is unlikely that mining will encounter large volumes of water from isolated perched sandstone channel aquifers as coal is removed from the Gilson seam in the permit area as a whole.

Mining within the SITLA tract has recently encountered fractures and minor faults, a few containing ground water. Water initially discharges from these structures at a significant rate from floor and roof followed by a slow decline in flow rates. It is likely these fractures are draining both isolated perched aquifers located near the roof of the mine but also sandstone channels containing water under potentiometric pressure beneath the mine floor.

The Price River and Castlegate Sandstone formations are also poor aquifers in the mine area as described in the previous sections. Only two springs have been found within the Dugout Mine area, including the SITLA tract, issuing from these formations. These formations do not conduct water readily, do not contain extensive aquifers, and do not appear to be saturated. Subsidence of these formations will not cause significant changes to subsurface water resources since these resources are apparently not present.

Water bearing strata within the North Horn and Flagstaff Formations (the contact between the two formations is indistinguishable in most of the SITLA tract) and the Colton Formation should not be significantly affected. Subsiding these formations may result in locally increased hydraulic conductivity within the strata but water loss to the underlying formations will be minimal, if at all. The fine grained units (siltstones and shales) that perch the aquifers within the North Horn/Flagstaff and Colton Formations should easily seal subsidence induced fractures and limit downward migration of water from the isolated aquifers. Additionally, the Price River Formation consists of interbedded mudstone, siltstone, and fine-grained sandstones. The finer-grained siltstone and mudstones would seal fractures within the formation and inhibit downward movement or loss of water from the North Horn/Flagstaff and Colton aquifers.

724.200 Surface Water Information

Water Quantity

The permit area exists within portions of the Dugout Creek, Soldier Creek, Pace Creek, and Rock Creek watersheds. Major tributaries of Soldier Creek whose watersheds extend into the permit area include Fish Creek and Pine Canyon. Based on observations and flow data obtained during the collection of water-quality samples within the permit and adjacent areas, portions of Dugout, Fish Creek and Pace Creek, are considered perennial within the permit area. Pine Canyon appears to be perennial in its upper reaches near the northern border of the permit area. Prior to 1999, Rock Creek appeared to be perennial in its upper reaches above the Castlegate Sandstone and only intermittent below the formation. Field observations from 2001 thru 2007 have shown the upper reaches to be functioning as intermittent by UDOGM regulations, however the reaches below the formation have functioned as ephemeral. Several tributaries of these streams within the permit and adjacent areas, are ephemeral.

Waddell et al. (1981) estimated that the average flow of Dugout Creek is approximately 7 cubic feet per second (5,100 acre-feet per year) and that up to 70 percent of the streamflow occurs during the period of May through July each year. The seasonal record of a stream gaging station which was installed on Dugout Creek during the period of October 1, 1979 through October 2, 1981 suggest that this estimate of the seasonal variation is correct (see Appendix 7-5). The location of this stream gaging station is in the vicinity of monitoring site DC-1 noted on Plate 7-1.

During the 1980 water year, Waddell et al. (1986) estimated that the total flow of Dugout Creek at station DC-1 (referred by them as station S60) was 1,900 acre-feet. They further estimated that 53 percent of this flow (1,000 acre-feet) was contributed by springs issuing from the Flagstaff Formation, 10 percent (200 acre-feet) was contributed by springs issuing from the Blackhawk and other formations, and 37 percent (700 acre-feet) was contributed as surface runoff.

The average flow of Soldier Creek has been estimated by Waddell et al. (1981) to be approximately 8 cubic feet per second (5,800 acre-feet per year). This flow is expected to vary seasonally in a manner similar to that reported for Dugout Creek (i.e., the majority of the flow occurring during the late spring and early summer months in response to snowmelt runoff).

During the 1980 water year, Waddell et al. (1986) estimated that the total flow of Soldier Creek at station G-5 was 4,200 acre-feet. The source of this runoff was estimated to be as follows:

- 43 percent (1,800 acre-feet) from springs issuing from the Flagstaff Formation;
- 24 percent (1,000 acre-feet) from springs issuing from the Blackhawk and other formations; and
- 33 percent (1,400 acre-feet) as surface runoff.

Hence, the relative contribution of the Flagstaff Formation to streamflow in Soldier Creek is lower than that in Dugout Creek, while the contribution of the Blackhawk and other formations to Dugout Creek is lower than that to Soldier Creek.

Seasonal fluctuations in the discharge of streams in the area are readily apparent in the hydrographs of Solider Creek (Figure 7-8) and Dugout Creek (Figure 7-9). Locations of these stations are noted on Plate 7-1. As indicated, the discharge of local streams is greatest in the late spring and early summer months when influenced predominantly by snowmelt runoff.

Waddell et al. (1986) performed seepage measurements along Pine Canyon and Soldier Creek in the autumns of 1979 and 1980, in an effort to evaluate the effects of bedrock formations on the baseflow of the creeks. The seepage measurements demonstrated significant inflow to Pine Canyon occurs from the Flagstaff Formation near the contact with the underlying North Horn Formation. In Soldier Creek, the investigation found that 1) base flow more than tripled as Soldier Creek crossed the North Horn Formation, 2) base flow decreased about 20 to 30 percent as the creek crossed the Price River Formation and Castlegate Sandstone, and 3) base flow increased 10 to 25 percent as the creek crossed the Blackhawk Formation.

Figure 7-10 presents semilog plots of streamflow in Soldier Creek (station G-5) and Dugout Creek (station DC-1) for the latter portion of 1980, as reported by Waddell et al. (1986). Included in this figure are plots of discharge rates for springs issuing from the Flagstaff Formation and from the underlying Blackhawk Formation, Castlegate Sandstone, and Price River and North Horn Formations (Waddell et al., 1986). At Soldier Creek, the curves are approximately parallel for streamflow and the composite flows issuing from the Flagstaff Formation through August.

Thereafter, the recession curve for the streamflow flattens, while that for the Flagstaff Formation continues to decrease. Based on this condition, Waddell et al. (1986) concluded that the discharge of Soldier Creek is controlled predominantly by seepage from the Flagstaff Formation during the spring and early summer and by seepage from the underlying formations (Blackhawk, Castlegate, Price River, and North Horn) during the late summer and fall.

The data presented in Figure 7-10 indicate that discharge from the Flagstaff Formation dominates the flow of Dugout Creek throughout the year. Seepage from the underlying formations may slightly influence the flow of Dugout Creek during the autumn months, but this influence appears to be minimal. The lack of seepage from the Blackhawk and immediately-overlying formations to Dugout Creek supports the conclusion presented in Section 724.100 that the flow of groundwater within the permit and adjacent areas is to the north-northwest (i.e., away from Dugout Canyon).

Limited flow data is available from monitoring points within Pace Canyon and Rock Canyon Creeks. However, the data included in Appendix 7-7 suggests that flow within Pace Canyon Creek varies seasonally. Data collected at points PC-1A and PC-2 since June 1999, which are included in the Division's water database and in the updated spreadsheets found in Appendix 7-7, supports this determination. Flows in spring/early summer are typically several times greater than in late summer/fall. Also, it is interesting to note that in 2002 and 2003 there have been periods when there is no flow at station PC-2 and flows measured in late summer/fall at PC-1A have been significantly less than in previous years. The drop in flow is undoubtedly related to the prolonged drought the area has been suffering through since 1999. Base flow within this drainage appears to originate from springs discharging from the Price River, Flagstaff/North Horn, and Colton Formations. The majority of the flow appears to originate from springs within the North Horn and Flagstaff Formations. A surface water monitoring point (Fan) has been added on Pace Creek at a location approximately 600 feet upstream from the top of the Pace Canyon Fan facilities disturbed area boundary. Surface flows measured at monitoring point Fan indicate that the stream is intermittent and likely fluctuates in flow volume seasonally.

Rock Canyon Creek base flow in its upper reaches appears to originate from springs discharging from the Northhorn Formation. Flow data from monitoring site RC-1 near the mouth of Rock Canyon indicates the lower sections of Rock Creek generally flow in response to spring runoff and after summer precipitation events. In 2002 and 2003, flow measured at RC-1 occurred only after a significant precipitation event. Again, the lack of flow in this creek is most likely related to the drought conditions that appear to have begun in the area in 1999.

Springs within Cow Canyon were included in the original baseline survey conducted in the mid-1990's and again in the summer of 2007. The field parameters were measured at the springs in Cow Canyon (Plate 7-1) and the results are included in Attachment 1 of the "Probable Hydrologic Consequence Addendum, October 2007, Revised April 2008" in Appendix 7-3. Seasonal field data was collected in 2007 at the junction of two small drainages (323) in the unnamed tributary of Cow Canyon. Monitoring site 323 was inaccessible until mid-May. Three samples of pH, conductivity, temperature and flow were taken between May and August. The flow ranged from 13 to 20.5 gallons per minute, pH ranged from 7.8 to 8.4, conductivity ranged from 591 to 675 and temperature ranged from 11 to 14 degrees centigrade.

Observations were made in 2007 during sampling of the unnamed tributary of Cow Canyon that the surface water in the fork below monitoring site 260 ran intermittently between spring site 260 and spring site 261 (Plate 7-1). This tributary appears to become perennial a short distance above site 261. In 2008, during monitoring activities the perennial nature of the tributary will again be evaluated.

The fork of the unnamed tributary of Cow Canyon which contains monitoring sites 321, 263 and 263A is neither perennial or intermittent. The discharge from the three spring's runs for a short distance and disappears. Flow associated with storm events in this fork has not been observed, however a defined channel does not exist from site 321 to site 263.

No streamflow data are available for ephemeral drainages in the permit and adjacent areas. When it does occur, ephemeral runoff in the area is expected to occur predominantly in the months of April and May in response to snowmelt runoff and in the months of August and September as a result of thunderstorm activity. Snowmelt may result in flow durations of a few weeks, while thunderstorms are expected to result in runoff with a short duration and high intensity.

Several small impoundments have been constructed in the permit and adjacent areas to capture water for stock watering. Those impoundments where water rights applications have been filed are located as shown on Plate 7-2. The impoundments capture water either from an adjacent spring or from snowmelt.

A UPDES permit application has been issued by the Utah Division of Water Quality as indicated in Appendix 7-6. This application applies to discharge from the sedimentation pond. Discharge from this point occurs only infrequently as a result of pond dewatering or after significant precipitation events. The application also applies to discharges from the underground mine workings.

Surface-water quality samples have been periodically collected in the permit and adjacent areas from stations located on Soldier Creek, Dugout Creek, Pine Canyon, Pace Creek, and Rock Canyon Creek (Plate 7-1). Analytical data from these sources are summarized in Appendix 7-7. These data were obtained from multiple sources, including (but not limited to) the Soldier Creek Coal Company M&RP and annual reports, U.S. Geological Survey publications, the Sage Point-Dugout Canyon permit application filed by Eureka Energy Company in 1980, Appendix 7-3 of this M&RP, and various consultant reports. Since not all monitoring parties were responsible to adhere to UDOGM or SMCRA rules, the laboratory parameters varied between reports. However, the data are still considered valid and appropriate for determining baseline conditions within the permit and adjacent areas. It should be noted that most of the manganese data presented in Appendix 7-3 represent total (as opposed to dissolved) concentrations.

In general, TDS concentrations of surface waters in the permit and adjacent areas vary inversely with the discharge rate. These concentrations also tend to increase in the downstream direction (Waddell et al., 1986). Total suspended solids concentrations in the local surface waters tend to vary directly with the flow rate (Waddell et al., 1986).

The data presented in Appendix 7-7 indicate that the dominant ions in surface water during high-flow periods are calcium and bicarbonate, whereas the dominant ions in the low-flow periods are sodium, magnesium, sulfate, and bicarbonate. During high-flow periods, runoff is rapid and most surface waters only interact chemically with the uppermost regions of the soil zone. Thus, they are dominated by calcium and bicarbonate ions. Furthermore, groundwater contributions from the

Flagstaff Formation (where calcium and bicarbonate are the primary ions) dominate the chemical quality of surface water during high-flow periods (see Figure 7-10).

During low-flow periods, groundwater contributes a larger percentage of the flow in the stream (see Figure 7-10). With its higher TDS concentrations and different solute types (particularly in the Blackhawk Formation), the solute composition of the surface water is altered during low-flow periods.

Data presented in Appendix 7-5 indicate that the TDS concentration of water in Dugout Creek at station DC-1 has varied from about 350 to 500 mg/l with a pH of 8.0 to 8.5. Total suspended solids concentrations have varied from 5 to 1,000 mg/l during the period of record.

Dissolved iron concentrations in Dugout Creek at station DC-1 have typically been less than 0.1 mg/l, while total iron concentrations are generally less than 1.0 mg/l. Dissolved manganese concentrations have typically been less than 0.01 mg/l, while total manganese concentrations are normally less than 0.1 mg/l. No seasonal variations in dissolved metals were noted. Total metals concentrations tend to vary directly with total suspended sediment concentrations.

It is important to note, the water chemistry data referenced was collected for Dugout Creek at DC-1 was obtained prior to the start of mine water discharge in 2002. Since mine water has been discharged, the TDS concentration in the water at DC-1 has varied between a minimum of 330 mg/L and maximum of 2160 mg/L and averages about 1000 mg/L. The pH has also varied in that time between a minimum of 7.3 and a maximum of 9.2 but typically is between 7.7 and 8.4. No appreciable increase in the total suspended solids concentration has been noted since the mine began discharging. Dissolved iron concentrations have risen slightly but average 0.11 mg/l. Total iron concentrations have also risen and average 0.74 mg/L. Dissolved manganese concentrations have risen but average 0.05 mg/L while total manganese concentrations average 0.06 mg/L. Additional discussions regarding the mine water discharge and participation in a total dissolved solids reduction project are included in the "Update to the Probable Hydrologic Consequences of Coal Mine at the Dugout Canyon Mine" in Appendix 7-3.

Historic data collected from Soldier Creek (Appendix 7-7) indicate that the total suspended solids concentration generally increases in the downstream direction and has varied from less than 10 to greater than 10,000 mg/l. Dissolved iron concentrations are typically less than 0.1 mg/l at stations G-1 and G-4, and less than 0.2 mg/l at G-5 (see Plate 7-1). The data do not indicate a seasonal variation in the concentration of dissolved iron. Total iron concentrations, which generally vary in accordance with the total suspended solids concentration, are typically less than 10 mg/l at all stations. Total manganese concentrations in Soldier Creek are generally less than 0.01 mg/l at G-1 and less than 0.10 mg/l at G-4 and G-5.

Data collected from Pine Canyon (Appendix 7-7) indicate that the total suspended solids concentration also tends to increase in the downstream direction and has varied from less than 10 to greater than 100 mg/l. Dissolved iron concentrations are typically less than 0.1 mg/l in Pine Canyon, with total iron concentrations typically being less than 1.0 mg/l. The data do not indicate a seasonal variation in the concentration of dissolved iron. However, total iron concentrations tend to vary in accordance with the total suspended solids concentration. Total manganese concentrations in Pine Canyon are generally less than 0.01 mg/l at G-2 and less than 0.03 mg/l at G-3.

Data collected from Pace Creek (Appendix 7-7) indicate dissolved iron concentrations are typically less than 0.1 mg/l, with total iron concentrations typically being less than 1.0 mg/l. The limited data do not indicate a seasonal variation in the concentration of dissolved iron. Total manganese concentrations in Pace Creek are generally less than 0.01 mg/l.

Surface runoff from the majority of the land surface in Sections 16 and 17 (T13S R13E) drains to the Cow Canyon drainage. Discharges from the localized perched Colton Formation groundwater systems in the vicinity contribute baseflow discharge to streams in the expansion area and sustain discharges in portions of the drainage. During the spring snowmelt event and in response to torrential precipitation events, streamflow in the drainages are augmented by surface runoff. Once the spring runoff season is complete many reaches of the stream drainages in the expansion area are dry. There is no discharge from a regional type aquifer system to the stream drainages in the Cow Canyon drainage area. Consequently, because impacts to the localized perched Colton Formation groundwater systems are not anticipated, detrimental impacts to baseflow in the stream drainages are likewise not anticipated.

724.300 Geologic Information

Geologic information related to the permit and adjacent areas is presented in Chapter 6 of this M&RP.

724.400 Climatological Information

Climatological data are summarized in Appendix 4-2 of this M&RP.

724.500 Supplemental Information

All information pertinent to a determination of the probable hydrologic consequences of the proposed Dugout Canyon Mine operation and reclamation are presented in this M&RP.

724.600 Survey of Renewable Resource Lands

The existence and recharge of groundwater systems in the permit and adjacent areas is discussed in Section 724.100 of this M&RP. A discussion of the potential for material damage or diminution of these groundwater systems and their recharge areas due to subsidence is provided in Section 728 of this M&RP.

724.700 Alluvial Valley Floor Requirements

Information regarding the presence or absence of alluvial valley floors in the permit and adjacent areas is presented in Chapter 9 of this M&RP.

725 Baseline Cumulative Impact Area Information

The hydrologic and geologic information required for the Division to develop a Cumulative Hydrologic Impact Assessment is presented in this M&RP under Chapters 6 and 7. Required information not available in these chapters is available from the Utah Divisions of Water Rights and Water Resources and from the U.S. Geological Survey and the U.S. Bureau of Land Management.

726 Modeling

No numerical groundwater or surface water modeling was conducted in support of this M&RP, other than that which has been published by others and referenced herein.

727 Alternative Water Source Information

No surface mining will be conducted in the permit and adjacent areas. Therefore, this section does not apply to the Dugout Canyon Mine.

728 Probable Hydrologic Consequences

This section addresses the probable hydrologic consequences of coal mining and reclamation operations in the mine permit and adjacent areas. Mitigating measures are discussed generally in this section and in detail in Section 730 of the M&RP.

728.100 Potential Impacts to Surface and Groundwater

Potential impacts of coal mining on the quality and quantity of surface and groundwater flow may include:

- Contamination from acid- or toxic-forming materials;
- Increased sediment yield from disturbed areas;
- Increased total dissolved solids concentrations;
- Flooding or stream flow alteration;
- Impacts to groundwater or surface water availability;
- Hydrocarbon contamination from above ground storage tanks or from the use of hydrocarbons in the permit area;
- Contamination of surface and groundwater from road salting; and
- Contamination of surface water from coal spillage due to hauling operations.

These potential impacts are addressed in the following sections of this M&RP.

728.200 Baseline Hydrologic and Geologic Information

Baseline geologic information is presented in Chapter 6 of this M&RP. Baseline hydrologic information is presented in Sections 724.100 and 724.200 of this M&RP.

728.300 PHC Determination

Potential Impacts to the Hydrologic Balance. Potential impacts of the Dugout Canyon Mine on the hydrologic balance of the permit and adjacent areas are addressed in the following subsections of this M&RP.

Acid- or Toxic- Forming Materials. Information on acid-and toxic-forming materials is presented in Chapter 6. These data show that no acid- or toxic-forming materials are present at the Dugout Canyon Mine. Thus, no significant potential exists for the contamination of surface and groundwater in the permit and adjacent areas by acid- or toxic-forming materials.

Sediment Yield. The potential impact of mining and reclamation on sediment yield is an increase in sediment in the surface waters downstream from disturbed areas. Sediment-control measures (such as sedimentation ponds, diversions, etc.) will be installed to minimize this impact. These facilities will be regularly inspected (see Section 514) and maintained to ensure that they remain in proper operating condition.

Sediment yields may increase locally due to subsidence. Subsidence cracks which intersect stream channels with steep gradients could, for a short period of time, cause an increase in the sediment yield of the stream. However, this sediment increase would cause the crack to quickly fill, recreating pre-subsidence stream channel conditions. Thus, the potential impact to sediment yield from subsidence in the permit area would be minor and of short duration.

Various sediment-control measures will be implemented during reclamation as the vegetation becomes established. As discussed in Section 542.200 of this M&RP, these measures will include installation of silt fences and straw-bale dikes in appropriate locations to minimize potential contributions of sediment to Dugout Creek and Pace Creek. These measures will reduce the amount of erosion from the reclaimed areas, thereby precluding adverse impacts to the environment.

Acidity, Total Suspended Solids, and Total Dissolved Solids. Probable impacts of mining and reclamation operations on the acidity and total suspended solids concentrations of surface and groundwater in the permit and adjacent areas were addressed previously in this section.

Data presented in Appendix 7-2 and summarized in Section 724.100 of this M&RP indicate that the average TDS concentration of water in the Blackhawk Formation (as measured in inflow to the nearby Soldier Canyon Mine) is approximately 750 mg/l and is of the sodium-bicarbonate type. As noted in Section 724.200, the TDS concentration of water in Dugout Creek ranges from 350 to 500 mg/l without mine discharge. The TDS concentration in Pace Creek ranges between 525 and 840 mg/l with an average TDS of about 620 mg/l. The dominant ions in these waters are calcium, magnesium and bicarbonate during high-flow periods, whereas the dominant ions during low-flow periods are sodium, magnesium, sulfate, and bicarbonate.

During periods of low streamflow, the dominant ions in the Blackhawk Formation water, Pace Creek and Dugout Creek should be similar. However, during periods of high streamflow, the dominant cation will be sodium in the Blackhawk water, magnesium in the Pace Creek water, and calcium in Dugout Creek. It should be noted that Dugout Canyon Mine uses powdered limestone or dolomite (i.e., calcium-magnesium-carbonate) for rock dust. It is not anticipated that gypsum rock dust (calcium-sulfate) will be used in the mine. Hence, dissolution of rock dust by water in the mine should not influence the chemical type of water in Dugout Creek or Pace Creek if mine water is discharged to the creek.

Typical iron and manganese concentrations in the Blackhawk Formation, Pace Creek and Dugout Creek (as summarized in previous sections) are:

	Blackhawk Formation	Dugout Creek	Pace Creek
Dissolved iron	<0.1 mg/l	<0.01 mg/l	<0.1 mg/l
Total iron	<0.5 mg/l	<1.0 mg/l	<1.0 mg/l
Dissolved manganese	--	<0.01 mg/l	–
Total manganese	<0.1 mg/l	<0.1 mg/l	<0.01 mg/l

As discussed previously in Section 724.200 discharge of mine water has increased the TDS, total and dissolved iron and dissolved manganese concentration is Dugout Creek below the mine site. Not enough data is yet available regarding the changes to the chemistry of Pace Creek water as a result of discharging mine water. However, the impacts are anticipated to be similar to those observed at Dugout Creek. The TDS concentration in Dugout Creek averages about 1000 mg/L since the mine started discharging. Dissolved and total iron average 0.11 mg/L and 0.74 mg/L respectively. Dissolved and total manganese average 0.05 mg/L and 0.06 mg/l respectively.

Dugout Creek and Pace Creek, as part of the lower Price River basin, is classified according to Section R317-2-13 of the Utah Administrative Code (Standards of Quality for Waters of the State) as a class 2B (secondary contact recreation use), 3C (nongame fish and other aquatic life use), and 4 (agricultural use) water. No TDS standards exist for class 2B and 3C water. The TDS standard for class 4 water is 1,200 mg/l.

It should also be noted that the dissolved iron standard for class 3C water is 1.0 mg/l. No dissolved iron standard exists for class 2B or 4 waters. The data presented above indicate that average discharge water from the mine does not exceed the dissolved iron standard of Dugout Creek or Pace Creek. No standards exist in the R317 regulations for total iron, dissolved manganese, or total manganese. The quality of the water discharged from the mine normally meets the limits set forth in its UPDES permit. Excursions from those limits occur when an upset condition exists within the mine. The upsets are typically related to power outages that allow the mine sections to flood followed by large volumes of water discharging from the mine.

One notable excursion from the UPDES limits occurred when mining in the Gilson seam on the east side of the Right Fork of Dugout Creek resulted in the operator draining the flooded old Knight Ideal Mine working in August 2002 and again in May 2003 to prevent catastrophic flooding of the current Dugout Canyon Mine operations. The old workings contained water with total iron in excess of 1 mg/l and this water was discharged to Dugout Creek at a rate that at times reached 1117 gpm. As a result of draining the old workings, the water discharged to Dugout Creek did have a total iron concentration in excess of the UPDES permit limit of 1 mg/l for a short period of time. It appears that water will be continuously drained from the Knight Ideal Mine for the foreseeable future to maintain safe underground working conditions but at a discharge rate expected to be much less than 100 gpm.

No hydrologic impacts have been noted at the adjacent Soldier Canyon Mine nor at the Dugout Canyon Mine due to subsidence. Although tension cracks may locally divert water into deeper formations, resulting in increased leaching of the formation and increased TDS concentrations, the potential of this occurring is considered minimal. This conclusion is based on experience at both the Soldier Canyon and Dugout Canyon Mine and on the fact that the shale content of the North Horn Formation, the Price River Formation, and the Blackhawk Formation should cause these subsidence cracks to heal quickly where they are saturated by groundwater flow. Thus, potential impacts on TDS concentrations would be minor and not of significant concern. To date (October 2007), mining and subsidence within the Dugout permit area has not resulted in the loss of surface flows in the Dugout Creek drainage or impacts to ground water discharge rates at the monitored seeps and springs.

Flooding or Streamflow Alteration. Runoff from all disturbed areas will flow through a sedimentation pond or other sediment-control device prior to discharge to Dugout Creek or Pace Creek. Three factors indicate that these sediment-control devices will minimize or preclude flooding impacts to downstream areas as a result of mining operations:

1. The sedimentation pond and sediment traps have been designed and will be constructed to be geotechnically stable. Thus, the potential is minimized for breaches of the sedimentation pond to occur that could cause downstream flooding.
2. The flow routing that occurs through the sedimentation pond and other sediment-control devices reduces peak flows from the disturbed areas. This precludes flooding impacts to downstream areas.
3. By retaining sediment on site in the sediment-control devices, the bottom elevations of Dugout Creek and Pace Creek downstream from the disturbed area will not be artificially raised. Thus, the hydraulic capacity of the stream channel will not be altered.

The volume of streamflow has increased in Dugout Creek and Pace Creek as water is discharged from the mine to the creeks. Potential impacts to the creek channels could include the displacement of fines on the channel bottom, and minor widening of the channel. However, the degree of widening will likely be minimized by the increased vigor and quantity of vegetation which will be sustained along the stream channel by the increased availability of water. In particular, it is anticipated that the deciduous streambank vegetative community (see Section 321.100) will increase in density and vigor as a result of mine-water discharges. This effect will occur for the distance downstream that surface flows can be sustained above channel transmission losses.

Care will be taken during discharge of this water to avoid flooding of downstream areas. Once mining ceases, the mine will be sealed and no discharges will occur. The streamflow in Dugout Creek and Pace Creek will then return to pre-mining discharge levels.

Following reclamation, stream channels which have been altered by mining operations will be returned to a stable state (see Section 762.100). The reclamation channels have been designed to safely pass the peak flow resulting from the 10-year, 6-hour or the 100-year, 6-hour precipitation event as appropriate for the channel and in accordance with the R645 regulations (Appendix 7-11). Thus, flooding in the reclaimed areas will be minimized. Interim sediment-control measures and maintenance of the reclaimed areas during the post-mining period will preclude deposition of significant amounts of sediment in downstream channels following reclamation, thus maintaining the hydraulic capacity of the channels and precluding adverse, off-site flooding impacts.

Subsidence tension cracks that appear on the surface will increase the secondary porosity of the formations overlying the Dugout Canyon Mine. During the period prior to healing of these cracks, this increased percolation will decrease runoff during the high-flow season (when the water would have rapidly entered the stream channel rather than flowing into the groundwater system). During low-flow periods, the result of this increased percolation will be an increase in the base flow of the stream. Hence, the net result will be a decrease in the flooding potential of the affected stream.

Subsidence under the main fork of Dugout Creek will occur in areas where overburden ranges from 600 to 1200 feet thick. The area of the least amount of overburden, approximately 600 feet, occurs in the southern half of Section 14, Township 13 South Range 12 East. Additionally, subsidence on the right hand fork of Dugout Creek may occur where overburden ranges from 500 feet to 2000 feet. The least amount of overburden on this fork of the creek occurs in the northeast quarter of Section 23, Township 13 South, Range 12 East. In both areas where the least amount of overburden occurs, the stream channels are lined with several feet of soils and fine grained sediments. Also, the upper Blackhawk Formation, which consists of interbedded shale, mudstone, siltstone, and sandstone, is exposed at the surface in a portion of these low overburden areas. The Castlegate Sandstone is present in the two low overburden areas but is rarely exposed in the channel floors.

To date, a short segment of the right hand fork has been undermined and subsided as the Gil 2 panel was mined in April 2005. The subsided area is located in the SW1/4 of Section 13 and the NW1/4 of Section 24, Township 13 South, Range 12 East. Monitoring of surface flows at DC-3 indicates no decrease in surface water flows in this channel.

The current mine plans include mining gate roads and entries under several sections of Pace Creek. However only limited subsidence will occur under Pace Creek in portions of Section 20, Township 13 South, Range 13 East where a longwall panel, Gil 5, has been mined (Plate 5-7). The panel was mined between September 2006 and May 2007. To date, no impacts due to mining have been observed in the channel for in-stream flow. The stream channel in this area is lined with several feet of soils and fine grained sediments. Surface cracks if they occurred in the sediments due to subsidence, likely quickly filled with fine grained material and restricted the water from entering the fractures. The upper units of the Price River Formation which consists of sandstone, and the lower units of the North Horn Formation which consist of interbedded sandstone and mudstone, underlie the stream in this area. The overburden above the Gilson seam where subsidence has occurred under Pace Creek is at least 1000 feet thick or more. As mining progresses to the east, the overburden becomes thicker due to changes in topographic elevation and the dip of the coal beds. Current mine plans do not include subsiding any perennial portion of Rock Canyon Creek.

A subsidence study performed at Burnout Canyon, a perennial stream drainage subsided by long wall mining at the Canyon Fuel Company, LLC Skyline Mines, suggests that thick fine grained soil mantles overlying bedrock appear to prevent noticeable stream flow losses to the bedrock (Rocky Mountain Research Station, 1998). Though the climatic regime and regional stratigraphy are not identical to the Burnout Canyon area, enough similarities exists to suggest that the bedrock, soils, and channel floors should react to subsidence in a similar fashion. As discussed in preceding sections, fractures related to subsidence within the fine grained sediments of the upper Blackhawk Formation in the Soldier Canyon Mine area tend to heal relatively rapidly. Also, fractures within the channel floor would be expected to fill quickly with fine grained sediments and become relatively impermeable. Therefore, the loss of stream flow to the mine is highly unlikely and losses to bedrock beneath the channel, or in the limited areas where bedrock is exposed in the channel floor, would be short lived.

Groundwater and Surface Water Availability. Potential impacts to the availability of surface and groundwater from the Dugout Canyon Mine operations include both decreased and increased stream flows and spring discharges caused by mine-related subsidence, bedrock fracturing, and aquifer dewatering. These potential impacts are discussed below.

Potential for Decreased Spring and Stream Flows

To date, limited surface subsidence has been identified as a result of coal mining in the Dugout Canyon Mine. However, bedrock fracturing routinely occurs in the rock units overlying the mined coal seams. Given the limited number of springs and limited groundwater resources of the Blackhawk, Castlegate, and Price River Formations in the permit and adjacent areas, subsidence or fracturing would affect the hydrologic balance in the area only if zones of increased vertical hydraulic conductivity were created which extended through the Price River Formation into the North Horn and Flagstaff Formations.

Several lines of evidence suggest that mining-related subsidence and bedrock fracturing have not resulted in decreased stream flows or groundwater discharge in the vicinity of the Dugout Canyon Mine. While to-date no monitored discharging springs have been undermined at Dugout Creek, several springs in the upper tributaries of Fish Creek were undermined in 2001 - 2003. These springs are numbered SC-15, SC-16, SC-17, and SC-18. These springs were originally identified as flowing springs in the 1980s. Subsequent visits to these sites in the fall of 1995 and summer of 2006 did not observe flows from these spring locations. It has been speculated these springs were originally identified after a significant wet cycle and the spring locations appear to represent re-emergence of flow from spring SC-14.

Ephemeral portions of Fish Creek and Dugout Creek drainages have been subsided and no significant adverse effects to those drainages have been noted. Active groundwater systems in the Flagstaff and North Horn Formations are separated from the Blackhawk groundwater system by the Price River Formation. As discussed in Section 724.100, this formation contains very few springs and is not considered to be a major groundwater resource. Past mining in the Soldier Canyon Mine has not increased the rate of spring discharge from the Price River Formation, indicating that groundwater is not being diverted into this formation. The absence of increased saturation in the Price River Formation due to coal mining indicates that vertical zones of artificially-increased hydraulic conductivity do not extend into the Price River Formation and from thence into the active groundwater systems of the North Horn and Flagstaff Formations.

Data presented in Appendix 7-3 and summarized in Section 724.100 indicate that the Blackhawk groundwater system, in the vicinity of mined coal seams, contains ancient groundwater which is compartmentalized both vertically and horizontally. Coal mining locally dewaters overlying rock layers in the Blackhawk Formation but does not appear to draw additional recharge from overlying or underlying groundwater systems (see Appendix 7-3).

The strong vertical gradients in Blackhawk Formation rock layers underlying actively mined coal seams in the Soldier Canyon Mine and the absence of significant discharge into the mine from these layers indicates that mining does not draw groundwater from the underling Mancos Shale. Additionally, the distinctive solute composition of Mancos Shale groundwater has not been observed inside the Soldier Canyon Mine (see Appendix 7-3).

Ground water has discharged to the Dugout Canyon Mine through fractures in the floor of the mine. Initial water chemistry of the mine water does not indicate this water is sourced from the underlying Mancos Shale. It is much more likely the fractures are draining isolated aquifers beneath the coal but hydaulically connected by the fractures. Flows from these fractures typically have steadily decreased after initially being encountered during mining.

From the above discussion, it appears that the Soldier Canyon Mine has not decreased groundwater discharge in overlying or underlying groundwater systems. Additionally, monitoring in the Dugout Canyon Mine area indicates mining within that area has not decreased groundwater discharge in overlying or underlying ground water systems.

Potential for Increased Stream Flows

Sufficient water has been encountered in the Dugout Canyon Mine workings requiring the mine to discharge water to Dugout Creek and Pace Creek. Originally, to estimate the potential quantity of inflow to the Dugout Canyon Mine, an investigation of Lines (1985) was reviewed. In this investigation, Lines (1985) evaluated groundwater conditions in the Trail Mountain Area, located in the hydrogeologically-similar Wasatch Plateau approximately 23 miles southwest of the proposed Dugout Canyon Mine permit area. Using a finite-difference model, Lines (1985) evaluated potential inflows into a hypothetical coal mine in the Blackhawk Formation. Initially, this model was used by the mine to predict the potential mine inflows. The results of this model indicated the flows would equal about 214 gpm. Mayo and Associates, while preparing the PHC for this mine, predicted a potential inflow of about 800 gpm of inflow. This calculation was based on the ground water inflow rates observed in the Soldier Canyon Mine and related to the rate of coal production. Mayo's calculations led him to believe that if approximately one million tons of coal are mine per year in the Dugout Mine, then the mine could expect an inflow rate of approximately 800 gpm. Dugout Mine typically mines three to four million tons of coal per year. Ground water production from the Dugout Mine has ranged from 0 gpm during the first four years of production to as high as 2800 gpm under emergency conditions. The average current rate of ground water production from the mine appears to be about 1900 gpm. This rate appears to be closer to that which Mayo predicted. It is anticipated that as mining continues down dip for the next several years, mine inflow rates may increase. This is based on the assumption that channel sandstones in the roof and floor will contain proportionately larger volumes of water as the distance from outcrop is increased. Also, as the panels are mined in the area between Rock and Pace Canyons and updip of current workings, it is likely the volume of ground water flowing into the mine will decrease.

Potential Hydrocarbon Contamination. Diesel fuel, oils, greases, and other hydrocarbon products will be stored and used at the site for a variety of purposes. Diesel and oil stored in above-ground tanks at the mine surface facilities may spill onto the ground during filling of the storage tank, leakage of the storage tank, or filling of vehicle tanks. Similarly, greases and other oils may be spilled during use in surface and underground operations.

The probable future extent of the contamination caused by diesel and oil spillage is expected to be small for three reasons. First, because the tanks will be located above ground, leakage from the tanks will be readily detected and repaired. Second, spillage during filling of the storage or vehicle tanks will be minimized to avoid loss of an economically valuable product.

Finally, the Spill Prevention Control and Countermeasure Plan developed for the site will provide inspection, training, and operation measures to minimize the extent of contamination resulting from the use of hydrocarbons at the site. This plan is not required to be submitted. However, a copy will be maintained at the mine site as required by the Utah Division of Water Quality.

Road Salting. When necessary for safety purposes, salt and/or ice melting compounds will be used on paved road areas. The paved road areas report to the sediment pond for treatment.

Coal Haulage. Coal will be hauled over the county road from the mine portal area to the Soldier Creek Road and thence to its ultimate destination. In the event of an accident which causes coal to spill from the trucks, residual coal following cleanup of the spill may wash into local streams during a runoff event. Possible impacts to the surface water are increased total suspended solids concentrations and turbidity from the fine coal particulates. The probability of a spill occurring in an area sufficiently close to a stream channel to introduce coal to the stream bed is considered small.

In addition to spills, wind may carry coal dust or small pieces of coal from the open top of the coal trucks into creeks near the roads. The impact from fugitive coal dust is considered to be insignificant due to the small amounts lost during haulage in the permit and adjacent areas.

Water Replacement. The water consumed in operating underground equipment, dust suppression, and evaporation is obtained from ground water sources. These underground water sources are not connected to the surface waters in the area. Research has been performed by the mine to verify that water currently entering the mine is not coming from the surface or depleting surface waters. Continued monitoring by the mine of the surface waters and seeps and springs flows in the permit and adjacent areas have shown no discernable impacts due to mining activities. It is the operator's position that the water consumed in operating Dugout Canyon Mine is not depleting surface water sources. In fact, there is an overall net gain to local river systems discharging to the Colorado River as a result of the mine's discharge.

The Permittee will replace the water supply of any land owner if such a water supply proves to be contaminated, diminished or interrupted as a result of the mining operations. First, a determination will be made by the Division in accordance with R645 - 301 - 731.800 as to whether or not material damage has occurred. Then, in accordance with Regulation R645-301-525.510, Dugout Canyon Mine will correct any material damage resulting from subsidence caused to surface lands (which includes water rights), to the extent technologically and economically feasible, by restoring the land to a condition capable of maintaining the value and reasonably foreseeable uses that it was capable of supporting before subsidence damage. Negotiations will be held with the water right holders to determine the best plan of action and implementation of water replacement.

729 Cumulative Hydrologic Impact Assessment (CHIA)

A Cumulative Hydrologic Impact Assessment to include the permit and adjacent areas is to be prepared by the Division.

730 OPERATION PLAN

731 General Requirements

This permit application includes an operation plan which addresses the following:

- Groundwater and Surface Water Protection and Monitoring Plan;
- Design Criteria and Plans;
- Performance Standards; and
- Reclamation Plan.

731.100 Hydrologic-Balance Protection

Groundwater Protection. To protect the hydrologic balance, coal mining and reclamation operations will be conducted to handle earth materials and runoff in a manner that minimizes acidic, toxic, or other harmful infiltration to the groundwater system. Additionally, the permittee will manage excavations and disturbances to prevent or control discharges of pollutants to the groundwater.

Water will be discharged from the mine in a controlled manner, in accordance with an approved UPDES permit, via a pipeline from the mine to the creek. The Dugout Creek discharge point is located at the upstream inlet to the Dugout Canyon culvert, UC-6. Riprap has been placed at the outlet of the pipe to prevent erosion. The Pace Creek discharge point is located southeast of the fan shaft. The pipe discharges directly to the creek. The pipe outlet is riprapped to prevent erosion. Any erosion that occurs at the points of discharge will be repaired as soon as practical.

Surface Water Protection. To protect the hydrologic balance, coal mining and reclamation operations will be conducted to handle earth materials and runoff in a manner that minimizes acidic or toxic drainage, prevents, to the extent possible, additional contributions of suspended solids to streamflow outside the permit area, and otherwise prevents water pollution. Additionally, the mine will maintain adequate runoff- and sediment-control facilities to protect local surface waters.

During initial construction to develop the surface facilities, and prior to installation of all runoff- and sediment-control facilities as outlined in Section 732 of this M&RP, silt fences will be installed along the top bank of Dugout Creek and its eastern tributary in areas prior to disturbance. These silt fences will be installed in accordance with Figure 5-4. If required for control of local erosion, straw-bale dikes may also be installed at the site during initial construction. These dikes will also be installed in accordance with Figure 5-4. The silt fences and straw-bale dikes will be periodically inspected, and accumulated sediment will be removed as needed to maintain functionality. Once the sedimentation pond, ditches, and culverts are installed, the silt fences and straw-bale dikes may be removed.

During initial construction to develop the surface facilities in Pace Canyon, and prior to installation of all runoff- and sediment-control facilities as outlined in Appendix 7-12 of this M&RP, silt fences will be installed along the disturbed area boundary and along the tributary drainages upstream and downstream of the surface facilities. These silt fences will be installed in accordance with Figure 5-4. If required for control of local erosion, straw-bale dikes may also be installed at the site during initial construction. These dikes will also be installed in accordance with Figure 5-4. The silt fences and straw-bale dikes will be periodically inspected, and accumulated sediment will be removed as needed to maintain functionality. Once the sedimentation trap, ditches, and culverts are installed, the interim silt fences and straw-bale dikes will be removed.

Once the runoff- and sediment-control facilities outlined in Section 732 have been installed, these structures will prevent additional contributions of suspended solids to streamflow outside the permit area. A description of sediment control following reclamation is presented in Sections 540 and 760 of this M&RP.

731.200 Water Monitoring

Groundwater Monitoring. Groundwater monitoring to be conducted in the permit and adjacent areas will consist of data collection from monitoring wells, springs, and mine-water discharges. Locations of wells and springs to be monitored are noted on Plate 7-1. The groundwater monitoring plans presented herein were developed based on information presented in the PHC determination, the baseline hydrologic data, the geologic data presented in Chapter 6 of this M&RP, and operational changes at the mine.

Monitoring wells included in the groundwater monitoring program are GW-10-2, GW-11-2, and GW-24-1. The remaining monitoring wells in the general vicinity are either too remote from the permit area to be indicative of impacts occurring from the Dugout Canyon operations (i.e., GW-5-1, GW-6-1, GW-32-1, and G-58.5) or are completed across multiple aquifers (i.e., GW-19-1), making data interpretation difficult.

The monitoring wells are all completed in the Price River Formation or the underlying Castlegate Sandstone. Because the Castlegate Sandstone immediately overlies the Blackhawk Formation, data collected from these wells allow hydrologic impacts of mining to be evaluated in groundwater systems which overlie the mine workings but underlie the Flagstaff and North Horn groundwater systems.

Water-level measurements will be collected on a quarterly basis when the wells are accessible. Given the ages of the wells and the probable deterioration of the casing materials, no attempts will be made to collect water-quality data from the monitoring wells.

The springs to be included in the operational and post-mining groundwater monitoring program are:

Spring	Formation
SC-65	Colton
SP-20	Flagstaff
SC-14	North Horn
SC-100	Flagstaff (at North Horn FM. Contact)
SC-116	North Horn
200	North Horn
203	North Horn
227	Castlegate Sandstone
259	North Horn
260	Colton
259A	Colton
321	Colton
322	Colton - Operational quarterly flow measurements only
324	Colton - Monitoring begins 3rd Quarter 2008

Locations of these springs are noted on Plate 7-1.

With the addition of 240 acres associated with Federal Coal Lease U-07064-027821, groundwater monitoring location 324 associated with existing water rights identified by an authorized representative of the Conover Trust was added in the third quarter of 2008.

The purpose of monitoring the above-listed springs will be to assess potential impacts to groundwater systems overlying the Blackhawk Formation due to subsidence and mine dewatering. Springs have been selected for monitoring in the Colton, Flagstaff, North Horn, and Castlegate Sandstone Formations. These springs are reasonably accessible and, based on the historical data, are representative of conditions within their respective formations.

It should be noted that reliable data have been difficult to collect from the limited number of springs issuing from the Blackhawk Formation within the permit and adjacent areas. As a result, no springs issuing from this formation have been included in the long-term monitoring program.

The ground water monitoring and sampling protocols to be implemented are described in Table 7-4. These protocols are based on the probable hydrologic consequences (PHC) of mining as presented in Section 728 and Appendix 7-3 of this M&RP and the requirements put forth in the Division's regulations. Table 7-4 is the same as that presented in Coal Regulatory Program Directive Tech-004, with the exception that total hardness and total alkalinity are not included. Total hardness, which is primarily of concern in water supplies being developed for domestic use, was not added to the list because summer-home development of the permit area is not an identified post-mining land use. Total alkalinity was not added to the list because the baseline data indicate that acid-generating materials, which may affect the alkalinity of the water, are not present within the permit and adjacent areas.

The protocols set forth in Table 7-4 will be followed during years of normal precipitation as defined in the PHC. Wet or dry (not normal) years for the mine area are defined based on the Natural Resources Conservation Services snow-pack measurements as of March 1 for the Price River-San Rafael River Basin. A wet year occurs when the snow pack water content is greater than 110% of normal and a dry year when the snow pack is less than 70% of normal. After the permit is issued, the following monitoring protocol will be implemented for the first wet or dry year occurrence:

1. Weekly measurements of flow during the first wet year and the first dry year following permit issuance will be obtained. The purpose of these measurements will be to prepare base-flow hydrographs of the monitored springs. Flow measurements during the first wet year and the first dry year will be collected weekly between April 1 and August 31 as conditions permit.

2. Water samples will be obtained during high- and low-flow season in conjunction with the quarterly sampling, if applicable. The samples will be analyzed in accordance with Table 7-4 with the addition of tritium analysis.

In addition to the above regular monitoring, one water sample will be collected at each spring sampling point during low flow period every fifth year, during the year preceding re-permitting, to be analyzed for baseline parameters (Table 7-4).

Groundwater was discovered discharging from old Gilson coal seam workings located on the east side of Dugout Canyon during construction of the Dugout Canyon Mine in September 1998. Prior to construction, this water seeped unnoticed through unconsolidated fill and into Dugout Creek. The water discharging from these old workings will be monitored on a quarterly basis for the parameters listed in Table 7-4 beginning in the fourth quarter of 1998. The monitoring point is labeled MD-1 on Plate 7-1.

Data will be collected from the Dugout Canyon Mine and Pace Canyon Fan Portal mine-water discharge point in accordance with the UPDES permits. No water will be discharged prior to obtaining the necessary UPDES permits. The monitoring requirements proposed herein, including the analytical parameters and the sampling frequency, may be modified in the future in consultation with the Division if the data demonstrate that such a modification is justified.

Data will be collected under the groundwater monitoring program every year following the completion of surface reclamation activities. During the post-mining period, water levels will be collected from the monitoring wells and data/samples will be collected from the identified springs once each year during September or October (i.e., the low-flow season while the sites are still accessible). Groundwater monitoring during the post-mining period will continue until bond release.

All groundwater monitoring data will be submitted to the Division by the end of the quarter following sampling. If analyses of any groundwater sample indicates noncompliance with the permit conditions, the permittee will promptly notify the Division and take immediate appropriate actions. UPDES reporting requirements will be met for the mine-water discharge points. The Snotel data used to determine "wet" or "dry" years, as described previously in this section, will be submitted with the first quarter water monitoring data beginning in the year 2001 or in the annual report.

Equipment, structures and other devices used in conjunction with monitoring the quality and quantity of groundwater in the permit and adjacent areas have been or will be installed, maintained, and operated in accordance with accepted procedures. Where feasible, this equipment will be removed or properly abandoned by the permittee when no longer needed.

Surface Water Monitoring. Surface water monitoring to be conducted in the permit and adjacent areas will consist of data collection from streams and sedimentation pond discharges. Locations of streams to be monitored are noted on Plate 7-1. The surface water monitoring plans presented herein were developed based on information presented in the PHC determination, the baseline hydrologic data, and the geologic data presented in Chapter 6 of this M&RP.

Station DC-1 will be monitored to evaluate surface-water conditions downstream from the proposed surface facilities. Stations DC-2 and DC-3 will provide data concerning background surface-water conditions immediately upstream from the proposed surface facilities. Stations DC-4 and DC-5 will be located at the Castlegate Sandstone-Blackhawk Formation contact and will provide data that will be used to determine the relationship between the Blackhawk Formation and the base flow of Dugout Creek.

PC-1a and PC-2 are located on Pace Creek and will be monitored to evaluate surface-water conditions up gradient and down gradient, respectively, of the permit area. Monitoring point (Fan) has been added on Pace Creek at a location approximately 600 feet upstream from the top of the Pace Canyon Fan facilities disturbed area boundary. Monitoring locations Fan and PC-2 will be monitored to evaluate surface water conditions up gradient and down gradient, respectively, of the Pace Canyon Fan facilities. RC-1 has also been established as monitoring point to obtain baseline data for future mine expansion. Baseline data was obtained from the aforementioned three sites (PC-1a, PC-2 and RC-1) for three years prior to initiating operational sampling.

PC-3 is located on Pace Creek below the confluence of an unnamed ephemeral drainage with Pace Creek (Plate 7-1). Degas Wells G-18, G-19 and the AMV road are located adjacent to the unnamed drainage at various elevations. Surface water monitoring location PC-3 was added during the permitting of the AMV road and Degas Wells G-18 and G-31, baseline data was not gathered for this monitoring location. The operational monitoring of PC-3 will begin the 4th quarter of 2007.

Protocols for surface-water monitoring within the permit and adjacent areas are:

- <u>DC-1, FAN, PC-3</u> - Quarterly data collection in accordance with Table 7-5 (operational parameters). This table is the same as that presented in Coal Regulatory Program Directive Tech-004, with the exception that total hardness and total alkalinity are not included. As explained above, total hardness, which is primarily of concern in water supplies being developed for domestic use, was not added to the list because summer-home development of the permit area is not an identified post-mining land use. Total alkalinity was not added to the list because the baseline data indicate that acid-generating materials, which may affect the alkalinity of the water, are not present within the permit and adjacent areas.

- <u>DC-2, DC-3, PC-1a, PC-2, and RC-1</u> - Quarterly data collection in accordance with Table 7-5. Collection of gain-loss hydrograph data during the first wet year and the first dry year following permit issuance. Wet and dry years will be defined as noted in the previous groundwater monitoring discussion. The hydrograph will be generated by collecting flow measurements during the first wet year and the first dry year on a weekly basis between April 1 and August 31 as conditions permit.

- <u>DC-4 and DC-5</u> - Collection of gain-loss hydrograph data during the first wet year and the first dry year following permit issuance, as described above. Collect flow measurements during the first wet year and the first dry year on a weekly basis between April 1 and August

31 as conditions permit. Samples will also be collected for laboratory analyses during the first wet year and the first dry year following permit issuance. Wet and dry years will be defined as noted above. These samples will be collected during the high-flow and low-flow seasons. The samples will be analyzed for tritium and the operational parameters contained in Table 7-5.

- 323 - Quarterly data collection in accordance with Table 7-5.

In addition to the above regular monitoring, one water sample will be collected at each sampling point during low flow period every fifth year, during the year preceding re-permitting, to be analyzed for baseline parameters (Table 7-5).

The monitoring requirements proposed herein, including the analytical parameters and the sampling frequency, may be modified in the future in consultation with the Division if the data demonstrate that such a modification is justified. Data will be collected from the sedimentation pond discharge point in accordance with the UPDES permit. Data will be collected under the surface water monitoring program every year until bond release.

All surface water monitoring data will be submitted to the Division by the end of the quarter following sampling. If analyses of any surface water sample indicates noncompliance with the permit conditions, SCM will promptly notify the Division and take immediate appropriate actions. UPDES reporting requirements will be met for the sedimentation pond discharge point.

Equipment, structures and other devices used in conjunction with monitoring the quality and quantity of surface water in the permit and adjacent areas have been or will be installed, maintained, and operated in accordance with accepted procedures. Where feasible, this equipment will be removed or properly abandoned by SCM when no longer needed.

Monitoring and Mitigation Plan Pace Creek

Dugout Canyon Mine plans to leave a barrier under the majority of Pace Creek within the permit boundary. The stretches of Pace Creek (10/04 mine map) which are planned for undermining are above entry development, not longwall panels. There is approximately 1000 feet of stream channel having over 500 feet of cover planned for mining in 2007, 400 feet has approximately 900 feet of cover planned for mining in 2008 and approximately 100 feet has 1250 feet of cover planned for mining in 2008-2009. A surface water monitoring and mitigation program will be initiated in this area prior to potential subsidence occurring. This monitoring program will include conducting a pre-mining subsidence photographic survey of the stream channel from surface water monitoring location PC1A to where Pace Creek leaves the SW1/4SW14 Section 20, T13S, R13E and a single reference site below the Pace Canyon fan site. The purpose of the photographs will be to provide a visual record of the stream channel prior to mining disturbance. Five reference sites will be identified within the photographed portion of Pace Creek where the monitoring of surface ground water flows, channel width and general geomorphology will occur. These reference sites will be established during low flow in the creek and monitored as outlined by the USDA Forest Service (Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245, Harrelson et. Al., 1994). The photographing of Pace Creek and the selection of monitoring sites will be done no later than the Spring of 2006 and submitted as part of the 2006 annual report.

The surface water flows and channel width at these stations will be monitored on a monthly basis, when accessible, while mining is occurring within the 15 degree angle-of-draw of the stream channel. The Division will be notified if the area is inaccessible due to road or climatic conditions and the monitoring could not be accomplished. Once mining has been completed within the angle-of draw, the sites will be monitored annually for up two years following undermining. A report on the subsidence related impacts, if any, to the surface water flows, will be provided monthly to the Division during monthly monitoring and annually during annual monitoring.

Mitigation will implement the Best Technology Currently Available in association with the repair of damage to the Pace Creek stream channel. The repairs may include the use of bentonite/soil mixes to fill persistant cracks that appear to be diverting water. Bentonite may also be used to line portions of the creek floor where leakage appears to be occurring. Other methods or chemicals, if environmentally safe and available, may be employed if bentonite and/or bentonite/soil mixes are ineffectual.

731.300 Acid- and Toxic-Forming Materials

Analyses presented in Chapter 6 of this M&RP indicate that acid- and toxic-forming materials are not present within the permit area. Parameters defining acid- and toxic-forming materials will periodically be monitored as described in Chapter 6 of this M&RP. In the event that acid- or toxic-forming materials are identified, they will be disposed of in appropriate waste-rock disposal facilities as described in Chapter 5 of this M&RP.

731.400 Transfer of Wells

Before final release of bond, exploration or monitoring wells will be sealed in a safe and environmentally sound manner in accordance with R645-301-631, R645-301-738, and R645-301-765. Ownership of wells will be transferred only with prior approval of the Division. The conditions of such a transfer will comply with State and local laws. The permittee will remain responsible for the management of the wells until bond release in accordance with R645-301-529, R645-301-551, R645-301-631, R645-301-738, and R645-301-765.

731.500 Discharges

Discharges into an Underground Mine. No discharges of surface water will be made to an underground mine in the permit and adjacent areas.

Gravity Discharges from an Underground Mine. No gravity discharges will be made from an underground mine in the permit and adjacent areas.

731.600 Stream Buffer Zones

The surface facilities for the Dugout Canyon Mine will be constructed within 100 feet of Dugout Creek (a perennial stream, intermittent adjacent to mine facilities) and Pace Creek (an intermittent stream adjacent to fan facilities). However, surface runoff- and sediment-control facilities designed for the site (as discussed in subsequent sections of this chapter) will ensure that coal mining and reclamation operations will not cause or contribute to the violation of applicable Utah or federal water standards and will not adversely affect the water quantity and quality or other environmental resources of the stream.

Stream Channel Diversions. Temporary or permanent stream channel diversions will comply with R645-301-742.300.

Buffer Zone Designation. The area surrounding the streams that is not to be disturbed will be designated as a buffer zone, and SCM will mark those zones as specified in Section 521.200 of this M&RP.

731.700 Cross Sections and Maps

The locations of water rights for current users of surface water flowing into, out of, and within the permit and adjacent areas is provided on Plate 7-2. The locations of each water diversion, collection, conveyance, treatment, storage, and discharge facility to be used in the Dugout Canyon area is presented on Plate 7-5 or in Addendum A to Appendix 7-9.

Locations and elevations of each station to be used for water monitoring during coal mining and reclamation operations are presented on Plate 7-1. The design details and cross sections for the sedimentation pond are provided on Plate 7-4. Other relevant cross sections or maps are presented and discussed in Chapter 5 of this M&RP.

731.800 Water Rights and Replacement

No surface mining will occur in the Dugout Canyon Mine permit area.

732 Sediment Control Measures

The sediment control measures within the permit area have been designed to prevent additional contributions of sediment to streamflow or to runoff outside the permit area. In addition, they have been designed to meet applicable effluent limitations, and minimize erosion to the extent possible.

The structures to be used for the runoff-control plan for the permit area include disturbed and undisturbed area diversion channels, a sedimentation pond, containment berms, silt fences, and road diversions and culverts.

Sediment control measures for the Pace Canyon Fan Portal Area are discussed in Appendix 7-12.

732.100 Siltation Structures

The siltation structure within the permit area will be a sedimentation pond as described in Section 732.200.

732.200 Sedimentation Ponds

There will be a single sedimentation pond operating at the mine facility located at the southwest end of the disturbed area. The sedimentation pond topography and cross sections are presented on Plate 7-4 of this M&RP. Details regarding sedimentation pond design are presented in Appendix 7-8. The staff gauge in the pond will be marked to indicate the 60% clean-out elevation as defined in Section 742. The sedimentation pond is defined as a Class A pond in accordance with TR-60 (U.S. Soil Conservation Service, 1976).

If sediment has accumulated to the 60% clean-out elevation, the pond will be cleaned. The sediment will be transported and either stored at the Banning Loadout or disposed of at the approved waste rock disposal sites as described in Chapter 5 of this M&RP or pumped back into the sealed, abandoned "Gilson West - Old Workings".

The sedimentation pond is within the disturbed area boundary and is subject to final reclamation. The area is included in the calculation of the disturbed area subject to bonding and in the calculation of final reclamation costs.

Compliance Requirements. The sedimentation pond will be maintained until removal in accordance with the reclamation plan (see Section 540 of this M&RP). When the pond is removed, the land will be revegetated in accordance with the reclamation plan defined in Section 540.

The sedimentation pond was designed to contain 0.40 acre-foot of sediment accumulation before being cleaned out. The sedimentation pond will fully contain the runoff from the 10-year, 24-hour storm event in addition to sediment accumulation. The primary spillway for the sedimentation pond will adequately pass the peak flow resulting from the 25-year, 6-hour precipitation event. The pond has also been designed with an emergency spillway to release water from the pond in the event that the primary spillway becomes blocked.

Additional design standards for the pond are presented in Section 742.

MSHA Requirements. MSHA requirements defined in 30 CFR 77.216 are not applicable since the sedimentation pond will not impound water or sediment to an elevation of 20 feet or more above the upstream toe of the structure. The pond will also store a volume less than 20 acre-feet.

732.300 Diversions

The objective of the runoff control plan is to isolate, to the maximum degree possible, runoff from disturbed areas from that of undisturbed areas. This is accomplished by:

- Allowing all upstream runoff in Dugout Creek to bypass the disturbed area through the use of culverts;
- Routing runoff from the adjacent undisturbed areas above the facilities through culverts and diversion ditches where feasible to bypass the disturbed area; and
- Routing any runoff from undisturbed areas which enters the disturbed area into the sediment control system.

The location of each diversion ditch or culvert for the main facility area is presented on Plate 7-5 or in Addendum A to Appendix 7-9. Details regarding design of the diversions are presented in Appendix 7-9. A brief list of the proposed diversion structures follows (refer to Plates 7-6 through 7-8 for the location of each watershed boundary):

<u>Diversion Ditches:</u>

- Interception ditch UD-1 along the southeast border of the disturbed area will collects runoff from adjacent undisturbed watersheds and direct the runoff into Dugout Creek.

- Disturbed drainage ditches DD-1a through DD-3care located within the main portion of the facility pad, directing disturbed-area runoff from this pad toward the sedimentation pond.
- Disturbed drainage ditch DD-3a through DD-3c are located along the north edge of the road that accesses the large and small substation pads. Runoff from ditches DD-3a through DD-3c is conveyed to the sedimentation pond via culvert DC-5 and ditches DD-2a through DD-2d.
- Disturbed drainage ditches DD-4 through DD-7 are located along the west side of the water-tank access road. These ditches convey runoff from the water tank access road to culverts DC-7 through DC-9. Culverts DC-8 and DC-9 discharge to the slope above Dugout Creek because crests in the road prevent runoff from reaching the sedimentation pond. Ditch DD-4 and Culvert DC-7 also discharge to the slope above Dugout Creek. Although runoff in DD-4 could reach the sediment pond it has been diverted because the runoff was creating large puddles and mud holes in front of the principle access portal. Alternate sediment control is provided for discharge from these ditches and culverts (see Section 742.200 of this M&RP).

Diversion Culverts:

- Culvert DC-4is located along the northwest portion of the main facility pad. This culvert conveys runoff from DD-2e to DD-2d and to the sedimentation pond.
- Culvert DC-6 will convey runoff from the portal pad via a drop inlet to the lower facility pad. This runoff will ultimately discharge to the sedimentation pond via ditches DD-9 and DD-2 and culvert DC-5.
- Culvert DC-1 will convey water from ditches located on the south side of the facility pad to the sedimentation pond.
- Culvert DC-5 will convey water from the substation access road into ditch DD-2 and then to the sedimentation pond. A drop inlet is used on this culvert.
- Culverts DC-7 DC-8 and DC-9 are located along the water-tank access road, conveying runoff from the roadside ditches to Dugout Creek. Because of the presence of the crest in the road between the facility pad and these culverts, this runoff cannot be conveyed to the sedimentation pond. Hence, alternate sediment control has been provided as noted in Section 742.200 of this M&RP.
- Culverts DC-2 and DC-3 convey runoff from the parking area and truck loop to ditches DD-2b and DD-2c respectively. Both culverts have drop inlets.
- Culverts UC-1 through UC-4convey undisturbed-area runoff from undisturbed watersheds to the Dugout Creek bypass culvert (UC-6). Culvert UC-4 conveys undisturbed-area runoff from ditch UD-1 to the Dugout Creek culvert (UC-6).

- Culvert UC-5 is located on the eastern tributary of Dugout Creek. Containing this tributary in a culvert will prevent uncontrolled sediment from the adjacent disturbed area from impacting this water during the operational period. Gabion baskets will be installed adjacent to the culvert as shown on Dwg. No. B101 in Appendix 7-9.
- Culvert UC-6 is located on the main branch of Dugout Creek, containing the creek through the disturbed area and allowing coal-haul trucks to enter and leave the loadout pad and mine access/haul road. Installation of this culvert will protect Dugout Creek from sediment which may be generated from the adjacent disturbed areas.
- Culvert DC-10 conveys runoff from the sediment basin beneath the storage racks west of the office/warehouse building into ditch DD-1a.
- Culvert DC-11 conveys runoff from the sediment trap to the sediment pond.

All diversion ditches will be maintained with adequate riprap or alternative erosion protection in the ditch sections where flow velocities are predicted to be sufficiently high to require a ditch lining. Adequate ditch capacities will be maintained in all ditch sections. Culverts will be kept free of debris and each outlet will be protected with riprap where deemed necessary. Detailed diversion design is presented in Section 742.

732.400 Road Drainage

Road drainage facilities will include diversion ditches, culverts, and containment berms. The road drainage diversion ditches and culverts for the mine site are included in the list of diversions presented in Section 732.300 above. Additional road drainage design information is presented in Section 742.

All road drainage diversions will be maintained and repaired to original condition following the occurrence of a large storm event. Culvert inlets and outlets will be kept clear of sediment and other debris. Culverts to be installed on Dugout Creek to permit turning of the coal haul trucks are discussed in Section 742.300.

733 Impoundments

733.100 General Plans

There will be a single sedimentation pond operating at the mine facility as described in Section 732.200. The sedimentation pond will be located in the southwest corner of the disturbed area. The sedimentation pond topography and cross sections are presented on Plate 7-4 of this M&RP.

Detailed design information is presented in Appendix 7-8. Details regarding the impoundments at the Pace Canyon Fan Portal Site can be found in Appendix 7-12.

Certification. All maps and cross sections of the sedimentation pond have been prepared by or under the direction of, and certified by a qualified, registered, professional engineer.

Maps and Cross Sections. The topography and cross sections for the sedimentation pond are provided on Plate 7-4 of this M&RP.

Narrative. A description of the sedimentation pond is presented in Sections 732.200 and 742 of this M&RP.

Subsidence Survey Results. No underground coal mining will occur beneath the proposed sedimentation pond. Therefore, there will be no effects on the pond or pond embankment from subsidence.

Hydrologic Impact. The hydrologic and geologic information required to assess the hydrologic impacts of the proposed sedimentation pond are presented in Section 724 and Chapter 6 of this M&RP, respectively.

Design Plans and Construction Schedule. There are no additional structures proposed for the mining operation at this time. Any structures proposed in the future will not be constructed until the Division has approved the detailed design plan for the structure.

733.200 Permanent and Temporary Impoundments

Requirements. The sedimentation pond has been designed using current, prudent engineering practices. Specific foundation design and construction criteria are presented in Chapter 5 of this M&RP. Specific hydrologic design criteria for the pond are presented in Section 743. The pond will be inspected regularly based on the schedule contained in Section 514.300.

Permanent Impoundments. There are no permanent impoundment structures proposed for use in mining and reclamation operations within the permit and adjacent areas.

Temporary Impoundments. The Division's authorization is being sought for the construction of the sedimentation pond as a temporary impoundment at the mine as part of coal mining and reclamation operations.

Hazard Notifications. The sedimentation pond will be examined for structural weakness and erosion in accordance with the schedule presented in Section 514.300. A report of these findings will be submitted to the Division as outlined in Section 514.300.

734 Discharge Structures

Discharge structures within the Dugout Canyon Mine facilities area will consist of the primary and emergency spillway on the sedimentation pond and a discharge line from the underground workings. Discharge structures at the Pace Canyon Fan Portal Site will consist of a spillway from the sediment trap and discharge line (UPDES) from the underground workings. All discharge structures will be constructed and maintained to comply with R645-301-744.

735 Disposal of Excess Spoil

There will be no excess spoil generated at the mine.

736 Coal Mine Waste

Coal mine waste will be stored and disposed of as described in Chapter 5.

737 Noncoal Mine Waste

Noncoal mine waste will be stored and disposed of as described in Chapter 5.

738 Temporary Casing and Sealing of Wells

Each groundwater monitoring well identified on Plate 7-1 will be operated and maintained as described in Section 748.

740 DESIGN CRITERIA AND PLANS

741 General Requirements

This M&RP includes site-specific plans that incorporate minimum design criteria for the control of drainage from disturbed and undisturbed areas. The design criteria and plans for the Pace Canyon Fan Portal Site can be found in Appendix 7-12.

742 Sediment Control Measures

742.100 General Requirements

Design. Sediment-control measures have been designed to provide the following:

- Prevent additional contributions of sediment to stream flow or to runoff outside the permit area;
- Meet the effluent limitations defined in Section 751; and
- Minimize erosion to the extent possible.

Measures and Methods. The sediment control measures at the mine will include practices carried out within and adjacent to the disturbed area. Sediment control methods will include:

- Retention of sediment within the disturbed area;

- Diversion of runoff away from the disturbed area;

- Diversion of runoff using channels or culverts through disturbed areas to prevent additional erosion;

- Provision of silt fences, riprap, contemporaneous revegetation, vegetative sediment filters, a sedimentation pond, and other measures that reduce overland flow velocities, reduce runoff volumes or trap sediment; and

- Treatment of mine drainage in underground sumps.

742.200 Siltation Structures

General Requirements. Additional contributions of suspended solids and sediment to stream flow or runoff outside the permit area will be prevented to the extent possible using a sedimentation pond. The pond will be constructed before mining operations begin. The structures will be certified by a qualified registered professional engineer.

The sedimentation pond has been designed and will be constructed and maintained as described in Chapter 5 and Sections 733 and 743.

Some areas within the disturbed area boundary will not flow to the sedimentation pond. Areas not contributing runoff to the sedimentation pond would be impractical, if not impossible, to divert to the sedimentation pond due to their location. The proposed disturbed areas which will not flow to the sedimentation pond can be generally described as areas downstream from the sedimentation pond, areas along the water-tank access road, and the area occupied by the water tanks.

Areas of alternate sediment control (ASCAs) are shown on Plate 7-8 and in Addendum A to Appendix 7-9. These include ASCA-1 (a small portion of the primary haul road downstream from the sedimentation pond), ASCA-2 (the water-tank access road upstream from the crest in the road below watershed WS-9 and upstream of culvert DC-8), ASCA-3 (the water-tank access road upstream from culvert DC-9 including the water tank area), ASCA-4 (the water-tank access road upstream of culvert DC-7), and ASCA-5 (the topsoil storage area) .

ASCA-1 consists of a small portion of the primary haul road adjacent to and downstream from the sedimentation pond. Sediment control in this area is provided by paving the road, thus precluding the production of sediment from the ASCA.

Runoff from ASCA-2 is precluded from flowing to the sedimentation pond because of a crest in the water-tank access road at the downstream edge of this ASCA. Instead, runoff from this area flows to Dugout Creek via culvert DC-8 (see Plate 7-5). Sediment generated from this ASCA is controlled by installing silt fences or straw-bale dikes in ditch DD-5 immediately upstream from the inlet to culvert DC-8. These sediment-control devices have been installed in accordance with Figure 5-4. Sediment which accumulates behind these devices will be periodically removed and either spread on the adjacent road or disposed of with waste-rock generated from the mine.

Runoff from ASCA-3 is precluded from flowing to the sedimentation pond for the reasons outlined above. This runoff will flow to Dugout Creek via culvert DC-9 (see Plate 7-5). Sediment generated from this ASCA will be controlled by installing silt fences or straw-bale dikes in ditch DD-6 immediately upstream from the inlet to culvert DC-9. These sediment-control devices were installed in accordance with Figure 5-4. Sediment which accumulates behind these devices will be periodically removed and either spread on the adjacent road or disposed of with waste-rock generated from the mine.

ASCA-3 also includes the water-tank area and the adjacent cut slope. Sediment yield from this area will be controlled by placing a layer of gravel around the water tanks and the explosives magazines. The cut slope west of the water tanks will also be contemporaneously reclaimed using the interim seed mix identified in Section 341.200 of this M&RP. Runoff which is generated from this ASCA will also flow through culvert DC-9, with additional sediment control being provided at the inlet to this culvert as discussed above.

An additional alternate sediment control measure (ASCA-5) is implemented at the topsoil storage area. Sediment contributions from this stockpile will be controlled by placing a berm around the stockpile to prevent both runoff from the pile and run-on to the pile. The location of this berm is indicated on Plate 2-3 and the design of the berm is noted in Appendix 7-9. Furthermore, erosion from the stockpile will be minimized through the establishment of a vegetative cover on the pile, as indicated in Section 234.200 of this M&RP.

Runoff from ASCA-4 is on the water-tank access road. Instead of runoff flowing to the sediment pond, runoff from this area will flow to Dugout Creek via culvert DC-7 . Sediment generated from this ASCA will be controlled by installing silt fences or straw-bale dikes in the ditch immediately upstream from the inlet to culvert DC-7. These sediment-control devices were installed in accordance with Figure 5-4. Sediment which accumulates behind these devices will be periodically removed and either spread on the adjacent road or disposed of with waste-rock generated from the mine.

Sediment-control measures were implemented during the relocation of the west fork of Dugout Creek. These measures will include installation of three straw-bale dikes and/or reinforced silt fences in appropriate locations within the creek channel below the relocation site to minimize potential contributions of sediment to Dugout Creek. The straw-bale dikes/silt fences will remain in-place until channel relocation and pad construction is completed.

Pace Canyon Fan Portal Facilities

The entire site is an ASCA area. Sediment from the site will be controlled by a combination of contemporaneous reclamation, revegetation, gravel, and the use of a sediment trap. Plate Figure 7-12E identifies the various alternative sediment control methods that will be used and where the methods will be implemented. Other than the realigned road and a small area on the outslope of the sediment trap embankment the entire site will drain to the sediment trap. Although calculations in Appendix 7-12, Attachment 2 demonstrate that the contemporaneous reclamation, gravel, and revegetation will reduce the sediment yield to less than pre-mining conditions a sediment trap was constructed to contain sediment generated by the site.

Sedimentation Ponds. A single sedimentation pond has been designed for the Dugout Canyon Mine facilities. The sedimentation pond is located in the southwest corner of the disturbed area. This pond will function individually.

The sedimentation pond will be located as near as possible to the disturbed areas as indicated on Plates 7-4 and 7-5. The pond will not be located within a perennial stream channel.

Design, Construction, and Maintenance

Sediment Storage Volume. The sedimentation pond has been designed to control sediment from disturbed and undisturbed areas. The disturbed area contributing runoff to the sedimentation pond contains 16.9 acres from watersheds DWS-1 through DWS-7 (portions of which will be undisturbed or contemporaneously reclaimed - see Appendix 7-9). The undisturbed area contributing runoff to the sedimentation pond contains 33.7 acres from watersheds WS-1, -3, -5, -6, -7, -8, -9a, and -11. Refer to Plates 7-7 and 7-8 for a delineation of watershed boundaries.

The sedimentation pond was designed to fully contain the sediment generated by disturbed and undisturbed areas. Based on calculations presented in Appendix 7-8, the sedimentation pond has been designed with a sediment storage capacity of 0.40 acre-foot. The elevation of the maximum sediment level will be 6954.4 feet. The 60% sediment clean-out volume of 0.24 acre-foot will have an elevation of 6951.7 feet.

Detention Time. An adequate detention time will be provided in the pond to allow the effluent to meet UPDES and 40 CFR Part 434 limitations. The decant water will be sampled and discharged from the pond in accordance with the above referenced effluent limitations.

Design Event. The sedimentation pond has been designed to fully contain runoff resulting from the 10-year, 24-hour precipitation event.

Pond Description. Several drainage areas, identified on Plates 7-7 and 7-8, will contribute runoff to the sedimentation pond. The disturbed drainage areas contributing to the pond will be DWS-1 through DWS-7 and the pond itself. The undisturbed drainage areas contributing to the pond will be WS-1, -3, -5, -6, -7, -8, -9a, and -11, as well as portions of the above-mentioned "disturbed" watersheds. These undisturbed drainage areas will discharge to the pond because construction of diversion ditches along the top of cut slopes may create cut-slope stability problems. Also, constructing ditches on steep slopes is expensive and disturbs a larger area. The selected course of action was to allow undisturbed runoff to flow onto the disturbed area and be treated in the sedimentation pond.

The curve numbers used to determine the runoff volumes were based on information presented in Appendix 7-8 and Appendix 7-9. The curve number for the pond area was assumed to be 100. Refer to Table 7-6 for a list of all disturbed and undisturbed watershed areas contributing to the sedimentation pond and their associated curve numbers.

The storm runoff volume to the sedimentation pond resulting from the 10-year, 24-hour storm event was calculated to be 69,913 cubic feet (1.60 acre-feet). The calculations, presented in Appendix

7-8, are based on hydrologic design methods described in Appendix 7-10. As presented above, the maximum sediment storage volume is 0.40 acre-foot (17.424 cubic feet). Thus, the capacity of the pond at the elevation of the primary spillway is 87,337 cubic feet (2.00 acre-feet), assuming the spillway does not spill during the 10-year, 24-hour storm.

In order to fully contain the runoff from the 10-year, 24-hour storm event and the maximum sediment storage, the primary spillway on the sedimentation pond will be set at an elevation of 6964.4 feet. The stage-capacity curve for the sedimentation pond is contained in Appendix 7-8 and summarized in Table 7-7.

The sedimentation pond has been designed with a 24-inch diameter primary spillway CMP riser attached to a 24-inch diameter CMP pipe barrel that is together capable of safely discharging the peak flow resulting from the 25-year, 6-hour precipitation event. The 25-year, 6-hour storm event was routed through the sedimentation pond to determine an adequate primary spillway. The computer software SEDCAD+ was used to design the primary spillway. SEDCAD assumes that the pond is full to the spillway elevation at the beginning of the storm event. The SEDCAD input and output for the sedimentation pond is contained in Appendix 7-8.

From the final analysis of the 25-year, 6-hour storm event, the maximum inflow rate to the sedimentation pond from storm runoff under design conditions was calculated to be 5.90 cubic feet per second (cfs), with a maximum outflow rate of 3.93 cfs. The corresponding high water elevation in the sedimentation pond will be 6964.3 feet, 1.7 feet below the top of the embankment and 0.2 foot below the crest of the emergency spillway. Hence, the pond has been designed with adequate freeboard.

An open-channel emergency spillway has been designed for the pond to allow discharge from the pond in the event that the primary spillway becomes plugged. Details regarding this emergency spillway are discussed in Appendix 7-8. As noted in that appendix, the emergency spillway was designed assuming that the primary spillway is nonfunctional. Under this scenario, the peak discharge from the pond will be 4.12 cfs, with a peak stage elevation of 6964.7 feet (0.2 foot above the crest of the emergency spillway and 1.3 feet below the crest of the pond embankment). Hence, freeboard on the pond will remain adequate even if the primary spillway plugs and becomes nonfunctional.

The emergency spillway has been designed with a median riprap diameter of 3 inches along the crest and 6 inches down the slope of the spillway. This riprap will be underlain with a geofabric liner. The maximum velocity exiting from the emergency spillway under design conditions will be 5.0 feet per second, which velocity is not considered to be erosive of the adjacent Dugout Creek channel.

Dewatering Device. A valved dewatering device will be installed on the riser of the primary spillway as indicated on Plate 7-4. The inlet to this device will be down turned to preclude the entry of oil from the surface of the pond. The inlet to the non-clogging dewatering device on the sedimentation pond will be at the elevation of the maximum sediment level (elevation 6954.8 feet). Water will be discharged from the pond in accordance with UPDES guidelines.

Short Circuiting. Short circuiting will be minimized in the sedimentation pond because the pond will fully contain the runoff from the 10-year, 24-hour precipitation event. Also, the sedimentation pond spillway will be approximately 150 feet from the primary inlet of the pond when the pond is at discharge stage, thereby increasing the residence time for storms which are larger than the 10-yr 24-hr event.

Sediment Removal. Sediment removal from the sedimentation pond will occur when the sediment level reaches the 60% clean-out level. From the stage-capacity curve presented on Plate 7-4, the 60% clean-out elevation is 6951.7 feet. The sediment will be transported and disposed of as discussed in Chapter 5, and Chapter 7, Section 732.200 of this M&RP. Water that meets the quality standards set forth in the UPDES permit will be discharged to Dugout Creek before sediment cleanout begins. Water not meeting the standards will either be used for dust suppression on mine roadways or be pumped into the sealed, abandoned, "Gilson West - Old Working" as shown on the MSHA approved map (Waste Water Disposal Appendix 5-3A). The Gilson seam is a closed system and does not discharge to the surface. Adding relatively small volumes of surface runoff water will not cause a disturbance in the hydrologic balance in the permit area. Water stored in the "Gilson West - Old Working" is planned to provide process and fire fighting water for the Dugout Canyon Mine.

When the pond is cleaned out potentially 87,120 cu. ft. or 651,657 gallons of water and sediment will be pumped underground. Samples of the slurry will be taken before pumping begins and will be tested using Table 6 of the Division's approved Soil and Overburden Handling Guidelines. This will be done to eliminate the potential of a hazardous substance entering the Gilson seam. A water sample will be obtained and analyzed for the UPDES discharge parameters. The only UPDES effluent limitation that should be exceeded will be the amount of total suspended solids. Since the water will not be discharged to Dugout Creek or off the mine site, no violation of the mines various permits will occur.

Excessive Settlement. The sedimentation pond is to be excavated from native undisturbed material, thereby making settlement highly unlikely. Less than 2 feet of the embankment will be constructed. The portion of the embankment to be constructed will be constructed in a manner to minimize settlement. Stability analyses presented in Chapter 5 indicated that the pond embankment will be stable under both normal and rapid drawdown conditions.

Embankment Material. During construction of the sedimentation pond, any material to be used in the embankment will be inspected to ensure the material is free of sod, large roots, frozen soil, and acid- or toxic forming coal-processing waste.

Compaction. The sedimentation pond will be primarily excavated out of native undisturbed ground, thereby eliminating the need for additional compaction. Any portion of the embankment that will be constructed will be compacted to a minimum dry density of 90 % as determined by ASTM D1557.

MSHA Sedimentation Ponds. MSHA requirements defined in 30 CFR 77.216 are mot applicable at this mine since the proposed sedimentation pond will not impound water or sediment to an elevation of 20 feet or more above the upstream toe of the structure. The pond will also store a volume less than 20 acre-feet.

Other Treatment Facilities. There are no other treatment facilities within the mine permit area.

Exemptions. No exemptions are being proposed at this time.

742.300 Diversions

General Requirements. The diversions within the permit area will consist of drainage ditches and culverts. All diversions within the permit area have been designed to minimize adverse impacts to the hydrologic balance, to prevent material damage outside the permit area, and to assure the safety of the public.

All diversions and diversion structures have been designed and will be constructed, and maintained and used to:

Be stable;
Provide protection against flooding and resultant damage to life and property;
Prevent, to the extent possible, additional contributions of suspended solids to stream flow outside the permit area; and
Comply with all applicable local, state, and federal laws and regulations.

All diversions within the permit area will removed when no longer needed. The diversions will be reclaimed in accordance with the reclamation plan defined in Chapter 5.

Peak discharge rates from the undisturbed and disturbed area drainages within the permit area were calculated for use in designing diversion ditches and culverts. With the exception of the culverts on Dugout Creek, the storm runoff calculations for the temporary diversion structures were based on the 10-year, 24-hour precipitation event of 1.95 inches. For the design of the Dugout Creek culverts, a 100-year, 6-hour precipitation event was used, with a storm depth of 2.05 inches.

Curve numbers were based on those defined in Appendix 7-9 and professional judgement. A description of the methods used to determine the peak discharge rates is presented in Appendix 7-10.

A precipitation gauge will be installed at the mine site in the summer of 2001 to monitor and assess the types of precipitation events occurring at the mine site. The information will be used to determine if precipitation events exceed design parameters.

The disturbed and undisturbed drainage areas within and above the facilities area are presented on Plates 7-6 through 7-8. A summary of the characteristics of watersheds contributing to the diversions is presented in Table 7-6.

All proposed diversions are presented on Plate 7-5 or in Addendum A to Appendix 7-9. The minimum capacity and freeboard of each diversion ditch and culvert was determined based on the minimum ditch slope. The maximum velocity and need for a channel lining or outlet protection was calculated based on the maximum ditch or culvert slope. Slopes were measured from a contour map with a scale of 1" = 50'. A description of the methods used to determine diversion capacities, flow velocities, and riprap sizes is presented in Appendix 7-10. All diversion calculations are presented in Appendix 7-9.

Diversion of Perennial and Intermittent Streams. Dugout Creek will be diverted through culverts within the disturbed area. UC-6 and UC-5 consist of 60-inch diameter CMPs with mitered inlets. Both culverts are designed to pass the peak flow, of approximately 90 cfs with a combined flow of approximately 180 cfs below their confluence, from a 100-year, 6-hour storm event without creating an excess headwater above the top of the culvert. The justification for diverting the creek with respect to the stream buffer zones is discussed in Section 731.600. To the extent feasible, these culverts will be installed during a season of the year other than the high-flow season.

Culvert UC-5 is located on the eastern tributary of Dugout Creek. This culvert will have a constant slope of 4.9% and an approximate length of 160 feet. This culvert will merge with UC-5 approximately 115 feet downstream from the inlet of UC-6.

Culvert UC-6 is installed on the main branch of Dugout Creek, with a slope that varies from about 2.2% to 8.0% and an approximate length of 2140 feet. This culvert will also consist of a 60-inch diameter CMP. To reduce the velocity at the culvert outlet below the velocities under natural conditions, a riprap basin was constructed in the channel immediately downstream from the outlet. This riprap basin will extend a minimum of 56.25 feet downstream from the culvert outlet and will be underlain with a geofabric to prevent piping of the soil beneath the riprap (see Appendix 7-9). This riprap section will be periodically monitored and modified if necessary to prevent erosion.

Detailed design calculations for culverts UC-6 and UC-5 can be found in Appendix 7-9. All designs have been prepared by or under the direction of, and certified by a qualified registered, professional engineer. The location of each culvert can be found on Plate 7-5 or in Addendum A to Appendix 7-9.

Calculations presented in Appendix 7-9 indicate that the capacity of Dugout Creek upstream and downstream of culverts UC-6 and UC-5 is in excess of 3,000 cfs. This high natural capacity of the stream channel has been caused by a combination of factors, including steep natural gradients, narrow valleys which preclude the development of flood plains, and erosion of the channels due to headcutting following failure of an old culvert located near the center of the operational facility prior to construction of the Dugout Canyon Mine. Hence, although UC-6 and UC-5 have been designed with a capacity of 180 cfs (see Appendix 7-9), the combined conditions of the stream channel noted above indicate that it is not feasible to design these culverts to have a capacity at least equal to that of the natural channel up- and downstream from the culverts.

The west fork of Dugout Creek near the Gilson water well will be relocated for approximately 50 feet. This will be necessary to protect the retaining wall that stabilizes the well site and other support facilities for the well, mainly the well house. Refer to Appendix 7-11 design calculations and typical channel drawing for RD-4, the relocated portion of Dugout Creek will mimic this design.

Diversion of Miscellaneous Flows. Diversion ditches and culverts have been utilized within the permit area to divert miscellaneous flows from disturbed and undisturbed area drainages.

Diversion Ditches. A summary table of the minimum channel geometry, channel slope, peak discharge, minimum riprap requirements, maximum flow velocity and minimum freeboard values for each diversion ditch within the facilities area is presented in Table 7-8. All calculations are contained in Appendix 7-9. Within the main facility area, diversion ditches will generally be lined with concrete if required for erosion protection, thereby aiding long-term maintenance of the ditches. Each ditch has adequate capacity and erosion protection to safely pass the peak flow resulting from the 10-year, 24-hour precipitation event. A description of the diversion ditches within the facilities area is presented in Section 732.300.

Diversion Culverts. A summary table of the culvert size, slope, peak discharge, outlet riprap, and outlet flow velocity for each culvert within the facilities area is presented in Table 7-9.

All calculations are contained in Appendix 7-9. Except for culverts UC-6 and UC-5, each culvert has adequate capacity and outlet erosion protection to safely pass the peak flow resulting from the 10-year, 24-hour precipitation event. Culverts UC-6 and UC-5 were designed to convey the peak runoff resulting from the 100-year, 6-hour precipitation event. A description of the diversion culverts within the facilities area is presented in Section 732.300.

Diversion Berms. Although several berms are noted on Plate 7-5, these will be installed primarily to meet MSHA requirements for safety concerns adjacent to slopes. However, these berms may also locally convey runoff from higher-elevation pads to lower-elevation pads, where it will be conveyed via diversion ditches to the sedimentation pond. Since none of the berms have been designed specifically to convey runoff, no calculations concerning the hydraulic characteristics of these berms are provided in Appendix 7-9.

742.400 Road Drainage

All Roads. The proposed roads within the facilities area are the county road which accesses the mine site and the additional roads noted on Plate 5-2. All of the roads will be constructed to include adequate drainage control with the use of diversion ditches and culverts. None of these roads are located in the channel of an intermittent or perennial stream. Control structures have been located to minimize downstream sedimentation and flooding. Diversion ditches and culverts for all roads are described in Section 732.300.

A generic cross section showing a typical diversion ditch adjacent to a road is provided in Figure 5-1. This cross section is typical of the ditches to be installed at the Dugout Canyon Mine. As noted in Table 7-8, each of the ditches to be installed at the site will have positive freeboard when flowing at the design rate. Hence, the ditches have been designed to avoid spreading of water on the adjacent roads during the design event.

Primary Roads. The location of primary roads is discussed in Section 527 and presented on Plate 5-2 of this M&RP. The county road which accesses the mine site will be located by Carbon County, where practical, along the alignment of the existing dirt road to minimize erosion and be on stable ground. The access road will not ford Dugout Creek. However, prior to entering the disturbed area, the county road will cross Dugout Creek using a 10' diameter circular corrugated metal pipe culvert with headwalls. As this culvert is located outside the disturbed area boundary and part of the county road, design of this structure was handled by Carbon County. Within the disturbed area, Dugout Creek will be diverted through culverts UC-5 and UC-6 to prevent uncontrolled sediment from reaching the stream and to allow for efficient use of the site. A riprap-lined energy dissipater will be constructed downstream from the outlet of culvert UC-6 to withstand the peak flow from a 100-year, 6-hour storm event. Calculations regarding the design of the energy dissipater can be found in Appendix 7-9.

The drainage control system for the primary roads within the permit area includes diversion ditches and culverts. Except for culverts UC-5 and UC-6, the diversions will adequately pass the peak runoff from the 10-year, 24-hour precipitation event. Culverts UC-6 and UC-5 have been designed to convey the peak flow resulting from the 100-year, 6-hour precipitation event. Culverts will be constructed to avoid plugging or collapse and erosion at the inlet or outlet. Drainage details for the access road are presented in Section 732.300.

Pace Canyon Road

Runoff and erosion on the road will be controlled by the use of water bars. The water bars will divert any runoff from the road before an erosive volume of water can accumulate. Four water bars will be placed approximately 200 feet apart on the road. The water bars were placed as shown on Figure 7-12A. The first water bar will be placed approximately 5 feet upgradient of the start of the realigned road to prevent any runoff rom the existing road from flowing onto the road. The other three water bars will divert any runoff that has fallen on the realigned road off the road into well vegetated areas. Due to the berm running parallel to the road only precipitation falling directly on the realigned road could impact the road. Therefore, very little runoff is expected to be generated. The little runoff generated by the realigned road will be controlled by the water bars.

743 Impoundments

All pertinent information regarding the sedimentation pond is presented in Sections 732.200 and 742.200.

744 Discharge Structures

The discharge structures within the permit area will be the primary and emergency spillways on the sedimentation pond and a discharge line from the underground workings. The spillways on the sedimentation pond will adequately pass the peak discharge from the 25-year, 6-hour precipitation event. Detailed information concerning the sedimentation pond is presented in Sections 732.200 and 742.200.

The primary spillway on the sedimentation pond will consist of a 24-inch steel riser with an oil-skimmer connected to a 24-inch diameter CMP barrel. The emergency spillway will consist of a riprap-lined open channel. The spillways will discharge directly to Dugout Creek. The design calculations for the spillways are presented in Appendix 7-8. The spillway details are presented on Plate 7-4.

744.100 Erosion Protection

The only discharge structures associated with an impoundment will be the spillways from the sedimentation pond. The primary spillway will consist of a 24-inch riser connected to a 24-inch diameter CMP barrel. The 24-inch CMP barrel will discharge directly to Dugout Creek. The slope of the 24-inch CMP barrel has been designed to be 2.2%. The peak discharge from the sedimentation pond during a 25-year, 6-hour storm event is 3.93 cfs. The flow velocity at the spillway outlet under peak flow conditions is 4.50 fps. This velocity is not considered to be erosive. The natural channel will be evaluated during construction to verify that materials in the native channel can withstand the projected peak flow velocity. The calculations for the spillway outlet are presented in Appendix 7-8.

744.200 Design Standards

All discharge structures within the permit area have been designed and will be constructed according to standard engineering procedures.

745 Disposal of Excess Spoil

There will be no excess spoil within the permit area.

746 Coal Mine Waste

746.100 General Requirements

All coal mine waste will be placed in a controlled manner to minimize adverse effects of leachate and surface water runoff on surface and groundwater quality and quantity. This waste will be placed in the Dugout, SUFCo or Skyline waste-rock disposal facility as described in Chapter 5.

746.200 Refuse Piles

A detailed description of the refuse piles at the Dugout, SUFCo and Skyline waste-rock disposal sites can be found in their respective M&RPs.

746.300 Impounding Structures

No impounding structures within the permit area will be constructed of coal mine waste or used to impound coal mine waste.

746.400 Return of Coal Processing Waste to Abandoned Underground Workings

No coal processing waste will be generated in the permit area.

747 Disposal of Noncoal Mine Waste

Disposal of noncoal mine waste is discussed in Chapter 5.

748 Casing and Sealing of Wells

Each water well has been cased, sealed, or otherwise managed, as approved by the Division, to prevent acid or other toxic drainage from entering ground or surface water, to minimize disturbance to the hydrologic balance, and to ensure the safety of people, livestock, fish and wildlife, and machinery in the permit and adjacent area. The drill logs and completion diagrams for the water wells are contained in Appendix 7-4.

If a water well is exposed by coal mining and reclamation operations, it will be permanently closed unless otherwise managed in a manner approved by the Division.

750 PERFORMANCE STANDARDS

All mining and reclamation operations will be conducted to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area, and support approved post-mining land uses.

751 Water Quality Standards and Effluent Limitations

Discharges of water from disturbed areas will be in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining contained in 40 CFR Part 434.

752 Sediment Control Measures

All sediment control measures will be located, maintained, constructed and reclaimed according to plans and designs presented in Sections 732, 742, and 760 of this M&RP.

A sediment trap was constructed in the ditch on the southeast side of the disturbed area as shown on Figure 1 in Addendum A to Appendix 7-9. The trap was installed to collect sediment prior to it reaching the pond, therefore requiring less frequent sediment pond cleaning. The sediment trap has been fully designed to pass design flows, regardless of the quantity of sediment and/or ice collected in the trap. Sediment accumulations within the trap would not be considered a compliance concern. If the trap is unable to direct the water to the pond through culvert DC-11 (24" CMP), the water will flow through the trap and proceed down the existing ditch into the sediment pond.

A sediment basin was constructed above the inlet to culvert DC-10. The function of the sediment basin and sediment trap will be the same, both will pass the design flow regardless of the quantity of sediment in the trap/basin and sediment accumulation will not be a compliance concern. The trap/basin designs are located in Addendum A to Appendix 7-9.

A sediment trap was constructed in association with the Pace Canyon Fan Portal site. Contemporaneous reclamation and gravel should adequately control sediment at the site, with the sediment trap providing an extra measure of protection. Details regarding this sediment trap can be found in Appendix 7-12.

752.100 Siltation Structures and Diversions

Siltation structures and diversions will be located, maintained, constructed and reclaimed according to plans and designs presented in Sections 732, 742, and 763 of this M&RP.

752.200 Road Drainage

All roads will be located, designed, constructed, reconstructed, used, maintained and reclaimed according to plans and designs presented in Sections 732.400, 742.400, and 762 of this M&RP. All roads have been designed to:

- Control or prevent erosion, siltation and the air pollution attendant to erosion by vegetating or otherwise stabilizing all exposed surfaces in accordance with current, prudent engineering practices;
- Control or prevent additional contributions of suspended solids to stream flow or runoff outside the permit area;
- Neither cause nor contribute to, directly or indirectly, the violation of effluent standards given under Section 751;
- Minimize the diminution to or degradation of the quality or quantity of surface- and groundwater systems; and
- Refrain from significantly altering the normal flow of water in streambeds or drainage channels.

753 Impoundments and Discharge Structures

Impoundments and discharge structures will be located, maintained, constructed and reclaimed as described in Sections 733, 734, 743, 745, and 760 of this M&RP.

754 Disposal of Excess Spoil, Coal Mine Waste and Noncoal Mine Waste

Disposal areas for coal mine waste and noncoal mine waste will be located, maintained, constructed and reclaimed as described in Sections 736, 737, 746, 747, 760 and Chapter 5 of this M&RP.

755 Casing and Sealing of Wells

All wells will be managed as described in Sections 551, 748 and 765 of this M&RP.

760 RECLAMATION

761 General Requirements

A detailed reclamation plan for the mine is presented in Section 540. In general, SCM will ensure that all temporary structures are removed and reclaimed. Other than for restoration of natural drainage patterns and drainage features associated with the water-tank access road (which will be retained for access to private land as part of the post-mining land use), no permanent diversions are included in the reclamation plan.

762 Roads

A road not to be retained for use under an approved post-mining land use will be reclaimed immediately after it is no longer needed for coal mining and reclamation operations.

762.100 Restoring the Natural Drainage Patterns

All natural drainage patterns will be restored during reclamation. Details regarding the reclamation of stream channels are provided in Appendix 7-11. As noted in that appendix and on Plate 5-5, the following channels will be restored during reclamation:

Channel	Location
RD-1	Upstream ephemeral tributary on the west side of Dugout Creek
RD-2	Middle ephemeral tributary on the west side of Dugout Creek
RD-3	Eastern perennial tributary of Dugout Creek
RD-4	Upper Dugout Creek
RD-5	Dugout Creek below confluence of RD-3 and RD-4
RD-6	Ephemeral channel across the reclaimed survey monument access road
RD-7	Upstream ephemeral tributary on the east side of Dugout Creek
RD-8	Middle ephemeral tributary on the east side of Dugout Creek
RD-9	Downstream ephemeral tributary on the west side of Dugout Creek
RD-10	Downstream ephemeral tributary on the east side of Dugout Creek

In accordance with R645-301-742.333, channels RD-1, RD-2, and RD-6 through RD-10 were designed to safely convey the peak flow resulting from the 10-year, 6-hour precipitation event. With the exception of RD-10, each channel was designed with a bottom width of 1 foot, a channel depth of 1 foot, 2H:1V side slopes, and a median riprap diameter of 3 inches. The riprap will be installed in these ephemeral drainages as an extra erosion-protection measure, even though design velocities are not expected to be erosive. RD-10 was designed with a similar cross section, but with a median riprap diameter of 6 inches.

During reclamation of the Pace Canyon Fan Portal Site two drainages will be affected. Both drainages had been disturbed by the road building activities prior to the construction of the Dugout Canyon Mine and Pace Canyon Fan Portal Facilities. In both drainages a section of the channel had been destroyed by the road construction. During reclamation these drainages will be reestablished. Reclamation channel PCRD-1 will be constructed in the drainage south of the portal with the exception of where the channel crosses the road. At the road crossing a swale will be constructed. The swale will have side slopes of 7.5:1 and a depth of 1 foot. Reclamation channel PCRD-1 will be constructed with a bottom width of 2.5 feet, side slopes of 2:1, depth of 1 foot and D_{50} = 6 inch riprap. The reclaimed channel (PCRD-1) will follow the preexisting natural channel meanders where a natural channel exists. Upper portions of the reconstructed channel will be constructed on native materials while lower portions of the channel will be constructed on regarded materials. The top and bottom of the reconstructed channel will tie into the natural undisturbed channel. The culvert in the drainage north of the site will be replaced by a swale with a bottom width of 5 feet, side slopes of 7.5:1 and a depth of 1 foot. In accordance with R645-301-742.333, these channels were designed to safely convey the peak flow resulting from the 10-year, 6-hour precipitation event. See Plate PC5-5 in Appendix 5-10 and Attachment 3 in Appendix 7-12 for the reclamation channel location and calculations respectively.

As a result of pre-SMCRA disturbances at the site, Dugout Creek and its eastern tributary have experienced significant instability. This instability is especially noteworthy in a 300-foot section of Dugout Creek near the central portion of the proposed disturbed area. In this section, past blockage of a culvert installed by prior operators resulted in a re-routing of the creek, together with extensive downcutting (both up- and downstream from the blockage) and erosion of the site. The results of this damage are evident throughout, as well as up- and downstream from, the proposed disturbed area as headcutting and deposition have occurred.

SCM is committed to restoring the Dugout Creek channel to a more natural functioning condition as a result of site reclamation. In an effort to determine the best means for accomplishing this channel restoration, Dugout Creek was evaluated within the proposed disturbed and adjacent areas by Mr. Galen W. Williams of EarthFax Engineering, Inc. Mr. Williams, who is a registered Professional Geologist in the state of Wyoming, received a Master of Science degree in Applied Geomorphology from the University of Utah in 1981. Since that time, he has performed multiple stream and river channel morphology studies as they relate to proposed hydroelectric projects and dams. His geographical area of expertise includes Utah, Idaho, Oregon, Washington, and Hawaii. Past work performed by Mr. Williams has included evaluations of the long-term morphological changes which occur to streams as a result of water development, including the development of designs to minimize the impacts of reduced flows resulting from diversion into penstocks and increased flows downstream from spillways and hydroelectric plant discharges.

Mr. Williams concluded from his site visit that Dugout Creek can currently be classified as a Type A4 stream (using the stream classification system of Rosgen, 1996). The "A" in the classification indicates that this stream type is generally entrenched and is characterized by a steep gradient (typically 4 to 10 percent) with a low width-to-depth ratio and low sinuosity. The "4" in the classification indicates that the channel material is generally composed of gravel, with lesser amounts of boulders, cobbles, sand, and fines. In its current form, the channel is very unstable and appears to be undergoing frequent change. Based on measurements collected by Mr. Williams in the existing truncated bend of the stream within the proposed disturbed area (i.e., that section of the stream which was largely abandoned when the upstream culvert blockage occurred), the natural stream at bankfull stage had a width of approximately 3 feet and a depth at the thalweg of approximately 1 foot within the disturbed area. This low-flow channel exists within a larger channel that has a width of approximately 8 to 12 feet at the top of the low-flow channel.

Mr. Williams concluded from his field observations that the high-energy system associated with Dugout Creek will require the establishment of a stable macro channel during reclamation to provide protection against mass wasting of the site by future runoff events. Within this macro channel, however, the formation of a micro channel should be encouraged through the establishment of selectively-placed "obstructions," such as boulders and logs which are anchored into the bank.

Mr. Williams cautioned that, due to the high energy associated with the Dugout Creek system, it would not be wise to physically construct a low-flow channel within the macro channel. To do so would likely be futile, since it would be essentially impossible to predetermine the morphological hydraulics of the micro system which would best fit the site. Hence, he recommended that the enhancement features be placed during reclamation, then allowing the stream to deposit sediment upstream from the obstructions. By this action, the stream would construct its own micro channel, with its associated "step-pool" system which is typical of Type A streams. If future runoff events cause variations within the micro system, Mr. Williams concluded that these changes will be in keeping with the morphological processes which are also typical of Type A streams. However, with the stability provided by the macro channel, the site should be protected, even if minor local changes occur within the reclaimed reaches of Dugout Creek.

To accomplish the above morphological goals, Dugout Creek will be reclaimed by first constructing a riprap-lined macro channel to serve as a stable base for future flows. Thus, the macro portion of channels RD-3, RD-4, and RD-5 have been designed to safely convey the peak flow resulting from the 100-year, 6-hour precipitation event (in accordance with R645-301-742.323). Both RD-3 and RD-4 were designed with a bottom width of 8 feet, a depth of 3 feet, and 2H:1V side slopes. The macro portion of each channel has been designed with a median riprap diameter of 12 inches. The macro portion of channel RD-5 (downstream from the confluence of RD-3 and RD-4) was designed with a bottom width of 8 feet, a depth of 4 feet, and 2H:1V side slopes.

The cross sections for all reclamation channels were designed using the minimum channel slope, while riprap sizing was designed using the maximum channel slope. Reclamation slopes were estimated from the topographic contours provided in Plate 5-5. In each case, the thickness of the installed riprap will be equal to twice the median diameter or 6 inches, whichever is greater. Sand filter blankets will be installed beneath the riprap at a thickness equal to one-half the thickness of the riprap or 6 inches, whichever is greater. Calculations indicating the expected volume of riprap and filter materials are provided in Appendix 7-11.

Since the site materials will be reworked during construction of the facility, pre-construction samples of channel bed materials would not likely be representative of reclamation conditions. Hence, no information is presented in this M&RP regarding filter blanket sizing. Following regrading of the materials at the location of each reclamation channel, and prior to installation of the riprap, samples of the bed material will be collected and analyzed to determine soil gradations. The filter blanket will then be sized in accordance with standard practices at the time (e.g., Barfield et al., 1981) to determine the thickness and gradation of filter blanket materials.

Upon construction of the macro channel, the stream type will change from an A4 to an A3 classification (the latter being a Type A stream, with the bed materials changing from predominantly gravel to primarily cobbles). According to Rosgen (1996) the following stream-channel stability enhancements are rated as fair to good when applied to an A3 stream:

- Low-stage check dams
- Bank-placed boulders
- Rock or log spurs

Figure 7-12 provides typical drawings of the above applications.

Rosgen (1996) also lists other applications which are appropriate for the enhancement of fish habitat in Type A3 streams. However, since Dugout Creek is not a fishery, only the above applications are considered appropriate.

As noted previously, Dugout Creek is estimated to have had a bankfull stage of approximately 1 foot within the low-flow (micro) channel prior to the damage created by the blocked culvert. Hence, to restore the channel to a more natural condition, the stream-channel stability enhancements noted above will be installed during reclamation to allow for the local upstream accumulation of approximately 1 foot of sediment. As the stream deposits the sediment behind the obstructions and cuts the micro channel, this will create an overbank flow section which will approximate natural conditions. Vegetation which becomes established on these overbank sections will aid in stabilizing them. Furthermore, with 2H:1V sideslopes on the macro channel, the macro channel will have a width of 12 feet at the top of the accumulated sediment in which the micro channel has formed. This 12-foot width is consistent with the dimensions of the natural channel as noted above.

According to Heede (1976), within the range of channel gradients anticipated for RD-3, RD-4, and RD-5, the slope of sediment deposits behind a channel obstruction are approximately 70 percent of the slope of the underlying channel. Based on a typical reclaimed channel slope of 5 percent (see Plate 5-5), the sediment deposits will have a surface slope of approximately 3.5 percent. Using equations developed by Heede (1976), these channel and sediment slopes indicate that placing the obstructions at an approximate spacing of every 60 feet will keep the upstream feature from being submerged by the sediment which accumulates behind the downstream feature (see Appendix 7-11). This approximate spacing will be used to place the stability features in RD-3, RD-4, and RD-5.

Plate 7-9 provides details concerning the proposed layout of the main reclamation channel at the site, including potential locations of the low-stage check dams, bank-placed boulders, and rock or log spurs. The exact location and type of obstruction at any individual point may vary from that indicated on Plate 7-9, depending on local conditions encountered at the time of reclamation. However, in any case, obstructions of the type noted above will be installed approximately every 60 feet within the reclaimed channel.

In general, Plate 7-9 indicates that the log or rock spurs noted in Figure 7-12 will be installed on sweeping bends in RD-5, with the spur pointing upstream at an angle of 20 to 30 degrees, as recommended by Rosgen (1996). The low-stage check dams and bank-placed boulders will be interspersed in the remaining locations of the stream. Based on a review of conditions in the abandoned portion of the natural stream channel, more bank-placed boulder enhancements will be used than low-stage check dams.

Table 7-10 presents an evaluation of the stability of Dugout Creek in its January 1998 condition and its predicted post-reclamation condition. This evaluation was prepared using the Pfankuch method as presented by Rosgen (1996). According to Table 7-10, the reclamation efforts presented herein will improve the stability of Dugout Creek from an overall rating of "poor" to a rating of "excellent." Furthermore, with the installation of the micro-channel features, the stream will be returned to a morphological condition which approximates its assumed pre-mining condition. Hence, the reclamation efforts described herein will result in a significant improvement to Dugout Creek.

The reclamation channels will be constructed in each area as soon as regrading of the area has been completed, but prior to placement of topsoil and revegetation. Channel construction will generally proceed from the upstream end to the downstream end. Where channels RD-1, RD-2, and RD-9 cross the road that will be retained following reclamation, the side slopes may be flattened to permit vehicular access across the channel. However, the minimum depths and cross sections noted above will be maintained in any case.

As noted on Plate 5-5, the reclamation channels will be aligned in their assumed premining locations. Of particular note, channel RD-5 will be aligned to follow the assumed premining meanders, even though the primary bypass culvert will be installed along a straighter path.

No toxic- or acid-forming materials will be used to grade areas where reclamation channels will be constructed. Furthermore, neither construction debris, nor grease, oil, joint coating, or other potential pollutants will be disposed of in areas underlying reclamation channels. Construction materials, bedding material, excavated soil, etc. will not be stockpiled in riparian or channel areas during reclamation.

Buffer Zone Designation. As part of the post-mining land use, an existing public road will be relocated across the reclaimed mine site. Due to the narrowness of the canyon, a portion of the road alignment will be located within the 100 foot zone that would normally be designated as a buffer zone for Dugout Creek. Following reclamation, the area surrounding the reconstructed Dugout Creek Channel that is not to be used for the public road will be designated as a buffer zone until bond release, and SCM will mark those zones, as specified in Section 521.200 of this M&RP.

762.200 Reshaping Cut and Fill Slopes

All cut and fill slopes will be reshaped to be compatible with the post-mining land use and to complement the drainage pattern of the surrounding terrain.

763 Siltation Structures

763.100 Maintenance of Siltation Structures

All siltation structures will be maintained until removed in accordance with the approved reclamation plan.

763.200 Removal of Siltation Structures

When a siltation structure is removed, the land on which the siltation structure was located will be regraded and revegetated in accordance with the reclamation plan presented in Section 540.

764 Structure Removal

A timetable for the removal of structures at the site is presented in Figure 5-3.

765 Permanent Casing and Sealing of Wells

When no longer needed for monitoring or other use approved by the Division upon a finding of no adverse environmental or health and safety effects, or unless approved for transfer as a water well, each well will be capped, sealed, backfilled, or otherwise properly managed, as required by the Division. Permanent closure measures will be designed to prevent access to the mine workings by people, livestock, fish and wildlife, machinery and to keep acid or other toxic drainage from entering ground or surface waters.

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TABLE 7-1

OBSERVATION WELL COMPLETION SUMMARY[(a)]

Well Number	Total Drilled Depth (ft)	Elev. Top of Casing (ft)	Casing ID (in)	Length of Perf. (ft)	Formation Monitored
GW-5-1	1,826	7,186.4	5	22	Blackhawk
GW-6-1	2,180	7,724.7	5	200	Blackhawk
GW-10-2	2,084	7,727.4	5	250	Castlegate
GW-11-2	2,399	8,203.8	5	175	Price River
GW-19-1	2,050	8,258.2	4	364	North Horn, Price River, Castlegate, Blackhawk
GW-24-1*	1,706	8,422.0	4	100	Castlegate
GW-32-1	2,360	7,152.1	2.5	50	Blackhawk
G-58.5	3,177	7,398	8.5	5	Blackhawk

(a) See Plate 7-1 for well locations.

* Monitoring discontinued 4th Quarter 2004 due to blockage.

TABLE7-2

HYDROLOGIC MONITORING SUMMARY

Site	Location	Elevation	Geo Unit	# Sam	Dates	# Sol. Anyl.	Data Source	Other Designations
SPRING SAMPLING SITES								
SC-11		8000	Flagstaff	2	9/95 to 10/95	0	6,8	
SC-12		8260	Flagstaff	2	9/95 to 10/95	0	6,8	
SC-13		8200	Flagstaff	2	9/95 to 10/95	0	6,8	
SC-14		8120	North Horn	2	9/95 to 10/95	0	6,8	
SC-15		8080	North Horn	2	9/95 to 10/95	0	6,8	
SC-16		8080	North Horn	2	9/95 to 10/95	0	6,8	
SC-17		7800	North Horn	2	9/95 to 10/95	0	6,8	
SC-18		7960	North Horn	2	9/95 to 10/95	0	6,8	
SC-41		7920	Flagstaff	2	7/76 to 10/95	0	6,8	
SC-41A		7880	Flagstaff	2	9/95 to 10/95	0	6,8	
SC-45		7680	Colton	2	9/95 to 10/95	0	6,8	
SC-46		7680	Colton	2	9/95 to 10/95	0	6,8	
SC-50		8380	Colton	2	7/76 to 10/95	0	6,8	
SC-58		8080	Flagstaff	2	9/95 to 10/95	0	6,8	
SC-59		7880	Flagstaff	2	9/95 to 10/95	0	6,8	
SC-61		6960	Blackhawk	2	9/95 to 10/95	0	6,8	
SC-62		6880	Blackhawk	2	9/95 to 10/95	0	6,8	
SC-64		6400	Starpoint	2	9/95 to 10/95	0	6,8	
SC-65		8200	Colton	2	7/76 to 10/95	0	6,8	
SC-80		7400	Castlegate	2	9/95 to 10/95	0	8	
SC-81		7360	Castlegate	2	9/95 to 10/95	0	8	
SC-82		8000	Flagstaff	2	9/95 to 10/95	0	8	
SC-83		7960	Flagstaff	2	9/95 to 10/95	0	8	
SC-84		8000	Flagstaff	2	9/95 to 10/95	0	8	
SC-85		8050	Flagstaff	2	9/95 to 10/95	0	8	
SC-86		8140	Flagstaff	2	9/95 to 10/95	0	8	
SC-87		7640	North Horn	1	9/95	0	8	
SC-88		7960	Flagstaff	2	9/95 to 10/95	0	8	
SC-89		8040	Flagstaff	3	9/95 to 10/98	0	8	
SC 90		7760	North Horn	3	9/95 to 10/98	0	8	

TABLE 7-2 (CONTINUED)

HYDROLOGIC MONITORING SUMMARY

Site	Location	Elevation	Geo Unit	# Sam	Dates	# Sol. Anyl.	Data Source	Other Designations
SC-91		7620	North Horn	3	9/95 to 10/98	0	8	
SC-92		7620	North Horn	1	9/95	0	8	
SC-92A		7665	North Horn	1	10/98	0	11	
SC-93		7820	North Horn	3	9/95 to 10/98	0	8	
SC-94		7920	North Horn	2	9/95 to 10/95	0	8	
SC-95		7840	North Horn	2	9/95 to 10/98	0	8	
SC-96		7800	North Horn	1	9/95	0	8	
SC-97		7800	North Horn	2	9/95 to 10/95	0	8	
SC-98		7840	North Horn	3	9/95 to 10/98	0	8	
SC-99		8380	Colton	2	9/95 to 10/95	0	8	
SC-100		7860	Flagstaff	2	9/95 to 10/95	0	8	
SC-101		7860	Flagstaff	2	9/95 to 10/95	0	8	
SC-102		7620	North Horn	2	9/95 to 10/95	0	8	
SC-103		7920	Flagstaff	2	9/95 to 10/95	0	8	
SC-104		7940	Flagstaff	2	9/95 to 10/95	0	8	
SC-105		7960	Flagstaff	2	9/95 to 10/95	0	8	
SC-106		7780	North Horn	2	10/95	0	8	
SC-107		7920	North Horn	2	10/95 to 10/98	0	8	
SC-108		8080	North Horn	1	10/95	0	8	
SC-109		8120	Flagstaff	2	10/95 to 10/98	0	8	
SC-110		8380	Flagstaff	2	10/95 to 10/98	0	8	
SC-111		8360	Flagstaff	2	10/95 to 10/98	0	8	
SC-112		8280	Flagstaff	2	10/95 to 10/98	0	8	
SC-113		8000	Flagstaff	1	10/95	0	8	
SC-114		8020	Flagstaff	2	9/95 to 10/95	0	8	
SC-115		8040	Flagstaff	1	10/95	0	8	
SC-116		7780	North Horn	2	10/95	0	8	
SC-200		7960	North Horn	1	9/95	0	8	
SC-201		7800	North Horn	1	9/95	0	8	
SC-202		7800	Castlegate	1	9/95	0	8	
SC-203		7920	North Horn	1	9/95	0	8	

TABLE 7-2 (CONTINUED)

HYDROLOGIC MONITORING SUMMARY

Site	Location	Elevation	Geo Unit	# Sam.	Dates	# Sol. Anyl.	Data Source	Other Designations
204		7849	North Horn	1	9/95	0	8	
205		7920	North Horn	1	9/95	0	8	
206		8120	North Horn	1	9/95	0	8	
207		8120	North Horn	1	9/95	0	8	
208		8120	North Horn	1	9/95	0	8	
209		8200	North Horn	1	9/95	0	8	
210		8400	Colton	1	9/95	0	8	
211		8640	Colton	1	9/95	0	8	
212		8640	Colton	1	9/95	0	8	
213		8240	Colton	1	9/95	0	8	
214		8320	Colton	1	9/95	0	8	
226		7890	North Horn	1	9/95	0	8	
227		7280	Castlegate	1	9/95	0	8	
228		7600	Price River	1	9/95	0	8	
258		8159	Flagstaff?	1	9/95	0	8	
259		8020	North Horn	1	9/95	0	8	
260		8657	Colton	1	9/95	0	8	
261		8499	Colton	1	9/95	0	8	
262		8407	Colton	1	9/95	0	8	
263		8211	Colton	1	9/95	0	8	
SP-2	(D-12-12) 30dcc	7560	North Horn	1	7/76	0	6	53 on data source 6
SP-3	(D-12-12) 33bcc	7400	Flagstaff	21	8/76 to 10/95	0	1,6,8	54 on data source 6
SP-[illegible]	(D-12-12) 34ccd	7605	Flagstaff	20	6/85 to 10/95	7	1,7,8	3 on data source 6
SP-7	(D-13-12) 4acd	7480	Flagstaff	2	9/95 to 10/95	0	6,7,8	57 on data source 6, G-87 on data source 7
SP-8	(D-13-12) 4bdc	7410	Flagstaff	29	7/76 to 10/95	26	1,6,7,8	2 on data source 6, G-88 on data source 7
SP-9	(D-13-12) 4cdd	7910	Flagstaff	3	6/76 to 10/95	0	6,8	33 on data source 6
SP-10	(D-13-12) 5cbc	6980	North Horn	53	6/76 to 11/93	29	1,2,4,6,9	Sulfur Spring, 8 on data source 6, G-89 on data source 2
SP-11	(D-13-12) 5cbc	6980	North Horn	1	6/76	0	6	24 on data source 6
SP-12	(D-13-12) 5ccb	6970	North Horn	1	6/76	0	6	9 on data source 6
SP-13	(D-13-12) 7aad	6880	North Horn	3	6/76 to 10/95	0	6,8	10 on data source 6
SP-15	(D-13-12) 8daa	7900	Flagstaff	44	7/76 to 10/95	12	1,4,5,6,7,8	Lower Little Pine Spring, 39 on data source 6

TABLE 7-2 (CONTINUED)

HYDROLOGIC MONITORING SUMMARY

Site	Location	Elevation	Geo Unit	# Sam	Dates	# Sol. Anyl.	Data Source	Other Designations
SP-16	(D-13-12) 8dad	7840	North Horn	3	7/76 to 10/95	0	6,8	Timber Road Spring, 38 on data source 6
SP-17	(D-13-12) 9cbb	7940	Flagstaff	7	7/76 to 10/95	3	1,2,6,8	40 on data source 6, G-90/S8-1 on data source 2
SP-18	(D-13-12) 9dcc	8120	Flagstaff	29	6/76 to 10/95	7	1,2,6,8	31 on data source 6, G-91 on data source 2
SP-19	(D-13-12) 9dcc	8090	Flagstaff	3	6/76 to 10/95	0	6,8	32 on data source 6
SP-20	(D-13-12) 9ddc	8090	Flagstaff	32	6/76 to 10/95	15	1,2,6,8,9	30 on data source 6, G-92 on data source 2
SP-21	(D-13-12) 10abb	7740	Flagstaff	37	6/76 to 10/95	11	1,2,6,7,8	Water Hole, 4 on data source 6, G-93 on data source 2
SP-22	(D-13-12) 10adb	7870	Flagstaff	23	7/76 to 10/95	3	2,6,8,9	Pine Canyon Spring, 42 on data source 6, G-94 on data source 2
G-95	(D-13-12) 11acd-S1	8000	Flagstaff	3	7/80 to 10/95	1	2,8	
G-96	(D-13-12) 12adb-S1	8060	Colton	2	7/80 to 9/95	1	2,8	
G-97	(D-13-12) 12cbb-S1	7920	Flagstaff	3	7/80 to 10/95	1	2,8	
G-100	(D-13-12) 23cbb-S1	6920	Blackhawk	3	7/80 to 10/95	1	2,8	
SURFACE WATER SAMPLING SITES								
G-1	(D-12-12) 33bba	7195	--	17	6/87 to 8/93	17	1,7	Soldier Creek
G-2	(D-13-12) 3cbb	7500	--	13	6/87 to 8/93	12	1,7	Pine Creek
G-3	(D-13-12) 5cbc	6995	--	43	6/76 to 10/85	17	9,7	Pine Creek, 23 on data source 6, S-52 on data source 7
G-4	(D-13-12) 5ccb	6995	--	85	6/76 to 12/86	30	1,5,7,9	22 on data source 6, Same as SC3 E-22
G-5	(D-13-12) 18acd	6595	--	70	10/79 to 11/93	44	1,7,9	73 on data source 6, S-59 on data source 7, Same as SC3 E-18
DC-1	(D-13-12) 23ccb	6960	--	17	7/76 to 8/81	17	2,9	S60 on data source 2
DC-2	(D-13-12) 23bac	7050	--	3	9/98 to 3/99	3	10	
DC-3	(D-13-12) 23bda	7050	--	3	9/98 to 3/99	3	10	
PC-1	(D-13-13) 19ddb	7260	--	12	4/78 to 10/79	3	6	
PC-1a	(D-13-13) 21cda	8040	--	2	3/99 to 6/99	2	10	
PC-2	(D-13-13) 30bbd	6885	--	15	4/78 to 6/99	11	6, 10	
RC-1	(D-13-13) 29cdd	7000	--	2	3/99 to 6/99	0	10	
UNDERGROUND MONITORING SITES (SOLDIER CANYON MINE)								
UG-ME			Blackhawk	5	8/89 to 8/90	1	1,7	
UG-1N			Blackhawk	17	1/90 to 11/93	5	1,7	
UG-2R			Blackhawk	27	6/85 to 2/89	10	1,7	
UG-8N			Blackhawk	18	6/85 to 11/86	9	1,7	
UG-8N BELT			Blackhawk	13	11/85 to 11/86	7	1,7	

TABLE 7-2 (CONTINUED)

HYDROLOGIC MONITORING SUMMARY

Site	Location	Elevation	Geo Unit	# Sam	Dates	# Sol. Anyl.	Data Source	Other Designations
UG-2N2E			Blackhawk	18	5/85 to 11/86	9	1,7	
UG-3N8E			Blackhawk	29	11/85 to 11/90	9	1,7	
UG-5E			Blackhawk	5	9/92 to 2/93	1	1,7	
UG-10E			Blackhawk	22	5/88 to 2/93	6	1,7	
UG-11E			Blackhawk	19	11/90 to 11/93	4	1,7	
UG-SHAFT			Blackhawk	34	6/85 to 11/90	14	1,7	
UG-3W			Blackhawk	10	2/92 to 11/93	3	1	
UG-MN3W (AREA)			Blackhawk	18	6/85 to 11/86	9	1,7	
MAYO AND ASSOCIATES FEBRUARY 1995 SAMPLING (SOLDIER CANYON MINE AND FORMER DUGOUT CANYON WORKINGS)								
UG-DH-SC38			Blackhawk	1	2/95	1	4	
UG-ME X-Cut 7			Blackhawk	1	2/95	1	4	
UG-12th West			Blackhawk	1	2/95	1	4	
UG-DH-SC12G			Blackhawk	1	2/95	1	4	
UG-8th West			Blackhawk	1	2/95	1	4	
UG-11th East			Blackhawk	1	2/95	1	4	
UG-Degas Hole			Blackhawk	1	2/95	1	4	Same as SC3 UG-11E
UG-3rd W. Pillar Area			Blackhawk	1	2/95	1	4	
Gilson Seam West	(D-13-12) 23bcd		Blackhawk	1	5/95	1	4	

DATA SOURCES

1 Soldier Creek Coal Company Annual Reports
2 Hydrology of the Price River Basin, 1986 U.S. Geological Survey Report
3 1993 EIS and 1994 Alkali Creek Spring and Seep Survey
4 Mayo and Associates 1995 Sampling
5 1980 Hydrologic Inventory Report, Vaughn Hansen Associates
6 Sage Point Permit Application
7 Soldier Canyon Mine Permit Application
8 EarthFax Engineering 1995 Seep and Spring Survey
9 Eureka Energy Company Water Quality Monitoring Logs
10 Dugout Canyon Mine
11 EarthFax Engineering 1998 Seep and Spring Survey

TABLE 7-3

HYDROGRAPH CHARACTERISTICS OF SELECTED SPRINGS ISSUING FROM THE FLAGSTAFF FORMATION[a]

Spring	Slope of Recession[b]		Range of Discharge[c]		No. of Observations
	S1	S2	Minimum	Maximum	
SP-8	37	--	0	3.9	5
SP-17	53	--	0	112	6
SP-18	42	105	3.3	125	8
SP-20	78	209	7.1	89	9
SP-21	73	263	13	249	8
SP-22	115	251	13	76	8
G-95	79	295	15	97	8
G-97	43	352	1.6	89	8

(a) Source: Waddell et al. (1986)
(b) Days per log cycle
(c) Gallons per minute

TABLE 7-4
Groundwater Monitoring Program
Field and Laboratory Measurement Protocol

Monitoring Wells	Protocol	Comments
GW-10-2	A, 1	Screened in Castlegate Sandstone
GW-11-2	A, 1	Screened in Price River Formation
GW-24-1	A, 1	Screened in Castlegate Sandstone
Springs		
SP-20 (S-30)	B, 2, 5	Flagstaff
SC-14	B, 2, 5	North Horn
SC-65	B, 2, 5	Colton
SC-100	B, 2, 5	Flagstaff (at North Horn FM. Contact)
SC-116	B, 3, 5	North Horn
200	B, 3, 5	North Horn
203	B, 3, 5	North Horn
227	B, 3, 5	Castlegate Sandstone
259	B, 3, 5	North Horn
259A	B	Colton
260	B, 3, 5	Colton
MD-1	C, 4	Gilson Seam Workings Discharge
321	B,6	Colton
322	B	Colton
324	B,6 *	Colton

Protocols
A Monitoring well: quarterly water level measurement only
B Spring: quarterly flow measurements
C Mine Water Discharge, abandoned Gilson Seam workings: quarterly flow measurements

Water quality
1 Monitoring well: No quality measurements.
2 Spring: quarterly operational groundwater quality parameters for two years beginning 3rd quarter 1999 after which quarterly field measurements only.
3 Spring: quarterly baseline parameters for three years beginning 1st quarter 1999 after which quarterly field measurements only.
4 Mine water discharge: quarterly operational water quality parameters.
5 During wet or dry years (as described in the PHC, Appendix 7-3), flows will be taken weekly between April 1 and August 31 as conditions permit. Also during the first wet or dry year, one operational laboratory sample and one Tritium sample will be obtained at these sites during high and low flow season.
6 Spring: quarterly operational groundwater quality parameters for two years beginning 3rd quarter 2007 after which field measurements only. * At site 324 quarterly operation ground water quality parameters for two years beginning 3rd quarter of 2008, after which field measurements only.

Groundwater Quality Parameters

FIELD MEASUREMENTS	REPORTED AS
Water Level or Flow	Feet or gpm or cfs
pH	pH units
Specific Conductivity	μs/cm @ 25°C
Temperature	°C

TABLE 7-4 (continued)
Groundwater Monitoring Program

Laboratory Parameters	Reported As	Operational Monitoring	Baseline Monitoring
Acidity	mg/l		X
Aluminum (Dissolved)	mg/l		X
Ammonia	mg/l		X
Arsenic (Dissolved)	mg/l		X
Boron (Dissolved)	mg/l		X
Bicarbonate	mg/l	X	X
Carbonate	mg/l	X	X
Calcium (Dissolved)	mg/l	X	X
Chloride	mg/l	X	X
Cadmium (Dissolved)	mg/l		X
Copper (Dissolved)	mg/l		X
Iron (Dissolved)	mg/l	X	X
Iron (Total)	mg/l	X	X
Lead (Dissolved)	mg/l		X
Magnesium (Dissolved)	mg/l	X	X
Manganese (Dissolved)	mg/l	X	X
Manganese (Total)	mg/l	X	X
Molybdenum (Dissolved)	mg/l		X
Oil and Grease	mg/l		
Potassium (Dissolved)	mg/l	X	X
Total Alkalinity	mg/l		X
Total Dissolved Solids	mg/l	X	X
Total Hardness (CaCO3)	mg/l		X
Total Suspended Solids	mg/l		
Selenium (Dissolved)	mg/l		X
Sodium (Dissolved)	mg/l	X	X
Sulfate	mg/l	X	X
Zinc (Dissolved)	mg/l		X
Anions	meq/l	X	X
Cations	meq/l	X	X

TABLE 7-5

Surface Water Monitoring Program

Field and Laboratory Measurement Protocol

Streams	Protocol	Comments
DC-1	1	Located on Dugout Creek downstream of mine
DC-2	2	Located on Dugout Creek immediately upstream of mine on left-hand fork
DC-3	2	Located on Dugout Creek immediately upstream of mine on right-hand fork
DC-4	3	Located on Dugout Creek upstream of mine on west fork of left-hand fork
DC-5	3	Located on Dugout Creek upstream of mine on east fork of left-hand fork
PC-1a	2	Located on Pace Creek on the eastern edge of State Coal Lease ML 48435-OBA
PC-2	2	Located on Pace Creek on the western edge of State Coal Lease ML 48435-OBA
PC-3	1	Located on Pace Creek in Section 20, T13S R13E
RC-1	2	Located on Rock Creek on the southern edge of State Coal Lease ML 48435-OBA
FAN	1	Located on Pace Creek above fan facilities
323	1	Located in SE1/4,SW1/4,SE1/4 of Section 8, Township T13S, R13E

Protocols

1 Stream: quarterly operational surface water quality measurements analyzed as per parameters listed below.

2 Stream: quarterly operational surface water quality measurements analyzed as per parameters listed below except during first wet or dry years when weekly flow will be obtained from April 1 through August 31, as conditions permit, in addition to quarterly samples.

3 Stream: weekly flow measurements during first wet or dry year will be obtained from April 1 through August 31 as conditions permit. Also during the first wet or dry year, one operational laboratory sample and one tritium sample will be obtained at these sites during high and low flow season.

Surface Water Quality Parameters

FIELD MEASUREMENTS	REPORTED AS
Flow	gpm or cfs
pH	pH units
Specific Conductivity	μs/cm @ 25°C
Dissolved Oxygen	mg/l
Temperature	°C

Laboratory Parameters	Reported As	Operational Monitoring	Baseline Monitoring
Acidity	mg/l		X
Aluminum (Dissolved)	mg/l		X
Ammonia	mg/l		X
Arsenic (Dissolved)	mg/l		X

TABLE 7-5 (continued)
Surface Water Monitoring Program

Laboratory Parameters	Reported As	Operational Monitoring	Baseline Monitoring
Boron (Dissolved)	mg/l		X
Bicarbonate	mg/l	X	X
Carbonate	mg/l	X	X
Calcium (Dissolved)	mg/l	X	X
Chloride	mg/l	X	X
Cadmium (Dissolved)	mg/l		X
Copper (Dissolved)	mg/l		X
Iron (Dissolved)	mg/l	X	X
Iron (Total)	mg/l	X	X
Lead (Dissolved)	mg/l		X
Magnesium (Dissolved)	mg/l	X	X
Manganese (Dissolved)	mg/l	X	X
Manganese (Total)	mg/l	X	X
Molybdenum (Dissolved)	mg/l		X
Oil and Grease	mg/l	X*	X*
Potassium (Dissolved)	mg/l	X	X
Total Alkalinity	mg/l		X
Total Dissolved Solids	mg/l	X	X
Total Hardness (CaCO3)	mg/l		X
Total Suspended Solids	mg/l	X	X
Selenium (Dissolved)	mg/l		X
Sodium (Dissolved)	mg/l	X	X
Sulfate	mg/l	X	X
Zinc (Dissolved)	mg/l		X
Anions	meq/l	X	X
Cations	meq/l	X	X

* Not sampled at monitoring sites DC-4, DC-5, and RC-1. These sites are outside the area that could be influenced by mining related disturbance.

TABLE 7-6
SUMMARY OF WATERSHED DATA

Watershed[a]	Curve Number	Area (acres)	Time of Concentration (hours)
WS-1	72	1.96	0.051
WS-2A	71	6.68	0.103
WS-2B	92	1.03	0.079
WS-3	70	4.87	0.071
WS-4	73	4.63	0.055
WS-5	70	15.9	0.119
WS-6	74	2.09	0.046
WS-7A	70	11.97	0.082
WS-7B	88	1.05	0.016
WS-8	71	5.45	0.072
WS-9	71	4.42	0.068
WS-10	70	47.77	0.198
WS-11	71	11.91	0.075
WS-12A	60	4.48	0.107
WS-12B	88	2.35	0.048
WS-13	67	15.31	0.123
WS-14	67	13.11	0.147
WS-15A	67	5.58	0.067
WS-15B	91	3.2	0.075
WS-16	95	0.56	0.059
WS-17	97	1.32	0.085
ODCWS-1a	66	1794.7	1.069
ODCWS-1b	66	1794.9	1.223

(a) See Plates 7-6, 7-7, and 7-8 for watershed boundaries

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TABLE 7-7

STAGE-CAPACITY CURVE FOR THE SEDIMENTATION POND

ELEVATION (FT)	AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
6,947	724		0
		3,668	
6,950	1,721		3,668
		15,180	
6,955	4,351		18,848
		30,225	
6,960	7,739		49,073
		48,500	
6,965	11,661		97,573

TABLE 7-8

SUMMARY OF DIVERSION DITCHES - 10-YEAR 6-HOUR STORM EVENT

Diversion Ditch	Design Flow (cfs)	Minimum Existing Conditions (c)						Calculation Results		Suggested Channel Depth (ft)[a]	Freeboard (ft)[a]
		Bottom Width (ft)	Side Slopes (ft)	Max. Bottom Slope (%)	Min. Bottom Slope (%)	Channel Depth (ft)	Riprap D_{50} (in)	Max. Velocity (ft/s)	Max. Flow Depth (ft)		
DD-1a	3.1	1.5	1:1	10.0	1.7	1.2	Rocky soil	5.25	0.54	1.04	0.66
DD-1b	1.4	0	1.9:1	20.0	1.7	1.0	Concrete	11.78	0.40	0.90	0.60
DD-2a	3.0	2.0	1.4:1	33.3	10.0	0.8	Grouted 6"	5.60	0.29	0.79	0.51
DD-2b	3.0	0	1.9:1	11.6	0.9	1.0	Concrete	11.62	0.60	1.10	0.40 (b)
DD-2c	1.5	1.0	1.9:1	1.4	0.9	0.83	Concrete	4.22	0.27	0.77	0.56
DD-2d	1.4	0	1.9:1	14.3	3.6	1.0	Concrete	10.39	0.34	0.84	0.66
DD-2e	0.7	0	1.9:1	13.3	3.1	1.0	Concrete	8.50	0.27	0.77	0.73
DD-3a	0.2	0.83	0.7:1	20.2	4.2	1.17	Bedrock	3.07	0.12	0.62	1.05
DD-3b	0.2	1.0	5:1	4.2	1.6	0.65	None	1.64	0.11	0.61	0.54
DD-3c	0.2	0.83	0.7:1	20.0	4.8	1.17	Bedrock	3.06	0.11	0.61	1.06
DD-4	0.2	0	1:1 20:1	25.4	0.8	0.75	None	2.90	0.15	0.65	0.60
DD-5	0.1	0	1:1 20:1	0.9	0.5	0.75	None	0.70	0.13	0.63	0.62
DD-6	0.3	0	1:1 20:1	9.1	2.5	0.75	None	2.19	0.15	0.65	0.60
DD-7	0.1	0	1:1 30:1	3.1	1.3	0.6	None	1.01	0.09	0.59	0.51
DD-8	0.5	4	1.5:1	35.7	12.2	0.7	6	2.35	0.06	0.56	0.64
DD-9	0.1	0	2:1	33.3	14.3	0.75	3	2.84	0.15	0.65	0.6
UD-1	0.2	0.75	1.2:1	25.8	9.6	1.0	Rocky soil	3.35	0.10	0.60	0.90

Note: The ditches described above represent the section of ditch with the least capacity to handle runoff. It does not indicate the ditch configuration everywhere.
(a) According to Barfield et.al., (1994) a freeboard of 0.2* (flow depth) or 0.5', whichever is greater should be an adequate freeboard.
(b) Ditch has slightly less than 0.5' of freeboard. However, the ditch can handle up to 12 cfs, which is over four times the design flow. Thus, this channel is adequate.
(c) Minimum existing conditions represent the minimum depth and bottom width and steepest side slopes measured at any point in the channel. For example the minimum bottom width does not occur where the side slopes are steepest. Thus, making calculations more conservative.

TABLE 7-9

SUMMARY OF DIVERSION CULVERTS

Culvert	Existing Pipe Diameter (in)	Inlet Type	Average Pipe Slope (%)	Maximum Allowable HW/D*	Inlet Control Capacity (cfs)	Design Discharge (cfs)	Minimum Allowable Culvert Size (in)	Design Status
DC-1	24	Headwall	4.0	1.5	18	2.3	12	OK
DC-2	12	Projecting	6.9	1.3	2.6	0.8	<12	OK
DC-3	12	Projecting	10.2	1.5	3.2	0.5	<12	OK
DC-4	24	Headwall	5.6	1.1	14.2	1.0	<12	OK
DC-5	18	Drop Inlet	14.6	2.4	15.5	0.2	<6	OK
DC-6	12 and 6	Drop Inlet	17.8	2.0	3.5	0.1	<6	OK
DC-7	22	Projecting	5.6	1.5	14	0.2	<6	OK
DC-8	18	Projecting	5.6	1.8	10	0.1	<6	OK
DC-9	30	Projecting	5.6	2.1	41	1.2	<12	OK
DC-10	22	Projecting	4.1	1.3	12	2.1	12	OK
DC-11	24	Headwall	4.4	1.0	13.0	3.1	15	OK
DC-12	18	Projecting	3.5	1.0	5.5	0.2	<6	OK
UC-1	18	Projecting	32.0	1.2	7	0.1	<6	OK
UC-2	18	Mitre	17.0	2.3	13	0.2	<6	OK
UC-3	18	Projecting	18.0	2.4	13	0.4	<12	OK
UC-4	18	Drop Inlet	25.0	2.0	11	0.2	<6	OK
UC-5	60	Headwall	2.0 +	1.8	230	89.2 @	<48	OK
UC-6 (inlet)	60	Headwall	2.0 +	2.6	300	90.4@	<48	OK
UC-6 (barrel)	60	NA	2.0 +	NA	NA	185.48 @	60	OK

* HW/D = Ratio of the maximum headwater depth and the culvert diameter
\+ Values are for the minimum pipe slope to insure adequate capacity.
@ 100-year 6-hour storm event
For a drop inlet the inlet control capacity is determined assuming a projecting culvert since the area of the grated inlet is greater than the area of the culvert.

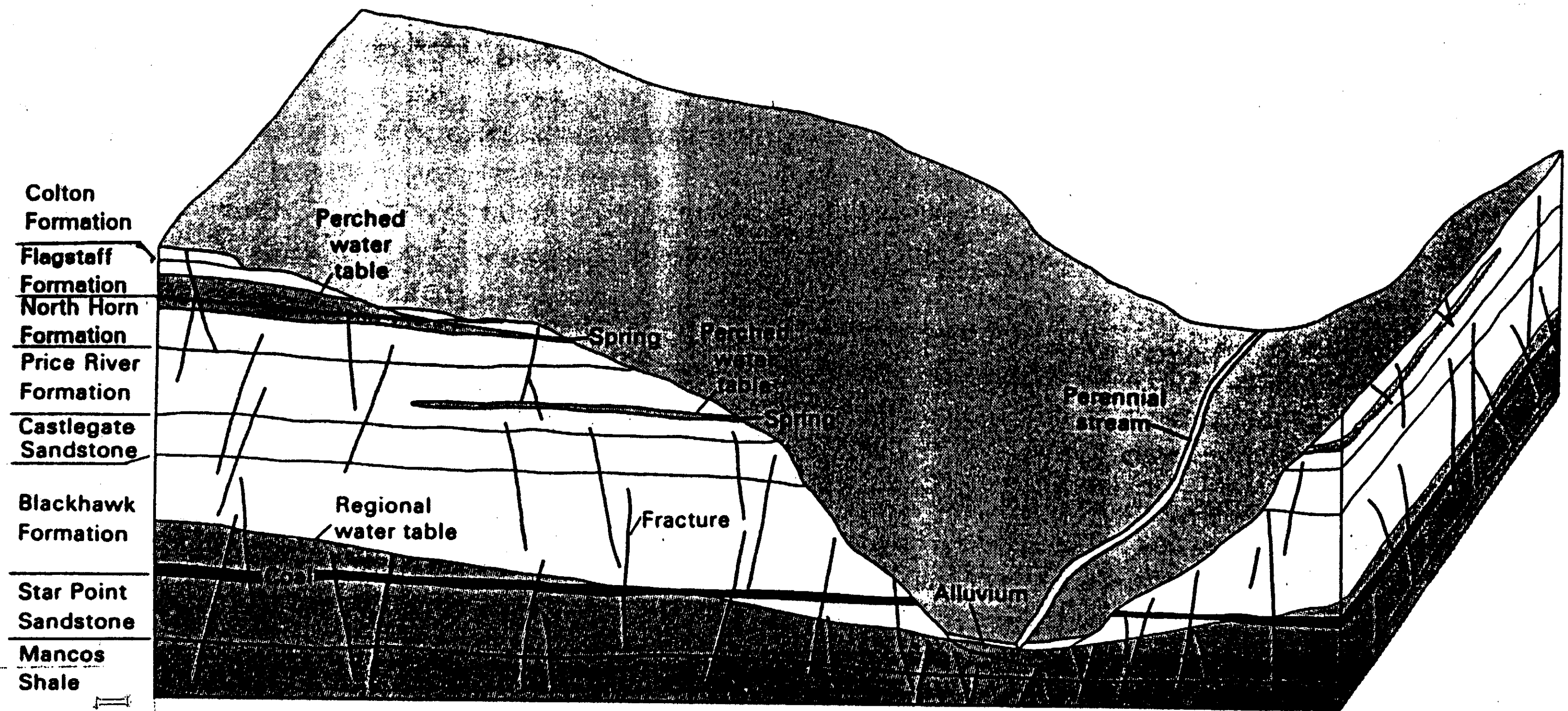
TABLE 7-10

DUGOUT CREEK CHANNEL STABILITY EVALUATION[a]

Category	Description	Rating[b]
	Existing Channel (January 1998)	
UPPER BANKS (above flood stage)		
Landform Slope	Bank slope gradient >60%	8 (P)
Mass Wasting	Frequent or large, causing year-long sediment	12 (P)
Debris Jam Potential	Moderate to heavy amounts, larger sizes	6 (F)
Vegetative Bank Protection	Shallow and discontinuous root mass	12 (P)
LOWER BANKS (below flood stage)		
Channel Capacity	Ample capacity with low width to depth ratio	1 (E)
Bank Rock Content	Rock fragments mostly in the 1-3" range	8 (P)
Obstructions to Flow	Unstable obstructions	6 (F)
Cutting	Almost continuous cuts over 24" high	16 (P)
Deposition	Minor deposition	8 (G)
BOTTOM (channel bottom)		
Rock Angularity	Well rounded in two dimensions	3 (F)
Brightness	Mixture of dull and bright surfaces	3 (F)
Consolidation of Particles	Mostly loose with minor overlap	6 (P)
Bottom Size Distribution	Poorly sorted	16 (P)
Scouring and Deposition	More than 50% of bottom in state of flux	24 (P)
Aquatic Vegetation	Very scarce or absent	4 (P)
REACH CONDITION TOTAL	---	133 (P)
	Post-Reclamation Channel	
UPPER BANKS (above riprap)		
Landform Slope	Bank slope gradient = 50%	6 (F)
Mass Wasting	Stabilized, no future mass wasting anticipated	3 (E)
Debris Jam Potential	Present, but mostly small twigs and limbs	4 (G)
Vegetative Bank Protection	Moderately deep and continuous root mass	6 (G)
LOWER BANKS (riprapped bank)		
Channel Capacity	Ample capacity with low width to depth ratio	1 (E)
Bank Rock Content	Entire bank is rock fragments, with 50%>12"	2 (E)
Obstructions to Flow	Obstructions firmly embedded, stable bed	2 (E)
Cutting	Little or no cutting, infrequent raw banks	4 (E)
Deposition	Minor deposition	8 (G)
BOTTOM (channel bottom)		
Rock Angularity	Sharp edges and corners, rough surfaces	1 (E)
Brightness	Surfaces generally not bright	1 (E)
Consolidation of Particles	Assorted sizes tightly packed and overlapping	2 (E)
Bottom Size Distribution	Well sorted	4 (E)
Scouring and Deposition	Minimal scour and deposition	6 (E)
Aquatic Vegetation	Common, with algae and moss in pools	[illegible]
REACH CONDITION TOTAL	---	52 (E)

[a] Based on the Pfankuch evaluation method, as presented by Rosgen (1996)

[b] E=excellent, G=good, F=fair, P=poor. Reach condition based on classification of existing stream as A4 and post-reclamation stream as A3



Modified from Lines (1985)

FIGURE 7-1. GENERAL HYDROSTRATIGRAPHIC CROSS SECTION

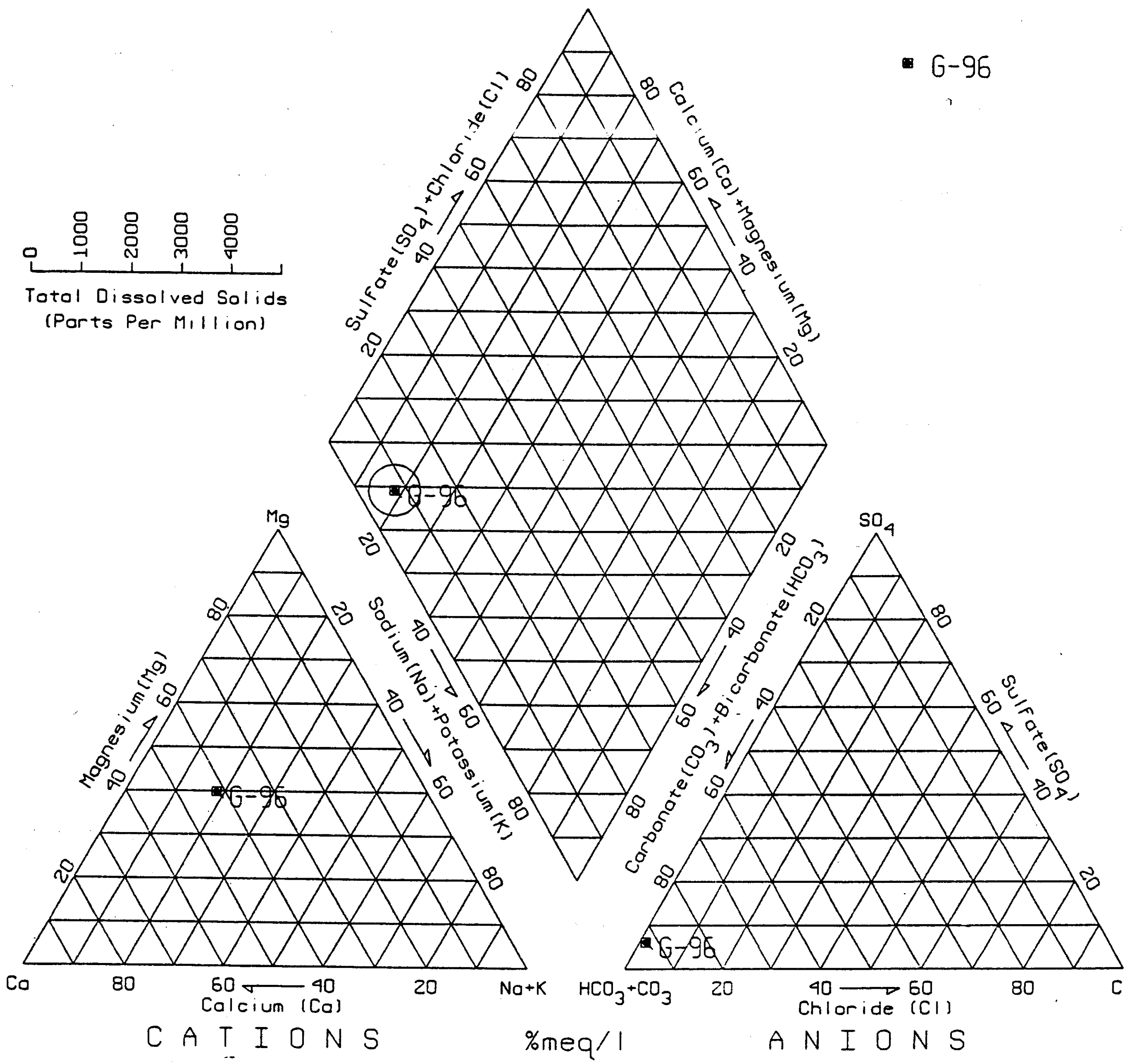


FIGURE 7-2. TRILINEAR PLOT OF A SAMPLE COLLECTED FROM THE COLTON FORMATION

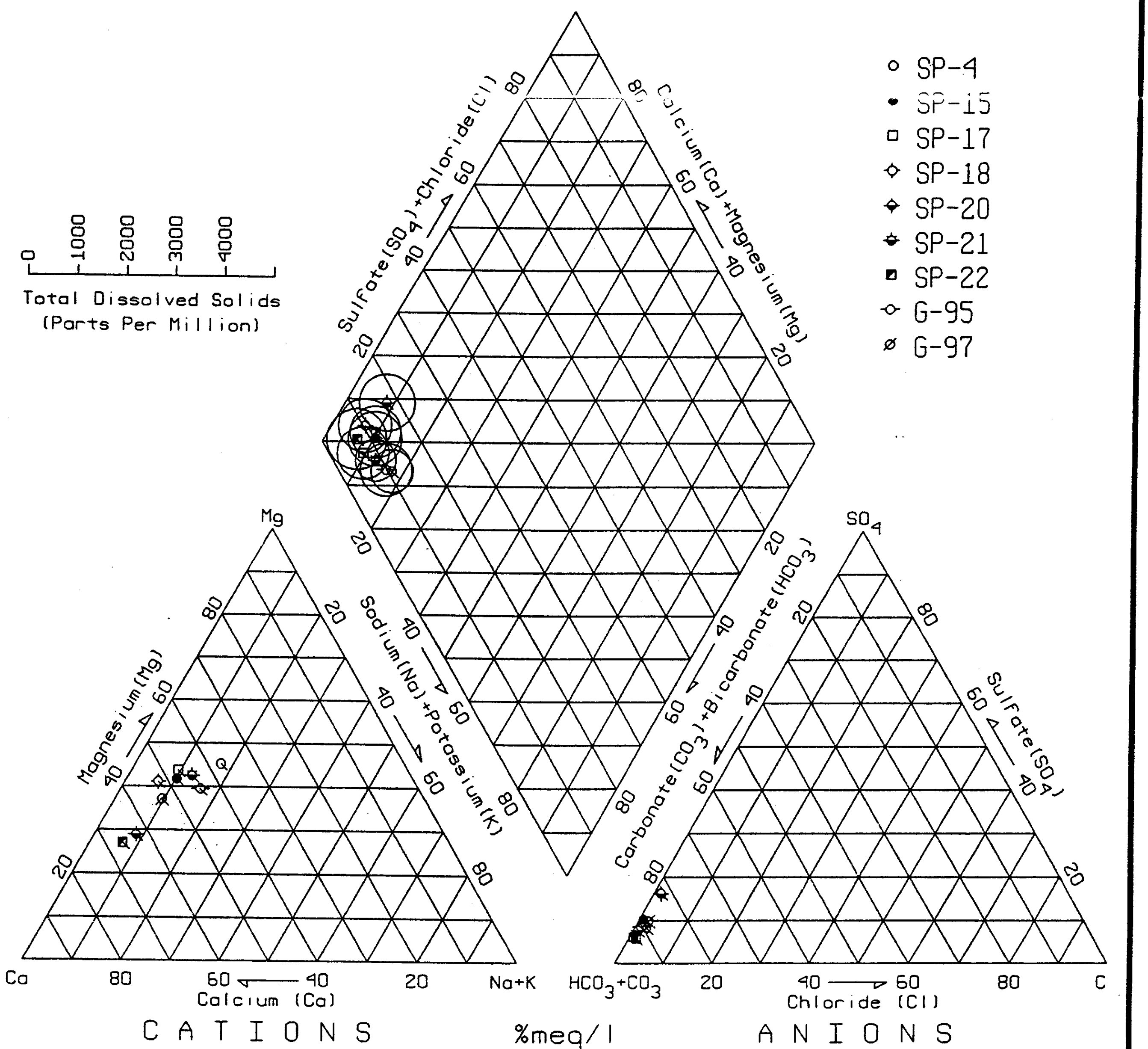
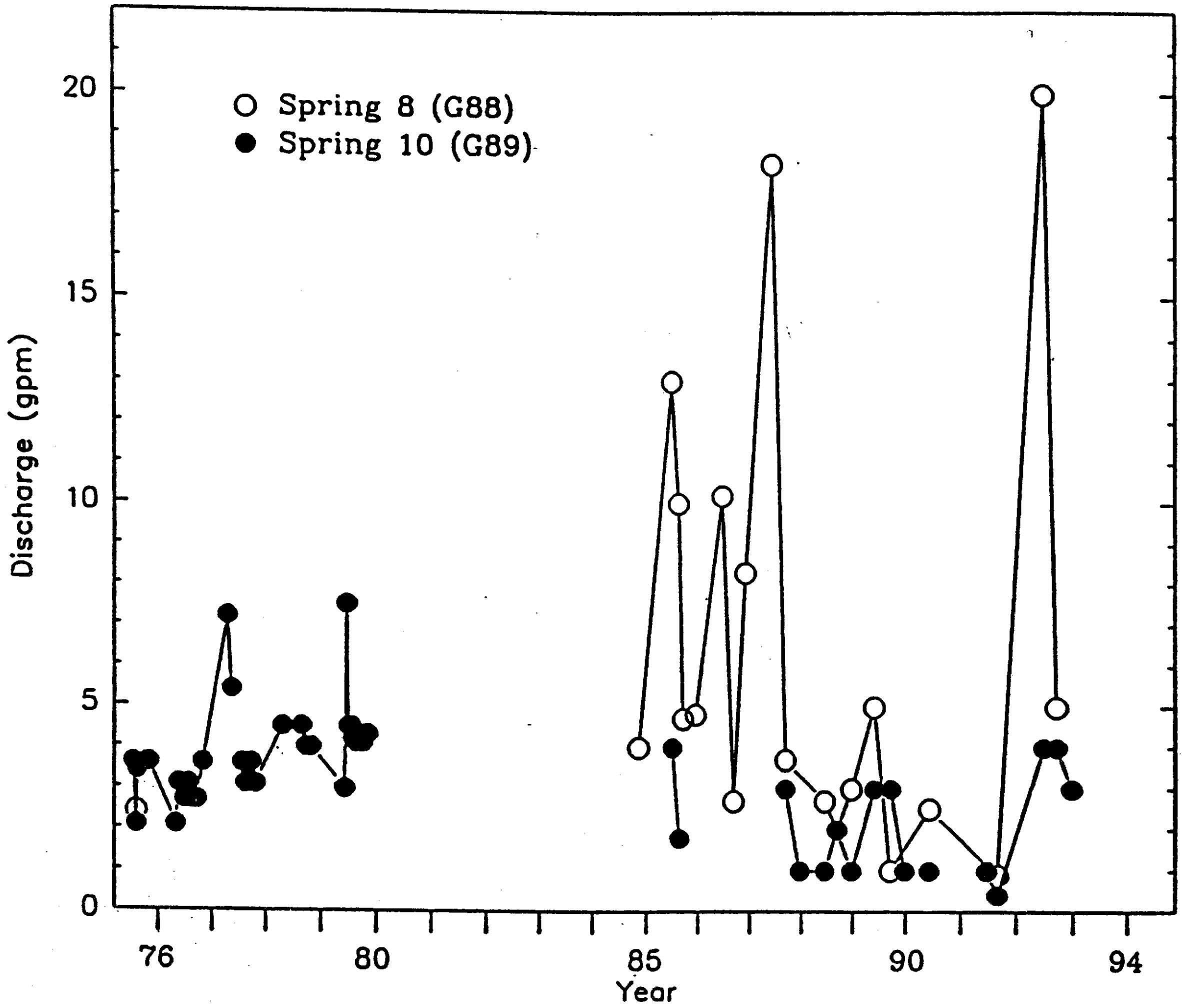


FIGURE 7-3. TRILINEAR PLOT OF SAMPLES COLLECTED FROM THE FLAGSTAFF FORMATION



Source: Mayo and Associates (1996)

FIGURE 7-4. HYDROGRAPHS OF SP-8 AND SP-10

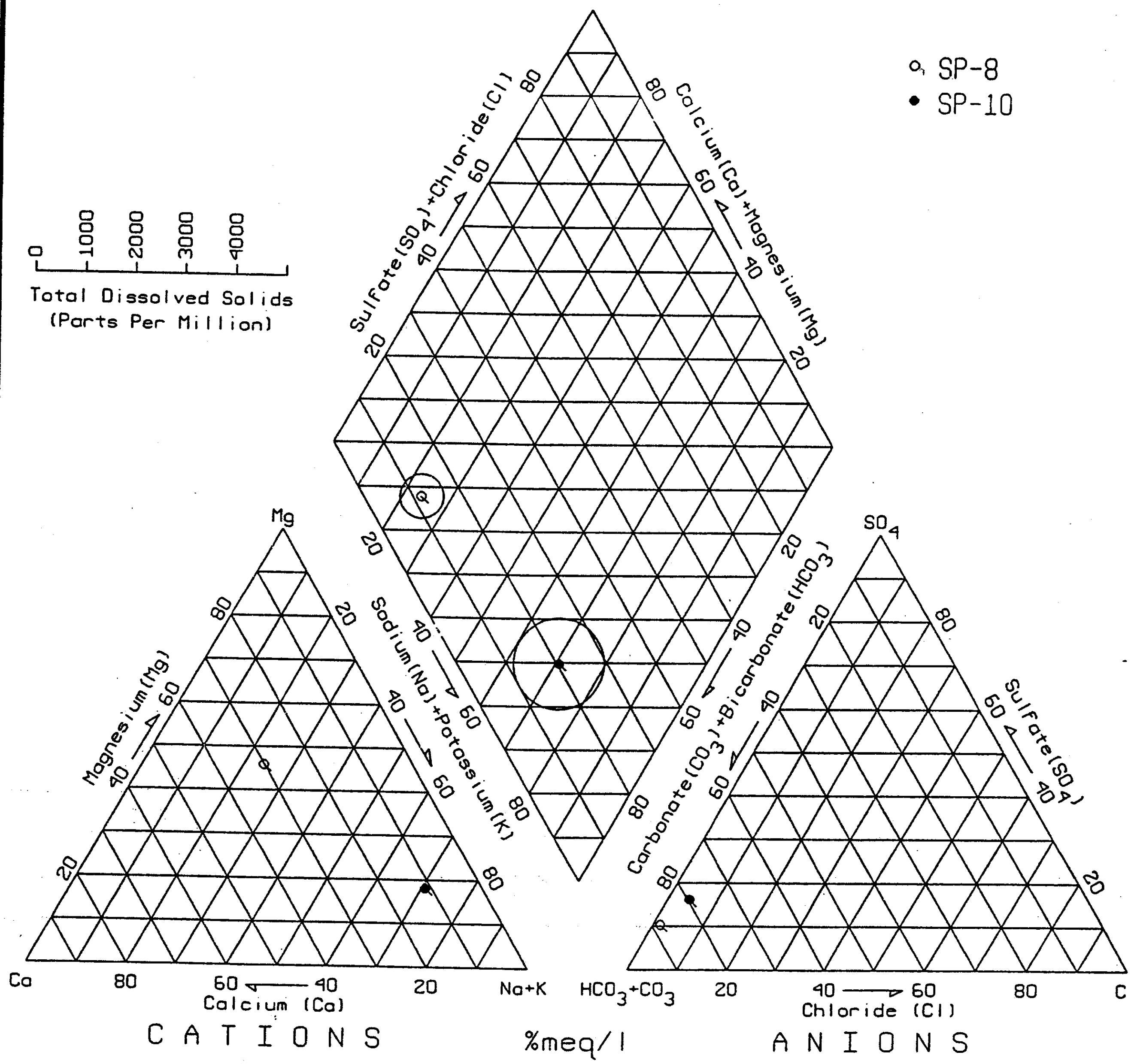


FIGURE 7-5. TRILINEAR PLOT OF SAMPLES COLLECTED FROM THE NORTH HORN FORMATION

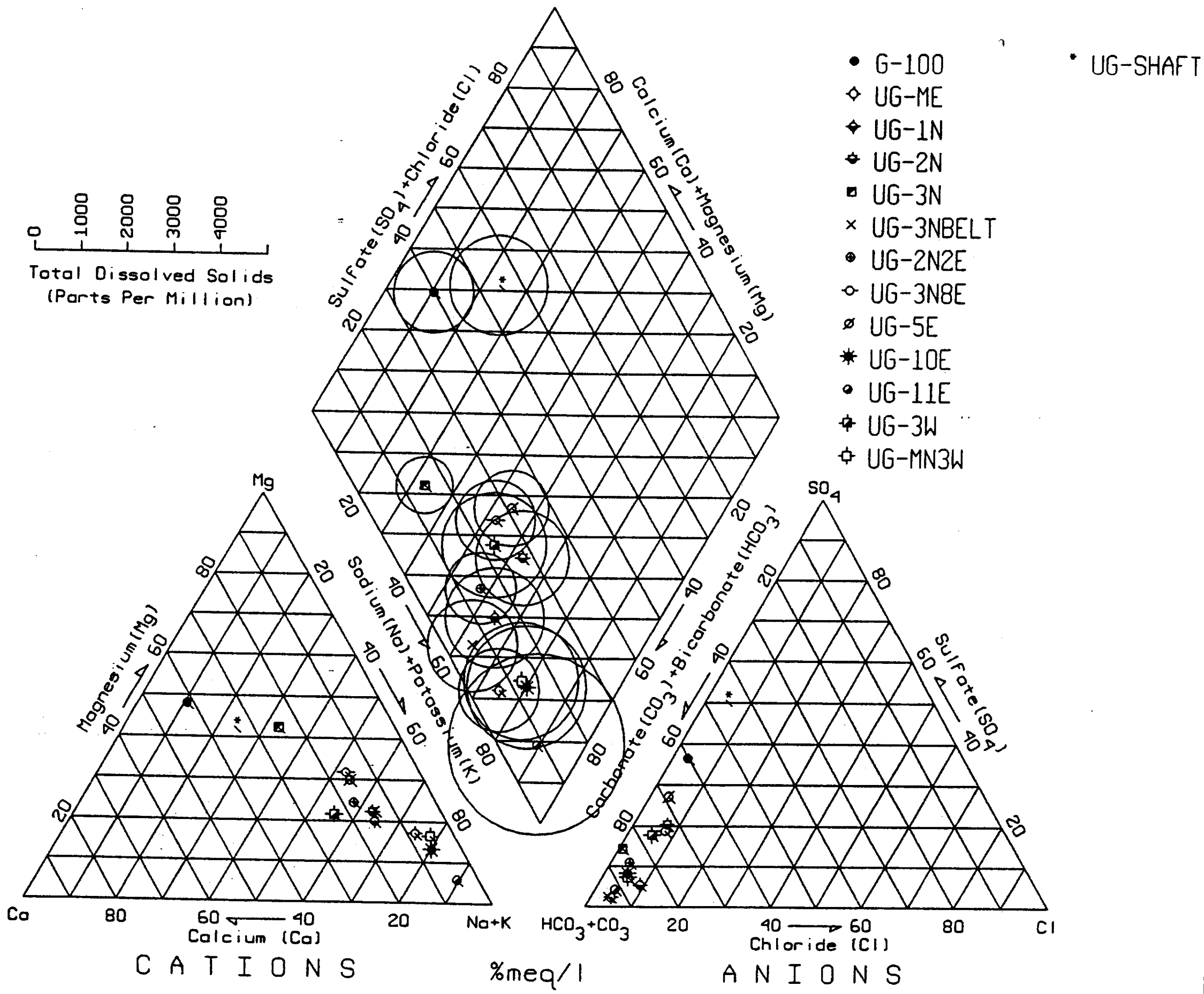
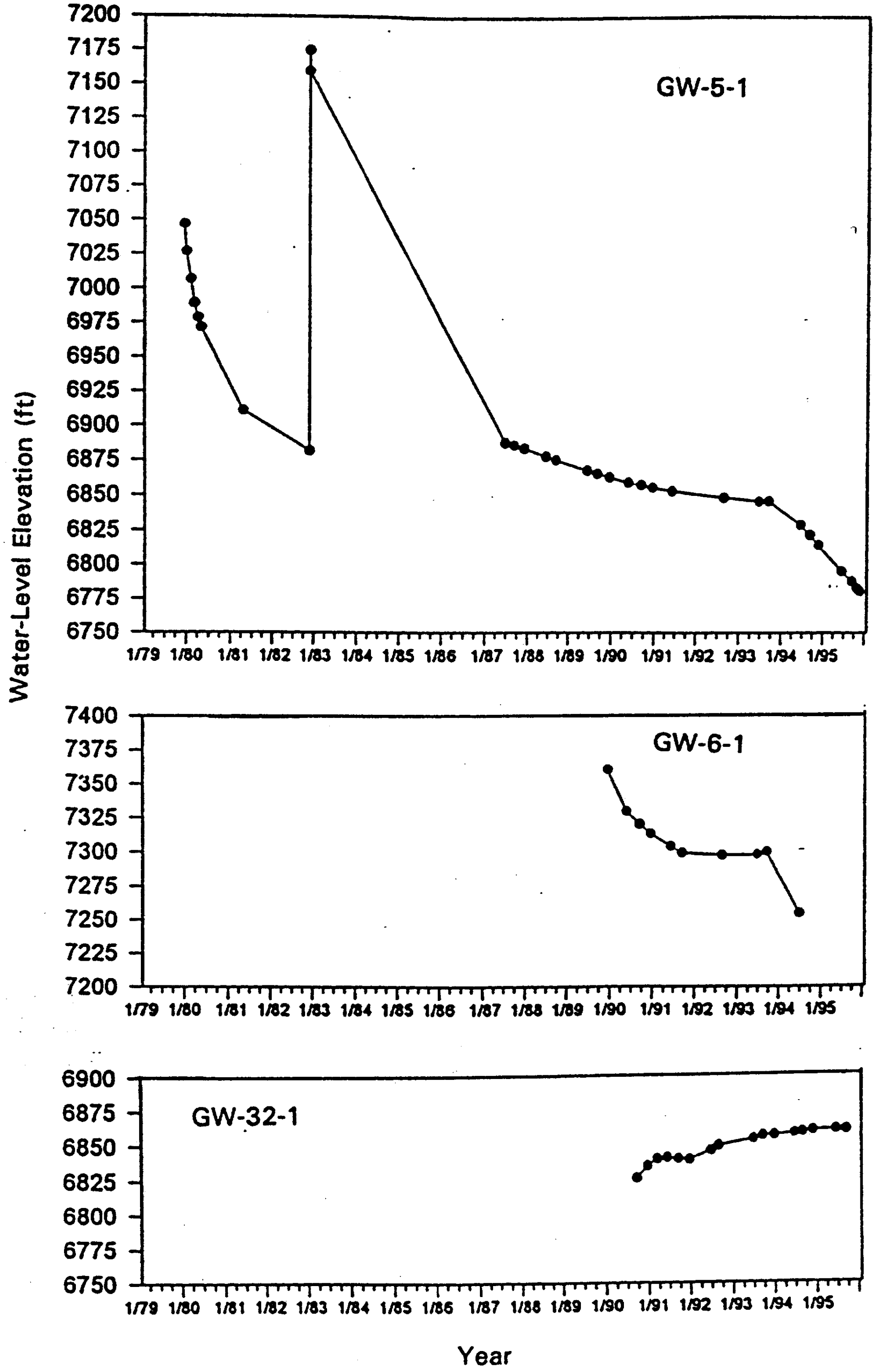


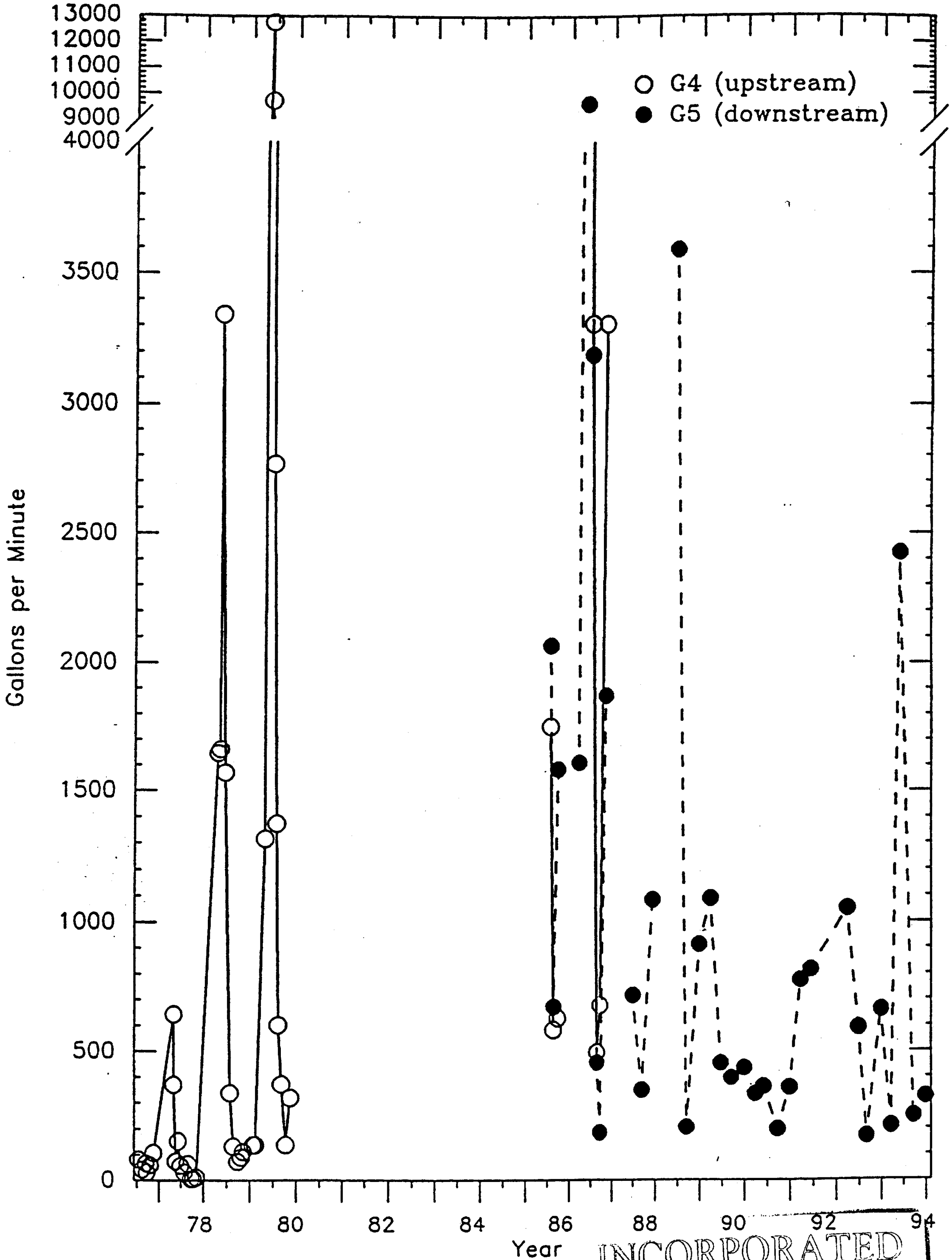
FIGURE 7-6. TRILINEAR PLOT OF SAMPLES COLLECTED FROM THE BLACKHAWK FORMATION



Modified from Mayo and Associates (1996)

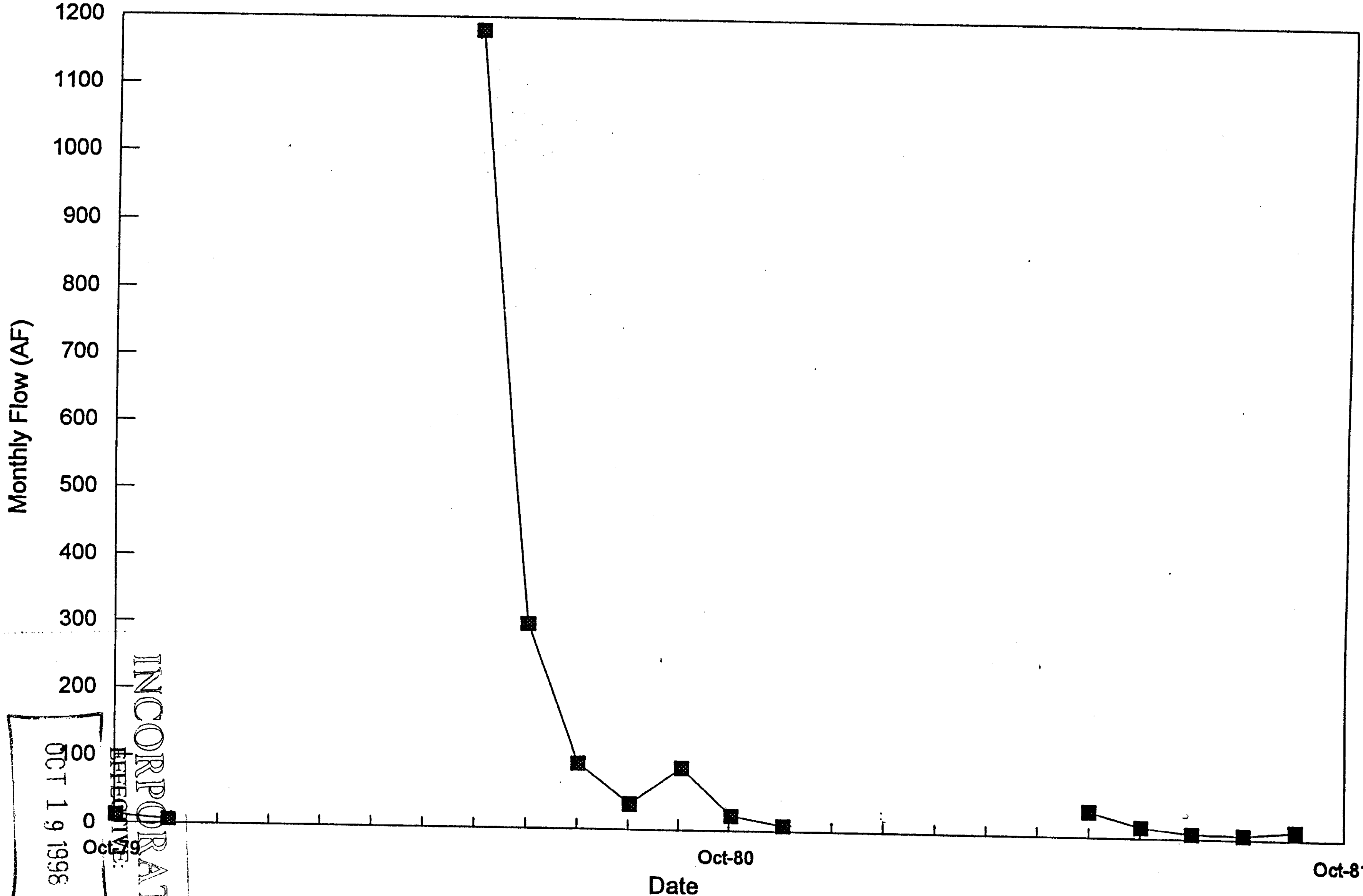
FIGURE 7-7. HYDROGRAPHS OF MONITORING WELLS COMPLETED IN THE BLACKHAWK FORMATION

See Plate 7-1 for well locations



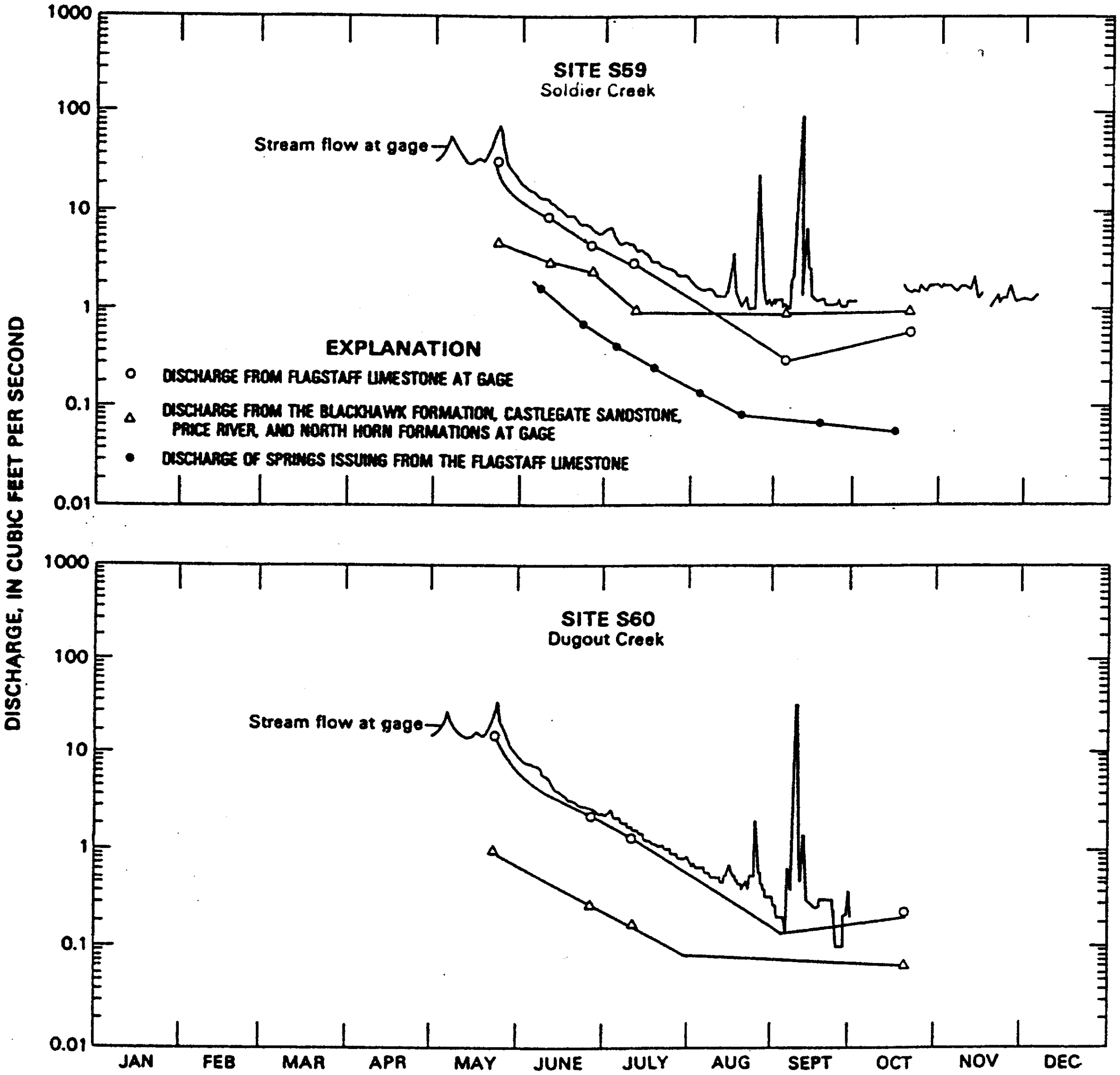
Source: Mayo and Associates (1996)

FIGURE 7-8. HYDROGRAPHS OF SOLDIER CREEK



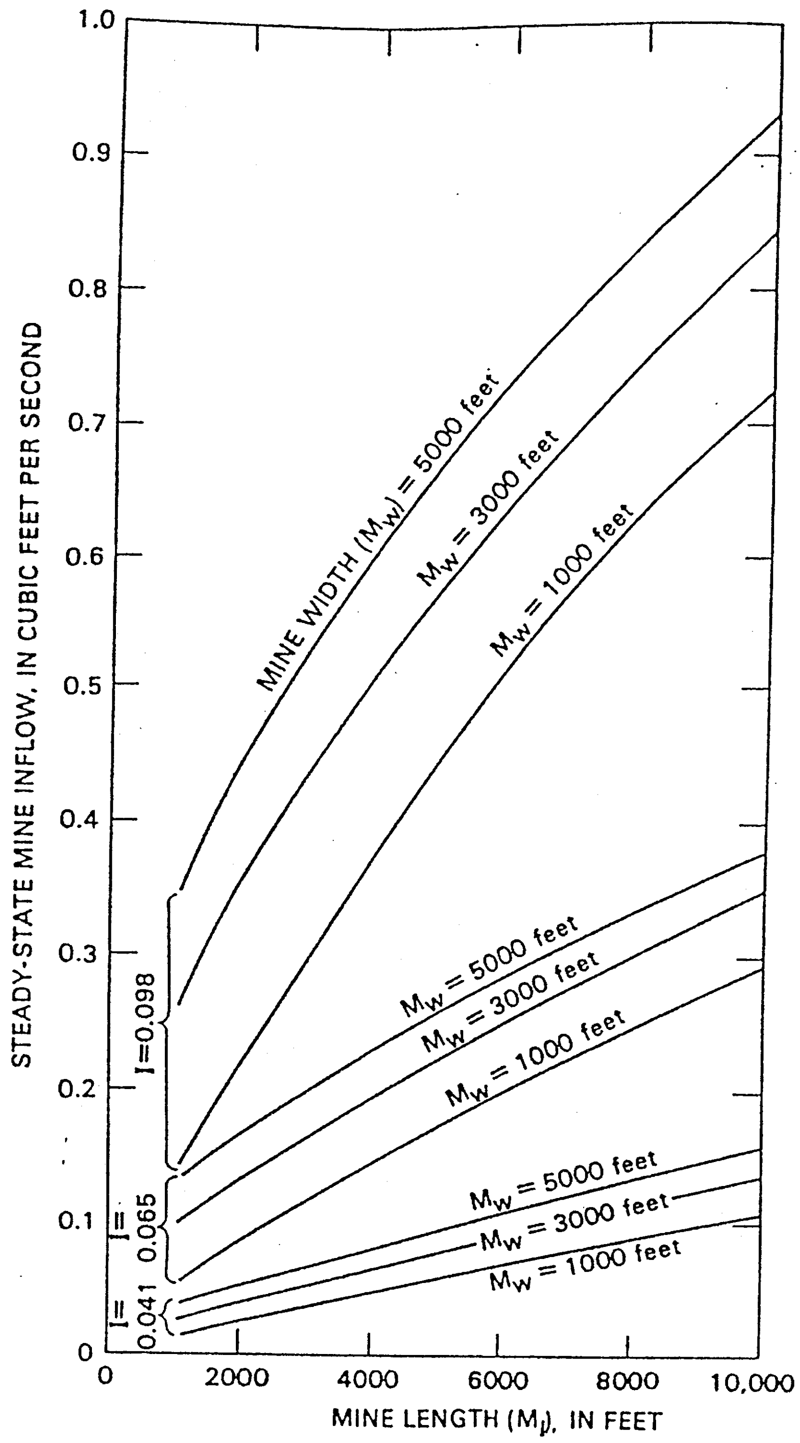
Data from U.S. Geological Survey

FIGURE 7-9. HYDROGRAPH OF DUGOUT CREEK



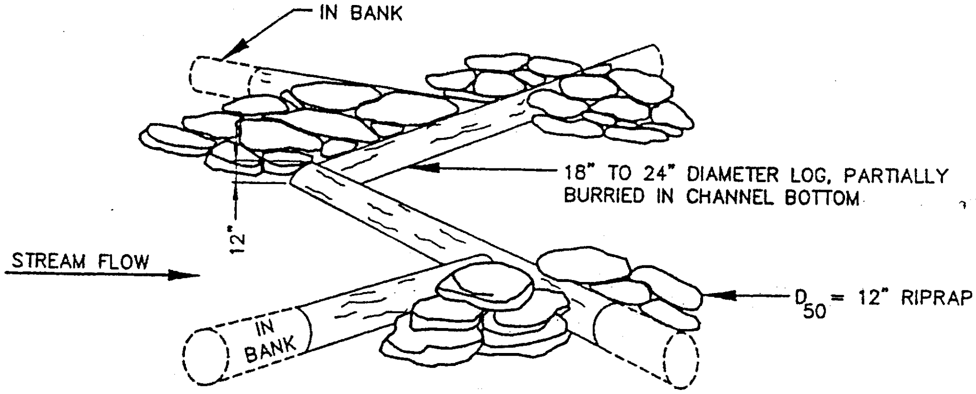
Modified from Waddell et al. (1986)

FIGURE 7-10. HYDROGRAPHS OF SOLDIER CREEK AND DUGOUT CREEK SHOWING BASE FLOW SEPARATION



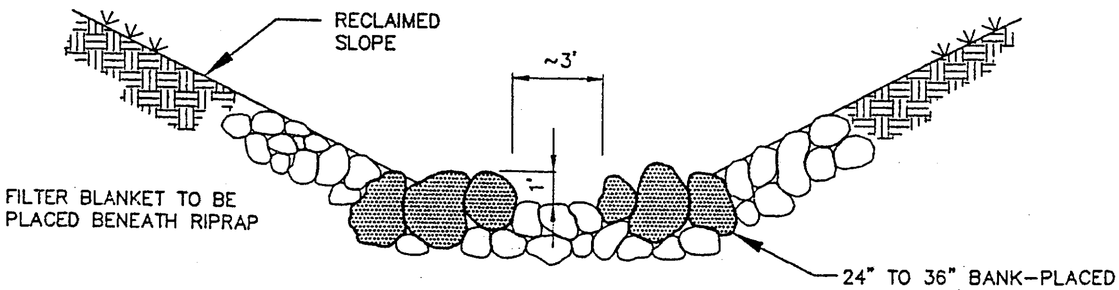
Source: Lines (1985)

FIGURE 7-11. PREDICTED MINE-WATER INFLOW AS A FUNCTION OF MINE LENGTH.

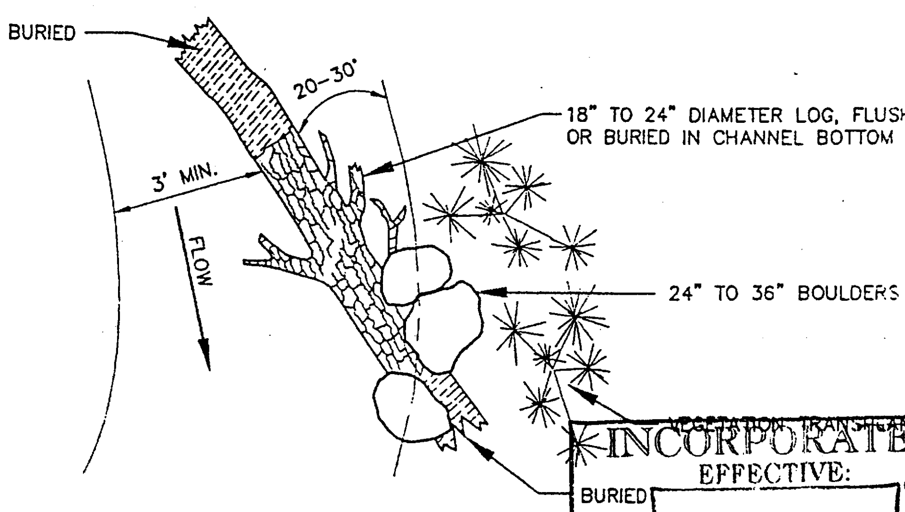


LOW-STAGE CHECK DAM

MODIFIED FROM: ROSGEN (1996)



BANK-PLACED BOULDERS



ROCK OR LOG SPURS

MODIFIED FROM: ROSGEN (1996)

FIGURE 7-12. CHANNEL STABILITY ENHANCEMENT STRUCTURES EarthFax