Section 2.05.6(3)
Protection of the Hydrologic Balance

Table of Contents

TABLES

SECTION 2.05.6(3)
PROTECTION OF THE HYDROLOGIC BALANCE

This section is divided into discussions: one of the protection of the Hydrologic Balance and the other of the Probable Hydrologic Consequences of mining. As of June 2001, significant data has been collected over the years to make better predictions of both of these topics.

A) PROTECTION OF THE HYDROLOGIC BALANCE

Introduction

Surface mining activities to be conducted at the New Horizon 2 mining area outlined in this permit application have been planned to minimize impacts on the hydrologic balance. Mining, reclamation, and monitoring plans and data reporting have been developed to be consistent with the findings of the Probable Hydrologic Consequences analysis presented at the end of this section. The following discussion addresses mining, reclamation, and monitoring plans, and data reporting in the context of how they relate to ground and surface water protection and monitoring. References to those sections which contain details regarding mining and reclamation plans and practices have been incorporated. Finally, discussions on stream buffer zones, alluvial valley floors, and water rights are also included.

Ground Water Protection

The discussion for ground water protection has been divided into three parts: 1) ground water quality; 2) ground water quantity; and 3) ground water monitoring.

Ground Water Quality

Mining practices that involve replacement of spoil material into mine pits are detailed in Section 2.05.4(2)(c), Backfilling and Grading. Topsoil and overburden handling procedures are detailed in Section 2.05.4(2)(d), Topsoil (Redistribution). These handling procedures were developed after reviewing the physical and chemical properties of the overburden, coal, and interburden in the New Horizon 2 mining area (see Section 2.04.6, Geology). The thin, isolated bands of acidic overburden identified in the New Horizon 2 area are situated between thick layers of overburden that exhibit a sufficient degree of neutralization potential. Extensive testing of the spoil water quality at the New Horizon #1 area has shown that some areas that have a higher pyritic content in the shale, which can result in oxidation of the pyrite, resulting in a lowering of the pH and an increase in Total Dissolved Solids. This can occur over hundreds of years in the spoil until the water quality gradually approaches that of the typical overburden, which is still very high in TDS. In the Probable Hydrologic Consequences Item 5) Potential impacts of replaced spoil on groundwater quality, this oxidation and its impacts are discussed in extensive detail. Overall, the impacts to the groundwater quality and the waters downstream are not significant, although they occur for a lengthy period of time.

WFC has developed plans for sampling overburden during mining to identify the quantity and quality of deleterious material (see Section 2.04.6, Geology).

Naturally occurring waters in the surrounding undisturbed ground water system exhibit a high degree of mineralization (see Section 2.04.7, Hydrology Description). Well yields are low. Most recharge to the local undisturbed ground water system is from both the Lower Second Park and the West Lateral irrigation ditches and associated laterals via seepage. This localized, artificial source of ground water recharge will augment slower, natural recharge contributions during the spoil resaturation process. As spoil resaturation progresses, the quality of ground water in the spoil will likely approach the water quality of surrounding geologic units.

Mixing and the overall high degree of neutralization potential of the spoil material will minimize changes in ground water quality. See following discussion on Probable Hydrologic Consequences. Based on physical and chemical analyses performed on core samples taken from the lithologic units to be affected by mining (see Section 2.04.6, Geology Description), a classification system has been developed for these units with regard to handling during operation and reclamation activities. A handling plan for those material classes identified by sampling as being potentially deleterious to revegetation or the ground water quality in either mining area has been developed and is presented in Section 2.05.4(2)(d), Topsoil (Redistribution).

It is not anticipated that WFC will transfer ownership and use of any wells completed within New Horizon 2 mining areas. Bore holes, shafts, wells, and auger holes will be cased and/or sealed to prevent possible ground water degradation from mixing of waters of different quality within the bore holes and acid or toxic surface runoff entering the bore holes. A specific plan for sealing of bore holes, exploration holes, auger holes, wells, and shafts is presented in Section 2.05.6(3)(b)(v), Hydrologic Reclamation Plan.

Ground Water Quantity

Typical backfilling methods largely involve the use of dozers and trucks (see Section 2.05.4(2)(c), Backfilling and Grading). Replaced spoil materials exhibit greater porosities and hydraulic conductivities because of increased void values, regardless of how the spoil material is replaced in the pits.
Spoil replacement (backfilling) using methods outlined in Section 2.05.4(2)(c), Backfilling and Grading, will ensure the eventual resaturation of the disturbed areas (pits), minimizing the adverse effects of mining on ground water flow. The New Horizon 2 mining area is located in a climate which generates less than 15 inches of precipitation annually. Evapotranspiration rates in the vicinity are relatively high (see Section 2.04.7, Hydrology Description). Textural analyses performed on potential spoil materials generally indicates that sandy clay loam materials will be replaced in the pits (see Section 2.04.6, Geology Description). Consequently, infiltration rates in reclaimed areas are expected to be slow to moderate. It follows that contributions to spoil resaturation and subsequent recharge to surrounding aquifers from precipitation will be slow. However, the upland and adjacent irrigation ditches and laterals will eventually provide a more rapid source of recharge to spoils. Seepage from the irrigation network has provided an artificial source of recharge to the undisturbed shallow ground water system. The resaturation and recharge of replaced spoils will also be augmented by the irrigation. This is discussed in more detail in sub-section 6.0.

Overburden and topsoil handling, reconditioning, and revegetation methods outlined in Sections 2.05.4(2)(d), Topsoil (Redistribution), and 2.05.4(2)(e), Revegetation,) will maximize the potential for establishing reclaimed areas that will exhibit infiltration rates and capacities adequate for insuring at least pre-mining rates and capacities. Timely reseeding and mulching of redistributed topsoil will augment the retention and eventual downward infiltration of soil moisture. Textures of topsoil material will generally range from sandy loam to loam, and topsoil material will exhibit moderate infiltration rates. Deep ripping of regraded spoil, followed by topsoil placement, chisel plowing, and disking will improve the infiltration potential of the reclaimed medium.

Significant ground water inflow to the pits will be removed by pumping the water to a sediment pond that will, at the time of pumping, have a sufficient available storage capacity, including the prescribed volume for the 10-year, 24-hour storm. Design criteria for all ponds is addressed in Section 2.05.3(3), Mine Facilities, and includes plans for storage of additional volumes pumped from pits or sumps. Maintenance of available storage capacity in the ponds involves dewatering and sediment removal.

Ground Water Monitoring

Since 1979, Peabody (New Horizon Mine's predecessor) progressively installed an extensive network of 35 wells to monitor the shallow aquifers beneath both the New Horizon 1 and the New Horizon 2 mining areas. The current ground water monitoring plan employed to monitor the extent and magnitude of any mining impacts is also discussed in Sections 2.04.7 and Section 2.05.6(3)(V)(b), Hydrologic Reclamation Plan. The ground water monitoring wells will be maintained for the life of the mining operations or until such time as the CDMG may agree that they are no longer necessary. All ground water monitoring installations will be removed upon completion of the postmining hydrologic monitoring phase of the Hydrologic Monitoring Program.

All ground water data collected from monitoring wells in each future water year will be compiled and submitted to the CDMG in the form of the New Horizon Annual Hydrology Report (AHR). The AHRs will be submitted within three months after the end of each water year.

Surface Water Protection

Section 2.05.3(3), Mine Facilities, contains descriptions, designs, and plans for a sediment pond, roads, diversions, and culverts that will be constructed and utilized at New Horizon 2 mining area during mining. All facilities that are discussed in Section 2.05.3(3) have been designed to ensure that the hydrologic balance is protected.

The discussion for surface water protection has been separated into three parts: 1) surface water quality; 2) surface water quantity; and 3) surface water monitoring.

Surface Water Quality

With the addition of Garvey and Burbridge properties for mining, the sediment pond (Pond 007) will be enlarged during the proposed operations for controlling surface water runoff from disturbed and reclaimed areas. The design of the pond has been developed to prevent additional contributions of sediment to stream flow outside the permit area, to minimize erosion, and incorporates detention times sufficient to ensure that all applicable effluent standards will be met. The pond discharge structures are designed according to standard engineering design procedures for protecting against erosion via emplacement of riprap and/or energy dissipators. The pond will be removed and reclaimed following the completion of mining and reclamation unless prior approval to retain this impoundment is obtained. The 1999 amendment to add lands to the north and west of the initial New Horizon 2 mine area resulted in the need for a number of new sediment ponds, which are shown in detail in the section on Mine Facilities.

The impact of a sediment pond and runoff from reclaimed areas on the quality of receiving streams was found to be of minimal significance (see Probable Hydrologic Consequences at the end of this section). Existing NPDES permit (CO-0000213) has been modified to include 007. All terms and agreements specified in the approved permit will be adhered to during the mining operation to ensure that effluent will meet the permit limitations. Based on past water quality monitoring, it is anticipated that no treatment of pond effluent is necessary. However, should the need for treatment of pond effluent be demonstrated, WFC will commit to designing treatment facilities or procedures to handle the equivalent of a 10-year, 24-hour effluent volume.

Plans for sampling overburden and topsoil after backfilling and grading have been developed and are presented in Section 2.05.4(2)(d), Topsoil (Redistribution). Based on these plans, surface runoff from disturbed reclaimed areas will not come in contact with materials that would contribute to elevated levels of acid or toxic constituents.

Topsoiling handling procedures (Section 2.05.4(2)(d), Topsoil (Redistribution)) and revegetation methods (Section 2.05.4(2)(e), Revegetation) have been developed to stabilize the landscape, prevent erosion, and minimize the additional contributions of sediment to runoff. They include: the seeding of temporary disturbance and topsoil piles; mulching, chisel plowing and deep ripping; cover cropping; and timely reseeding of reclaimed areas (regraded and topsoiled) with seed mixes designed for rapid establishment and development of effective hydrologic cover. Those areas that are affected by mining will be graded to postmining topographies that generally feature slopes no greater than 5:1. In combination with the reclamation and topsoil handling techniques, reduced slopes will minimize the potential for erosion due to accelerated sheet wash or gullying.

Diversions have been designed according to accepted design criteria, and will be built to minimize erosion and prevent additional contributions of sediment by limiting the flow velocities and tractive forces that cause erosion. Temporary diversions in place longer than a growing season will be seeded with a temporary seed mix as outlined in Section 2.05.4(2)(e). Diversions have been designed to maximize geomorphic stability while minimizing disturbance. All temporary diversions will be removed and reclaimed after mining activities have been completed. Plans have been developed for water rights augmentation pumping that will meet effluent limitations and minimize erosion. Drainage from haulage and access roads will be routed to the sediment pond. Where necessary, culverts will be designed and constructed using approved engineering design criteria to minimize erosion and prevent the contribution of additional sediment to runoff.

Surface Water Quantity

Map 2.05.3(3)-1 details pond diversion and culvert locations that will control all drainage into, through, and out of New Horizon 2 mining area. The plan has been developed for insuring that changes in surface water quantities are minimized. The impact of designed structures proposed for the New Horizon 2 mining area (sediment pond, diversions, culverts, etc.), was determined to have no significant effect on surface water quantity (see Probable Hydrologic Consequences at the end of this section).

The sediment ponds have been designed according to acceptable engineering criteria to contain (at a minimum) the 10-year, 24-hour runoff volumes. WFC will ensure that the ponds maintain this capacity by dewatering and/or excavating excessive sediment accumulated according to plans outlined in Section 2.05.3(3), Mine Facilities. The bottom and sides of the sediment pond will be compacted to a sufficient density to prevent excessive leakage of pond water to the shallow aquifers.

Diversions have been designed to pass the 10-year, 24-hour runoff volumes in accordance with approved engineering design criteria. Culverts and road drainageways will insure that runoff originating within or outside each mining area will be controlled and adequately routed through to minimize changes in surface water quantities.

The postmining landscape is designed to protect the hydrologic balance by establishing slopes that generally will not exceed 5:1. Any highwall reductions will result in maximum slopes not to exceed 5:1. Reclaimed hillslopes proposed for the New Horizon 2 mining area approximate the original premining contours.

Topsoil material will exhibit infiltration rates generally similar to premining soils. At the New Horizon Mine, future reclaimed areas will be manipulated mechanically using chisel plowing and ripping of graded and topsoiled areas in combination with timely reseeding to minimize overland flow rates and volumes.

Surface Water Monitoring

WFC will continue to collect data from the currently approved monitoring sites. See Section 2.04.7. The current Surface Water Monitoring Plan employed to monitor the extent and magnitude of any mining impacts is discussed in Section 2.04.7.1 Hydrology Description.

The surface water monitor will be maintained for the life of the mining operation or until such a time as CDMG may agree that they are no longer necessary. The surface water monitoring installation will be removed upon completion of the postmining phase of the Hydrologic Monitoring Program.

All surface water data collected at each monitoring site in each future water year will be compiled and submitted to the CDMG in the form of the New Horizon Annual Hydrology Report (AHR) within three months after the end of each water year. Future AHRs will include copies of quarterly NPDES discharge monitoring reports for each NPDES monitoring site submitted to the Colorado Department of Health during the same water year.

Stream Buffer Zones

The stream buffer zone along Calamity Draw (land within 100 feet of a perennial stream or stream with a biological community as defined by Section 4.05.18(3) of the CDMG regulations) will be affected by associated disturbance activities within the New Horizon 2 area (see Map 2.05.3-1). The mining and operations plan for New Horizon 2 has been developed so that there will be no disturbance to the main channel of Calamity Draw. Disturbance within the buffer zone will be limited and consist of activities related to the construction of a drainage ditch C-18 (formerly East Ditch) to convey runoff from upgradient disturbed areas to the Pond 007, which is located at the southwest corner of the permit boundary. The City of Nucla has previously constructed the City's sewer line within the 100-foot stream buffer zone. The C-18 (formerly East Ditch) was constructed close to the permit boundary in order to allow all drainage from disturbed areas to be intercepted and routed to Pond 007, to allow access around the south end of the pits and to maximize coal recovery. The stream buffer zone area within the permit boundary is approximately 0.4 acres of a very narrow strip of land approximately 860 feet long where Calamity Draw meanders close to the permit area. The drainage ditch will be designed to handle the runoff from a 10-year, 24-hour storm event and should preclude the potential of any water quality degradation in Calamity Draw as a result of these associated disturbances within the buffer zone. Because the anticipated operations will not result in disturbance of the main channel, there should be no impact to the quantity of streamflow in Calamity Draw from the buffer zone disturbance.

After mining and related activities, the following reclamation plan for the area will be implemented to help insure the reestablishment of vegetation generally similar to that which occurs within the buffer zone.

The areas within the buffer zone that may potentially be affected are dominated by the graminoid component of the swale/drainage vegetation type (see Section 2.04.10). Nearly all of the dominant species that occur in this component are rhizomatous species capable of forming dense sods, while also reproducing from seed. These species, unfortunately, are not available from plant material suppliers. Adjacent undisturbed stands will rapidly reinvade the reclaimed areas by means of plant popagules (seed or extension of rhizomes).

Anticipated disturbance relates only to those activities necessary to the construction of the diversion ditch. Salvaged topsoil will be replaced following necessary grading to reclaim the ditch and shape the final contours. As part of seedbed preparation, the replaced topsoil will be disked with the first pass made partially into adjacent native vegetation to "tie" the reclaimed and native sites together. This operation also serves to pull and mix native plant rooting materials into the edges of the reclaimed area, thus hastening reinvasion. As with any sod forming species, the cutting up and dispersal of rooting materials tends to increase regeneration and stimulate the stand. In the interim, Seed Mix #6, Irrigated Pasture-Poorly Drained Phase (Section 2.05.4(2)(e), Revegetation) will be seeded on all reclaimed areas on or immediately adjacent to the buffer zone in order to stabilize the site. Creeping foxtail (Alopecurus arundinaceus) contained in Seed Mix #6, is one of the few other grasses available on the market that has the potential to tolerate poorly drained sites. Creeping foxtail is also a valuable species for wildlife, providing both early spring growth for food and later growth for nesting and escape cover. Birdsfoot trefoil (Lotus corniculatus) is included in the mix because it is adapted to wet or poorly drained sites and will provide soil nitrogen benefits to the established plant community. It is a non-bloating legume that will also provide forage and cover benefits to wildlife. Reestablishing native vegetation will eventually crowd it out of the stand, particularly if it is consistently an understory plant. Revegetation will follow the methods described in Revegetation Methods - Irrigated Pasture. Maintenance, monitoring, and management activities are detailed in various sections of Section 2.05.4(2)(e), Revegetation.

The foregoing discussion has been provided to support WFC's right to enter the stream buffer zone of a perennial stream to construct parts of the C-18 (East Ditch) directing runoff to Pond 007. The approval is predicated on WFC's commitment to protect the hydrologic balance by minimizing and mitigating the disturbance using the above-referenced engineering design and mining and reclamation plans.

Water Rights and Alternative Water Supplies

Introduction

A new inventory of water rights around both New Horizon mine sites was made in 2001. Ground water rights within the immediate region (2 mile radius) around the New Horizon Mine are presented in the Appendix to Section 2.04.7-1. In all, 29 ground water rights have been identified in the vicinity of the New Horizon 1 and New Horizon 2 mining areas. All monitoring wells installed by the permittee and domestic wells within the surrounding area are shown on Map 2.04.7-1-A.

Analyses and programs integral to the Water Rights Plan are presented in several sections of the permit. A review of these sections is appropriate. Pit inflow volumes and pit pumpage drawdown projections are discussed and presented in Probable Hydrologic Consequences at the end of this section. Impacts of mining discharges on downstream water quality and the shallow ground water quality for water use considerations are also presented in Probable Hydrologic Consequences at the end of this section. Specific ground and surface water monitors for the purpose of verifying drawdowns and changes related to water rights in streamflow volumes will be agreed to with CDMG. Finally, the detailed water rights plan which integrates the above-referenced information is presented in Attachment 2.05.6(3(b)(v)-1 (formerly Peabody Attachment 16-1.).

<u>Water Rights Protection and Mitigation Plan</u>

The following discussion briefly summarizes the approach to the water rights plan. All ground and surface water rights within a reasonable distance of the New Horizon Mine have been documented. Pit inflow and pit pumpage drawdown analyses were performed and tabulated. Drawdowns and pit bottom elevations were compared against water righted well production zone elevations to determine which wells, if any, could potentially be impacted by the mining induced drawdowns. Similarly, surface water rights within the one-foot drawdown contours were identified as those surface water rights which could potentially be impacted by the mining induced drawdowns. Drawdown depletion rates were then estimated at the different surface water right locations and replacement rates were determined for each.

Calculations were performed to estimate industrial uses of surface water and evaporative losses from the six sediment ponds receiving runoff from the mining areas. This work was performed by Peabody. An augmentation plan was then developed for augmenting these surface water losses during each month of the irrigation period and storing water during the winter months, Table 9 in Attachment 2.05.6(3)(b)(v)-1 (formerly Peabody Attachment 16-1).

Calculations were performed for Tuttle and Calamity Draws and the San Miguel River to determine if mine discharges would diminish receiving water quality to the extent that surface water rights would be injured (preclude present or potential uses of the water). This was determined not to be a significant impact and no mitigation is required.

Finally, specific, additional monitors will be proposed as part of the water rights plan to help insure that the impact and water loss volume projections were reasonable. Piezometers may be proposed in the immediate vicinity of the New Horizon 2 mining area to help quantify drawdowns.

Alternative Water Supplies

WFC will use the following alternative water sources to mitigate any ground or surface water right impacts. WFC has available 114.5 acre-feet of surface water, which is a consumptive use credit associated with WFC's ownership of 21 shares of the Colorado Cooperative Company (CCC). WFC has an absolute 4 acre-foot storage right for the 001 reservoir at the New Horizon 1 mining area and is projected to have 18 acre-feet of pit pumpage during the non-irrigation season available to them for use. WFC also has a 1.5 acre-foot ground water right associated with the mined out shop well.

It is from these alternative sources of water that the surface water augmentation plan has been developed. No ground water impacts requiring mitigation are forecast. However, should a ground water supply be diminished to such an extent that it precludes its use, WFC will replace this supply with surface water available to them or will replace the well. Only 62.1 acre-feet of CCC water is required for the surface water augmentation plan.

Alluvial Valley Floors

Introduction

At the request of the CDMG, Peabody submitted, on November 17, 1980, a report entitled "Reconnaissance Investigation for the Identification of Potential Alluvial Valley Floors in the Vicinity of the Nucla Mine". The reconnaissance area included those portions of Tuttle and Calamity Draws which are adjacent to or near the New Horizon Mine. The San Miguel River was not taken into consideration. However, CDMG undertook a study in 1983 to determine if the San Miguel River could be considered a potential alluvial valley floor where it runs adjacent to the New Horizon Mine. The results of that study determined that there was a sufficient distance separating the mine from the San Miguel River to mitigate any impacts that may occur. Refer to the CDMG's Nucla Mine Proposed Decision and findings of Compliance Document (1983) for the results of their study.

The discussion that follows is based on information contained in Section 2.04.7, field observations, and interpretation of false-color infrared and color aerial photographs at scales of 1" = 500'.

Geomorphology

The areas (First and Second Park) in which the New Horizon Mine and the New Horizon 2 mining area are situated were formed by a regional uplift of sedimentary rocks with the uppermost strata being the Cretaceous Dakota sandstone and Burrow Canyon formations. The formations are overlain by varying thicknesses of undifferentiated eolian silts and sands. These deposits have subsequently been reworked by water, forming rolling upland valleys that are dissected by both Tuttle and Calamity Draws. Since completion of the Colorado Cooperative Company's main irrigation ditch around 1910, the unconsolidated deposits have been further reworked by man to form broad rolling valleys across the First and Second Park, making the area more conducive for irrigation and agriculture.

The New Horizon 2 mining area is located entirely within the Calamity Draw watershed (7.0 square miles) which is less than half the size of the Tuttle Draw watershed. Calamity Draw is also an upland drainage area that is tributary to the San Miguel River. The middle and upper portion of this watershed (the First Park) has been intensively irrigated and cultivated since about 1910. Presently, the watershed is comprised of irrigated pasture, rangeland, and the town site of Nucla. Agricultural and irrigation practices have resulted in a disjointed tributary drainage pattern which is almost completely controlled by the return ditches of the irrigation network. Most of the tributaries, especially in the mid and upper portion of Calamity Draw, are intermittent with flow being controlled by the timing and application of irrigation water. Calamity Draw, in the vicinity of the New Horizon 2 mining area, is a perennial, meandering stream with a narrow incised (up to three feet) channel. The banks are stable as a result of vegetation encroachment.

Calamity Draw has the same valley bottom widths and geomorphic features as Tuttle Draw, but is less steep and confining. The perennial flows of both draws are due to irrigation return water and the limited baseflow is maintained by overburden ground water discharge. The overburden aquifer is recharged from the upland irrigation system.

<u>Irrigation</u>

The area in the vicinity of New Horizon 2 has (since about 1910) had an extensive man-made irrigation system. The water used for flood irrigation is diverted from the San Miguel River approximately 15 miles east of the New Horizon Mine by the Colorado Cooperative Ditch Company. The irrigation ditches transect basins and commonly run along the basin divides (see Map 2.04.7-1A for the exact location of the irrigation ditches). The main irrigation ditches have a network of feeder ditches running from them for irrigating outlying fields. These ditches are a source of ground water recharge, causing ground water mounding in the shallow ground water aquifer system. The effects of mounding near the New Horizon Mine are apparent from monitor well water levels and hydrographs (see Attachment 2.05.6(3)-1, formerly Peabody Appendix 7-2). Perennial flow occurs in Tuttle Draw as a result of ground water discharge and return flow from the irrigation of the upland area. Site inspections confirm that water used for irrigation is obtained from the San Miguel River and no flood irrigation water is obtained from Tuttle Draw or Calamity Draw. The

West Lateral Ditch crosses the proposed New Horizon 2 mining area.

In regard to the agricultural water quality standards, the San Miguel River water delivered by the irrigation ditches is more suitable for irrigation purposes than the waters in Tuttle or Calamity Draw. The agricultural suitability (National Academy of Sciences, 1972) of surface water in Calamity and Tuttle Draws falls within the category of water that can only be used for salt tolerant plants on permeable soils with careful management practices (TDS from 2,000 to 5,000 mg/l). Using the same classification system, water supplied by the West Lateral irrigation ditch (San Miguel River) (TDS 500 mg/l or lower) will have no detrimental effects on plants. Waters of Tuttle and Calamity Draws have commonly exceeded the manganese and PH agricultural standards.

Since the early part of this century, it has been a regional practice to obtain water for irrigation from the San Miguel River. Because of the incised nature of the stream channel, it is difficult to flood irrigate from either Tuttle or Calamity Draw. From field reconnaissance investigations, it has also been determined that water pumpage from these draws for irrigation purposes is occurring infrequently.

Subirrigation

A small amount of subirrigation does occur along the Tuttle and Calamity Draw stream channels. Much of the alluvial ground water along these draws is a result of seepage from the irrigation ditches. In many areas where the subirrigation occurs, the vegetation and soil quickly dry up when the ditch is turned off from October to April. The subirrigation along Tuttle or Calamity Draw is not considered extensive enough to support agricultural development.

Conclusion

The CDRMS concluded in its Decision and Findings of Compliance Document (1983) that no alluvial valley floors exist in either the New Horizon permit area or the potentially affected area (Tuttle Draw) associated with the New Horizon Mine. WFC concludes, based on the following criteria, that no alluvial valley floors exist along the potentially affected area of Calamity Draw associated with the New Horizon 2 mining area. Water availability, quality, the limited extent of the unconsolidated streamlaid deposits and subirrigated areas, and the incised nature of Calamity Draw make it infeasible and impractical to construct a flood irrigation system employing gravity drainage. This conclusion is substantiated by the results of an EPA alluvial valley floor study (EPA 1977) which addresses most coal mining areas of the west and the fact that flood irrigation is not being practiced along Calamity Draw.

Finally, based on geomorphic criteria alone, neither Tuttle or Calamity Draws meet the necessary criteria to be identified as alluvial valley floors, as they display geomorphic features that are indicative of upland areas rather than alluvial valley floors.

Hydrology Monitoring Plan

When Western Fuels-Colorado (WFC) purchased the Nucla Mine (now the New Horizon Mine) from Peabody Coal Company in April, 1992, there was (and is) existing mining permit C-81-008 covering the property. WFC will continue to operate under that permit.

WFC has developed a new hydrological monitoring program with the advice and consent of CDMG. The monitoring program is described in detail in Section 2.04.7.

B) PROBABLE HYDROLOGIC CONSEQUENCES

In support of its original application to mine the Nucla and Nucla East properties (now the New Horizon 1 and New Horizon 2 mining areas), Peabody Coal Company performed extensive and detailed computer modeling to determine probable hydrologic consequences of mining. Details of the computer modeling are available in Attachment 2.05.6(3)-2 (formerly Peabody Tab 17).

This discussion incorporates water monitoring results through the spring of 2001, which have been valuable in predicting long term probable hydrologic consequences.

Peabody summarized the discussion in Attachment 2.05.6(3)-2 (formerly Peabody Tab 17) by listing the probable hydrologic consequences and the results of the analysis of each impact. This summary is presented as Table 2.05.6(3)-1 on the following pages. The table has been modified to incorporate new findings with both the New Horizon #1 and #2 mines. As can be seen, all of the probable impacts have been determined to have no short or long term significance or a plan has been presented to mitigate those determined to have some significance.

Following the summary table is a detailed discussion of each of the potential impacts to the hydrologic balance.

TABLE 2.05.6.(3)-1
SUMMARY OF CONSEQUENCES OF THE LIFE-OF-MINE MINING PLAN FOR THE NEW HORIZON MINING AREA

Probable Hydrologic Consequences	Analysis Results	Significance
Ground Water		
1. Interruption of ground water flow and drawdowns	Maximum projected pit inflow rates will be approximately 5,230 ft^3/day during year 5 of mining at the New Horizon 2 mining area. The maximum extent of the 1 foot drawdown contour is estimated to be 4,000 feet from the center of the pit.	Short term impact of minimal significance. Any injury to surface water rights will be mitigated according to the surface water augmentation plan. Wells proximate to mining areas are completed in deeper units and are not likely to be injured (little significance). Ground water rights mitigation plan addresses alternative ground or surface water sources should they be needed. No short or long term significant impacts.
2. Removal of wells and ponds by mining.	No water righted wells are projected to be removed in the remaining areas to be mined except the Garvey Well (water Right 42) and the Ernest Well (Water Right 1). These wells and the land in which they are located, have been bought by the permittee.	No impact.
3. Impact of replaced spoil material on ground water flow and recharge capacity.	Horizontal hydraulic conductivities will be higher in the spoil as a result of higher percentages of interconnected porosities. Existing and reclaimed topsoil infiltration rates are similar except for some loss of soil structure in the reclaimed topsoil. Vertical hydraulic conductivities in the overburden are principally limited to interconnected fractures. Flow impeding ledges of consolidated rock are absent in the spoil but there is poorer sorting of grain sizes.	Short term impact to topsoil structure but of little significance as far as infiltration rate changes because of plowing and disking practices in the reclamation. Vertical hydraulic conductivities in the spoil will improve because they are no longer dependent on fracture flow. Horizontal hydraulic conductivities should also be higher.
4. Containment of pit inflow pumpage and impacts on water quality.	Only one exceedence of an NPDES standard has occurred as a result of pond discharges since 1979. Pit pumpage impacts to Calamity Draw and San Miguel water quality are 1.5 percent and .08 percent increases in TDS, respectively.	There is very little chance of federal or state receiving stream water quality standards being exceeded in any pond discharges. If any problem were to occur, the discharge could be stopped from the pond and the problem could be remediated. Pit pumpage impacts in terms of TDS increases in Calamity Draw and the San Miguel River will be very slight. No short or long term significant impacts

TABLE 2.05.6.(3)-1 (CONT.)

CONSEQUENCES OF THE LIFE-OF-MINE MINING PLAN FOR THE NEW HORIZON MINING AREA

Probable Hydrologic consequences	Analysis Results	Significance
Ground Water (Cont.)		
5. Impact of spoil water quality on ground and surface water quality.	Geochemical controls on water quality suggest that the water chemistry and concentrations of most elements of concern are controlled by mineralogic reactions that will resist changes in water chemistry. Irrigation water will enter the spoil and will increase in TDS and will discharge from spoil springs but the quality will be essentially the same as the current overburden water quality. This will occur for at least hundreds of years and the spoil water quality will gradually improve to the quality of the irrigation water as pyrite is oxidized and dissolved solids are flushed out.	No indication of significant long or short term impacts to the local ground water quality. Impact to San Miguel water quality is of little significance. Impacts to Calamity and Tuttle Draw water quality are measurable, but are of little significance in terms of water use. See detailed discussion in Probable Hydrologic Consequences under Item 5) Potential impacts of replaced spoil on groundwater quality
Surface Water		
1. Effects of mining on the local geomorphology.	A stream channel course has been altered, the length has been reduced, and the overall gradient will be slightly increased after the removal of the 001 pond. Watershed areas will increase, elevations and slopes will be reduced, and slope lengths and time of concentration will increase.	Adequate reclamation and channel design has resulted in a stable channel. Monitoring conducted in the channel since 1980 indicates no additional contributions of suspended sediment. Watershed impacts will be mitigated by contour ripping, mulching and prompt revegetation. The watershed impacts are expected to be very minimal. Once full reclamation is done on the property by 2014, the site will have no impact on the local geomorphology.
2. Effects of sediment ponds on channel characteristics and downstream users.	Channel reaches below the frequently discharging ponds, will become incised with active meandering channels and vegetation will encroach along the channel edges. AVF study indicates that the channels in Tuttle and Calamity Draws are too incised for flood irrigation, hence neither Draw is determined to be an AVF. Surface water impounded by the sediment ponds may affect water rights downstream.	Long term channel impacts until bond release followed by short term channel readjustment period when ponds are remove. Impacts are of minimal significance and increased vegetation should help control sediment during channel readjustment period. No mitigation is necessary for AVF's (negative determination). WFC has water rights to more water than required for mining related uses. An augmentation plan has been developed for mitigating any impacts proven on downstream users.

TABLE 2.05.6.(3)-1 (CONT.)

CONSEQUENCES OF THE LIFE-OF-MINE MINING PLAN FOR THE NEW HORIZON MINING AREA

Probable Hydrologic Consequences	Analysis Results	Significance
3. Effects of sediment pond discharges, diversions and culverts at road crossings on surface water quality.	Sediment ponds designed for 10-year, 24-hour events. Historic NPDES monitoring have only resulted in one exceedences of TSS. No exceedences of any other required parameter has been observed. Diversions and culverts are designed to adequately convey runoff through and around disturbed areas without contributing additional suspended sediment.	Sediment pond discharge impacts will be negligible because discharges will meet NPDES permit limits. Diversions and culvert impacts will be negligible because they have been designed to minimize erosion and to protect the hydrologic balance.
4. Effects of runoff from reclaimed areas on the quality of streamflow.	Reduced runoff rates and volumes, and lower sediment concentrations and yields. Possible large reductions in runoff due to lower slopes and longer hydraulic lengths. Lower slopes and reclamation practices will result in reduced sediment loads.	Impacts due to reduced runoff will be negligible due to the relatively small reclaimed basin sizes. Flow in the vicinity of both mining areas is dominated by irrigation return water, not runoff.
5. Effects of runoff from reclaimed areas on the quality of streamflow.	Reclaimed area runoff water will be suitable for livestock drinking water. Runoff from reclaimed areas as measured at NPDES 001 has not degraded the quality of water of receiving streams.	No short or long term significant impacts.

Potential impacts to the hydrologic balance and the likelihood that these impacts will occur are given below.

1) Containment of pit inflow and impacts on water quality. All runoff and pit pumpage from disturbed areas will be routed through approved NPDES sedimentation pond(s). These pond(s) will be designed and constructed to impound runoff and pit pumpage from areas disturbed by mining and provide sufficient residence time to insure that the pond discharge water chemistry meets the effluent requirements specified in the NPDES Permit. A review of the chemical and flow data indicates that the potential for any discharge from any NPDES pond to exceed receiving stream or federal standards is minimal. Past history of mine operations at the Nucla Mine indicate very few exceedances of the standards over the years of operations.

2) Interruption of groundwater flow and drawdown. In order to develop the impact assessment for groundwater quantity, two different analyses techniques were utilized. First, pit inflow volumes were determined on an annual basis using an analytical approach developed by McWhorter, 1982. The second analysis involved the determination of annual pit inflow rates and annual drawdowns in the adjacent overburden and coal aquifers as a result of the pit inflows. This analysis utilized the USGS 3-dimensional finite-difference groundwater flow model MODFLOW.

Transient simulations were performed for a five-year period, using the maximum drawdown estimates for the overburden and coal. These drawdown results are expressed as a maximum at the pit and are expressed as a conical depression which results in decreased drawdown at further distance from the mine. For the overburden, the pit drawdown was 5 feet for years 1 and 2, 8 feet during year 3, 15 feet during year 4, and 30 feet during year 5. The drawdown for the coal simulation was 8 feet during year 1, 5.8 feet during year 2, 6 feet during year 3, 7.3 feet during year 4, and 8 feet during year 5. The zero impact contour for the overburden and coal after five years of mining is approximately 4,000 feet. The overburden and coal drawdown contours do not intersect any of the boundaries, therefore, no impact of the San Miguel River from drawdown in the deeper part of the overburden or coal is predicted. Shallow aquifer flow into Tuttle and Calamity Draws in the vicinity of the pit will be decreased, but will be offset by pumpage from the pit. Simulated average daily pit inflow for the coal and overburden aquifers varied from 1,255 cubic feet per day in year 1 to 5,604 cubic feet per day in year 5. WFC's approach to these potential impacts is to monitor the aquifers and discharge from the pit to determine the extent of drawdown. The hydrological monitoring program should provide reasonably accurate measurements of effects of mining. Should the monitoring show that impacts to the groundwater aquifers are precluding its use, WFC will provide alternate water sources of comparable quantity and quality. As described in the water augmentation plan, WFC has a 114 acre foot consumptive use right on the Highline Canal which would be used to mitigate the potential 26 acre foot impact on surface water right users from pit inflow drawdown.

3) Impact on groundwater rights. Ground water rights within the immediate region (2 mile radius) around the New Horizon Mine are presented in Appendix 2.04.7-1. In all, 29 ground water rights have been identified in the vicinity of the New Horizon 1 and New Horizon 2 mining areas. All monitoring wells installed by the permittee and domestic wells within the surrounding area are shown on Map 2.04.7-1-A. Two wells are within the mine area will be affected, the Garvey well (Water Right #42) and the Ernest well (Water Right #1). These wells, as well as the land in which they are located, have been bought by the permittee.

Of the 29 water rights within the surrounding area, 27 wells have intakes too deep to be affected by the pit pumping induced drawdowns in the overburden aquifer. These wells are installed in the Burro Canyon Formation, which is below the Dakota coals to be mined. Significant shales separate the coals from the strata of the wells. Two righted wells W-O09 and W041 have intakes close to the elevation of the bottom of the mine pit. The wells are located approximately 2,300 feet east of New Horizon 2. At the eastern boundary of New Horizon 2, mining will only extend 10 feet below the water table. Therefore, drawdown impacts to these wells are expected to be small. The wells are righted for irrigation water use. This area has been mined and reclaimed over 6 years ago and there has not been any problem identified with these wells. Although some data on these wells is available in Attachment 1 of this section, WFC will attempt to gather some additional information from a few of the nearby water supply wells to the New Horizon #2 Mine.

4) Impact of spoil material on groundwater flow and recharge. The mine pit will remain open only until the coal has been removed. Following the short-term water level decline on the groundwater system as a result of pumpage of groundwater inflow to the pit, a potential long-term impact to the local groundwater flow is the period of time necessary for resaturation of the spoil material and reestablishment of a flow gradient. Another potential impact is increased recharge into the spoil from precipitation and irrigation, resulting in spoil springs developing downgradient.

Figure 2.05.6(3)-1 shows a general cross-section downgradient through the New Horizon #2 mine spoil.

Spoil material at the New Horizon 2 mine will be replaced into the mine pit areas using 3 techniques: 1) cast blasting, end dumping of trucks from the spoil bench and dozing. These techniques will increase permeabilities of the material in comparison to the original overburden. Due to truck dumping from the spoil bench, large rock will settle near the bottom of the pit and provide a permeable channel for groundwater flow. The hydraulic conductivity (K) of the spoil, as measured in well GW-N27, is 40 ft/day, which is far greater than any measurement made in the overburden. K values in the overburden generally range from 3.0 to 5.5 ft/day. The New Horizon #1 site has had continued seasonal irrigation from the North Lateral and its secondary ditch which flows immediately north of the New Horizon #1 reclaimed areas. Water from this irrigation and some added precipitation have moved through the spoil and saturated it until it discharges at the low point of the base of the coal which is at the Spoil Spring and the Pond 001 discharge. Flow from this point fluctuates in response to the use of irrigation. It is believed that the spoil in the New Horizon #2 Mine area will remain relatively dry until irrigation is resumed from the West Lateral Ditch. Once this irrigation is resumed, recharge will rapidly infiltrate into the spoil, move to the southwest according to the basal gradient and develop a spring at the low point of the lowwall crest, as was experienced at the New Horizon #1 Mine. This point can be seen on Map 2.04.7-1A, near the northwest corner of the permit area near Tuttle Draw. This point was calculated in CAD using the entire excavated area for the mine compared to the surface topography. If any spring develops here, it would discharge into Tuttle Draw. The Morgan property should not experience any spoil springs.

Although a large diameter HDPE pipe will be used to carry the ditch water through the permit area, infiltration will begin when the permanent HDPE pipe will be used in re-establishing irrigation in the reclaimed area. This will occur in 2003 for the area east of 2700 Road and will occur after 2010 for the remainder of the mine area west of 2700 Road. It is estimated that full irrigation of the reclaimed area will take place by year 2013. Although the pipe will be used to carry the ditch flow until the end of its useful life in 30-50 years, its use is not relevant to the prediction of irrigation recharge since this recharge will occur over 99% of the area even when the permanent pipe is in place.

From soil information, knowledge of the irrigation practices, discussions with USGS, and the rainfall date for the site, the following recharge data has been calculated: 2" from rain and snowmelt, 13" from irrigation and 1" from underburden recharge and overburden recharge at the uphill spoil/overburden contact. Total long-term recharge is therefore 16" per year. These predictions are approximate but suffice in predicting the behavior of the groundwater in the spoil.

The total affected area is roughly 768 acres. The volume of the reclaim spoil to be recharged below the 5580 spoil spring elevation equals 2,778 ac.ft. as determined from D.T.M. modeling of the spoil area and the pit bottom. Spoil porosity of 15% is determined for the overburden. This yields a pore volume of (0.15)(2778 ac.ft.) = 416 ac.ft.

<u>Worst Case Discharge</u>
With a pore volume of 416 ac.ft. and assuming a total recharge of 16" per year from all sources over the 768 acres of spoil, annual recharge equals (16/12)(768) = 1024 ac.ft. per year after full irrigation in 2013. It should be noted that a portion of the reclaimed area will be restored to dry land pasture and will therefore will not contribute irrigation recharge, however, other areas will have a greater recharge than 16" total, therefore, the average of 16" over the reclaimed area is reasonable. From the year 2003 to 2013, the expected recharge should only be 10% of this amount, since irrigation will not be used on the majority of the area and the fresh-placed spoil will be relatively dry.

Spoil spring discharge = (Spoil Spring Recharge) – (Seepage into Low Wall)

Seepage into Low Wall = (10 ft. thick permeable sandstone bed in low wall)(8500 ft. wide seepage area)(0.10 ft. per day seepage velocity)(1/43,560 cu. ft. to ac. ft.)(365 days per year) = 72 ac.ft.

Spoil Spring Discharge = (1024 ac.ft. recharge) – (72 ac.ft. seepage into low wall) = 952 ac.ft. In the year 2000, the NPDES 001 discharge at the New Horizon #1 Mine showed an average flow of 271,000 gallons per day or 320 acre-feet per year. The NPDES 001 discharge is for practical purposes composed entirely of spoil water. The New Horizon #2 spoil area is much bigger, therefore the predicted flow of 1024 acre-feet per year for this area is a reasonable maximum flow when compared to what is being observed at the #1 Mine.

Worst case time to spring discharge = (Pore Volume)/(Recharge Volume)

= (416 ac.ft.) / (952 ac.ft.) = 0.4 years to actual spring flow after full irrigation is resumed on the reclaimed land in 2013. This is in the worst case scenario with the maximum amount of spoil exposed to irrigation water.

Realistic Discharge

Roughly 422 acres of irrigated land will be constructed in reclamation of the New Horizon #2 mine. An analysis of these areas separately will provide a more realistic calculation of the potential spoil discharge.

With a pore volume of 416 ac.ft. and assuming a total recharge of 16" per year from all sources over the 422 acres of spoil, annual recharge equals (16/12)(422) = 563 ac.ft. per year after full irrigation in 2013. It should be noted that a portion of the reclaimed area will be restored to dry land pasture and will therefore will not contribute irrigation recharge, however, other areas will have a greater recharge than 16" total, therefore, the average of 16" over the reclaimed area is reasonable. From the year 2003 to 2013, the expected recharge should only be 10% of this amount, since irrigation will not be used on the majority of the area and the fresh-placed spoil will be relatively dry.

Spoil spring discharge = (Spoil Spring Recharge) – (Seepage into Low Wall)

Seepage into Low Wall = (10 ft. thick permeable sandstone bed in low wall)(8500 ft. wide seepage area)(0.10 ft. per day seepage velocity)(1/43,560 cu. ft. to ac. ft.)(365 days per year) = 72 ac.ft.

Spoil Spring Discharge = (563 ac.ft. recharge) – (72 ac.ft. seepage into low wall) = 490 ac.ft. In the year 2000, the NPDES 001 discharge at the New Horizon #1 Mine showed an average flow of 271,000 gallons per day or 320 acre-feet per year. The NPDES 001 discharge is for practical purposes composed entirely of spoil water. The New Horizon #2 irrigated spoil area is bigger, therefore the predicted flow of 490 acre-feet per year for this area is a reasonable maximum flow when compared to what is being observed at the #1 Mine.

Realistic case time to spring discharge = (Pore Volume)/(Recharge Volume)

= (416 ac.ft.) / (490 ac.ft.) = 0.8 years to actual spring flow after full irrigation is resumed on the reclaimed land in 2013. This is the most realistic case of when the spoil spring will begin to flow.

In both the worst case and the more realistic discharge scenario, it may begin to discharge slightly sooner since irrigation may begin on the eastern portion of the reclaimed area sooner than 2013, thus contributing some discharge. Also, recharge from precipitation has not been factored in the spoil prior to 2013. Assuming that the permanent pipe is installed in the year 2003 and has a life of 30 years, the pipe would be replaced by the ditch in the year 2033. At this time recharge would increase slightly since water from the ditch would provide additional infiltration, however, the ditch area is so small (0.87 acres) compared to the area of the spoil (768 acres) and the area of irrigation (422 acres), that the increase in infiltration would be negligible. Therefore, the worst case prediction for flow in the spoil spring at the New Horizon #2 Mine is 952 acre feet per year, while the most realistic flow for the spoil spring is 490 acre feet per year. This is a potential flow of 1.31 cfs (worst case) and 0.68 cfs (realistic case).

In both cases, the flow is higher than the previously calculated spoil spring flow from when the New Horizon #2 mine covered a smaller area. That flow was 0.57 cfs. The greater flow at New Horizon #2 mine will lead to a lower impact on area water quality due to dilution.

Overall, there should be no detrimental impacts from the mining operation on groundwater flow and recharge rates. It is definite that ground water flow and recharge in the spoil material will be increased, since the overburden aquifers have historically had very low flow rates and also poor quality. These aquifers have not been used for any wells in the surrounding area and cannot be considered a water resource. The ground water aquifers below the Dakota coals, in the Burro Canyon Formation, are used in surrounding wells and have better water quality but they will not be affected by the mining and reclamation of this site. Shale layers below the mined coals prevent interaction between the spoil and these aquifers, which get their recharge from long distances away from the mine operation.

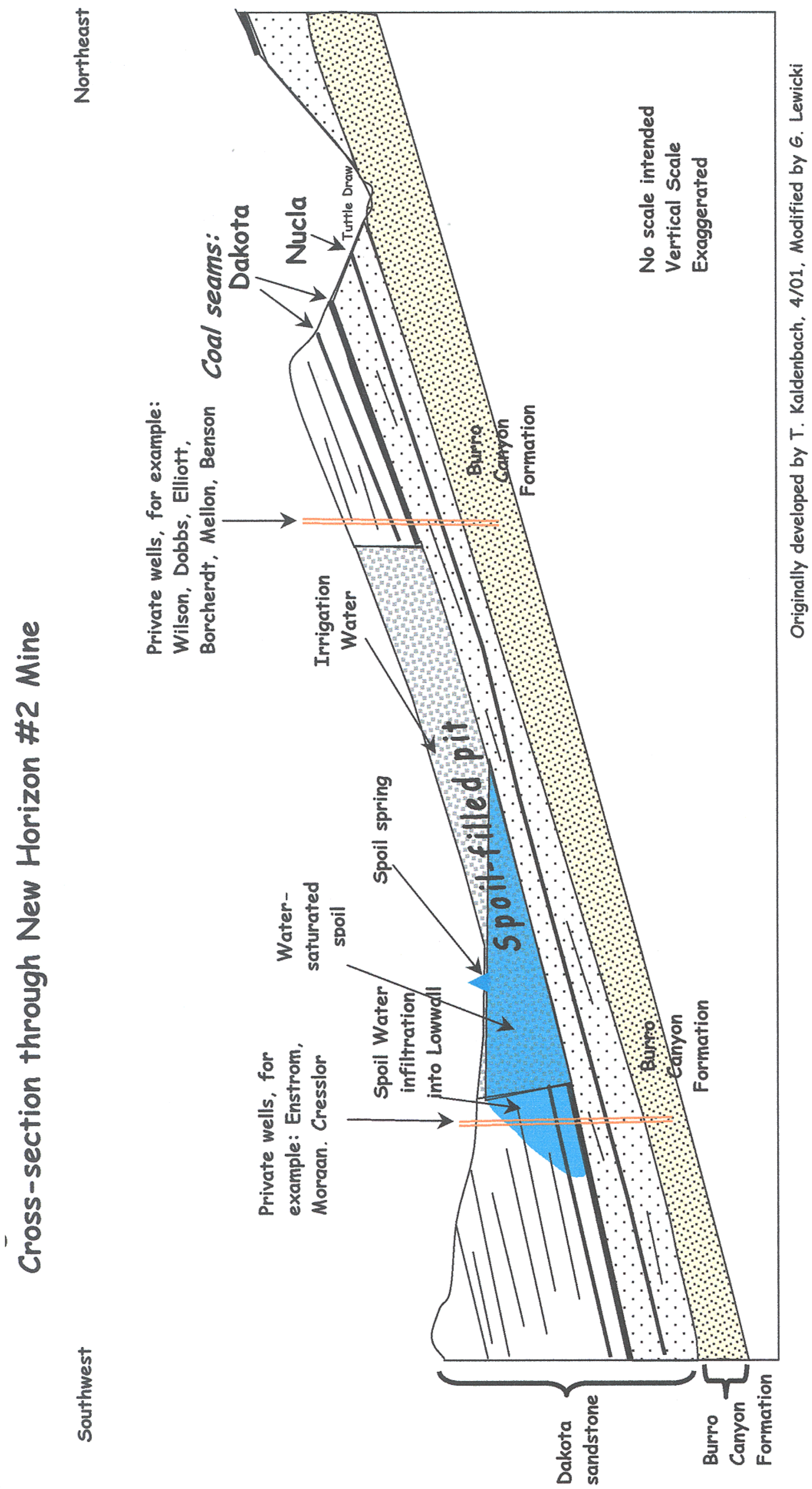

Figure 2.05.6(3)-1

5) Potential impacts of replaced spoil on groundwater quality. Since the operation will disrupt the overburden above the Dakota coals and remove the Dakota coals, these are the only two stratigraphic zones that will be affected by the operation. As described in the section on overbuden water quality, the pre-mine quality of the overburden water is poor, with TDS generally in the 3000 ppm range and some ions exceeding limits for most water uses. The primary potential for impacts to ground water quality will occur from increased water infiltration causing an accelerated oxidation of pyrite in the spoil. Other salts may also dissolve more readily in the highly permeable spoil. The minor amounts of sulfuric acid produced can cause lower pH, which then results in higher rates of dissolution of other chemical compounds in the spoil, resulting in higher TDS. This water will saturate the spoil at the lowwall and form a spring at the low point. Also, the spoil water can infiltrate into the lowwall strata of the Dakota Sandstone formation.

Spoil Water Chemistry

Concerning impacts from the conversion of overburden to spoil, the available data indicate that a small proportion of the overburden may produce acid through the oxidation of pyrite. Based on laboratory tests on overburden cores, calcite is present throughout the overburden. Calcite serves two functions. First, it buffers the pH of the water, which overall tends to slow the oxidation of pyrite, slowing the production of acid. Second, it will neutralize the acid that is produced. The core samples that exhibited low paste pH's are surrounded by non-acid producing, calcite-bearing rocks. The water that contacts the low-paste pH materials will have first reacted with calcite, and therefore developed a pH-buffer capacity of its own. The groundwater monitoring data indicate that mixed overburden and interburden waters have near neutral pH's. Sample pH's less than 6 are associated only with the lower Dakota coal. Where the coal's permeability is high enough to produce about 5 gpm during sampling, the acid-producing reactions do not appear to be fast enough to maintain the pH of the water less than 5. Oxidation rates may increase because of the mining process. However, the supply of oxidation is only one of the constraints on the production of acid. Other constraints are imposed by the quantity of calcite present and the reactivity of the pyrite. The paste-pH test, conducted under oxidizing conditions, indicates that a very small proportion of the overburden is likely to produce acid. This overburden is generally located in a thin zone immediately above the coals. The acid that is produced should be quickly neutralized. During the mining process, WFC will test the overburden and if acidic layers are encountered, they will be mixed with non-acidic layers to neutralize any acid forming effects.

The ability of the calcite in the overburden spoil to neutralize any acid produced is dependent upon a number of factors such as:

a) the uniform distribution of calcite in the replaced spoil,
b) the higher transmissivity of the spoil to allow irrigation water with higher levels of oxygen to move quickly through the spoil, resulting in faster breakdown of the pyrite in the spoil,
c) high void channels developing in the spoil at the bottom of the pit which may serve as the primary conduit for flow in the spoil,
d) the quantity of calcite available in the areas needed most,
e) other chemistry which may influence the neutralization reactions.

For these reasons, there is a possibility that water leaching through the spoil may result in a higher level of TDS for some period of time, until pyrite in the overburden spoil is fully oxidized and removed. This was found to occur at the Seneca II Coal Mine in northwest Colorado and was the subject of a study by the USGS in 1994. Sampling data gathered through the last 13 years at the New Horizon Mine suggests that some pyrite is oxidizing but is being neutralized, as described below.

The analysis of geochemical controls on groundwater quality at the New Horizon #1 Mine spoil suggests that the water chemistry and concentrations of most elements of concern are controlled by mineralogic reactions that will resist changes in water chemistry. It appears that any pyrite (FeS_2) oxidation gets neutralized by calcite ($CaCO_3$) present in the same spoil material. This results in the iron precipitating as iron oxides. The slightly higher than normal pH of the natural water means that there is sufficient acid-neutralizing ions such as hydroxyl (OH-) or bicarbonate (HCO_3^-) in solution to absorb the acidic hydrogen (H+) ions produced by the pyrite oxidation. Soluble sulfate (SO_4^{-2}) ions are also produced by the pyrite oxidation, and they are quickly taken up by the calcite to produce calcium sulfate or gypsum ($CaSO_4$), which is not very soluble and also precipitates out of solution, especially when the pH of the solution is near normal. The (CO_3^{-2}) anion in the calcite goes in solution to replace the sulfate. Calcium stays as a solid in the new gypsum produced. Overall, the net change to the water quality is not significant as compared to overburden water, but some pyrite has been converted to other solid compounds: gypsum and iron oxides such as limonite. Strong support for this occurring is seen in the water quality comparison of overburden water to spoil water. Well GW-N9 is north of the mined areas of New Horizon #1 and has been unaffected by the mine since the flow gradient is to the southwest. This well is best to use in the comparison. Spoil Spring 1, which developed near the southwestern end of the reclaimed mine best represents the spoil water. Table 2.05.6.(3)-2 shows the chemistry of these waters sampled at the same time.

If the pyrite breakdown were occurring without any neutralization, the pH of the spoil water would be lower than overburden water. This has not occurred; however, the replacement of sulfate ion by carbonate ion from the calcite should be seen as an increased carbonate or bicarbonate in solution. This is exactly what is seen between the overburden water and the spoil water for each sampling period except for the August 1998 sample, which must have had outside influence of surface water flows since its total dissolved solids is much less than any other sample. All other ions in solution are more or less proportional to the level of TDS in the sample. Bicarbonate, on the other hand, has consistently increased by approximately 33%.

There is no significant trend in TDS differences from the overburden water to the spoil water, although averaging the samples from 1995, 1996, 2000 and 2001 shows a difference of 200 ppm or a 6.6% increase. Overall, water quality of the spoil water may be only slightly higher in TDS than the undisturbed overburden water. The quality of both waters are relatively poor. However, the spoil water quality is affected to a significant degree by the time of year when irrigation is occurring on the surface. Table 2.05.6.(3)-3 shows the TDS levels and flow rates for various samples taken from 1987 to the present for the Spoil Spring and the NPDES 001 discharge. TDS for wells GW-N9 and GW-N15, which are located in undisturbed overburden, are also included in the table.

The monthly flows and TDS values from the NPDES 001 discharge show a direct correlation between TDS and flow rate. As the flow rate gets lower, the TDS gets higher.

TABLE 2.05.6.(3)-2

Water Quality Comparison - Overburden Water (GW-N9) vs. Spoil Water (Spoil Spring)

Sample Date	**11/95**		**8/96**		**8/98**		**8/99**		**8/00**		**3/01**	
Parameter	**GW-N9**	**Spoil Spr.**	**GW-N9**	**Spoil Spr.**	**GW-N9**	**Spoil Spr.**	**GW-N9**	**Spoil Spr.**	**GW-N9**	**Spoil Spr.**	**GW-N9**	**Spoil Spr.**
Sulfate	1820	2020	2010	2000	2020	790	not	1240	1840	1890	2200	1980
Magnesium	157	222	224	220	218	102	sampled	151	158	190	236	215
Iron total	14.8	.06	1.64	.09	.74	1.3		.62	.42	.73	.27	1.18
Bicarbonate	292	415	323	411	330	295		322	280	368	302	419
Calcium	564	537	549	555	550	269		398	555	542	567	541
TDS	2950	3280	3120	3210	3350	1560		2120	2740	3280	3210	3050
Flow in cfs		.09		.17		.26		.40		.26		.18

It is important to understand what is truly different from the pre-mine condition to the spoil condition. In the pre-mine condition, very good quality water from precipitation and from the irrigation ditches infiltrates through the soil and through the more permeable strata and picks up dissolved solids. The water quality becomes poor (approx. 3000 ppm TDS), but this process takes a very long time since the water moves very slowly through the tight strata with low hydraulic permeabilitites, which are in the range of 3.5 to 5.5 ft/day.

In the case of the spoil, the hydraulic permeability is increased to 40 ft/day and much more irrigation water is recharged rapidly through the permeable, broken spoil material. This good quality water picks up dissolved solids as in the case of the overburden, it simply does it much more rapidly. Water infiltrating into the spoil at the upper end of the New Horizon #1 spoil may only spend 15-45 days in the spoil before the water is discharged at the spring. Yet, during this short time, it has managed to become approximately the same quality as the overburden water. The average TDS of the irrigation ditch water is only 100 to 280 ppm. Due to the increased porosity and higher level of oxygen in the rapidly infiltrating precipitation water and irrigation water, the pyrite breaks down at a faster rate but is buffered by the calcite, as described above. Therefore, the overall impacts to water quality are the following:

A) In the pre-mine condition, a large portion of the irrigation water runs off the surface and picks up some TDS in the fields and is gathered in return ditches. In the post-mine condition, a large portion of the irrigation water will infiltrate and recharge the spoil due to the increase in porosity. The TDS of the spoil water at the New Horizon #1 Mine will increase approximately 6% compared to that of the overburden water immediately after re-establishment of irrigation. This is approximately 3300 ppm of TDS. Since the flowpath through the New Horizon #2 spoil is greater than the New Horizon #1 spoil, the expected increase in TDS for this water is 10% over background TDS in the overburden water. This is approximately 3425 ppm of TDS. A potential maximum is 4000 ppm TDS. Water movement through the spoil will also be considerably faster than the movement in the overburden.

B) Spoil springs will be present at both reclaimed mine areas which discharge the majority of the spoil water to the surface. This is an impact since no spoil springs existed in the pre-mine condition.

C) Once the pyrite and easily dissolved salts are washed out of the spoil, the water in both spoil springs will gradually get lower in TDS until some time many years from now, the spoil spring water quality will get better than the overburden quality. At a time much more distant in the future and much more difficult to calculate, the spoil water will approach the irrigation water quality. Time periods for this to occur are given later in this section.

TABLE 2.05.6.(3)-3

Flow Rates vs. TDS for Selected Surface Water Locations

Overburden Wells GW-N9 and GW-N15 Included for Comparison

NPDES 001 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	SW-N1 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	**SW-N3** DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	**SPOIL SPR 1** DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	**GW-N9** DATE	TDS (mg/l)	**GW-N15** DATE	TDS (mg/l)
Jan-86			Jan-86			Jan-86			Jan-86			Jan-86		Jan-86	
Feb-86			Feb-86			Feb-86			Feb-86			Feb-86		Feb-86	
Mar-86			Mar-86			Mar-86			Mar-86			Mar-86		Mar-86	
Apr-86			Apr-86			Apr-86			Apr-86			Apr-86		Apr-86	
May-86			May-86			May-86			May-86			May-86		May-86	
Jun-86			Jun-86			Jun-86			Jun-86			Jun-86		Jun-86	
Jul-86			Jul-86			Jul-86			Jul-86			Jul-86		Jul-86	
Aug-86			Aug-86			Aug-86			Aug-86			Aug-86		Aug-86	
Sep-86			Sep-86			Sep-86			Sep-86			Sep-86		Sep-86	
Oct-86	2546	0.4	Oct-86	1346	0.24	Oct-86			Oct-86			Oct-86	3242	Oct-86	7498
Nov-86	2848	0.23	Nov-86	1542	0.59	Nov-86			Nov-86			Nov-86		Nov-86	
Dec-86	2742	0.23	Dec-86	1466	0.19	Dec-86			Dec-86			Dec-86		Dec-86	
Jan-87	2042	0.29	Jan-87	1434	0.09	Jan-87			Jan-87	3414	0.02	Jan-87		Jan-87	6648
Feb-87	3074	0.09	Feb-87			Feb-87			Feb-87			Feb-87		Feb-87	
Mar-87	3664	0.01	Mar-87			Mar-87			Mar-87			Mar-87		Mar-87	
Apr-87	3245	0.06	Apr-87			Apr-87			Apr-87			Apr-87	4130	Apr-87	10074
May-87	1364	0.92	May-87	944	1.42	May-87	1670	1.69	May-87	3422	0.04	May-87		May-87	
Jun-87			Jun-87			Jun-87			Jun-87			Jun-87		Jun-87	
Jul-87	1842	0.45	Jul-87			Jul-87			Jul-87			Jul-87		Jul-87	
Aug-87	1914	1.48	Aug-87			Aug-87			Aug-87			Aug-87		Aug-87	
Sep-87	1368	0.99	Sep-87			Sep-87			Sep-87			Sep-87		Sep-87	
Oct-87			Oct-87			Oct-87			Oct-87			Oct-87		Oct-87	
Nov-87			Nov-87			Nov-87			Nov-87			Nov-87		Nov-87	
Dec-87			Dec-87			Dec-87			Dec-87			Dec-87		Dec-87	
Jan-89			Jan-89			Jan-89			Jan-89			Jan-89		Jan-89	
Feb-89			Feb-89			Feb-89			Feb-89			Feb-89		Feb-89	
Mar-89			Mar-89			Mar-89			Mar-89			Mar-89		Mar-89	
Apr-89			Apr-89			Apr-89			Apr-89			Apr-89		Apr-89	
May-89			May-89			May-89			May-89			May-89		May-89	
Jun-89			Jun-89			Jun-89			Jun-89			Jun-89		Jun-89	
Jul-89			Jul-89			Jul-89			Jul-89			Jul-89		Jul-89	
Aug-89			Aug-89			Aug-89			Aug-89			Aug-89		Aug-89	
Sep-89			Sep-89			Sep-89			Sep-89			Sep-89		Sep-89	
Oct-89	1830	0.372	Oct-89	868	0.465	Oct-89	2108	1.598	Oct-89	3484		Oct-89	2916	Oct-89	1618
Nov-89	3142	0.226	Nov-89			Nov-89			Nov-89			Nov-89		Nov-89	
Dec-89	3356	0.171	Dec-89			Dec-89			Dec-89			Dec-89		Dec-89	
Jan-90	3364	0.115	Jan-90			Jan-90			Jan-90			Jan-90		Jan-90	
Feb-90	3252	0.096	Feb-90			Feb-90			Feb-90			Feb-90		Feb-90	
Mar-90	3366	0.065	Mar-90			Mar-90			Mar-90			Mar-90		Mar-90	
Apr-90	2928	0.084	Apr-90	816	0.865	Apr-90	1320	2.015	Apr-90	3776		Apr-90		Apr-90	
May-90	1510	0.424	May-90			May-90			May-90			May-90		May-90	
Jun-90	1138	1.66	Jun-90			Jun-90			Jun-90			Jun-90		Jun-90	
Jul-90	1388	1.14	Jul-90			Jul-90			Jul-90			Jul-90		Jul-90	
Aug-90	1556	0.938	Aug-90			Aug-90			Aug-90			Aug-90		Aug-90	
Sep-90	1958	1.181	Sep-90	568	1.575	Sep-90	1180	4.1	Sep-90	3762		Sep-90	3100	Sep-90	
Oct-90	1368	1.22	Oct-90			Oct-90			Oct-90			Oct-90		Oct-90	
Nov-90	3182	0.24	Nov-90			Nov-90			Nov-90			Nov-90		Nov-90	
Dec-90	2896	0.171	Dec-90			Dec-90			Dec-90			Dec-90		Dec-90	
Jan-91	3414	0.115	Jan-91			Jan-91			Jan-91			Jan-91		Jan-91	
Feb-91	3108	0.068	Feb-91			Feb-91			Feb-91			Feb-91		Feb-91	
Mar-91	3082	0.115	Mar-91			Mar-91			Mar-91			Mar-91		Mar-91	
Apr-91	3272	0.052	Apr-91	1610	0.171	Apr-91	2668	0.421	Apr-91	3802	0.018	Apr-91		Apr-91	
May-91	1344	0.672	May-91			May-91			May-91			May-91		May-91	
Jun-91	1528	0.491	Jun-91			Jun-91			Jun-91			Jun-91		Jun-91	
Jul-91	1368	0.991	Jul-91			Jul-91			Jul-91			Jul-91		Jul-91	
Aug-91	1772	0.672	Aug-91			Aug-91			Aug-91			Aug-91		Aug-91	
Sep-91	1548	1.061	Sep-91	662	1.13	Sep-91	1392	3.182	Sep-91	3500	0.105	Sep-91	3058	Sep-91	
Oct-91	3112	0.306	Oct-91			Oct-91			Oct-91			Oct-91		Oct-91	

NPDES 001 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	SW-N1 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	SW-N3 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	SPOIL SPR 1 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D)	GW-N9 DATE	TDS (mg/l)	GW-N15 DATE	TDS (mg/l)
Nov-91	3154	0.234	Nov-91			Nov-91			Nov-91			Nov-91		Nov-91	
Dec-91	3464	0.165	Dec-91			Dec-91			Dec-91			Dec-91		Dec-91	
Jan-92	3524	0.115	Jan-92			Jan-92			Jan-92			Jan-92		Jan-92	
Feb-92	3108	0.088	Feb-92			Feb-92			Feb-92			Feb-92		Feb-92	
Mar-92	3328	0.058	Mar-92			Mar-92			Mar-92			Mar-92		Mar-92	
Apr-92	3318	0.046	Apr-92	1474	0.247	Apr-92	2640	0.403	Apr-92	3630		Apr-92		Apr-92	
May-92	576	0.955	May-92			May-92			May-92			May-92		May-92	
Jun-92	2158	0.159	Jun-92			Jun-92			Jun-92			Jun-92		Jun-92	
Jul-92	2026	0.383	Jul-92			Jul-92			Jul-92			Jul-92		Jul-92	
Aug-92	1794	1.028	Aug-92			Aug-92			Aug-92			Aug-92		Aug-92	
Sep-92	1742	1.028	Sep-92	448	3.11	Sep-92	1144	6.163	Sep-92	3260	0.007	Sep-92	3012	Sep-92	
Oct-92			Oct-92			Oct-92			Oct-92			Oct-92		Oct-92	
Nov-92			Nov-92			Nov-92			Nov-92			Nov-92		Nov-92	
Dec-92			Dec-92			Dec-92			Dec-92			Dec-92		Dec-92	
Jan-93	2998	0.0986	Jan-93	1394	0.0931	Jan-93	2150	0.3102	Jan-93	3426	0.0045	Jan-93		Jan-93	
Feb-93	3008	0.0655	Feb-93	1462	0.0801	Feb-93	1762	0.221	Feb-93	3442	0.0071	Feb-93		Feb-93	
Mar-93	3154	0.0513	Mar-93	1424	0.0575	Mar-93	2176	0.1926	Mar-93	3466	0.0071	Mar-93		Mar-93	
Apr-93	3230	0.035	Apr-93	1278	0.1183	Apr-93	2206	0.0924	Apr-93	3446		Apr-93		Apr-93	
May-93	3374	0.0768	May-93	500	1.2093	May-93	710	1.3663	May-93	3636	0.0142	May-93	3428	May-93	1146
Jun-93	1274	0.4212	Jun-93	548	0.2288	Jun-93	1524	0.3936	Jun-93	3156	0.0213	Jun-93		Jun-93	
Jul-93	1468	0.5802	Jul-93	436	0.5494	Jul-93	1006	0.192	Jul-93	3328	0.0142	Jul-93		Jul-93	
Aug-93	1506	0.6317	Aug-93			Aug-93			Aug-93			Aug-93		Aug-93	
Sep-93	2368	0.6811	Sep-93			Sep-93			Sep-93			Sep-93		Sep-93	1218
Oct-93	2722	0.3524	Oct-93			Oct-93			Oct-93			Oct-93		Oct-93	
Nov-93	2886	0.1748	Nov-93	1194	0.1932	Nov-93	1850	0.3742	Nov-93			Nov-93	2942	Nov-93	2712
Dec-93	3018	0.117	Dec-93			Dec-93			Dec-93			Dec-93		Dec-93	
Jan-94	3066	0.0805	Jan-94			Jan-94			Jan-94			Jan-94		Jan-94	
Feb-94	2964	0.0579	Feb-94			Feb-94			Feb-94			Feb-94		Feb-94	
Mar-94	3044	0.0473	Mar-94			Mar-94			Mar-94			Mar-94		Mar-94	3468
Apr-94	3130	0.0299	Apr-94			Apr-94			Apr-94			Apr-94		Apr-94	
May-94	1804	0.1077	May-94			May-94	1166	0.2889	May-94			May-94	3946	May-94	2144
Jun-94	1390	0.2582	Jun-94	794	0.4001	Jun-94			Jun-94			Jun-94		Jun-94	
Jul-94	DNS	0.4893	Jul-94			Jul-94			Jul-94			Jul-94		Jul-94	
Aug-94	1864	0.3303	Aug-94			Aug-94			Aug-94			Aug-94		Aug-94	2986
Sep-94	2130	0.2579	Sep-94			Sep-94			Sep-94			Sep-94		Sep-94	
Oct-94	2874	0.269	Oct-94			Oct-94			Oct-94			Oct-94		Oct-94	
Nov-94	2940	0.1367	Nov-94	1420	0.3387	Nov-94	2210	0.4563	Nov-94	3210	0.0323	Nov-94	2880	Nov-94	2320
Dec-94	2970	0.0909	Dec-94			Dec-94			Dec-94			Dec-94		Dec-94	
Jan-95	2920	0.0656	Jan-95			Jan-95			Jan-95			Jan-95		Jan-95	
Feb-95	2920	0.0456	Feb-95			Feb-95			Feb-95			Feb-95		Feb-95	2939
Mar-95	2900	0.0462	Mar-95			Mar-95			Mar-95			Mar-95		Mar-95	
Apr-95	2980	0.0301	Apr-95			Apr-95			Apr-95			Apr-95		Apr-95	
May-95	2200	0.0921	May-95	624	0.711	May-95	1150	0.8402	May-95	3330	0.0504	May-95		May-95	2400
Jun-95	720	0.4649	Jun-95			Jun-95			Jun-95			Jun-95		Jun-95	
Jul-95	2170	0.4804	Jul-95			Jul-95			Jul-95			Jul-95		Jul-95	
Aug-95	2370	0.2428	Aug-95			Aug-95			Aug-95			Aug-95		Aug-95	1520
Sep-95	1330	0.2853	Sep-95			Sep-95			Sep-95			Sep-95		Sep-95	
Oct-95	2280	0.334	Oct-95			Oct-95			Oct-95			Oct-95		Oct-95	
Nov-95	2740	0.1365	Nov-95	1420	0.2747	Nov-95	1880	0.4925	Nov-95	3280	0.0599	Nov-95	2950	Nov-95	1700
Dec-95	2870	0.0207	Dec-95			Dec-95			Dec-95			Dec-95		Dec-95	
Jan-96	3060	0.0624	Jan-96			Jan-96			Jan-96			Jan-96		Jan-96	
Feb-96	2940	0.0412	Feb-96			Feb-96			Feb-96			Feb-96		Feb-96	
Mar-96	3180	0.0274	Mar-96			Mar-96			Mar-96			Mar-96		Mar-96	2400
Apr-96	3040	0.0153	Apr-96			Apr-96			Apr-96			Apr-96		Apr-96	
May-96	2700	0.1853	May-96			May-96			May-96			May-96		May-96	
Jun-96	1620	0.3652	Jun-96			Jun-96			Jun-96			Jun-96		Jun-96	
Jul-96	1360	0.4547	Jul-96			Jul-96			Jul-96			Jul-96		Jul-96	
Aug-96	2180	0.4249	Aug-96	820	0.2508	Aug-96	2370	0.9036	Aug-96	3210	0.113	Aug-96	3120	Aug-96	1270
Sep-96	2210	0.6326	Sep-96			Sep-96			Sep-96			Sep-96		Sep-96	
Oct-96	1730	0.5446	Oct-96			Oct-96			Oct-96			Oct-96		Oct-96	
Nov-96	2800	0.2342	Nov-96			Nov-96			Nov-96			Nov-96		Nov-96	
Dec-96	2770	0.1803	Dec-96			Dec-96			Dec-96			Dec-96		Dec-96	
Jan-97	2880	0.156	Jan-97			Jan-97			Jan-97			Jan-97		Jan-97	
Feb-97	2820	0.1143	Feb-97			Feb-97			Feb-97			Feb-97		Feb-97	1830
Mar-97	2850	0.0852	Mar-97			Mar-97			Mar-97			Mar-97		Mar-97	
Apr-97	3040	0.085	Apr-97			Apr-97			Apr-97			Apr-97		Apr-97	
May-97	2700	0.1821	May-97			May-97			May-97			May-97		May-97	
Jun-97	1620	0.5081	Jun-97			Jun-97			Jun-97			Jun-97		Jun-97	
Jul-97	1520	0.4854	Jul-97			Jul-97			Jul-97			Jul-97		Jul-97	
Aug-97	DNS	0.4794	Aug-97	700	1.0348	Aug-97	550	0.6392	Aug-97	3100	0.1047	Aug-97	3180	Aug-97	1180

NPDES 001 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D	SW-N1 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D	SW-N3 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D	SPOIL SPR 1 DATE	TDS (mg/l)	FLOW (AVG MM GAL/D	GW-N9 DATE	TDS (mg/l)	GW-N15 DATE	TDS (mg/l)
Sep-97	940	0.3888	Sep-97			Sep-97			Sep-97			Sep-97		Sep-97	
Oct-97	1900	0.2431	Oct-97			Oct-97			Oct-97			Oct-97		Oct-97	
Nov-97	2870	0.0843	Nov-97			Nov-97			Nov-97			Nov-97		Nov-97	
Dec-97	2800	0.0699	Dec-97			Dec-97			Dec-97			Dec-97		Dec-97	
Jan-98	2920	0.0481	Jan-98			Jan-98			Jan-98			Jan-98		Jan-98	
Feb-98	2870	0.0341	Feb-98			Feb-98			Feb-98			Feb-98		Feb-98	2210
Mar-98	2880	0.0204	Mar-98			Mar-98			Mar-98			Mar-98		Mar-98	
Apr-98	2870	0.0104	Apr-98			Apr-98			Apr-98			Apr-98		Apr-98	
May-98	2100	0.1822	May-98			May-98			May-98			May-98		May-98	
Jun-98	1690	0.1614	Jun-98			Jun-98			Jun-98			Jun-98		Jun-98	
Jul-98	1520	0.1906	Jul-98			Jul-98			Jul-98			Jul-98		Jul-98	
Aug-98	2890	0.3486	Aug-98	790	0.1409	Aug-98	810	0.6282	Aug-98	1560	0.1651	Aug-98		Aug-98	1030
Sep-98	940	0.4613	Sep-98			Sep-98			Sep-98			Sep-98		Sep-98	
Oct-98	1730	0.2496	Oct-98			Oct-98			Oct-98			Oct-98		Oct-98	
Nov-98	2800	0.0843	Nov-98			Nov-98			Nov-98			Nov-98		Nov-98	
Dec-98	2770	0.07	Dec-98			Dec-98			Dec-98			Dec-98		Dec-98	
Jan-99	2920	0.1	Jan-99			Jan-99			Jan-99			Jan-99		Jan-99	
Feb-99	2870	0.0756	Feb-99			Feb-99			Feb-99			Feb-99		Feb-99	
Mar-99	2880	0.0498	Mar-99			Mar-99			Mar-99			Mar-99		Mar-99	
Apr-99	1810	0.0602	Apr-99			Apr-99			Apr-99			Apr-99		Apr-99	
May-99	2490	0.2615	May-99			May-99			May-99			May-99		May-99	
Jun-99	1130	0.4666	Jun-99			Jun-99			Jun-99			Jun-99		Jun-99	
Jul-99	1420	0.5757	Jul-99			Jul-99			Jul-99			Jul-99		Jul-99	
Aug-99	1130	0.4174	Aug-99	1080	0.3684	Aug-99	810	1.0406	Aug-99	2120	0.2566	Aug-99		Aug-99	
Sep-99	1950	0.4288	Sep-99			Sep-99			Sep-99			Sep-99		Sep-99	
Oct-99	2520	0.2575	Oct-99			Oct-99			Oct-99			Oct-99		Oct-99	
Nov-99	2640	0.2164	Nov-99			Nov-99			Nov-99			Nov-99		Nov-99	
Dec-99	2820	0.1312	Dec-99			Dec-99			Dec-99			Dec-99		Dec-99	
Jan-00	2610	0.0689	Jan-00			Jan-00			Jan-00			Jan-00		Jan-00	
Feb-00	2800	0.0917	Feb-00			Feb-00			Feb-00			Feb-00		Feb-00	
Mar-00	2460	0.1312	Mar-00			Mar-00			Mar-00			Mar-00		Mar-00	
Apr-00	2770	0.025	Apr-00			Apr-00			Apr-00			Apr-00		Apr-00	
May-00	2410	0.0501	May-00			May-00			May-00			May-00		May-00	
Jun-00	1590	0.2693	Jun-00			Jun-00			Jun-00			Jun-00		Jun-00	
Jul-00	1950	0.2246	Jul-00			Jul-00			Jul-00			Jul-00		Jul-00	
Aug-00	1980	0.25	Aug-00	870	0.3684	Aug-00	1110	1.2477	Aug-00	3280	0.1651	Aug-00		Aug-00	
Sep-00	1560	0.3771	Sep-00			Sep-00			Sep-00			Sep-00		Sep-00	
Oct-00	2290	0.2761	Oct-00			Oct-00			Oct-00			Oct-00		Oct-00	
Nov-00	2710	0.1317	Nov-00			Nov-00			Nov-00			Nov-00		Nov-00	
Dec-00	2780	0.0927	Dec-00			Dec-00			Dec-00			Dec-00		Dec-00	

DNS signifies *Did Not Sample*.

As can be seen from the table, the TDS of the NPDES 001 discharge at the New Horizon #1 Mine fluctuates inversely in response to flows during irrigation season. The overburden wells and Spoil Spring #1 fluctuate to a lesser extent. The August 1996 sample in the spoil spring appears to be an aberration and not a trend.

Spoil Water Infiltration into Lowwall

Figure 2.05.6(3)-1 shows how infiltration will build up in the spoil downgradient and begin to seep into the lowwall. This spoil water may enter one or more of the minor sandstone beds of the overburden (Dakota Sandstone). This annual infiltration is calculated below, assuming a 10' thick somewhat permeable bed in the lowwall strata:

Seepage into Low Wall = (10' ft. thick permeable sandstone bed in low wall)(8500' ft. wide seepage area)(0.10 ft. per day seepage velocity)(1/43,560 cu. ft. to ac. ft.)(365 days per year) = 72 ac.ft per year.

The seepage velocity could be as high as 0.3 feet per day, depending upon the sandstone permeability. Using a worst case of 0.3 feet/day, this results in a travel of 1000 feet every 10 years.

It is strongly believed that spoil water seepage into the lowwall will not have any significant impact on water quality, flow rates, well usage etc. due to four reasons:

1) As described in this section, the water quality of the spoil water will be at a maximum 6% to 10% higher in TDS than the existing overburden water quality, which is relatively poor. Therefore, regardless of the seepage rates into the sandstone zones, the water quality will be very similar to what has been consistently tested in the overburden, with a TDS from 2800 to 3500 ppm.

2) Due to the low seepage rates, the movement is very slow (1000 feet every 10 years).

3) The sandstones above the Dakota coals have historically been too poor in quality and too low in flow rates to provide useful wells. For this reason, no known wells in the vicinity of the mine area have been completed in the Dakota sandstone. It is very unlikely that any new wells will be completed in the Dakota sandstone in the vicinity since the Burro Canyon Formation provides significantly better water quality and flow and is located only 50 to 100 feet deeper than the Dakota sands.

4) The local wells are completed in the Burro Canyon Formation, which is below the Dakota coals. Although this zone has significantly better quality water, these sandstones are separated from the spoil by shale layers with very low permeabilities, therefore these aquifers cannot be affected by the spoil water.

6) Impact of spoil water quality on surface water quality.

Spoil Water Quality

The chemistry of the water interacting with the spoil is described in the previous section. In order to determine the impact of the spoil water quality on the surface water, it is first necessary to predict the expected quality of the spoil leachate for the New Horizon #1 and #2 mines. The principal impact from a quality perspective is that irrigation water will seep rapidly through the spoil, increase in TDS and then discharge through a spoil spring at each mine area. Since the pre-mine site did not have spoil springs, there is a potential impact to the quality of the receiving waters. The spoil spring at the New Horizon #1 Mine enters Tuttle Draw while the predicted spring for the New Horizon #2 Mine will enter a tributary to Tuttle Draw and within 1 mile, will also enter Tuttle Draw. Increases or decreases in pH have never been observed on the site. The Spoil Spring 1 discharge best represents the quality of the spoil leachate at the New Horizon #1 Mine, since this flow is solely of water emanating from the spoil and has very little surface water influence. The NPDES 001 discharge is comprised of the flow from Spoil Spring 1, a second spoil spring above a tributary drainage and very rarely, surface flows. From samples of Spoil Spring 1 discharge over the past 12 years, an expected average TDS is 3300 ppm TDS, which is approximately 6% higher than average levels in the overburden samples taken over the same period. Since the New Horizon #2 Mine is larger and has a longer flow path through the spoil, it is estimated that TDS levels will be 10% higher than average levels in the overburden, resulting in a TDS of 3425 ppm.

Timeframes of Elevated TDS in Spoil Water

The time period that these slightly elevated level of TDS in the spoil water and spoil spring discharges is difficult to calculate. In 1994, the USGS did a detailed study of the impacts of infiltration into spoil at the Seneca II Coal Mine in Routt County, CO. This study is Water Resources Investigations Report 92-4187 titled *Hydrology and Geochemistry of a Surface Coal Mine in Northwest Colorado*. Lysimeters were installed to measure infiltration rates into the spoil, and samples of inflow water, spoil water and spring discharge were analyzed for the entire area. It was determined that pyrite oxidation was the principal cause of elevated TDS, and that the percent of pyrite in the spoil was the determining factor in the length of time that the TDS would be elevated in the spoil water. A spoil pyrite content of 1% by weight, for example, was predicted to fully oxidize in 1600 years (their Table 18). TDS levels in the spoil water were approximately 4500 ppm, which was a significant increase over the overburden aquifer water in the area. The coal mine overburden at this site was similar in age to that of the New Horizon Mine.

For the New Horizon site, the USGS study methodology can be used as a basis to predict the time frames of slightly elevated TDS in the spoil water.

The New Horizon Mines are similar to the Seneca II Mine in terms of depositional history and observed spoil leachate chemistry. These similarities indicate the oxidation of pyrite can be assumed to be the main source of increased TDS in spoil aquifer water at New Horizon, as at Seneca II Mine.

The pyritic sulfur content in New Horizon's spoil averaged 0.52% (by weight) in the 72 overburden core samples whose analyses are reported in the permit application. Pyrite is 53% sulfur (by weight); therefore, the 0.52% pyritic sulfur content indicates that pyrite comprises roughly 0.98% of the mass of the subject mine's spoil. Applying Williams and Clark's 1,600 year exhaustion time for 1.0% pyrite, the subject mine's spoil can be expected to generate high sulfate concentrations for at least 1,500 years.

The calculated 1,600 year duration is reduced to about 800 years when reductions are taken into account for piping through the spoil (assumed to be 25%) and lower annual precipitation (12 inches at New Horizon versus 17 inches at Seneca). The calculated 800-year duration is not meant to be a precise prediction of the duration of elevated dissolved solids, but indicates the elevated solids can be expected to last, possibly, several centuries.

The New Horizon Mine has two significant differences to the results observed at Seneca II. First, the calcite present in the spoil at New Horizon seems to react with acid produced by the oxidation of pyrite and take a substantial amount of sulfate from solution into solid calcium sulfate. This keeps the dissolved solids content somewhat constant no matter how high or low the the inflow water quality is with regard to TDS. Second, the Seneca II site is a dryland reclaimed area where the only recharge into the spoil is a minor amount from precipitation and seepage from the underburden aquifers. Total measured discharge from the spoil was only 3" per year. The New Horizon Mine is principally irrigated with water of very good quality over a large portion of the year. As described earlier, this results in a total movement through the spoil of approximately 16" per year. Since the amount of water moving through the New Horizon spoil is so much greater, it should oxidize the pyrite much more rapidly and also flush other salts which are contributing to the increase in TDS at a much higher rate. For this reason, a ratio of the discharge at both sites could be used to predict the time frame of slightly elevated spoil water quality. This ratio - 3"/16", as applied to 1500 years results in a time frame of 280 years until all the pyrite is oxidized. When considering all the variables involved, this means that it could dissipate within a range of 100 to 500 years. The TDS should begin to drop before this time. Once the pyrite is fully oxidized and other salts are flushed out, the spoil water quality should approach the irrigation water quality, possibly dropping to 300 ppm TDS.

Impacts To Receiving Waters

Since these spoil springs were never present in the pre-mine landscape, their impact to the quality of the receiving waters must be addressed. As described earlier, a spoil spring will develop on the northwestern part of the New Horizon #2 mine area where the single lowest point occurs along the lowwall crest, which can be seen on Map 2.04.7-1-A. The sample point Spoil Spring 1 represents the spoil water discharge from the New Horizon #1 Mine and has has been monitored since 1987. Its location is shown on Map 2.04.7-1-A. Spoil Spring 1 discharges into Tuttle Draw a short distance downstream. The predicted Spoil Spring 2 from the New Horizon #2 Mine will discharge into the minor tributary to Tuttle Draw, located immediately south of the western edge of the mine area. This tributary enters Tuttle Draw less than 1 mile downstream. Tuttle Draw enters the San Miguel River approximately 2 miles to the southwest.

Sample site SW-N108 is located in Calamity Draw immediately upstream of any influence from the mine. Sample site Sw-N1 is located in Tuttle Draw immediately upstream of any influence from the mine. Sample data over the past 12 years from these sites has shown that the TDS of the waters drops significantly when irrigation is active in the area. Therefore, the impacts to the receiving waters will be studied for both cases, with and without irrigation. The irrigation case corresponds to the September/October time period when flows are fairly low in the San Miguel River. The non-irrigation period corresponds to March/April when flows in the San Miguel are usually at peak. This is shown on Table 2.05.6(3)-4.

TABLE 2.05.6.(3)-4
Flow Rates vs. TDS for Spoil Waters and Receiving Streams

	Irrigation - Sept/Oct	No Irrigation- March/April
#1 Mine Spoil Water (NPDES 001 Discharge) TDS	1967	2885
#1 Mine Spoil Water (NPDES 001 Discharge) Flow CFS	.376	.041
Tuttle Draw #1 Mine Pre-Mix Point (SW-N3) TDS	1680	2094
Tuttle Draw #1 Mine Pre-Mix Point (SW-N3) Flow CFS	2.3	0.8
Tuttle Draw #1 Mine Post-Mix Point TDS(calculated)	1720	2133
Tuttle Draw #1 Mine Post-Mix Point Flow CFS (calculated)	2.676	0.841
#2 Mine Spoil Water TDS (4% above #1 Mine Levels)	2045	3000
#2 Mine Spoil Water Flow CFS (worst case)	1.31	.113
#2 Mine Spoil Water Flow CFS (realistic case)	.68	.113
Tuttle Draw #2 Mine Pre-Mix Point TDS (same as #1 Mine Post-Mix)	1827	2235
Tuttle Draw #2 Mine Pre-Mix Point Flow CFS (same as #1 Mine Post-Mix)	3.986	0.954
Tuttle Draw #2 Mine Post-Mix Point TDS (calculated)	1881	2316
Tuttle Draw #2 Mine Post-Mix Point Flow CFS (calculated)	5.296	1.067
San Miguel River Pre-Mix Point TDS (Peabody Tab 17)	620	450
San Miguel River Pre-Mix Point Flow CFS (Peabody Tab 17)	141	817
San Miguel River Post-Mix Point TDS (calculated)	666	452
San Miguel River Post-Mix Point Flow CFS (calculated)	146.30	818.07

The values for the NPDES 001 Discharge and SW-N3 are averaged from measurements made from 1993 to present. Table 2.05.6(3)-3 shows this information for these as well as other sample points.

As is seen from the table, the spoil water inflows from both mine areas influence the quality of Tuttle Draw to a minor degree. However, within 4500 feet, this flow enters the San Miguel River where the flow is so much larger than the Tuttle Draw flow that the impact is negligible. During periods of irrigation, Tuttle Draw is flowing at a higher rate while the River is running low, which is the time of maximum impact of the flows. at this time, the increase in TDS of the River is from 620 to 652 ppm, or an increase of 5.1%. It should be noted that Tuttle Draw flows are always higher in TDS than the River, regardless of the spoil springs, therefore, the impact from the spoil springs may be only 2-3% increase in TDS. During March/April, the River is flowing fast and Tuttle Draw is at low flow, therefore the increase in TDS for the River is only 2 ppm, or an increase of 0.4%. Also, these impacts are for the time when the spoil material is leaching salts at a maximum. As described earlier, the TDS levels will drop as pyrite and salts are leached out of the spoil, lessening the impact to the waters downstream even further.

Calamity Draw is not included in the above table since the spoil springs from both mine areas will not enter this stream. This intermittent stream should not be affected in the long term by the mining and reclamation operation.

Overall, the effects of the spoil springs are not significant to the waters downstream.

7) Effects of mining on the local geomorphology. Impacts from mining on the local geomorphology will be long term, but appear to be of minimal significance. The reestablished reach of the drainage running south into Pond 007 will result in a shorter, slightly steeper stream channel. The potential for increased sediment loads in the drainage (once pond 007 is removed) should be offset by the stable bank sides and the relatively small change in overall gradient. The reclaimed land will be graded to enhance irrigation and restore similar drainage patterns to those which existed on the area prior to mining. The increased runoff and consequent erosion potential on disturbed basins in the mining area due to the temporary loss of topsoil structure should be of minimal significance since all disturbed areas will be protected by a system of sediment ponds. Contour ripping, mulching and revegetation have been demonstrated to minimize soil erosion and will be used to mitigate the increased runoff potential until the topsoil structure is developed. Irrigation will help this to occur rapidly.

8) Effects of sediment ponds on channel characteristics and downstream users. Potential impacts of sediment pond 007 and the other future ponds on downstream users will involve possible reductions in flow due to impounded water. The water augmentation plan discusses the available water which will be used should impacts be identified. WFC currently has rights to a sufficient quantity of water to supply all users associated with the mining activities, plus an additional quantity of water that can be used to mitigate any impact to downstream users.

9) Effects of sediment pond discharge on surface water quality. The effects of sediment ponds on surface water quality will be negligible because each structure has been designed to minimize impacts to the hydrologic balance. The ponds involve such minor areas of disturbance that chemical and sediment changes in the flows will be unmeasurable.

10) Effects of runoff from reclaimed areas on the quality of streamflow. Due to the relatively small area of disturbance in the New Horizon 2 mining area, any reductions in runoff will have only a minimal impact on streamflow quantity, as flow in Calamity Draw is dominated by irrigation return flow. Decreased sediment loads predicated by SEDCAD+ indicate that reclamation efforts conducted in the mining area will ensure that additional contributions of suspended sediment in runoff from reclaimed areas will not occur. Effects of runoff from reclaimed areas on the quality of streamflow. Based on past operating history at the Nucla Mine, no significant trend toward higher concentrations of the selected parameters have been detected. In addition, the pond discharge will be monitored in accordance with NPDES discharge limitations and any potential impact will be identified. Therefore, runoff from the reclaimed area should have no significant impact over time on the quality of receiving stream water quality. As a result, post mining land uses which currently occur in the area should not be affected due to the mine plan which has been approved.

Summary. The discussion presented herein of the probable hydrologic consequences of the revised mine plan approved by WFC identifies the potential effects of mining. Table 2.05.6(3)-1 summarizes the discussion by listing the probable hydrologic consequences and the results of the analysis of each. As can be seen, all of the probable impacts have been determined to be of a short term nature, of minimal significance, or a plan has been presented to mitigate those determined to have some significance. As a result, mining and post mining effects to current land uses should be negligible.

Literature Cited

Boettcher, Arnold J. 1972. Ground Water Occurrence in Northern and Central Parts of Western Colorado: Colorado Water Resource Cir. 15, USGS.

Botz, M.K., and D. Pedersen. 1976. Summary of Water Quality Criteria: Water Quality i Bureau, Montana Dept. of Health and Environmental Sciences. Helena, Montana. 2 pp.

Branson, F.A., Gilford, G.F., Renard, K.G. and R.F. Hadley. 1981. Rangeland Hydrology: Society for Range Management, Range Science Series: Kendall/Hunt Publishing Co., Dubuque, Iowa, 340 p.

Colorado Department of Health-Water Quality Control Division. 1983 (Revised,September 12, 1986). Classifications and Numeric Standards, Lower Dolores and Gunnison River Basin (Planning Region 10), January 11, pages 14 of 17 and 15 of 17.

________ 1986. The Basic Standards for Ground Water - Draft Copy (April).

Cooper, H.H., Jr., and C.E. Jacob. 1946. A Generalized Graphical Method for Evaluating Formation Constants and Summary Well Field History: Trans. Am. Geophysical Union, Vol. 27, pp. 526-534.

Cooper, H.H. Jr., J.D. Bredehoeft, and I.S. Papadopulos. 1967. Response of a finite -diameter well to an instantaneous charge of water: Water Resources Research, V. 3., No. 1, pp. 263-269.

Hem, J.D. 1970. Study and Interpretation of the Chemical tics of Natural Water: Geological Survey Water Supply Paper 1473.

Iorns, W.Y., C.H. Hembree, and G.L. Oakland. 1965. Water Resources of the Upper Colorado River Basin--Technical Report: USGS Prof. Paper 441-A, pp. 1-40.

_______ 1965a. Water Resources of the Grand Division - Technical Report: USGS Prof. Paper 441-C, pp. 75-180.

Kircher, J.E., Choquette, A.F., and B.D. Richter. 1985. Estimation of Natural Stream Flow Characteristics in Western Colorado: USGS Water-Resources Investigations Report 85-4086.

Lohman, S.W. 1965. Geology and Artesian Water Supply, Grand Junction, Colorado: USGS Prof. Paper 451.

________1972. Ground Water Hydraulics: U.S. Geologic Survey Professional Paper 708, 70 pp.

McKee, J.E., and H.H. Wolf. 1963. Water Quality Criteria: The Resources Agency of California, State Water Resources Control Board Publication No. 3-A. 548 pp.

McWhorter, D.B. 1982. Procedures for Predictire Analysis of Selected Hydrologic Impacts of Surface Mining: Section 5 - Single Well Aquifer Tests in Coal Hydrology: Industrial Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Cincinnati, Ohio.

Mercer, D.M. 1967. The Colorado Co-operative Company, 1894-1904.The Colorado Magazine XLIV/4:293-306.

National Academy of Sciences. 1972. Water Quality Criteria 1972:National Academy of Engineering, Washington, D.C.. p. 335.

_________1974. Nutrients and Toxic Substances in Water for Livestock Use.

Neuman, S.P. 1975. Analysis of Pumping Test Data from Anisotropic Unconfined Aquifers Considering Delayed Gravity Response: Water Resources Research, Vol. 2, No. 2, pp. 329-342.

Odum, E.P. 1971. Fundamentals of Ecology: W.B. Saunders Co., Philadelphia, Pa., 574 p.

Papadopulos, S.S., Bredehoeft, J.D., and H.H. Cooper. 1973. On the Analysis of Slug Test Data: Water Resources Research, Vol. 9, No. 4, pp. 1087-1089.

Price, D. and T. Arnow. 1974. Summary Appraisals of the Nation's Ground Water Resources, Upper Colorado Region: USGS Prof. Paper 813-C.

Robinson, T.W. 1958. Phreatophytes: U.S. Geological Survey Water Supply Paper 1423, 84 p.

Theis, C.V. 1935. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground Water Storage: Trans Am Geophysical Union pp. 519-524.

U.S. Department of Agriculture. Colorado Irrigation Guide: Soil Conservation Service Field Office Technical Guide, Section 4.

U.S. Department of Commerce. 1968. Climatic Atlas of the United States: Environmental Science Service Administration, Environmental Data Service, June, 1968.

U.S. Department of Interior, Bureau of Reclamation, 1977. Ground Water Manual. U.S. Government Printing Office, Washington, D.C.. p.28.

U.S. Environmental Protection Agency. 1976. Quality Criteria for Water: Washington, D.C., pp. 501.

U.S. Salinity Laboratory Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils: U.S. Department of Agriculture Handbook 60, 160 p. 7-20

National Academy of Sciences. 1972. Water Quality Criteria 1972: National Academy of Engineering. Washington, D.C. p. 335.

Rahn, P.H. 1976. Potential of Coal Strip Mine Spoils as Aquifers in the Powder River Basin: Project No. 10470025, Old West Regional Commission, Billings, MT. 108 p.

United States E.P.A. 1977. Subirrigated Alluvial Valley Floors: A Reconnaissance of Their Properties and Occurrence in Coal Resource Lands in the Interior Western United States.

VanVoast, W.A. and R.B. Hedges. 1975. Hydrogeologic Aspects of Existing and Proposed Strip Coal Mines Near Decker, Southeastern Montana: Montana Bureau of Mines and Geology Bulletin 97. 31 p.

Williams, R.S. and Clark, G.M., 1994 USGS Water Resouces Investigation Report 92-4187 Hydrology and Geochemistry of a Surface Coal Mine in Northwestern Colorado