CHAPTER 19

HYDROLOGIC RECLAMATION PLAN

CHAPTER 19

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CHAPTER 19

HYDROLOGIC RECLAMATION PLAN

Introduction

The hydrologic reclamation plan is presented in two parts. The first part focuses on specific practices that are conducted to minimize the impact of mining on the hydrologic balance within and adjacent to the leasehold. The second part addresses those impacts that may occur regardless of these practices. The emphasis of the second part is on the monitoring of the extent and magnitude of mining impacts. Where possible, reference has been made to those chapters that contain details regarding certain practices.

Practices Employed to Minimize the Impact of Mining on the Hydrologic System

Acid and Toxic Materials. Overburden and parting materials are placed in or adjacent to mining pits. Therefore, overburden and innerburden core chemical analyses have been conducted and the results reviewed by a biologist, geologist, soil scientist and hydrologist to assess the acid potential of the material and to determine the concentrations of salts and trace metals (Chapter 8). Further, hydrologists have made a determination as to whether shallow aquifers (Wepo or alluvial) will be intercepted by the pits to be mined (Chapter 18). Where aquifers will be intercepted, the hydrologists have made an assessment as to: (1) the significance of the saturated regions as aquifers; (2) the value of the ground water to the quality of the human environment; and (3) the value of the ground water to support the postmining land use of the mined area. These analyses indicate the portions of the alluvial and Wepo aquifers within the leasehold which may be potentially affected by mining, exhibit low yields to wells and show a water quality which is predominantly unsuitable for use as domestic, irrigation or livestock water. As such, the portions of the aquifers within the PWCC leasehold have no importance in regards to domestic water consumption and irrigation use. In terms of supporting the postmining land use of the area as livestock drinking water, the portions of these aquifers monitored within the PWCC leasehold yield water that is marginally suitable to unsuitable. The above statements are based upon comparisons of the water against accepted domestic, irrigation and livestock water quality criteria (Table 1, page 11). As of 2003, only 4 of the 34 sampleable alluvial monitoring wells and 9 of the 26 sampleable Wepo monitoring wells yield water that meets all of the current livestock drinking water quality criteria.

None of the monitoring wells in either aquifer yield water that meets domestic drinking water criteria. Only 5 of the 26 Wepo monitoring wells yield water quality suitable for use as irrigation water and these five wells exhibit such low yields they cannot be considered for irrigation use. None of the alluvial monitoring wells yield water suitable for use as irrigation water.

Surface water protection is achieved through drainage control and reclamation practices. Where spoil encroaches upon significant drainages, channel diversions have been designed and will or have been constructed to divert surface water runoff and minimize the formation of acidic or toxic drainage or increased suspended solids (Chapter 6). Further, runoff from mined areas is and will be contained by sediment ponds (Chapter 6).

Contemporaneous restabilization (Chapter 20) and reconstruction of a nontoxic plant growth medium (Chapter 22) will also protect surface water quality from potential detrimental effects of surface water drainage.

Drainage Control and Water Quality Standards. All runoff from lands disturbed by mining will be routed through sediment ponds designed to contain the runoff from 10-year, 24-hour storm events plus sediment unless alternative water control structures are approved by the regulatory authority. NPDES Permit No. AZ0022179 has been issued for the Black Mesa and Kayenta Mines by the Environmental Protection Agency. This permit contains effluent limits, sampling and reporting requirements (Chapter 16) designed to protect surface water quality.

Reclamation practices also serve to protect the hydrologic balance and achieve water quality standards. The Surface Stability and Drainage System Development Plan in the Backfilling and Grading section of Chapter 21 addresses the reclamation procedures employed to reestablish a more stable and controlled drainage system in the reclaimed areas. The Revegetation Plan in Chapter 23 describes procedures used to minimize erosion through mulching and contemporaneous revegetation. Additionally, the Minesoil Reconstruction Plan in Chapter 22 describes ripping and contour discing procedures employed to stabilize the ground surface, promote revegetation and minimize erosion. These surface treatments, in addition to the spoil sampling program to ensure that acid and toxic materials are sufficiently buried, will minimize the chemical and sediment loads contributed to streamflows from reclaimed areas.

A plan for evaluating the success of reclamation practices with regard to controlling drainage and chemical and sediment loads from reclaimed areas was developed and implemented. The plan employed a small watershed study (Attachment 4, Chapter 16) consisting of runoff plots, runoff volume, sediment and water quality samplers and flumes; monitoring water quality and persistence in 15 permanent internal impoundments (PIIs) in the N1, N2, J1/N6, J3, and J27 mining areas (Chapter 15, Permanent Impoundment Monitoring Section); and the calibration and use of a rainfall/runoff/sediment yield model (EASI) which was used to compare premining values against postmining values (Application for Release of Reclamation Liability N1/N2 and J27 Interim Program Indian Lands, Black Mesa and Kayenta Mines, March 1994).

More emphasis was given to runoff plot data than the small watershed flume data when determining EASI model calibration coefficients because total runoff and sediment data for each storm event were collected and measured directly. Overall, the EASI model reasonably reproduced comparable values to the runoff and sediment yield values measured at the small watershed plots and flumes for a range of highly variable rainfall events.

The permanent internal impoundment monitoring referenced above was conducted at all or some of the 15 pond sites from 1981 to 1999. During this time some 296 water quality samples from the PIIs were analyzed. Excepting some early (pre-1985) fluoride, lead, TDS and sulfate values at 3 of these impoundments (112,113 and 116), only N2-RA exceeded livestock water quality criteria and only for TDS and SO4. All other PII water quality data was comparable to or more suitable than baseflow and stream runoff water quality measured in the principal channels on the leasehold. During this same time period approximately 500 monthly water level measurements at 14 of the PIIs and 2-3 years of continuous water level measurements at 5 of the PIIs were collected. The water level data showed that reclaimed watershed runoff is sufficient enough to allow an average permanent impoundment water persistence of greater than 80 percent.

The following conclusions were reached from the EASI model comparisons of pre- and postmine watersheds. Drainage densities for postmine conditions are about one-half of the premine drainage densities. Pre- and postmine runoff was found to be quite similar. Sediment yield from reclaimed hillslopes is generally two times higher than from premine hillslopes having comparable hillslope length and gradient. However, total sediment yields predicted from reclaimed watersheds are lower than premine watershed predictions.

This is because channels, not the hillslopes, are the primary sources of sediment in both pre- and postmine conditions; channels tend to be flatter in the postmine landscape; and the greater number of depressions in the postmine landscape capture a significant amount of the sediment which could potentially be transported out of the reclaimed watersheds. The above studies and modeling indicate the reclamation practices are performing well in regards to controlling the runoff, chemical and sediment loads leaving the reclaimed watersheds.

<u>Restoration of Approximate Premining Ground Water Recharge Capacity</u>. Draglines, dozers and scrapers accomplish the backfilling and grading of mined areas. This technique results in some compaction, but is estimated by VanVoast and Hedges (1975) to increase permeability when compared to the original stratified state of the overburden material. Permeability increases are primarily attributed to increased void volumes and segregation of particle sizes. The topsoiled surface will be contour-disked which will increase the rainfall and overland flow infiltration. Infiltration rates, however, are likely not critical to the recharge of the Wepo aquifer. Distances from the land surface to the saturated portions of the Wepo aquifer and the limited annual precipitation preclude significant rainfall and snowmelt recharge other than in burn and clinker or highly fractured areas. These areas are found adjacent to, rather than in the coalfields following mining.

The time period necessary for the spoil material to become resaturated and for final ground water flow patterns to be established in areas where pits have intersected portions of the Wepo aquifer depend upon the resultant porosity and permeability of the replaced spoil material. The resaturation may take from a few years to 100 years to occur, but the magnitude of this impact will be small (Chapter 18). The maximum drawdowns will occur in the pits themselves and are estimated to be approximately 60 feet and 45 feet for the J-19/20 and J-16 pits, respectively. Following the resaturation period, ground water levels will recover to near premining levels.

<u>Water Rights and Alternative Water Supplies</u>. The State of Arizona is proceeding with the adjudication of water rights in the Little Colorado River Basin, which includes Black Mesa. This adjudication is still in the process of being finalized. Once the adjudication is final, it is believed Peabody's water use will be a prescribed use based on the allotments to each Tribe. Peabody's use of water on Black Mesa for the mining

operations is authorized in the three mining lease agreements (Lease Nos. 14-20-0603-8580, 14-20-0603-9910 and 14-20-0450-5743) with the Tribes. The mining lease agreements clearly state that Peabody may use that amount of water necessary for its mining operations, including the transportation by slurry pipeline of coal mined from the lease areas.

At this time, the only documented local usage of the Wepo or alluvial aquifers is in the immediate vicinity of the leasehold at three wells: 4T-405; 4K-389; and 4K-380 (Chapter 17, Pre-existing Wells and Springs). Though PWCC's Wepo and alluvial monitoring well network suggests there is small likelihood of a Wepo or alluvial well being suitable for use as livestock drinking water, these three wells are being used for livestock water because they are also partly screened in the underlying Toreva aquifer. The completion information for well 4K-380 states it is partially completed in the Toreva and the completion depths for wells 4K-389 and 4T-405 suggest they are also partially open to the Toreva aquifer. All three wells are located off lease (two of them are at least 2 miles south of the leasehold). Because the Toreva aquifer is of better quality than the Wepo aquifer, this would account for how three wells adjacent to the leasehold could be of suitable quality for livestock use when so few of the monitoring wells on the leasehold meet livestock drinking water criteria.

Theoretical pit pumpage drawdowns in the Wepo aquifer could potentially reduce the available height of water in well 4K-389 by 25 percent. Potential pit pumpage drawdowns in wells 4T-405 and 4K-380 are within the range of natural shallower aquifer water level fluctuations. The windmills located on the PWCC leasehold are completed entirely in lower aquifers and won't be affected by pit pumpage drawdowns in the shallower Wepo aquifer.

Regardless of the potential for mining impacts to any well, PWCC has made available to all local residents in the area of the leasehold water of domestic drinking water quality at standpipes located near the N6 and N14 mining areas. The water supplied is from the Navajo aquifer and is available on a 24-hour basis.

Monitoring Plan

Introduction. In addition to the activities designed to minimize disturbances to the hydrologic balance discussed above, ground and surface water monitoring plans have been developed to assess the impacts to the hydrologic system identified in Chapter 18, Probable Hydrologic Consequences. The results of the monitoring plan have and will continue to be employed to support the PHC conclusions that disturbances to the hydrologic balance will be minimal and that the potential uses of the ground and surface water systems affected by mining will not be changed.

The parameters observed at each monitoring site as well as sampling and monitoring frequencies are documented in Chapter 16, Hydrological Monitoring Program. Table 2 (page 12) shows which monitoring sites are utilized to address each of the probable hydrologic consequences discussed in Chapter 18. The following monitoring plan discussions will address how the monitoring data or programs will be used to determine impacts to the hydrologic balance.

Ground Water Monitoring Plan.

Wepo and Alluvial Aquifer Quantity and Quality. Not all alluvial and Wepo monitoring wells are projected to be impacted in terms of water levels and/or water quality as a result of mining areas intercepting the Wepo aquifer. Only portions of the N2, N7, N10, N99, J1/N6, J16, J19 and J21 mining areas have been determined to intercept the Wepo aquifer. This determination is based on documented pit inflows in those areas already mined and on comparisons of the Wepo/alluvial aquifer potentiometric surface with bottom of pit contours for those areas remaining to be mined.

From the pit inflow calculations presented in Chapter 18, Probable Hydrologic Consequences, theoretical drawdowns in the Wepo and alluvial aquifers were determined for Figures 1 and 1a in Chapter 18. Since all wells exhibit water level fluctuations owing to climatic changes and water quality sampling stresses, only those wells within the zone of >5 feet of drawdown on Figure 1 are considered likely to be affected by mining interception of the Wepo aquifer. Prior to 2001 only those wells within this >5 ft. zone were evaluated in discussions of water level monitoring, while all other wells were considered to be background wells. In July 2001, PWCC received the first of several approvals from OSM to modify its ground water monitoring program (OSM, 2001a; OSM, 2001b; OSM, 2002). Collectively, these approvals allowed for the removal (abandonment) of 26 alluvial, spoil and Wepo monitoring wells; idling twelve additional alluvial and Wepo monitoring wells; and for reducing frequency of monitoring at all remaining wells. Owing to these revisions, and starting with the 2001 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines, a previous distinction made between potentially affected versus unaffected wells was dismissed. At present every alluvial, spoil or Wepo well is considered unaffected until such time as water level drops beyond historic ranges, or persistent trends, shifts, or abrupt changes in either water levels or water chemistry become evident. Several of these wells have pre-disturbance baseline water level data against which future water levels can be compared for impact assessments. In the rest of the cases, current water levels can be compared against 5 to 10 year historic water level ranges. To date only Wepo wells 53, 62R, former Wepo well 62 and former alluvial wells 74 and 75 have shown clear evidence of mining induced drawdowns.

The approach to evaluating the Wepo and alluvial monitoring wells for mining-induced water quality impacts is similar to the water level approach in that the analysis is closely linked to the wet pits and the Wepo/alluvial potentiometric surface. Where the approach differs is water quality impacts can only occur downgradient (in the direction of decreasing potentiometric head) from the wet pits, and can only occur after the pits have been reclaimed and ground water levels have reestablished so ground water flow through the mining areas can return to what it was prior to mining. Hydraulic characteristics for each aquifer (Chapter 15, Attachments 9 and 14) were evaluated to determine which wells downgradient from the wet pits would have potential water quality impacts. The hydraulic conductivities measured during pumping tests in each aquifer are low with average Wepo values being lower than the average alluvial values. In order to determine mining-induced changes in the water chemistry at the Wepo, alluvial, and spoil monitoring wells, trend analyses will be performed for sodium, bicarbonate, sulfate, and total dissolved solids concentrations measured at these wells. Persistent trends of increasing concentrations of two or more of these major ions will suggest that mining impacts to the water quality are occurring. Also, water type changes or shifts on trilinear diagram plots of the water chemistry for these wells will suggest mining impacts to the water quality.

Navajo Aquifer Quality and Quantity. Water level changes in the Navajo well bore holes on the leasehold are of little direct use in assessing drawdown in the N-aquifer as they are significantly influenced by well efficiency and pumpage rate changes. Regional water level monitoring of the N-aquifer by the U.S. Geological Survey (USGS) in conjunction with periodically revised flow model runs will be utilized to assess the separate impacts from Peabody and Tribal pumpage on N-aquifer water levels. As input to the model runs, Peabody will provide continuous pumpage data for the eight N-aquifer wells located on the leasehold.

Navajo aquifer water quality changes will be compared against five-year ranges determined from Peabody monitoring data. Significant increases in TDS, chloride and sulfate will suggest higher amounts of induced recharge from the overlying D-aquifer system. The USGS monitoring program will be relied on to measure water quality changes in regional N-aquifer wells. Annual progress reports from the USGS typically compare current chemical concentrations against average values determined over the period of sampling record. Significant increases in parameter levels over the long-term averages will be considered to suggest changes resulting from increased leakage of poorer quality D-aquifer water.

Spring Flows and Quality. Spring flows and quality changes on the leasehold will be compared to ranges developed from the five-year baseline-monitoring database. Significant flow or quality deviations from the five-year ranges not explainable by climatic fluctuations will be considered suggestive of impacts from mining. Regional spring flows and water quality will be monitored by the USGS. Significant deviations from average values for the period of record will be considered suggestive of impacts from Tribal and Peabody N-aquifer pumpage.

Surface-Water Monitoring Plan.

Streamflows and Stream Water Quality. Between 1980 and 2001, PWCC conducted extensive monitoring of streamflow and stream water quality in each of the major washes that cross the leasehold. These monitoring data were compiled, analyzed, interpreted and used as the basis for a hydrologic program revision document submitted to OSM entitled "Justification of Monitor and Monitoring Frequency Reductions at the Black Mesa and Kayenta Mines, Arizona" (PWCC, 2001a). OSM approved this revision to Chapter 16 in several stages, resulting in significant changes to the surface-water monitoring program (refer to OSM (2001a, 2001b and 2002a) and PWCC (2001b) for details). Included in this revision was the abandonment of eight stream-monitoring stations; the idling of one additional stream station; discontinuance of channel geomorphology monitoring and; discontinuance of sediment monitoring at all remaining stream monitoring sites. As of July 2002, the PWCC surface-water monitoring network on Black Mesa consists of four down-gradient stream stations that monitor for water quantity and quality.

Since many factors influence streamflows and stream water chemistry on the leasehold, comparisons with five-year averages (as is done with well water chemistry) may not prove meaningful. Instead, trending analyses is utilized to detect changes or trends in surface-water chemistry that may suggest mining impacts. Consistently decreasing flows or increasing concentration levels, not associated with climatic fluctuations or local phreatophyte development, will be considered to suggest mining impacts. Regional baseflow monitoring will be performed by the USGS. Consistent reductions in baseflow at Moenkopi, Laguna Creek and Mexican Water will be interpreted as impacts from Tribal and Peabody pumpage, excepting periods of drought.

Reclaimed Area Runoff, Water Quality and Sediment Yields. Analyses for potential impacts of reclaimed areas on streamflows and stream water quality have been conducted as part of the small watershed studies, the permanent impoundment studies and the EASI runoff and sediment yield modeling which has been described in the previous section on Drainage Control and Water Quality Standards. The small watershed data and EASI model runs showed: runoff plot (hill slope) sediment yield data was higher on reclaimed areas; total watershed runoff volumes were comparable between reclaimed and undisturbed areas; and total watershed sediment yields were higher from undisturbed areas. Monitoring of permanent impoundments showed reclaimed area runoff for a range of watershed sizes was good (some water persistence 80 percent of the time in the internal impoundments) and overall runoff water quality was equal to or better than baseflow and runoff in the principal channels on the leasehold.

Literature Cited

VanVoast, W.A. and R.B. Hedges. "Hydrologic Aspects of Strip Coal Mining in Southwestern Montana - Emphasis One Year of Mining Near Decker, Montana." Montana Bureau of Mines and Geology Bulletin 93. 1975.

Peabody Western Coal Company. PWCC Application for Reduction in Monitoring, Chapter 16, Hydrologic Monitoring Program Permit Revision, Permit AZ-0001D. Document submitted to OSMRE on March 5, 2001. Enclosure to this document entitled: "Justification of Monitor and Monitoring Frequency Reductions at the Black Mesa and Kayenta Mines, Arizona". 2001a

Peabody Western Coal Company. "Chapter 16 Phase 2 Monitoring Reduction Permit Revision, Permit AZ-0001D". Document submitted to OSMRE on November 6, 2001. Enclosure to this document entitled: "Justification of Phase 2 Monitor and Monitoring Frequency Reductions at the Black Mesa and Kayenta Mines, Arizona". 2001b.

OSMRE. "Permit Revision AZ0001D/Chapter 16, Hydrologic Monitoring Program/Kayenta Mine/OSM Project AZ0001D-1-70". Document received by PWCC on May 4, 2001. 2001a.

OSMRE. "Permit Revision AZ0001D/Chapter 16, Hydrologic Monitoring Program/Kayenta Mine/OSM Project AZ0001D-1-70". Document received by PWCC on July 11, 2001. 2001b.

OSMRE. "Chapter 16, Hydrologic Monitoring Program Phase 2 Monitoring Reduction/Kayenta Mine/OSM Project AZ0001D-1-84". Document received by PWCC on July 24, 2002. 2002a.

Peabody Western Coal Company. 2001 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines.

Table 1

Recommended Numeric Water Quality Standards for Domestic, Livestock, Agricultural Irrigation, and Ephemeral Aquatic Water Uses

Chemical Parameter	Water Use Standard			
	Domestic	Livestock	Irrigation	Aquatic
Alkalinity, mg/l	-	170	-	-
Aluminum, mg/l	0.05-0.2	5.0	5.0	0.75
Arsenic, ug/l	50	200	100	360
Antimony, ug/l	6.0	-	-	88
Bicarbonate, mg/l	150	-	172	-
Barium, ug/l	1000	-	1000	5000
Beryllium, ug/l	4.0T	-	100	65
Boron, ug/l	5000	5000	750	-
Cadmium, ug/l	5.0	50	10	Acute-Cd
Calcium, mg/l	-	1000	-	-
Chloride, mg/l	250	1500	100	-
Chromium, ug/l	100	1000	100	16
Cobalt, ug/l	-	1000	50	1000
Copper, ug/l	1000-1300	500	200	Acute-Cu
Cyanide, mg/l	0.2T	5.2T	-	41T
Fluoride, mg/l	2.0-4.0	2.0	15	1.5
Gross Alpha	15.0	-	-	-
Iron, mg/l	0.3	-	20	(0.2)
Lead, ug/l	15-50	100	5000	Acute-Pb
Magnesium, mg/l	125	500	24	(300)
Manganese, mg/l	0.05	10	10	1.0
Mercury, ug/l	2.0	10TR	-	2.4TR
Molybdenum, ug/l	-	-	10	-
Nickel, ug/l	1000	-	200	Acute-Ni
Nitrate, mg/l	10	100	-	-
Nitrite, mg/l	1.0	10	-	-
pH, s.u.	6.5-9.0	6.5-9.0	4.5-9.0	6.5-9.0
Potassium, mg/l	340	-	-	(50)
Radium 226, pCi/L	5.0	-	-	-
Radium 228, pCi/L	5.0	-	-	-
Selenium, ug/l *	50	50	130	20TR
Selenium, ug/l **	-	-	250	-
Silica, mg/l	50	-	50	-
Silver, ug/l	100	-	50	Acute-Ag
Sodium, mg/l	-	2000	-	(500)
Sulfate, mg/l	250	500	200	-
Solids, Dis., mg/l	500	6999	500	-
Thallium, ug/l	2.0T	-	-	700
Uranium, mg/l	35T	-	-	-
Vanadium, ug/l	-	100	100	-
Zinc, mg/l	5.0	25	2.0	Acute-Zn

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TR Total Recoverable Analyses

mg/l Milligrams per liter

ug/l Micrograms per liter

s.u. Standard Units

All standards are dissolved, unless indicted otherwise. These standards are taken from a variety of sources, including:

Navajo Nation Env. Protection Agency, Primary Drinking Water Quality Regulations (2001) - most domestic standards and Navajo Nation Draft Surface Water Quality Standards (1999) -- most livestock, irrigation and aquatic standards

Hopi Tribe, Draft Hopi Water Quality Standards (1998) -- livestock pH standard

National Academy of Science, Water Quality Criteria (1974, 1980) -- numerous standards

United States Env. Protection Agency, National Primary and Secondary Drinking Water Standards (2001) -- domestic F and Al

Montana Dept. Health and Env. Sciences (see Botz and Pederson, 1976) -- numerous standards

Arizona Dept. of Env. Quality, Numeric Water Quality Standards (2002) -- livestock, irrigation and aquatic standards)

Wyoming Dept. Env. Quality (1980) -- livestock chloride and sulfate

Shaded values are secondary Domestic standards, as are the lower limits for Copper and Fluoride.

Values in parentheses are levels at which adverse effects have been known to occur, according to Botz and Pederson (1976)

* Selenium standard in the presence of </= 500 mg/l of sulfate.

** Selenium standard in the presence of > 500 mg/l of sulfate.

Acute metals standards are derived from complex equations utilizing lab-determined hardness values, and are not given here. Refer to "Footnotes to the Numeric Surface Water Quality Standards", Navajo Nation Draft Surface Water Quality Standards (1999).

TABLE 2

Monitoring Sites and Programs Utilized to Substantiate Significance Findings of Chapter 18, Probable Hydrologic Consequences

	Alluvial Well Monitoring Sites															
	13R	17	19	23R	27R	29	31R	69	71	72	77	80R	83	87	89R	93
Interruption of Ground Water Flow and Drawdowns	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Local Wells and Springs by Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Containment and Discharge of Pit Inflow Pumpage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Replaced Spoil Material on Ground Water Flow and Recharge Capacity	-	-	X	X	X	X	X	-	-	-	-	X	X	-	X	X
Impact of Replaced Spoil on Ground Water Quality	-	-	X	X	X	X	-	-	-	-	-	X	X	-	X	X
Interception of Wepo Recharge to the Alluvial Aquifer	-	-	X	X	X	X	X	-	-	-	-	X	X	-	X	X
Truncation of Alluvial Aquifers by Dams	-	X	-	X	-	X	X	-	-	-	-	X	X	-	X	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	-	-	X	X	X	X	-	-	-	-	-	X	X	-	X	X
Mining Interruption of Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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TABLE 2 (cont.)

Monitoring Sites and Programs Utilized to Substantiate Significance Findings of Chapter 18, Probable Hydrologic Consequences

	Alluvial Well Monitoring Sites													
	95	98R	99R	101R	104R	105R	106R	108R	165	168	169	170	172	180
Interruption of Ground Water Flow and Drawdowns	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Local Wells and Springs by Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Containment and Discharge of Pit Inflow Pumpage	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Replaced Spoil Material on Ground Water Flow and Recharge Capacity	X	-	X	X	X	X	X	X	X	X	X	X	X	X
Impact of Replaced Spoil on Ground Water Quality	X	-	X	X	X	X	X	X	X	X	X	X	X	X
Interception of Wepo Recharge to the Alluvial Aquifer	X	-	X	X	X	X	X	X	X	X	X	X	X	X
Truncation of Alluvial Aquifers by Dams	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	X	-	X	X	X	X	X	X	X	X	X	X	X	X
Mining Interruption of Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	-	-	-	-	-	-	-	-	-	-	-	-	-	-
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Monitoring Sites and Programs Utilized to Substantiate Significance Findings of Chapter 18, Probable Hydrologic Consequences

	Alluvial Well Monitoring Sites						Wepo Well Monitoring Sites								
	181	182	193	197	199	200	40	41	42	43R	44	45	46	47R	49
Interruption of Ground Water Flow and Drawdowns	-	-	-	-	-	-	X	-	-	X	X	X	X	X	X
Removal of Local Wells and Springs by Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Containment and Discharge of Pit Inflow Pumpage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Replaced Spoil Material on Ground Water Flow and Recharge Capacity	X	X	X	X	X	X	X	-	-	X	X	X	X	X	X
Impact of Replaced Spoil on Ground Water Quality	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Interception of Wepo Recharge to the Alluvial Aquifer	X	X	X	X	X	X	-	-	-	-	-	-	-	-	-
Truncation of Alluvial Aquifers by Dams	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	X	X	X	X	X	X	X	-	-	X	X	X	X	X	X
Mining Interruption of Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Monitoring Sites and Programs Utilized to Substantiate Significance Findings of Chapter 18, Probable Hydrologic Consequences

	Wepo Well Monitoring Sites																
	51	52	53	54	55	56	57	58	59	60	61	62R	65	66	67	68	178
Interruption of Ground Water Flow and Drawdowns	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	-	X
Removal of Local Wells and Springs by Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Containment and Discharge of Pit Inflow Pumpage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Replaced Spoil Material on Ground Water Flow and Recharge Capacity	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Impact of Replaced Spoil on Ground Water Quality	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Interception of Wepo Recharge to the Alluvial Aquifer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truncation of Alluvial Aquifers by Dams	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mining Interruption of Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Monitoring Sites and Programs Utilized to Substantiate Significance Findings of Chapter 18, Probable Hydrologic Consequences

	Navajo Well Monitoring Sites							
	2	3	4	5	6	7	8	9
Interruption of Ground Water Flow and Drawdowns	-	-	-	-	-	-	-	-
Removal of Local Wells and Springs by Mining	-	-	-	-	-	-	-	-
Containment and Discharge of Pit Inflow Pumpage	-	-	-	-	-	-	-	-
Impact of Replaced Spoil Material on Ground Water Flow and Recharge Capacity	-	-	-	-	-	-	-	-
Impact of Replaced Spoil on Ground Water Quality	-	-	-	-	-	-	-	-
Interception of Wepo Recharge to the Alluvial Aquifer	-	-	-	-	-	-	-	-
Truncation of Alluvial Aquifers by Dams	-	-	-	-	-	-	-	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	-	-	-	-	-	-	-	-
Mining Interruption of Spring Flow	-	-	-	-	-	-	-	-
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow	X	X	X	X	X	X	X	X
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	X	X	X	X	X	X	X	X
Impacts of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	-	-	-	-	-	-	-	-
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	-	-	-	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	-	-	-	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	-	-	-	-	-	-	-	-
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	-	-	-	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	-	-	-	-	-	-

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Monitoring Sites and Programs Utilized to Substantiate Significance Findings of Chapter 18, Probable Hydrologic Consequences

	Stream Monitoring Sites					Spring Monitoring Sites						Local
	15	25	26	34	155	91	92	111	147	151	191	Springs
Interruption of Ground Water Flow and Drawdowns	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Local Wells and Springs by Mining	-	-	-	-	-	X	X	X	-	-	X	X
Containment and Discharge of Pit Inflow Pumpage	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Replaced Spoil Material on Ground Water Flow and Recharge Capacity	-	-	-	-	-	-	-	-	-	X	-	X
Impact of Replaced Spoil on Ground Water Quality	-	-	-	-	-	-	-	-	-	X	-	-
Interception of Wepo Recharge to the Alluvial Aquifer	-	-	-	-	-	-	-	-	-	-	-	-
Truncation of Alluvial Aquifers by Dams	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	-	-	-	-	-	-	-	-	-	-	-	-
Mining Interruption of Spring Flow	-	-	-	-	-	X	X	X	-	-	X	X
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow	-	-	-	-	-	-	-	-	-	-	-	-
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	-	-	-	-	-	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	X	X	X	X	X	-	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	X	X	X	X	X	-	-	-	X	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	X	X	X	X	X	-	-	-	X	-	-	-
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	X	X	X	-	-	-	-	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	X	X	X	X	X	-	-	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	X	X	X	X	X	-	-	-	-	-	-	-
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	X	X	X	X	X	-	-	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	-	-	-	-	-	-	-	-	-	-

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Monitoring Sites and Programs Utilized to Substantiate Significance Findings
of Chapter 18, Probable Hydrologic Consequences

	Spoil Well Monitoring Sites		Impoundments		
	161	Future Wells	Permanent	Permanent Internal	Other Internal
Interruption of Ground Water Flow and Drawdowns	-	-	-	-	-
Removal of Local Wells and Springs by Mining	-	-	-	-	-
Containment and Discharge of Pit Inflow Pumpage	-	-	-	-	-
Impact of Replaced Spoil Material on Ground Water *Flow and Recharge Capacity*	X	X	-	-	-
Impact of Replaced Spoil on Ground Water Quality	X	X	-	-	-
Interception of Wepo Recharge to the Alluvial Aquifer	-	-	-	-	-
Truncation of Alluvial Aquifers by Dams	-	-	-	-	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	-	-	-	-	-
Mining Interruption of Spring Flow	-	-	-	-	-
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow	-	-	-	-	-
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	-	-	X	X	X
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	-	-	X	X	X
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	-	-	X	X	X
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	-	-	X	X	X
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	X	X	X

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Monitoring Sites and Programs Utilized to Substantiate Significance Findings of Chapter 18, Probable Hydrologic Consequences

	Local Well Inventory	NPDES Ponds	Regional USGS N-Aquifer, Stream & Spring Monitoring	PWCC 3-D Flow Model	Monitoring of Channel Characteristics	Small Watershed Studies
Interruption of Ground Water Flow and Drawdowns	-	-	-	-	-	-
Removal of Local Wells and Springs by Mining	X	-	-	-	-	-
Containment and Discharge of Pit Inflow Pumpage	-	X	-	-	-	-
Impact of Replaced Spoil Material on Ground Water Flow and Recharge Capacity	-	-	-	-	-	-
Impact of Replaced Spoil on Ground Water Quality	-	-	-	-	-	-
Interception of Wepo Recharge to the Alluvial Aquifer	-	-	-	-	-	-
Truncation of Alluvial Aquifers by Dams	-	-	-	-	-	-
Effects of Changed Wepo Aquifer Recharge Water Quality on the Alluvial Aquifer	-	-	-	-	-	-
Mining Interruption of Spring Flow	X	-	-	-	-	-
Impact of Peabody Navajo Wellfield Pumpage on Regional Water Levels and Stream and Spring Flow		-	X	X	-	-
Effects of Induced Leakage of Poorer Quality Water From the Overlying D-aquifer System on the N-aquifer Water Quality	-	-	X	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Runoff and Channel Characteristics	-	-	-	-	X	-
Impact of Dams, Sediment Ponds and Impoundments on Downstream Users	-	-	-	-	-	-
Impact of Dams, Sediment Ponds and Impoundments on Stream Water Quality	-	X	-	-	-	-
Impact of Stream Channel Diversions on Channel Characteristics and Runoff Water Quality	-	-	-	-	-	-
Effects of Culverts at Road Crossings on Stream Runoff and Water Quality	-	-	-	-	-	-
Effects of Runoff From Reclaimed Areas on the Quantity and Quality of Streamflow	-	-	-	-	-	X
The Impact of the Reclamation Plan on the Stability of Reclaimed Areas and the Reestablishment of Drainage Systems	-	-	-	-	-	-
Removal of Pre-existing Surface Water Structures	-	-	-	-	-	-

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