CHAPTER 11

OPERATION PLAN

11.1 LAND STATUS AND MARKERS

EXHIBITS 11-1 through 11-6 show the land status classifications of lands within the Navajo Mine leasehold. These lands are divided into Pre-Law, Interim, and Permanent Program land classifications.
Signs clearly identifying BHP Minerals and/or Navajo Mine, the permit identification number, and blast warning signs are posted at all points of public or permittee road access into the permit area. Signs are made of durable material and will be maintained until bond release.

11.1.1 Stream Buffer Zones

Stream Buffer Zone designations have been evaluated and identified for the permit areas and lands adjacent to the leasehold (see Section 11.6.4). A buffer zone was established in December 1995. The requirements under 30 CFR § 816.57 will be observed, and the zones marked as specified under Section 816.11. Identified Stream Buffer Zone designations and authorized stream crossings are delineated and shown on EXHIBITS 11-9 through 11-11.

The markers are spaced approximately 300 feet apart and are routinely checked and maintained. Any adjustments to the buffer zone boundary will be made as necessary.

Activities that necessitate travel into or through the designated crossings follow. Access to surface water samplers, access to groundwater wells, ~~access to Area IV North~~ for environmental data and resource gathering for future mine planning (i.e. surveys, core drilling), access for locals (public) use, and access for routine maintenance (i.e. powerlines, roads, Lowe Diversion outlet, etc.).

11.1.2 Incidental Boundary Revision (IBR)

The IBR appends an additional 106 acres contiguous with the permit boundary along the east boundary of the Lowe and Dixon pits in Area 3 as shown in Exhibit 1-2, Sheet 2 of 2. The IBR area will be used for power lines and access roads, and to facilitate activities ancillary to mining and reclamation. The IBR area will not be used for any new major facilities such as preparation plants or coal mine waste disposal areas. The IBR area will not increase the size of the area from which coal will be removed beyond the existing permit boundary in accordance with the current Resource Recovery and Protection Plan (R2P2).

Activities that necessitate travel into or through the designated crossings follow. Access to surface water samplers, access to groundwater wells, access to Area IV North for environmental data and resource gathering for future mine planning (i.e. surveys, core drilling), access for locals (public) use, and access for routine maintenance (i.e. powerlines, roads, Lowe Diversion outlet, etc.).

11.2 MINING PROCEDURES AND TECHNIQUES

Dragline stripping is the primary mining method used in the permit area for multiple coal seam mining. The typical sequence for multiple seam mining is as follows:

1. Vegetation and Topdressing removal (where it exists)
2. Drilling and blasting overburden
3. Overburden removal
4. Drilling and blasting coal
5. Coal removal
6. Drilling and blasting interburden
7. Interburden removal

Steps 6 and 7 are repeated for each additional mineable coal seam.

The coal seams in the permit area are exposed in pits ranging in width appropriate for the size of the dragline, in depths from 5 to 240 feet, and in lengths from 1,000 to 15,000 feet. Each pit is stripped by walking draglines in parallel cuts called "strips".

11.2.1 Vegetation and Topdressing Removal

Past soil investigations have revealed that Navajo Mine has only a negligible topsoil resource within its lease. As such, the material that is suitable for plant growth at Navajo Mine is considered a topsoil substitute. Materials to be used as topsoil substitute at Navajo Mine are denoted based upon their *in situ* location in the soil profile. The material found in the top 60 inches of the soil profile is called "topdressing", while the material found deeper than 60 inches in the soil profile is called "regolith".

Navajo Mine will salvage all suitable topdressing for use as topsoil substitute. The maximum extent of allowable disturbance in front of the pit is 1,800 feet beyond the extent of mining (i.e., highwall). Topdressing removal will precede pre-stripping activities where required or to facilitate mining activities where no pre-stripping is required, refer to section 11.2.3.2 Overburden Stripping Method. The extent of topdressing removal will fully consider and comply with the applicable hydrology performance standards.

The defined extent of topdressing removal will facilitate the ability to utilize opportunistic direct live haul of topdressing, which may result in increased reclamation success. In addition, the defined extent offers greater flexibility in mining and equipment operations.

Navajo Mine currently has no in situ reserves for Areas I and II. There is in-situ topdressing material remaining in Area III and IV North. This material will be direct hauled to active reclamation areas whenever possible. Topdressing removal activities are conducted in opportunistic blocks that maximize the direct haul and respread of the topdressing into active reclamation plots.

Suitable regolith may be salvaged for use in reclamation as either topsoil substitute or root-zone material, or it may be spoiled if deemed necessary by the operator. Regolith in each resource area (I, II, III ~~and IV~~) will be salvaged or spoiled depending on the need for topsoil or root-zone material in that specific resource area. Where practical and feasible, regolith that has been found suitable for use as topsoil substitute will be removed for use as topsoil substitute. A large quantity of topdressing and regolith has been salvaged and stockpiled, without segregation in Stockpiles LWR1_RG_N (Lowe Regolith Stockpile #9), LWR4_RG_N (Lowe Regolith Stockpile #10), and DXR1_RG_W (Dixon Regolith Stockpile #3). Regolith stored in these stockpiles has been adequately sampled and consist of materials that are considered suitable for use as topdressing substitute and root-zone material. Therefore, no further sampling and analysis will be required on regolith stored in these specific stockpiles.

If stockpiling of the topdressing and regolith is necessary in the future, the topdressing and regolith will be segregated and stockpiled in separate piles.

11.2.1.1 Topsoil Substitute - Topdressing Sampling

An intensive pre-salvage soil-sampling program is conducted to identify soil material suitable for topsoil substitute. The methodologies utilized in the sampling program are in part based on the Soil Resources of the Navajo Mine (CHAPTER 8).

Soils are sampled on a square grid basis at 200-foot centers. This spacing results in a sampling density of approximately one sample per acre. The density and location of sampling is based on conditions observed during the development of the detailed soil survey (CHAPTER 8). Badlands and Natrargids, which lack perennial vegetation, are typically unsuitable sources of topsoil substitute at the Navajo Mine; therefore they are not sampled. As personnel at Navajo Mine gain experience with the pre-disturbance sampling and salvage program, efforts will be made to refine the sampling density. Homogeneous mapping units will require less intensive sampling than heterogeneous mapping units. The proposed sampling density is designed to adequately sample the most heterogeneous mapping unit.

At each soil sample site, a pit is excavated to either an observable unsuitable layer (e.g., bedrock, paralithic contact, extreme clay accumulations, rock fragments, or extremely hard consistence) or to a depth of five feet. Five feet is the maximum depth that Navajo Mine will allow personnel to sample within a pit. Depths of greater than five feet creates a safety hazard because it exposes personnel to the possibility of collapsing walls. Samples for analyses are taken by a soil scientist from representative soil horizons, except A and E horizons, if present, through the five-foot profile. Each sample is described as to depth, dry consistence, texture, and other physical characteristics that aid in the classification of the material. Field notes for each sample and soil profile are collected and maintained on file at Navajo Mine. If it is not feasible to remove a sample of the unsuitable layer, the characteristics and depth of the layer are included as part of the field notes. Once an unsuitable layer of soil is identified, sampling does not continue below that depth.

Soil samples are sent to a soil analytical laboratory for the following analyses to determine topsoil substitute suitability.

1. pH
2. Electrical Conductivity (EC)
3. Soluble Ca, Mg, Na - Sodium Absorption Ratio (SAR)
4. Saturation percent
5. Texture
6. Extractable Selenium

The suite of parameters used to evaluate topsoil substitute suitability were revised based upon an analysis of historical sample data, conducted in December 2001, from more than 5,000 samples. This analysis provided the justification for eliminating carbonate percentage, acid-base potential, boron, and total selenium from the analytical suite. The justification showed that eliminating these parameters from analysis would not adversely affect the suitability of reconstructed soils or reclamation success.

The soils are analyzed using the methodology outlined in TABLE 11-1. Determination of topsoil substitute suitability is based on the OSMRE TOPSOIL AND TOPSOIL SUBSTITUTE SUITABILITY CRITERIA FOR THE SOUTHWESTERN UNITED STATES as presented in TABLE 11-2. Soils that have one or more characteristics that are rated unsuitable are not salvaged for use as topsoil substitute.

TABLE 11-1

METHODS OF SOIL ANALYSIS

ANALYSIS	METHOD
pH	Page, A.L., Miller, R.H. and Keeney, D.R., eds. Methods of Soil Analysis, Part 2 - Chemical and Microbiological Properties. ASA Monograph No. 9, 2nd edition. Madison, Wisconsin: American Society of Agronomy; 1982. Methods 9-3.1.2, pp. 160-161.
Electrical Conductivity (EC)	Page, A.L., Miller, R.H. and Keeney, D.R., eds. Methods of Soil Analysis, Part 2 - Chemical and Microbiological Properties. ASA Monograph No. 9, 2nd edition. Madison, Wisconsin: American Society of Agronomy; 1982. Methods 9-3.1.2, pp. 160-161. Method 10-2.3.1,; pp 169. Method 10.3.3; pp 172. Richards, L.A., ed. Diagnosis and Improvement of Saline and Alkali Soils. USDA Handbook No. 60. Washington, D.C.: USDA; 1954. Method (4a), pp. 89.
Soluble Ca, Mg, Na	Extraction: USDA Handbook 60, Method 3a-Saturation Extract, pp. 84. Analysis: Inductively Coupled Argon Plasma Atomic Emission Spectrometer (ICP).
Sodium Adsorption Ratio (SAR)	Extraction: USDA Handbook 60, Method 3a-Saturation Extract, pp. 84. Analysis: Inductively Coupled Argon Plasma Atomic Emission Spectrometer (ICP). Equation: USDA Handbook 60, Method 20b - Estimation of Exchangeable Sodium - Percentage and Exchangeable - Potassium - Percentage from Soluble Cations, pp. 102.
Texture	EPA 300/2-78-054. Field and Laboratories Methods Applicable to Overburden and Mine Soils. Method 3.4.3.5, pg 122. Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E., and Clark, F.E. ASA Monograph No. 9; Methods of Soil Analysis, Part One. Method 43-5, p. 562. ASTM D422-68.

TABLE 11-1 (cont.)

METHODS OF SOIL ANALYSIS

ANALYSIS	METHOD
Saturation %	Miller, R.H. and Keeny, D.R., eds. Methods of Soil Analysis: Part 2 - Chemical and Microbiological Properties. ASA Monograph No. 9, 2nd edition. Madison, Wisconsin: American Society of Agronomy; 1982: Method G10.2.3 pp. 169. Richards, L.A., ed. Diagnosis and Improvement of Saline and Alkali Soils. USDA Handbook No. 60, Washington, D.C.: USDA; 1954. Method 27a, pp. 107.
Soluble Selenium	Page, A.L., Miller, R.H., and Keeney, D.R., eds. Methods of Soil Analysis: Part 2 - Chemical and Microbiological Properties. ASA Monograph No. 9. 2nd Edition. Madison, Wisconsin: American Society of Agronomy; 1982. Method 25-9.1, pp. 443-444.
Erosion Factor	USDA-SCS. National Soils Handbook. July 1983. Method 603.2-1. pp. 603-29.

TABLE 11-2

NAVAJO MINE TOPSOIL AND TOPSOIL SUBSTITUTE SUITABILITY CRITERIA[1/2]

	Good	Marginal	Unsuitable
PH	6.0-8.4	5.5-6.0 8.4-8.8	< 5.5 > 8.8
EC mmhos/cm[3]	< 4.0	4.0-12.0	> 12.0
SAR[4] sl & coarser l & cl 40% clay	 < 12.0 < 10.0 < 8.0	 12.0-18.0 10.0-16.0 8.0-14.0	 > 18.0 > 16.0 > 14.0
Texture	< 35% clay	<45% clay	>45% clay
Saturation %	20-80	20-80	< 20 - > 80
Coarse Fragments[5] < 3 inch % > 3 inch %	 0-15 0-3	 15-35 3-10	 > 35 > 10
Erosion Factor[6]	0.37	0.37	> 0.37
Selenium Extractable		0.15 ppm	> 0.15 ppm

1. These suitability criteria may be modified on a case-by-case basis if sufficient data are submitted to support the modifications and the submitted data technically represent the site-specific nature of the modification.
2. When spoil/overburden materials are used as topsoil substitute, then these materials must also be analyzed for total selenium concentration and acid-base potential (ABP). Analysis of these constituents is in addition to the parameters listed in this table. Materials that exceed 0.80 mg/Kg total selenium or have pyritic sulfur ABP < -5t/Kt are unsuitable for use as topsoil substitute.
3. When EC is < 2.0, then SAR cannot be > 18.
4. SAR values can be modified if adequate data is submitted to support proposed modifications.
5. Coarse fragment content will be determined from field ocular estimates. For topsoil substitutes/supplements, percentage can be increased if it is shown that the higher percentage will increase slope stability and/or vegetation establishment. Suitability will be determined on a site specific basis.
6. For each material proposed to reclaim slopes $\geq$ 25% (4h:1v), a K factor must be determined from the results of appropriate physical and chemical analyses, as outlined in the National Soils Handbook (SCS, 1983). Material suitability will be determined using the Revised Universal Soil Loss Equation (Renard, ARS, 1990).

Each sampling location is identified in the field by survey lath marked with the pit identification number. A 1:6000 scale map is constructed showing the location of each sample point along with the assigned pit identification number.

Soil analyses received on a yearly cycle from 1 through June 30 will July be forwarded annually to the Office of Surface Mining on or before August 31. The analyses are filed with the corresponding pit identification number and sampling depth. A map showing the location of each sampling site and the field descriptions are also submitted.

11.2.1.2 Topsoil Substitute - Regolith Sampling

When regolith is to be used as topsoil substitute or root-zone material, it will be sampled in situ and must meet the suitability criteria as outlined in TABLE 11-2.Regolith will be analyzed for the parameters listed in TABLE 11-2. Sampling will be conducted with a drill rig using a core barrel auger in areas where the baseline soil survey and pre-strip topdressing survey indicate potential sources of suitable regolith below five feet. Soil samples will be collected in continuous five-foot intervals to bedrock, or the desired sampling depth, from drill holes located on 800-foot centers.

Stockpiled regolith located in Stockpiles LWRI RG N, LWR4 RG N, and DXR1 RG W has been adequately characterized and is considered suitable for use as topsoil substitute and root-zone material. No additional sampling and analysis will be required for regolith materials stored in these particular stockpiles.

Sampling and analysis data for *in situ* material will be submitted on or before August 31 of each year and will include information for the period between July 1 and June 30. After submission of sufficient representative data, an application may be made to OSM to reduce sampling density or eliminate it altogether

11.2.2 Blasting Operations

Navajo Mine complies with the following laws governing the use of explosives where applicable:

26 CFR Part 181	"Commerce in Explosives",
30 CFR Part 77	"Mine Safety and Health Regulations"
30 CFR Part 816	"Permanent Program Performance Standards - Surface Mining Activities"

All blasting at the Navajo Mine is conducted under the supervision of OSM certified blasters. The blaster and one other person present at the firing of a blast and all personnel responsible for blasting operations will be familiar with the blasting plan and site specific performance standards.

All drill and blast designs will be approved by a certified blaster. The design will contain drill patterns, delay periods, tie in description, amount and type of explosives used, and pertinent data of the closest structure.

Navajo Mine will prepare and submit a comprehensive blasting plan before blasting within 1,000 feet of any building used as a dwelling, public building, school, church, or community or institutional building outside the permit area or within 500 feet of an active or inactive underground mine (see Section 12.7, Subsidence Plan). These blasting plans will be submitted to the regulatory authority 45 days prior to the blast occurring. Changes to these plans will be made if required by the regulatory authority.

The location of all the explosives handling and storage areas are shown on EXHIBIT 11-7.

11.2.2.1 Preblasting Survey

Navajo Mine notified in writing all known residents located within one-half mile of the permit area on how to request a pre-blast survey. All pre-blast surveys were completed by February 28, 1986. A list of all known residences within one-half mile of the permit area is included in APPENDIX 11-A. A map showing the blast areas described in the Public Blast Notice and the location of all known residences can be found on EXHIBIT 11-8.

11.2.2.2 Blasting Schedule

All blasting at the Navajo Mine shall conform to the blasting schedule as described in the Public Blast Notice except for emergency situations. Emergency situations warranting detonation outside the specified periods include any situation that constitutes a safety hazard to employees, a safety hazard to non-employees, and/or has the potential to damage equipment, mine or otherwise as a result of blasting.

The Public Blast Notice will be published at regular intervals which will not exceed 12 months, or at least 10 days but not more than 30 days before blasting when the information in the Public Blast Notice changes significantly. Copies of the Public Blast Notice will be distributed to local governments, public utilities, and each residence within one-half mile of the blasting area. A copy of the Public Blast Notice and a Distribution List for the Public Blasting Notice is shown in APPENDIX 11-B. Proof of publication of the Public Blasting Notice will be kept on the mine site at all times and may be reviewed by the regulatory authority upon request.

11.2.2.3 Blasting Signs, Warnings and Access Control

Conspicuous signs posted at all entrances to the Navajo Mine contain the following warning "WARNING! EXPLOSIVES IN USE" and lists the audible blast warning and the methods to control blast area access. In addition, signs indicate that "Loaded holes are barricaded and marked with the warning: DANGER-EXPLOSIVES-KEEP OUT".

Ten minutes before a blast, a short siren will be sounded for a period of five seconds. An audible blast warning consisting of a long wail siren is started five minutes before the blast. Thirty seconds before the blast, the siren is changed to a yelp. The all clear signal given after the blast area is cleared consists of a series of three, five second audible pulses, broken by five second intervals of silence between each pulse.

Access to the general area of blasting is controlled by posted signs, normally temporary signs reading "DANGER EXPLOSIVES - LOADED HOLES - NO UNAUTHORIZED ENTRY - CALL BLAST FOREMAN BEFORE ENTERING" or some equivalent message to warn the party reading the sign. Access to the immediate area of the blast is controlled by manned roadblocks that deny access to the area by unauthorized personnel. Access is denied at least five minutes prior to the actual explosion and not allowed until the area is cleared.

11.2.2.4 Control of Adverse Effects

Blasting at the Navajo Mine is conducted so that air blast does not exceed the prescribed limits listed in Section 816.67(b)(i) of 30 CFR at any dwelling, public building, school, church, or community or institutional building outside the permit area. Navajo Mine periodically monitors air blast to insure compliance with the standards.

All blasts at the Navajo Mine are designed so that fly rock does not travel more than one-half the distance to the nearest building or dwelling, beyond the blast area, or off the permit area.

Blasting is conducted so that the maximum ground vibration does not exceed the limits listed in section 816.67(d)(i) of 30 CFR at the location of any dwelling, public building, school, church, or community or institutional building outside the permit area. To ensure that the maximum peak particle velocity for ground vibration is not exceeded, the scale-distance equation as described in 30 CFR 816.67(d)(3) is utilized.

Seismic monitoring will not be required when blasting is performed in accordance with the approved scale-distance equation. When application of the approved scale-distance equation shows that the allowable peak particle velocity may be exceeded, seismic monitoring will be conducted using a seismograph. The data will be included in the blast report for this particular shot.

When blasting in the vicinity of outside pipelines and/or power lines, the peak particle velocity at that location will not exceed five inches per second (White Industrial Seismology, Inc., 1985). The vicinity of the pipeline and/or power lines is defined as any location that is less than 800 feet from the pipeline and/or power line. One of the following methods will be used to show that the peak particle velocity of five inches per second at the location of the pipelines and/or power lines is not exceeded:

1. A seismograph record will be kept for each blast within the vicinity of pipelines and/or power lines, or

2. A previously approved scale-distance factor for maximum peak particle velocities of less than five inches per second will be used when blasting in the vicinity of pipelines and/or power lines. The modified scale-distance factor is DS = 13. (for backup data please see Appendix 11-C).

It is not anticipated that structures other than those mentioned above will be encountered at the Navajo Mine. In the event that other structures are encountered, such as water towers, tunnels, dams, impoundments, underground mines, or other utilities, a maximum peak particle velocity limit will be developed to use in the vicinity of the structure. After obtaining regulatory authority approval, one of the above mentioned methods will be used to show that the maximum allowable peak particle velocity limit is not exceeded at the location of the structure.

The maximum airblast and ground vibration limits will not apply at structures owned by Navajo Mine and not leased to another person. There are no structures owned by Navajo Mine and leased to another person.

11.2.2.5 Blasting Records

All blasting data is recorded on blast reports which are retained for three years. Copies of sample blast reports are found in APPENDIX 11-C. Text discussing blasting report practices are also located in Appendix 11-C.

11.2.3 Overburden Removal

11.2.3.1 Overburden Drilling and Blasting

After the suitable topdressing material has been removed, rotary drills are used to drill overburden blast holes. Blast hole diameter ranges from 5 inches to 10-5/8 inches. Blast holes are typically drilled to the top of coal. To prevent coal shattering and accompanying coal loss from overburden blasting, blast holes are drilled until coal is encountered and backfilled with 1 to 10 feet of drill hole stemming. On some cast shots holes may be drilled to a specified elevation of three to seven feet above the coal seam and not backfilled to reduce coal loss due to the movement of the overburden over the coal seam.

Once the rotary drill has completed drilling a block of blast holes, the holes are then loaded with bulk explosives. ANFO or a mixture of ANFO and emulsions are the most widely used blasting agents; however, some slurries may be used in wet areas. The explosive column is detonated by a 1/2 to 3 pound primer initiated with either a non-electric detonating cord or an electric blasting cap. Normally, to ensure proper blast sequencing, the shots are controlled using in-hole delays and/or surface delays.

11.2.3.2 <u>Overburden Stripping Methods</u>

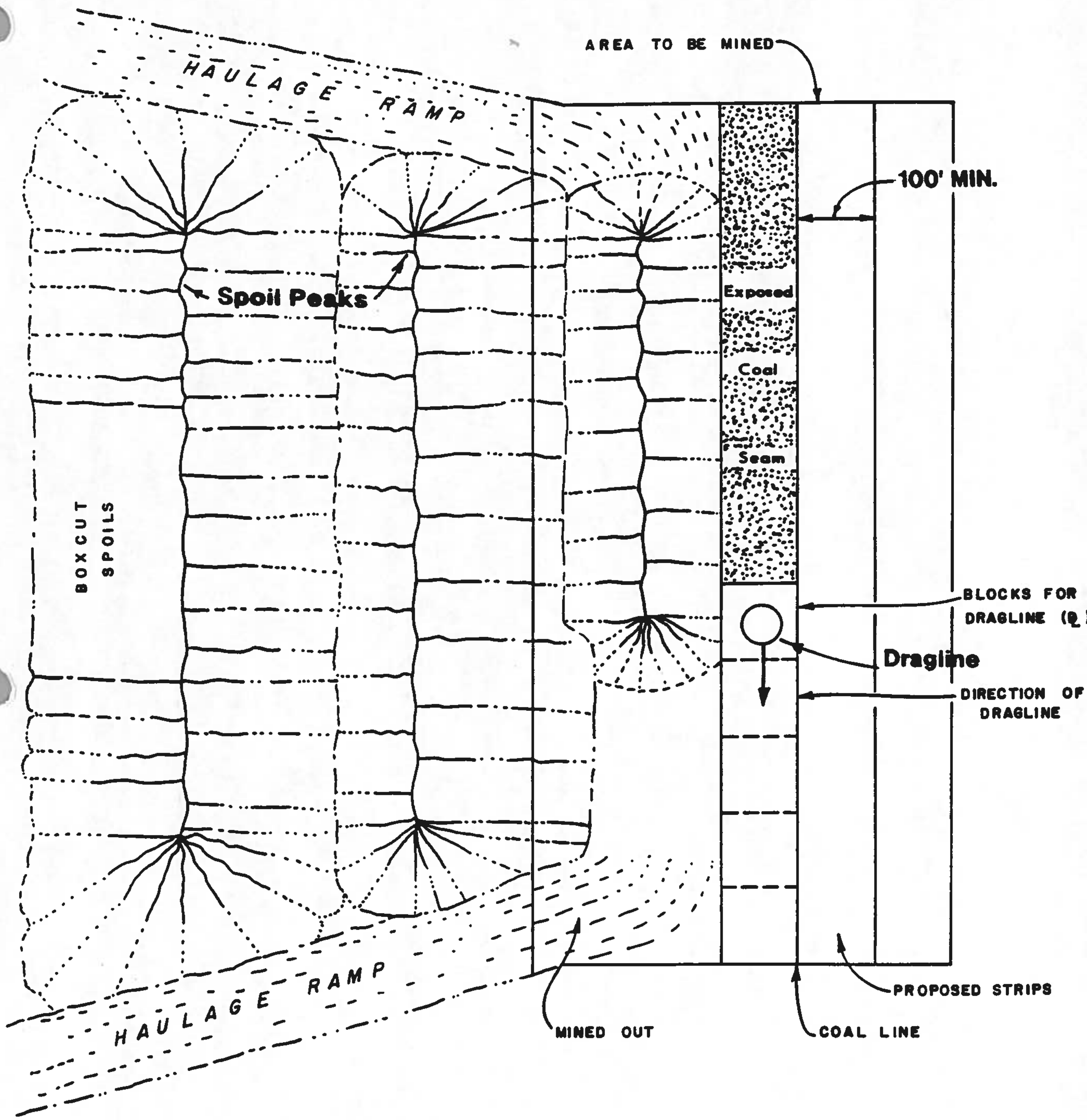
Overburden and interburden material is primarily removed with walking draglines to expose the coal seam by taking parallel strips ranging in width appropriate for the size of the dragline. A minimum pit width of 100 feet is required to facilitate the mining equipment. The overburden is removed using the dragline in a series of blocks the length of which depends on the particular pit geometry. The material is spoiled into the previously mined out strip as shown in FIGURE 11-2.

Generally, two methods of stripping are employed. The first is conventional side casting, which is generally employed on the upper seams. The second is conventional spoil-side stripping, which is used on the lower seams. The geologic conditions, such as depth of coal and the number of coal seams, along with the size of dragline and basic configurations, determine the methods of stripping employed in any given pit.

In addition to the primary dragline stripping, dozers and trucks are utilized in overburden / interburden removal in conjunction with the dragline methods. Dozer and truck stripping is utilized to buffer inventory lows and to remove overburden in isolated areas where dragline stripping is not logistically practical (e.g. mesas, very short pit lengths, short pit extents, etc.). In addition, trucks and dozers are utilized on thin burdens where dragline operations are not effective (within dragline pits).

TEXT CONTINUED ON PAGE 11-18

Figure 11-2
TYPICAL STRIP LAYOUT



At the Navajo Mine, the pit names are also associated with area names such as; Area 1, Area 2 and Area 3. The progression of uncovered coal is in linear strips as shown on Exhibits 12-02 and 12-03. Pre-Stripping is done in the deeper parts of Area 3 and Area 2 to keep the total pit depth for the dragline under 200 feet. Pre-Stripping is accomplished using a fleet of end-dump haul trucks and a front-end loader. Pre-Strip material will be removed in front of the active mining strip and placed in final grading areas. Information compiled from Exhibits 12-02 and 12-03 is on Table 11-25 (Areas Mined by Year). This table summarizes pit locations, mining sequences, start and end dates of mining and approximate acres disturbed.

Refer to Exhibit 12-02 for Area 2. The current active pits in this area are Hosteen/Yazzie and Yazzie Overlook. Pre-Stripping with a truck and loader fleet will occur for the entire area. Exhibit 12-02 provides specific stripping sequence by permit term year. Upon finishing the Hosteen/Yazzie and Yazzie Overlook pits, coal-mining activities in Area 2 will be complete.

For Area 3, refer to Exhibit 12-03. The current active pits in Area 3 are Lowe and Dixon pit. Exhibit 12-03 provides specific stripping sequence by permit term year. Pre-Stripping with a truck and loader fleet in Area 3 will continue 4 strips ahead of the active mining strip. Lowe pit will be mined out ahead of Dixon pit. Upon finishing Dixon pit, coal-mining activities in Area 3 will be completed.

~~For Area 4N, refer to Exhibit 12-03. Area 4N will become active in Pit development in Year 1 and will begin mining in Year 2. Area 4N will remain active throughout the permit term. Upon finishing Area 4N pit, coal-mining activities in Area 4N will be complete.~~

Table 11-25 Areas Mined by Year

YEAR	AREA (LOCATION)	PIT NAMES (LOCATION)	STRIP #	APPROXIMATE ACRES DISTURBED
1	Area 2	Hosteen / Yazzie	13-18	109
1	Area 3	Lowe	58-60	43
1	Area 3	Dixon	60-62	94
	Sub Total Year 1			**246**
2	Area 2	Hosteen/Yazzie	19	9
2	Area 2	Overlook	23-24	10
2	Area 3	Lowe	58,61-63	48
2	Area 3	Dixon	63-65	82
2	Area 3	Corridor Road	5	5
	Sub Total Year 2			**154**
3	Area 2	Hosteen/Yazzie	20-22	15
3	Area 2	Overlook	25-30	18
3	Area 3	Lowe	64-66	43
3	Area 3	Dixon	66-68	76
	Sub Total Year 3			**152**
4	Area 3	Lowe	67	19
4	Area 3	Dixon	69-70	51
4	Area 3	Corridor Road	1-3	18
	Sub Total Year 4			**88**
5	Area 3	Corridor Road	4	6
5	Area 3	Dixon	71-74	84
	Sub Total Year 5			**90**
6-10	Area 3	Dixon	75-86	236
	Sub Total Years 6-10			**236**

* table does not include prestrip disturbance ahead of mining

Year 1 Commences Sept. 1, 2009

11.2.4 Coal Removal

After the coal is exposed by the stripping operation it is drilled and blasted for subsequent mining. After a block of blast holes is drilled they are normally primed with a booster and detonating cord or non-electric blasting caps. Surface delays are used to ensure proper blast sequencing. Then the holes are loaded with ANFO, or in wet situations with an emulsion/ANFO blend or bagged slurry product. Thin coal seams are normally ripped with dozers rather than blasted. Once the coal is broken up it is mined by front-end loaders. The entire thickness of the coal seam is mined in one pass except where a major shale parting or coal quality makes a distinct division in the coal seam. In this case, the top part of the seam is mined by the front-end loader, then the parting is ripped by dozers and pushed into the adjoining spoil area. Finally the rest of the seam is mined with the front-end loaders. The face of the coal is generally across the width of the pit and is advanced evenly. The top of the coal is cleaned using small front-end loaders with the diluted coal piled on the spoil side of the pit.

Although operations at the Navajo Mine are engineered and designed to recover the maximum amount of coal, a small percent of coal is lost as coal wedges, coal ribs, and the top and bottom of coal seams. There are a number of operational and safety related conditions which necessitate limited coal losses. In general, two types of wedge losses occur; a wedge left on upper seams in multiple seam pits as a safety berm and a wedge left on spoil encroached seams as a spoil barrier. A small percent of coal may be lost on the top and bottom of the coal seam and as coal ribs due to the geologic condition of the coal and due to the equipment utilized in the stripping and mining sequences.

When mining multiple seams, upper seams are mined from benches where the bottom of coal elevation is higher than the toe of the spoil. When these conditions are encountered, a wedge of coal is typically left as a safety berm which prevents trucks and loaders from accidentally going over the highwall. Once the coal seam has been mined out, front-end loaders are used to recover as much of the wedge as possible.

When a seam is spoil encroached the coal wedge acts as a spoil barrier, contributing to spoil stability and reducing the occurrence of loose material rolling into the active pit. Both spoil slides and loose material rolling into the pit are potentially serious safety hazards. Once the seam has been mined out, front-end loaders are used to recover as much of the spoil-side wedges as safely possible.

A mine railroad system and a fleet of bottom-dump trucks constitutes the coal haulage system. In most pits, the coal is loaded into the trucks which travel up the pit ramps to the major haul roads where the coal is stockpiled next to the rail system. Within an approximate 6.5 mile radius of the power plant the coal can be hauled directly from the pits to the processing plant.

At the stockpile front-end loaders are used to load the coal into rail cars for dumping at the processing plant. Normally, one electric locomotive pulls approximately 20 cars from the stockpiles to the processing plant.

Navajo Mine has a contract with the owners of the Four Corners Power Plant to provide coal for the power plant through the year 2016. The tonnage per year is subject to change depending on the Four Corners Plant's demand for power, the availability of the mining equipment and possible additional sales generated through future contracts. The anticipated tonnages to be mined from the permit area for the five fiscal years of the permit is discussed in Section 11.3, Annual Coal Production.

11.2.5 Waste Handling, Storage, Transportation, and Disposal

Coal waste materials are routinely cleaned up around the mine and coal plant then disposed of in the mine pit. Disposal of this material performed using end dump trucks with the material placed along the bottom of a pit adjacent to the wedge or spoil side. Coal not meeting contract specifications is disposed of in a mine pit.

Municipal trash from Navajo Mine operations is disposed of in the San Juan County Regional landfill (Appendix 11-KK). This material is accumulated in dumpsters located around the site and transported to the landfill by a contractor.

Materials classified as hazardous by the Environmental Protection Agency (EPA) are accumulated, managed, and disposed of following applicable U.S. and Navajo Nation EPA

(Appendix 11-LL), Department of Transportation (DOT), and Office of Safety and Hazard Administration regulations. Non-hazardous materials that can be recycled or reused, are accumulated, managed, and recycled or reused following applicable EPA regulations. The nonhazardous materials that can not be recycled or reused are accumulated, managed, shipped offsite and disposed of following applicable EPA and DOT regulations. Railroad ties are stored and reused on the mine site or offsite for landscaping. Railroad ties are not disposed of on the mine site. Ties that can not be reused are disposed of following the applicable environmental standards.

11.2.5.1 Historic Coal Combustion By-products (Ash) Disposal

Coal Combustion Byproducts (CCB) placement from Arizona Public Service (APS) in mined-out pits and ramps at Navajo Mine is anticipated to end when Pinto pit is complete by January 2008. CCBs generated by APS after January 2008 is scheduled to be sold to vendors for beneficial uses or disposed on APS property. As a contingency, Navajo Mine will continue to maintain SMCRA permit approval to place CCB's in South Barber pit, through the current permit period (2009). By 2009 if APS continues to dispose of CCBs through means other than Navajo Mine all reference to CCB disposal will be removed from the permit.

Under Navajo Mine's fuel supply contract with Arizona Public Service (APS), Navajo Mine accepted Coal Combustion Byproducts (CCB) or ash, from Four Corners Power Plant units 4 and 5 for disposal in final pits and ramps. CCB disposed of at Navajo Mine included: fly ash, scrubber sludge and bottom ash. In general, the major chemical constituents of CCB disposed of at Navajo Mine include: Silicon Dioxide (SiO_2), Aluminum Oxide (Al_2O_3) and Calcium Sulfite ($CaSO_3$) (see the Leach Study, APPENDIX 11-K). Since 1971, CCB from the Four Corners Power Plant have been placed in mined-out pits and ramps of the Navajo Mine.

Fly ash and bottom ash are generated by the combustion of coal at Four Corners Power Plant. The fly ash is collected in emission control baghouses. Fabric bags in the baghouses act as a filter removing the fly ash from the flue gas stream of units 4 and 5. Ash too large to be carried by the flue gas to the baghouse falls to the bottom of the boiler during the combustion process and is removed as bottom ash. Scrubber sludge is the byproduct of removing SO_2 from the flue gas. The SO_2 reacts with lime to form calcium sulfite and calcium sulfate. A description of the physical and chemical properties of the CCB is contained in APPENDIX 11-K.

11.2.5.1.1 Ash Disposal Areas

Historic Ash disposal locations at Navajo Mine through November 2007 on interim and permanent program areas are shown on Exhibit 11-149. The future ash disposal locations are indicated on Exhibits 12-5A, 12-6A, and Exhibit 12-6B. These exhibits show permanent program locations on top of final surface configuration.

Listed below are the available ash disposal areas at Navajo Mine and the approximate available disposal volumes.

Area Name	Land Status	Volume in mcyd
Pinto Pit	Permanent Program	1.9
South Barber Final Pit	Permanent Program	18.6

11.2.5.1.2 Ash Disposal Schedule

Disposal areas and the approximate ash disposal schedule follow.

Active / Potential Ash Disposal Areas	Active Dates
Pinto Pit	2004 – 2007
South Barber Final Pit	2005 – 2009

11.2.5.1.3 Ash Disposal Method

The haulage and disposal of CCB may utilize any of the equipment listed in Section 11.4 of the PAP. Typically, ash is hauled in 85-ton end dump trucks and is dumped into the pit. A dozer is used to push ash into the backfilled pit and for dump site maintenance. When equipment or other needs dictate, a single lift or multiple lifts are used to backfill the pits and ramps. A grader and water truck are used to maintain the ash haul road and to control fugitive dust.

11.2.5.1.4 Ash Haulage Routes

Roads used for ash haulage will meet the Roads General Performance Standards, stated in section 11.5.6.1.6 of the PAP. Methods outlined in Sections 11.2.8 and 11.2.10 for dust and surface water control will be employed in ash disposal operations.

11.2.5.1.5 Ash Regulatory Compliance

In 1993 the United States Environmental Protection Agency (U.S.EPA) made a final regulatory determination that CCB are exempt from regulation as a hazardous waste under Subtitle C of the Resource Conservation and Recovery Act (RCRA, 58 FR 42466, August 9, 1993). In its regulatory determination, EPA concluded that the State or Tribal industrial solid waste management programs implemented under Subtitle D of RCRA were adequate regulatory controls for managing the disposal of CCB.

The Navajo Nation codified the Navajo Nation Solid Waste Act on 18 October 1990 (4 N.T.C. 101 as amended by the Navajo Nation Council Resolution No. CJY–51– 97) and finalized their regulations on February 1, 1999. The Navajo Nation Solid Waste Regulations specifically excludes CCB from the definition of a Solid Waste. Based on this exclusion, CCB are not regulated as a solid waste. In accordance with the following documents, BHP has the right to dump CCB (ash) on leased premises. A mining lease between the Navajo Nation and BHP (Utah

Construction Company) dated July 26, 1957 and the subsequent amendments. Resolution ACAP-43-68 of the Advisory Committee of the Navajo Tribal Council dated April 15, 1968, Approval of Resolution ACAP-43-68 by the Bureau of Indian Affairs dated May 15, 1968. Copies of these documents will be kept on the mine site at all times and may be reviewed by the regulatory authority upon request.

11.2.5.5 Landfarming of Petroleum Contaminated Soils

West Hosteen Landfarm

Area III washbay water and sludge containing petroleum products is managed at Navajo Mine using landfarming. When necessary, Petroleum Contaminated Soils (PCS) resulting from accidental spill and leaks are also managed using landfarming. The West Hosteen landfarm consists of one cell 110' x 185' with a 2' liner consisting of compacted clay material. Liner material is composed of suitable spoil that meets compaction specifications for a 1 x 10-7 cm/sec maximum hydraulic conductivity. A 6" buffer layer of uncompacted material is placed between the compacted liner and the petroleum contaminated soils. The landfarm is located and built so that surface flows will not enter the landfarm area. The landfarm cell is designed and constructed to contain a 100-yr. 6-hr. event. The process of landfarming includes natural aeration, volatilization, disking, and the periodic addition of water and nutrients to support bioactivity.

Based on technical experience with similar operations Navajo Mine expects the concentrations of petroleum hydrocarbons to be remediated within one year after placement into the landfarm. The performance of the landfarm will depend on the original hydrocarbon concentrations of the soil and the soil temperature conditions. Cooler temperatures slow the natural bio-remediation process.

The landfarm materials are limited to non-hazardous petroleum contaminated soils and floor dry (diatomaceous earth) with oil and diesel. Materials are analyzed if direct operator knowledge is unavailable to determine the level of contamination, non-hazardous waste classification, and remediation time necessary. Treatment of the soils will be considered complete when levels are demonstrated to be below 100-ppm total petroleum hydrocarbon levels required by the Navajo

Nation. Soils will be analyzed and classified as a non-regulated soil and landfarm material will be spoiled. The landfarm location is shown on EXHIBIT 11-124. No landfarm is located with eight feet of any coal outcrop.

Once the landfarm is no longer needed, completion of the site will follow the applicable reclamation and revegetation activities found at Chapter 12.

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11.2.6 Air Pollution Control and Clean Water Act, and Health and Safety Compliance

The air pollutant of concern in mining activities is fugitive particulate emissions. The emissions are minimized by various control measures, as described in Section 11.2.8, including periodic watering of frequently traveled roads, revegetation as soon after regrading as possible, and efficient topsoil storage procedures to minimize wind erosion. In all mining activities, mine personnel will make an effort to minimize fugitive dust emissions and ensure that total suspended particulate standards are not violated by Navajo Mine. See Section 11.5.7 for additional information.

An air quality monitoring report will be submitted to OSM within 60 days of the end of each calendar quarter. If measurements at a particular monitor exceed the 24-hour air quality standard for PM_{10}, an initial assessment will be submitted as part of the respective quarterly report. The National Ambient Air Quality Standards (NAAQS)/New Mexico Ambient Quality Standards (NMAAQS) 24-hour reference standard for PM_{10} is 150 ug/m^3.

To comply with the requirements of the Clean Water Act, point source discharges comply with the provisions of the existing National Pollutant Discharge Elimination System (NPDES) permit. See APPENDIX 11-J for permit requirements and CHAPTER 6, EXHIBIT 6-7 for outfall locations. The oil/chemical bulk storage and transfer areas are provided with secondary containment and/or drainage control systems so that any accidental leakage or spills are controlled, cleaned up and collected. All collected waste oils are sold for reprocessing or contracted to be disposed of properly.

Sediment ponds will be inspected following a precipitation event that exceeds the 10-year, 6-hour event of 1.3 inches as measured at the automated MET I precipitation gauge for Area I and MET II for Areas II and III. The inspection will occur within 36 hours (conditions permitting) after the end of the day (12:00 am) in which the precipitation occurs. The inspection will record the following items: structure identification, date and time of inspection, staff gauge reading, condition and function of spillways (inlet and outlet) and embankment, whether a water sample was taken, and any downstream flows and possible causes.

Drainage from the coal plant area flows to zero discharge ponds. The sewage is treated in a water treatment package plant, the discharge of which goes to an evaporation pond. See Section 11.5.7 for additional information.

Hydrologic monitoring reports are submitted quarterly and a detailed report is submitted twice during the permit term. See Section 11.6.5 for additional information.

To comply with the requirements of MSHA, the mine has a qualified and certified staff trained to protect the health and safety of its employees and provide first aid. These personnel have the appropriate MSHA certifications in training, sampling, and in maintenance and calibration of sampling equipment as required in 30 CFR Part 71 and 48. Each new employee receives 24 hours of safety, health, and first aid training. All miners are given eight hours of refresher training annually and when they are transferred to new positions they receive health and safety training for their new tasks. Weekly safety meetings are held with all miners to discuss health and safety issues.

Industrial hygiene programs at the mine include dust and noise monitoring, as well as special sampling for other contaminants, and implementation and maintenance of engineering control measures such as ventilation. The mine also has an audiometric testing program. All accidents and illnesses are investigated thoroughly to avoid recurrence.

11.2.7 Coal Mine Waste Fires

The Navajo Mine's mining operations do not generate any coal mine waste; therefore, no coal refuse piles have been constructed. Future plans do not require the construction of refuse piles, therefore, a MSHA coal mine waste fire control plan is not required, per 30 CFR 77.214 through 77.215(4).

Spoil fires caused by stripping sequence and spoiling methodology occasionally occur in the spoil rows and previously mined out areas of the pits. Coal spoil fires are controlled or extinguished by covering the burning spoil with non-coal spoil material to smother the fire. Coal spoil fires that cannot be covered, will be manipulated with a dozer to expose the coal spoil material allowing it to burn itself out.

If a coal stockpile fire occurs, the burning coal is removed from the pile and spread out on the ground away from the pile. The fire is smothered by back dragging the material by mine equipment or is left spread out to burn itself out.

Extinguishing operations will be initiated immediately after a coal spoil/stockpile fire is reported. Coal fires are carefully evaluated and deemed safe before equipment and personnel are allowed to enter the area for extinguishing operations. Only experienced personnel conduct extinguishing operations. Coal fires will be monitored until all evidence indicates that the fire has burned itself out or is extinguished.

To ensure safe working conditions all work areas are inspected each work shift by the supervisor in charge of the work area. An inspection log is maintained with follow-up actions for any unsafe conditions identified. This shift inspection is required by MSHA. Any potential fire hazard is identified and reported during this inspection by the on shift supervisor.

11.2.8 Fugitive Dust Control Measures

Navajo Mine employs a number of practices to control or minimize the amount of fugitive dust from the mining operations. Deliberate mining practices that result in the reduction of fugitive dust are called direct control measures (e.g., switching from truck to railroad will decrease road dust, and certain activities within a mine pit increase pit retention of dust). A direct control of one activity, such as haul road watering, may result in an indirect control of adjacent areas, by watering of work areas adjacent to the haul roads.

The following direct and indirect fugitive dust control practices are applied at the Navajo Mine:

Control Measure	Fugitive Dust Categories		
	Road	Coal	Mining
1. Unpaved haulroads and ancillary roads are watered with water trucks as needed to suppress dust.	D[1]	I[2]	I
2. Heavily-travelled portions of unpaved primary roads may be chemically stabilized with LIGNOSITE (lignosulfonate), Magnesium Chloride, Coherex, Semi-Pave, or watered as needed to suppress dust.	D	-	-

Control Measure		Fugitive Dust Categories		
		Road	Coal	Mining
3.	Haulroads that are in use are graded as necessary during hauling operations.	D	I	I
4.	High use routes of travel in mining areas are graded as necessary.	D	-	I
5.	Maximum vehicle speed on paved and unpaved mine roads is limited to 45 mph within the permit area for all mine vehicles.	D	I	I
6.	Travel of unauthorized vehicles on other than established roads is restricted.	D	-	I
7.	The area of disturbed land is minimized. This includes the number and size of areas to be blasted at any one time.	I	-	D
8.	Curtains are installed around the drill stems on overburden drills. Water sprays and/or vacuum dust suppression systems are used to help suppress fugitive dust emissions when drilling overburden material.	-	-	D
9.	Regular inspections for coal fires are made throughout the mine area. If a coal fire ignites by spontaneous combustion, that portion of the coal is separated or buried to extinguish the fire where possible.	-	-	D

Control Measure	Fugitive Dust Categories Road	Coal	Mining
10. The area accessible by vehicles around the coal plant is watered as needed to suppress dust.	-	D	-
11. Dust suppression at the coal plant is accomplished by a spraying system using a mixture of water and/or chemical suppressants. The spraying system is located at key unloading points, crushing areas, and conveyor transfer points. Also contributing to dust suppression are the covers over the main conveyor systems which assist to further reduce coal dust emissions.	-	D	-
12. Coal placed at designated coal stock-piles is smoothed and compacted as necessary. Compaction of the coal reduces spontaneous fires and fugitive dust, and allows the coal trucks to operate on the stockpile as needed.	I	-	D
13. Dust control during construction of a soil stockpile (topdressing stockpile) is done by spraying the working area with water from a water truck. Inactive stockpiles will be seeded as described in Section 11.5.3	-	-	D

Control Measure	Fugitive Dust Categories Road	Coal	Mining
14. Revegetation of graded areas minimizes fugitive dust.	-	-	D
15. Maximizing the use of the train decreases the use of coal trucks and minimizes dust emissions.	D	I	-
16. The increase in multiple seam mining will increase the amount of operational time spent by mining equipment in mining pits. This will increase particulate deposition by increasing pit retention of the fugitive dust generated by mining.	I	-	D

[1]D = direct impact by control measure on appropriate fugitive dust category.

[2]I = indirect impact by control measure on appropriate fugitive dust category.

11.2.9 Wildlife Monitoring

Prior to land disturbing activities at the mine, wildlife resources will be examined to determine the need for buffer areas or wildlife features requiring mitigation in order to minimize adverse impacts on wildlife. Assessment of impacts to wildlife and a mitigation plan are detailed in CHAPTER 10, Sections 10.5 and 10.6, respectively.

Annual mine operation plans are reviewed to identify potential conflicts with raptor nesting so that consideration can be made for mitigation. Early identification of conflicts is desirable to allow flexibility in resolving the conflicts with the least possible impact to the birds' or the mine's activities. For example, it is much easier and less costly to move a raptor nest before or after the nesting season than when it contains young. Any moving of raptors and their nests will require special purpose permits and will be closely coordinated with the Navajo Fish and Wildlife Department (NFWD) and the United States Fish and Wildlife Service (USFWS) as necessary. The raptor nest monitoring program gathers data on the species using each nest, activity status, and number of young produced. If any golden or bald eagle nests are found on the mine permit area, its discovery and location will be reported to OSM/Denver.

Through consultation with the Bureau of Indian Affairs (BIA) and the NFWD, BHP will establish buffer zones for active raptor nest locations and restrict mining activity in these areas. All raptor nesting habitat within the buffer zone will be periodically surveyed to document the status of active and inactive nests.

Annual raptor survey reports are organized to outline the methods, results, and summary of the historical and new active breeding areas. Mapping of nesting site locations is maintained by the NFWD. Permits required to conduct off lease monitoring activities under this plan will be obtained from the NFWD. Results of each year's raptor survey will be submitted to OSMRE by August 31 of each year.

Prairie dog colonies will be surveyed for the black-footed ferret, as determined necessary after consultation with the NFWD. Also, topdressing stripping activities described in CHAPTER 11, Section 11.2.1, are scheduled during late March through July. The area to be disturbed will be examined prior to disturbance to determine if burrowing owls are nesting in the area. If burrowing owls are nesting, activities that would disturb the site would be rescheduled to prevent destruction of an active nest, or other appropriate measures employed after consultation with the regulatory authorities. Prairie dog colonies will be surveyed as necessary in consultation with the NFWD. Additionally, areas to be disturbed during burrowing owl breeding season will be surveyed to determine if burrowing owls are nesting in the area.

General wildlife monitoring activities are conducted constantly by the Navajo Mine environmental staff as they routinely travel around the permit area during their daily activities. Particular attention is paid to documenting any use of the permit area by Threatened or Endangered (T and E) species and/or other species of high interest. When T and E species are observed on mine lease, OSM and the Navajo Nation will be notified immediately. The annual General Wildlife Monitoring report, will document any findings or sightings of general wildlife, T and E species, or other high interest species. This report will be submitted to OSMREby August 31 of each year.

Wildlife monitoring as discussed under this Section can also be found in CHAPTER 10, WILDLIFE. The specifics regarding mitigation techniques, plans, and other requirements are found under Sections 10.6, "Fish and Wildlife Mitigation Plan", and 10.7, "Monitoring Plan".

11.2.10 Surface Water Control Measures

Surface water controls used at Navajo Mine perform two basic functions. First, impoundments and diversions keep surface flows that originate outside the permit area (upstream) from entering active mining areas. Section 11.5.4 describes these impoundments and the performance standards they are designed to meet

Other surface water controls are designed, constructed, and maintained, using the best technology currently available, to prevent additional contributions of sediment to stream flow or to runoff outside the permit area. The specific controls vary according to the category of mining or reclamation operations from which the drainage is to be controlled. All surface water controls are designed and constructed to reduce, where possible, the waste of water through evaporation. TABLE 11-2a summarizes the controls used at Navajo Mine. Following the table is a description of each sediment control method and its application in specific mining and reclamation operations.

It is very important to recognize that site specific conditions may require the limited application of a control method listed in TABLE 11-2a to a mining or reclamation operation for which a different method is listed. In any case, the control methods will be designed, constructed and maintained according to prudent engineering practices and the best technology currently available.

TABLE 11-2a

SEDIMENT CONTROLS

Operation	Control Method	Performance Standard; Design Criteria	Refer To:
1. Topdressing Stockpiles	Berms, Ditches, Dewatering	Reference[1]; zero discharge[2]	Section 11.5.4
2. Immediate Mining Areas (includes topdressing removal, overburden drilling, equipment storage, stripping, spoils prior to completion of top-dressing placement)	Berms, Ditches, Dewatering, Sediment Ponds[3]	Reference[1]; zero discharge[2], 10 yr-24 hr storm event[6], PE certification, NPDES criteria (as approved)	Section 11.5.4
3. Coal Handling & Ancillary Areas (coal stockpiles, coal preparation plant. shops)	Sediment Ponds	Minimum 10-yr., 24-hr. event, P.E. certification, NPDES criteria (as approved)	Sections 11.5.2 and 11.5.4
3a. Railroad & Haulroad Transportation Corridors	Alternative Sedimentation Control (BTCA's and BMP's): Siltation fences, mulching, low gradient ditches, riprap channels, etc.	Refer to Section 11.5.6.2.2 of the PAP for design criteria.	Sections 11.5.6.1.6, 11.5.6.2.2 and 12.6.5
4. Reclamation Areas (graded with topdressing in place)	Recontouring[4], mulching[5], revegetation, terraces, Sediment Ponds[7]	Background Surface Water quality[9], 10 yr-24 hr storm event[8], PE certification, NPDES criteria (as approved),	Sections 11.5.4 and 12.6
5. Miscellaneous Areas (rail storage yards, irrigation pumping facilities, electrical substations, MET stations, temporary rail storage areas for replacement materials)	Berms, ditches, BTCA's and BMP's; (siltation fences, rock mulch, plant mulch, fiber logs, straw bales, rock check dams other technologies deemed suitable for the application)	Reference [10]	Section 11.5.4

1 30 CFR 701.5, 780.21(h), and 816.45.

2 Zero discharge means "no discharge" for any event up to the 10-yr., 24-hr. precipitation event; P.E. certified structures will be built only where a discharge resulting from an event greater than the 10-yr., 24-hr. event could leave the permit area.

3 Used only if the surface runoff is not retained in the Immediate Mining Area and there is a potential for the runoff to leave the permit area or enter a reclaimed area.

4,5 "Handbook of Alternative Sediment Control Methodologies for Mined Lands", Mining and Reclamation Council of America and Hess and Fisher Engineers, Inc., March 1985; contained in Permit NM-0003C, Chapter 27, Appendix 27-J, pages 5-17 and 79-81.

6 This criteria applies only to structures that control the surface runoff which may have the potential of leaving the permit area or entering a reclaimed area.

7 Used only if the surface runoff has the potential of leaving the permit area.

8 This criteria applies only to siltation structures at the NPDES discharge points. The "Reclamation Surface Stabilization Handbook" in the PAP outlines the design criteria for structures within the reclamation areas.

9 30 CFR 816.42 and 40 CFR Part 434 Subpart H Western Alkaline Coal Mining Subcategory.

10 30CFR 816.45 and 816.46.

Operation 1: Topdressing Stockpiles

The berms and/or ditches that encircle the topdressing stockpiles will divert the surface runoff along the stockpile to a point where it can either be retained and/or dewatered, see section 11.5.4.5 for additional detail. The berms are normally constructed by dozers or front end loaders, while the ditches are usually formed with motor graders. The berms and ditches are inspected on a routine basis and repaired as needed.

The typical berm and/or ditch shown on Figure 11-9 and typical dewatering system shown on Figure 11-9a will be used on stockpiles that have other surface drainage controls downstream, such as sediment pond, impoundments or the mining pit. It will not be used on the stockpiles near the permit boundary where there would be potential for a discharge to occur off the permit area. If, such is the case a site specific design certified by a professional engineer will be submitted for approval.

Operation 2: Immediate Mining And Active Grading Areas

Surface runoff from immediate mining and active grading areas (includes topdressing removal, overburden drilling, storage, stripping, spoil piles, pits and primary/final regrading of the last spoil row) is contained by berms (See Exhibit 11-104). Water is conveyed to the pit or a ramp, a depression in ungraded spoils, or a depression along a berm or sediment pond. Water may be evaporated, used for dust suppression, or it may be discharged if NPDES permit conditions are met. There will be no discharge from precipitation events up to and including the 10-yr., 24-hr event.

Diversion berms will be used in situations where runoff from the immediate mining areas or active grading areas must be prevented from leaving the permit area or entering a reclaimed (topsoiled) area. The berm in these situations function as diversion structure. The diversion berms are used on permanent, interim, and pre-law lands. There are three known situations where the berms are required.

1. In advance of mining where the general slope of the land will allow water to flow away from the advancing highwall and away from existing drainage control structures;
2. Following mining where the final grading is occurring and the general slope of the land allows water to flow toward reclaimed or off the permit areas; and
3. Areas at the end of the pits where drainage from topsoil stripped areas, spoils, or regraded areas has potential to leave the permit area or enter reclaimed lands.

Several factors are considered in the design criteria for diversion berms, the most important dimension of the immediate mining area diversion berm is it's height. There are two water drainage conditions which determine the height, and they are; (1) water flowing along a berm, thus the berm functions as a diversion, and (2) water is contained by the berm in areas of relatively small depression. The maximum height of the diversion berm will be four feet, except in areas where the berm crosses topographical lows in which case the berm may be seven feet. A diversion berm may impound water in low areas. The maximum depth of water impounded by a diversion berm will be six feet (three feet of running water and three feet of standing water). See EXHIBIT 11-104 for a typical design layout of a diversion berm.

The assumptions and design criteria used for diversion berms are as follows:

- A minimum of 1 foot of freeboard will be maintained at all times
- The 10 year, 24 hour design storm event (1.6 inches of rainfall) will be used

- Type II-65 storm type
- Maximum delta Z is 125' to calculate Tc
- Areas have a Curve Number of 89
- Maximum area of concern is 300 acres
- Minimum area of concern is 25 acres
- Areas are approximated as squares (conservative for calculating Tc)
- Areas have a flow length equal to the square root of the area times 1.5
- Berm serves as an erodible channel
- Mannings number (n) assumed at 0.03
- Berm side grade = 2:1
- Regraded slope of 1% - 15% adjacent
- Flowline grade 1% - 15%
- Berm Height can be calculated from the following reformatted Mannings equation:

$$b = ([Q \times n \times \{C_2^{2/3}\}] / [1.486 \times \{FS / 100\}^{1/2} \times \{C_1^{5/3}\}])^{3/8}$$

where;

$b =$	berm height
$Q =$	peak flow cfs form drainage area
$n =$	mannings number
$FS =$	flowline grade in percent
$C_1 =$	$1 + 50/IS$
$IS =$	internal embankment grade
$C_2 =$	$(5)^{1/2} + ([IS^2 + 100^2]^{1/2} / IS)$

From the above, the minimum calculated height for the berm is 1.29 feet and the maximum is 3.14 feet. From this equation it was also noted that some flows will exceed the erosive velocity of the soil however, since the channels are generally in spoil, they will self armor over time. Sediment will be retained within the disturbed areas not yet reclaimed and will not leave the permit area. For supporting data see Appendix 11-N of the mine permit.

Operation 3: Coal Handling and Ancillary Areas

Runoff from coal handling and ancillary areas (including coal stockpiles, the coal plant, maintenance shops and associated areas) is conveyed to sediment ponds. Additional information on sediment ponds can be found in Section 11.5.4.

Operation 4: Reclamation Areas

Runoff from reclamation areas (graded spoils with topdressing in place) is controlled by a series of measures that, in combination, limit contributions of sediment to stream flow outside the permit area to levels no greater than the levels found in background conditions.

The sequence in which reclamation area sediment controls are put into place is important to the functioning of the controls. The sequence is as follows:

a. Spoils are recontoured by grading with dozers (see CHAPTER 12, Section 12.3, for a complete description of the backfilling and grading operation),

b. The berms and ditches, which were placed around spoils before grading (see Operation 2, above), are removed.

c. Topdressing is placed on the spoils immediately following removal of the berms (see b., above),

d. Mulch is applied to the topdressed area and crimped.

e. The area is seeded. and the remaining steps of the revegetation plan are carried out to establish a diverse, effective vegetation cover.

As mining progresses, active mining areas (Operation 2, above) are reclaimed as described here. Lease-wide revegetated areas are shown on EXHIBITS 12-8 through 12-10. To prevent possible degradation, topdressing replacement operations will begin within five days following removal of the active mining area berms and ditches.

The sediment control methods described above in a. through e (i.e., re-contouring, and grass/straw mulch,) are designed and installed at Navajo Mine according to the specifications found in M.A.R.C. and Hess and Fisher Engineers, Inc. (1985). A copy of the report is found in Permit NM-0003C, Chapter 27, Appendix 27-J.

As part of the surface water control plan, a monitoring scheme as outlined in Section 11.4.7 and CHAPTER 7, Section 7.4 will be instituted. Also see Permit NM-0003C; Chapter 27, Appendices G and K for additional documentation on the surface water monitoring program.

Operation 5. Miscellaneous Areas

There are some facilities that are not included in the previous sections. These areas include, but are not limited to, railroad maintenance storage yards, irrigation pumping facilities, electrical substations, MET stations, and temporary rail storage yards for replacement materials. In these instances a variety of BTCA's or BMP's may be used individually or in combination to ensure compliance with applicable regulations. These controls include, but are not limited to, siltation fences, rock mulch, plant mulch, and fiber logs, straw bales, and rock check dams. New or enhanced technologies and practices will be used where deemed a more viable option.

11.3 ANNUAL COAL PRODUCTION

Navajo Mine has a contract with the Four Corners Power Plant to provide coal for the power plant through July 2016, with the likelihood of extension beyond that date. The following list gives the anticipated tonnage to be mined from the entire lease for each fiscal year of the permit term and five-year blocks beyond that time.

Fiscal Year	Estimated Production
2009	8,967,000
2010	8,629,000
2011	8,825,000
2012	8,571,000
2013	8,571,000
14-19	41,600,000
20-24	41,600,000
TOTAL	126,763,000

Each year's total tonnage may be subject to change depending on the Four Corners Plant's demand for power and availability of mining equipment. EXHIBITS 12-01 through 12-03 show the anticipated areas to be mined during the permit period.

11.4 MAJOR MINING EQUIPMENT

The following is a list of typical major mining equipment used in the permit area at Navajo Mine:

MINE EQUIPMENT LIST

ITEM	QUANTITY
Draglines	3
Overburden Drills	3

ITEM	QUANTITY
Coal Drills	1
Exploration Drill	0
Dozers	12
Rubber Tire Dozers	1
Large Front-end Loaders	7
Small Front-end Loaders	3
Graders	4
Scrapers	3
Coal Haulers	5
End Dumps	8
Mix Trucks	2
Water Trucks	3
Cable Reels	2
Shovels	0
Locomotives	5
Rail Road Cars	57
Stemming Truck	1

The pieces of equipment are subject to change during the permit period due to equipment outages and replacement schedules.

11.5 MINE FACILITIES

Mine facilities for the Navajo Mine are comprised of transportation facilities, topdressing stockpiles, water and air monitoring facilities, diversions, and water storage and/or treatment facilities such as ponds, impoundments, berms, or embankments.

Support facilities include various permanent structures (structures in place for greater than 6 months) which are greater than 100 ft^2 and not readily mobile (e.g. not on wheels or skids) or are attached to a permanent foundation. This may include structures within industrial complex areas, equipment storage areas, water pipelines, water loadouts, electric power lines, explosives/blasting agent storage areas, and coal sizing and storage facilities. EXHIBITS 11-9 through 11-11 show the locations of all mine facilities.

Various structures not meeting the size criteria outlined above, mobile structures, utility connections, and other such facilities of insignificant magnitude will be situated on lands classified as Approved Disturbance/Bond Areas (see EXHIBIT 11-1 through 11-6). These structures will be operated under the regulatory requirements, but will not require regulatory approval. Plans for all proposed Support Facilities as defined in OSM's December 2, 1992 letter, will be submitted to OSM for prior approval per 30 CFR § 780.38

Upon bond release, the support facilities will become the property of the Navajo Nation, as specified in Navajo Mine's lease agreement. The bond amount is based on the maximum reclamation requirements (Section 12.9) and includes removal of all facilities. The bond will be adjusted accordingly in the future if the Navajo Nation wants to retain any facilities. Following removal, the affected areas will be regraded, topdressed, and revegetated as discussed in CHAPTER 12, RECLAMATION PLAN.

11.5.1 Industrial Complex

The industrial complex is composed of two major portions:

1. The North Area support facilities, covering approximately 70 acres and located adjacent to the Four Corners Power Plant about four miles south of the northern end of the permit area and,

2. The Area III support facilities, covering approximately 30 acres and located about 11 miles south of the northern end of the permit area.

The Navajo Mine North Area (built starting in 1962) includes; a heavy equipment repair shop, a carpentry and plumbing shop, an auto repair shop, fuel and lube tanks, storage yards, a coal waste storage yard, a tire installation and repair shop, change rooms, a heavy equipment ready line, a wash bay, a sewage treatment facility, a coal plant, a weld shop, a irrigation system pump house, a reclamation seed building, a reclamation yard, a coal lab, a railroad yard, a warehouse with associated storage yard, a communication tower, offices for training, field maintenance, and security. South of the North Area Support facilities is a potable water tank that is used for these facilities.

Area III (built starting in 1982) includes an engineering and production office building, an equipment maintenance shop, a weld shop, an equipment loading dock, a vehicle fueling area, a propane tank, a warehouse-storage building, change rooms, a wash bay, a potable water tank, a heavy equipment ready line, an employee coal stockpile, a recycling facility, a sewage facility, a solvent containment building, a safety building and security offices. South of Area III is a second communication tower for the mine radio system transmitter/repeater.

The North Area and Area III Diesel Loadout areas are protected from spills by containment bunkers.

All of these facilities are currently in use and maintained in good condition. The Navajo Mine area support facilities and associated parking lots are designed to comply with Federal Regulation 30 CFR Part 816.181.

11.5.1.1 Reclamation Storage Yard

The reclamation storage yard is a 5.6-acre storage area located west of the Lowe loadout. The facility was created by blading the area level, applying a thin layer of regolith material, followed by the creation of 3 ft. berm (FIGURE 11-6B) around the yard. The facility is used for the storage of revegetation equipment (tractors and implements), irrigation pipe and supplies, fencing material, and other reclamation materials.

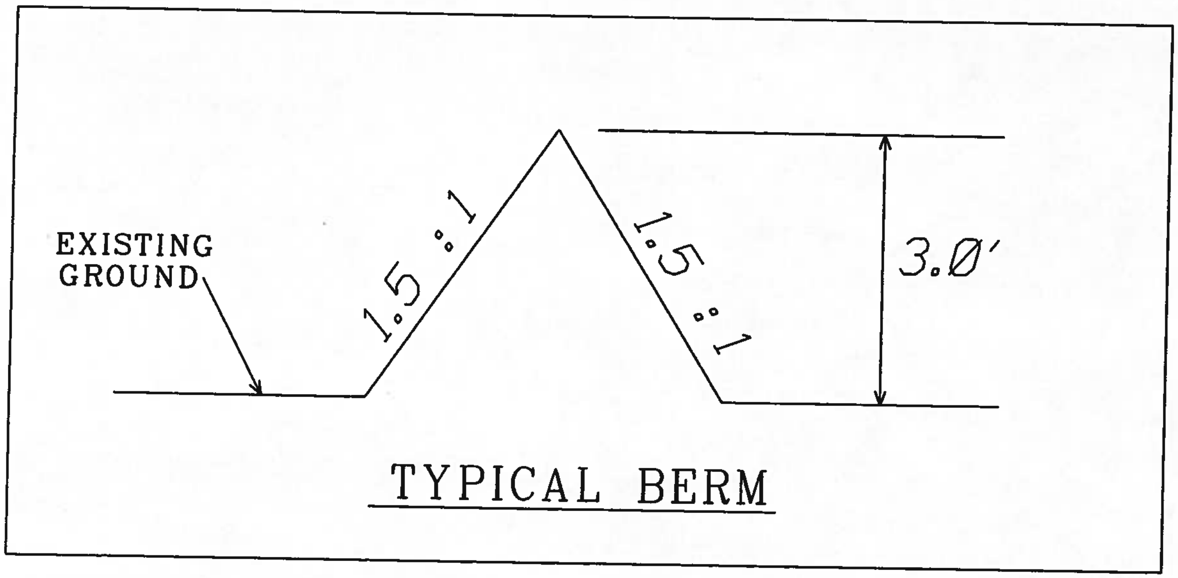
11.5.1.2 Water Pipelines

The irrigation pipeline (built starting in 1975) provides water from Morgan Lake for the irrigation of revegetation plots. The pipeline also supplies water to the storage ponds at the Barber and Lowe water loadout facilities. The location and details of the pipeline are displayed on EXHIBITS 11-9 through 11-11.

A potable water line is used to supply the facilities with fresh water. It is supplied from the Navajo Tribe Utilities Authority (NTUA) line that runs between Farmington and Shiprock, New Mexico. It supplies the North Area and Area III support facilities. The location and details of the potable water line are displayed on EXHIBITS 11-9 through 11-11. Construction of the potable water line began in 1962, and continued in 1982 to the Area III Industrial Complex.

11.5.1.3 Water Intakes

The location of three major water supply intakes for current users of surface water flowing into, out of, and within one mile of the Navajo Mine permit area are shown on EXHIBITS 11-9 through 11-11. The three sites are all in the Morgan Lake vicinity and include the Four Corners Power Plant's intake canal, Navajo Mine's irrigation uptake, and a water loadout facility which intakes near the irrigation uptake.



TYPICAL BERM

CERTIFICATION STATEMENT

I, Leonard Raymond, hereby certify that this drawing was reviewed by me and that the information shown is accurate and complete to the best of my knowledgE.

LEONARD RAYMOND NEW MEXICO 6600 REGISTERED PROFESSIONAL ENGINEER 11-7-00

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	ENG.	E.O.	P.E.	P.S.	CHIEF ENG.
C	11-07-00	PJF	RELOCATED RECLAMATION STORAGE YARD (West of Lowe Coal Sotckpile)	LR	HC	LR		
B	10-09-96	PJF	RECLAMATION STORAGE YARD (West of Navajo Pit) OSM APPROVAL ON SEPT 17, 1996.					
A	9-12-96	PJF	SUBMITTED TO OSM FOR APPROVAL.					

APPROVALS

Figure 11-6b

BHP NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

TYPICAL BERM RECLAMATION STORAGE YARD

PREPARED BY PJF	DRAWN BY PJF	SCALE N.T.S.
APPROVED BY	DATE 10-09-96	DWG. LOC. PJF\MStation
DWG. No.	REF. DWG. EXHIBIT 11-10 (Mine Structure)	

...\Ch_11_Figures\FIG11-6B.DGN Nov. 07, 2000 09:01:48

Other surface water use on or within one mile of the permit area consists of livestock watering ponds. These ponds have been constructed to capture and store the intermittent surface waters near the permit area and are shown on EXHIBIT 7-2.

A water monitoring network and various water control measures, as described in Section 11.5.7 of this chapter and in Section 7.4 of CHAPTER 7, will be implemented throughout the life of the mine to ensure that impacts to surface waters are minimized. Navajo Mine has water rights on the San Juan River which can be used to offset any adverse impacts to the State of New Mexico and present users. These rights will be maintained throughout the mining operation and a period thereafter, for retirement, if required to any affected San Juan Basin water users. Should it become necessary, Navajo Mine will develop water supplies of suitable quantity, quality and location, and provide an adequate distribution system to ensure that water supplies will be maintained at an equal or better condition.

11.5.1.4 Water Loadouts

There are three water loadouts, one at the North Complex, one near Barber Stockpile, and one near Lowe Stockpile. These loadouts supply water to water trucks used for haulroad dust suppression. A water loadout typically consists of

1. A storage pond, (except at the North Complex, see Section 11.5.1.3),

2. An overhead pipe for filling the trucks,

3. A concrete pad for parking while the truck is being filled, and

4. A pump to fill the trucks.

These facilities have been constructed to minimize erosion and siltation. Embankments and drainageways are regularly examined after each storm event. The location of the water loadouts is shown on EXHIBITS 11-9 through 11-11.

11.5.1.5 Electric Power Lines

Arizona Public Service Company supplies the mine with power at 69,000 volts. Approximately 31 miles of mainline and nine miles of stublines make up the existing power distribution network for Areas II, III, and IV North. The mainlines originate at the Four Corners Power Plant and branch to the east and west sides of the pits in Areas II, III, and IV North. Stublines service the pits about every 5,000' from the east side. On the west, the power line follows the railroad catenary. See EXHIBITS 11-9 through 11-11 for details. Power lines will be constructed to meet the recommended design criteria (Miller et al., 1975) to prevent the electrocution of raptors.

11.5.1.6 ANFO/Explosives Storage

There are three ammonium nitrate storage facilities at Navajo Mine:

1. Barber Stockpile,
2. Yazzie Pit area, and
3. Dixon.

A typical ANFO facility has nitrate silos, diesel fuel storage tanks, and silos for emulsion blasting product.

There are explosives magazines at the north-end of Lowe Pit which was built in accordance with the Bureau of Alcohol, Tobacco, and Firearms Division regulations 26 CFR Parts 181.198 and 181.200. This area is used for storing primers, blasting cord, delays, and wet hole blasting product. See EXHIBIT 11-7 for locations of these stores.

11.5.2 Coal Facilities

11.5.2.1 Coal Storage

The Navajo Mine has four coal stockpiles. Three are field stockpiles located at railroad spurs, ~~one is a field stockpile in Area IVN for operational capacity,~~ and the last is an emergency coal stockpile located near the north area coal plant. The approximate maximum capacities and date of construction of these stockpiles are:

Name	Capacity (tons)	Construction Date
Barber	1,500,000	1973
Hosteen	800,000	1974
Emergency	80,000	1988
Lowe	2,700,000	1982
~~Proposed A4N~~	~~2,000,000~~	~~2009 (estimated)~~
Total	5,080,000~~7,080,000~~	

Barber Hosteen and Lowe field stockpiles are divided down the center by the railroad spur to facilitate blending. This division allows coal of varying qualities to be stacked on either side of the rail.

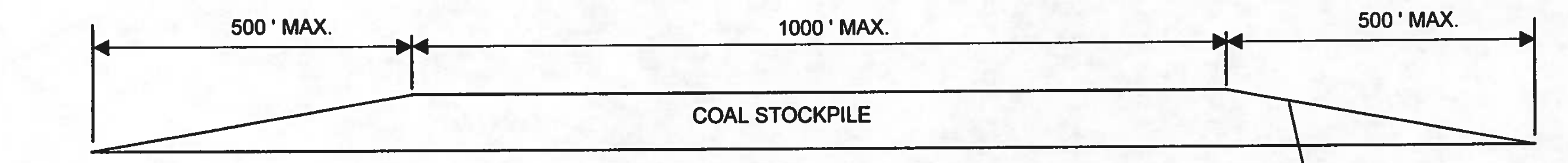
The stockpiles are built with bottom-dump haul trucks and rubber-tired dozers. The trucks drive up a pile on one end, dump their loads, then drive off the other end. Rubber-tired dozers then level the pile and compact the coal. Large front-end loaders load the coal from the piles onto trains for delivery to the coal plant. FIGURES 11-7 and 11-8 show typical cross sections and plan views of the coal stockpiles, while EXHIBITS 11-9 through 11-11 show their locations. Section 11.5.4 provides detailed descriptions of the surface runoff impoundments in the stockpile areas.

The employee coal dump is maintained near the Area III facilities to allow employees and chapter members to gather coal for their own use. The dump is cleaned out periodically, and the coal is transported to field stockpiles. Typically the employee coal dump is open from October through March.

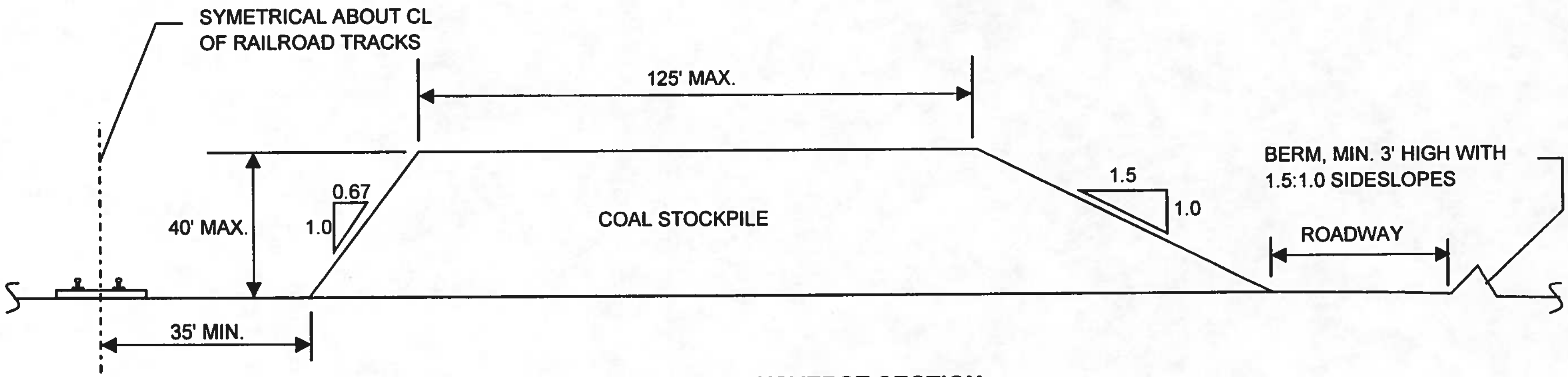
11.5.2.2 Coal Plant

The coal plant is owned and operated by the Navajo Mine and is located adjacent to the Four Corners Power Plant (EXHIBITS 11-9 through 11-11). It includes a coal delivery terminus, crushers, conveyors, and stacking and reclaiming equipment. The coal delivery terminus is a rail/truck-conveyor interface in which coal is dumped from bottom-dump rail cars or trucks into hoppers. From there the coal is fed into the crusher and conveyor system for stacking in blend piles. From the blend piles, the coal is reclaimed for delivery to the Four Corners Power Plant. The sales grade of the coal is based on contract obligations with the power plant. Delivery to the power plant is on a continuous, 24 hour basis.

Coal waste materials are also stored at various locations from time to time within the plant area. This is to allow for staging waste materials prior to being disposed of in pit. All of the area containing waste materials is within primary sediment control and permitted disturbance.



TYPICAL LONGITUDINAL SECTION
NTS



TYPICAL TRANSVERSE SECTION
NTS

NOTES:
1. THE BERM CONVEYS SURFACE RUNOFF EITHER DIRECTLY INTO A SEDIMENT POND OR TO A DITCH/CHANNEL LEADING TO A SEDIMENT POND.
2. SEE APPENDIX 11-Z FOR THE SUPPORTING DESIGN DATA FOR THE BERM
3. SEE FIGURE 11-8 FOR TYPICAL PLAN.

CERTIFICATION STATEMENT
I, LEONARD RAYMOND, HEREBY CERTIFY THAT THIS FIGURE WAS REVIEWED BY ME AND THE INFORMATION SHOWN IS ACCURATE AND COMPLETE TO THE BEST OF MY KNOWLEDGE.

LEONARD RAYMOND
NEW MEXICO
6680
REGISTERED PROFESSIONAL ENGINEER
1-15-98

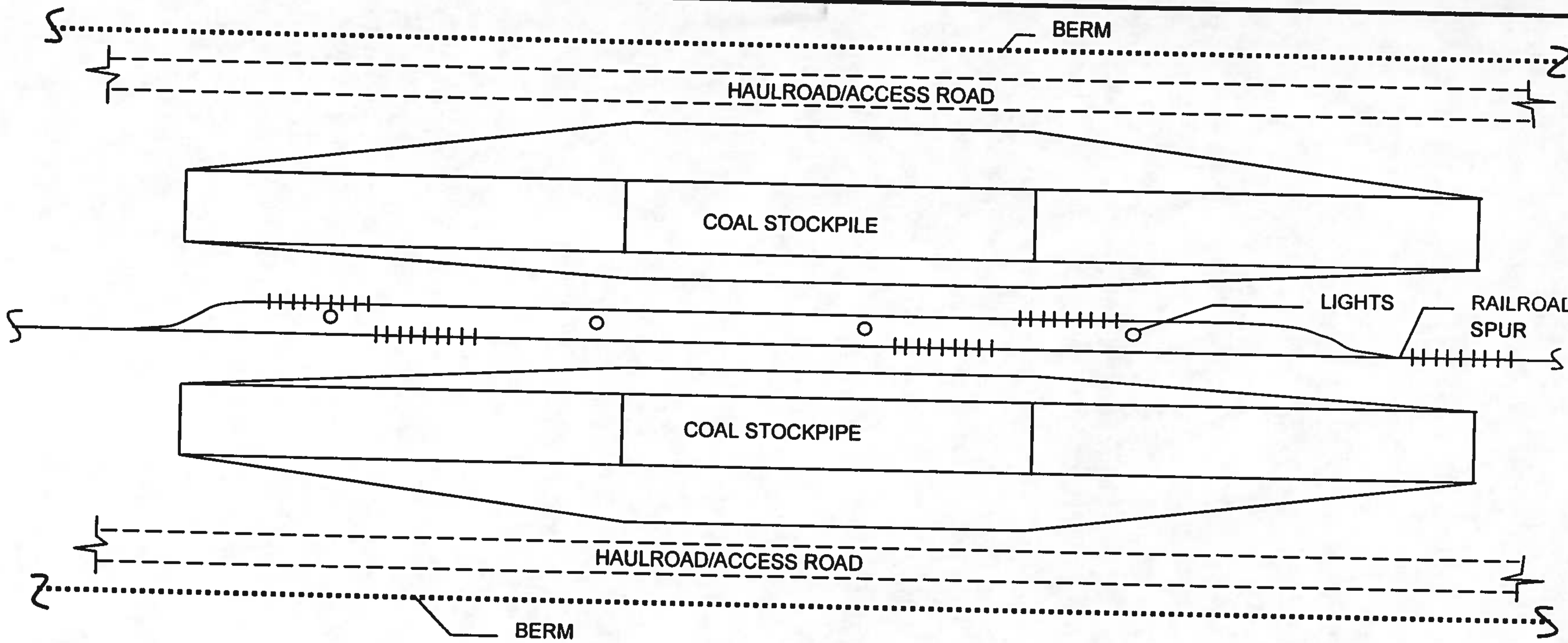
FIGURE 11- 7

REV. NO.	DATE	REVISIONS:	APPROVALS: ENGR.	E.Q.	P.E.	CHIEF ENGR
1	6/4/98	MIDTERM UPDATES & REVISIONS	LR		LR	

BHP NAVAJO COAL COMPANY
NAVAJO MINE
SAFETY PAYS
PO BOX 1717 FRUITLAND, NM 87416

COAL STOCKPILE AREA
TYPICAL SECTIONS

Drawn By: LR | Approved By: LR | Date: 6/3/98



TYPICAL PLAN
NTS

NOTES:
1. SEE FIGURE 11-7 FOR TYPICAL CROSS SECTIONS.

CERTIFICATION STATEMENT

I, LEONARD RAYMOND, HEREBY CERTIFY THAT THIS FIGURE WAS REVIEWED BY ME AND THE INFORMATION SHOWN IS ACCURATE AND COMPLETE TO THE BEST OF MY KNOWLEDGE.

LEONARD RAYMOND NEW MEXICO 6600 REGISTERED PROFESSIONAL ENGINEER 7-15-98

REV. NO	DATE	REVISIONS	APPROVALS ENGR	E.Q.	P.E.	CHIEF ENGR
1	6/4/98	MIDTERM UPDATES & REVISIONS	LR		LR	

FIGURE 11- 8

BHP NAVAJO COAL COMPANY
NAVAJO MINE SAFETY PAYS
PO BOX 1717 FRUITLAND, NM 87416

COAL STOCKPILE AREA TYPICAL PLAN

Drawn By: LR | Approved By: LR | Date: 6/3/98

These facilities are designed, constructed, maintained, and used in a manner which prevents additional contributions of suspended solids to runoff outside the permit area. The facility is not a coal cleaning operation, but a stacking and reclaiming facility; therefore, no water or Coal Plant wastes are discharged from the Coal Plant area. Total water usage is confined to dust suppressant sprays and housekeeping. Fugitive dust control measures are outlined in Section 11.2.8 of this chapter.

11.5.3 Topdressing , Regolith and Overburden Stockpiles

Topdressing Stockpiles

There are numerous topdressing stockpiles in use in the permit area, as shown on EXHIBITS 11-9 through 11-11. TABLE 11-3 gives the stockpile inventories and approximate volumes. Removed topsoil is stockpiled only when it is impractical to be promptly redistributed on graded areas.

Topdressing is not removed from stockpiles until required for redistribution on graded areas. However, stockpiles may be relocated to facilitate mining and/or reclamation. Changes or revisions to the permit necessitated by topdressing stockpile relocations will also be submitted to OSMRE.

Topdressing stockpiles are situated on stable sites in such a manner as to minimize wind and water erosion, and to avoid sources of contamination. Berms and/or surface water control structures are constructed around the stockpiles as described in Section 11.5.4.5. Topdressing stockpiles may be stockpiled with slopes at angle of repose. Topdressing stockpiles which remain undisturbed for greater than six months will be mulched on side slopes less than 4:1 (H:V). Topdressing stockpiles which will be undisturbed for greater than one year or longer will be seeded and mulched, on side slopes less than 4:1, during the next appropriate seeding period using procedures described in CHAPTER 12. After the stockpiles are reclaimed, the stockpile areas will be left with adequate topdressing so that they may also be reclaimed. All stockpiles are clearly marked so that other mining activities do not inadvertently disturb or contaminate them.

TABLE 11-3

TOPDRESSING STOCKPILE APPROXIMATE VOLUME

New Stockpile Name[1]	Old Stockpile Name	Approx. Volume (cyds)[3]
Airport_TS	Airport 1	9,919
DBR12_TS_E[2]	Doby 1	732,845
DBR13_TS_W	Doby R13	412,272
HSR1_TS_S	-	144,865
BBR3_TS_S		36,016
BBR5_TS_S	Barber 5	164,829
LWR1_TS_W[2]	Lowe 2	250,338
LWR2_TS_E	Lowe 4	17,162
LWR4_TS_N	-	716,713
LWR4_TS_E	Lowe/Dixon 1	118,668
LWR4_TS_S	-	0
DXR1_TS_N	-	0
DXR1_TS_S	-	372,164
DXR2_TS_W	-	413,515
DXR4_TS	-	899,820
~~TS-401~~	-	~~60,333~~
~~TS-402~~	-	~~71,444~~
~~TS-403~~	-	~~148,000~~
IBR_TS_N	-	136,200

Regolith Stockpiles Capacities

New Stockpile Name[1]	Old Stockpile Name	Approx. Volume (cyds)[3]
DXR1_RG_W	Dixon 3	475,100
LWR1_RG_N	Lowe 9	1,818,552
LWR4_RG_N	Lowe 10	468,633

[1]Topdressing stockpiles are shown on EXHIBITS 11-9, 11-10 & 11-11 (CHAPTER 11).
TS, Topdressing stockpiles. RG, Regolith stockpiles.
[2]Designates stockpiles that have snow fences installed.
[3] Volumes were calculated using aerial survey and/or loader count. Volumes do not include 10% rehandling loss so total volume will differ from 12-4 and 12-9.

TABLE 11-3A

MISCELLANEOUS MITIGATION AREA CAPACITIES

Miscellaneous Mitigation Areas[1,2]

Area Name	Capacities (cyds)
Yazzie Overlook	315,027
North Barber Spoil Cut Area	816,538

[1] Areas identified as suitable mitigation material, which is Not Regolith material
[2] Areas are shown on Detailed Soils Maps (CHAPTER 8).

Snow fences are currently used on several stockpiles for stabilization (TABLE 11-3). Where snow fences are not controlling erosion they will be removed and the stockpiles will be seeded and mulched. In the future, snow fencing will not be used on topdressing stockpiles.

Regolith Stockpiles:

Regolith stockpiles to be used as topsoil substitute or root zone material will be identified and managed the same as topdressing stockpiles.

Overburden Stockpiles

There are no overburden stockpiles in the permit area.

11.5.4 Ponds, Impoundments, Dewatering Structures, Berms and Embankments

Ponds, impoundments, berms or embankments are used within the permit area to: 1) capture and/or treat surface water runoff from unreclaimed spoil, coal handling, shop, office or maintenance facilities, or other disturbed areas where runoff could leave the permit area, 2) prevent surface water runoff from undisturbed upstream areas from entering into active mine pits, and 3) reduce the amount of topdressing loss from topdressing stockpiles due to wind and surface water erosion. Upon disturbance/removal of sediment ponds due to mining advancement, the pit will provide drainage and sediment control during mining operations. The remaining sediment ponds will provide drainage and sediment control during regrade and reclamation. Other appropriate water and sediment control structures may be constructed as needed.

All temporary drainage control structures such as sedimentation ponds, impoundments, berms and embankments will be reclaimed according to the procedures outlined in CHAPTER 12.

11.5.4.1 Sewer and Loadout Facility Ponds

TABLE 11-4A through 11-4F, lists the sewer and loadout facility ponds at Navajo Mine with a brief description of each pond. Navajo Nation Permit No. 96.289 allows for the use of lagoon water from the North Sewer Lagoon for operational use, subject to permit conditions.

11.5.4.2 Sediment Ponds

The pond tables (see Table 11-5 for index listing of the pond tables) identify each sediment pond and specify the criteria used for the design of each pond. The pond tables also provide references for locating the supporting design data, design drawing, and the as-built drawing for each pond. The pond tables and the referenced data for each respective pond provide the information required for demonstrating that the ponds comply with CFR 30 Parts 816.46, 816.47 and 816.49. The hazard classification for each pond is also specified on the pond tables. The locations of the ponds are shown on Exhibits 11-13B through 11-13E.

The sediment ponds are designed to retain either the 10 year-24 hour or the 100 year-6 hour precipitation event. Riprap material is placed at the pond inlets and spillways if the hydraulic analysis indicates that a protective lining is required to minimize and control erosion. The spillways are designed to safely pass the peak discharge from the 25 year-6 hour precipitation event.

To ensure that the design capacity is maintained, the maximum permissible gauge reading for the water/sediment level will be provided. The volume above the maximum permissible water/sediment level is equal to the design volume and the volume below it, the excess volume. If the water or sediment level should exceed the maximum permissible gauge reading then the impoundment will be either pumped or cleaned out down to an acceptable level. This will insure that the design volume is maintained at all times. The maximum permissible gauge reading for water/sediment level to maintain the design volume will be provided for each impoundment, except for the sewer ponds, storage ponds for dust suppressant water, highwall impoundments, and North Cells. The permissible water/sediment level in the North Cells will be referenced from the top of overflow between Cell B and C. The maximum gauge reading for the permissible water/sediment level are on the pond tables, see Table 11-5 for index listing of the pond tables.

The watershed sizes and curve numbers change due to areas being mined and reclaimed. This results in changes in the volume of surface runoff that need to be retained by the impoundments. The hydrology and the maximum permissible gauge reading will be updated annually to account for these changes.

After a runoff event, 90% of the design capacity will be restored within 10 days, provided the pond is accessible. Weather and ground conditions may limit access to some ponds particularly those in the reclaimed areas. Accessing these ponds during muddy conditions with dewatering equipment will cause excessive damage to the adjacent reclaimed lands. In such a case, the dewatering will occur as soon as conditions improve.

Inspection and maintenance will be done on a periodic basis to ensure the ponds are kept in good condition and functional. Inspections will be performed on a quarterly basis; the fourth quarter inspection will be an annual inspection that will be submitted to the regulatory agency. The quarterly inspections will be kept on file at the mine site. Any maintenance items identified from the inspections will be promptly repaired or corrected.

Approval for additional sediment ponds will be obtained from the regulatory agency prior to construction. The detail engineering drawings and the supporting design data will be submitted for review and approval. After completion of construction an as-built drawing of the pond will be submitted for review. A registered professional engineer will certify both the design and the as-built drawings.

TEXT CONTINUED ON PAGE 11-58

Notes:
- All references unless otherwise noted are from the current approved PAP.

Table 11-4A Area III Sewer Pond 1

Type of Pond	Sewage
Location	EXHIBIT 11-13D
Purpose	Collects and retains effluent from the Area III Complex.
Design Information	APPENDIX 11-AA & EXHIBIT 11-107
As-Built Information	EXHIBITS 11-26, 11-27 and 11-107
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	1.2
As-Built Capacity (ac-ft)	4.2
Curve Number (SCS)	89
Design Storm Event	100 yr, 6 hr
Peak Discharge (cfs)	2.67
Runoff Volume (ac-ft)	0.11
Max. Permissible Gauge Reading for Water/Sediment (ft)	N/A, Elev. 5446.9
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low Potential
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	N/A
Comments	Lined.

Table 11-4C Barber Loadout

Type of Pond	**Sediment**
Location	EXHIBIT 11-13C
Purpose	Water storage for dust suppression.
Design Information	APPENDIX 11-AA
As-Built Information	EXHIBIT 11-28
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	3.6
As-Built Capacity (ac-ft)	19.0
Curve Number (SCS)	89
Design Storm Event	100 yr, 6 hr
Peak Discharge (cfs)	8.01
Runoff Volume (ac-ft)	0.33
Max. Permissible Gauge Reading for Water/Sediment (ft)	N/A
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low Potential
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	N/A
Comments	Fed by Irrigation Pipeline, no surface water runoff stored.

Table 11-4D Lowe Loadout

Type of Pond	**Sediment**
Location	EXHIBIT 11-13E
Purpose	Water storage for dust suppression.
Design Information	APPENDIX 11-AA
As-Built Information	EXHIBITS 11-29 and 11-108
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	3.4
As-Built Capacity (ac-ft)	18.0
Curve Number (SCS)	89
Design Storm Event	100 yr, 6 hr
Peak Discharge (cfs)	7.57
Runoff Volume (ac-ft)	0.31
Max. Permissible Gauge Reading for Water/Sediment (ft)	N/A
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low Potential
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	N/A
Comments	Fed by Irrigation Pipeline, no surface water runoff stored.

Table 11-4E North Sewer Pond

Type of Pond	Sediment
Location	EXHIBIT 11-13B
Purpose	Collect and contain all effluent from sewage facilities in the north industrial area.
Design Information	APPENDIX 11-AA
As-Built Information	EXHIBITS 11-15 through 11-25 and 11-105
Intended Life Span	Will be removed in 2025
Watershed Area (ac)	2.2
As-Built Capacity (ac-ft)	8.1
Curve Number (SCS)	100
Design Storm Event	100 yr, 6 hr
Peak Discharge (cfs)	6.43
Runoff Volume (ac-ft)	0.38
Max. Permissible Gauge Reading for Water/Sediment (ft)	N/A, Elev. 5337.5
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low Potential
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	N/A
Comments	Lined with gauge post.

Table 11-4F Area III Sewer Pond-2

	Sediment
Location	EXHIBIT 11 – 13D.
Purpose	Collect and contain all effluent from sewage facilities in the Area III Complex site.
Design Information	Exhibit 11-107
As-Built Information	Exhibit 11-107
Intended Life Span	Will be removed 2025
Watershed Area (ac)	N/A
As-Built Capacity (ac-ft)	5.0
Curve Number (SCS)	N/A
Design Storm Event	N/A
Peak Discharge (cfs)	N/A
Runoff Volume (ac-ft)	N/A
Max. Permissible Gauge Reading for Water/Sediment (ft)	Elev. 5447.0
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	N/A
Spillway Type	Low Potential
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	N/A
Comments	Lined.

Table 11-5 Pond Cross Reference

Italic print represents pending information

Pond Name	Pond Information
Lowe Hole 3 Pond 2	Table 11-5A
OPEN	Table 11-5B
Lowe Impoundment 1	Table 11-5C
Barber Stockpile Pond 2	Table 11-5D
Barber Stockpile Pond 3	Table 11-5E
South Barber Pond	Table 11-5F
OPEN	Table 11-5G
Collyer Road Pond #4	Table 11-5H
OPEN	Table 11-5I
Emma's Pond	Table 11-5J
Hosteen Stockpile Pond 1	Table 11-5K
Hosteen Stockpile Pond 2	Table 11-5L
Hosteen Stockpile Pond 3	Table 11-5M
OPEN	Table 11-5N
Lowe Railroad Impoundment #1	Table 11-5Q
Lowe Railroad Impoundment #2	Table 11-5R
Lowe Stockpile Pond	Table 11-5S
North Pinto Pond	Table 11-5T
North Pond All Cells	Table 11-5U
North Pond 1 Cell A	Table 11-5V
North Pond 1 Cell A2	Table 11-5W
North Pond 1 Cell B	Table 11-5X
North Pond 1 Cell C	Table 11-5Y
Pond 5	Table 11-5Z
Northwest Dixon	Table 11-5AA
South Dixon Pond 1	Table 11-5AB
South Dixon Pond 2	Table 11-5AC
South Dixon Pond 3	Table 11-5AD
Southwest Dixon Pond	Table 11-5AE
Vinnel Pond	Table 11-5AF

Table 11-5 Pond Cross Reference

Cont'd

Pond Name	Pond Information
Block C Pond 1	Table 11-5AG
Block C Pond 2	Table 11-5AH
Block C Pond 3	Table 11-5AI
Lowe 3 Pond 3	Table 11-5AJ
Mason Pond	Table 11-5AK
Employee Coal Dump Pond	Table 11-5AL
Pond 401	Table 11-5AM
Area 4 North Pond 412	Table 11-5AN
South Dixon Pond 7	Table 11-5AO
Area 4 North Pond 3	Table 11-5AP
Area 4 North Pond 4	Table 11-5AQ
Pond 405	Table 11-5AR
Pond 411	Table 11-5AS
Pond 413	Table 11-5AT
Pond 402	Table 11-5AU
Pond 404	Table 11-5AW
Pond 408	Table 11-5AX
Pond 409	Table 11-5AY
Pond 410	Table 11-5AZ
Pond 301	Table 11-5BA
Pond 302	Table 11-5BB

General Notes:

- All references unless otherwise noted are from the current approved PAP.
- 25 yr – 6 hr Peak Discharge is the design flow for all spillway design.
- All ponds without spillways are designed to handle runoff volume with 1 ft. of freeboard except where noted.

Table 11-5A Lowe Hole 3 Pond 2

Type of Pond	**Impoundment**
Location	EXHIBIT11-13E-1
Purpose	Minimizes inflow into Lowe Pit, thus enhancing the safety of the mining operations. Not classified as a sediment pond.
Design Information	APPENDIX 11-AA, Exhibit 11-127A
As-Built Information	EXHIBITS 11-127D
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	628.7
As-Built Capacity (ac-ft)	9.82
Curve Number (SCS)	88
Design Storm Event	2 year-6 hour
Peak Discharge (cfs)	23.8
Runoff Volume (ac-ft)	7.7
Max. Permissible Gauge Reading for Water/Sediment (ft)	N/A
Depth at Upstream Toe (ft)	10
NRCS Hazard Classification	Low
Spillway Type	Emergency
25 yr - 6 hr Peak Discharge (cfs)	109.1 (spillway)
Foundation Soil Type	Spoils (shale and sandstone cobbles)
Comments	Pond minimizes the inflow of runoff into Lowe Pit during the more frequent low intensity storms. Overflow will be retained in the pit; off lease discharge is very unlikely.

Table 11-5B
Open

Table 11-5C Lowe Impoundment 1

Type of Pond	Impoundment
Location	EXHIBIT 11-13E-1
Purpose	Minimizes inflow into Lowe Pit, thus enhancing the safety of the mining operations. Not classified as a sediment pond.
Design Information	APPENDIX 11-AA and Exhibit 11-127
As-Built Information	Pending
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	1642 ac.
As-Built Capacity (ac-ft)	Pending As-built
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	25 year 6 hour for spillway
Peak Discharge (cfs)	241.9
Runoff Volume (ac-ft)	50.04
Max. Permissible Gauge Reading for Water/Sediment (ft)	N/A
Depth at Upstream Toe (ft)	7.5
NRCS Hazard Classification	Low Potential
Spillway Type	Emergency
25 yr - 6 hr Peak Discharge (cfs)	241.9
Foundation Soil Type	Clay
Comments	Spoil.

Table 11-5D Barber Stockpile Pond 2

Type of Pond	Sediment
Location	EXHIBIT11-13C &11-13D
Purpose	Contain surface runoff water runoff from the Barber Stockpile area.
Design Information	APPENDIX 11-AA
As-Built Information	EXHIBIT 11-43
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	106.6
As-Built Capacity (ac-ft)	8.02
Curve Number (SCS)	81.9
Design Storm Event	100 year – 6 hour
Peak Discharge (cfs)	82.12
Runoff Volume (ac-ft)	5.72
Max. Permissible Gauge Reading for Water/Sediment (ft)	5.1, Elev.5280.0
Depth at Upstream Toe (ft)	4
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	Incised ponds with mild slopes.

Table 11-5E Barber Stockpile Pond 3

Type of Pond	Detention
Location	EXHIBIT11-13C &11-13D
Purpose	Contain surface runoff water runoff from the Barber Stockpile area.
Design Information	APPENDIX 11-AA
As-Built Information	EXHIBIT 11-44.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	59.8
As-Built Capacity (ac-ft)	3.74
Curve Number (SCS)	76
Design Storm Event	10 year – 24 hour
Peak Discharge (cfs)	4.28
Runoff Volume (ac-ft)	1.13
Max. Permissible Gauge Reading for Water/Sediment (ft)	5.6, Elev. 5347.6
Depth at Upstream Toe (ft)	4
NRCS Hazard Classification	Low
Spillway Type	Trickle Tube & Emergency Spillway
25 yr - 6 hr Peak Discharge (cfs)	0.63 at spillway
Foundation Soil Type	Sandy Clay
Comments	Incised ponds with mild slopes.

Table 11-5F South Barber Pond

Type of Pond	Sediment
Location	EXHIBIT 11-13D
Purpose	Contain runoff from South Barber Ramp 5 reclaim area.
Design Information	Exhibit 11-50, APPENDIX 11-AA
As-Built Information	Exhibit 11-50A
Intended Life Span	2016
Watershed Area (ac)	157.4
As-Built Capacity (ac-ft)	6.17
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	70.0
Runoff Volume (ac-ft)	5.43
Max. Permissible Gauge Reading for Water/Sediment (ft)	2.2 (elev. 5384.2)
Depth at Upstream Toe (ft)	8.0
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Clay spoils
Comments	

Table 11-5H Collyer Road Pond #4

Type of Pond	Sediment
Location	EXHIBIT 11-13E
Purpose	Surface water and Sediment control for South Dixon Pit.
Design Information	Appendix 11- AA
As-Built Information	EXHIBIT 11-109
Intended Life Span	Will be removed in 2025
Watershed Area (ac)	142.1 – Worst case using AOC topo./ (45.8 Ac.– Current topo).
As-Built Capacity (ac-ft)	11.8
Curve Number (SCS)	86/(78 and 86)
Design Storm Event	100 year - 6 hour
Peak Discharge (cfs)	81.9/(40.1)
Runoff Volume (ac-ft)	10.0/(2.4)
Max. Permissible Gauge Reading for Water/Sediment (ft)	2.4, Elev. 5263.4/(7.0, Elev. 5268.0)
Depth at Upstream Toe (ft)	8.0
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay
Comments	Meets the applicable mass stability criteria of 30 CFR δ 816.49 based on evidence from NM-0003C Chapter 29.

Table 11-5J Emma's Pond

Type of Pond	Sediment
Location	EXHIBITS 11-13B
Purpose	Prevents undisturbed surface water runoff from entering the north industrial area.
Design Information	Appendix 11-D, EXH. 11-31 & 34
As-Built Information	EXHIBIT 11-33
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	91.5
As-Built Capacity (ac-ft)	9.66
Curve Number (SCS)	80
Design Storm Event	100 year-6 hour
Peak Discharge (cfs)	76.22
Runoff Volume (ac-ft)	3.34
Max. Permissible Gauge Reading for Water/Sediment (ft)	5.8, Elev. 5358.6
NRCS Hazard Classification	Low
Spillway Type	Emergency Spillway
25 yr - 6 hr Peak Discharge (cfs)	7.14 (discharge at spillway)
Foundation Soil Type	Sand with some clay.
Comments	Static factor of safety of 1.5 and seismic factor of safety of 1.2.

Table 11-5K Hosteen Stockpile Pond 1

Type of Pond	Sediment
Location	EXHIBITS 11-13C
Purpose	Contain surface water runoff from the Hosteen Stockpile area.
Design Information	APPENDIX 11-AA.
As-Built Information	EXHIBITS 11-39
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	155.54
As-Built Capacity (ac-ft)	10.71
Curve Number (SCS)	79.1
Design Storm Event	10 year – 24 hour
Peak Discharge (cfs)	22.17
Runoff Volume (ac-ft)	4.01
Max. Permissible Gauge Reading for Water/Sediment (ft)	11.3, Elev. 5269.2
Depth at Upstream Toe (ft)	15
NRCS Hazard Classification	Low
Spillway Type	Emergency Spillway
25 yr - 6 hr Peak Discharge (cfs)	16.06 at spillway
Foundation Soil Type	Sandstone and shale
Comments	

Table 11-5L Hosteen Stockpile Pond 2

Type of Pond	Sediment
Location	EXHIBITS 11-13C
Purpose	Contain surface water runoff from the Hosteen Stockpile area.
Design Information	APPENDIX 11-AA.
As-Built Information	EXHIBITS 11-40
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	122.8
As-Built Capacity (ac-ft)	12.98
Curve Number (SCS)	83
Design Storm Event	10 year – 24 hour
Peak Discharge (cfs)	26.55
Runoff Volume (ac-ft)	4.36
Max. Permissible Gauge Reading for Water/Sediment (ft)	7.7, Elev.5300.5
Depth at Upstream Toe (ft)	15
NRCS Hazard Classification	Low
Spillway Type	Trickle Tube & Emergency Spillway
25 yr - 6 hr Peak Discharge (cfs)	37.71
Foundation Soil Type	Spoils (sandstone and shale)
Comments	

Table 11-5M Hosteen Stockpile Pond 3

Type of Pond	Sediment
Location	EXHIBITS 11-13C
Purpose	Contain surface water runoff from the Hosteen Stockpile area.
Design Information	APPENDIX 11-AA.
As-Built Information	EXHIBIT 11-41.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	135.2
As-Built Capacity (ac-ft)	7.36
Curve Number (SCS)	80.9
Design Storm Event	100 year – 6 hour
Peak Discharge (cfs)	68.03
Runoff Volume (ac-ft)	6.76
Max. Permissible Gauge Reading for Water/Sediment (ft)	1.5, Elev. 5266.1
Depth at Upstream Toe (ft)	8
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Shale
Comments	

Table 11-5N OPEN

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Table 11-5Q Lowe Railroad Impoundment #1

Type of Pond	Sediment
Location	EXHIBIT 11-13E.
Purpose	To contain sediment and runoff on lease.
Design Information	Appendix 11-Q.
As-Built Information	EXHIBIT 11-67
Intended Life Span	This pond will be reclaimed in 2015.
Watershed Area (ac)	105.73
As-Built Capacity (ac-ft)	19.2
Curve Number (SCS)	87.4 (Weighted Average, see design information for actual subwatershed Curve Numbers)
Design Storm Event	100 year – 6 hour
Peak Discharge (cfs)	89.73
Runoff Volume (ac-ft)	6.84
Max. Permissible Gauge Reading for Water/Sediment (ft)	13.5 Elev. 5303.5
Depth at Upstream Toe (ft)	13
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	The western boundary of this pond is the railroad embankment. The railroad embankment has the potential to hold 99.26 ac-ft of water.

Table 11-5R Lowe Railroad Impoundment #2

Type of Pond	Sediment
Location	EXHIBIT 11-13E.
Purpose	To contain sediment and runoff on lease.
Design Information	Appendix 11-Q.
As-Built Information	EXHIBIT 11-67B
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	133.27
As-Built Capacity (ac-ft)	18.37
Curve Number (SCS)	81.7 (Weighted Average, see design information for actual subwatershed Curve Numbers)
Design Storm Event	10-yr., 24-hr.
Peak Discharge (cfs)	103.69
Runoff Volume (ac-ft)	6.65
Max. Permissible Gauge Reading for Water/Sediment (ft)	6.3 Elev. 5324.3
Depth at Upstream Toe (ft)	8
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay with Limestone
Comments	Large embankment with small drainage area and no culvert. Partially incised.

Table 11-5S Lowe Stockpile Pond

Type of Pond	Sediment
Location	EXHIBITS 11-13E.
Purpose	Contain runoff from the Lowe stockpile area.
Design Information	APPENDIX 11-AA.
As-Built Information	EXHIBIT 11-45.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	51.8
As-Built Capacity (ac-ft)	5.60
Curve Number (SCS)	89
Design Storm Event	10-yr., 24-hr.
Peak Discharge (cfs)	13.35
Runoff Volume (ac-ft)	2.99
Max. Permissible Gauge Reading for Water/Sediment (ft)	7.8, Elev. 5308.6
Depth at Upstream Toe (ft)	11
NRCS Hazard Classification	Low
Spillway Type	Emergency Spillway
25 yr - 6 hr Peak Discharge (cfs)	17.52
Foundation Soil Type	Badlands
Comments	Partially incised with maximum height of 6 ft. and slopes not excessively steep.

Table 11-5T North Pinto Pond

Type of Pond	Sediment
Location	EXHIBIT 11-13B.
Purpose	Sediment control for Pinto Pit and prevents runoff from entering the North Area support facility.
Design Information	APPENDIX 11-G
As-Built Information	EXHIBIT 11-35.
Intended Life Span	Will be removed in 2025
Watershed Area (ac)	76.9
As-Built Capacity (ac-ft)	5.36
Curve Number (SCS)	80
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	42.4
Runoff Volume (ac-ft)	3.60
Max. Permissible Gauge Reading for Water/Sediment (ft)	3.1, Elev. 5375.3
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay
Comments	

Table 11-5U North Pond Cell A, B & C (combined)

Type of Pond	Sediment
Location	EXHIBIT 11-13B.
Purpose	Retains surface runoff from the North Facility excluding the coal handling facilities.
Design Information	APP. 11-AA, & EXH. 11-24, 11-25 & 11-106.
As-Built Information	EXHIBIT 11-106.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	214.9
As-Built Capacity (ac-ft)	31.8
Curve Number (SCS)	See APPENDIX 11-AA
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	138.4
Runoff Volume (ac-ft)	11.39
Max. Permissible Gauge Reading for Water/Sediment (ft)	Cells A, B and C function together. The max. permissible water level is at elevation 5330.3 in all cells.
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay.
Comments	Consists of 3 cells: A, , B & C. A & B are lined.

Table 11-5V North Pond 1 Cell A

Type of Pond	Sediment
Location	EXHIBIT 11-13B.
Purpose	Retains surface runoff from the North Facility excluding the coal handling facilities.
Design Information	APP. 11-AA, EXH 11-24, 11-25 & 11-106.
As-Built Information	EXHIBIT 11-106.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	See Table 11-5U North Pond 1 Cells A, B & C
As-Built Capacity (ac-ft)	4.8
Curve Number (SCS)	See Appendix 11-AA.
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	See Table 11-5U North Pond 1 Cells A, B & C
Runoff Volume (ac-ft)	See Table 11-5U North Pond 1 Cells A, B & C
Max. Permissible Gauge Reading for Water/Sediment (ft)	Elev. 5330.3
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay.
Comments	Lined, incised pond.

Table 11-5W North Pond 1 Cell A2

Type of Pond	Sediment
Location	EXHIBIT 11-13B
Purpose	In conjunction with Pond 5 retains surface runoff from the coal handling facilities and the coal plant washdown water. Cell A2 tied to N. Loadout, Barber Loadout, and Lowe Loadout for dust suppression needs and de-watering. Water collected in Pond 5 is pumped to Cell A2.
Design Information	APPENDIX 11-L, Appendix 11-AA & EXH. 11-106.
As-Built Information	EXHIBITS 11-15 through 11-23 & 11-106.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	51.9
As-Built Capacity (ac-ft)	5.4
Curve Number (SCS)	See APPENDIX 11-AA.
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	16.3
Runoff Volume (ac-ft)	2.67
Max. Permissible Gauge Reading for Water/Sediment (ft)	Elev. 5328.8
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay.
Comments	Incised pond. Sump with pump/motor.

Table 11-5X North Pond 1 Cell B

Type of Pond	Sediment
Location	EXHIBIT 11-13B
Purpose	Retains surface runoff from the North Facility excluding the coal handling facilities.
Design Information	APP. 11-AA, EXH 11-24, 11-25 & 11-106.
As-Built Information	EXHIBIT 11-106.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	See Table 11-5U North Pond 1 Cells A, B & C
As-Built Capacity (ac-ft)	14.3
Curve Number (SCS)	See APPENDIX 11-AA
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	See Table 11-5U North Pond 1 All Cells A, B & C
Runoff Volume (ac-ft)	See Table 11-5U North Pond 1 All Cells A, B & C
Max. Permissible Gauge Reading for Water/Sediment (ft)	Elev. 5330.3
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay.
Comments	Incised Pond.

Table 11-5Y North Pond 1 Cell C

Type of Pond	Sediment
Location	EXHIBIT 11-13B
Purpose	Retains surface runoff from the North Facility excluding the coal handling facilities.
Design Information	APP. 11-AA, EXH 11-24, 11-25 & 11-106.
As-Built Information	EXHIBIT& 11-106.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	See Table 11-5U North Pond 1 Cells A, B & C
As-Built Capacity (ac-ft)	12.68
Curve Number (SCS)	See APPENDIX 11-AA
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	See Table 11-5U North Pond 1 Cells A, B & C
Runoff Volume (ac-ft)	See Table 11-5U North Pond 1 Cells A, B & C
Max. Permissible Gauge Reading for Water/Sediment (ft)	Elev. 5330.3
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay.
Comments	Incised Pond.

Table 11-5Z Pond 5

Type of Pond	Sediment
Location	EXHIBIT 11-13B.
Purpose	In conjunction with Pond 1 Cell A2 retains the surface runoff from the coal handling facilities and the coal plant washdown water. Water collected in Pond 5 is pumped to Cell A2.
Design Information	APPENDIX 11-AA & EXHIBIT 11-105A.
As-Built Information	EXHIBITS 11-15 through 11-23 & 11-105A
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	41.9
As-Built Capacity (ac-ft)	2.29
Curve Number (SCS)	See APPENDIX 11-AA
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	36.53
Runoff Volume (ac-ft)	1.92
Max. Permissible Gauge Reading for Water/Sediment (ft)	Elev. 5329.6
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay
Comments	Incised, lined pond. Pond contains 25 HP pump that discharges at 1400 gpm.

Note: The excess runoff is pumped into Cell A.

Table 11-5AA Northwest Dixon

Type of Pond	Sediment
Location	EXHIBITS 11-13E.
Purpose	Contain runoff from the outslope of the northwest portion of the Dixon boxcut spoils and adjacent off-lease area.
Design Information	Appendix 11-AA.
As-Built Information	EXHIBIT 11-47.
Intended Life Span	Will be removed in 2025.
Watershed Area (ac)	62.2
As-Built Capacity (ac-ft)	5.9
Curve Number (SCS)	83
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	47.84
Runoff Volume (ac-ft)	4.42
Max. Permissible Gauge Reading for Water/Sediment (ft)	4.3, Elev. 5348.4
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay
Comments	Incised Pond.

Table 11-5AB South Dixon Pond 1

Type of Pond	Sediment
Location	EXHIBIT 11-13E
Purpose	Sediment Control for South Dixon (Block D).
Design Information	APPENDIX 11-T, EX. 11-51A
As-Built Information	EXHIBIT 11-51C
Intended Life Span	Will be removed in 2009.
Watershed Area (ac)	296.46
As-Built Capacity (ac-ft)	11.89
Curve Number (SCS)	80
Design Storm Event	10-yr., 24-hr.
Peak Discharge (cfs)	73.11
Runoff Volume (ac-ft)	6.63
Max. Permissible Gauge Reading for Water/Sediment (ft)	3.5, Elev. 5240.5
Depth at Upstream Toe (ft)	5
NRCS Hazard Classification	Low
Spillway Type	Emergency Spillway
25 yr - 6 hr Peak Discharge (cfs)	61.11 (at peak stage)
Foundation Soil Type	Sandy clay
Comments	Partially incised.

Table 11-5AC South Dixon Pond 2

Type of Pond	Sediment
Location	EXHIBIT 11-13E
Purpose	Sediment Control for South Dixon (Block D).
Design Information	APPENDIX 11-T, EX. 11-117A (modification)
As-Built Information	EXHIBIT 11-117B
Intended Life Span	Will be removed in 2009.
Watershed Area (ac)	28.4
As-Built Capacity (ac-ft)	4.62
Curve Number (SCS)	80
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	23.15
Runoff Volume (ac-ft)	1.33
Max. Permissible Gauge Reading for Water/Sediment (ft)	7.1, Elev. 5248.6
Depth at Upstream Toe (ft)	7
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay.
Comments	Partially incised with medium embankments providing freeboard.

Table 11-5AD South Dixon Pond 3

Type of Pond	Sediment
Location	EXHIBIT 11-13E
Purpose	Sediment Control for South Dixon (Block D).
Design Information	APPENDIX 11-T, EX. 11-51B
As-Built Information	EXHIBIT 11-51D
Intended Life Span	Will be removed in 2009.
Watershed Area (ac)	28.18
As-Built Capacity (ac-ft)	4.6
Curve Number (SCS)	80
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	22.60
Runoff Volume (ac-ft)	1.05
Max. Permissible Gauge Reading for Water/Sediment (ft)	3.0, Elev. 5246.25
Depth at Upstream Toe (ft)	6
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay.
Comments	Partially incised with medium embankments providing freeboard.

Table 11-5AE Southwest Dixon Pond

Type of Pond	Sediment
Location	EXHIBIT 11-13E.
Purpose	Contain runoff from the outslope of the Southwest portion of the Dixon boxcut spoils and adjacent off-lease areas.
Design Information	APPENDIX 11-AA, pg. 105-114.
As-Built Information	EXHIBIT 11-48.
Intended Life Span	Will be removed in 2009.
Watershed Area (ac)	37.80
As-Built Capacity (ac-ft)	2.71
Curve Number (SCS)	80
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	33.33
Runoff Volume (ac-ft)	2.01
Max. Permissible Gauge Reading for Water/Sediment (ft)	4.8, Elev. 5371.1
Depth at Upstream Toe (ft)	6
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay
Comments	Partially incised with medium embankments providing freeboard.

Table 11-5AF Vinnel Pond

Type of Pond	Sediment
Location	EXHIBIT 11-13B
Purpose	Contain runoff from the disturbed Vinnel area.
Design Information	EX. 11-46. APPENDIX 11-AA.
As-Built Information	EXHIBIT 11-46a
Intended Life Span	Will be removed in 2006.
Watershed Area (ac)	276.5
As-Built Capacity (ac-ft)	9.76
Curve Number (SCS)	76
Design Storm Event	10-yr., 24-hr.
Peak Discharge (cfs)	11.06
Runoff Volume (ac-ft)	4.78
Max. Permissible Gauge Reading for Water/Sediment (ft)	6.2, Elev. 5364.1
Depth at Upstream Toe (ft)	6
NRCS Hazard Classification	Low
Spillway Type	Emergency Spillway
25 yr - 6 hr Peak Discharge (cfs)	19.60
Foundation Soil Type	Clayey sand
Comments	Partially incised with medium embankments providing freeboard.

Table 11-5AG Block C Pond 1

Type of Pond	Sediment
Location	EXHIBIT 11-13D.
Purpose	Retain surface runoff from the outslope of the Western portion of the Block C mining area and adjacent railroad.
Design Information	EXHIBIT 11-133, APPENDIX 11-AA.
As-Built Information	EXHIBIT 11-133A
Intended Life Span	Will be removed in 2015.
Watershed Area (ac)	49.48
As-Built Capacity (ac-ft)	5.1
Curve Number (SCS)	81
Design Storm Event	100 year-6 hour
Peak Discharge (cfs)	38.54
Runoff Volume (ac-ft)	2.49
Max. Permissible Gauge Reading for Water/Sediment (ft)	10.3, Elev. 5306.7
Depth at Upstream Toe (ft)	N/A – Incised
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Clayey Sand
Comments	Incised

Table 11-5AH Block C Pond 2

Type of Pond	Sediment
Location	EXHIBITS 13-D.
Purpose	Retain surface runoff from the outslope of the central portion of the Block C mining area and adjacent railroad.
Design Information	EXHIBIT 11-134, APPENDIX 11-AA
As-Built Information	EXHIBIT 11-134A.
Intended Life Span	Will be removed in 2015.
Watershed Area (ac)	66.64
As-Built Capacity (ac-ft)	6.0
Curve Number (SCS)	85
Design Storm Event	100 year-6 hour
Peak Discharge (cfs)	62.1
Runoff Volume (ac-ft)	4.42
Max. Permissible Gauge Reading for Water/Sediment (ft)	4.5, Elev. 5303.1
Depth at Upstream Toe (ft)	11
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Clayey Sand
Comments	Partially incised with medium roadway embankment providing capacity and 1 ft. freeboard.

Table 11-5AI Block C Pond 3

Type of Pond	Sediment
Location	EXHIBIT 11-13C, 11-13D
Purpose	Retain surface runoff from the Block C mining area, adjacent railroad and Barber Coal Stockpile area.
Design Information	EXHIBIT 11-135, APPENDIX 11-AA.
As-Built Information	EXHIBIT 11-135A & 135B
Intended Life Span	Will be removed in 2015.
Watershed Area (ac)	275.1
As-Built Capacity (ac-ft)	11.08
Curve Number (SCS)	82.8
Design Storm Event	10-yr., 24-hr.
Peak Discharge (cfs)	46.3
Runoff Volume (ac-ft)	9.9
Max. Permissible Gauge Reading for Water/Sediment (ft)	7.0, Elev. 5268.0
Depth at Upstream Toe (ft)	14
NRCS Hazard Classification	Low
Spillway Type	Drop Inlet Pipe
25 yr - 6 hr Peak Discharge (cfs)	27.21 (out of spillway)
Foundation Soil Type	Clayey Sand
Comments	Medium roadway embankment providing capacity and 1 ft. freeboard.

Table 11-5AJ Lowe Hole 3 Pond 3

Type of Pond	Impoundment
Location	EXHIBIT 11-13E
Purpose	Minimize surface runoff into the pit.
Design Information	EXHIBIT 11-127, 127A, 127B, APPENDIX 11-AA.
As-Built Information	EXHIBIT 11-127C
Intended Life Span	Will be removed in 2009.
Watershed Area (ac)	39.61
As-Built Capacity (ac-ft)	4.75
Curve Number (SCS)	79.67
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	32.45
Runoff Volume (ac-ft)	2.01
Max. Permissible Gauge Reading for Water/Sediment (ft)	N/A
Depth at Upstream Toe (ft)	0' Incised
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Spoils
Comments	Incised pond with mild slopes

Table 11-5AK Mason Pond

Type of Pond	Sediment
Location	EXHIBIT 11-13D
Purpose	Retain surface runoff from a portion of regrade between Barber Ramps 5 and 6, and the adjacent Barber haulroad.
Design Information	EXHIBIT 11-139, APPENDIX 11-AA.
As-Built Information	EXHIBIT 11-139A
Intended Life Span	Will be removed in 2015.
Watershed Area (ac)	133.2
As-Built Capacity (ac-ft)	10.09 design capacity, will be updated after construction.
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	96.4
Runoff Volume (ac-ft)	7.2
Max. Permissible Gauge Reading for Water/Sediment (ft)	4.4, Elev. 5383.9
Depth at Upstream Toe (ft)	9
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Clayey Sand
Comments	Partially incised with medium embankments providing freeboard.

Table 11-5AL Employee Coal Dump

Type of Pond	Sediment
Location	EXHIBIT 11-13D
Purpose	Retain surface runoff from the Employee Coal Dump area
Design Information	EXHIBIT 11-132B, APPENDIX 11-AA.
As-Built Information	Exhibit 11-132C.
Intended Life Span	2015
Watershed Area (ac)	6.2
As-Built Capacity (ac-ft)	2.58.
Curve Number (SCS)	89
Design Storm Event	100-yr., 6-hr.
Peak Discharge (cfs)	12.12
Runoff Volume (ac-ft)	0.53
Max. Permissible Gauge Reading for Water/Sediment (ft)	5.9, Elev. 5458.48.
Depth at Upstream Toe (ft)	N/A
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy clay
Comments	

Table 11-5AM Area 4 North Pond 401

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from box cut spoils
Design Information	APPENDIX 11-AA and Exhibit 11-01
As-Built Information	Exhibit 11-01 As-built
Intended Life Span	Until Completion of Final Reclamation
Watershed Area (ac)	20.8
As-Built Capacity (ac-ft)	3.9 plus 1-foot freeboard (as-built)
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	1.4
Max. Permissible Gauge Reading for Water/Sediment (ft)	7.4 (as-built)
Depth at Upstream Toe (ft)	9
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	

Table 11-5AN Area 4 North Pond 412

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from box cut spoils
Design Information	APPENDIX 11-AA and Exhibit 11-111
As-Built Information	Exhibit 11-111 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	30.6
As-Built Capacity (ac-ft)	3.2 plus 1-foot freeboard
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year – 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	3.0
Max. Permissible Gauge Reading for Water/Sediment (ft)	1.7 (as-built)
Depth at Upstream Toe (ft)	9.8
NRCS Hazard Classification	Low
Spillway Type	Not required
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	

Table 11-5AP Area 4 North Pond 3

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from box cut spoils
Design Information	APPENDIX 11-AA and Exhibit 11-115
As-Built Information	As-built will be provided after construction
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	8.6
As-Built Capacity (ac-ft)	1.2 plus 1-foot freeboard
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	0.8
Max. Permissible Gauge Reading for Water/Sediment (ft)	2.4
Depth at Upstream Toe (ft)	7
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	

Table 11-5AQ Area 4 North Pond 4

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from box cut spoils
Design Information	APPENDIX 11-AA and Exhibit 11-118
As-Built Information	Exhibit 11-118 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	46.3
As-Built Capacity (ac-ft)	5.6 plus 1-foot freeboard
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year – 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	4.5
Max. Permissible Gauge Reading for Water/Sediment (ft)	3.2
Depth at Upstream Toe (ft)	8.7
NRCS Hazard Classification	Low
Spillway Type	Not required
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	

Table 11-5AR Area 4 North Pond 405

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from box cut spoils
Design Information	APPENDIX 11-AA and Exhibit 11-05
As-Built Information	Exhibit 11-05 As-built
Intended Life Span	2016
Watershed Area (ac)	90.6
As-Built Capacity (ac-ft)	8.2
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year-6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	6.3
Max. Permissible Gauge Reading for Water/Sediment (ft)	4.9
Depth at Upstream Toe (ft)	8.9
NRCS Hazard Classification	Low
Spillway Type	Not required
25 yr - 6 hr Peak Discharge (cfs)	NA
Foundation Soil Type	Sandy Clay
Comments	

Table 11-5AS Area 4 North Pond 411

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from mining area
Design Information	APPENDIX 11-AA and Exhibit 11-161
As-Built Information	Exhibit 11-161 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	12.5
As-Built Capacity (ac-ft)	1.7 plus 1-foot freeboard
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year – 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	1.2
Max. Permissible Gauge Reading for Water/Sediment (ft)	3.2
Depth at Upstream Toe (ft)	8.3
NRCS Hazard Classification	Low
Spillway Type	Not required
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	

Table 11-5AT Area 4 North Pond 413

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from mining area
Design Information	APPENDIX 11-AA and Exhibit 11-6
As-Built Information	Exhibit 11-6 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	6.8
As-Built Capacity (ac-ft)	2.6 plus 1-foot freeboard
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	0.6
Max. Permissible Gauge Reading for Water/Sediment (ft)	7.7
Depth at Upstream Toe (ft)	10
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Loam
Comments	

Table 11-5AU Area 4 North Pond 402

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from box cut spoils
Design Information	APPENDIX 11-AA and Exhibit 11-02
As-Built Information	Exhibit 11-04 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	96.8
As-Built Capacity (ac-ft)	7.9
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	6.8
Max. Permissible Gauge Reading for Water/Sediment (ft)	6.0
Depth at Upstream Toe (ft)	15.4
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Loam
Comments	

Table 11-5AW Area 4 North Pond 404

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from box cut spoils
Design Information	APPENDIX 11-AA and Exhibit 11-04
As-Built Information	Exhibit 11-04 As-built
Intended Life Span	2016
Watershed Area (ac)	11.7
As-Built Capacity (ac-ft)	1.6
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	1.0
Max. Permissible Gauge Reading for Water/Sediment (ft)	3.9
Depth at Upstream Toe (ft)	6.1
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Loam
Comments	

Table 11-5AX Area 4 North Pond 408

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from topsoil stockpile TS-401
Design Information	APPENDIX 11-AA and Exhibit 11-158
As-Built Information	Exhibit 11-158 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	6.18
As-Built Capacity (ac-ft)	1.5
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	0.4
Max. Permissible Gauge Reading for Water/Sediment (ft)	4.5
Depth at Upstream Toe (ft)	5.2
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Loam
Comments	

Table 11-5AY Area 4 North Pond 409

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from topsoil stockpile TS-402
Design Information	APPENDIX 11-AA and Exhibit 11-159
As-Built Information	Exhibit 11-159 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	2.83
As-Built Capacity (ac-ft)	0.26
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	0.2
Max. Permissible Gauge Reading for Water/Sediment (ft)	1.6
Depth at Upstream Toe (ft)	3.5
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Loam
Comments	

Table 11-5AZ Area 4 North Pond 410

Type of Pond	Sediment
Location	EXHIBIT 11-13F
Purpose	Retains the runoff from topsoil stockpile TS-402
Design Information	APPENDIX 11-AA and Exhibit 11-159
As-Built Information	Exhibit 11-159 As-built
Intended Life Span	Until completion of final reclamation
Watershed Area (ac)	2.37
As-Built Capacity (ac-ft)	0.93
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	0.17
Max. Permissible Gauge Reading for Water/Sediment (ft)	2.7
Depth at Upstream Toe (ft)	3.0
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Loam
Comments	

Table 11-5BA Pond 301

Type of Pond	Sediment
Location	EXHIBIT 11-13E
Purpose	Retains the runoff from South Dixon pit area
Design Information	APPENDIX 11-AA and Exhibit 11-162
As-Built Information	Exhibit 11-162
Intended Life Span	2016
Watershed Area (ac)	32.9
As-Built Capacity (ac-ft)	7.5 plus 1-foot freeboard
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	2.4
Max. Permissible Gauge Reading for Water/Sediment (ft)	5.1, Elev. 5297.2
Depth at Upstream Toe (ft)	8.0
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	

Table 11-5BB Pond 302

Type of Pond	Sediment
Location	EXHIBIT 11-13E
Purpose	Retains the runoff from South Dixon pit area
Design Information	APPENDIX 11-AA and Exhibit 11-162
As-Built Information	As-built will be provided after construction
Intended Life Span	2016
Watershed Area (ac)	41.7
As-Built Capacity (ac-ft)	8.2 plus 1-foot freeboard (design capacity)
Curve Number (SCS)	Refer to Appendix 11-AA
Design Storm Event	100 year 6 hour
Peak Discharge (cfs)	Refer to Appendix 11-AA
Runoff Volume (ac-ft)	3.8
Max. Permissible Gauge Reading for Water/Sediment (ft)	4.1 (based on design, will be revised based on as-built)
Depth at Upstream Toe (ft)	8.0
NRCS Hazard Classification	Low
Spillway Type	N/A
25 yr - 6 hr Peak Discharge (cfs)	N/A
Foundation Soil Type	Sandy Clay
Comments	

Modification to Operations of Pond 5 and North Cells

The operations of Pond 5 and the North Cells were modified to reduce the frequent clean-out of Cell A (lined) and to increase the flow path in Cell A2. In order for Pond 5 to maintain sufficient capacity the stormwater and plant washdown water is being pumped to Cell A2. Cell A2 was divided into three additional cells to increase the flow path, which will allow coal fines to settle and to facilitate cleaning. The pump from Pond 5 has a maximum flow of 3.5 cfs so the outlet pipe from Cell A2 is sufficient to handle the flow into Cell A.

Cell A, Cell B and Cell C will collect the stormwater from the North Facility and equipment washdown water from the North Shop. Cell A has a liner; all the flows are diverted into this cell except for the runoff from the side slope into the other two cells. The overflow from Cell A to Cell B is equipped with a skimmer to retain any hydrocarbons within the lined cell. This will be the main hydrocarbon treatment for the North Facilities.

The water collected in Cells B and C will be periodically pumped to either the Lowe Loadout Pond or Barber Loadout Pond via the existing mainline to be used as dust suppressant water on the haulroads. If the water truck loadout ponds are full or for some reason cannot receive the water from Cell A2 then the water will be pumped to other sediment ponds having sufficient capacity. The permissible gauge reading or elevation will not be exceeded when pumping to other ponds.

This is a temporary solution for managing the effluent collected in Pond 5. The plant washdown system has been automated to comply with MSHA standards and the amount of effluent generated has increased significantly. For the long term solution an engineer study will be done to determine the best way to manage the plant washdown water.

The hydrology data and design exhibits have been revised to reflect the operational modification. The revised or updated hydrology data for Pond 5 and the North Cells are presented in Appendix AA. The embankment placed over the spillway between Cell A and Cell A2 is presented on Exhibit 11-106. The cells were surveyed after completion of recent clean-out. This survey data has been incorporated into the revised exhibit.

11.5.4.3. Ponds with a Single Closed Spillway

Five sediment ponds at Navajo Mine have been constructed, each with a single closed spillway. The ponds constructed as such are: Hosteen #3, Barber #2, and Block C Ponds 1, 2, and 3. All are located along the railroad embankment in Area 2. The ponds were designed to retain the runoff from the 10-year 24-hour storm event, and to discharge the 25-year 6-hour peak flow through the spillway. To facilitate the construction of several of the ponds the existing culverts beneath the railroad were converted to spillways.

The surface mine regulations at 30 CFR 816.49(a)(9) allow for the use of a single closed spillway only when it is combined with an emergency spillway. To demonstrate compliance with regulations, the ponds described above were re-evaluated as containment structures that rely primarily on storage capacity to control the runoff from the 100-year 6-hour storm event as specified in section 816.49(c)(2) of the regulations.

With the exception of the Block C Pond 3, each of the other ponds are capable of retaining the runoff from the 100-year 6-hour storm event without discharging at the spillway. The as-built pond capacities and the runoff volumes from the 100-year 6-hour storm are summarized on Table A below. The hydrologic analyses were revised by adjusting the curve numbers for the watersheds to account for reclaimed areas. This resulted in reductions of the runoff volumes. Refer to Appendix 11-AA for the hydrologic analyses. The watershed areas are shown on Exhibits 11-13C and 11-13D.

TABLE A

PONDS WITH SINGLE CLOSED SPILLWAY
AS-BUILT CAPACITY VS. STORM RUNOFF VOLUME

Pond	As-built Capacity (ac-ft)	100 yr-6 hr Runoff Volume (ac-ft)	Comments:
Block C Pond 1	5.10	2.49	Sufficient capacity to retain the 100 hr-6 hr runoff volume
Block C Pond 2	6.00	4.42	Sufficient capacity to retain the 100 hr-6 hr runoff volume
Block C Pond 3	11.08	16.41	Insufficient capacity to retain the 100 hr-6 hr runoff volume
Barber #2	8.02	5.72	Sufficient capacity to retain the 100 hr-6 hr runoff volume
Hosteen #3	7.36	6.76	Sufficient capacity to retain the 100 hr-6 hr runoff volume

Block C Pond 3 will not contain the runoff from the 100-year 6-hour storm without discharging at the spillway. The risk is that the closed channel spillway could become plugged during a storm event that is greater than the design storm (10-year 24-hour) and water would overtop and possibly breach the embankment. However, this risk would be very minimal or eliminated if the pond basin could retain the runoff volume from the 100- year 6-hour storm with the spillway plugged.

Analysis of this scenario shows that the peak stage for the 100-year 6-hour storm with no outflow at the spillway is at elevation 5273.8 (16.41 acre-feet). This is approximately 1.2 feet above the existing spillway elevation. The maximum capacity of the pond before it would top the embankment is 64.7 acre-feet at elevation 5279. In other words, even if the closed channel spillway were plugged, the pond basin has more than sufficient capacity to retain the runoff from the 100-year 6-hour storm event. In fact, the pond will only overflow if four consecutive 100-year 6-hour storms were to occur. This is very unlikely. The stage storage for the pond is presented on Table B below.

TABLE 11-7

HIGHWALL IMPOUNDMENTS AND IMPOUNDMENTS HAZARD CLASSIFICATION

IMPOUNDMENT ID.	LOCATION	CURRENT STATUS	WATERSHED AREA (ACRES)	CAPACITY (AC-FT)	DEPTH AT UPSTREAM TOE (FT)	HAZARD POTENTIAL	COMMENTS[1]:
Lowe Hole 3 Pond 2	Lowe	active	688.0	11.6	see comment	Low	impoundment (incised), see App.11-AA, Exh. 11-127A & 11-127D
Lowe Hole 3 Pond 3	Lowe	active	41.8	4.6	12.0	Low	impoundment, see Appendix 11-AA and Exhibit 11-127B.
Lowe-Dixon Diversion Pond	Lowe	active	1,604.6	19.5	11.8	Low	Impoundment
North Fork Pond	Dixon	active	198.7	19.5	12.3	Low	Impoundment
South Dixon Pond 7	Dixon	active	25.3	11.8	10.0	Low	Impoundment
Area 4-North Pond 406	A4N	active	238.1	14.2	9.0	Low	Impoundment, see Appendix 11-AA and Exhibit 11-156.
Area 4-North Pond 407	A4N	active	124.8	15.4	15.0	Low	Impoundment, see Appendix 11-AA and Exhibit 11-157.

(1) The standard design and as-built information for the highwall impoundments are in Appendix 11-II.

TABLE B

BLOCK B POND 3
STAGE STORAGE

Elevation (ft)	Area (ac)	Inc. Volume (ac-ft)	Cum. Volume (ac-ft)	Comments
5261.0	0.00	0.00	0.00	
5262.0	0.00	0.00	0.00	
5263.0	0.01	0.01	0.01	
5264.0	0.03	0.02	0.02	
5265.0	0.09	0.06	0.08	
5266.0	0.25	0.17	0.25	
5267.0	0.40	0.33	0.57	
5268.0	0.71	0.56	1.13	
5269.0	1.11	0.91	2.04	
5270.0	1.75	1.43	3.46	
5271.0	2.57	2.16	5.62	
5272.0	3.51	3.04	8.66	
5272.6	4.05	2.27	10.93	Spillway elevation
5273.0	4.40	1.69	12.62	
5273.8			16.41	Peak stage for 100 yr-6 hr runoff
5274.0	5.45	4.93	17.54	
5275.0	6.59	6.02	23.56	
5276.0	8.66	7.63	31.19	
5277.0	10.15	9.40	40.59	
5278.0	11.80	10.97	51.57	
5279.0	14.27	13.03	64.60	Pond basin crest elevation

These analyses support the conclusion to retain the single closed spillways in all five ponds. Four of the ponds (Hosteen #3, Barber #2, and Block C Ponds 1, and 2) will be maintained and operated to retain the 100-year 6-hour runoff volume. Block C Pond 3 will continue to be maintained and operated in compliance with the requirements for a 10-year 24-hour capacity sediment pond. If the spillway should become plugged during a storm event larger than the design storm, there is more than sufficient capacity to retain the runoff without overtopping and breaching the pond embankment.

11.5.4.4 Highwall Impoundments

TABLE 11-7 identifies the impoundments and classification, whereas, EXHIBIT 11-13B through 11-13E provides locations. Highwall impoundments are constructed according to a typical design shown on the Highwall Impoundments Standard Design drawing (Appendix 11-II). Detailed design information also can be found in Appendix 11-II, Highwall Impoundment Design and As-Built Information. The standard design package for highwall impoundments serves as a pre-approved design for these structures, therefore structures constructed according to the typical design standard do not require approval prior to construction. As-built information for highwall structures are shown on the Highwall Impoundment As-Builts drawing in Appendix 11-II. Under normal circumstances, as-built information for highwall structures is submitted to OSM within sixty days following construction.

A brief description of each highwall impoundment at the Navajo Mine is included in TABLE 11-7. The locations are shown on EXHIBITS 11-13B through 11-13E. The impoundments are designed and built to prevent water from entering active mining pits. In no case will discharge from any of the impoundments leave the permit area as the pits would intercept the flows.

11.5.4.5 Berms

Berms are inspected regularly to ensure their stability and ability to perform as designed. When degradation of the berms is observed they will be reestablished using a blade or other appropriate equipment.

Topdressing Stockpile Berms

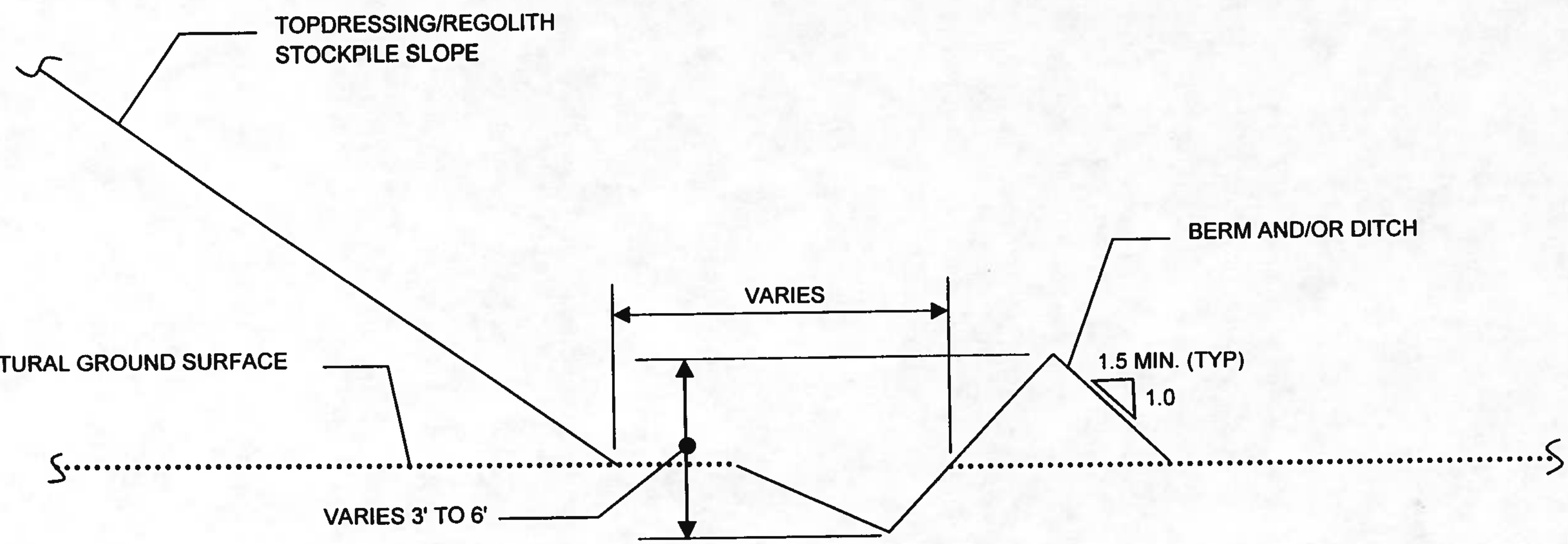
EXHIBITS 11-9 through 11-11 provide the location of all current topdressing stockpiles as discussed in Section 11.5.3. In an effort to reduce topdressing loss resulting from wind and water erosion, berms and/or ditches are constructed around the perimeters of each topdressing stockpile or ponds are built. In addition, stockpiles that have a slope at angle of repose, a berm will be placed on the top to eliminate runoff erosion along the slopes.

FIGURE 11-9 provides a typical design and cross section of the berm surrounding the topdressing stockpiles. See Section 11.2.10, Surface Water Control Measures, for application of the typical design.

During periods when the topdressing stockpiles are active, breaches in the berms will be created to allow for equipment access. These berms will be reconstructed after the topdressing stockpiles become inactive.

Immediate Mining Area and Active Grading Area Berms

See Section 11.2.10, Surface Water Control Measures, Operation 2: "Immediate Mining Area and Active Grading Areas", for text discussion.



TYPICAL SECTION
NTS

NOTES:

1. THE TYPICAL BERM AND/OR DITCH SHOWN WILL BE USED AROUND ONLY THE TOPDRESSING/REGOLITH STOCKPILES HAVING OTHER SURFACE RUNOFF CONTROLS DOWNSTREAM, SUCH AS SEDIMENT PONDS, IMPOUNDMENTS OR THE PIT. IT WILL NOT BE USED IF THE STOCKPILE IS LOCATED NEAR THE PERMIT BOUNDARY AND THERE IS A POTENTIAL FOR A DISCHARGE OFF THE PERMIT AREA OCCURRING. FOR THE LATTER CASE A SITE SPECIFIC DESIGN WILL BE SUBMITTED FOR APPROVAL.

CERTIFICATION STATEMENT
I, LEONARD RAYMOND, HEREBY CERTIFY THAT THIS FIGURE WAS REVIEWED BY ME AND THE INFORMATION SHOWN IS ACCURATE AND COMPLETE TO THE BEST OF MY KNOWLEDGE.

LEONARD RAYMOND NEW MEXICO 6600 REGISTERED PROFESSIONAL ENGINEER 7-15-98

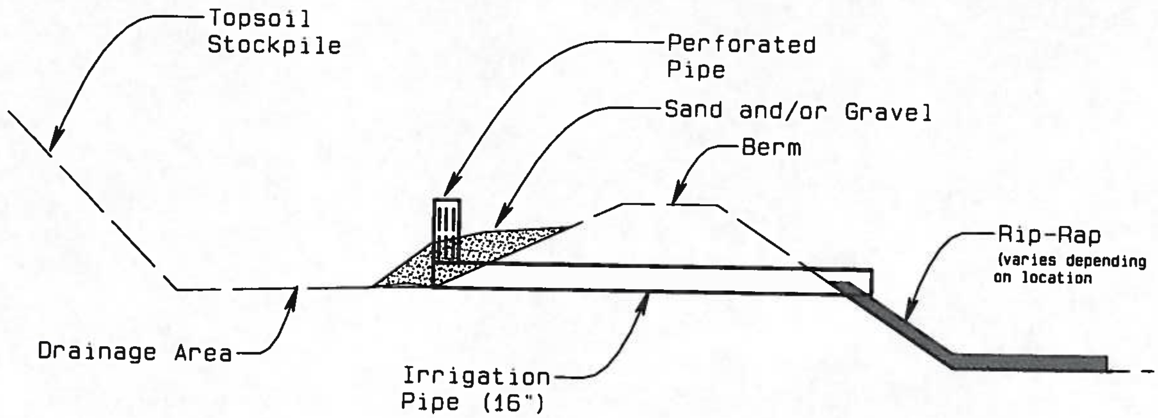
FIGURE 11- 9

REV. NO.	DATE	REVISIONS:	APPROVALS ENGR.	E.Q.	P.E.	CHIEF ENGR
1	6/4/98	MIDTERM UPDATES & REVISIONS	LR		LR	

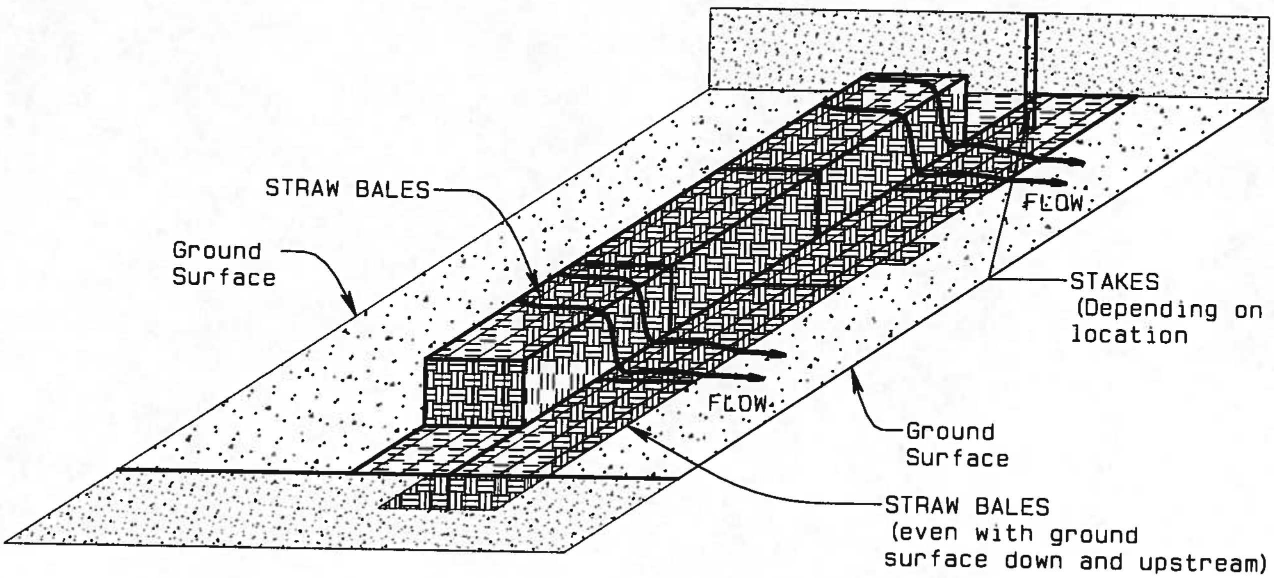
BHP NAVAJO COAL COMPANY
NAVAJO MINE
SAFETY PAYS
PO BOX 1717 FRUITLAND, NM 87416

TOPDRESSING/REGOLITH STOCKPILE BERM - TYPICAL SECTION

Drawn By: LR | Approved By: LR | Date: 6/3/98



TYPICAL DRAINAGE AREA
PERFORATED PIPE STRUCUTURE



TYPICAL DRAINAGE AREA
STRAW BALE STRUCTURE

FIGURE 11-9A

NAVAJO COAL COMPANY

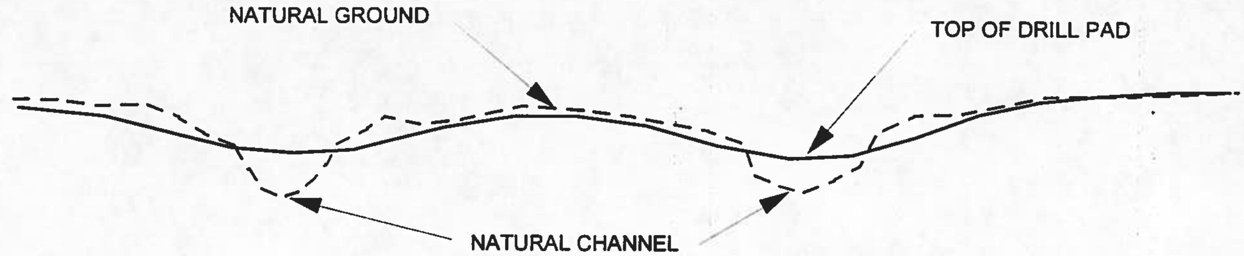
bhpbilliton

P.O. BOX 1717 FRUITLAND, NEW MEXICO 87416/PHONE 505-598-3209/FAX 505-598-3361

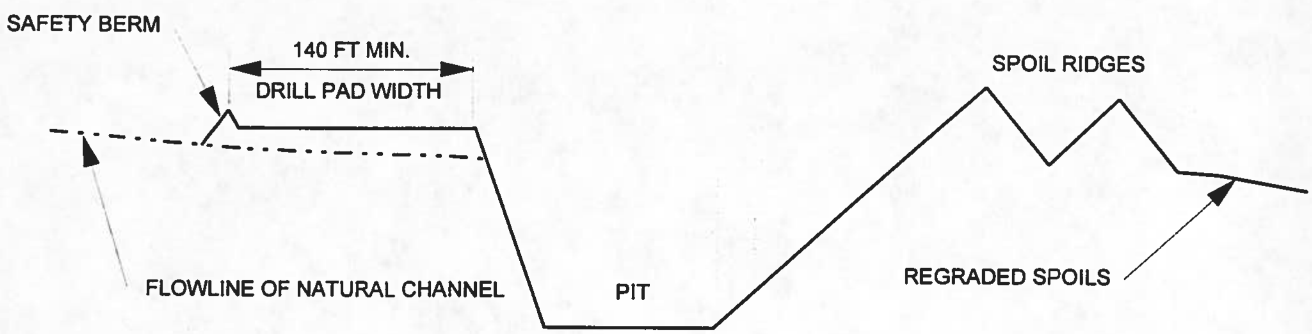
NAVAJO MINE
TYPICAL DEWATERING
STRUCTURE

PREPARED BY Shawn Smith	DRAWN BY PJF	SCALE N.T.S.
APPROVED BY	DATE 8-15-08	

PATH: \\ENCH...-SRV02\Data\Departments\Eng_EO\Engineering New Structure\ENGTECH\OTHER'S\SSMITH\Typical ...erm Drainage.pro



TYPICAL DRILL PAD SECTION
LONGITUDINAL DIRECTION
NTS



TYPICAL DRILL PAD SECTION
PERPENDICULAR TO HIGHWALL AND AT CHANNEL
NTS

FIGURE 11-11.1		
BHP NAVAJO COAL COMPANY NAVAJO MINE SAFETY PAYS P.O. BOX FRUITLAND, NM 87416		
DRILL PAD **TYPICAL SECTIONS**		
PREPARED BY: LR	DRAWN BY: LR	SCALE: NTS
APPROVED BY:	DATE: 3-28-97	DWG.LOC.
DWG. NO.	REF. DWG.	

Coal Stockpile Berms

Berms are installed adjacent to the coal stockpiles to help divert the surface runoff into a sediment pond or other drainage control structures. The berms convey surface runoff either directly into a sediment pond or into a ditch or channel that leads to a sediment pond. They are examined after storm events, and kept in good condition to ensure that they function properly and as intended. A typical section of the berm is shown on Figure 11-7 and the design for the worst case scenario is in Appendix 11-Z.

Dewatering Structures

Dewatering structures may be incorporated into berms to protect from breaching. The typical cross sections for dewatering systems are shown on Figure 11-9a and are designed for the worst case scenerio. Structures will be examined after storm events, and kept in good condition to ensure that they function properly and as intended.

The assumptions and design criteria used for diversion berms are as follows:

- A minimum of 1 foot of freeboard will be maintained at all times
- The 10 year, 6 hour design storm event (1.3 inches of rainfall) will be used
- Type II-70 storm type
- Worse case Tc = 0.126
- Areas have a Curve Number of 84
- Maximum area of concern is 75 acres

Based on these assumptions a 16 inch steel pipe or an eight foot strawbale segment is sufficient for this type of storm. These dewatering systems will not be placed in an area of greater than 75 acres.

11.5.4.6 Embankments

Embankments are constructed in areas where the transportation facilities (haulroads, roads, railroad, etc) traverse across topographic lows. The embankments have culverts to prevent surface runoff from impounding on the upstream side, except for the section of railroad embankment just north of the Lowe Coal Stockpile. This section of railroad embankment impounds the surface runoff from two watersheds, which have been designated as Lowe Impoundment #1 and #2. The detail designs, plans and sections of these impoundments are shown on Exhibits 11-67 and 11-67A. Where as, the location of the embankments and the culverts are shown on Exhibits 11-79 thru 11-84.

When segments of the transportation facilities are no longer needed they will be regraded and reclaimed in accordance with Chapter 12 of the mine permit.

11.5.4.7 Hazard Classification

All impoundment's have been classified using the Soil Conservation Service (SCS) criteria for Class B and C dams (TR-60), and MSHA's criteria for impoundment's (30 CFR 77.216 (a) (1)). Tables 11-4A through 11-4E, Tables 11-5A through 11-5AI, and Table 11-7 identify the impoundment's and classification, whereas Exhibits 11-13B, 11-13C, 11-13D and 11-13E provide the locations.

All impoundment's have been determined to be low hazard potential. In the event of a failure there is no potential hazard to homes, utilities, roads, or other structures downstream. Lowe Railroad Embankment #1 meets the MSHA impoundment criteria (embankment height higher than 20 feet and capacity greater than 20 acre-feet).

11.5.4.8 Miscellaneous Hydrologic Structures

Design proposals submitted to OSM will contain the appropriate engineering design analysis. Design analysis data (e.g. SEDCAD) for miscellaneous hydrologic structures is contained in APPENDIX 11-Z.

11.5.4.9 Land Use/Condition, Hydrologic Groups and Curve Numbers

The NRCS has classified soil types into four hydrologic group ratings; A, B, C or D. To establish uniformity in the curve numbers used for reclaimed, ndisturbed and cultivated (NAPI fields) lands. The curve numbers that will be used for the soils in the respective hydrologic groups and land types, are shown on Table 11-16. The land use/conditions and curve numbers were taken from SCS Engineering Division Technical Release 55, June 1986, "Urban Hydrology for Small Watersheds", Table 2-2d, page 2-8.

Reclaimed Areas

From the referenced table the type of land use/conditions for the reclaimed lands at Navajo Mine is between "Herbaceous" and "Desert Shrub", each with poor hydrologic condition. The curve numbers for the reclaimed lands were determined by interpolating between the curve numbers associated with the two land use/conditions. These curve numbers are conservative for the reclaimed lands. For the land use/condition "Herbaceous" and "Desert Shrub" the reference table does not take into account the mechanical treatments applied to the reclaimed lands such as, contouring, terracing, mulching, and small depressions. These land treatments are incorporated into the final reclamation to reduce the potential surface runoff and soil loss, but were not accounted for in establishing the curve numbers.

For the land use/conditions listed under "Arid and Semiarid Rangelands" the reference table does not five curve numbers for hydrologic soil group A, except for "Desert Shrub". A curve number of 63 is given for "Desert Shrub", hydrologic soil group A with poor hydrologic condition. A slightly higher curve number of 65 will be used for hydrologic soil group A in reclaimed lands

The runoff curve number for the reclaimed lands in each mine area (Area I, II, III, and IV) was estimated from the type and quantity of topdressing material to be salvaged from each area. Refer to Table 11-15 for the topdresssing soil types and quantities for each mine area. The hydrologic group classification or rating for each soil mapping unit was obtained from the NRCS soil surveys. The curve numbers associated with each hydrologic group rating was obtained from Table 11-16. The weighted curve number values were calculated using the volume of material from each mapping unit and it's contribution to the total volume of topdressing available in each mine area. The weighted values for each mine area were summed to arrive at a mean curve number. Refer to Table 11-16A through 11-16D for the weighted runoff curve numbers for each mine area.

Undisturbed and Cultivated Areas

The land use/condition for undisturbed areas will be identical to the reclaimed lands (same curve numbers). The curve numbers for undisturbed areas will be determined on a case by case basis. The soil types and hydrologic group classification for all the soil types will be obtained from NRCS soil surveys. The curve number associated with the hydrologic group classification will be taken from Table 11-16. In large watersheds with several sub-watersheds, a mean curve number will be calculated for each sub-watershed.

The type of land use and condition selected for the NAPI cultivated fields from the referenced table is "Row crops, Straight row" with good hydrologic conditions. This is conservative since the crop residue cover was not taken into account.

Spoil Material

Spoil material at Navajo Mine typically exhibits hydrologic properties found in hydrologic grouping D. Therefore, a curve number of 89 will be used to model surface discharge for all watersheds composed of disturbed spoil material.

11.5.5 Diversions

All planned permanent diversions will be designed in accordance with Navajo Mine's Reclamation Surface Stabilization Handbook (BHP-Navajo Mine, 1992) (OSM approval date July 22, 1992). Designs and as-builts for diversion structures will be completed and submitted for OSM approval.

Should an existing diversion require additional maintenance (erosion control, improved vegetation establishment, etc.) the channel will be manipulated with either appropriate machinery or by the use of cattle impaction, which ever is deemed most effective by the operator. Machinery may be used to control erosion, and/or prepare for reclamation activities. Where appropriate and feasible, cattle will be used to impact inslopes. Cattle impaction will reduce erosion, incorporate mulch and seed into the soil and increase water infiltration by creating increased surface roughness.

11.5.5.2 Lowe/Dixon Diversion Channel Extension

The Lowe/Dixon Diversion Channel Extension will be removed during the 2nd Quarter of 2009 as Dixon Pit dragline stripping operations advance east. The location and alignment of the diversion extension are shown on EXHIBIT 11-74.

The length of the diversion extension is approximately 5102 feet. Dixon Pit operations will remove the Southern portion of the Lowe-Dixon Diversion and nearly all the Lowe-Dixon Diversion Extension, from Sta.. 0+00 to Sta.. 45+00. The alignment, profile and typical sections are presented on EXHIBIT 11-74B and 11-74C. These two Exhibits will be removed from the permit after the diversion structure has been eliminated.

The diversion is designed to meet the criteria for a temporary diversion as outlined in CFR Part 816.43. A temporary diversion must safely pass the peak discharge from the 10 year–6 hour precipitation event. The hydrology for the Lowe/Dixon Diversion Channel Extension was model in SEDCAD to simulate the 2, 5 and 10 year–6 hour storm events. The watershed subdivisions used in the model is presented in EXHIBIT 11-74A. The results from the SEDCAD runs are presented in Appendix 11-RR. This information will also be removed from the permit after the diversion structure has been eliminated.

The channel design utility in SEDCAD was used to proportion the diversion channel. The diversion channel is designed to 1) remain stable during the peak flow from the 2 and 5 year-6 hour storm and 2) safely pass the peak flow from the 10 year-6 hour storm event with a minimum freeboard of one foot. The reach from Station 0+00 to 10+42 is at a steep grade, which will require a protective lining (riprap). The remaining downstream reach is in cut at a shallow grade and is primarily in the badlands. The soil composition of the badlands is predominately shale and clays. The limiting velocity used in the design for stability is the erosive velocity of the soil, which is estimated to be 5.0 fps. The Manning's roughness coefficient for the unlined reach was estimated to be 0.031 and the reach that would be lined with riprap was estimated to be 0.040. The SEDCAD output for the channel design is presented in Appendix 11-RR. The peak flows, flow depths and velocities are summarized in the tables following. This information will also be removed from the permit after the diversion structure has been eliminated.

MAXIMUM PEAK FLOWS (cfs)

Channel Reach	2 year-6 hour	5 year-6 hour	10 year-6 hour
Station 0+00 to 10+42	117	244	342
Station 10+42 to 51+02	129	265	371

FLOW DEPTHS AND VELOCITIES AT PEAK FLOWS

	2 year-6 hour		5 year-6 hour		10 year-6 hour	
Channel Reach (% grade)	Flow Depth (ft)	Average Velocity (fps)	Flow Depth (ft)	Average Velocity (fps)	Flow Depth (ft)	Average Velocity (fps)
Station 0+00 to 0+81 (4.87%)	0.79	6.52	1.22	8.43	1.48	9.45
Station 0+81 to 10+42 (2.86%)	0.93	5.48	1.42	7.06	1.72	7.89
Station 10+42 to 51+02 (0.471%)	1.43	3.71	2.14	4.68	2.57	5.19

The flow velocities in the reach (Station 0+00 to 10+42) with the steeper grades exceed 5 fps, but this reach will be riprapped with rock to stabilize the channel. The riprap design is presented in Appendix 11-RR. In the unlined reach (Station 10+42 to 51+02) the flow velocities during the peak flows from the 2 and 5 year-6 hour storm events are less than 5 fps, which indicates that the channel will remain stable with minimal amount of erosion. Some erosion is expected occur during flows that are greater than the 5 year-6 hour peak flow but will not be significant since the grade is very shallow. This information will also be removed from the permit after the diversion structure has been eliminated.

The maximum flow depth during the peak flow from the 10 year-6 hour storm event is approximately 2.6 feet. The minimum design depth is 6 feet, thus the channel will safely pass the peak flow from the 10 year-6 hour storm event with a minimum freeboard of 2.4 feet. This information will also be removed from the permit after the diversion structure has been eliminated.

The existing side drainages entering the diversion channel will be riprapped to control erosion. The riprap material is sized for the 10 year-6 hour peak flow. The locations and details of the riprapped downdrains are presented on EXHIBIT 11-74B and 11-74C. The hydrology and design data for the downdrains are in Appendix 11-RR in the PAP.

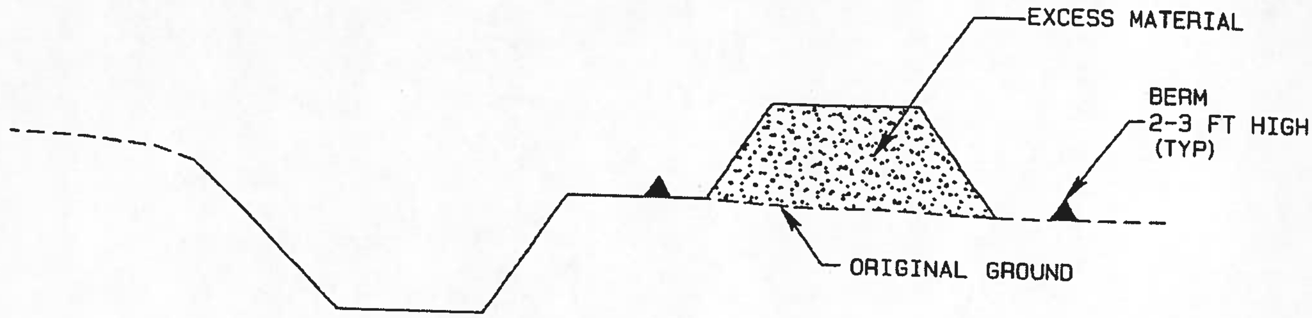
The design criteria for the riprapped downdrains was revised, the flows to the downdrains are from ephemeral streams such flows are classified as miscellaneous flows. Temporary diversions for miscellaneous flows are designed to safely pass the peak flow from the 2 year-6 hour storm event (CFR 816.43(c)(3)). The revised design data for the riprapped downdrains are presented in Appendix 11-RR (as-built data) of the PAP.

The Burnham Road will be re-routed twice to facilitate the mining of Dixon Pit Extension. The first re-route will occur during or prior to the construction of Lowe/Dixon Diversion Channel Extension. This re-route will be a short segment that will be aligned along the east side of the diversion channel extension as shown on EXHIBIT 11-74. The second re-route will occur just prior to mining out the Lowe/Dixon Diversion Channel and the extension. This re-route will align the road around the northern and eastern boundary of the pit extension area. The alignment and the design of the re-routes will be coordinated with the BIA Roads Department. For the location and alignment of the re-routes refer to Exhibits 11-143. For more detailed information refer to Section 11.5.6.1.7 "Relocation or Use of Public Roads".

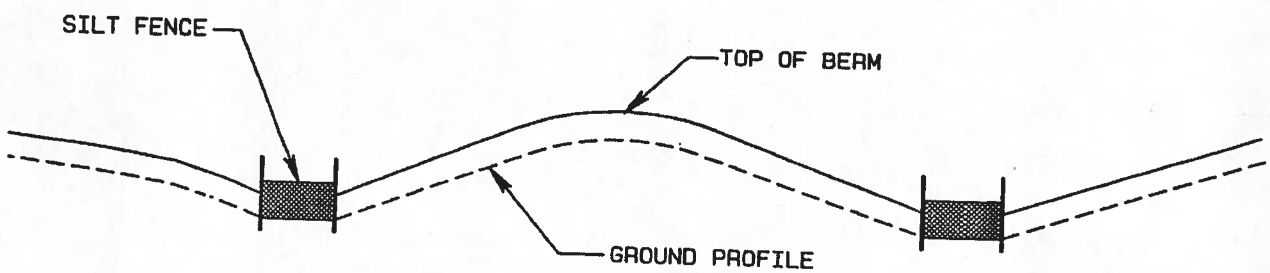
When the diversion is no longer needed it will be re-graded and reclaimed in accordance with the guidelines and procedures outlined in Chapter 12, Sections 12.3, 12.5 and 12.6.

Drainage/Sediment Control for Excess Material Dump

The excess excavation or waste will be dumped along the west side of the diversion channel adjacent to the crest of the cut. To control drainage and sediment from the dump a berm will be constructed adjacent to the toe of slope that will direct the drainage to the low points. At the natural low points or existing drainages there will be a break in the berm with a silt fence release the drainage and retain the sediment. In some cases where the natural topography is favorable a berm may not be required to direct the drainage to the low point where the silt fence will be placed. Refer to the typical section and profile on Figure 11-3 for location of berm and silt fences.



TYPICAL SECTION
NTS



TYPICAL PROFILE
NTS

REV. NO.	DATE	DRAFT. BY	REVISION DESCRIPTION	PLN	E.O.	P.E.	RPLS
1	3-01-02	PJF	SUBMITTED TO OSM FOR REVIEW AND APPROVAL		HC	LR	

APPROVALS

FIGURE 11-3

BHP BILLITON NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

LOWE/DIXON DIVERSION CHANNEL EXTENSION DRAINAGE CONTROL FOR EXCESS MATERIAL DUMP

PREPARED BY LR	DRAWN BY PJF	SCALE 1" = NTS
APPROVED BY LR	DATE Mar. 7, 2002	

PATH C:\DRAFTING-2001\DATA-02401\PAP EXHIBIT UPDATES\N_FORK_L-DIXON DIV-CHAN.pro

11.5.5.3 Removed, because structure was removed.
Rev-0822
Lowe Dixon Diversion
11/25/08

11.5.5.4 North Fork Diversion Channel

The primary function of the North Fork Diversion Channel will be to prevent or minimize the inflow of surface water into the Dixon Pit Extension, enhancing the efficiency and safety of the mining operations. The upstream end of the diversion starts near the northern permit boundary where the North Fork enters the permit area. The diversion routes the North Fork drainage towards the south into a natural drainage, which is a tributary of the Middle Fork of the Cottonwood Arroyo. The location and alignment of the diversion are shown on EXHIBIT 11-142.

The total length of the diversion is approximately 6,340 feet. The portion to be constructed is approximately 3,980 feet in length and the portion in the natural drainage is approximately 2,360

The total length of the diversion is approximately 6,340 feet. The portion to be constructed is approximately 3,980 feet in length and the portion in the natural drainage is approximately 2,360 feet in length. The constructed portion will have a grade of 0.263% and the portion in the natural drainage has an average grade of 0.988%. The alignment, profile and typical sections for the portion that will be constructed are presented on Exhibit 11-142B and 11-142C. The constructed portion of the diversion passes through a ridge between Station 26+50 and 31+30. The side slopes through this reach were steepened to minimize excavation and surface disturbance.

The diversion is design to meet the criteria for a temporary diversion as outlined in CFR Part 816.43. A temporary diversion must safely pass the peak discharge from the 10 year–6 hour precipitation event. The hydrology for the North Fork of the Cottonwood was model in SEDCAD to simulate the 2, 5 and 10 year–6 hour storm events. The watershed subdivisions used in the model is presented in Exhibit 11-142A. The results from the SEDCAD runs are presented in Appendix 11-QQ. The peak discharge from the 2, 5 and 10 year-6 hour precipitation events are 244, 472 and 647 cfs, respectively.

The channel design utility in SEDCAD was used to proportion the diversion channel. The diversion channel is designed to 1) remain stable during the peak flow from the 2 and 5 year-6 hour storm events and 2) safely pass the peak flow from the 10 year-6 hour storm event with a minimum freeboard of one foot. The entire length of the diversion is located in the badlands. The oil composition in the badlands is predominately shale and clays. The limiting velocity used in the design for stability is the erosive velocity of the soil, which is estimated to be 5.0 fps. The

Manning's roughness coefficient was estimated to be 0.031 in the portion to be constructed. The SEDCAD output for the channel design is presented in Appendix 11-QQ. The flow depths and velocities from the SEDCAD channel design utility are summarized in the table below.

FLOW DEPTHS AND VELOCITIES FOR THE PORTION TO BE CONSTRUCTED

Channel Reach	2 year-6 hour		5 year-6 hour		10 year-6 hour	
	Flow Depth (ft)	Average Velocity (fps)	Flow Depth (ft)	Average Velocity (fps)	Flow Depth (ft)	Average Velocity (fps)
Station 0+00 to 26+37	2.17	3.58	3.13	4.39	3.71	4.83
Station 26+37 to 26+88	2.21	3.69	3.21	4.56	3.83	5.02
Station 26+88 to 27+85	2.24	3.77	3.28	4.68	3.93	5.17
Station 27+85 to 29+30	2.26	3.81	3.32	4.74	3.98	5.25
Station 29+30 to 31+30	2.19	3.65	3.18	4.50	3.79	4.96
Station 31+30 to 39+80	2.17	3.58	3.13	4.39	3.71	4.83

The flow velocities during the peak flows from the 2 and 5 year-6 hour storm events are all less than 5 fps, which indicates that the channel will remain stable with minimal amount of erosion. Some erosion can be expected occur from flows that are greater than the peak flow from the 5 year-6 hour storm. The maximum flow depth during the peak flow from 10 year-6 hour storm event is approximately 4 feet. The minimum design depth is 6 feet thus the channel will safely pass the peak flow form the 10 year-6 hour storm event with a minimum freeboard of 2 feet.

The portion of the diversion in the natural drainage was hydraulically evaluated using Manning's Equation. The flow depths and velocities were determined for the peak flows from the 2, 5 and 10 year-6 hour storm events at five cross sections. The Manning's roughness coefficient (n-value) for the natural drainage was estimated to be: 0.042 for the over bank flow, 0.035 for the channel banks, and 0.030 for the channel bottom. The n-value for the over bank flow is estimated to range from 0.032 to 0.047. In isolated short reaches the n-value is as low as 0.032 and as high as 0.047 but is predominately between 0.040 and 0.045. For this evaluation an n-value of 0.042 was used for the over bank flow. A composite n-value was calculated for each flow depth at each section. The cross section and stage flow data are presented in Appendix 11-QQ. The flow depths and velocities are summarized in the following table.

FLOW DEPTHS AND VELOCITIES FOR THE PORTION IN THE EXISTING DRAINAGE

	2 year-6 hour		5 year-6 hour		10 year-6 hour	
Location	Flow Depth (ft)	Average Velocity (fps)	Flow Depth (ft)	Average Velocity (fps)	Flow Depth (ft)	Average Velocity (fps))
Station 6+02.75 (Section A-A')	1.74	3.42	2.22	4.37	2.52	4.98
Station 10+61.75 (Section B-B')	2.02	3.27	2.52	4.09	2.83	4.51
Station 13+85 (Section C-C')	2.08	3.76	2.59	4.82	2.89	5.41
Station 17+80 (Section D-D')	3.50	4.10	4.20	4.05	4.50	4.56
Station 21+88.34 (Section E-E')	4.51	6.14	5.89	6.60	7.08	4.49

The flow velocities during the peak flow from the 2 and 5 year-6 hour storm events are all less than 5 fps at each section except at Station 21+88. Station 21+88 is approximately 170 feet upstream from the point where the drainage enters the Middle Fork of the Cottonwood Arroyo. The channel in the vicinity of Station 21+88 is deeply incised. The channel bed has eroded downward to match the elevation of the channel bed in the Middle Fork. The higher flow velocities in this reach are due to the incised channel confining the flow. The average velocity during the peak flow from the 10 year-6 hour storm for this reach is 4.49 fps, but the velocity in the incised portion of the channel is probably in the range of 6 to 7 fps. Some erosion is expected to occur through this reach particularly in the lateral direction thus widening the channel. The extent of widening will depend on the magnitude of the flows that occur while the diversion is in service.

The typical configuration of the natural drainage is a swale with an incised channel. The dimension of the incised channel varies as follows:

Location	Depth (ft)	Width (ft)
Station 0+00 to 14+00	0.5 to 1.0	1.0 to 2.0
Station 14+00 to 17+60	1.0 to 2.5	1.5 to 3.0
Station 17+60 to 23+60	2.5 to 7.0	2.5 to 5.0

With the increased flows through the natural drainage some erosion is expected to occur. Additional down cutting of the channel bed is expected to occur particularly during storms that are greater than the 10 year-6 hour events. The major channels in the surrounding area have stabilized at grades between 0.7 and 0.9%. The reach of the diversion that is in the natural channel has an average grade of 1.0%. From field observations there is indications of bedrock outcropping at Station 0+50 and about midway at Station 10+10. These may develop into natural grade control structures. The rock outcrop at the upstream end does not appear to be as competent as the one downstream. In the worst-case scenario, maximum head cutting will occur if the channel stabilizes to a 0.7% grade. If this occurs the head cutting at Station 0+50 and 10+10 is expected to be approximately 3.0 and 4.0 feet, respectively. Assuming the outcropping rock is competent to withstand the flow velocities.

To minimize surface disturbance the channel in the natural drainage will be allowed to stabilize through natural processes. However if head cutting should exceed 5 feet in any reach, then corrective measures will be taken to prevent further head cutting upstream. The depth of head cutting will be measured from the current flow line. Riprapped drop structures will be considered as a mitigation measure. If the channel were not allowed to develop and stabilize through natural processes the alternative would be to construct a channel at a uniform grade on the current alignment. This will require m10/99; 6/01ore surface disturbance and excavation.

Riprapped downdrains will be installed to control erosion in locations where existing side drainages enter the diversion channel. The riprap rock is sized for the 10 year-6 hour peak flow. For the locations and details of the riprapped downdrains see Exhibit 11-142B and 11-142C. The hydrology and design data for the downdrains are presented in Appendix 11-QQ in the PAP.

The design criteria for the riprapped downdrains was revised, the flows to the downdrains are from ephemeral streams such flows are classified as miscellaneous flows. Temporary diversions for miscellaneous flows are designed to safely pass the peak flow from the 2 year-6 hour storm event (CFR 816.43(c)(3)). The revised design data for the riprapped downdrains are presented in Appendix 11-QQ (as-built data) of the PAP.

When the diversion is no longer needed it will be re-graded and reclaimed in accordance with the guidelines and procedures outlined in Chapter 12, Sections 12.3, 12.5 and 12.6.

Drainage/Sediment Control for Excess Material Dump

During construction the excess excavation or waste was dumped along the west side of the diversion channel. To control drainage and sediment from the dump a berm will be constructed adjacent to the toe of west slope that will direct the drainage to the low points. At the natural low points or existing drainages there will be a break in the berm with a silt fence to release the drainage and retain the sediment. In some cases where the natural topo is favorable a berm may not be required to direct the drainage to the low point where the silt fence will be placed. Refer to the typical section and profile on Figure 11-4 for location of berm and silt fences.

On the east side of the dump the slope for the most part is constructed flush with the cut slope of the channel. A short segment at the north end has a 15-foot bench at the crest of the cut. There is essentially no room to construct a berm or ditch to collect the runoff from the dump slope without moving the dump towards the west. In lieu of moving the dump to create room for placing drainage control structures an evaluation comparing the soil loss from the undisturbed surface with the dump slope was done to determine the potential degree of impact.

Slope/length measurements were taken on the east slope and on the undisturbed area adjacent to the west side of the dump. The data was used as input parameters in RUSLE Version 1.06 to determine the soil loss. The input parameters along the length of the dump were averaged based on similarity of conditions. The weighted average soil loss is based on the lengths of similar conditions along the dump and not on area. Refer to the tables below for the field measurements taken and the results from RUSLE Version 1.06. The estimated weighted average soil loss from the east dump slope is 2.0 ton/acre and from the undisturbed surface it is 1.9 ton/acre. The soil loss from the east dump slope is 5% more than the adjacent undisturbed surface. The additional sediment from the dump slope is very minimal, thus the potential impact to the downstream flow would be insignificant. Also the area in question (east dump slope) is very small compared to the total surface disturbance for the South Dixon Pit extension.

EXCESS MATERIAL DUMP - SLOPE/LENGTH MEASUREMENTS

Location/Station	Slope Dist. (ft)	Elev. Diff. (ft)	Horiz. Dist. (ft)	Slope (%)	Rock Cover (%)
Sta. 4 to 11 (700 ft)	27	15.3	22.2	68.8%	
	25	13.4	21.1	63.5%	
Average	26	14.4	21.7	66.1%	75
Sta. 11 to 19 (800 ft)	45	13.7	42.9	32.0%	50
Sta. 19 to 24 (500 ft)	31	4.8	30.6	15.7%	50
Sta. 24 to 27 (300 ft)	70	19.0	67.4	28.2%	40
Sta. 31 to 39.8 (880 ft)	20	9.3	17.7	52.5%	
	20	9.6	17.5	54.7%	
Average	20	9.5	17.6	53.6%	75

UNDISTURBED SURFACE - SLOPE/LENGTH MEASUREMENTS*

Location/Station	Slope Dist. (ft)	Elev. Diff. (ft)	Horiz. Dist. (ft)	Slope (%)	Rock Cover (%)
	48	9.8	47.0	20.9%	
Sta. 4 to 16 (1200 ft)	35	5.9	34.5	17.1%	
	26	3.7	25.7	14.4%	
	33	6.9	32.3	21.5%	
	37	9.0	35.9	25.1%	
	26	5.3	25.5	20.8%	
	17	7.2	15.4	46.8%	
	33	10.2	31.4	32.5%	
Average	32		31.0	24.9%	15
	47	5.3	46.7	11.3%	
Sta. 16 to 23 & Sta. 31 to	45	3.2	44.9	7.1%	
39.8 (1580 ft)	36	2.8	35.9	7.8%	
Average	43		42.5	8.8%	40
	67	3.8	66.9	5.7%	
Sta. 23 to 27 (400 ft)	70	3.7	69.9	5.3%	
	60	2.9	59.9	4.8%	
	48	2.7	47.9	5.6%	
	17	0.9	17.0	5.3%	
Average	52		52.3	5.3%	50

* Measurements were taken on the undisturbed surface along the west side of the waste material dump.

ESTIMATED SOIL LOSS - EXCESS MATERIAL DUMP

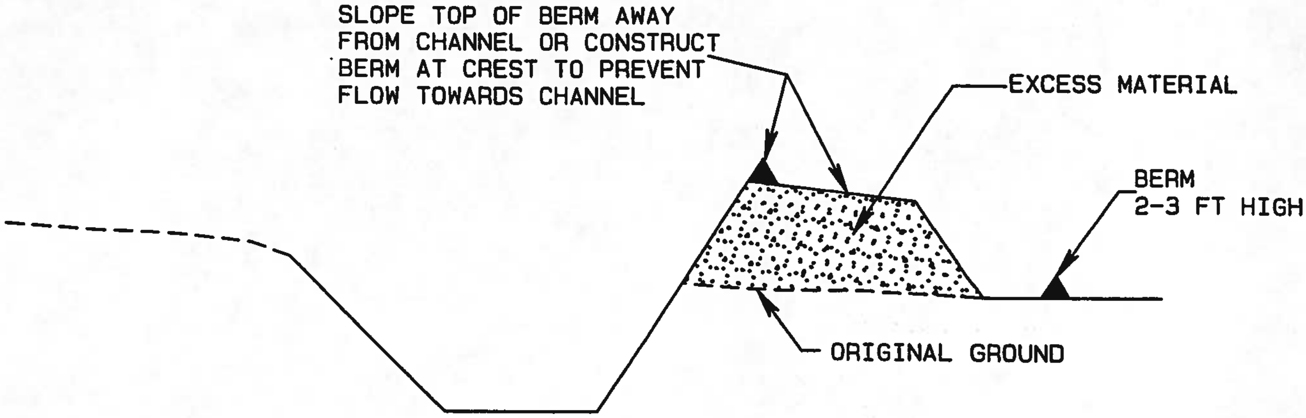
(RUSLE Version 1.06)

filename	R	K	LS	C	P	A	Location/ Station	Length (ft)	% of Total Length	Weighted Soil Loss (tn/ac)
NFD1A	20	0.21	6.25	0.06	1.0	1.8	4 to 11	700.0	22.0%	0.40
NFD1B	20	0.21	3.40	0.20	1.0	2.8	11 to 19	800.0	25.2%	0.70
NFD1C	20	0.21	1.38	0.22	1.0	1.3	19 to 24	500.0	15.7%	0.20
NFD1D	20	0.21	3.88	0.24	1.0	4.0	24 to 27	300.0	9.4%	0.38
NFD1E	20	0.21	3.09	0.08	1.0	1.1	31 to 39.8	880.0	27.7%	0.30
									Weighted Average	**2.0**

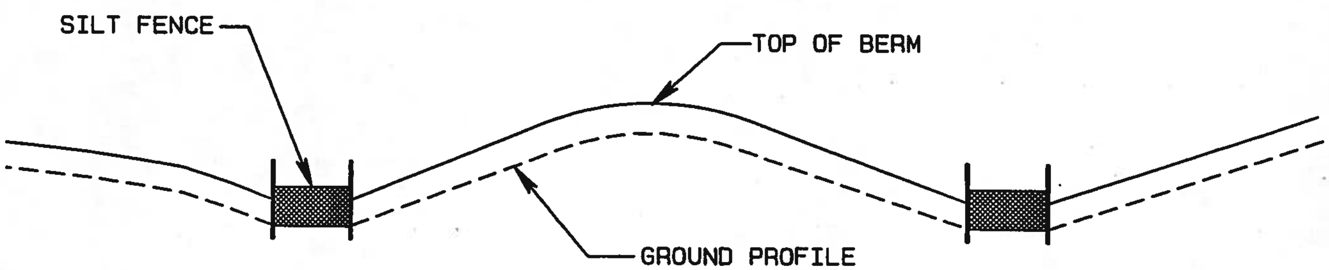
ESTIMATED SOIL LOSS - UNDISTURBED SURFACE

(RUSLE Version 1.06)

filename	R	K	LS	C	P	A	Location/ Station	Length (ft)	% of Total Length	Weighted Soil Loss (tn/ac)
NFD2A	20	0.21	3.03	0.31	1.0	4.00	4 To 16	1200.0	37.7%	1.51
NFD2B	20	0.21	0.92	0.17	1.0	0.65	16 to 23	700.0	22.0%	0.14
NFD2C	20	0.21	0.60	0.13	1.0	0.33	23 to 27	400.0	12.6%	0.04
NFD2D	20	0.21	0.92	0.17	1.0	0.65	31 to 39.8	880.0	27.7%	0.18
									Weighted Average	**1.9**



TYPICAL SECTION
NTS



TYPICAL PROFILE
NTS

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PLN	E.G.	P.E.	RPLS
A	3-07-02	PJF	SUBMITTED TO OSM FOR REVIEW AND APPROVED.		MC	LR	
				APPROVALS			

FIGURE 11-4

BHP BILLITON NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

NORTH FORK DIVESION CHANNEL
DRAINAGE CONTROL FOR
EXCESS MATERIAL DUMP

PREPARED BY LR	DRAWN BY PJF	SCALE 1" = NTS
APPROVED BY LR	DATE Mar. 7, 2002	

PATH: C:\DRAFTING-2001\DATA-92401\PAP EXHIBIT UPDATES\N_FORK_L-DIXON DIV-CHAN.pro

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[PAGES 11-85 THROUGH 11-94]

11.5.6 Transportation Facilities

Transportation facilities at Navajo Mine consist of approximately 90 to 100 miles of road and 15.4 miles of railroad. EXHIBITS 11-79 through 11-84 show the existing roads (Primary and Ancillary) and the existing railroad. In the construction of the roads and the railroad, the following were taken into consideration: the mine's safety program, minimization of erosion, impact on wildlife, and alteration of existing drainage channels. All routes of travel defined as roads in 30 CFR § 701.5, are included in this section of the permit. "As-Built" drawings of road designs approved by OSMRE are kept on file at Navajo Mine and will be available within 30 days of completed construction of the design. Presently, Navajo Mine does not have plans to retain any roads for postmining use. Refer to CHAPTERS 2 and 12 of the Permit Application Package for more information on postmining land use.

11.5.6.1 Mine Roads

11.5.6.1.1 Introduction

Per 30 CFR § 816.150 (a), the Navajo Mine roads are classified into two broad categories. The two classifications are Primary and Ancillary roads. The roads which fall into these two classifications are:

A. Primary Roads

1. **Access Roads**: Frequently used roads by the mine personnel for direct access to permit facilities, or for transporting/tramming of large coal mining equipment between coal stockpiles or to shop areas.
2. **Coal Mine Haulroads**: Roads used to transport coal to stockpiles or dump hopper. These roads run from the top of pit ramps to stockpiles or hopper areas.

Primary roads are constructed to the same standards, whether they are an access road or a haulroad. The only real difference in these roads is their usage and widths. Since the construction standards are the same for each type of road, one typical cross section drawing is provided to cover all Primary Roads. The typical drawing common to both access roads and haulroads is numbered EXHIBIT 11-84a. Information on individual road segment width is provided in TABLE 11-11. Routes of travel for which drainage control is otherwise provided, or which will be obliterated during the process of mining or reclamation, are not considered either primary or ancillary roads.

B. Ancillary Roads

1. Service or inspection roads for power lines and substations.
2. Environmental Service Roads used for:
    a. Topsoil Stockpiling and Maintenance.
    b. Maintenance of Revegetated Plots.
    c. Air Quality Monitoring Stations.
    d. Hydrologic Sampling Stations; Surface & Ground Water.
    e. 16 Inch Diameter Irrigation Pipeline Access.
    f. Access to Experimental Research Plots.
    g. Access to ponds and other surface water control structures
3. Railroad access road used for inspection and maintenance.

Table 11-11
Primary Road Segments

Road Areas	Length (feet)	Width (feet)	Grade (%)	Surface Material	Use	Area (acres)	Constr. Date	Anticipated Removal Date	Located on Exhibit	References
Area 3 By-pass Road	3970	70	0-4%	Gravel/Dirt	Access/Haul	6.37	1982	2019	11-82	Exhibit 11-90 to 92
Area III Main Access Road	5,160	60	0-4%	Pavement	Access	7.09	1982	2019	11-82	Design shown on EX. 11-112D and 11-12E
Barber By-pass Road	6,300	70	0-6%	Gravel/Dirt	Access/Haul	10.10	2003	2019	11-82	Exhibit 11-100 and 11-101A-C
Barber Haulroad	11,000	60	0-6%	Dirt	Haul	15.12	1978	2019	11-82	Modification design shown in EX. 11-129. Typical shown on EX. 11-84a.
Barber Hosteen Bypass (Gorman Road)	4,850	70	0-6%	Dirt	Access	7.78	1978	2019	11-81, 82	Typical shown on EX. 11-84A. Also known as Gorman Haulroad Road.
Big Fill Road	19,450	60	0-5%	Gravel/Dirt	Access	26.74	1973	2019	11-81	Typical shown on EX. 11-84A.
Block B Access Road	13,220	60	0-4%	Gravel/Dirt	Access	18.17	1992	2019	11-82	EX. 34-7F (CH. 34, NM-0003C PAP).
Burn's Pass Road	2,980	70	0-7%	Dirt	Access/Haul	4.78	1977	2019	11-81	Exhibit 11-64
Coal Plant Road	3,780	40	0-8%	Gravel/Dirt	Access	3.46	1996	2019	11-80	As-built shown on EX. 11-122a-d.
Dixon Haul Road	8,150	70	0-4%	Gravel/Dirt	Access/Haul	13.07	1999	2019	11-83	Exhibit 11-137, 137A & B
Doby Road	6,175	60	0-5%	Gravel/Dirt	Access	8.49	1970	2019	11-80	Typical shown on EX. 11-84A.
Employee Coal Dump Access Road	270	35	5%	Dirt	Access	0.22	1999	2019	11-82	Figure 11-28, Typical shown on EX. 11-84a.
Hosteen Haulroad	7,000	60	0-6%	Dirt	Haul	9.62	1977	2019	11-81	Drainage design shown in EX. 11-130. Typical shown on EX. 11-84a.
Hosteen Yazzie Haulroad	11,700	60	0-5%	Dirt	Haul	16.08	2000	2019	11-82	As-built shown on EX. 11-141c-e
Lowe Boxcut Road	5,720	70	0-6%	Gravel/Dirt	Access	9.17	1996	2019	11-82	As-built shown on EX. 11-103d-h.
Lowe Bypass Road	5,910	30	0-6%	Gravel/Dirt	Access	4.06	1994	2019	11-83	Design and as-built are shown on EX. 11-102a & b
Lynch Skyline	2,050	65	1-6%	Dirt	Access	3.05	1983	2019	11-81, 82	Typical shown on EX. 11-84A.
Mason Road	5,225	70	0-2%	Dirt	Access/Haul	8.38	1980	2019	11-82	Asbuilt shown on Exh. 11-138*.
Neck Road	8,500	120	0-6%	Gravel/Dirt	Access	23.37	1978	2019	11-82	Typical shown on EX. 11-84A.
Pinto Reroute	4,500	70	0-5%	Gravel/Dirt	Access	7.22	1989	2019	11-80	Typical shown on EX. 11-84A.
Pinto Road	5,500	60	0-5%	Gravel/Dirt	Access/Haul	7.56	1965	2019	11-80	Typical shown on EX. 11-84A.
Re-aligned Ramp 7 Road	5,225	30	0-6%	Gravel/Dirt	Access	3.59	1998	2019	11-80	As-built shown on EX. 11-119c-f.
Yazzie Skyline Road	6,450	65	0-7%	Dirt	Access	9.60	1970	2019	11-81	Typical shown on EX. 11-84A.
Yazzie Spoil Side Road	3,450	70	0-4%	Dirt	Access/Haul	5.53	2004	2019	11-81	Design shown on Exhibit 11-95
Yazzie Silos Access Road	400	50	0-8%	Dirt	Access	0.46	2005	2019	11-81	Design shown on Exhibit 11-07
Lowe Ramp-2 Haulroad	687	70	4%	Dirt	Access/Haul	1.40	2008	2019	11-83	As-built shown on EX. 11-153.
Dixon Ramp-2 Haulroad	1,398	60	0-7%	Dirt	Access/Haul	2.60	2008	2019	11-83	As-built shown on EX. 11-154.
Cottonwood Crossing Road	1,250	120	0-3%	Gravel/Dirt	Access/Haul	3.40	2009	2019	11-84	As-built shown in Appendix-TT
Area IVN Perimeter Haulroad (East segment)	2,200	120	0-1%	Gravel/Dirt	Access/Haul	6.05	2009	2019	11-94	Location shown on Exhibit 11-84
Area IVN Perimeter Haulroad (West segment)	4,100	120	0-4%	Gravel/Dirt	Access/Haul	11.27	2009	2019	11-94	Location shown on Exhibit 11-84
Total Length/Area Primary Roads [miles/acres]	31.5					253.8				

Note*Typical Cross-sections for primary road is shown on Exhibit 11-84A
Road locations shown on Exhibit 11-79 to 11-84.

4. Access Road to equipment and parts storage yard.
5. Access road to vital mine Support Facilities.

Ancillary roads are mostly small vehicle service roads, used infrequently for inspection or monitoring purposes. Ancillary roads with in the planned mining area will be removed as part of the normal mining operation and reclaimed as part of normal reclamation. Other ancillary roads will be reclaimed when they are no longer required.

Ancillary Roads Construction

Ancillary roads will be constructed or reconstructed according to the typical cross-section shown in Exhibit 11-84b. Approval will not be required prior to construction of any ancillary road. Instead, the actual alignment of any new road will be determined and added to the appropriate exhibit (Exhibit 11-79 through 11-84). The revised exhibit will then be certified and submitted to OSM within 60 days after completion of construction of the ancillary road.

11.5.6.1.2 Existing Road Locations

Primary Roads

The existing roads which are classified as primary roads are shown on EXHIBITS 11-79 through 11-84.

The existing primary roads were constructed for a maximum service life of anywhere between 5 to 20 years. Most primary roads are generally aligned to accommodate the mining pits and overall strip design layouts. Generally, primary roads are located to facilitate the coal haulage from the pits to the railroad stockpiles.

As shown in these EXHIBITS 11-79 through 11-84 one continuous Primary road is shown traversing through Areas 1, 2, 3 and 4 North. This road is the main Primary road with an approximate length of 15 miles. The point of beginning for the road is the North Area facilities, ending at Area IV North. There are several turnouts off this road which are also considered as Primary roads. Refer to TABLE 11-11 for more detail.

Ancillary Roads

Locations of roads classified as Ancillary are shown in EXHIBITS 11-79 through 11-84.

Where it is appropriate, most Ancillary roads are located where minimal or no road work is required for construction. Ancillary roads are usually one lane (7 ft. to 12 ft.) roads with no embankment.

11.5.6.1.3 Primary Road Conditions

Refer to EXHIBITS 11-84A and 11-112D (Area III Main Access Road) for Primary Road Typical Cross Sections. TABLE 11-11 contains information on each of the Primary Road segments.

Pinto Haulroad and Pinto Reroute

This haulroad was built during the early periods of Area I coal mining operations. The approximate date of Pinto Haulroad construction is 1965. The road is approximately 60 feet in width. Presently the road is in good condition and maintained by periodic blade work and side ditch cleaning.

A portion of the Pinto Haulroad was rerouted in 1989. The newer section of the road is shown as Pinto Reroute in EXHIBIT 11-80.

At the present time, the road is occasionally used for coal haulage from Pinto Pit. The majority of the time, however, it is used as a major access route to the Area I industrial complex. The termination of the haulroad is in the emergency coal stockpile area. The road's present sub-grade and surface course condition are excellent.

Doby Haulroad

The Doby Haulroad was built in 1970 and was used at that time primarily to mine the Doby Pit coal. This road, in conjunction with the Pinto Road, was once used for long haul from Doby Pit Ramp #14 to the North Plant.

Presently, the Doby Road is used as a main access road between Yazzie Pit and Pinto Pit. The roads present sub-grade and surface course condition are excellent.

Yazzie Skyline Road

This road was used as a haulroad for the mining of Yazzie Pit coal via ramps 3 and 4. It is now used as the primary access route from the southern portions of the mine to the north facilities. Equipment and vehicles traveling this route continues from the Burn's Pass road through Yazzie Skyline Road, Doby Road and Pinto Road to the Plant. This road is located on regraded spoils the entire length of the road up to the Yazzie "Y" intersection (see EXHIBIT 11-81).

The current condition of the road is good to excellent for the sub-grade.

Neck Road

The Neck Road was constructed in 1978 for access to the Area III coal reserves. After the Neck Road was constructed, the Area III reserves were developed.

During the next few years, following the opening of Area III Coal reserves, this road was primarily used as a dragline walk-road. Also anticipated at the time of construction was eventually placing the railroad through this route. However, the railroad roadway was built at a separate location on a later date.

The current condition of this road's sub-grade is excellent. Traffic on this road consists of small vehicles, coal trucks, and coal & overburden drills and also provides access to, and along, segments of the main irrigation pipeline.

Big Fill Road

The Big Fill Road begins at Turnout #1 (EXHIBITS 11-80 and 11-81) on the Doby Road and ends at the Barber Railroad Stockpile. The road was built in 1973 primarily as a railroad access road. During this period, the Yazzie Skyline Road did not join the Hosteen Pit Roads, so the Big Fill Road was the primary access to Hosteen and Barber Stockpiles.

The Big Fill Road shares its sub-grade with the railroad roadway. Thus, the road sub-grade was constructed in accordance with "AREA" (American Railway Engineering Associated) sub-grade specifications.

Over the years, a surface course of railroad ballast has drifted onto the road by blade work. This surface course of ballast has greatly improved the structural integrity of the road's sub-grade structure.

At the present time, this road is mainly used for access purposes only. For safety reasons, this road is no longer used as a coal haulage road due to its narrow width. For emergency hauling situations, this road may be utilized. Occasionally, an escorted, oversized piece of equipment will be trammed or transported on this road to get to the Barber or Hosteen Stockpiles.

Dixon Haulroad

The Dixon Haulroad begins at the south end of Dixon pit, bends to the west toward the spoils, and then follows the regraded area north to the Lowe Coal Stockpile. The road will be used for truck haulage for coal mining and reclamation, and as an access road to south Dixon ~~and eventually to Area IV North~~. The road is designed to Primary Road standards per Section 11.5.6. The road design and location can be found in Exhibit 11-137 and 11-83, respectively. The road information is included in TABLE 11-11, Section 11.5.6. Hydrology information for culvert design on CP-128 is located in Appendix 11-V, with the culvert location on Exhibit 11-12E also in this appendix. The road shall be constructed and maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards".

Burn's Pass Road

The Burn's Pass Road begins at Turnout #2 (shown on EXHIBIT 11-81) and ends at the intersection with North Hosteen Ramp #1.

This road is primarily a maintenance access road to North Hosteen Ramp #1 and the main irrigation line. The road's sub-grade is mostly original ground that has been bladed. The road is in good condition.

Hosteen Haulroad

The Hosteen Haul Road serves Hosteen Pit Ramps #1 and #3. The haulroad is also the continuation of the Burn's Pass Road at the top of Ramp #1.

This road is used mainly for hauling the Hosteen Pit coal to the railroad stockpile. The majority of the road is built on reclaimed surface and is presently in good condition.

The condition of the existing road sub-grade is excellent with no visible failure or deterioration of road surface course.

Ramp 7 Road

The Ramp 7 Road is an existing mine primary road which has been re-aligned to improve road safety and to facilitate reclamation in the area. The re-aligned Ramp 7 Road is designed to Primary road standards, refer to EXHIBIT 11-119, 11-119A and 11-119B for design drawings and APPENDIX 11-Z for supporting design data.

Lynch Skyline Haulroad

This road is a mining haulroad which connects North Barber Ramp #2 with Barber Railroad Stockpile.

The road was built in 1983 by dozers and graders. The road is presently in good condition. The road is located on regraded spoils to more closely accommodate the spoil Ramp #2 location and the mining of coal seams #7 and #8.

Yazzie Silos Access Road

This road connects with the Yazzie Spoil Side Road and provides access to the silos and diesel tank. The primary function is access for the delivery of blasting agents either into or out of the storage containers. The location of the road is shown on Exhibit 11-81 and the design is shown on Exhibit 11-07. Road information can be found on Table 11-11 (Section 11.5.6). The road is constructed and maintained as outlined in Section 11.5.6.1.6 “Roads General Performance Standards”.

Coal Plant Road

The Coal Plant Road is located at the North Industrial Complex. The function of the road is to provide access from the eastern side of the North Industrial Complex, to the Coal Plant. The road will be used primarily by Coal Plant personnel and equipment. The road was redesigned as a primary road per the requirements of section 11.5.6.1 of the PAP, 30 CFR Part 816.151, and meets the performance standards of section 11.5.6.1.6 of the PAP. The length of the road is approximately 3300 ft. The average width of the road is 40 ft. Road design and cross-sections are shown in EXHIBITS 11-122 a-d. The roads maximum and minimum elevations are 5349 ft. and 5335 ft. and respectively.

The Plant Road watershed is approximately 3.8 acres. All surface runoff from the Plant Road will drain as sheet flow down the sides of the road. Flow from station 0 to 21.5 and 21.5 to 38, will be captured by Pond 5 and Cell A2 respectively (see EXHIBIT 11- 12 B).

Yazzie Spoil Side Road

This road connects Yazzie Pit activities with the Yazzie Skyline Road. Yazzie Spoil Side road is used for coal haulage, pit access, reclamation haulage, access around the east end of the pit, and power line access. The location of the road is shown on Exhibit 11-81 and the design is shown on Exhibit 11-95. Road information can be found on Table 11-11 (Section 11.5.6). Yazzie Spoil Side road contains two culverts (shown on Exhibit 11-83), the Sedcad for these pipes can be found in Appendix 11-V. The road is constructed and maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards".

Area III Access Roads

Main Access Road: was constructed in 1992 and provides small vehicle paved access to the Area III Facilities from the east. This 0.86 mile paved road connects the Area III Facilities to BIA Road N4104. The road is maintained and in excellent condition. As required under the Grant of Easement for Right-of-Way, this read will be operated and maintained under the stipulations therein (see CHAPTER 1, Section 1.3.3).

Employee Coal Dump Access Road

The Employee Coal Dump Access Road will be used to facilitate the Area III employee coal dump. The road alleviates the safety concerns associated with the current traffic pattern. The road is designed to the Primary Road standards per Section 11.5.6.1 of the PAP and 30 CFR 816.151. The general road design can be found on Figure 11-28. The typical road cross section and location can be found in Exhibit 11-84A and Exhibit 11-82, respectively. The road information is included in TABLE 11-11, Section 11.5.6. For hydrology information on the added watershed to the Area III Employee Coal Dump, refer to Appendix 11-AA and Exhibit 11-13D. The road shall be constructed and maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards".

Mason Road

Mason Road commences at Turnout #5 (shown on EXHIBIT 11-82) near the north end of the Neck Road. This road was built in 1980 for access to Mason and Barber Pit Ramps. In 1998, BHP submitted to OSM, a modification to widen the Mason Road to a width of 70 ft. to facilitate coal haul from the new Barber Ramp 6 to Barber Stockpile. Barber Ramp 6 is no longer active but the road has been left in place to facilitate other mine operations

Barber Haulroad

The Mason Road turns into Barber Haulroad serving Ramp 5 and the Barber Stockpile area. Barber Ramp 5 is no longer active but the road has been left in place to facilitate other mine operations

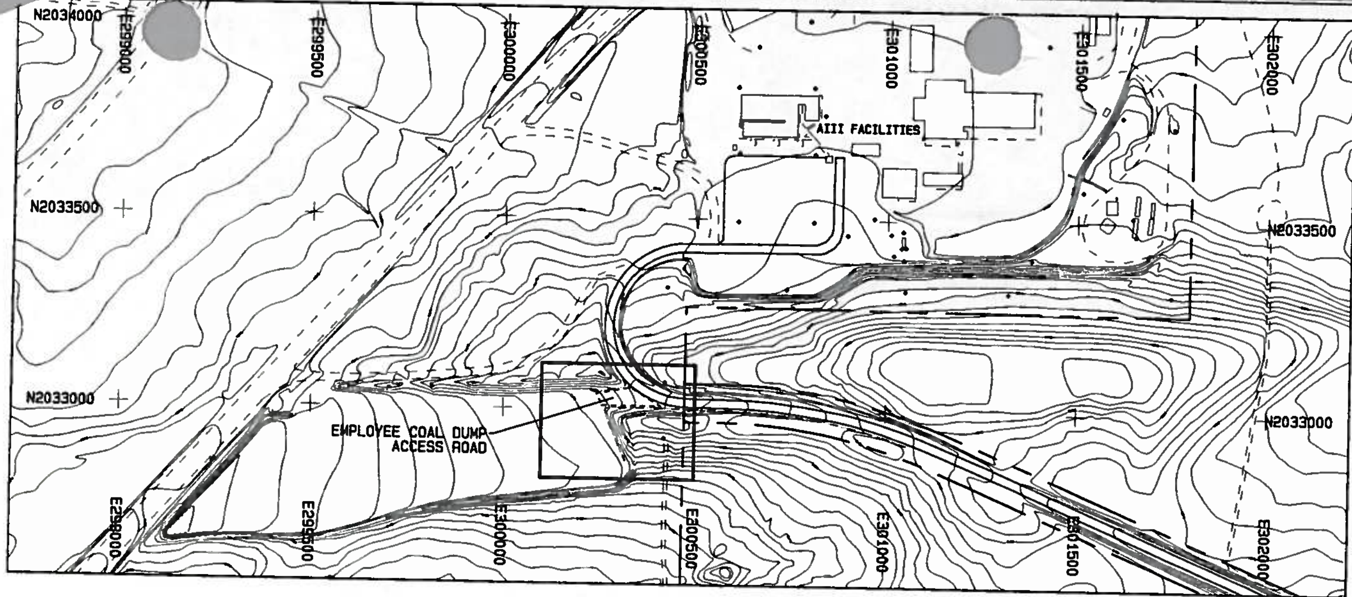
In 1997, BHP submitted to OSM, a modification to widen the Barber Haulroad to the width of 50 ft. to eliminate safety concerns associated with road width. The modification of Barber Haulroad included widening a 2,796 ft. section from the end of Mason Road to the intersection of Ramp No. 5. A culvert (CP-119) was installed to provide adequate drainage for the road.

Block B Access Road

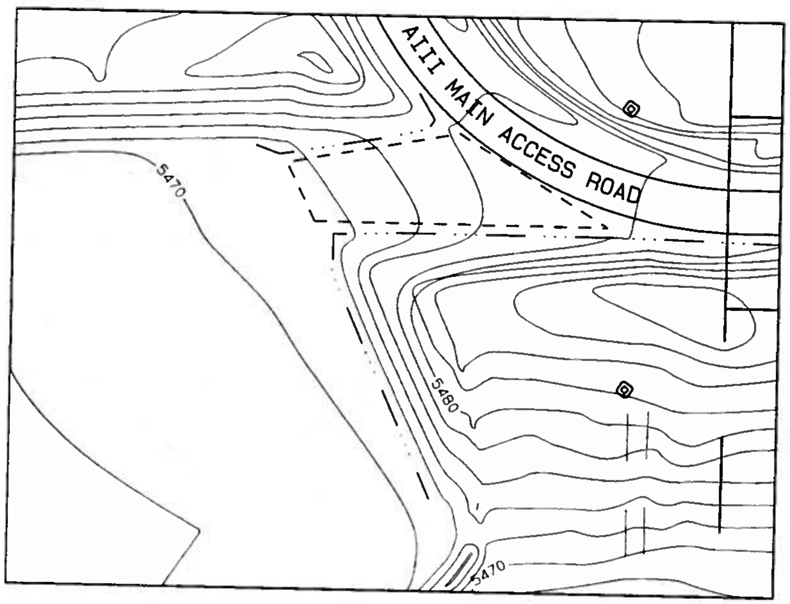
This road connects with the Hosteen Yazzie Haulroad at the north end and terminates at the Area III facilities. The Block B Access Road is used for pre-strip material haulage, access to Hosteen and Yazzie Pit, and power line access. In 2004 the final strip in Barber Pit disturbed the Block B Access Road, the layback of the highwall has narrowed up the road significantly in some reaches. The road will be reconstructed to facilitate the haulage of pre-strip material from Hosteen Pit to South Barber Pit. The reconstruction requires backfilling portion of the pit along the highwall to obtain the road width required. The design for the reconstruction of the road is presented on Exhibits 11-63, 11-63A and 11-63B. The location of the road is shown on Exhibit 11-82. The road is constructed and maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards".

Lowe Bypass Road

The Lowe Bypass Road is located in the southwestern Lowe Pit area near the Lowe Stockpile. It was constructed in 1994 as an ancillary road for light vehicles to obtain access to Dixon Pit, Lowe Stockpile, and the southern Lowe Pit area without using the main haulroads. The north end of this road ties into Lowe Ramp #2; the southern portion crosses Dixon Ramp 1 and ties



SCALE: 1" = 500'



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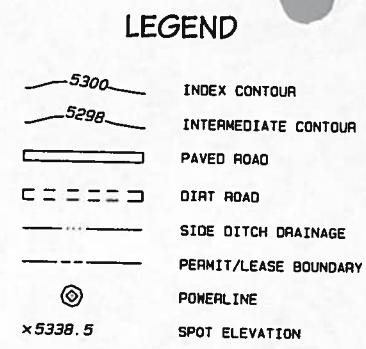

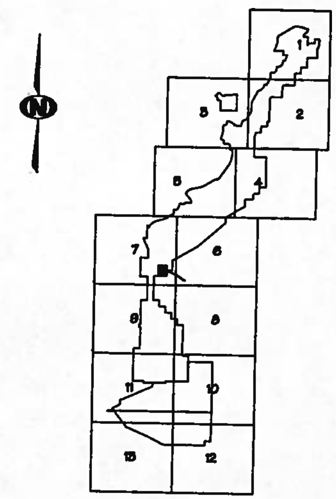

NOTES:

1. REFER EXHIBIT 11-132 FOR DESIGN POND INFORMATION.
2. FOR POND WATERSHED REFER EXHIBIT 11-13D.
3. FOR ROAD INFORMATION REFER EXHIBIT 11-82.
4. SEE APPENDIX 11-AA FOR SUPPORTING DESIGN DATA.
5. FOR TYPICAL ROAD SECTION REFER EXHIBIT 11-84A.

CERTIFICATION STATEMENT

I, Leonard Raymond, hereby certify that this drawing was reviewed by me and that the information shown is accurate and complete to the best of my knowledge.

LEONARD RAYMOND NEW MEXICO 6600 REGISTERED PROFESSIONAL ENGINEER

11-2-99

REV. NO.	DATE SUBMITTED	DRAFT. BY	REVISION DESCRIPTION	ENG.	E.Q.	P.E.	P.S.	DATE APPROVED BY OSM
A	10/29/99	BH	SUBMITTED TO OSM					

FIGURE 11-28

NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 1717 FRUITLAND, NEW MEXICO 87416

AREA III EMPLOYEE COAL DUMP ACCESS ROAD

PREPARED BY BH	DRAWN BY BH	SCALE: AS NOTED
APPROVED BY LR	DATE 10/29/99	REF DWG AS NOTED

DWG LOC J:\OSM_SUBM\PER_PROG\Ch_11_Figures\emcd_road\emcdrd_des.pro into the Dixon Haulroad (see EXHIBIT 11-102a). In 1995 the road status was changed from Ancillary to Primary. The road now functions as an access road for light vehicles and is in good condition.

Lowe Boxcut Road

The Lowe Boxcut Road is located in the northwestern Lowe area and replaces the northern portion of the current Lowe Road (see EXHIBIT 11-83 and 11-103a). The road is classified as a Primary road and is used for access by light and heavy vehicle types. The road offers access to the Neck Road (north of proposed road), the Lowe Coal Stockpile area, and Lowe Ramps 1 and 2. The road was constructed to meet the performance standards noted in section 11.5.6.1.6. Location and design information for this road is available in EXHIBITS 11-83, 11-103a through 11-103c; TABLE 11-11; and APPENDIX 11-S. The length of the road is 5,402 ft. and is approximately 70 ft. wide. Other details and as-builts can be obtained from EXHIBITS 11-103a through 11-103h.

Gorman Haulroad

Gorman haulroad is located in the North Barber area. The Gorman haulroad comes off the Barber Ramp haul route, connecting this route with the Barber Coal Stockpile. The road width will be increased to 70-feet to accommodate coal truck traffic. EXHIBIT 11-87 shows the design plan/profile and the hydrology information is shown in EXHIBIT 11-89. The haulroad data is listed in TABLE 11-11.

The design to widen this road has been approved by the Regulatory Authority, but the field construction has not commenced. The design was submitted in the anticipation of hauling coal between Barber and Hosteen Coal Stockpiles. In the event that this need should arise in the future, Navajo Mine proposes to retain the approved design discussion for future construction.

Hosteen Yazzie Haulroad

The Hosteen Yazzie Haulroad will be used to facilitate the Area II pre-stripping activities in the North Barber and Hosteen Yazzie Pits. The primary function of the road shall serve as a truck haulage road. The road is designed to Primary Road standards per Section 11.5.6.1 of the PAP and 30 CFR 816.151. The road design and as-builts can be found in Exhibits 11-141, 141a – e, and location on Exhibit 11-81. The road information is included in TABLE 11-11, Section 11.5.6. For hydrology information on culvert designs CP-129 through CP-149 (excluding CP-135, 140, and 147), refer to Appendix 11-V and Exhibit 11-12 & 12C-1. The road was constructed and will be maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards".

Cottonwood Crossing

The Cottonwood Crossing connects with the south end of the Dixon Haulroad and continues south across the Cottonwood Arroyo connecting with the A4N East and West Perimeter Roads. This road serves as the primary access to the mining activities in Area 4 North. The Cottonwood Crossing is used for coal haulage, pit access, and power line access. The location of the crossing is shown on Exhibit 11-84 and the detail designs are presented in Appendix 11-TT. Only the detail civil drawings and the hydraulic analysis of the box culverts and spillway are included in Appendix 11-TT. The structural and geotechnical detail engineering data and drawings were not included in Appendix 11-TT. This information however can be made available upon request. The road is constructed and maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards".

A4N West Perimeter Road

This road connects with the Cottonwood crossing and bends around the west end of the Area 4 North pit. This road intersects with the ramps coming out the Area 4 North pit. The West Perimeter Road is used for coal haulage, pit access, access around the west end of the pit, and power line access. The location of the road is shown on Exhibit 11-84 and the design is shown on 11-94A thru C. Road information can be found on Table 11-11 (Section 11.5.6). The road is constructed and maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards". Slope stability analysis for the road embankments have been completed, see Appendix 11-I.

A4N East Perimeter Road

This road connects with the Cottonwood crossing and bends around the east end of the Area 4 North pit. This road intersects with the ramps coming out the Area 4 North pit. The East Perimeter Road is used for coal haulage, pit access, access around the east end of the pit, and power line access. The location of the road is shown on Exhibit 11-84 and the design is shown on Exhibit 11-94. Road information can be found on Table 11-11 (Section 11.5.6). The road is constructed and maintained as outlined in Section 11.5.6.1.6 "Roads General Performance Standards". Slope stability analysis for the road embankments have been completed, see Appendix 11-I.

Area 3 By-pass Road

In order to facilitate the uninterrupted mining of the remaining South Barber strips, a single reroute around the remaining mining strips was constructed in December 1994. The by-pass road is 60 foot wide, approximately 4,000 feet long, and is located west of the Area III Facility Complex.

Exhibit 11-82 shows the location of the Area 3 By-pass Road. Typical traffic will consist of pickup trucks and passenger vehicles using the road for pit access. Other traffic will include: 1) one-ton service trucks, 2) low boy delivery of dozers, drills, and dragline buckets, 3) forty-ton fuel and lube trucks, and 4) special delivery to the north area of the mine.

11.5.6.1.4 Ancillary Road Conditions

Ancillary roads are either: a two-track road, or a well maintained road (see EXHIBIT 11-84b for Typical Cross-Sections). These roads are used periodically to:

- service and/or inspect the power lines,
- service and/or inspect the railroad tracks,
- obtain access to survey control points,
- transport various equipment or parts,
- obtain access to monitoring stations (i.e., air and water sites),
- service and operate the irrigation system,
- obtain access to reclaimed areas,
- obtain access to stockpiles (either to inspect or to commence reclamation operations),
- obtain access to equipment and parts storage yard,
- obtain access to research plots, and
- service and/or maintain the potable water system.

Some roads, which are established during topsoil stockpiling operations, remain until the stockpile is depleted. These roads are not serviced unless it is needed during stockpile idle periods.

Air Quality monitoring station roads are one-lane roads, which are used on a weekly basis. The monitoring sites are shown on EXHIBIT 4-1 and discussion is also in CHAPTER 4. Hydrologic sampling stations (reference CHAPTER 6 and 7) roads are also one-lane roads, which are used on a weekly basis.

The irrigation pipeline access roads parallel the pipeline where no other means of access is available. Typically, the road traffic is traveled during the spring and summer month's irrigation season. Very little blading is usually conducted on these roads due to the small amount of traffic.

11.5.6.1.5 [Blank due to text discussion reformat]

Table 11-12a Primary Road Culverts

(Culvert locations can be found on Exhibits 11-12B through 11-12E)

Culvert Label	Watershed Area (ac)	Culvert Diameter (inches)	Installed Slope (%)	Culvert Length (feet)	Tailwater Depth (ft)	Design Q (cfs)	Required HW (ft)	Available HW (ft)	Hydrology Information Appendix
CP-18	460.6	90.0	3.0	305	0	142.90	4.7	36.6	11-V
CP-20	42.2	24.0	2.5	262	2.6	27.18	12.0	27	11-V
CP-22	80.6	48.0	1.0	282	0	32.15	2.6	10	11-V
CP-31	23611.2	48.0	3.1	150	3.5	325.70	8.5	9.5	11-V
CP-32		48.0	3.1	150	3.5	325.70	8.5	9.5	11-V
CP-33		48.0	3.1	150	3.5	325.70	8.5	9.5	11-V
CP-34		48.0	3.1	150	3.5	325.70	8.5	9.5	11-V
CP-35A	662.4	24.0	2.4	147	0	18.22	2.9	4.3	11-V
CP-35B		24.0	2.4	147	0	18.22	2.9	4.3	11-V
CP-36	19.1	48.0	0.6	70	0	15.97	1.8	6.5	11-V
CP-37	21.3	24.0	1.5	160	0.9	12.29	2.3	5.5	11-V
CP-45	135.0	16.0	1.0	58	0	7.51	2.6	3	11-V
CP-49	2.6	12.0	2.0	140	0	3.01	1.4	8	11-V
CP-50	72.2	30.0	2.1	140	0	49.00	5.9	7	11-V
CP-51	122.1	36.0	1.1	134	0	71.06	6.3	6.7	11-V
CP-52	510.6	42.0	0.7	137	0	112.00	8.4	8.6	11-V
CP-53		42.0	0.7	141	0	112.00	8.4	8.6	11-V
CP-53a	Removed culvert CP-53a, not install								
CP-54	18.5	18.0	1.1	178	0	13.47	5.0	12.5	11-V
CP-55	319.1	42.0	1.6	204	0	139.63	11.3	11.5	11-V
CP-55a	Removed culvert CP-55a, not install								
CP-56	195.1	48.0	1.7	170	0	109.90	12.3	16.5	11-V
CP-57	3.7	18.0	3.0	174	0	4.28	1.3	10.4	11-V
CP-58	4.7	18.0	3.3	140	0	5.44	1.5	9.8	11-V
CP-59	4.5	18.0	3.4	142	0	5.24	1.5	9.6	11-V
CP-60	13.8	18.0	2.5	230	0	15.95	5.2	7	11-V
CP-61	53.9	30.0	2.9	140	0	39.23	4.4	6.5	11-V
CP-62	8.7	18.0	3.6	128	0	10.07	2.4	3.7	11-V
CP-63A	4.36	16.0	1.0	40	0	10.13	3.5	3	11-V
CP-63B		15.0	2.8	133	0	10.13	4.5	4.5	11-V
CP-66	RESERVED								
CP-67	CULVERT REMOVED								

Table 11-12a Primary Road Culverts

(Culvert locations can be found on Exhibits 11-12B through 11-12E)

Culvert Label	Watershed Area (ac)	Culvert Diameter (inches)	Installed Slope (%)	Culvert Length (feet)	Tailwater Depth (ft)	Design Q (cfs)	Required HW (ft)	Available HW (ft)	Hydrology Information Appendix
CP-68	Plugged and made inactive, surface run off diverted into pit								
CP-69	7.1	72.0	1.1	83	0	5.05	1.0	7.00	11-V
CP-74	15.7	76.0	1.1	110	0	16.93	0.5	7.00	11-V
CP-77	46.5	36.0	1.0	231	0	14.22	1.8	6.00	11-V
CP-83	64.7	24.0	14.0	155	0	7.99	1.6	10.54	11-V
CP-84	5.5	15.6	0.9	48	0	3.90	1.5	2.50	11-V
CP-85	5.2	15.6	2.7	65	0	3.85	1.5	2.50	11-V
CP-91	17.8	18.0	1.0	70	0	10.95	1.8	2.80	11-V
CP-93	51.2	48.0	1.0	230	0	23.08	2.0	4.00	11-V
CP-103	29.2	30.0	1.0	124	0	22.75	2.9	4.00	11-V
CP-104	64.2	36.0	1.0	161	0	28.78	2.8	4.00	11-V
CP-106	1.8	10.0	6.5	75	0	1.16	1.0	1.60	11-V
CP-107	4.6	10.0	9.0	75	0	2.12	1.5	1.50	11-V
CP-109	Culvert I								
CP-111	14575.6	96.0	1.1	175	0	311.20	7.0	12.00	11-JJ
CP-119	31.9	18.0	2.2	95	0	4.15	1.2	3.83	11-V
CP-120	95.2	30.0	1.5	100	0	35.03	3.8	5.00	11-V
CP-122	13.0	24.0	1.0	54	0	2.26	0.8	6.00	11-Z
CP-123	187.4	24.0	1.0	50	0	6.32	1.3	3.30	11-Z
CP-124	372.0	24.0	1.0	50	0	7.74	1.5	3.30	11-Z
CP-126	24.6	24.0	1.5	144	0	13.21	2.8	3.60	11-V
CP-128	58.6	24.0	1.5	116	0	14.23	3.3	8.00	11-V
CP-129	1.7	24.0	3.7	148	0	1.97	1.0	4.00	11-V
CP-130	0.9	24.0	5.2	142	0	1.04	0.7	15.40	11-V
CP-131	19.0	24.0	1.9	146	0	12.47	3.5	19.20	11-V
CP-132	12.0	24.0	2.6	132	0	7.51	1.6	12.40	11-V

Table 11-12a Primary Road Culverts
(Culvert locations can be found on Exhibits 11-12B through 11-12E)

Culvert Label	Watershed Area (ac)	Culvert Diameter (inches)	Installed Slope (%)	Culvert Length (feet)	Tailwater Depth (ft)	Design Q (cfs)	Required HW (ft)	Available HW (ft)	Hydrology Information Appendix
CP-133	4.6	24.0	2.2	124	0	5.32	2.0	13.90	11-V
CP-134	137.0	42.0	1.7	132	0	81.00	5.4	13.50	11-V
CP-136	74.4	24.0	1.8	112	0	38.62	3.7	5.60	11-V
CP-137	25.8	24.0	1.9	226	0	17.23	4.2	29.30	11-V
CP-138	2.2	24.0	1.3	168	0	2.55	1.0	26.00	11-V
CP-139	16.5	24.0	2.2	154	0	16.52	3.7	3.90	11-V
CP-140	19.5	24	1.5	100	0	2.6	2.5	4.00	11-V
CP-141	6.0	24.0	2.0	122	0	6.95	1.6	8.30	11-V
CP-142	4.0	24.0	2.6	192	0	4.63	1.3	18.80	11-V
CP-143	4.2	24.0	4.6	226	0	4.86	1.3	3.50	11-V
CP-144	105.7	42.0	2.0	168	0	58.82	4.7	20.80	11-V
CP-145	23.0	24.0	1.5	188	0	15.46	3.4	12.90	11-V
CP-150	12.8	24.0	1.9	120	0	13.91	2.2	4.00	11-V
CP-151	Plugged and made inactive, surface run off diverted into pit								
CP-157	28.7	24.0	2.3	86	0	20.90	3.3	4.10	11-V
CP-158	38.9	24.0	2.0	94	0	28.33	5.7	6.10	11-V
CP-159	11.4	24.0	4.8	94	0	13.20	2.0	4.70	11-V
CP-160	23.7	24.0	0.9	90	0	16.66	2.9	4.90	11-V
CP-161	102.1	42.0	3.0	100	0	59.76	4.1	4.40	11-V
CP-162	40.2	24.0	2.1	86	0	28.88	5.8	8.00	11-V
CP-163	17,258.7	96.0	0.9	150	0	647.00	12.5	13.60	11-V
CP-164	45.5	30.0	1.5	94	0	27.11	3.1	4.50	11-V
CP-165	14.7	18.0	1.4	86	0	10.54	3.2	3.60	11-V
CP-166	13.0	24.0	2.0	100	0	15.05	2.4	5.00	11-V
CP-167	1.3	18.0	8.8	136	0	1.50	0.5	5.00	11-V
CP-168	0.7	12.0	9.7	110	0	0.81	0.5	2.50	11-V
CP-171	246.3	24.0	2.7	60	0	22.28	4.0	4	11-V
CP-173	6.8	24.0	3.5	74	0	8.21	1.5	4.3	11-V
CP-182	34.1	24	1.9	140	0	24.1	4.0	5	11-V
CP-183	6.5	24	2.0	130	0	6.61	1.4	3.85	11-V

Table 11-12a Primary Road Culverts
(Culvert locations can be found on Exhibits 11-12B through 11-12E)

Culvert Label	Watershed Area (ac)	Culvert Diameter (inches)	Installed Slope (%)	Culvert Length (feet)	Tailwater Depth (ft)	Design Q (cfs)	Required HW (ft)	Available HW (ft)	Hydrology Information Appendix
CP-185	24.38	24	9.0	130	0	9.94	1.8	3.2	11-V
CP-186	108.5	24	2.9	206	0	13.02	2.0	5.3	11.V
CP-187	54.5	24	1.5	206	0	4.95	1.3	3.95	11.V
CP-189	90.6	30	5.2	330	0	65.7	23	23	11.V
CP-300	8.9	24	8.2	110	0	4.59	1.0	3.2	11.V
CP-301	1.3	24.0	6.3	122	0	1.24	0.5	8.90	11.V
CP-302	8.4	18.0	5.6	80	0	8.31	1.3	3.50	11.V
CP-303	2.4	18.0	4.1	86	0	2.85	0.8	3.3	11.V
CP-304	2.3	18.0	5.0	80	0	2.23	0.7	2.8	11.V
CP-305A&B	14.6	18 (2)	6.3	120	0	8.23	1.5	2.6	11.V
CP-306	2.7	18	3.3	80	0	2.67	0.7	5.5	11.V
CP-307	20.6	18	5.4	80	0	11.5	1.3	6.8	11.V
CP-308A&B	22.2	18	2.7	80	0	12.01	1.8	2.3	11.V
CP-309	9.2	18	2.3	80	0	9.08	1.3	5	11-V
CP-310	23317.7	96	1.0	120	0	564.05	8.0	12.5	11-V
CP-311	37.9	24	1.3	100	0	17.73	1.5	7.3	11-V
CP-312	5.5	24.0	2.4	80	0	4.76	1.0	2.60	11-V
CP-313	9.4	24.0	2.0	100	0	8.07	1.5	2.60	11-V
CP-314	10.4	24.0	1.1	80	0	6.30	1.5	3	11-V
CP-315	84.5	24.0	1.3	100	0	31.67	2.0	6.5	11-V
CP-316	23.7	24	2.0	100	0	8.9	1.3	6.3	11-V
CP-317	23687.4	96	1.0	93	0	561.93	8.0	13	11-V
CP-318	5.2	24	1.6	92	0	6.22	1.0	5.6	11-V
CP-319	6.2	24	2.4	100	0	7.52	1.3	4	11-V
CP-320A&B	10.0	18 (2)	1.3	80	0	12.01	1.5	4.9	11-V
CP-321	28.4	24	1.4	100	0	33.95	2.0	7.1	11-V
CP-322	28.7	24	1.3	60	0	20.79	1.8	4.8	11-V
CP-323	106.8	18	1.0	124	0	7.03	1.8	3	11-V

Table 11-12b Ancillary Road Culverts
(Culvert locations can be found on Exhibits 11-12B through 11-12E)

Culvert Label	Watershed Area (ac)	Culvert Diameter (inches)	Installed Slope (%)	Culvert Length (feet)	Tailwater Depth (ft)	Design Q (cfs)	Required HW (ft)	Available HW (ft)	Hydrology Information Appendix
CP-75A	37.4	7.2	0.6	106	0	10.44	25	2.3	11-V
CP-75B		7.2	0.6	106	0	10.44	25	2.3	11-V
CP-76	4.1	24.0	1.3	89	0	3.18	1.0	3.00	11-V
CP-79	5.3	15	23.43	37	0	5.71	2	1.3	11-V
CP-80A	17.1	15.0	4.4	31	0	6.49	3.0	3.50	11-V
CP-80B		15.0	2.3	31	0	6.49	3.0	3.50	11-V
CP-81A	24.5	15.0	3.1	34	0	7.75	2.8	2.80	11-V
CP-81B		15.0	3.2	24	0	7.75	2.8	2.80	11-V
CP-88	3.9	14.5	1.8	39	0	1.60	1.0	2.70	11-V
CP-89	0.6	15.0	5.5	22	0	0.65	0.5	2.00	11-V
CP-90	1.21	15.0	9.16	24	0	1.3	0.62	1.5	11-V
CP-92	138.7	30.0	3.5	50	0	18.90	2.9	4.00	11-V
CP-94	1.7	12.0	0.9	31	0	2.22	1.5	2	11-V
CP-95	9.6	24.0	1.0	26	0	9.94	1.8	3.5	11-V
CP-96	2.3	18.0	0.5	144	0	1.8	0.2	2	11-V
CP-108	332.3	30.0	0.1	28	0	29.09	3.7	5.40	11-V
CP-110	0.4	117x79 arch	1.7	110	0	0.45	5.0	10.00	11-V
CP-125	4.2	16.0	1.3	28	0	1.12	0.6	1.80	11-V
CP-175	14.4	16	1.5	40	0	5.88	1.7	2.20	11-V
CP-176	2.6	16	4.5	35	0	1.06	0.4	1.90	11-V
CP-177	58.6	30	3.0	40	0	16.58	2.0	3.50	11-V
CP-178	0.6	16	3.0	36	0	0.25	0.2	1.60	11-V
CP-179	0.7	16	4.0	40	0	0.29	0.2	1.90	11-V
CP-181A	23	16	2.4	33	0	4.7	1.4	2.70	11-V
CP-181B		16	2.4	33	0	4.7	1.4	2.70	11-V
CP-184	11.43	16.0	0.20	191	0	4.04	1.3	2.0	11-V
CP-189	0.6	16	3.1	40	0	0.31	2.3	3.5	11-V
CP-190	1.1	16	1.3	40	0	0.56	1.1	4.85	11-V
CP-202	2.9	18.0	3.8	30	0	1.18	0.6	3.5	11-V
CP-203	4.2	18.0	4.9	30	0	1.72	0.7	2.5	11-V
CP-204	3.5	18.0	2.6	61	0	1.43	0.6	6	11-V
CP-205	10.76	24.0	1.5	60	0	14.64	2.4	3.4	11-V
CP-206	12.67	24.0	2	60	0	17.24	2.7	3.5	11-V
CP-207	5.12	16.0	1.5	44	0	6.97	2.3	3.2	11-V

Table 11-12c Downdrains

(Culvert locations can be found on Exhibits 11-12B through 11-12F and Exhibits 11-79 through 11-84)

Culvert Label	Watershed Area (ac)	Culvert Diameter (inches)	Installed Slope (%)	Culvert Length (feet)	Tailwater Depth (ft)	Design Q (cfs)	Required HW (ft)	Available HW (ft)	Hydrology Information Appendix
CP-86	23.9	15	10.99	14	0	5.02	1.6	2.25	11-V
CP-87	6.0	15.6	10.2	19	0.00	4.65	1.5	3.80	11-V
DD-01	19.5	30.0	34.0	36	0.00	2.04	0.6	4.00	11-V
DD-02		30.0	34.9	53	0.00	2.04	0.6	4.00	11-V
DD-03		30.0	37.6	53	0.00	2.04	0.6	4.00	11-V
DD-04	1.7	16.0	66.3	65	0.00	1.12	0.5	2.00	11-V
DD-05	10.4	42.0	28.6	29	0.00	3.22	0.8	4.00	11-V
DD-06	15.2	15.0	19.7	44	0.00	5.08	0.5	4.00	11-V
DD-07	56.2	15.0	20.4	325	0.00	5.18	2.2	2.25	11-V
DD-08		15.0	67.4	90	0.00	5.18	2.2	2.25	11-V
DD-09		15.0	66.3	87	0.00	5.18	2.2	2.25	11-V
DD-10	4.6	15.0	50.3	105	0.00	0.33	0.5	1.25	11-V
DD-11		15.0	12.1	408	0.00	0.33	0.5	1.25	11-V
DD-12		15.0	58.8	68	0.00	0.33	0.5	1.25	11-V
DD-13	15.0	15.0	27.9	206	0.00	0.97	0.6	1.25	11-V
DD-14		15.0	34.4	153	0.00	0.97	0.6	1.25	11-V
DD-15		15.0	32.4	154	0.00	0.97	0.6	1.25	11-V
DD-16	61.6	15.0	28.9	160	0.00	7.79	2.7	2.75	11-V
DD-17		15.0	29.4	126	0.00	7.79	2.7	2.75	11-V
DD-18		15.0	23.8	170	0.00	7.79	2.7	2.75	11-V
DD-19	4.3	15.0	36.0	55	0.00	5.00	1.5	5.00	11-V
DD-20	1.4	15.0	36.0	55	0.00	1.60	0.8	4.50	11-V
DD-21	5.3	15.0	45.0	68	0.00	3.90	1.0	4.90	11-V
DD-22	0.2	15.0	50.0	250	0.00	0.22	0.3	1.50	11-V
DD-23	0.1	16.0	68.0	52	0.00	1.08	0.9	1.80	11-V
DD-24	0.1	10.0	50.0	45	0.00	0.54	1.0	1.40	11-V
DD-25	0.9	9.0	25.0	68	0.00	1.08	0.9	1.80	11-U
DD-27	0.4	12.0	65.0	25	0.00	0.54	0.4	1.00	11-U
DD-29	1.81	16.0	60.0	73	0.00	1.84	0.8	5.00	11-V
DD-30	6.3	4.0	50.0	334	0.00	1.09	1.6	5.11	11-V

11.5.6.1.6 Roads General Performance Standards

Primary Roads Dust Control

Fugitive dust control measures of Primary roads are outlined in Section 11.2.8 of this chapter.

Ancillary Roads Dust Control

Ancillary roads are usually not treated or watered.

Protection of Fish, Wildlife, their Habitat and Related Environmental Values.

Roads and railroads will be located and constructed in such a manner to minimize the impact to fish and wildlife habitat and related environmental values, as outlined in CHAPTER 10, Section 10.6.2. This program to minimize or prevent impacts to wildlife during operation of the mine (including road location and construction) includes:

1. Limiting the amount of vegetation and topography disturbed to only that necessary to conduct mining,

2. Designing facilities to prevent mortality of raptors, and

3. Monitoring important wildlife habitats so appropriate plans can be developed and implemented to avoid significant undesirable impact.

Construction

All roads are built with minimization of embankment fill materials. Where fills are required, the nearest road cut material is used until the desired material balance is achieved. The compaction of road surfaces is achieved by repetitive travel of water trucks, scrapers, compactors, and dozers during construction.

Primary Road Construction Dates

TABLE 11-11 presents the approximate construction dates of the Primary roads.

Primary Roads Surfacing

Depending upon site specific conditions such as geomorphological factors, material availability, and economics, present Primary Roads are commonly surfaced with one or more of the following:

1. Compacted shale, silty clay, and sandy silt,
2. Compacted gravel or crushed stone,
3. Asphalt coating in some areas,
4. Aggregate red dog (scoria).

All road surfacing materials are non-toxic and non-acid forming. Also see CHAPTER 8, SOIL RESOURCES.

Road Maintenance

Routine road maintenance will consist of surface repairs; blading of side ditches and roadway surfaces; application of water and chemical road stabilizers; maintaining drainage control structures to standards of engineered design; and maintaining safety berms. Periodic inspections will be conducted to insure proper maintenance and safe operating conditions.

Primary Roads – Water and Sediment Control

Primary Roads will be designed and maintained in such a manner to minimize the contribution of additional suspended solids to surface runoff leaving the permit area. If the results from the hydraulic analysis indicate the potential for erosion to occur, rip-rap rock or other forms of protective lining will be installed. Primary Road drainage controls will be designed for a 10 yr-6 hr storm event. The design and construction of Primary Roads will both be certified by a Professional Engineer. The construction will not commence until the designs are approved by the Regulatory Authority.

Ancillary Roads Control of Siltation

For existing and future Ancillary Roads, the runoff is usually drained into internal depression, or routed through existing nearby channels to impoundments or open mining pits. These roads are located so as to: 1) minimize construction efforts and disturbance, 2) keep road gradients minimal to deter erosion, and 3) minimize impact on existing drainage channels. Ancillary road drainage control structures will be designed for a 2 yr-6 hr storm event. Measures will be taken to prevent contributions of additional suspended solids to stream flow or runoff outside the permit area, such as locating roads to prevent runoff from leaving the permit area, installing culverts, installing filter fences, or vegetating or otherwise stabilizing exposed surfaces such as sideslopes and roadcuts.

Surface Water Control

The Primary Roads are located with minimal impact upon existing drainage channels. At topographical lows or where roads intersect drainage channels, surface flows are routed through the road embankments with culverts.

All culverts are designed to safely pass the peak discharge from a 10 yr-6 hr event for Primary Roads and 2 yr-6 hr storm event for Ancillary Roads. EXHIBIT 11-84a shows the existing haulroad and access road culvert typical cross sections.

The utility routine for sizing culverts in SEDCAD+ was used to design the culverts. The design peak flows were determined with the SEDCAD+ computer program.. All culvert watersheds were delineated, soil curve numbers determined and precipitation values for the event obtained from NOAA Atlas IV-New Mexico.

Hydrologic and channel information pertinent to the Primary Road culverts, and downdrains are located in TABLE 11-12a and 11-12c. Hydrologic and channel information pertinent to the Ancillary Road culverts are located on TABLE 11-12b. All culvert and downdrain locations and corresponding watershed are shown on EXHIBITS 11-12B through 11-12F. Reference APPENDIX 11-V and 11-Z for additional culvert information.

Primary Road Static Stability

Primary Road embankment heights vary from 0 to 36 feet. The majority of the road embankment heights average less than 10 feet. Embankment height is defined as the difference in elevation from toe to grade.

Historically, Navajo Mine has not had problems with road embankments stability based upon the following reasons:

1. The mine's geologic setting is in an area with an abundance of clay and shaley material with the majority of road embankments being constructed of this material, The cohesive values of the two types of soils vary from 1,000 to 10,000 pounds per square foot,
2. The majority of the roads are on level ground, which requires minimum fill,
3. There is no evidence of the presence of shallow ground water where embankments are located, and
4. In the immediate natural hillsides and roads, there is no evidence of failures such as:
    a. creep
    b. landslides
    c. flows-wet & dry

Other embankments which consist of the same materials and construction methods as the existing roads have been tested for stability (See APPENDIX 11-I, "Slope Stability", for more information). As a worst case scenario, refer APPENDIX 11-Q-29, "Lowe Railroad Embankment #1 Stability Analysis" as all Primary Road embankment heights are less than the embankment height used in the stability analysis.

11.5.6.1.7 Relocation or Use of Public Roads

NIIP Road N3003 and BIA Road N5028

There are two public roads, N3003 (Navajo Indian Irrigation Project (NIIP) road) and BIA road N5028, within the permit areas as illustrated in EXHIBITS 11-79 through 11-84. NIIP road, N3003, is located east of Custer Pit and will not be affected by mining activities. Public road N5028 is an unimproved, 32 foot wide, dirt road (without proper drainage structures). It is located east of the present Area III mining activities and primarily serves the community of Burnham Chapter.

To facilitate the mining activities in the Dixon Pit extension area portions of N5028 will be relocated in two phases as described below. BHP will follow the guidelines as outlined under 30 CFR 761.12(d) (Procedures) and 780.33 (Relocation or use of public roads).

- In the first phase, as detailed on the Exhibit 11-143, "South Dixon Pit Extension – Burnham Road Re-route Location Map", approximately 3,750 feet of the road will re-routed along the east side of the proposed Lowe/Dixon Diversion Extension. The existing culvert in the North Fork of the Cottonwood Wash will be replaced with a culvert capable of safely passing the 10yr-6hr storm event. Width of the road will be in compliance with county specs for roads. For more detailed information refer to Exhibits 11-59 and 11-59A. The duration of this road re-route will be approximately 2001 to 2008.
- In the second phase the road will be re-routed around the northern and eastern side of the Dixon Pit extension, see Exhibit 11-143 for alignment. The length of the re-route is approximately 14,500 feet increasing the length of the road by approximately 8,500 feet. Culverts will be installed where drainages intersect the roadway. This road will also meet county specs for roads, be passable in inclement weather and will be maintained by BHP. For more detailed information refer to Exhibit 11-60 and 11-60A thru C. The duration of this road alignment will be approximately 2008 to 2024 or the projected closing of Dixon Pit.
- The final phase will be the permanent reroute of the road, which will be incorporated into final reclamation of Dixon Pit. The approximate timing for this phase is 2024. The alignment will be through the reclaimed area, the end result would be straighter route than original road. The road will be constructed to meet the county road specs. The final phase will also include releasing this section of road back to the BIA Roads Department.

Blasting operations in the vicinity of N5028 will follow the procedures outlined in Section 11.2.2 Blasting Operations.

Public Road N36

The public road N36 right-of-way was granted in December, 1984. The right-of-way consists of part of BHP Minerals original leasehold in the Watson Pit area. BHP amended the leasehold in December, 1984, (see Permit NM-0003C, CHAPTER 32, APPENDIX 32-B for documentation regarding the release of the land and OSM's approval letter to BHP).

The BIA Roads Department began construction of N36 in April, 1985, adjacent to Watson Pit in the northern portion of the permit area. There will be no mining activities within 100 feet of the N36 right-of-way.

Table Mesa Road

The Table Mesa Road is located in two sections on the mine site. The first section branches off the Area III Main Access Road to the west and intersects the Area III By-pass Road. The second section extends off the Neck Road and crosses the railroad west into the Mason area. The road is approximately 22 feet wide and 1,000 feet long for the east section and 5,200 feet long for the west section. The Table Mesa Road is shown on Exhibit 11-82.

11.5.6.1.8 Removal and Reclamation of Roads

The Primary Road anticipated removal dates are included in TABLE 11-11. Each Ancillary Road shall be reclaimed in accordance with the reclamation methods outlined in Chapter 12, Section 12.3.2 as soon as practicable after it is no longer needed for mining and reclamation operations.

11.5.6.2 Railroad

11.5.6.2.1 Railroad Plan

The Navajo Mine Railroad consists of one main line and five spurs. The five spurs are as follows:

Pinto Siding:	Located south of the North Area Industrial Complex
Spur B:	Located at Hosteen Stockpile,
Spur C:	Located at Barber Stockpile,
Spur D:	Commences in Area II and continues to Area III, and services Lowe Stockpile, and
North Spur:	The tail track for access to the North Shop locomotive repair bay.

In general, the mainline of the railroad is parallel to the mine's permit line geometry in the north-south direction. The end points of the mainline are at the North Plant (Area I) and Lowe Pit (Area III). The majority of the alignment consists of a single track, although the railroad stockpiles have double tracks to accommodate coal loading operations. The railroad alignment layout is shown in EXHIBITS 11-79 through 11-83.

The main railroad line beginning from the north operations of Area I was constructed around 1975. As the mine progressed to the south, the railroad extension of Spur D into Area III was constructed in 1982.

A railroad service road runs parallel to the railroad tracks for the entire alignment. The service road is properly maintained to ensure that no adverse conditions arise that are harmful to the environment. Two 7-foot diameter reinforced concrete pipes serve as a cattle crossing near railroad culverts CP-1 and CP-6.

There are 10 rail storage yards along the rail right-of-way. See Mine Structures Map, Exhibits 11-9, 10, 11 for locations. These areas are used to store both old and new rail materials for maintenance and replacement of deteriorated sections of track. Materials include but are not limited to ballast, ties, rail, fill dirt, and hardware related to track construction. All storage areas have sediment control as described in 11.2.10 Operation 5 and Table 11-2a for miscellaneous applications. On occasion new panel tracks (new complete sections of track) will be placed at various locations, both in and out of storage yards, along the rail right-of-way to facilitate track repairs. This practice will not be a long-term storage of materials but a process to facilitate track maintenance in a short period of time. Length of time will vary however from a few days to possibly a few months due to customer demand and scheduling down time for the rail. In instances where materials are not in an approved storage yard, sediment control methods from 11.2.10 Operation 5 will be used to mitigate any offsite disturbance.

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11.5.6.2.2 Railroad Drainage and Erosion Control

The railroad is designed and constructed to control contribution of additional sediment to the downstream flows leaving the permit area. Side ditches are provided in the cut section to collect the surface runoff from the cut slopes, track bed, service road and adjacent undisturbed areas. The grades of the side ditches/channels coincide with the railroad gradient which in most cases are 1.0 % or less. The watersheds for the side ditches are generally small. The flow velocity in the side ditches will seldom exceed the erosive velocity of the soil. The use of low gradient side ditches is a "best management practice" (BMP) in controlling the flow velocity and thereby minimizing the contribution of additional sediment to the downstream flows. At fill sections, relief ditches are utilized to route surface runoff to a natural drainage channel. The relief ditches are located along the toe of the railroad embankment. The grade of the relief ditches varies from moderate to steep depending on the topography. The flow velocity in the relief ditches will in some cases exceed the erosive velocity of the soil. In cases where the erosive velocity are exceeded and there is visible erosion, other types of BMP will be considered to control the sediment or erosion. The procedure and design criteria outlined below will be used to determine the type BMP that will be applied to control the sediment or erosion, if any is required.

- Field survey each concentrated flow or ditch created due to the construction of the railroad. From the field surveys and topographic maps determine the ditch slopes, sizes, flow lengths, soil types, approximate watersheds, and note any visible erosion.

- Using the data obtained above perform hydrological analysis for each ditch. Since the watersheds are small and numerous, several worse case hydrology analysis will be done at appropriate watershed size increments. The criteria below will be used for the worse case hydrology analysis.
  - Minimum Design Storm Event – the 10 year – 6 hour storm
  - Storm Distribution Type – SCS Type II-65

Table 11-13 Railroad Culverts

(Culvert locations can be found on Exhibits 11-12B through 11-12E and Exhibits 11-79 through 11-84)

Culvert Label	Watershed Area (ac)	Culvert Diameter (inches)	Installed Slope (%)	Culvert Length (feet)	Tailwater Depth (ft)	Design Q (cfs)	Required HW (ft)	Available HW (ft)	Hydrology Information Appendix
CP-01	92.1	48	2.5	76	2.7	40.02	2.8	13.7	11-V
CP-02	133.5	48	3.2	183	3.3	76.61	4.8	35.6	11-Z
CP-03	87.6	48	2.6	100	2.1	44.35	3.5	18.6	11-V
CP-04	40.9	48	1.8	68	2	25.50	2.0	13.8	11-V
CP-05	27209.8	84	0.7	311	0	585.50	15.0	70.3	11-V
CP-06	195.1	60	2.1	218	1	68.54	3.8	36	11-V
CP-07[1]	103.9	42	1.1	158	0	23.58	0.8	2	11-AA
CP-08[2]	76.2	30	0.4	81	0	21.70	1.0	2.5	11-AA
CP-09[2]	76.2	30	4.3	48	0	21.70	2.6	6.5	11-AA
CP-10[3]	55.8	24	4.2	120	0	13.00	2.2	2.7	11-AA
CP-11	12.2	24	0.6	107	1	13.15	2.5	8.6	11-V
CP-12	26.5	24	2.2	101	1.2	18.52	2.9	6.3	11-V
CP-13	79.3	30	3.5	73	1.7	37.13	5.0	13.4	11-V
CP-14	79.3	30	3.7	129	4	37.13	5.0	8.5	11-V
CP-15	28.0	24	2.6	108	0.5	20.88	4.0	11.9	11-V
CP-16	196.4	60	1.1	153	0	15.18	2.7	42.5	11-V
CP-17	492.60	108	0.3	187	0	145.80	5.5	8.6	11-V
CP-19	72.3	30	0.6	203	0	49.45	9.6	23.4	11-V
CP-23[4]	122.7	58 x 36 Arch	1.5	146	3.8	41.59	1	10	11-AA
CP-24[4]		58 x 36 Arch	1.5	146	3.8	41.59	1	10	11-AA
CP-97[5]	89.1	24	0.93	140	0	10.99	1.87	7.2	11-AA
CP-98	2.0	16	1	80	0	2.16	1.6	2.5	11-U
CP-99	2.0	16	1	80	0	2.16	1.6	2.5	11-U
CP-100	0.2	24	2	60	0	0.54	1.6	3	11-U
CP-101	2.0	12	1	40	0	2.16	1.6	3	11-U
CP-102	1.0	24	1	50	0	1.08	2.4	3	11-U

Notes:

[1] Spillway for Block C Pond 3
[2] Spillway for Block C Pond 2
[3] Spillway for Block C Pond 1
[4] Spillway for Barber Stockpile Pond #2
[5] Spillway for Hosteen Stockpile Pond #3

- ♦ Time of Concentration – Assumed to be equal to zero or instantaneous. This would be a conservative analysis giving higher peak discharges for design purposes.
- ♦ Curve Number – Assumed to be equal to 89 for all watersheds. The recommended curve number for a graveled road on a Class C soil is 89. The assumption is conservative since the adjacent undisturbed areas that will be contributing surface runoff to the design structures have lower curve numbers.
- ♦ The Sedcad+ computer software will be used to model the hydrology.
- ♦ For worse case analysis use watershed increments of 0.5, 1.0, 2.0, 4.0, 6.0, and 8.0 acres. The watersheds greater than 8.0 acres will be modeled separately.
- ♦ For watersheds greater than 8.0 acres the criteria above will also apply except for the curve number and time of concentration. The curve number will be determined using the procedure outlined in Chapter 11 Section 11.5.4.8. The time of concentration will be determined based on actual watershed configuration.

- Perform the hydraulic analysis using the results from the hydrology analysis above. The Sedcad+ channel design utility will be utilized for the hydraulic analysis of the ditches/channels. The ditches/channels will be verified to safely pass the peak discharge from the 10 year – 6 hour storm event. The maximum flow velocity will be determined for each ditch/channel and compared to the erosive velocity of the soil.

- If the flow velocity is less than the erosive velocity, the existing ditch/channel configuration is sufficient in controlling the contribution of additional sediment to the downstream flow and no additional BMP is warranted.

- If the flow velocity in a ditch/channel exceeds the erosive velocity an appropriate type of BMP will be considered for controlling sediment and erosion.
    - ♦ For watersheds ≤ 8.0 acres and the flow velocity > erosive velocity.
        - ◊ If there is no erosion visible a silt fence or straw bale barrier will be installed.
        - ◊ If erosion is visible a protective channel lining, i.e. rip-rap or straw bale check dams will be installed.

- For watersheds > 8.0 acres and the flow velocity > erosive velocity a protective channel lining, i.e. rip-rap will be placed.

Refer to Appendix 11-U for supporting design data. For locations of side ditches, relief ditches, drop structures, culverts, downdrain pipes, silt fences, straw bale barriers, straw bale check dams, and livestock crossings, see Exhibit 11-14A through 11-14G. For typical sections of ditches, drop structures, downdrain pipes, silt fences, straw bale barriers, straw bale check dams, and railroad cut/fill sections, see Exhibit 11-14H and 11-14J.

The railroad embankment slopes generally are hydrologically stable, very little rilling or erosion occurs on the slopes. Overland sheet flow is the primary type of flow that occurs on the embankment slopes. The stability is partly due to the infiltration of ballast material (1.5 inch crushed rock) into the embankment slopes. On large embankments with long slopes, berms/ditches and downdrain pipes are used to prevent concentrated flows from running down the slopes. Berms and ditches are located at the crest of railroad embankments to divert surface runoff to the downdrain pipes. The downdrain pipes extend from the crest of the embankment to the toe. Energy dissipater will be installed at the outlet of the downdrain pipes to prevent scouring. Overall a very minimal amount of sediment has been transported to the toe of the embankments during the period the rail system has been in service, approximately 25 years. Deposition occurs immediately adjacent to the toe of the embankment inside the ROW or permit area.

The railroad culverts were checked for capacity and adequacy for a peak discharge from a 10-yr, 6-hr event. Peak flows were determined with the SEDCAD+ computer program. Culvert watersheds were delineated, soil curve numbers were determined, and precipitation values for events were obtained from NOAA Atlas IV-New Mexico. The railroad culverts and pertinent information are shown in TABLE 11-12C and TABLE 11-13. Their locations and corresponding watersheds are shown in EXHIBITS 11-12B through 11-12F. Refer to Appendix 11-V and 11-U for hydrological analysis and SEDCAD+ runs.

All necessary field data obtained to evaluate the existing culverts were obtained from cross sectional surveys. The cross sectional survey determined the following culvert data:

1. Pipe size type and length
2. Pipe invert slope, and
3. Headwater depths of road embankments over pipe.

With the above information. the railroad culverts were checked for the design discharge using SEDCAD+. The field surveyed "Available Maximum Headwater Depth" was compared with calculated headwater to check pipe adequacy.

The majority of the railroad culverts are of single barrel arrangements except for the culverts CP-23 & 24. Culverts CP-23 & 24 consist of two 57 inch by 38 inch corrugated steel pipe-arches with 4 feet diameter CMP drop inlets and serve as emergency spillways for Barber Stockpile Pond #2. The spillway was checked using an equivalent round pipe for the arch pipe, the equivalent round pipe is a 48 inch diameter pipe. See SEDCAD+ run in Appendix 11-AA and Exhibit 11-43 for more details.

Culvert numbers 8, 9, 13, and 14 are arranged in the field in series. Culvert CP-8 is immediately upstream of culvert CP-9, and culvert CP-14 is upstream of CP-13 (CP-8/9 are not in series with CP-14/13). Analysis of these culverts commenced with the downstream pipe. This way, the controlling headwater depth of the downstream pipe is the tailwater depth for the upstream pipe's outlet HW depth calculations. In both cases (CP-8/9 and CP-14/13) the upstream pipe outlet and downstream pipe inlet are submerged at peak design discharge.

The controlling headwater depths for CP-8/9 and CP-14/13 are inlet/inlet and outlet/inlet, respectively. See FIGURES 11-22 and 11-23 for the drawings of pipes in a series.

All drainage and erosion control structures along the railroad will be maintained to ensure that no adverse condition that maybe harmful to the environment will arise. Structures will be inspected after each major storm event, any adverse conditions identified will be corrected.

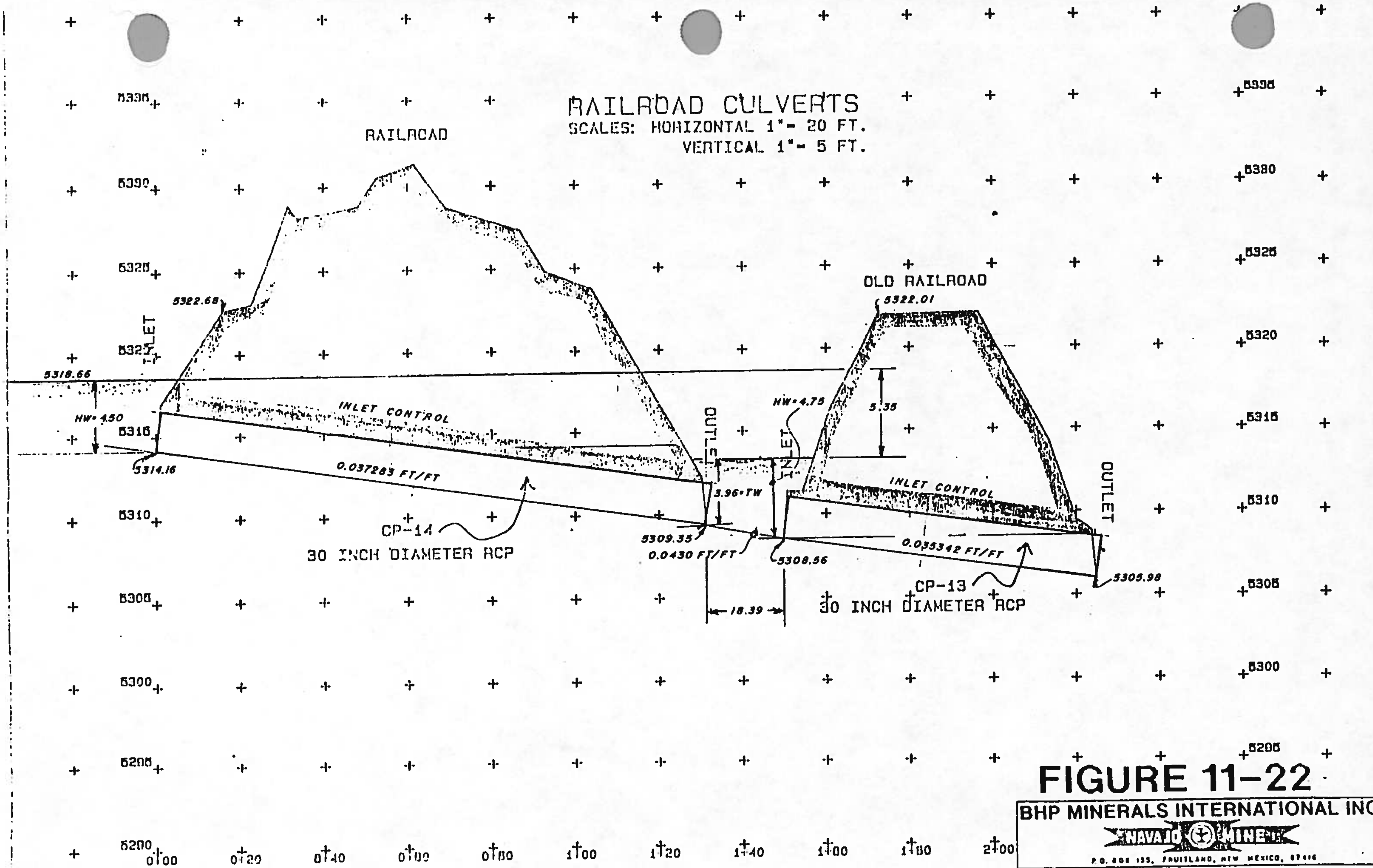

FIGURE 11-22

BHP MINERALS INTERNATIONAL INC.

NAVAJO MINE

P.O. BOX 155, FRUITLAND, NEW MEXICO, 87416

RAILROAD CULVERTS CP-14 AND CP-13 CROSS-SECTION

REV. NO.	DATE	REVISIONS	APPROVALS: DRAFT BY	ENGR.	CHIEF ENGR.	PROJECT MGR.
1	10/92	Midterm Permit Review	PF	[illegible]	GAP	RCV

DRAWN BY PF	SCALE AS SHOWN
APPROVED BY	DATE NOV. 10, 1992 FIG.
DRAWING NO.	LOCATION NO.

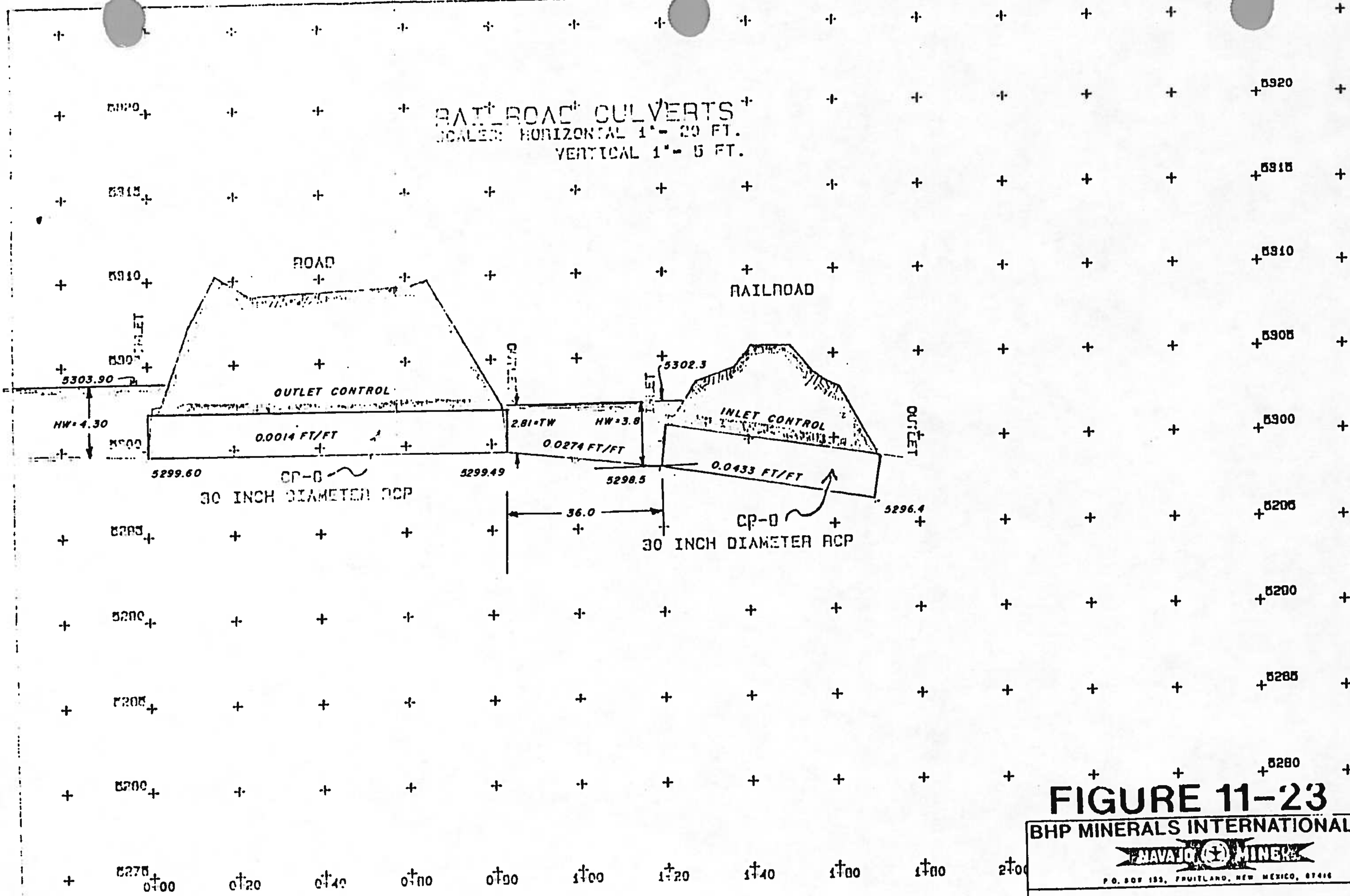

FIGURE 11-23

BHP MINERALS INTERNATIONAL INC

NAVAJO MINE

P.O. BOX 155, FRUITLAND, NEW MEXICO, 87416

RAILROAD CULVERTS CP-8 AND CP-9 CROSS-SECTION

REV. NO.	DATE	REVISIONS	DRAFT BY	ENGR.	LINE MGR.	PROJECT MGR.
1	10/92	Midterm Permit Reviw	PF	[illegible]	GAP	RCV

DRAWN BY PF | SCALE AS SHOWN
APPROVED BY | DATE NOV. 10, 1992 | FIG.
DRAWING NO. | LOCATION NO.

11.5.6.2.3 Railroad Maintenance

Railroad maintenance will consist of railroad track repairs, rail testing, maintaining drainage control structures, and maintaining access roads. The railroad shall be inspected periodically and repairs will be made to areas found defective or unsafe. The inspection will include the railroad track, drainage controls structures, and roads along the railroad. The overhead catenary system will be inspected on a monthly basis. The steel rail will be routinely tested and maintained according to the test results. All drainage control structures along the railroad will be maintained to ensure that no adverse condition that maybe harmful to the environment will arise. Structures will be inspected after each major storm event, any adverse conditions identified will be corrected. The railroad access road will be maintained as outlined in Section 11.5.6.1.6 of this chapter.

11.5.6.2.4 Railroad Static Stability

The majority of the alignments are located on original ground with the exception of four embankments. The railroad has two major embankments with culverts: the Chinde Wash and the Up-Dip Barber Railroad embankments.

The Chinde Wash embankment (Big Fill) has a static safety factor of 1.5. See Permit NM-0003C, CHAPTER 34, APPENDIX 34-D for a copy of the report on this certification. Figures 5 and 6 of this report were done by two different consulting firms with several years time between each drawing. Figure 5 was drawn by Terratech in 1973 and referenced by Steffen, Robertson and Kristen (SRK) in their 1985 report. SRK drew Figure 6 for their report and the minor differences between figures 5 and 6 reflect only the different approach each author utilized. Both drawings and the analyses performed by the two consultants resulted in nearly identical factors of safety for the structure (see APPENDIX 34-D, page 34-D-15). A Seismic Stability Analysis for the Big-Fill was performed by SRK in 1987. The summary concluded based on a design horizontal acceleration of 0.08g, the safety factor of the fill, against failure under earthquake loading, generally exceeds 1.2. This is considered adequate for the stability of the fill. The findings report can be found in Permit NM-0003C, CHAPTER 29, APPENDIX 29-E.

The drop structure at the Chinde Wash embankment (Big Fill) will receive periodic maintenance following major precipitation events. Riprap, sized to pass a 10 yr-6 hr flow, has been placed on filter fabric so as to prevent erosion. The riprap is comprised of an appropriate gradation of particle sizes. All remedial measures recommended by SRK were completed in 1985 (see Permit NM-0003C, CHAPTER, APPENDIX 34-D).

The Up-Dip Barber Railroad embankment has a minimum safety factor of 4.4. See Permit NM-0003C, CHAPTER 34, APPENDIX 34-F for the safety factor determination and the laboratory test results for the embankment.

Two additional embankments impound water along the railroad. These embankments are Lowe Embankments No. 1 and No. 2 and are located along the railroad just north of the Lowe Pit Coal Stockpile in Area III. Both embankments contain small surface water runoff from the Lowe haulroad and spoil storage areas. A stability analysis was conducted in 1987 by Western Technologies Inc. Results on the largest of these embankments reported a static safety factor of 3.4. A copy of the analysis is found in Permit NM-0003C, CHAPTER 29, APPENDIX 29-C.

11.5.6.2.5 Removal and Reclamation of Railroads

The Navajo Mine railroad shall remain in use for the life of the mine. The railroads shall be removed and reclaimed as outlined in CHAPTER 12, Section 12.3.3.

11.5.7 Water and Air Quality Control Facilities

Water quality control facilities at Navajo Mine consist of:

1) numerous sediment ponds, sewer ponds, and/or pond systems, as discussed in Sections 11.5.4 and 11.2.10,

2) the use of alternate sediment control across the mine site, as discussed in Section 12.6.5, and

3) the use of diversions and berm/ditch systems to contain water within or divert water away from areas disturbed by mining activities, as discussed in Sections 11.5.4, 11.5.5, and 11.2.10.

Various water monitoring stations are monitored by Navajo Mine personnel to help identify the effectiveness of these control facilities, as discussed in CHAPTERS 6 and 7.

Air quality control facilities at Navajo Mine consist of the dust suppression system in place at the coal plant, as discussed in Section 11.2.8.

11.6 PROBABLE HYDROLOGIC CONSEQUENCES

11.6.1 Summary of Probable Hydrologic Consequences

This Section provides a detailed assessment of the probable hydrologic consequences of mining activities to surface and groundwater. The results and conclusions presented are based on baseline groundwater and surface water information contained in CHAPTERS 6 and 7, respectively.

Literature sources for this study include published and unpublished reports, papers, and data authored or developed by several state and federal natural resource management agencies. Reports published by private consultants and academic institutions were also used. Site-specific data were developed through drilling, monitor/piezometer well installations, and pump testing as described in CHAPTER 6. Additional data were provided from past geological investigations and from observations made by BHP staff during the day-to-day operations of the mine.

Water quality parameters will be monitored to confirm predictions made in the PHC and reported to the regulatory authority as outlined in CHAPTERS 6 and 7.

11.6.1.1 Groundwater

Probable hydrological consequences of mining activities upon the quality and quantity of groundwater are negligible. As discussed in Section 11.6.2.2, groundwater quality is expected to generally improve (metal concentration usually decreases while sulfate values increase) when natural groundwater is exposed to spoil. When groundwater travels through the coal seams, additional attenuation of some chemical species is also seen, further reducing the potential impact of mining on regional groundwater quality. Mining activities are not expected to have a degradation effect on any principal aquifer (Section 11.6.2.3). Impacts to the San Juan River water quality due to groundwater affected by mining are expected to be so small as to be unmeasurable (Section 11.6.2.4).

The quantity of groundwater available is also expected to be essentially unchanged. As discussed in Section 11.6.2.5, a slight drop in local water tables is expected while the pits are open. Following mining, recharge to the aquifer along the disturbed zone is expected to increase.

Mining activities will not disrupt a developed water source (Section 11.6.2.5). Groundwater quality in the Fruitland Formation is naturally poor and production is so low, that regional use is virtually nonexistent (CHAPTER 6).

The collected baseline and monitoring data was used to describe and evaluate the geologic setting of the mine and the occurrence of groundwater at the mine with respect to mining operations and potential groundwater quality impacts. Based on drilling and excavation activities, only the Quaternary Alluvium, the coal seams and inter-bedded lithologic units of the Fruitland Formation, and the Pictured Cliffs Sandstone bear appreciable amounts of water within the mine area. Water level determinations from mine area monitor and piezometer wells are discussed in CHAPTER 6.

Estimates of groundwater flow velocities, projected travel times, and volumes of groundwater flow were calculated for the evaluations of potential spoil leachate transport. These analyses were compared with the results of the Leach study (APPENDIX 11-K) to determine the effect of potential leachate transport to groundwater from CCB and spoil disposal.

No acid forming or toxic materials are present in the spoil or CCB as demonstrated by the toxicity tests in APPENDIX 11-K. Characterization investigations conducted on CCB disposal at Navajo Mine contained in APPENDIX 11-K demonstrate that no degradation effects will occur to post-mine groundwater. In addition, analysis of solid samples of spoil and CCB indicate that, except for boron, the two materials have similar parameter concentrations.

TABLE 11-14

COMPARISON OF NATURAL GROUNDWATER QUALITY BEFORE AND AFTER LEACHING THROUGH A SPOIL MIXTURE

Parameter		Groundwater (Composite 5) (see Table 27.B2 in APPENDIX 11-K)	Composite 3 Leached through Spoil S-3 (see Table 27.B17 in APPENDIX 11-K)	Percent Change
Acidity	mg/l CaC03	1	1	0
Alkalinity	mg/l CaC03	940	860	- 9
Chloride	mg/l	2000	320	- 84
Cyanide	mg/l	0.02	0.02	0
Fluoride	mg/l	1.3	2.2	69
Nitrate	mg/l N03	11	12	9
pH		9.5	8.3	- 13
Phenolics	mg/l	0.02	0.01	- 50
Residue	mg/l	4600	4800	4
Specific Conductance		8100	6840	- 16
Sulfate	mg/l	55	1800	3173
Aluminum	mg/l	1.7	0.1	- 94
Arsenic	mg/l	0.017	0.003	- 82
Barium	mg/l	2.5	0.037	- 99
Boron	mg/l	0.42	0.5	19
Cadmium	mg/l	0.0015	0.001	- 33
Calcium	mg/l	140	110	- 21
Chromium	mg/l	0.034	0.005	- 85
Cobalt	mg/l	0.017	0.012	- 29
Copper	mg/l	0.04	0.02	- 50
Iron	mg/l	5.6	0.08	- 99
Lead	mg/l	0.08	0.03	- 63
Magnesium	mg/l	11	19	73
Manganese	mg/l	0.7	0.26	- 63
Mercury	mg/l	0.0002	0.0002	0
Molybdenum	mg/l	0.007	0.007	0
Nickel	mg/l	0.04	0.01	- 75
Potassium	mg/l	12	16	33
Selenium	mg/l	0.02	0.02	0
Silver	mg/l	0.0085	0.002	- 76
Sodium	mg/l	1600	1300	- 19
Zinc	mg/l	0.09	0.05	- 44
Total Dissolved Metals	mg/l	1774.275	1446.137	- 18

CCB disposal does not adversely effect post-mine groundwater quality. The chemical effect is dominantly a small change in the major ion chemistry (i.e., changes in sulfate and sodium concentrations), as opposed to any degradation or harmful changes in groundwater quality. Furthermore, spoil will likely cause similar or greater changes in post-mine water chemistry than CCB disposal.

Navajo Mine well data collected from historic CCB disposal on pre-law and interim lands (Supplemental Groundwater Study (SGS), APPENDIX 11-MM) support the leach study conclusion of no degradation effects to groundwater. Conclusions reported in these two Navajo Mine studies (Leach and SGS) are further supported by independent research (U.S.G.S.) at other western surface coal mines.

CCB disposal locations and techniques are described in Section 11.2.5.1.

11.6.1.2 Surface Water

A slight decrease in surface water availability is expected due to the improved infiltration of topdressing materials placed on badlands areas (Section 11.6.3). Surface water quality is expected to be at least as good as it was before mining as a result of the revegetation practices outlined in Section 12.6.

Ephemeral surface flows are unpredictable and of such poor water quality, that essentially no use is made of the water for agricultural or other purposes (CHAPTERS 6 and 7). Stock watering ponds are the principal use made of water on or near the permit area. Steps are taken to assure that this use is not impaired.

Sediment control measures, as outlined in Section 11.2.10, will prevent additional contributions of sediment to stream flow or to runoff outside the permit area. Sediment yield will thus not be adversely affected. Acidity, total suspended and dissolved solids and other important water quality parameters will not be adversely affected by mining activities. See APPENDIX 11-K, TABLE 11-14 and Section 11.6.3 for details.

11.6.2 Assessment of Potential Groundwater Quality Impacts

The assessment of potential impacts to groundwater quality on any potential receptors caused by Navajo Mine mining operations was evaluated using a groundwater and surface water leach transport study. The study (APPENDIX 11-K) contains information on natural groundwater and surface water quality and presents water quality changes when surface water and groundwater is leached through representative spoils, fly ash, bottom ash, and mixtures of ash and spoil.

Baseline data used to determine transport mechanisms for post-mine groundwater is contained in Chapter 5, - Geology and Chapter 6 - Groundwater. This information includes aquifer characteristics, regional hydrology information, and geology.

11.6.2.1 Groundwater Quality Impacts due to Spoil

Laboratory analyses of Fruitland Formation coal seam water and spoil leachate indicate that these waters are relatively poor in quality. Both water types exceed the New Mexico Quality Control Commission (NMQCC) standards and criteria for groundwater for fluoride, chloride, sulfate, and total dissolved solids. Table 14, from the leach study, shows natural groundwater quality and the change in water quality when it is passed through the spoil mixture.

In most cases, when groundwater is exposed to spoils, the overall quality improves. In general, most metal concentrations, such as iron, decrease after exposure to spoil. When groundwater containing low sulfate levels interacts with the spoil, sulfate levels increase. Laboratory data suggest that colloidal hydroxides are formed when the spoils and water interact. This intimate interaction and mixing facilitates the adsorption and precipitation of metals, thus reducing their concentrations.

The attenuation data from the leach study showed that the concentrations of many parameters would be reduced after contact with the coal seam. The results of these reductions or retardation factors indicate that a contaminant plume would not migrate through the coal seam at the same rate that water migrates.

The No. 2-3, No. 4-6, No. 7, and No. 8 Coal Seams at Navajo Mine were identified as the major units capable of transporting leachate out of the mining area. Groundwater movement within these seams, even under worst-case conditions, is no greater than 0.076 feet per day. Based on this flow rate, the shortest time of travel for leachate-affected groundwater from the northern most portion of the mine to a potential receptor point (San Juan River) was estimated to be about 200 years. Retardation factors for specific chemical species suggest that contaminants will lag behind this flow rate by at least an order of magnitude.

When the coal seams and inter-bedded lithologic units of the Fruitland Formation are treated as a single aquifer, groundwater movement, under worse case conditions, was 0.06 feet per day. Based on this flow rate, and worse case assumptions, the shortest time of travel for leachate affected groundwater from the northern most portion of the mine to reach the San Juan River was estimated to be 240 years.

The travel time for groundwater from the permit area will be considerably greater. Not only is travel time long, but the quantity of leachate-affected groundwater that could reach any potential receptors is relatively small even under worst-case conditions. The flow rates are four orders of magnitude (10^{-4}) smaller than those found in the San Juan River under extreme low-flow conditions. Thus, this potentially affected groundwater would have no measurable impacts on San Juan River water quality.

Potential future use of groundwater within the reclaimed mine is negligible, due to the low permeability of the spoil and poor water quality. In addition, the use of groundwater from bedrock units near the mine is limited, due to the low permeability and poor water quality historically encountered in these units.

While wells completed in the Quaternary Alluvium of the San Juan River Valley could potentially intercept leachate-affected groundwater received from the coal seam alluvium contact, the dilution of this groundwater by recharge from the San Juan River to the alluvium will greatly reduce the impact of this addition.

In comparison, the estimated worst-case flow contribution of coal seam leachate to mean annual flow in the San Juan River rates was determined to be 0.000002:1.0. For the historical low flow in the San Juan River, this ratio is raised only to 0.0005:1.0. Thus, even when historical low flows in the San Juan River are considered, the dilution rate for leachate-affected groundwater would still be very high.

When the coal seams and inter-bedded lithologic units of the Fruitland Formation are treated as a single aquifer, the estimated worse case flow contribution of leachate-affected groundwater to mean annual flow in the San Juan River was determined to be 0.000074: 1.0.

11.6.2.2 Groundwater Impacts due to CCB Disposal

The probable hydrologic consequences resulting from pit disposal of CCB at Navajo Mine is no degradation in the quality or quantity of post-mine groundwater. This probable consequence of CCB disposal is the result of review and analysis of data collected from Navajo Mine and outside sources. The data reviewed includes results of laboratory analysis on parameter concentrations of the ash, leachate tests, water quality and quantity data from Navajo Mine ash and coal wells, aquifer transmissivity tests. A literature review was also completed.

Groundwater transport mechanisms discussed above for spoil are similar for the transport of CCB leachate. Consequently, the analysis and discussion that follows focuses on potential changes to post-mine groundwater chemistry due to CCB disposal.

Parameter concentrations (mg/kg) of a solid matrix of CCB and of spoil disposed of at Navajo Mine are presented in Table 14a and 14b (Taken from the APPENDIX 11-K, Tables 27-B3 and 27-B4). The only notable parameter differences with the spoil are that fly ash has elevated concentrations of boron, and slightly higher concentrations of selenium and barium. For the remainder of the trace metals, the concentrations of spoil, fly ash and bottom ash are similar. Both bottom ash and fly ash have lower concentrations of sulfate, sodium and calcium when compared to spoil.

Fly ash and bottom ash are not classified as hazardous wastes. Solid samples of fly ash, bottom ash and spoil were subjected to the Extraction Procedure (EP) Toxicity Test and the extract from this procedure was subsequently analyzed for a suite of metals and general chemistry. The results (APPENDIX 11-K, Table 27.B11) were all below the limits for EP toxicity used to classify a material as toxic.

Table 14c is a comparison of surface and groundwater concentrations before and after they have been leached through different solid mixtures of spoil. The water chemistry of the leaching groundwater or surface water that was used is also presented for further comparison. The data presented in Table 14c was selectively obtained from data tables contained in Appendix 11-K. Several general relationships are evident from Table 14c for both ground and surface water follow.

1. Surface water leached through fly ash or bottom ash had lower TDS than when leached through either spoil S-4 or S-5 and is similar to the original concentration of the surface water (pre-leach).

TABLE 11-14a
ASH ANALYSIS SUMMARY
(TABLE 27-B3, APPENDIX K)

PARAMETER	UNIT	ASH	
		FLY ASH (No sludge)	BOTTOM ASH
Acidity[1]	mg/kg $CaCO_3$	<100[3]	397
Alkalinity[1]	mg/kg $CaCO_3$	11,577	2,976
Chloride	mg/kg	100	124
Cyanide	mg/kg	0.20	0.22
Fluoride	mg/kg	176	81
Nitrate[1]	mg/kg No_3-N	<1	2
pH		NA[2]	NA
Phenolics	mg/kg	1.29	1.36
Residue:			
Filterable @ 180 °C	mg/kg	NA	NA
Specific Conductance @ 25 °C	µmhos/cm	NA	NA
Sulfate[1]	mg/kg SO_4^{-2}	1,667	<100
Metals:			
Aluminum	mg/kg	6,600	2,000
Arsenic	mg/kg	11	0.38
Barium	mg/kg	850	420
Boron	mg/kg	160	10
Cadmium	mg/kg	0.4	<0.1
Calcium	mg/kg	12,000	3,000
Chromium	mg/kg	5	<1
Cobalt	mg/kg	2	1
Copper	mg/kg	0.063	0.023
Iron	mg/kg	5,300	2,100
Lead	mg/kg	26	<1
Magnesium	mg/kg	530	150
Manganese	mg/kg	99	32
Mercury	mg/kg	0.2	<0.1
Molybdenum	mg/kg	<6	<6
Nickel	mg/kg	2	<1
Potassium	mg/kg	162	44
Selenium	mg/kg	6.5	<2[4]
Silver	mg/kg	<0.2	<0.2
Sodium	mg/kg	430	84
Zinc	mg/kg	13	5

(1) Water leachable.
(2) NA – not analyzed.
(3) < - Less than.
(4) Higher detection limits due to matrix interference.

TABLE 11-14b
SPOILS AND OVERBURDEN ANALYSIS SUMMARY
(TABLE 27-B4 APPENDIX K)

PARAMETER	UNIT	S–1	S–2	S–3	S–4	S-5	D-1	D-2
Acidity(1)	mg/kg $CaCO_3$	399	299	197	399	298	399	398
Alkalinity(1)	mg/kg $CaCO_3$	3,293	3,693	3,945	3,593	3,777	7,186	3,877
Chloride(1)	mg/kg	250	150	246	200	248	399	149
Cyanide	mg/kg	0.17	1.18	0.20	0.25	0.20	0.08	0.20
Fluoride	mg/kg	471	463	420	575	503	403	332
Nitrate(1)	mg/kg NO_3-N	29	16	12	20	24	15	20
pH		NA(2)	NA	NA	NA	NA	NA	NA
Phenolics	mg/kg	1.09	1.19	1.09	1.18	1.05	0.90	1.98
Residue:								
Filterable @ 180 °C	mg/kg	NA	NA	NA	NA	NA	NA	NA
Specific Conductance @ 25 °C	µmhos/cm	NA	NA	NA	NA	NA	NA	NA
Sulfate	mg/kg SO_4^{-2}	8,982	7,236	6,410	12,724	6,610	1,946	3,529
Metals:								
Aluminum	mg/kg	8,100	7,400	5,500	6,600	6,600	9,200	6,200
Arsenic	mg/kg	6.5	6.0	36	17	4.3	4.5	4.6
Barium	mg/kg	180	42	130	520	150	110	120
Boron	mg/kg	9	8	4	<3(3)	4	<3	<3
Cadmium	mg/kg	1.0	0.9	1.1	0.9	0.8	1.1	0.9
Calcium	mg/kg	16,000	17,000	7,9000	9,500	27,000	14,000	11,000
Chromium	mg/kg	3	3	2	3	3	6	6
Cobalt	mg/kg	7	7	8	7	9	7	6
Copper	mg/kg	11	6	6	15	9	10	0.143
Iron	mg/kg	14,000	13,000	39,000	27,000	14,000	20,000	18,000
Lead	mg/kg	35	32	58	35	32	42	72
Magnesium	mg/kg	2,900	3,100	2,300	2,100	2,900	4,100	6,200
Manganese	mg/kg	200	200	360	190	470	350	250
Mercury	mg/kg	<0.1	<0.1	0.2	0.8	<0.1	0.2	0.2
Molybdenum	mg/kg	<6	<6	<6	<6	<6	<6	<6
Nickel	mg/kg	10	9	13	10	13	10	9
Potassium	mg/kg	1,100	1,400	906	1,200	1,400	903	801
Selenium	mg/kg	<1(4)	<2(4)	<2(4)	<2(4)	<2(4)	<1(4)	<1(4)
Silver	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Sodium	mg/kg	2,600	2,700	2,700	3,500	2,700	2,900	1,400
Zinc	mg/kg	66	63	58	71	69	63	56

(1) Water leachable.
(2) NA – not analyzed.
(3) < - Less than.
(4) Higher detection limits due to matrix interference.

Table 11-14c

Selective Results of Batch Leach Tests

Comparison of leaching water (surface water from Chinde Wash and groundwater from Coal seam #4-6) and leachate water produced (Data from IT Corporation Leach Report, Appendix 11-K, Tables 27.B13 through 27B.29) (Concentrations in milligrams per liter).

Water Source	PH	TDS	Ca	Na	Cl	Sulfate	Fe	Mn	B	Se	As	Cd
Surface Water from Chinde Wash	7.8	1,900	230	280	15	1,200	0.45	0.08	0.31	<0.001	<0.001	<0.001
SW Leachate:												
Spoils S-4	7.8	4,600	640	850	43	2,700	0.06	0.7	<0.5	0.20	0.002	<0.001
Spoils S-5	8.2	3,500	320	750	27	2,300	0.02	0.26	<0.5	0.018	0.002	<0.001
Fly Ash	12.2	2,000	290	380	16	590	0.02	0.02	1.0	0.09	0.009	<0.001
Bottom Ash	8.5	2,000	260	330	22	940	0.03	0.07	<0.5	0.046	<0.001	<0.001
Ash w/ S-4	7.7	5,300	670	850	37	3,200	0.02	1.4	<0.5	0.018	<0.003	<0.001
Ash w/ S-5	8.1	4,500	550	800	29	3,000	0.08	0.39	<0.5	0.010	<0.003	<0.001
Groundwater from coal seams 4-6 (Composite #4)	8.2	9,800	140	3,500	5,200	120	0.15	0.03	0.53	0.011	0.015	0.001
GW Leachate:												
Spoils S-4	7.8	12,000	730	3,200	5,500	2,700	0.06	0.7	<0.5	0.20	0.002	<0.001
Spoils S-5	8.2	11,000	530	3,200	5,600	2,300	0.02	0.26	<0.5	0.018	0.002	<0.001
Fly Ash	12	10,000	520	3,000	5,600	320	0.02	0.02	6.2	0.22	0.017	<0.001
Bottom Ash	8.5	8,700	170	3,500	5,500	170	0.03	0.07	0.6	0.020	<0.001	<0.001
Ash w/ S-4	7.9	12,000	790	3,100	5,700	2,000	0.04	1.3	<0.5	0.016	0.009	<0.001
Ash w/ S-5	7.9	12,000	740	3,700	5,600	2,000	0.09	0.64	0.9	0.009	0.008	<0.001

2. Concentrations in the surface water leachate for boron and selenium increased when leached through fly ash. However, the levels of boron declined when leached through a mixture of ash and spoil, and the increased selenium concentrations are similar to the selenium concentrations in leachate produced by spoil alone. The iron concentration in both surface and groundwater decreased following leaching through spoil, CCB, or a mixture of the two.

3. Leachate produced from mixtures of ash and spoil has a lower TDS and lower trace metal concentrations than natural groundwater from coal seam #4-6.

4. In general, the leachates produced do not widely differ from that of coal seam groundwater. TDS concentrations in the leachate have increased (except for bottom ash, which had a lower TDS than the groundwater) due to increases in sulfate, calcium and chloride concentrations. However, the increased TDS concentration is small in comparison to the original concentration of the coal groundwater.

5. Trace metal concentrations are similar for all the leachates produced, with the exception of fly ash alone, which increased boron concentrations. However, boron concentrations in groundwater leached through a mixture of ash and spoil are similar to the original concentration of the groundwater

The leach study predicts that in the event CCB should contact groundwater, regardless if the water originates from coal seam groundwater or infiltrating surface water, no degradation to post-mine groundwater should occur. The leach study concludes that the spoils are capable of retarding the movement of metals in water. Specifically, levels of metals such as barium, iron, selenium and lead decreased in some cases. Geochemical processes postulated as responsible are adsorption; the high cation-exchange-capacity (CEC) measured in the spoil, and precipitation.

Data collected during the Supplemental Groundwater Study (SGS) (APPENDIX 11-MM) provide a field confirmation of laboratory predictions made in the leach study. The purpose of the SGS was to investigate possible impacts to groundwater from previous CCB disposal at Navajo Mine. The investigation was accomplished by installing six groundwater-monitoring wells in and around ash and spoil disposal areas in Bitsui pit. The wells were monitored quarterly for static water levels and water quality.

Results from the SGS and more recent monitoring indicate that parameter concentrations are similar for water derived from an ash well when compared to water derived from a spoil well. Monitoring data has recorded elevated levels of boron in well Bitsui-1. Bitsui-1 is screened in ash and has approximately a fifty-foot column of water in the well. No other parameters in Bitsui-1 are elevated relative to the down gradient spoil wells (Bitsui-4, Bitsui-5, and Bitsui-6). TDS concentrations in Bitsui-4, Bitsui-1, Bitsui-6 are similar. A complete summary of data from the SGS, including summary statistics, time verse concentration plots, and trilinear diagrams is in APPENDIX 11-MM.

Elevated levels of boron from Bitsui-1 compare favorably with lab results and predictions made in the leach study for surface and groundwater leached through fly ash. The lack of elevated constituents in surrounding Bitsui spoil monitoring wells, particularly boron, confirms predictions that geochemical processes within the spoil are attenuating metals migration and thus limiting the extent of effects from saturated CCB.

A recent USGS report on the effects of coal mining in Montana on water quality documents that as spoil water migrates through an unmined coal aquifer, TDS concentrations may decrease. Clark (1995) reports that at the Decker Mine, TDS concentrations decreased from 4,100 milligrams per liter (mg/l) to 2,100 mg/l along a flow path from a spoils aquifer to a down gradient coal aquifer. Geochemical processes postulated as responsible for the decrease in TDS are sulfate reducing bacteria, reverse cation exchange of sodium for calcium, and precipitation of carbonate and iron-sulfate minerals.

The determination of no significant impact to post-mine groundwater from CCB disposal is based on laboratory and field studies conducted at Navajo Mine. The primary basis for this conclusion relies upon the basic chemical characteristics of the CCB. CCB are similar in chemical composition to spoil with the exception that fly ash has greater concentrations of boron, selenium and barium. EP Toxicity tests conducted on CCB determined that the material is not a hazardous substance. Leachate studies and well monitoring verified changes in water chemistry due to contact with spoil and CCB and that boron levels can increase within the ash alone. However, the studies also verified that attenuation processes active in the spoil could reduce metal concentrations, particularly boron.

If sufficient post-mine groundwater does contact the CCB in a large enough volume to migrate, significant geochemical processes occurring along the migration flow path will likely diminish the concentration of any elevated metals, such as boron. The same geochemical processes as discussed above for spoil leachate (Section 11.6.2.2.1) may also reduce the salt load carried by the post-mine groundwater. The small volume and slow rate at which post-mine groundwater migrates toward a receiving water (i.e., San Juan River) will prevent detection of any effects down gradient.

In the unlikely event that groundwater does saturate CCB, the probable result is that concentrations of boron may increase and that the overall chemistry of the major ions will likely change. However, as this water migrates into spoil following contact with the CCB, boron concentrations are predicted to decrease due to attenuation. Other trace metal concentrations in groundwater are not predicted to increase. In fact, changes to the water chemistry are as much effected by spoil as by ash, particularly for infiltrating surface water.

This assessment, therefore, determined that the significance of potential groundwater quality impacts of mining operations is minimal based on the following.

1. The estimated quality of leachate from mine spoil relative to the existing poor groundwater quality in units directly contacted by the mine.

2. The apparent chemical attenuation (retardation) potential of the spoils and coal seams.

3. The low velocity of flow in the coal seams.

4. Regardless of whether CCB disposal is wet or dry, no degradation to post-mine groundwater will occur.

5. The relatively benign nature of CCB.

6. Groundwater will not be significantly degraded should CCB actually contact groundwater.

7. The high potential for dilution of any leachate-affected groundwater received by the San Juan River and San Juan River Valley alluvial aquifer. Under a worst case condition of post-mine groundwater discharge to a potable receiving water, impacts will be so small as to be unmeasurable due to attenuation processes and slow flow rates.

11.6.2.3 Potential Migration of Spoil Leachate in Groundwater

During mining operations, all strata overlying the Fruitland coal seams are stripped to expose the coal for mining. As mining operations proceed, each cut is successively backfilled with spoil for reclamation.

The coal seams and inter-bedded lithologic units of the Fruitland Formation are the only laterally extensive water-bearing unit to be directly disturbed by mining operations. During mining operations, each successive open cut will serve as a source of drawdown for water in the overlying formations.

The ten to twenty-five foot thick layer of shale separating the bottom of the lowest mineable coal seam and the Pictured Cliffs Sandstone (see CHAPTER 6) acts to isolate groundwater in the Pictured Cliffs from mining activities. To date, no noticeable upward seepage through the shale or significant disruption of the mine floor (shale layer) has been observed in the pits, even though some of the pits are significantly below the projected potentiometric levels that are found in the Pictured Cliffs Formation. In the area of the Navajo Mine, the Pictured Cliff Sandstone was found to yield very small quantities of poor quality water. It is, therefore, unlikely that leachate will enter the Pictured Cliffs Sandstone and should it occur, the potential for the transport of leachate and significant degradation of water quality in this unit would be extremely small.

Because the coal seams will be disrupted by mining activities and spoil materials placed in the reclaimed mine areas will directly abut the coal seams at the limits of the mine cuts, the coal seams and inter-bedded lithologic units of the Fruitland Formation are considered to be the water bearing units of principal concern, with respect to potential groundwater quality impacts of mining.

11.6.2.3.1 Present Flow Conditions in Coal Seams of the Fruitland Formation

To evaluate the potential effects of the mine spoil on groundwater in the coal seams and inter-bedded lithologic units of the Fruitland Formation, the flow characteristics of this unit were determined. Groundwater flow conditions in the coal seams and inter-bedded lithologic units of the Fruitland Formation were determined from water level data obtained from a system of monitor/piezometer wells installed by BHP in the individual coal seams during the summer of 1983 and 1984 and from surrounding wells (see CHAPTER 6). From these data, potentiometric maps (shown in EXHIBITS 6-2 through 6-5) were constructed.

Based on an analysis of these potentiometric surface maps, coal seam groundwater occurs primarily under confined conditions within the mine area. Nearly all of the North Area and Area II Seams were found to be dry, with minor occurrences of water only near eastern and northern lease boundaries. In the southern part of Area III, all but the No. 8 Coal Seam was found to be saturated throughout most of the permit area.

Discharge locations for the No. 8 Coal Seam included the outcrop (subcrop) locations in the San Juan River Valley to the north and Cottonwood Arroyo Valley to the south, and down dip towards the center of the San Juan Basin where the groundwater flow joins the regional flow to the north. Discharge from the No. 7 Seam appears to be at Cottonwood Arroyo to the south and down dip; however, very flat flow gradients were found. Discharge from the No. 4-6 and No. 2-3 seams is principally at the Cottonwood Arroyo stream valley and down dip towards the middle of the San Juan Basin where it also joins the regional flow north to the San Juan River.

The subcrop of the No. 8 Seam beneath the San Juan River Valley Alluvium occurs at elevations below the water levels in the coal seam to the south. Based on the direction of flow indicated by the potentiometric map for Coal Seam No. 8, this subcrop could serve as a discharge point for this coal seam. However, no significant seeps or springs have been observed to date along the exposure of the No. 8 Coal Seam in the San Juan River Valley north of the mine.

Discharge from the coal seam may also occur as leakage into the units which are above or below the Fruitland Formation. Because of the significant thickness of shale, mudstone, and siltstone which overlies the coal seam as the upper portion of the Fruitland Formation and the lower shale member of the Kirtland Shale, upward leakage through these units is in all probability very small and occurs only down dip from the mine. The layer of shale below the main coal seam (No. 8) also serves to restrict inter-flow between the coal seam and the Pictured Cliffs Sandstone. This conclusion is supported by observations made during mining, as discussed earlier. Potential discharges of coal seam water to the Pictured Cliffs would be limited from further downward migration by the extensive thickness of shale and other low permeability materials in the Lewis Shale which is below the Pictured Cliffs.

11.6.2.3.2 Structural Effects on Groundwater Flow

Small scale faults and related structural features were discovered during mining and drilling operations within the mine lease area. The effect of these small scale warps and faults on vertical permeability of the coal seam and the hydraulic interconnection between strata at the mine is not known. Because strata in the area of the mine have not been intensively folded and faults in the strata tend to be limited in displacement and extent, vertical permeability between strata is probably limited by the lithologic composition of the strata. The presence of perched groundwater conditions within the coal seams and the absence of water in adjacent units supports this assertion. A more detailed analysis of the hydrogeologic effects of the various minor structural features found at the mine are presented in CHAPTER 6.

11.6.2.3.3 Postmining Flow Conditions

Following the completion of mining activities, the last cuts will be backfilled with mine spoil. These filled mine pits may then begin to receive contributions of groundwater from their contacts with the coal seams at the periphery of the reclaimed pits, and from the alluvial subcrops to the west. Due to high evapotranspiration rates, surface water percolation into the reclaimed spoil is expected to be negligible, though higher than pre-mine conditions. This conclusion is supported by infiltration studies by Stone (1984, 1986, 1987), which indicate that surface recharge rates for reclaimed areas are approximately 0.003 inches per year. Pit inflow modeling studies at mines adjacent to the Navajo Mine indicate that water levels in the backfilled mine blocks generally rise at a rate of less than one foot per year as a result of inflow received from the coal seams (San Juan Coal Company, 1982; San Juan Coal Company, 1983).

Based upon laboratory determinations, the hydraulic conductivity or permeability for compacted backfilled spoil is in the range of 3.5 to 5.4 x 10^{-6} centimeter per second (APPENDIX 11-K). Uncompacted spoils are expected to have permeabilities similar to that of the Fruitland Formation as a whole. This conclusion is consistent with dragline spoils permeability information reported by Van Vost et al. (1976). Thus, the permeability of backfilled materials is approximately the same as that of the coal seams and interbedded lithologic units of the Fruitland Formation; i.e., 1.2 feet per day. As a result, groundwater flow through the mined out areas should be roughly equivalent to that which occurred in these areas before mining.

As water levels in the reclaimed mine areas rise with time, the pits will receive successively less inflow from the coal seams. After the water levels in the coal seams have sufficiently recovered, the coal will begin to receive leachate from the spoil as groundwater flows through the mine blocks. Rising water levels in the mine area will cause water within the reclaimed mine blocks to abut the undisturbed coal seams and interbedded lithologic units of the Fruitland Formation at the periphery of the mine. The flow rate through the Fruitland Formation is described in detail in CHAPTER 6.

After significant recovery has occurred in the coal, the area discharge and recharge points to the north and south of the mine should serve as the principal controls to flow in the Fruitland coal seams. Due to the probable absence of a confining layer, water table conditions will ultimately be attained in the reclaimed pits.

11.6.2.3.4 Potential Rate of Spoil Leachate Transport

To evaluate the potential water quality impact of spoil on the coal seams and on the interbedded lithologic units of the Fruitland Formation, conceptual models for leachate transport were used. The first conceptual model considered flow and discharge rates in the coal seams and hydrologic relationships of the coal seams to receptor points as a means of assessing leachate transport. This model entails the simplification of the coal seam flow system for calculation purposes. These simplification measures can be expected to bias the calculated outcome to over predict leachate transport. Estimates of hydraulic variables and physical relationships used for the model are based on presently available data. Where known variability exists in a given input value, the value selected for computations represents the highest or lowest reasonable value providing an over prediction (or conservative estimate) of potential leachate migration.

Based on tests conducted by BHP, the permeability of the coal seams appears to be very low and somewhat variable in the area of the mine. The permeability is primarily attributable to cleating and small scale fracturing of the coal. To provide a conservative estimate of flow in the coal seam, favoring higher flow and leachate transport rates, the highest value of hydraulic conductivity determined was used for the purposes of calculating flow towards potential receptor points.

11.6.2.3.4.1 North Area

No. 8 Coal Seam

As stated in CHAPTER 6, flow in the No. 8 Coal Seam is generally towards the east (down dip) and towards major discharge points (e.g., San Juan River). Most of the permit area is dry with limited saturated areas on the eastern permit boundary and to the north. For the purpose of this evaluation, it is assumed that groundwater will extend throughout all areas where only partial saturation currently exists and that flow will take place in one direction, towards the formation contact in the San Juan River alluvial aquifer (see FIGURE 11-24). By assuming this hydrologic scenario, a worst-case conceptual model is obtained.

The most northern portion of the mine area, where spoils will be placed, is approximately 6,000 feet from the formation contact with the San Juan River alluvial aquifer. Based on the highest estimates of groundwater velocity (0.076 feet per day) and assuming that the leachate will take the shortest path of travel, it is estimated that about 216 years would be required for leachate emanating from the most northern area of the mine to reach the coal seam contact with the San Juan River. Travel time from the permit area will be considerably greater as the nearest portion of the permit area is an additional 20,000 feet from the most northern portion of the mine area. As seen from FIGURE 11-24, the distance of flow from the most southern spoil area is about 43,000 feet. This distance corresponds with a leachate travel time to the San Juan alluvial aquifer of about 1,568 years.

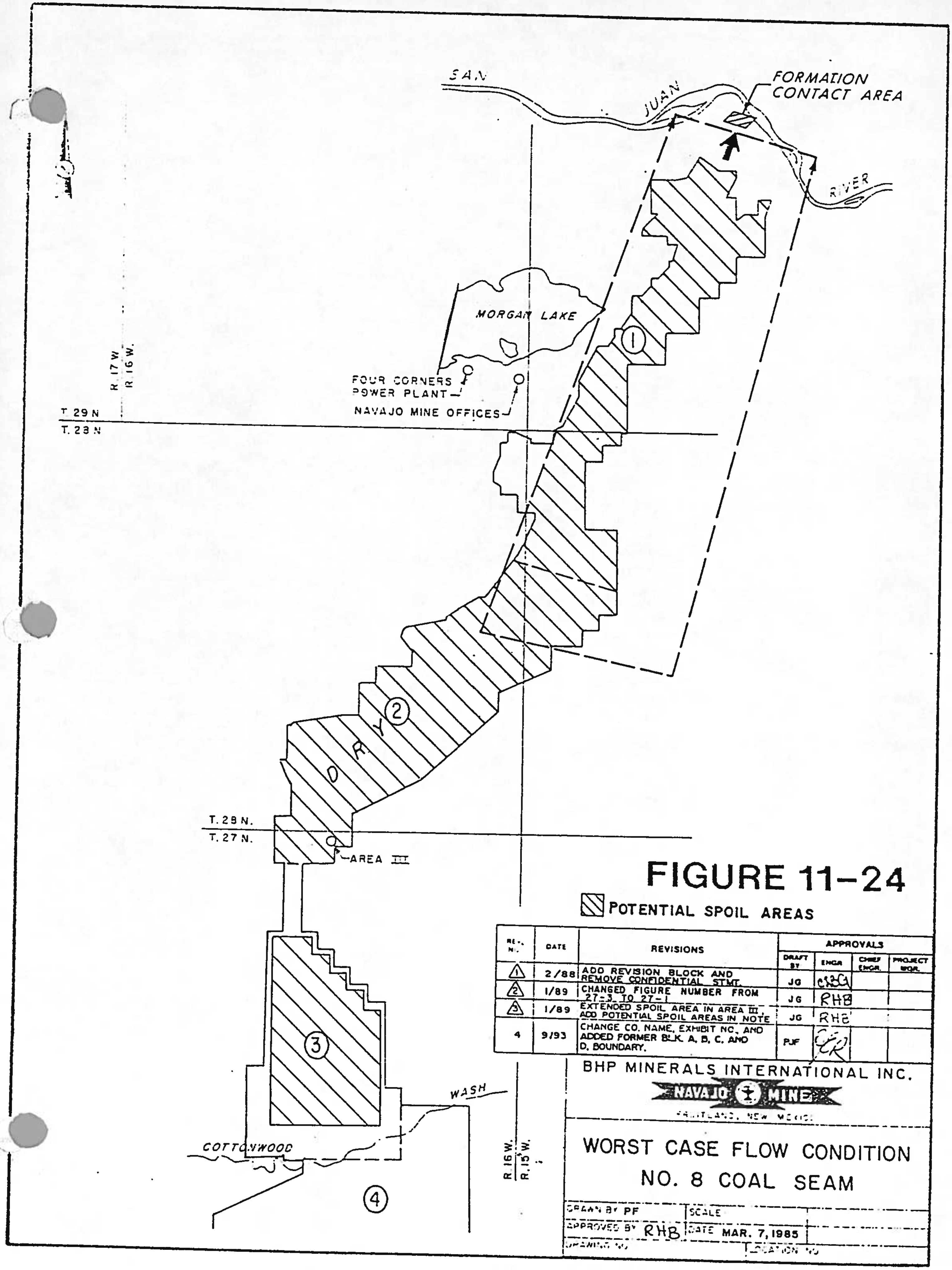

FIGURE 11-24

POTENTIAL SPOIL AREAS

REV. NO.	DATE	REVISIONS	DRAFT BY	ENGR.	CHIEF ENGR.	PROJECT MGR.
1	2/88	ADD REVISION BLOCK AND REMOVE CONFIDENTIAL STMT.	JG	CJBG		
2	1/89	CHANGED FIGURE NUMBER FROM 27-3 TO 27-1	JG	RHB		
3	1/89	EXTENDED SPOIL AREA IN AREA III, ADD POTENTIAL SPOIL AREAS IN NOTE	JG	RHB		
4	9/93	CHANGE CO. NAME, EXHIBIT NO. AND ADDED FORMER BLK. A, B, C, AND D. BOUNDARY.	PJF	[illegible]		

BHP MINERALS INTERNATIONAL INC.

NAVAJO MINE

FRUITLAND, NEW MEXICO

WORST CASE FLOW CONDITION
NO. 8 COAL SEAM

DRAWN BY PF	SCALE	
APPROVED BY RHB	DATE MAR. 7, 1985	
DRAWING NO.	LOCATION NO.	

No. 4-6 Coal Seam

The No. 4-6 Coal Seam is only partially saturated within the permit area. These saturated areas are restricted to Area III and the extreme eastern permit boundary of mid-Area II. As discussed in CHAPTER 6, the No. 4-6 unit pinches out entirely in the southern portion of the North Area. Flow from this seam is then encompassed in that of the interbedded lithologic units of the Fruitland Formation. Flow from the entire formation is considered in Section 11.6.2.3.4.3.

11.6.2.3.4.2 Areas II-III

In Area II, the No. 8 Coal Seam was not found to contain water within the permit area. Because of this fact, no transport of water will occur and no hydrologic impact assessment is needed.

As discussed in CHAPTER 6, the No. 8, 7, 4-6, and 2-3 Coal Seams all exhibit extremely low permeabilities and flow velocities. Travel times for all these units from the extreme southern portion of Area III, assuming that leachate will take the shortest path of travel towards Cottonwood Arroyo located in Area IV North, are in excess of 1,000 years.

11.6.2.3.4.3 Coal Seams and Interbedded Lithologic Units Treated as a Single Aquifer

When the coal seams and interbedded lithologic units of the Fruitland Formation are treated as a single aquifer, the potential migration of spoil leachate in groundwater is found to be similar to that predicted using No. 8 Coal Seam (i.e., flow rates were found to be 0.06 feet per day). Travel time, using the formation as a whole, from the northern most point on the mine to the San Juan River was found to be at least 240 years. See CHAPTER 6 for a complete discussion.

11.6.2.4 Potential Direct Impact to the San Juan River

In order to evaluate the potential impact of leachate on the San Juan River and its associated alluvial aquifer, the volume of flow received from the mine area by the river valley alluvium, and ultimately, the river was evaluated. As discussed earlier, the contact area between the San Juan alluvial aquifer and the No. 8 Coal Seam can be considered as a primary discharge point. Little is known about how much coal seam water from the mine area currently discharges at the seam outcrop along the walls of the San Juan River Valley and at the seam contact with river alluvium. In actuality, most of the water flowing through the mine area may not discharge directly north to the river valley but rather continue down dip toward the center of the San Juan Basin and then join the regional flow to the north.

In the interest of arriving at a conservative estimate of leachate discharge to the alluvial aquifer and river, it is assumed that all coal seam groundwater which flows through the mine area will produce spoil leachate and that all of this leachate will enter the alluvial aquifer at the coal seam-alluvium contact. Given that the general direction of flow is to the north and that the lateral extent of the mine perpendicular to this flow direction is approximately 5,500 feet (as shown in FIGURE 11-24), the discharge of spoil leachate to the alluvium can be estimated using the following equation:

$$Q = v . N_e . L . M$$

where:

Q = Estimated discharge of spoil leachate-affected groundwater from the mine to the alluvial aquifer (ft^3/year)

v	=	Velocity of groundwater in the main coal seam = 27.7 ft/yr
N_e	=	Effective porosity of the coal seam = 0.05
L	=	Lateral extent of the mine normal to the general direction of flow in the coal seam = 5,500 ft
M	=	Estimated average thickness of the coal seam in the southern area of the mine = 18 ft

Substitution values:

Q = [27.7 ft/year] . [0.05] . [5,500 ft] . [18 ft] or,

Q = 137,300 ft^3/yr or 3.1 acre/ft/yr

Based on the gross overestimation used in calculating the yearly production of leachate-affected groundwater to the alluvial aquifer, it is felt that the actual value of leachate inflow will be considerably less. The results of these calculations, nonetheless, demonstrate that the annual production of leachate-affected groundwater to the river valley is small, especially when compared to the average flow in the San Juan River.

Groundwater contributions to the San Juan River Valley alluvium from bedrock sources are reported to be small (Stone et al., 1983). Historical low flow discharge reported for the San Juan River at the Farmington and Shiprock, New Mexico gauging stations (14 and 8 cfs, respectively) (Stone et al., 1983) during the period of record (1935 to present) support this contention. In addition, relatively low values of specific conductivity for wells completed in the river valley alluvial aquifer in the area of the mine suggest that poor quality water from bedrock sources is not a major source of recharge to this aquifer.

Mean discharge for the San Juan River at the Farmington and Shiprock gauging stations is reported as 2,370 and 2,175 cubic feet per second, respectively (Stone et al., 1983). In relation to the conservative estimate of spoil leachate discharge to the alluvial aquifer and San Juan River from the coal seam, stream flows are very large. Using the mean flow of the San Juan River at the Shiprock station (as a conservative estimate for the San Juan River near Waterflow, New Mexico) the ratio of the estimated discharge of spoil leachate-affected groundwater from the coal seam to average discharge in the San Juan River is:

$$R = \frac{Q_c}{Q_r}$$

Where:

Q_c = Estimated discharge of spoil leachate-affected groundwater from the main coal seam to the San Juan River = 137,300 ft^3/yr

Q_r = Mean annual flow in the San Juan River at the Shiprock Station = 2,175 $ft^3/sec \times 3.1536 \times 10^7$ sec/yr = 6.86×10^{10} ft^3/yr

$$\text{or} \quad R = \frac{137{,}300 \ ft^3/yr}{6.86 \times 10^{10} \ ft^3/yr} = 2.00 \times 10^{-6}$$

If the historical low discharge of 8 ft^3/sec or 2.52×10^8 ft^3/yr at the Shiprock gauging station is used, the ratio becomes:

$$R = \frac{137{,}300 \ ft^3/yr}{2.52 \times 10^{8} \ ft^3/yr} = 5.45 \times 10^{-4}$$

Given the calculations, the potential contribution of leachate-affected groundwater to the San Juan River flow, even under extreme low-flow conditions, will be extremely small. Based on the laboratory determinations of leachate quality and chemical interactions (attenuation potentials) and the flow calculations, affected groundwater will have no significant effect on the quality of water in the San Juan River.

Spoil leachate-affected groundwater could also possibly reach wells completed in the San Juan River Valley alluvium, especially in the vicinity of the coal seam alluvium contact. The impact, if any, of leachate-affected groundwater reaching these wells will be negligible because the majority of recharge received by this aquifer, in the area of the mine, comes from the San Juan River itself.

When the coal seams and interbedded lithologic units of the Fruitland Formation are treated as a single aquifer, the direct impact to the San Juan River is found to be negligible. The estimated worse case flow contribution of leachate-affected groundwater to mean annual flow in the San Juan River was determined to be 0.000074:1.0. The impact from this small contribution is expected to be unmeasurable. See CHAPTER 6.

11.6.2.5 <u>Assessment of Potential Groundwater Quantity Impacts</u>

The potential impact of mining activities on groundwater quantities are addressed in detail in CHAPTER 6. In that analysis, a three dimensional model was used to evaluate hydrologic consequences due to stress propagation from pit inflow. The analysis showed that the stress propagation resulted in minimal impacts to the hydraulic regime as drawdowns of only two to three feet were computed near the mine area for the coal seams and interbedded lithologic units of the

Fruitland Formation. The Pictured Cliffs Sandstone unit is projected to see a drawdown of less than 0.005 feet. The effects of mining on the water bearing strata decrease by orders of magnitude within a few miles of the mine area.

Average inflow to the entire mine area is projected to be approximately 239 acre-feet per year over a total simulation time of 12 years. This volume is predominately from storage with only minor contributions (4 acre-feet) from captured surface flows. Actual field experience indicates that this figure is probably very generous as none of the pits collect sufficient groundwater to form puddles or ponds which must be pumped to facilitate mining. The pit floors remain dry except on rare occasions when surface flows are captured. It is assumed that bedrock groundwater inflows to the mine are minor and primarily consumed by evaporation from the highwall.

Postmine surface recharge to the aquifers through the regraded spoils is expected to be greater than pre-mine recharge, by approximately 80 to 100 percent (Stone, 1987).

11.6.2.6 Assessment of Impact on Adjacent Groundwater Users

Wells located on or near the permit area are shown on FIGURE 11-25. No use is made of BHP's wells located on or near the permit except for taking water measurements. Other wells which could be impacted by mining are located to the east and north of the permit area. Wells located to the west and south will not be impacted as the groundwater flows near the mine go east and then turn north, joining the regional pattern.

Evaluation of the wells whose water quality could potentially be affected will proceed on a case by case basis. Numbers 70, 93, and 91 (FIGURE 11-25) of Township 26N, Range 16W are non-BHP wells to the east of the permit boundary. All three are alluvial, hand dug wells. They will not be affected as their source of water is derived from a formation geologically above those potentially impacted by contamination (i.e., Kirtland/ Fruitland Formation and Pictured Cliffs Sandstone). Numbers 38, 44, and 46 are several miles east of the permit boundary located in Township 27N, Range 15W. Number 46 is an alluvial, hand dug well and cannot be impacted. Numbers 38 and 44 derive their source of water from the Pictured Cliffs Sandstone. Water quality has caused 38 to be abandoned and 44 to be classified unfit for human consumption. Numbers 51 and 41 (Township 28N, Range 15W), are several miles east of the permit boundary, and both have been abandoned . Based on the velocity calculations above, they can be ruled out for further evaluation. Number 149, in the southeast corner of Township 29N, Range 15W, appears to be a test well installed by Public Service Company of New Mexico. Between the mining area and the San Juan River of Township 29N, Range 15W, there exist only three non-BHP wells with associated beneficial uses (numbers 54, 56, and 146). Wells north of the San Juan River are not considered, as the San Juan acts as an aquifer discharge point in this vicinity (CHAPTER 6). Number 146 is an alluvial well, approximately 28 feet deep. Ownership and usage is unknown, but the well appears to be attached to a windmill. Numbers 54 and 56 are springs owned by the Navajo Nation. It is unknown whether the springs are currently flowing. Spring 56 appears to derive its source from the Pictured Cliffs Sandstone, which has a permeability lower than the Fruitland Formation. Consequently, migration rate through the Pictured Cliffs would be less than the 0.06 feet/day as computed above. Spring 54

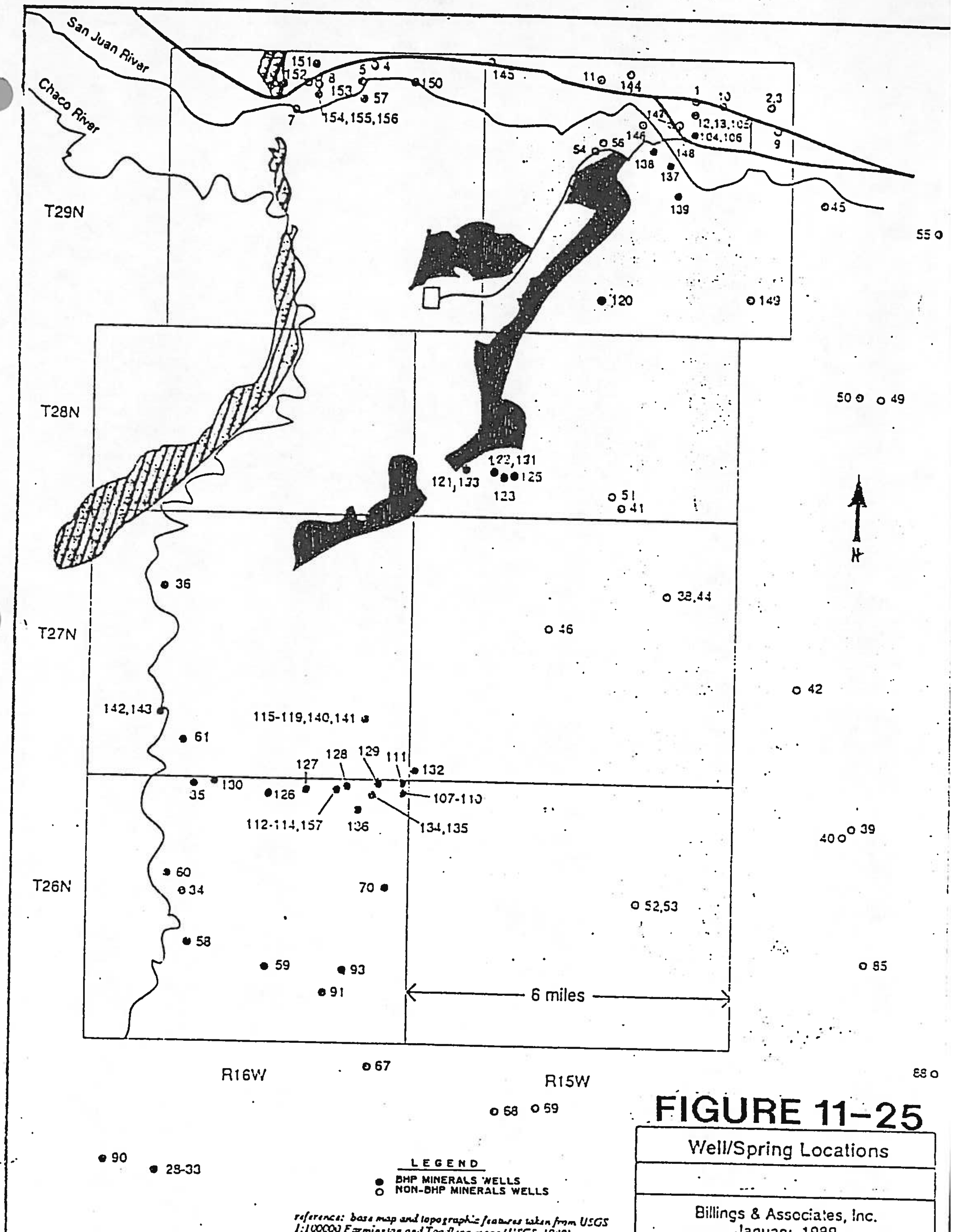

FIGURE 11-25

Well/Spring Locations

Billings & Associates, Inc.
January, 1989

surfaces from a terrace, and the ultimate water source is unknown. Uses for both springs include domestic, stock and/or irrigation, with a total dissolved solids ranging from 600 to 700 mg/L.

Thus, over the vast majority of the permit boundary area, the only wells that could be potentially affected by BHP activities are BHP wells. Given that the BHP wells are for monitoring purposes, any potential impact to these wells does not preclude their use. The database and analysis identify three locations (numbers 54, 56, and 146) within the range of potential contaminant migration, if the source of water was derived from the Fruitland Formation. Given the recharge mechanisms and dilution capabilities of the alluvial fill of the San Juan River, potential impact to 146 is considered negligible. The ultimate source of water from Spring 54 is unknown. The source of water to Spring 56 is from the Pictured Cliffs Sandstone. Groundwater velocity through the Pictured Cliffs is estimated to be approximately 0.0003 feet/day (0.11 feet/year), based on an average gradient of 0.0038 ft/ft (CHAPTER 6), hydraulic conductivity of 0.007 ft/day, an effective porosity of 0.1, and use of the pore velocity equation presented in CHAPTER 6.

11.6.3 Probable Hydrologic Consequences - Surface Water

11.6.3.1 Introduction

Baseline surface water information is provided in CHAPTER 7. Postmine surface water drainage information is provided in Section 11.6.5 and 11.6.5.1. This subsection provides an assessment of hydrologic impacts related to mining and reclamation activities planned for the permit.

As discussed in CHAPTER 7, there are eight drainages within the Permit Area. These drainages are Bitsui Wash, Chinde Wash, Hosteen Wash, Barber Wash, Neck Arroyo, Lowe Arroyo, Cottonwood Arroyo, and Pinabete Arroyo. Each of these drainages has been or will be disturbed by mining activities. However, only a very minor portion of the Neck and Pinabete drainage basins will be disturbed by mining activities.

Peak Flow, runoff volume, sediment yield, and peak sediment concentrations were predicted for both pre- and postmine drainages for Chinde Wash, Hosteen Wash, Barber Wash, South Barber Drainage, Neck Arroyo, Lowe Arroyo, Cottonwood Arroyo and the tributaries to the Chaco Wash and Pinabete Arroyo that are projected to be disturbed. These estimates were developed using the SEDCAD+ modeling technique as described in CHAPTER 7. Pre-mine and undisturbed runoff curve numbers were developed from the soil cover complexes within each drainage. For areas disturbed by mining, an analysis of the available topdressing types and quantities was made (TABLES 11-15 and 11-16) to determine an appropriate curve number. This analysis indicated that, as a whole, the available topdressing material has a curve number close to that of the Shiprock Soil Complex "Sk" in TABLES 11-15 and 11-16. The curve number of reclaimed areas was based on this soil type.

The Probable Hydrologic Consequences (PHC) analysis also includes a geomorphic characterization and evaluation of reclaimed channels and surface topography. Dynamic equilibrium is the criterion under which reclaimed stream channels are evaluated. From a hydrologic perspective, postmining topography is evaluated on the basis of adequate drainage density.

TABLE 11-15
TOPDRESSING TYPES AND QUANTITIES (1)

Soil Mapping Unit Symbol	Soil Mapping Units	Percent of Map Unit (3)	Soil volume (Cubic yards) Area I	Area II	Area III	Area IV	Total	Title of SCS Soil Survey (4)	Hydrologic Group
Ba	Badland	-	0	0	0	0	0		
Bb (2)	Bacobi and	39	37,061	20,523	201,579	342,305	601,468	1	C
-	Monierco soils	61	57,967	32,101	315,290	535,401	940,759	2	D
Bc	Blancot	-	0	0	664,484	0	664,484	2	B
Bh	Blancot, very hard	-	0	0	307,680	0	307,680	2	B
Fa	Farb and Persayo Soils	-	8,024	83,158	0	161,922	253,104	2	D/D
Gr	Grieta	-	0	0	0	69,104	69,104	3	B
Jc	Jocity - Gilco	-	503,634	183,596	481,270	1,525,313	2,693,813	3	B/B
Jh	Jocity, very hard	-	0	0	103,722	46,339	150,061	3	B
Ma	Mack	-	0	0	1,433,038	176,992	1,610,030	5	C
Mn	Mayqueen	-	295,981	55,176	0	23,851	375,008	2	B
Ms	Mayqueen - Shiprock	-	421,971	341,951	614,672	333,565	1,712,159	2	B
Mv	Mayqueen - Shiprock, very hard	-	85,805	0	61,024	0	146,829	2	B
Na	Nakai	-	0	0	0	53,010	53,010	4	B
Nt	Natrargids	-	0	6,628	0	0	6,628	2	D
Nv	Natrargids, overblown	-	2,159	82,861	97,028	218,490	400,538	2	D
Ra	Razito	-	599,753	521,804	458,595	311,260	1,891,412	5	A
Rh	Razito, very hard	-	73,893	0	21,089	196,707	291,689	5	A
Rl	Redlands Variant	-	19,683	33,505	945,193	331,678	1,330,059	5	B
Rv	Redlands Variant, very hard	-	0	0	105,452	61,901	167,353	5	B
Sc	Shiprock	-	192,636	540,865	868,130	160,006	1,761,637	2	B
Sh	Shiprock, very hard	-	22,430	21,812	67,523	143,239	255,004	2	B
Sl	Shiprock - Blancot	-	278,724	0	23,813	0	302,537	2	B/B
Sv	Shiprock Variant	-	0	0	416,510	70,420	486,930	2	B
Sz	Stumble	-	0	0	15,596	105,082	120,678	2	A
Ta	Trail	-	0	23,210	0	0	23,210	5	A
Th	Trail, very hard	-	0	16,144	0	4,538	20,682	5	A
TOTAL:			2,599,721	1,963,334	7,201,688	4,871,123	16,635,866		

(1) This information was generated from Chapter 8 Soil Resources, Approved PAP for Navajo Mine.

(2) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(3) Percentages of each major mapping unit component were derived from Chapter 8.5.2 Soil Mapping Unit Descriptions, Approved PAP for Navajo Mine.

(4) 1= Soil Survey Coconino County, Arizona; 2= Soil Survey San Juan County, New Mexico, Eastern Part; 3= Soil Survey Sandoval County, New Mexico; 4= Soil Survey San Juan County, Utah; 5= Soil Survey Shiprock Area, Parts Of San Juan County, New Mexico and Apache County, Arizona.

TABLE 11-16

LAND TYPES AND CURVE NUMBERS

Land Use/Condition [1]	Curve Numbers for Hydrologic Groups [5]			
	A	B	C	D
Reclaimed Lands [2]	65	78	86	91
Undisturbed Lands [3]	65	78	86	91
NAPI Caltivated Lands [4]	67	78	85	89

(1) Land use/conditions and the associated curve numbers were taken from Ms. Pamela J. Schwab and Dr. Richard Warner (1987), "SEDCAD+ User's Manual", Civil Software Design, Table 5.3, pages 110-112.

(2) From reference (1) the land use/condition for reclaimed lands is between "Herbaceous" and "Desert Shrub", each with poor hydrologic condition. The curve numbers were determined by interpolating between the curve numbers associated with the two land use/conditions.

(3) The type of land use/condition for undisturbed areas will be identical to reclaimed lands (same curve numbers).

(4) The type of land use/conditions selected form reference (1) is "Row crops, Straight row" with good hydrologic conditions.

(5) The hydrologic group classification for the soil types will be obtained from the NRCS soil surveys.

TABLE 11-16A

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA I

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group [2]	Curve Number [3]	Weighted Value
Bb[1]	Bacobi and	37,061	1.43	C/	86.0	1.23
-	Monierco Soils	57,967	2.23	D	91.0	2.03
Bc	Blancot	0	0.00	B	78.0	0.00
Bh	Blancot, very hard	0	0.00	B	78.0	0.00
Fa	Farb and Persayo Soils	8,024	0.31	D/D	91.0	0.28
Gr	Grieta	0	0.00	B	78.0	0.00
Jc	Jocity - Gilco	503,634	19.37	B/B	78.0	15.11
Jh	Jocity, very hard	0	0.00	B	78.0	0.00
Ma	Mack	0	0.00	C	86.0	0.00
Mn	Mayqueen	295,981	11.39	B	78.0	8.88
Ms	Mayqueen - Shiprock	421,971	16.23	B/B	78.0	12.66
Mv	Mayqueen - Shiprock, very hard	85,805	3.30	B/B	78.0	2.57
Na	Nakia	0	0.00	B	78.0	0.00
Nt	Natrargids	0	0.00	D	91.0	0.00
Nv	Natrargids, overblown	2,159	0.08	D	91.0	0.08
Ra	Razito	599,753	23.07	A	65.0	15.00
Rh	Razito, very hard	73,893	2.84	A	65.0	1.85
Rl	Redlands Variant	19,683	0.76	B	78.0	0.59
Rv	Redlands Variant, very hard	0	0.00	B	78.0	0.00
Sc	Shiprock	192,636	7.41	B	78.0	5.78
Sh	Shiprock, very hard	22,430	0.86	B	78.0	0.67
Sl	Shiprock - Blancot	278,724	10.72	B/B	78.0	8.36
Sv	Shiprock Variant	0	0.00	B	78.0	0.00
Sz	Stumble	0	0.00	A	65.0	0.00
Ta	Trail	0	0.00	A	65.0	0.00
Th	Trail, very hard	0	0.00	A	65.0	0.00
Totals		2,599,721	100.00			75.09

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey.

(3) Curve number associated with the hydrologicl group classification was taken from Table 11-16 (reclaimed).

TABLE 11-16B

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA II

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group (2)	Curve Number (3)	Weighted Value
Bb(1)	Bacobi and	20,523	1.05	C/	86.0	0.90
-	Monierco Soils	32,101	1.64	D	91.0	1.49
Bc	Blancot	0	0.00	B	78.0	0.00
Bh	Blancot, very hard	0	0.00	B	78.0	0.00
Fa	Farb and Persayo Soils	83,158	4.24	D/D	91.0	3.85
Gr	Grieta	0	0.00	B	78.0	0.00
Jc	Jocity - Gilco	183,596	9.35	B/B	78.0	7.29
Jh	Jocity, very hard	0	0.00	B	78.0	0.00
Ma	Mack	0	0.00	C	86.0	0.00
Mn	Mayqueen	55,176	2.81	B	78.0	2.19
Ms	Mayqueen - Shiprock	341.951	17.42	B/B	78.0	13.59
Mv	Mayqueen - Shiprock, very hard	0	0.00	B/B	78.0	0.00
Na	Nakia	0	0.00	B	78.0	0.00
Nt	Natrargids	6,628	0.34	D	91.0	0.31
Nv	Natrargids. overblown	82,861	4.22	D	91.0	3.84
Ra	Razito	521,804	26.58	A	65.0	17.28
Rh	Razito, very hard	0	0.00	A	65.0	0.00
Rl	Redlands Variant	33,505	1.71	B	78.0	1.33
Rv	Redlands Variant, very hard	0	0.00	B	78.0	0.00
Sc	Shiprock	540,865	27.55	B	78.0	21.49
Sh	Shiprock, very hard	21,812	1.11	B	78.0	0.87
Sl	Shiprock - Blancot	0	0.00	B/B	78.0	0.00
Sv	Shiprock Variant	0	0.00	B	78.0	0.00
Sz	Stumble	0	0.00	A	65.0	0.00
Ta	Trail	23.210	1.18	A	65.0	0.77
Th	Trail. very hard	16.144	0.82	A	65.0	0.53
Totals		1.963,334	100.00			75.72

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey.

(3) Curve number associated with the hydrologicl group classification was taken from Table 11-16 (reclaimed).

TABLE 11-16C

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA III

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group [2]	Curve Number [3]	Weighted Value
Bb [1]	Bacobi and	201,579	2.80	C/	86.0	2.41
-	Monierco Soils	315,290	4.38	D	91.0	3.98
Bc	Blancot	664,484	9.23	B	78.0	7.20
Bh	Blancot, very hard	307,680	4.27	B	78.0	3.33
Fa	Farb and Persayo Soils	0	0.00	D/D	91.0	0.00
Gr	Grieta	0	0.00	B	78.0	0.00
Jc	Jocity - Gilco	481,270	6.68	B/B	78.0	5.21
Jh	Jocity, very hard	103,722	1.44	B	78.0	1.12
Ma	Mack	1,433,038	19.90	C	86.0	17.11
Mn	Mayqueen	0	0.00	B	78.0	0.00
Ms	Mayqueen - Shiprock	614,672	8.54	B/B	78.0	6.66
Mv	Mayqueen - Shiprock, very hard	61,024	0.85	B/B	78.0	0.66
Na	Nakia	0	0.00	B	78.0	0.00
Nt	Natrargids	0	0.00	D	91.0	0.00
Nv	Natrargids, overblown	97,028	1.35	D	91.0	1.23
Ra	Razito	458,595	6.37	A	65.0	4.14
Rh	Razito, very hard	21,089	0.29	A	65.0	0.19
Rl	Redlands Variant	945,193	13.12	B	78.0	10.24
Rv	Redlands Variant, very hard	105,452	1.46	B	78.0	1.14
Sc	Shiprock	868,130	12.05	B	78.0	9.40
Sh	Shiprock, very hard	67,523	0.94	B	78.0	0.73
Sl	Shiprock - Blancot	23,813	0.33	B/B	78.0	0.26
Sv	Shiprock Variant	416,510	5.78	B	78.0	4.51
Sz	Stumble	15,596	0.22	A	65.0	0.14
Ta	Trail	0	0.00	A	65.0	0.00
Th	Trail, very hard	0	0.00	A	65.0	0.00
Totals		7,201,688	100.00			79.67

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey.

(3) Curve number associated with the hydrologicl group classification was taken from Table 11-16 (reclaimed).

TABLE 11-16D

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA IV

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group (2)	Curve Number (3)	Weighted Value
Bb (1)	Bacobi and	342,305	7.03	C/	86.0	6.04
-	Monierco Soils	535,401	10.99	D	91.0	10.00
Bc	Blancot	0	0.00	B	78.0	0.00
Bh	Blancot, very hard	0	0.00	B	78.0	0.00
Fa	Farb and Persayo Soils	161,922	3.32	D/D	91.0	3.02
Gr	Grieta	69,104	1.42	B	78.0	1.11
Jc	Jocity - Gilco	1,525,313	31.31	B/B	78.0	24.42
Jh	Jocity, very hard	46,339	0.95	B	78.0	0.74
Ma	Mack	176,992	3.63	C	86.0	3.12
Mn	Mayqueen	23,851	0.49	B	78.0	0.38
Ms	Mayqueen - Shiprock	333,565	6.85	B/B	78.0	5.34
Mv	Mayqueen - Shiprock, very hard	0	0.00	B/B	78.0	0.00
Na	Nakia	53,010	1.09	B	78.0	0.85
Nt	Natrargids	0	0.00	D	91.0	0.00
Nv	Natrargids, overblown	218,490	4.49	D	91.0	4.08
Ra	Razito	311,260	6.39	A	65.0	4.15
Rh	Razito, very hard	196,707	4.04	A	65.0	2.62
Rl	Redlands Variant	331,678	6.81	B	78.0	5.31
Rv	Redlands Variant, very hard	61,901	1.27	B	78.0	0.99
Sc	Shiprock	160,006	3.28	B	78.0	2.56
Sh	Shiprock, very hard	143,239	2.94	B	78.0	2.29
Sl	Shiprock - Blancot	0	0.00	B/B	78.0	0.00
Sv	Shiprock Variant	70,420	1.45	B	78.0	1.13
Sz	Stumble	105,082	2.16	A	65.0	1.40
Ta	Trail	0	0.00	A	65.0	0.00
Th	Trail, very hard	4,538	0.09	A	65.0	0.06
Totals		4,871,123	100.00			79.65

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey.

(3) Curve number associated with the hydrologicl group classification was taken from Table 11-16 (reclaimed).

Dynamic equilibrium is the condition that exists when stream channels are neither aggrading or degrading over time. It does not mean there is no reworking of channel materials or change in channel geometry.

Drainage density is an integrative measure of drainage basin morphology. Drainage density is the length of stream channels per unit area within a drainage basin. The restoration of postmine drainage networks within the range of pre-mine drainage densities and configurations or regional norms will ensure that pre-mine geomorphic conditions are achieved.

Drainage densities are calculated by measuring the total stream length in miles and dividing that length by the drainage area in square miles. Pre-mining and postmining stream lengths were measured for the total drainage area of each stream as well as the area within the lease boundary only. U.S.G.S. 7.5 minute quadrangles were used to determine the pre-mining drainage densities. Postmining drainage densities were determined from the 1:6000 scale final surface configuration topography maps provided in CHAPTER 12.

The Chinde Wash and Cottonwood Arroyo are impacted by the activities of the Navajo Agricultural Products Industry located hydraulically upgradient from the mine. These impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. However, the impacts are similar to both streams with the exception that the Chinde is a perennial stream.

NAPI direct discharges are a result of an over supply of water in the canal that is released directly to the wash. Discharge events for both streams are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel. The indirect NAPI related discharges are a result of return flows to the wash caused by the infiltrating irrigation water. The irrigation return waters have changed the Chinde Wash into a perennial stream with a base flow containing greater dissolved –solids concentrations. The greater dissolved-solids concentrations are from irrigation return waters leaching the unconfined surface formations. The Cottonwood Arroyo is not impacted by perennial flows but increased mineralization is deposited on the stream banks as a result of seeps in the upper reaches that is down stream during precipitation flow events. The impacts of the NAPI activities on the baseline hydrologic balance of the Cottonwood Arroyo will be highly variable increases in the flow, discharge, and water quality concentrations of the channel's hydrologic balance. Moreover, these impacts increase the already highly variable hydrologic balance and further decrease the potential for post mining changes to the hydrologic balance as a result of mining. Quantitative data to characterize the NAPI impacts is being collected as part of the surface water monitoring plan.

The Surface Water PHC discussion is provided below for each major permit area drainage.

11.6.3.3 Chinde Wash

The present watershed area of Chinde Wash is about 42.4 square miles (27,130 acres). An additional 11 square miles does not contribute to the present Chinde watershed as it is diverted by NAPI's Ojo Amarillo canal into Cottonwood Arroyo. About 4.06 square miles of the Chinde Wash drainage basin is disturbed by mining activities. Chinde Wash increases in size by 1,124 acres primarily because of changes in the drainage divide between Hosteen Wash and Chinde Wash, and the drainage divide between Dodge Diversion and Chinde Wash.

Pre-mining drainage density of Chinde Wash was estimated to be 1.4 mi./sq. mile for the entire drainage area and 2.8-mi./sq. mile for the area disturbed by mining. Higher drainage density within the mine area reflects the greater relief in this area. Postmining drainage density for Chinde Wash is 4.7 mi./sq. mile over the area disturbed by mining. Both pre- and postmining drainage densities appear to be relatively low. However, the calculated drainage density is dependent upon the criteria for measuring drainage length. The criterion used in this analysis was to include only stream channels identified on the topographic maps. Thus, contour crenulations associated with badlands topography did not enter into the drainage density measurement.

These results indicate a higher postmining drainage density for the area disturbed by mining. This higher drainage density will be adequate to prevent gullies forming in light of the lower relief associated with the postmining surface. Final Surface Configuration designs weredeveloped in CHAPTER 12 (see Section 12.3, EXHIBITS 12-5A, 12-6A and 12-6B). For design of reclaimed channels, see Section 11.6.5.

The largest hydrologic change is in the Doby reclamation area where the westward drainages from the off lease undisturbed surface are diverted towards the south via a post-mine channel (Doby North Channel) that runs north to south along the eastern lease boundary. The pre-mine topography had no major channel; the surface sloped down towards the west with primarily sheet flow drainages and some small channels. The post-mine channel also collects surface runoff from a portion of the reclaimed surface to the west and diverts the flow into a tributary of the Chinde Diversion. Refer to Exhibit 11-85 and 12-5A for the location and alignment of the post-mine channel.

Comparison of SEDCAD4 predictions for pre- (see CHAPTER 7, APPENDIX 7-G) and postmining (see CHAPTER 11, APPENDIX 11-BB) flows and sedimentology from a 10-year, 6-hour event are provided in TABLE 11-17. Sediment yields for the 10-year, 6-hour event at the downstream outlet (Structure 24) are predicted to decline, despite an increase of 1,124 acres in watershed size postmining, from a pre-mining yield of 8,657 tons to a postmining yield of 8,159 tons. The predicted decreases in sediment yield are due to the lower slopes and better vegetation cover on reclaimed areas.

The peak flow resulting form a 10-yr., 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 715 cfs to a postmining estimate 705 cfs for Chinde Wash below the lease boundary (Structure 24).

The runoff volume was predicted to decline from 502 acre-feet, pre-mining, to 488 acre-feet, postmining. The postmining SEDCAD 4 modeling for the 10-yr., 6-hr event indicates that although the total sediment is less than the pre-mine, the peak sediment concentration (milligrams per liter, mg/l) and peak settleable concentration (milliliters per liter, ml/l) increased following mining. The peak sediment concentration increased from 50,387 mg/l to 77,099 mg/l and the peak settleable concentration from 4.16 ml/l to 13.24 ml/l.

Baseline water quality in Chinde Wash indicates concentrations that usually exceed drinking water standards (see CHAPTER 7). Postmining concentrations of sulfate, iron, manganese, and TDS parameters may actually decrease slightly due to better distribution of topsoil over the disturbed areas and lower concentrations of sediment in stream flows. However, any change would be marginal and chemical quality of surface water following mining would be expected to approximate pre-mining conditions.

TABLE 11-17
COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
CHINDE ARROYO
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0 Watershed Designation		**Pre-Mine**				**Post-Mine**				**Difference From Pre-Mine**			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S24	S24	27,130	715	8,657	0.3	28,254	705	8,159	0.3	1,124	-10	-498	0.0
S17 SW1	S17 SW1	1,100	34	141	0.1	824	40	66	0.1	-276	6	-75	0.0
S15 SW1	S15 SW1	595	43	92	0.2	600	26	45	0.1	5	-17	-47	-0.1
S11	S27	446	172	1,380	3.1	1,726	332	2,757	1.6	1,280	160	1,377	-1.5
S18 SW1	S18 SW1	146	10	24	0.2	120	10	15	0.1	-26	0	-9	0.0

11.6.3.3.1 Surface Water Gain/Loss in Chinde Wash

The results of a gain/loss study conducted from April 1999 through March 2000 are reported in Appendix OO, Chinde Wash Surface Water Gain/Loss Report. The synoptic, NAPI and continuous surface water monitoring data collected during the monitoring year for Chinde Wash records that during base flow and NAPI operational spills there is a net loss of surface water from the NAPI discharge point to Navajo Mine monitoring station CD-2A, a distance of nine miles. For example, on April 18, 1999, flow volume declined from 8.0 acre-feet at CD-1A to 0.5 acre-feet at CD-2A during a NAPI operational spill. Similar instances of flow volume decreases between CD-1A and CD-2A occurred throughout the year, such as on July 1, 1999 in which CD-1A recorded 11.11 acre-feet of volume and CD-2A recorded only 0.82 of volume for the same NAPI operational spill.

However, by dividing this nine mile reach into smaller reaches and measuring flow between these reaches, the reach (Reach 3) above the Yazzie highwall and upstream of reclaimed lands was identified as losing a significant amount of flow. In addition, the synoptic data documents that surface flows across reclaimed lands consisting of spoil (Reach 4) change very little and in fact are dominated by a slight increase. Thus, the conclusion of the report is that the effects of mining on surface water flow volumes both during and after mining are minimal.

Changes in surface flows are minimal in the regraded spoil reach (Reach 4) because spoil at Navajo Mine is comprised dominantly of sodic mudstone and siltstone that have a very low permeability. Synoptic monitoring identified that base flow increased across the reclaimed land during three measurements by 119 (202 to 321), 11 (0 to 11) and 49 (458 to 507) gpm and decreased during one measurement by 30 (115 to 85) gpm along Reach 4. Pit run spoil permeability was determined in the Leach Study (Chapter 11, Appendix K) to be 10^{-6} cm/sec (four samples that ranged from 1.66×10^{-6} to 5.4×10^{-6} cm/sec), which is a similar permeability to that of a compacted soil liner. Based on the data from the Chinde Gain/Loss Report and permeability values, future surface water losses along the permanent Chinde Wash diversion are expected to be negligible.

Losses of surface water from the NAPI discharge point to Navajo Mine monitoring station CD-2A are occurring above the Yazzie highwall due to a large and highly vegetated area upstream of the Yazzie highwall, and to a lessor extent due to seeps along the highwall itself immediately below the diversion. Synoptic monitoring recorded a decrease in flow of surface water during three measurements along Reach 3 for the first three-quarters of 772 (974 to 202), 283 (283 to 0) and 275 (390 to 115) gpm, respectively.

The effect that the large and densely vegetated area has on surface water flow is two-fold: 1) it reduces peak flows, and 2) it enhances surface water loss. Surface water losses occur due to the flows spreading out, creating a larger surface area for infiltration and evaporation. The extensive and dense vegetated area will consume water by transpiration during the majority of the year. In addition, un-quantified seeps have been observed on the Yazzie highwall face beneath the Chinde temporary diversion confirming that surface water is infiltrating in the vegetated area. The cumulative effects of these processes, without an additional source of incoming water, is to reduce the amount of available surface water for downstream flows

Following backfilling of Yazzie pit, the seeps on the face of the highwall beneath the temporary diversion will decrease significantly or stop due to the placement of low-permeability spoil against the highwall.

The continuous monitoring data also recorded that during large storm events, there is an increase in flow volume from CD-1A to CD-2A. This flow volume increase is typical of an ephemeral channel and is the result of increasing watershed size downstream. Specifically, the contributions of additional flow from tributaries progressively produce an increasing volume of flow downstream.

Synoptic flow measurements and continuous flow data collected and reported in the Chinde Gain/Loss Report (Appendix OO) have adequately characterized and documented gains and losses of surface water flows along specific reaches of Chinde Wash. In particular, the data collected support the conclusion that future reconstructed channels built in spoils will not significantly alter surface water flows due to vertical infiltration.

11.6.3.4 Hosteen Wash

The Hosteen Wash watershed area is about 9.1 square miles. Mining activities disturbs approximately 3.7 square miles of this drainage. The Hosteen Wash watershed will decrease in size by 1,271 acres postmining. This is largely a result of postmining changes in the drainage divide between Hosteen and Chinde Wash, in which Chinde Wash increases by 844 acres.

Pre-mining drainage density for Hosteen Wash was estimated to be 3.18-mi./sq. mile for the entire drainage area and 2.8-mi./sq. mile for the area disturbed by mining. Postmining drainage density for Hosteen Wash is 6.1 mi./sq. mile over the area disturbed by mining. These results indicate a higher postmining drainage density for the wash. This higher drainage density is to ensure that gullying would not develop on this watershed due to insufficient drainage.

Final Surface Configuration designs were developed in CHAPTER 12 (see Section 12.3, EXHIBITS 12-6A and 12-6B). For design of reclaimed channels, see Section 11.6.5. Drainage geometry and grade were selected to maximize stability without causing sediment deposition. Sediment deposition may produce local convexities as a result of the aggrading conditions in the channel. These convexities may develop headcuts and begin to erode.

With the postmining channel, some reworking of channel materials will occur, especially during the large flood events. However, channel aggradation or channel degradation would not develop within the reclaimed channel because the graded profile and channel dimensions will be designed to maintain dynamic equilibrium. See the Reclamation Surface Stabilization Handbook for information regarding the design of reclamation structures.

Comparison of SEDCAD 4 predictions for pre- (see CHAPTER 7, APPENDIX 7-A) and postmining (see CHAPTER 11, APPENDIX 11-CC) flows and sedimentology are provided in TABLE 11-18. This comparison indicates decreases in flow and sediment yields associated with postmining conditions. These predicted decreases are due to a reduction in the badlands area and a slightly lower curve number attributed to reclaimed areas.

The peak flow resulting from a 10-yr., 6-hr precipitation event is predicted to decline from a pre-mining estimate of 1,417 cfs (Structure 9) to a postmining estimate of 538 cfs (Structure 18) for the entire Hosteen drainage. The runoff volume was predicted to decline from 247 acre-feet, pre-mining to 126 acre –feet, postmining.

The SEDCAD 4.0 modeling for the 10-yr., 6-hr event indicates that the predicted peak sediment concentration for post-mining will decrease and the peak settleable concentration will increase. The peak sediment concentration decreased from 45,433 mg/l to 37,159 mg/l and the peak settleable concentration increased from 1.11 ml/l to 2.31 ml/l. The increase in peak settleable solids is attributable to replacement of pre-mining badland areas (clay-rich) with a postmining sandy loam soil. The clay rich areas will increase the suspended solids concentration, while sandy loam areas will decrease the suspended solids concentration and increase the settable solids (sand) concentration. The Sedcad analysis also indicates that the total sediment yield will decrease from a pre-mine yield of 8,658 tons to a post-mine yield of 3,400 tons.

TABLE 11-18
COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
HOSTEEN WASH
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0 Watershed Designation		Pre-Mine				Post-Mine				Difference From Pre-Mine			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S9	S18	5,833	1,417	8,658	1.5	4,518	538	3400	0.8	-1,316	-879	-5,258	-0.7
S2	S11	2,379	640	3,617	1.5	2,264	414	1843	0.8	-115	-226	-1,774	-0.7
S6	S15	1,964	668	3,655	1.9	818	64	181	0.2	-1,146	-604	-3,474	-1.6
S12SW1	S5SW1	279	144	479	1.7	240	15	30	0.1	-39	-129	-449	-1.6
S2SW2	S11SW1	146	79	259	1.8	213	13	31	0.1	67	-66	-228	-1.6
S6SW6	S14SW1	178	79	273	1.5	143	8	18	0.1	-36	-71	-255	-1.4
S6SW5	S13SW1	194	91	269	1.4	94	7	11	0.1	-100	-84	-258	-1.3
S12SW2	S6SW1	107	49	84	0.8	169	13	29	0.2	62	-36	-55	-0.6
S2SW1	S11SW2	203	25	49	0.2	86	14	34	0.4	-117	-11	-15	0.2
S13SW2	S9SW1	275	146	569	2.1	410	20	46	0.1	135	-126	-523	-2.0

Comparison of pre-mining and postmining flows and sediment yields resulting from a 10-yr., 6-hr precipitation event were performed separately for several sub-watersheds disturbed by mining within the Hosteen Drainage (TABLE 11-18). In all of the sub-watersheds compared, with one exception, the flows and sediment yields declined as a result of mining, even in subwatersheds that increased in size following mining.

Baseline water quality in Hosteen Wash should be similar to that of Chinde Wash because of the similar soils, geology and vegetation found within the basins (see CHAPTER 7). Postmining concentrations for sulfate, iron manganese and TDS should decrease slightly due to reduction of badlands area and better distribution of topsoil over the disturbed areas. Acid forming or toxic materials are not present in the drainage.

11.6.3.5 Barber Wash

The Barber Wash watershed area is about 5.3 square miles. Mining activities disturbs approximately 1.4 square miles of this drainage. Barber Wash will decrease in size by 849 acres postmining. This is largely due to post-mining topography changes at the drainage divide between the Barber and South Barber drainages, in which the South Barber drainage increases by 928 acres. The upper portion of the Barber drainage has the most significant change; approximately 928 acres will be diverted into the South Barber Channel (see Exhibits 7-4C and 11-75A).

Pre-mining drainage density for Barber Wash was estimated to be 1.75 mi./sq. mile for the entire drainage area and 1.46 mi./sq. mile for the area disturbed by mining. Postmining drainage density for Barber Wash is 6.7 mi./sq. mile over the area disturbed by mining.

These results indicate a higher postmining drainage density over the area disturbed by mining. The postmining drainage density may be greater than necessary to achieve a geomorphically stable topographic condition. The increased drainage density was deemed necessary to avoid excessive overland flow lengths. In the event the drainage network is too extensive for the associated flows and sediment yields, the drainage density would decrease where channel flows are insufficient to transport sediment yield from overland flow and upstream contributions. This may occur in the upper reaches of some channels. As these headwater channels fill with sediment, drainage density will decrease as the channel network approaches an equilibrium with the flow and sediment yield regime of the contributing watershed.

Final Surface Configuration designs were developed in CHAPTER 12 (see Sections 12.3, EXHIBITS 12-6A and 12-6B). For design of reclaimed channels, see Section 11.6.5. Drainage geometry and grade were selected to maximize stability without causing sediment deposition. Sediment deposition may produce local convexities as a result of the aggrading conditions in the channel. These convexities may in turn develop headcuts and begin to erode.

Comparison of SEDCAD 4.0 predictions for pre- (see CHAPTER 7, APPENDIX 7-B) and postmining (see CHAPTER 11, APPENDIX 11-DD) peak flows and sediment yields resulting from a 10-yr., 6-hr precipitation event are provided in TABLE 11-19. In all cases, the comparison indicates a decrease in flow and sediment yields associated with postmining conditions. These predicted decreases are due to a reduction in the badlands area and a lower curve number attributed to reclaimed areas.

The peak flow resulting from a 10-yr., 6-hr precipitation event was predicted to decline from a pre-mining estimate of 404 cfs to a postmining estimate of 284 cfs for the entire Barber drainage. The runoff volume was predicted to decline from 101 acre-feet, pre-mining, to 59 acre-feet, postmining.

The SEDCAD 4.0 modeling for the 10-yr., 6-hr event indicates that the predicted peak sediment concentration (milligrams per liter) for post-mine decreased compared to pre-mine, 24,586 mg/l for post-mine and 27,241 for pre-mine. Total sediment yields (tons) decreased for postmining conditions while the predicted settleable solid concentrations increased. The settleable solids concentration for the post-mine is 2.2 ml/l compared to the pre-mine concentration of 0.36 ml/l.

The change is attributable to replacement of premining badland areas (clay-rich) with a postmining sandy loam soil. The clay rich areas will increase the suspended solids concentration, while sandy loam areas may decrease the suspended solids concentration and increase the settable solids concentration.

The peak concentrations of suspended solids and settleable solids are only order-of-magnitude predictions, it is concluded that there should be no significant change between pre- and postmining in the peak concentrations of total suspended solids and total settleable solids. Sediment yields for the same event declined from a pre-mining yield of 1,672 tons to a postmining yield of 1,076 tons.

Baseline water quality in Barber Wash should be similar to Chinde Arroyo because of similar soils, geology and vegetation found within the basins (see CHAPTER 7). Postmining concentrations for sulfate, iron, and manganese should decrease slightly due to a reduction of badlands area and better distribution of topsoil over the disturbed areas. Acid forming or toxic materials are not present within the drainage.

11.6.3.6 Neck Arroyo

The Neck Arroyo watershed area is about 1.88 square miles. Approximately 14 percent of this drainage lies within the permit area, although mining disturbs about three percent of the drainage, while about one percent of the drainage will be directly disturbed by the location of roads.

It is possible that road crossings and rail crossings could slightly alter the flow and sediment equilibrium resulting in either temporary aggrading or degrading conditions to develop in the stream channel above or below the road crossing. After removal of the road crossing the affected channel reach will return to the approximate pre-mine condition. Acid forming or toxic materials are not present where they could contaminate water supplies within Neck Arroyo.

TABLE 11-23
COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
SOUTH BARBER DRAINAGE
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0 Watershed Designation		Pre-Mine				Post-Mine				Difference From Pre-Mine			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S2	S6	526	166	599	1.1	1,454	166	765	0.5	928	0	166	-0.6

TABLE 11-19
COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
BARBER WASH
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0 Watershed Designation		**Pre-Mine**				**Post-Mine**				**Difference From Pre-Mine**			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S2	S9	3,364	404	1,672	0.5	2,515	284	1,076	0.4	-849	-120	-596	-0.1
S7	S8	1,716	285	831	0.5	849	86	336	0.4	-867	-199	-495	-0.1
S6SW1	S5	678	175	503	0.7	437	23	44	0.1	-241	-152	-459	-0.6

Comparison of SEDCAD+ predictions for pre- (see CHAPTER 7) and postmining flows and sedimentology are provided in TABLE 11-20. This comparison suggests slight decreases in flow and sediment yields under postmining conditions. These decreases are due to the lower curve number attributed to reclaimed areas and also lower slopes and better vegetation cover on reclaimed areas.

TABLE 11-20

COMPARISON OF PRE- & POST MINING PEAK FLOWS AND SEDIMENT YIELDS
NECK ARROYO
10 - YEAR, 6 - HOUR PRECIPITATION EVENT

SEDCAD+ Subwatershed				Pre-mining		Postmining		Difference from Pre-mining	
J	B	S	SW	Flow (cfs)	Sediment (Tons)	Flow (cfs)	Sediment (Tons)	Flow (cfs)	Sediment (Tons)
1	1	1	1	31.18	348.00	30.79	343.69	-0.39	-4.31
1	1	1	5	31.38	402.34	27.52	361.50	-3.86	-40.84

The peak flow resulting from a 10-yr., 6-hr precipitation event was predicted to decline from a pre-mining estimate of 247 cfs to a postmining estimate of 244 cfs for the entire Neck drainage. Likewise, the runoff volume was predicted to decline from 39.0 acre-feet, pre-mining, to 38.7 acre-feet, postmining.

The SEDCAD+ modeling for the 10-yr., 6-hr event indicates that predicted peak concentration of total suspended solids increased slightly for postmining conditions even though peak settleable solids concentrations and sediment yields decreased. This slight increase in total suspended solid concentrations appears to result from numerical error associated with routing high concentrations of sediment in flood flows. Since the peak concentrations of suspended solids and settleable solids are only order-of-magnitude predictions, it can be concluded that there should be no significant change between pre- and postmining in the peak concentrations of total suspended solids and total settleable solids. Sediment yields for the same event declined from a pre-mining yield of 14,351 tons to a postmining yield of 14,284 tons.

Comparison of pre-mining and postmining flows and sediment yields resulting from 10-yr., 6-hr precipitation event were performed separately for each sub-watershed disturbed by mining within the Neck arroyo drainage (TABLE 11-20). In all cases, the flows and sediment yields remained the same or declined as a result of mining.

Pre-mining drainage density for Neck Arroyo was estimated to be 3.11 sq./mi. for the entire drainage area and should not change as a result of mining.

11.6.3.7 Lowe Arroyo

The Lowe Arroyo watershed area is about 11.25 square miles. Approximately four square miles of this drainage lies within the permit area. Final surface configuration and drainage designs have been developed as discussed in CHAPTER 12 (see Section 12.3) and Section 11.6.5.1.

Drainage geometry and grade were selected to maximize stability without causing sediment deposition. Such sediment deposition may subsequently develop headcuts and erode as local convexities in the channel develop as a result of aggrading conditions. With the postmining channel, some reworking of channel materials will occur especially during the large flood events. However, major channel aggradation or channel degradation would not develop within the reclaimed channel because the graded profile and channel dimensions are designed to maintain dynamic equilibrium. Channel instabilities could develop as a result of headcuts working upstream from changes in base level on Chaco Wash or the San Juan River.

The largest hydrologic change is the routing of undisturbed drainages east of the lease boundary. Premine, the drainages east of the lease formed the main branch of the Lowe channel which flowed east to west toward SEDCAD structure 10. In the postmine, these drainages are routed to the south initially before flowing west and north toward SEDCAD structure 11 (See pre- and postmine watershed maps for Lowe, Exhibits 7-4 & 11-77). As shown on Table 11-21, the watershed to structure 7 decreases by 1808 acres in the postmine while the watershed to structure 11 increases by 1584 acres. The outlet for the Lowe drainage is the same location (lease boundary) as the premine at structure 12.

The southern post mining drainage that flows to structure 11 differs from the premine channel alignment in order to accommodate a lower gradient in the reclaimed channel. The post mining drainage that flows to structure 10 has a similar alignment as the premine channel.

TABLE 11-21

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
LOWE WASH
10-YEAR, 6-HOUR PRECIPITATION EVENT

SEDCAD 4.0 WATERSHED DESIGNATION		Pre-Mine				Post-Mine				Difference From Pre-Mine			
Pre-mine	Post-mine	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S5	S5	386	55	76	0.2	2,074	317.93	1,071	0.5	1,688	263	996	0.3
S7	S7	2,087	382	1,132	0.5	279	38.37	63	0.2	-1,808	-344	-1,069	-0.3
S8	S6	609	96	166	0.3	2,599	371.51	1,279	0.5	1,990	276	1,113	0.2
S9	S9	541	241	1,005	1.9	341	124.17	416	1.2	-200	-117	-589	-0.6
S10	S10	4,659	735	2,431	0.5	6,798	490	2,811	0.4	2,139	-245	380	-0.1
S11	S11	1,846	129	246	0.1	3,430	329	1,313	0.4	1,584	200	1,067	0.2
S12 (Lease Line)	S12	7,046	926	3,682	0.5	7,139	514	3,227	0.5	93	-412	-455	-0.1
S13 (Outlet)	S13	7,855	919	3,951	0.5	7,945	527	3,426	0.4	90	-392	-525	-0.1

In the postmine, the Lowe watershed increases by 93 acres at the expense of Cottonwood Wash. This change in watershed acres occurs along the southern boundary between Lowe and Cottonwood drainages. The shifting of 93 acres from Cottonwood Wash to Lowe Wash will have no appreciable effect on the peak flows or sediment yields of either watershed due to their large size and reclamation practices.

Comparison of SEDCAD 4.0 predictions for pre-mining (see APPENDIX 7-D and APPENDIX 11-X) and postmining flows and sedimentology provided in TABLE 11-21 for a 10-year, 6-hour event. Overall there is a slight decrease in peak flow and sediment yields postmining. Sediment yields for the 10-year, 6-hour event at the downstream outlet (Structure 12, lease line) are predicted to decline, despite an increase of 93 acres in watershed size postmining, from a pre-mining yield of 3682 tons to a postmining yield of 3227 tons. The decline in sediment yields and peak flows is due primarily to a lower curve number resulting from reclaiming with sandy topsoil, better vegetation cover on reclaimed areas and terraces that reduce the slope lengths for the post-mine drainage. .

The peak flow resulting form a 10-yr., 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 926 cfs to a postmining estimate 514 cfs for Lowe Wash below the lease boundary (Structure 12). The runoff volume at structure 12 is predicted to decline from 238 acre-feet, pre-mining, to 192 acre-feet, postmining.

11.6.3.8 Cottonwood Arroyo

The Cottonwood Arroyo watershed area is about 80 square miles and approximately 14 percent of this drainage is within the mine lease area. The pre-mining watershed areas are shown on Exhibit 7-4A. The final surface topography and drainage configuration has been developed and is discussed in Section 11.6.5.1 and Chapter 12.3.

The primary hydrologic change to Cottonwood Wash is the disturbance of the North Fork of Cottonwood Wash. Approximately 10,662 feet of the North Fork will be permanently re-aligned from the pre-mine due to reclamation (See Exhibit 11-77). As noted in the discussion of Lowe Wash, the Cottonwood Wash watershed will slightly decrease from the premine but with no appreciable hydrologic effects.

Table 11-22 shows the comparison of flow and sediment yield for the 10-yr, 6-hr. precipitation event for portions of Cottonwood tributaries that drain the mined area and the outlet of Cottonwood Wash into Chaco Wash. The differences in sediment yields (tons/acre) and peak flow are negligible between pre and postmining at the lease line (structure 36). Sediment yields for the 10-year, 6-hour event at the downstream lease line are predicted to slightly decrease from a pre-mining yield of 30,644 tons to a postmining yield of 30,409 tons. The small changes in the sediment and peak flow figures reflect the small amount of mining disturbance in the Cottonwood watershed as a whole.

The peak flow resulting from a 10-yr., 6-hr precipitation event at the lease line is predicted to slightly decrease from a pre-mining estimate of 2,890 cfs to a postmining estimate 2,880 cfs. The runoff volume at structure 36 is predicted to decline from 1,473 acre-feet, pre-mining, to 1,384 acre-feet, postmining

TABLE 11-22

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
COTTONWOOD WASH
10-YEAR, 6-HOUR PRECIPITATION EVENT

The post mine is redacted from permit

The Difference is redacted from permit

SEDCAD 4.0 WATERSHED DESIGNATION		Pre-Mine				Post-Mine				Difference From Pre-Mine			
Pre	Post	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S21	S21	13,492	1,561	13,076	1.0	13,332	1,527	13,029	1.0	-160	-34	[illegible]	0.0
S34	S34	18,191	674	7,939	0.4	18,279	565	8,049	0.4	88	[illegible]	110	0.0
S36 (lease line)	S36	49,221	2,890	30,538	0.6	49,104	2,880	30,409	0.6	-117	-10	-129	0.0
S37(Outlet)	S37	51,430	2,854	30,543	0.6	51,173	2,831	30,586	0.6	-257	-22	43	0.0

Pages 11-193 to 11-196

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11.6.3.9 San Juan River and Chaco River

The San Juan River Basin covers an area of about 12,900 square miles. Approximately 0.2 percent of this drainage lies within the permit area. The Chaco River has a watershed area of 4,350 square miles. The mine permit area occupies about 0.6 percent of the total drainage area.

The San Juan River and Chaco River channels and flood plains will not be directly impacted by mining activities. The only possible impact on these rivers would be through the discharge of surface or groundwater from the mine area or from reclaimed surface and backfill.

The Chaco River does not receive groundwater base flow and thus would not be impacted by changes in groundwater quality. A relatively small amount of groundwater from backfill areas could reach the San Juan River after a period of about 200 years. As explained in Section 11.6.2.4, this quantity is so small relative to flows in the San Juan River that little change in the water quality of the San Juan River would be expected. Furthermore, based on leaching studies of overburden and spoils, chemical quality expected from backfill leachate would be very similar to baseline quality in coal seams. Consequently, no change in water quality in the San Juan River would be expected from groundwater from the mine area.

Storm runoff from the active mine area is totally contained within the mine and is not discharged to surface water courses. Consequently there would be no impact on surface water quality of the San Juan and Chaco Rivers as a result of mine water discharges.

Diversion of flows in the major channels such as Chinde may result in minor disruption of dynamic equilibrium within the stream channel. These changes could increase or decrease sediment loads along segments of the channel but are usually unlikely to change sediment loads to the San Juan or Chaco Rivers. The diversion of Chinde Wash through the Big Fill culvert is one example where flood attenuation may reduce sediment loads downstream to the Chaco River. The hydrologic consequences of such changes are temporary adjustments in channel grade and geometry until a new equilibrium is reached. From field observations it appears that channel adjustments have already occurred downstream of the Big Fill culvert and the channel is approaching equilibrium conditions.

Analysis of impacts of reclamation of drainages and stream channels, as described in Section 11.6.3.1 through 11.6.3.8, indicates only minor changes in flow and sedimentology which are likely to have minimal impact on channel conditions and sediment loads in the San Juan and Chaco Rivers.

11.6.3.10 Surface Water Reference Criteria

Surface water reference criteria were developed from eight (8) years of surface water monitoring data to aid in the evaluation of future surface water monitoring data.

Each reference criteria value at each station (TABLE 11-24a through 11-24g) was determined by selecting the larger of the mean plus two (2) standard deviations which was determined from the baseline data, the maximum value in the data set or the standard. The standard was determined as the smallest of the following three (3) categories:

- Irrigation Water criteria
- Livestock Water Criteria
- 40 CFR Part 434 Coal Mining Point Source Effluent Limitations

Reference criteria were not determined for calcium, magnesium, sodium, potassium, carbonate, bicarbonate and sulfate because these parameters will be used to calculate an ion balance.

The reference criteria will be adjusted based on changing technical information and regulations and new field data. The criteria will be re-evaluated at permit renewal time.

11.6.3.11 South Barber Drainage

The South Barber Drainage has a watershed of about 0.8 square miles. Mining activities will disturb approximately 0.03 square miles (17 acres) of this drainage area. The post-mine topography will increase the South Barber drainage by 928 acres. This is largely due to the post-mining topography changes at the drainage divide between the Barber and South Barber drainages that increases the South Barber drainage by 928 acres. The most significant change from pre-mine is that the upper portion of the Barber drainage will be diverted into the South Barber Channel (see Exhibits 7-4C and 11-75A).

Pre-mining drainage density for the South Barber drainage was estimated to be 5.93 mi./sq. mile for the entire drainage area. Post-mining drainage density for the South Barber drainage is 5.98 mi./sq. mile over the area disturbed by mining. These results indicate that the post-mining and pre-mining drainage densities are about equal. This along with other erosion control practices on the reclaimed areas will ensure that the sediment yield from the post-mining surface will be less than pre-mine.

Final Surface Configuration designs are presented in CHAPTER 12 (see Sections 12.3, EXHIBITS 12-6A and 12-6B). For design of reclaimed channels, see Section 11.6.5. Drainage geometry and grade were selected to maximize stability without causing sediment deposition. Sediment deposition may produce local convexities as a result of the aggrading conditions in the channel. These convexities may in turn develop headcuts and begin to erode.

Comparison of SEDCAD 4.0 predictions for pre-mining (APPENDIX 7-N) and post-mining (APPENDIX 11-EE) flows and sedimentology is provided in TABLE 11-23 for a 10-year, 6-hour event. The comparison indicates an increase in the total sediment yield for post-mining and the peak flows remain about equal. The predicted sediment yield is 765 tons for post-mine and 599 tons for pre-mine. The predicted peak flows are approximately equal at 166 cfs. The increase in sediment yield for post-mine condition is primarily due to the increased drainage area; the yield in tons per acre is 1.1 tons/ac for pre-mine and 0.5 tons/ac for post-mine.

The Sedcad modeling also indicates for the post-mine condition a decrease in peak sediment concentration and an increase in peak settleable concentration. The predicted peak sediment concentration is 39,347 mg/l for post-mine and 40,564 mg/l for pre-mine. The predicted peak settleable concentration is 1.36 ml/l for post-mine and 0.0 ml/l for pre-mine. The change is attributable to replacement of pre-mining badland areas (clay-rich) with a post-mining sandy loam soil. The clay rich areas will increase the suspended solids concentration, while sandy loam areas may decrease the suspended solids concentration and increase the settable solids concentration.

The comparison indicates there is no significant change between the pre and post-mine peak sediment and peak settleable concentrations. For the same storm event the total sediment yield in tons per acre declined for the post-mine condition.

~~11.6.3.11 Pinabete/Chaco Tributaries~~

~~Three tributaries to the Pinabete Arroyo will be disturbed by mining activities in Area 4 North. The tributaries are identified as Tributary A, B, and C on Exhibit 11-77. The Pinabete Arroyo drainage basin is about 59.1 square miles. A small portion, approximately 1.7 square miles or 2.9 percent of the drainage basin will be disturbed. The post mining topography increases the Pinabete Arroyo drainage basin by 84 acres. This is primary due to the topography changes at the drainage divide between the Pinabete Arroyo and Cottonwood Arroyo.~~

~~A tributary to the Chaco Wash will also be disturbed by mining activities in Area 4 North. The tributary is identified as Tributary A to the Chaco on Exhibit 11-77. The Chaco Wash drainage basin is approximately 4,350 square miles. A very small portion, approximately 0.8 square miles will be disturbed. Due to the topography changes at the drainage divide between the Chaco Wash and Cottonwood Arroyo the drainage basin or affected tributary decreases by 53 acres.~~

~~Pre-mining drainage density within the Area 4 North disturbance area was estimated to be 2.64 mi./sq. mile. Post-mining drainage density for the area was estimated to be 2.67 mi./sq. mile. The pre and post-mine drainage density are approximately equal. This will achieve geomorphically stable conditions that are equivalent to pre-mine.~~

~~Final Surface Configuration designs were developed in CHAPTER 12 (see Section 12.3, EXHIBITS 12-7A). For design of the reclaimed channels, see Section 11.6.5.3.~~

~~Comparison of SEDCAD 4 predictions for pre- (see CHAPTER 7, APPENDIX 7-O) and postmining (see CHAPTER 11, APPENDIX 11-SS) flows and sedimentology are provided in~~

TABLE 11-30. The comparison of the peak flows and sediment yields from the 10 year 6 hour storm event indicates decreases in flow and sediment yield in the post-mine conditions from Tributary B and C to the Pinabete that are sufficient to offset the increases in sediment yield and flow from Tributary A to the Chaco and Tributary A to the Pinabete. The total sediment yield is predicted to decline from 468 tons pre-mine to 346 tons post-mine. The total flow leaving the permit area is predicted to decline from 238 cfs pre-mine to 180 cfs post-mine.

The runoff volume resulting from a 10 year 6 hour precipitation event in the post-mine condition is predicted to decline from a pre-mining estimate of 30 ac-ft to a post-mining estimate of 23 ac-ft for all the tributaries combined.

The SEDCAD 4.0 modeling for the 10 year 6 hour event indicates that the predicted peak sediment concentration for Tributary A to the Chaco and Tributary B to the Pinabete in the post-mining conditions are similar to pre-mine even though the predicted peak settleable solids concentration increased from 8 ml/l to 9 ml/l and 0 ml/l to 11 ml/l, respectively. The increase in peak settleable solids is attributable to replacement of premining badland areas (clay-rich) with a postmining sandy loam soil. The clay rich areas will increase the suspended solids concentration, while sandy loam areas will decrease the suspended solids concentration and increase the settable solids (sand) concentration.

The modeling also indicates a decrease in peak sediment concentration for Tributary C to the Pinabete in the post-mine condition that is sufficient to offset the increase peak sediment concentration for Tributary A to the Pinabete. The peak sediment concentration for Tributary C and A to the Pinabete are 41,628 mg/l pre-mine, 31,607 mg/l post-mine and 9,517 mg/l pre-mine, 15,224 mg/l post-mine, respectively. The overall sediment yield, all tributaries combined, is 0.4 tons/acre pre-mine and 0.2 tons/acre post-mine.

TABLE 11-30

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS TRIBUTARIES TO THE CHACO AND PINABETE 10-YEAR, 6-HOUR PRECIPITATION EVENT

SEDCAD 4.0 WATERSHED DESIGNATION			Pre-Mine					Post-Mine					Difference From Pre-Mine				
	Pre	Post	Area (acres)	Peak Flow (cfs)	Runoff (ac-ft)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Runoff (ac-ft)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Runoff (ac-ft)	Sediment (tons)	Yield (tons/acre)
Tributary A to Chaco	S1SW1	S1SW1	295	31	4	41	0.1	381	47	6	68	0.2	85	16	2	27	0.0
Tributary A to Pinabete	S1SW1	S1SW1	345	30	5	40	0.1	371	41	6	67	0.2	26	12	0	27	0.1
Tributary B to Pinabete	S1SW1	S1SW1	476	130	17	269	0.6	401	44	6	96	0.2	-75	-86	-10	-173	-0.3
Tributary C to Pinabete	S1SW1	S1SW1	142	47	4	118	0.8	314	46	5	114	0.4	172	-1	1	-4	-0.5
Total Sediment Yield and Flow off Permit area			1,258	238	30	468	0.4	1,467	180	23	346	0.2	209	-59	-7	-123	-0.1

The post mine is redacted from permit

The difference from pre-mine is redacted from permit

TABLE 11-24a
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CD-1[1,2]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	3189	10
pH	Units	8.7	-
TDS	mg/l	2284	25
TSS	mg/l	1265	25
Calcium	mg/l	120	10
Magnesium	mg/l	32.4	10
Sodium	mg/l	586	25
Potassium	mg/l	5.23	0.5
Carbonate	mg/l	44.3	2
Bicarbonate	mg/l	572	10
Sulfate	mg/l	986	10
Chloride	mg/l	139	10
Fluoride	mg/l	4.3	0.1
Iron	mg/l	20.7	0.25
Boron	mg/l	0.90	0.1
Selenium	mg/l	0.015	0.001

(1) Data set includes NAPI irrigation, seasonal seepage, and precipitation runoff samples.

(2) Data set represents samples from 1996-2003.

TABLE 11-24b
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CD-2[1,2]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	4187	10
pH	Units	8.5	-
TDS	mg/l	3328	25
TSS	mg/l	365	25
Calcium	mg/l	624	10
Magnesium	mg/l	56.4	10
Sodium	mg/l	727	25
Potassium	mg/l	11.0	0.5
Carbonate	mg/l	36.8	2
Bicarbonate	mg/l	398	10
Sulfate	mg/l	1763	10
Chloride	mg/l	176	10
Fluoride	mg/l	2.14	0.1
Iron	mg/l	6.1	0.25
Boron	mg/l	0.55	0.1
Selenium	mg/l	0.013	0.001

(1) Data set includes NAPI irrigation, seasonal seepage, and precipitation runoff samples.

(2) Data set represents samples from 1996-2003

TABLE 11-24c
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CN-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	2019	1
pH	Units	8.6	-
TDS	mg/l	1611	25
TSS	mg/l	293,000	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.84	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	0.78	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24d
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CNS-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	2300	1
pH	Units	8.7	-
TDS	mg/l	1669	25
TSS	mg/l	1,120,000	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.84	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	1.02	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24e
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CS-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	5620	1
pH	Units	8.62	-
TDS	mg/l	1240	25
TSS	mg/l	1,030,000	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.32	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	17.6	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	1.10	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24f
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION NB-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	8200	1
pH	Units	8.6	-
TDS	mg/l	8260	25
TSS	mg/l	67,300	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	2.96	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	0.98	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24g
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION NB-2[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	4200	1
pH	Units	8.6	-
TDS	mg/l	3840	25
TSS	mg/l	64,500	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.86	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	0.75	0.1
Selenium	mg/l	0.022	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

11.6.4 Stream Buffer Zone Evaluation

Seven major drainages have been identified within the Navajo Mine permit area and are discussed in Section 11.6.3.1, and shown on EXHIBIT'S 7-3, 7-4, and 7-4C (CHAPTER 7). The seven drainages are: Chinde Wash, Hosteen Wash, Barber Wash, Neck Arroyo, Lowe Arroyo, Cottonwood Arroyo and Pinabete Arroyo. Mining or support activities are projected to occur in all of the listed drainages except in the Pinabete Arroyo.

Mining will not occur in the Neck Arroyo, however, transportation roads and facilities are present. The drainage to the Lowe Arroyo has been diverted around the mining area see Section 11.5.5.3.

A Summary of the Probable Hydrologic Consequences, Section 11.6.1, the discussion of mining activities upon the quality and quantity of surface water was concluded to be negligible. See CHAPTER 7, for a review and understanding of the results and conclusions reached for surface water in Section 11.6.1. The conclusions reached in Section 11.6.1, meets the requirements found at 30 CFR 816.57.

Those areas identified as stream buffer zones (EXHIBIT'S 11-9 through 11-11) outside the approved mining disturbance (see CHAPTER 12, EXHIBIT'S 12-1, 12-2, and 12-3 for scheduled mining disturbance) will not be disturbed by surface mining activities (30 CFR 816.57(b)) and will be marked as described in Section 11.1.1. The remaining drainages will not be marked since none of the sub-watersheds within the identified drainages meet the definition of buffer zone stream.

The stream buffer zone for the Pinabete Arroyo will fall outside the permit boundary, thus it will not be identified and marked.

11.6.5 Area II Reclaimed Channels

Three reclaimed channels in the Area II FSC have watersheds that are larger than 640 acres, which require detailed designs according to the Reclamation Surface Stabilization Handbook. The three reclaimed channels are Chinde Arroyo Branch 1, Hosteen Wash Branch 1, and South Barber Channel. The design of the main branch of Chinde Arroyo will be submitted under a separate cover. The alignments of the reclaimed channels are shown on EXHIBIT 11-76 and the pre-mine surface configuration with channels is shown on EXHIBIT 11-76F.

The design of the reclaimed channel was based on a comparison of pre-mine channel flow velocities with post-mine channel flow velocities using HEC-RAS. Specifically, the design philosophy was to design a channel that is: 1) equally or more stable than the pre-mine channel (by demonstrating that the post-mine flow velocities are less than the pre-mine), and 2) able to convey the 100-year, 6-hour event.

Table 11-26 compares pre-mining and post-mining channel velocities for the entire channel reach that was modeled. Both the maximum and average flow velocities are provided for each of the three drainages modeled. Table 11-27 provides a detailed breakdown between channel reaches (channel stations) by listing the design flows that were input at each station and the corresponding flow velocities for that particular channel reach. For all design storm events, the reclaimed channels have a lower maximum and average flow velocity than the premine channels see Table 11-26. Results of the HEC-RAS analysis also indicate that the reclaimed channels will convey the peak flows generated by the 100-year, 6-hour precipitation event. Complete HEC-RAS output files for all three modeled channels by design storm events (2, 10, 25, 100-year, 6-hour peak flows) are provided in Appendix 11-NN (post-mine) and Appendix 11-PP (pre-mine).

The lower post-mine flow velocities are attributed to lower peak flows and different channel geometries in the reclaimed channel versus the pre-mine channel. The lower peak flows result from replacement of pre-mine badlands with reclaimed areas that have lower curve numbers. Generally, the pre-mine channels that were modeled are incised, which confines the flow and increases the flow depth, producing higher channel velocities than the reclaimed channel. The grades of the pre-mine channels were also steeper. The reclaimed channel section consists of a pilot channel and a main channel or a floodplain (See EXHIBIT 11-76E). The geometry of the design sections for the reclaimed channels were proportioned depending on the magnitude of the flows.

Pre-mine and post-mine channel peak flows were estimated using SEDCAD for the 2, 10, 25, and 100-year, 6-hour events. The supporting documentation for the pre-mine peak flow estimations are in Appendix 7-A (Hosteen Wash), 7-B (Barber Wash), 7-G (Chinde Arroyo) and 7N (South Barber Channel). The supporting documentation for the post-mine peak flow estimations are in Appendix 11-BB (Chinde Arroyo), 11-CC (Hosteen Wash), 11-DD (Barber Wash), and 11-EE (South Barber Channel).

The pre-mining SEDCAD drainage subdivision for Chinde Arroyo is shown on EXHIBIT 7-3, the post-mining drainage subdivision is shown on EXHIBIT 11-75. The pre-mining SEDCAD drainage subdivision for Hosteen, Barber, and South Barber drainages is shown on EXHIBIT 7-4C, the post-mining drainage subdivision is shown on EXHIBIT 11-75A.

The peak flows were input upstream of the prediction points or SEDCAD structures for both the pre-mine and post-mine HEC-RAS analysis. Inputting the peak flows in this manner will generate conservative results. The results of the HEC-RAS pre-mine analysis for the 2, 10, 25, and 100-year, 6-hour peak flow for the modeled channels are in Appendix 11-PP, HEC-RAS Results for Area II Pre-Mine Channels.

Analysis of Pre-mine Channels

Due to the lack of detailed cross-sectional channel data within the lease, the development of the pre-mine channel sections used in the HEC-RAS is based on one representative surveyed cross-section. This cross-section is taken from both upstream and downstream of the lease for each respective drainage. The surveyed downstream cross-section was repetitively projected upstream across the lease to a transition zone for that particular channel. Similarly, the surveyed upstream cross-section was repetitively projected downstream across the lease to the transition zone.

The transition zone, 1300 to 1500 feet in length, connects the upstream and downstream channel configuration. The length and location of the transition between the upstream and downstream cross-sections was based on topographic information. Natural pre-mine transitions (I.E., incised badland channel to a broad valley channel) are evident from the topography and these approximate locations determined the location of the modeled transitions.

This method of interpolation across the lease area for development of the pre-mine channel for the HEC-RAS analysis was applied for modeling Hosteen Wash Branch 1. Locations of the transitions and the representative upstream and downstream cross-sections used in the HEC-RAS modeling are shown on the pre-mine plan and profile sheets, Exhibit 11-76G.

The channel profiles used in the HEC-RAS pre-mine analysis were extracted from USGS and aerial surveys at 10-foot contours.

Analysis of Reclaimed Channels

The flow velocities in the reclaimed channels were determined by inputting the reclaimed channel sections into HEC-RAS. The reclaimed channel reaches are transitioned into the existing natural channel at the upstream and downstream ends. The transitions of the reclaimed channel to the natural channel generally occurred over a 500 to 700 foot reach. The post-mine peak flows and gradient for that particular drainage dictated the geometry of the reclaimed channel. The reclaimed channel cross-sections are shown on EXHIBIT 11-76E, Sheet 1. The locations of the transition reaches and the design sections used in the HEC-RAS model are shown on the plan and profile sheets EXHIBITS 11-76A, 11-76B, and 11-76C.

The reclaimed channel profiles are generally uniform, which was stipulated by the elevation of the channel bottom at the upstream and downstream lease boundaries. Except where the reclamation has been completed, such as the downstream reach of the Barber Reclaimed Channel. In this case, the elevation of the channel just up-stream of the completed reclamation and the channel elevation downstream at the lease line will determine the grade.

Due to the completed reclamation in Up Dip Barber the grade of the Barber Reclaimed Channel is set and will not change. Because this area is reclaimed and includes an existing vegetated channel, the necessity of constructing a reclaimed channel and resultant disturbance to the area across the reclamation should be evaluated. Specifically, the natural channel that has developed and which will continue to develop during the time prior to final reclamation will likely have a similar geometry to the reclaimed channel, particularly the pilot channel. The lower reach of the Barber Reclaimed Channel will be monitored for channel development and stability in order to determine if construction of the reclaimed channel is required.

The profile of the Barber Reclaimed Channel just east of the rail will have a significant drop; this reach of channel will require a riprapped drop structure to control erosion. The drop structure will be designed for a 25-year, 6-hour stability and 100-year, 6-hour capacity. The reclamation of the channel will be done during the final reclamation of the railroad embankment. The embankment material will be used to reduce the grade of the drop structure.

Chinde Branch 1 in the post-mining topography is a tributary to the to the Chinde Permanent Diversion, which did not occur in the pre-mine topography. The post-mining topography changes the pre-mine drainage pattern by diverting the upstream watersheds of the Hosteen Wash into the Chinde Arroyo watershed. Consequently, the results of the HEC-RAS analysis could not be compared to a corresponding pre-mine channel. However, the flow velocities can be compared to velocities in the other pre-mine channels analyzed. The flow velocities in Chinde Branch 1 are all less than the velocities in the other pre-mine channels, except for the Barber Wash 2-year, 6-hour average velocity (see Table 11-26).

The Chinde Branch 1 Reclaimed Channel converges with the Chinde Diversion at approximately Sta 0+00, see EXHIBIT 11-76A. The HEC-RAS analysis for Chinde Branch 1 includes this station and the subsequent stations upstream. The channel reach downstream of Sta 0+00 to the western lease boundary will be a part of the Chinde Permanent Diversion. The design section for Chinde Branch 1 is shown on Exhibit 11-76 E, Sheet 1.

South Barber Channel in the post-mining topography is a tributary to the Neck Arroyo. The post-mining topography changes the pre-mine drainage pattern by diverting the upstream watersheds of the Barber Wash into the South Barber watershed. The reclaimed South Barber Channel will have a riprapped drop structure from Station 13+91 to 20+70. Refer to Appendix 11-DD for riprap size design and Exhibit 11-76C and 11-76E for the profile and typical section. The flow velocities in South Barber Channel are less than or equal to the velocities of the pre-mine channel (see Table 11-26).

Reclaimed Channel Development

The reclaimed channels are designed to have flow velocities equal to or less than the pre-mine channels. Some erosion is expected, particularly in the pilot channels. All natural channels erode because they are in constant state of change depending the magnitude of flows conveyed. During low flows deposition will occur in some reaches of the channel and erosion in other reaches. Deposition will occur in reaches where the channel bed widens and the flow spreads out, thus reducing the velocity. Erosion (down cutting with some lateral movement) will occur in reaches

TABLE 11-26

PRE-MINE AND POST-MINING CHANNEL VELOCITIES

Chinde Branch 1

Storm Event	Pre-Mine Maximum Velocity (fps)	Pre-Mine Average Velocity (fps)	Post-Mining Maximum Velocity (fps)	Post-Mining Average Velocity (fps)
2-Year	n/a	n/a	4.43	4.02
10-Year	n/a	n/a	6.80	4.50
25-Year	n/a	n/a	7.62	4.88
100-Year	n/a	n/a	8.09	5.19

Hosteen Wash Branch 1

Storm Event	Pre-Mine Maximum Velocity (fps)	Pre-Mine Average Velocity (fps)	Post-Mining Maximum Velocity (fps)	Post-Mining Average Velocity (fps)
2-Year	9.56	4.81	6.65	5.10
10-Year	12.91	6.23	9.42	4.63
25-Year	14.38	6.92	9.58	4.97
100-Year	15.97	7.62	10.63	5.42

South Barber Channel

Storm Event	Pre-Mine Maximum Velocity (fps)	Pre-Mine Average Velocity (fps)	Post-Mining Maximum Velocity (fps)	Post-Mining Average Velocity (fps)
2-Year	7.65	5.13	7.65	3.53
10-Year	10.25	6.78	10.25	4.41
25-Year	11.05	7.42	11.05	4.85
100-Year	12.25	7.92	12.21	5.30

TABLE 11-27

HEC-RAS RESULTS

Chinde Branch 1 Post-mining

Flow Change Location (Sta)	2-Year			10-Year			25-Year			100-Year		
	Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)	
		Max	Avg		Max	Avg		Max	Avg		Max	Avg
192.92	38	3.59	3.47	104	4.92	4.76	149	5.61	4.82	213	6.19	4.85
170.00	101	4.22	4.18	258	6.80	4.31	468	7.62	4.88	511	7.75	4.93
123.00	112	4.43	4.10	332	6.21	4.49	496	7.04	4.92	741	8.05	5.41
37.00	108	4.33	4.19	333	6.17	4.48	503	7.06	4.89	758	8.09	5.36

Hosteen Branch 1 Pre-mine

Flow Change Location (Sta)	2-Year			10-Year			25-Year			100-Year		
	Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)	
		Max	Avg		Max	Avg		Max	Avg		Max	Avg
104.00	62	6.46	2.20	192	7.91	2.72	286	12.90	3.22	423	8.94	3.23
74.00	135	8.76	4.28	395	10.39	4.91	583	11.00	5.16	854	11.77	5.51
46.00	180	8.79	7.01	511	11.87	9.58	748	13.27	10.70	1,089	14.73	12.17
6.00	226	9.56	8.91	640	12.91	12.16	937	14.38	13.53	1,366	15.97	15.03

Hosteen Branch 1 Post-mining

Flow Change Location (Sta)	2-Year			10-Year			25-Year			100-Year		
	Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)	
		Max	Avg		Max	Avg		Max	Avg		Max	Avg
86.00	121	6.30	4.83	364	8.43	4.52	540	9.26	4.91	793	10.17	5.37
28.00	125	6.65	6.33	409	9.42	5.16	627	9.58	5.24	951	10.63	5.64

South Barber Channel Pre-mine

Flow Change Location (Sta)	2-Year			10-Year			25-Year			100-Year		
	Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)	
		Max	Avg		Max	Avg		Max	Avg		Max	Avg
15.42	51	7.65	5.13	166	10.25	6.78	251	11.05	7.42	375	12.25	7.92

South Barber Channel Post-mining

Flow Change Location (Sta)	2-Year			10-Year			25-Year			100-Year		
	Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)		Q (cfs)	Velocity (fps)	
		Max	Avg		Max	Avg		Max	Avg		Max	Avg
107.54	24	3.23	3.14	73	4.56	3.76	110	5.28	4.08	164	6.04	4.51
87.54	22	3.16	2.80	78	4.81	3.42	123	5.52	3.82	192	6.27	4.26
27.00	31	2.98	2.87	103	4.43	3.38	159	5.09	3.68	243	5.87	3.97
20.70	51	7.65	5.06	166	10.25	6.58	251	11.05	7.19	377	12.21	7.71

where the channel bed narrows and confines the flow, which increases the velocity. This generally occurs in reaches with increases in channel bed slopes.

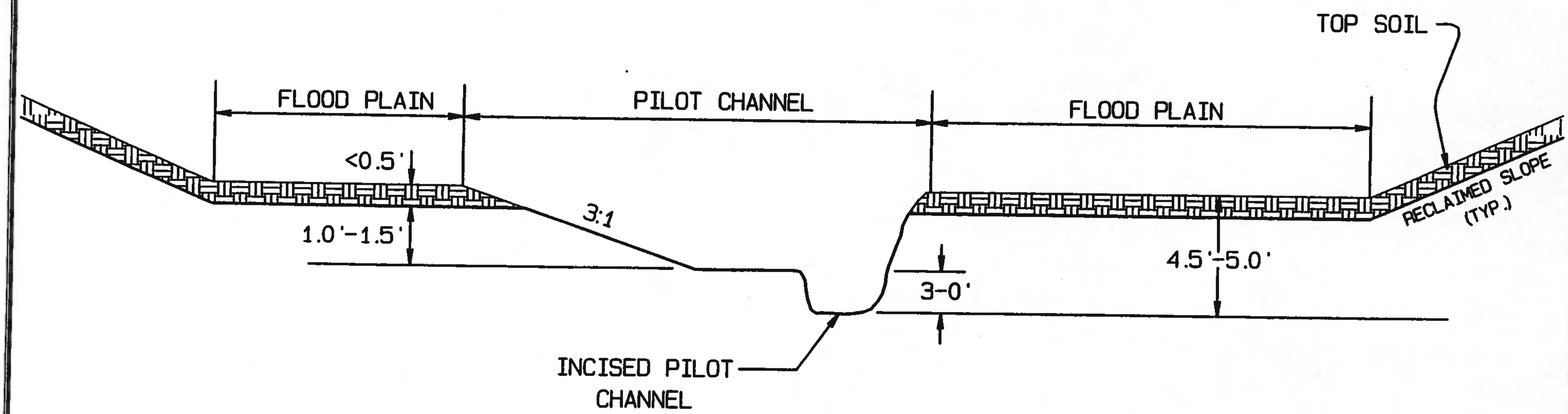
During high flows the sediment deposited during the low flows will be washed down stream and lateral movement of the channel banks will also occur with some down cutting of the channel bed. This process is also expected to occur in the reclaimed channels. Lateral movement of the pilot channel is expected but will be confined within the banks of the main channel. The pilot channel in time is expected to resemble the surrounding natural channels. It could be incised in some reaches of the channel with depths as deep as 5 feet at the floodplain. The incised channel depths in the existing or natural channels directly downstream of the lease are much deeper (See EXHIBIT 11-76E). Erosion is expected to occur in the reclaimed channels but the erosion rate will be less since the flow velocities in the reclaimed channels are less than the pre-mine (See TABLES 11-26 and 11-27).

The erosion depth or incised pilot channel depth was selected based on observations of channel erosion in mine spoils. Typically at a scour depth of three feet or less into the spoil material, armoring of the channel bottom has occurred as the finer-grained sediments are winnowed away. Armoring of the channel consists of the preferential concentration of the remaining coarser material that range in size from pea – sized gravel up to large (3 foot length of the long axis) sandstone cobbles and boulders.

Low frequency (10-year, 6-hour or greater) large flows and corresponding higher velocities are required to transport these coarse materials. Consequently for the higher frequency (2-year, 6-hour) smaller flows, the abundant coarse materials in combination with vegetation will serve to stabilize the grade and minimize erosion and down cutting.

Cut bank depths up to 5 feet deep could result if a 3 feet deep incised pilot channel should migrate and abut against a 1.5 to 2.0 feet thick floodplain bank (See FIGURE 11-27). If the incised pilot channel exceeds three feet deep or should erode beyond the toe of the main channel into the reclaimed slope, the area/erosion will be repaired.

FIGURE 11-27



TYPICAL RECLAIMED INCISED PILOT CHANNEL SECTION
NTS

11.6.5.1 Area III Reclaimed Channels

Seven post-mining or reclaimed channels in the Area III FSC have watersheds that are larger than 640 acres, which require detailed designs according to the Reclamation Surface Stabilization Handbook. The alignment of the seven post-mining/reclaimed channels are shown on Exhibit 11-78 and are designated as Lowe, Lowe North, Lowe North R2, Lowe North R3, Lowe North R4, Lowe South, and North Fork. The pre-mine surface configuration with channels is shown on EXHIBIT 11-78A.

The design of the reclaimed channel was based on a comparison of pre-mine channel flow velocities with post-mine channel flow velocities using HEC-RAS. Specifically, the design philosophy was to design a channel that is: 1) equally or more stable than the pre-mine channel by demonstrating that the post-mine flow velocities are less than the pre-mine, and 2) able to convey the 100-year, 6-hour event.

Mining has disturbed the main channel and tributaries of Lowe North and Lowe South Branches; therefore detailed cross-sections of the pre-mine channels are not available to perform a HEC_RAS analysis for comparison with the reclaimed channels. In lieu of a comparison with pre-mining channel conditions, the reclaimed channels were designed to have average flow velocities less than 5 fps during the peak flow from a 2 year-6 hour storm event. The limiting criterion of 5 fps is based on the erosive velocity of the spoils, which is 5 fps. The bottom and banks of the reclaimed channels will be in the regraded spoils. The channel bottoms and banks will not be topsoiled. Only the North Fork pre-mine channel and the downstream reach of the Lowe Arroyo near the western lease boundary were analyzed as pre-mine channels for comparisons with the post-mining channel.

Table 11-28 compares pre-mining and post-mining channel velocities for the entire channel reaches that were modeled. Both the maximum and average flow velocities are provided for each of the drainages modeled. Table 11-29 provides a detailed breakdown between channel reaches (channel stations) by listing the design flows that were input at each station and the corresponding flow velocities for that particular channel reach. For all design storm events the reclaimed channels have a lower maximum and average flow velocity than the premine channels. For all the reclaimed channels not compared to a pre-mining channel the average flow velocities during the 2 year-6 hour storm event are less than 5 fps. Results of the HEC-RAS analysis also indicate that the reclaimed channels will convey the peak flows generated by the 100-year, 6-hour precipitation event. The HEC-RAS output files for all the reclaimed and pre-mining channels modeled are provided in Appendix 11-X1 and 11-Y1 (post-mining); and Appendix 11-X2 and 11-Y2 (pre-mining).

The lower post-mine flow velocities are attributed to lower peak flows and different channel geometries in the reclaimed channel versus the pre-mine channel. The lower peak flows result from the replacement of pre-mine badlands with reclaimed areas that have lower curve numbers. Generally, the pre-mine channels that were modeled are incised, which confines the flow and increases the flow depth, producing higher channel velocities than the reclaimed channel. The grades of the pre-mine channels were also steeper. The reclaimed typical channel section consists of a main channel that will retain the 2 year-6 hour peak flow with a floodplain. The flows larger than the 2 year-6 hour peak flow will overflow into the floodplain (See EXHIBIT 11-78C). The geometry of the design sections for the reclaimed channels was proportioned depending on the magnitude of the flows.

Pre-mine and post-mine channel peak flows were estimated using SEDCAD for the 2, 10, 25, and 100-year, 6-hour events. The peak flows were input at the prediction points or SEDCAD structures for both the pre-mine and post-mine HEC-RAS analysis. The supporting documentation for the pre-mining peak flow estimations are in Appendix 7-D (Lowe Arroyo), and 7-H (Cottonwood Arroyo). The supporting documentation for the post-mining peak flow estimations are in Appendix 11-X (Lowe Arroyo), and 11-Y (Cottonwood Arroyo).

The pre-mining SEDCAD drainage subdivision for Lowe and Cottonwood Arroyo is shown on EXHIBIT 7-4, the post-mining drainage subdivision is shown on EXHIBIT 11-77.

Analysis of Pre-mine Channels

Mining has not disturbed the North Fork of the Cottonwood Arroyo, the reach inside the permit boundary was field surveyed to obtain cross-sections on approximately 100-foot intervals. The locations of the cross-sections are shown on Exhibit 11-78A, Sheet 3. The cross-section data and the predicted peak flows from SEDCAD were input into HEC-RAS to obtain pre-mining channel flow velocities and depths. The HEC-RAS results are presented in Appendix 11-Y2 and summarized on Table 11-28 and 11-29 in this section.

The downstream reach of the Lowe Arroyo at the western permit boundary was also surveyed to obtain cross-sections on approximately 100-foot intervals. Mining has not disturbed this reach of channel. The cross-section data and the predicted peak flows were input into HEC-RAS to obtain both pre-mining and post-mining channel flow velocities and depths for comparative purposes. The HEC-RAS results are presented in Appendix 11-X2 (pre-mining) and Appendix 11-X1 (post-mining) with results summarized on Table 11-28 and 11-29 in this section.

The Manning's roughness coefficients (n) used for the North Fork pre-mine channel in the HEC-RAS analysis were as follows: 0.045 for the floodplain, 0.035 for the channel banks, and 0.030 for the channel bottom. For the Lowe Arroyo pre-mine channel, the reach in the vicinity of the western permit boundary, the n values used were: 0.045 for the floodplain and a composite n of 0.033 for the channel bottom and channel banks.

Due to the lack of detailed cross-sectional data of the North Lowe and Lowe South main channels including its tributaries, the pre-mine HEC-RAS analysis were not preformed for these channels.

Analysis of Reclaimed Channels

The flow velocities in the reclaimed channels were determined by inputting the reclaimed channel sections into HEC-RAS. The reclaimed channel sections were taken from the Area III FSC on approximately 200-foot intervals. The reclaimed channel reaches are transitioned into the existing natural channel at the upstream and downstream ends. The transitions of the reclaimed channel to the natural channel generally occurred over a 100 to 200 foot reach. The post-mine peak flows and the gradient of that particular drainage channel dictated the geometry of the reclaimed channel. The locations of reclaimed channel cross-sections used in HEC-RAS are shown on EXHIBIT 11-78, Sheets 2-4. The typical reclaimed channel sections are shown on EXHIBITS 11-78C and the profiles are shown on Exhibit 11-78B.

The Manning's roughness coefficients (n) used for the reclaimed channels in the HEC-RAS analysis were as follows: 0.045 for the floodplain and a composite n of 0.033 for the channel bottom and channel banks. For the configuration of the reclaimed channels analyzed the composite n is approximately equivalent to a channel having n values of 0.030 for the channel bottom and 0.035 for the channel banks.

Due to lack of detailed cross-sections of the pre-mine channels in the Lowe Arroyo watershed a comparative analysis could not be made between pre-mining and post-mining conditions. In lieu of a comparative analysis, the reclaimed channels in the Lowe drainage area were designed to have flow velocities less than 5 fps during the 2 year-6 hour peak flow. The gradients of the reclaimed channels in the Lowe drainage area are also generally less than pre-mine, except in the steep reaches where drop structures are required. This coupled with the cross-sectional configuration of the reclaimed channel strongly indicates that the post-mine flow velocities could possibly be less than the pre-mine. The HEC-RAS results for the reclaimed channels within the Lowe watershed are in Appendix 11-X1 and summarized on Table 11-28 and 11-29.

Drop structures will be utilized in the steep reaches of the reclaimed channels to control erosion. The drop structures will be designed to remain stable during the 25 year-6 hour peak flow and pass the 100 year-6 hour peak flow with a 1-foot freeboard. A computer software, Rip-rap Design Systems, Version 2; WEST Consultants, Inc.; San Diego, Ca, which calculates rip-rap size utilizing seven different methods was used to determine the rip-rap size. Four design methods (ASCE, USBR, Isbash, and HEC-11) were used to determine the D_{50} rock size. For the selected D_{50} rock size refer to the drop structure schedule on Exhibit 11-78C. The supporting design data for the drop structures is presented in Appendix 11-X3. The locations of the drop structures are shown on the plan and profile drawings, Exhibit 11-78, Sheets 2 and 3; and Exhibit 78B, Sheets 1 and 2, respectively.

Tributaries having less than 640 acres of watershed may require rip-rap down drains depending on the grade at the entrance into the main reclaimed channel. The designs for these down drains will be done during the final regarding process and will be presented on reclamation as-built drawings. The as-built drawings will be submitted to the regulatory agency.

Reclaimed Channel Development

The reclaimed channels are designed to have the average flow velocities less than the pre-mine channels or less than 5 fps. Some erosion is expected, particularly in the main channels. All natural channels erode because they are in constant state of change depending the magnitude of flows conveyed. During low flows deposition will occur in some reaches of the channel and erosion in other reaches. Deposition will occur in reaches where the channel bed widens and the flow spreads out, thus reducing the velocity. Erosion (down cutting with some lateral movement) will occur in reaches where the channel bed narrows and confines the flow, which increases the velocity. This generally occurs in reaches with increases in channel bed slopes.

During high flows the sediment deposited during the low flows will be washed down stream and lateral movement of the channel banks will also occur with some down cutting of the channel bed. This process is also expected to occur in the reclaimed channels. A pilot channel is expected to develop within the main channel. Lateral movement of the pilot channel is expected occur but will be confined within the banks of the main channel. The pilot channel in time is expected to resemble the surrounding natural channels. It could be incised in some reaches of the channel with depths as deep as 6 feet at the floodplain. The incised channel depths in the existing or natural channels directly downstream of the lease are much deeper. Erosion is expected to occur in the reclaimed channels but the erosion rate will be less since the flow velocities in the reclaimed channels are less than the pre-mine (See TABLES 11-28 and 11-29).

The erosion depth or incised pilot channel depth was selected based on observations of channel erosion in mine spoils. Typically at a scour depth of three feet or less into the spoil material, armoring of the channel bottom has occurred as the finer-grained sediments are winnowed away. Armoring of the channel consists of the preferential concentration of the remaining coarser material that range in size from pea-sized gravel up to large (3 foot length of the long axis) sandstone cobbles and boulders.

Low frequency (10-year, 6-hour or greater) large flows and corresponding higher velocities are required to transport these coarse materials. Consequently for the higher frequency (2-year, 6-hour) smaller flows, the abundant coarse materials in combination with vegetation will serve to stabilize the grade and minimize erosion and down cutting.

Cut bank depths up to 6 feet deep could result if a 3 feet deep incised pilot channel should migrate and abut against a 2.0 to 2.5 feet thick floodplain bank (See FIGURE 11-29). If the incised pilot channel exceeds three feet deep or should erode beyond the toe of the main channel into the reclaimed slope, the area/erosion will be repaired.

TABLE 11-28
PRE-MINE AND POST-MINING CHANNEL VELOCITIES

North Fork

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	9.34	5.18	6.42	4.79
10-Year	12.08	6.46	8.71	4.73
25-Year	12.58	6.88	9.47	4.66
100-Year	13.48	7.20	10.73	4.70

Lowe

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	8.80	4.46	7.76	3.87
10-Year	11.59	5.95	8.70	5.20
25-Year	12.95	6.55	10.18	5.90
100-Year	14.51	7.13	12.03	6.56

Lowe North

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	5.58	4.32
10-Year	n/a	n/a	7.94	4.40
25-Year	n/a	n/a	8.38	4.42
100-Year	n/a	n/a	9.35	4.50

Lowe North R1

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	2.21	2.02
10-Year	n/a	n/a	3.76	3.40
25-Year	n/a	n/a	4.41	3.97
100-Year	n/a	n/a	5.11	4.57

Lowe North R2

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	3.93	3.83
10-Year	n/a	n/a	5.99	4.11
25-Year	n/a	n/a	7.06	4.03
100-Year	n/a	n/a	8.03	3.98

Lowe North R3

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	5.24	4.47
10-Year	n/a	n/a	7.15	6.14
25-Year	n/a	n/a	7.98	6.76
100-Year	n/a	n/a	9.09	7.49

Lowe North R4

	Pre-Mine		Post-Mining*	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	n/a	n/a
10-Year	n/a	n/a	n/a	n/a
25-Year	n/a	n/a	n/a	n/a
100-Year	n/a	n/a	n/a	n/a

Lowe South

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	4.87	3.38
10-Year	n/a	n/a	7.09	3.55
25-Year	n/a	n/a	7.39	3.57
100-Year	n/a	n/a	8.24	3.68

* The reclaimed reach is riprapped.

TABLE 11-29
HEC-RAS RESULTS

North Fork Pre-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
150.00	256.0	9.34	5.18	674.0	12.08	6.46	971.0	12.58	6.88	1,401.0	13.48	7.20

North Fork Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
142.24	249	6.42	4.79	665	8.71	4.73	962	9.47	4.66	1,393	10.73	4.70
13.03*	1,050	N/A	N/A	2,880	N/A	N/A	4,196	N/A	N/A	6,107	N/A	N/A

* For the flow change the reach is undisturbed.

Lowe Pre-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
38.83	253.0	8.80	5.00	735.0	11.59	7.13	1,089.0	12.95	8.07	1,597.0	14.32	9.09
15.95	315.0	7.35	5.77	926.0	10.96	8.05	1,370.0	12.67	9.04	2,017.0	14.51	10.01

Lowe Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
38.83	127.0	7.76	3.94	386.0	7.09	4.56	578.0	8.25	5.08	859.0	9.66	5.47
33.20	146.0	7.09	3.60	490.0	8.47	5.33	755.0	9.97	6.20	1,156.0	11.21	7.02
15.95	155.0	7.09	3.87	514.0	8.70	5.29	791.0	10.18	6.01	1,206.0	12.03	6.72

Lowe North Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
90.01	125.00	5.26	4.14	372.0	7.03	4.24	553.0	7.69	4.35	820.0	8.78	4.46
53.09	127.00	5.58	4.73	386.0	7.94	4.77	578.0	8.38	4.59	859.0	9.35	4.58

Lowe North R1 Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
12.73	17.0	2.21	2.02	77.0	3.76	3.40	126.0	4.41	3.97	202.0	5.11	4.57

Lowe North R2 Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
14.00	112.0	3.93	3.83	307.0	5.99	4.11	445.0	7.06	4.03	643.0	8.03	3.98

Lowe North R3 Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
15.89	33.0	5.24	4.04	98.0	7.15	5.42	144.0	7.98	5.96	210.0	9.09	6.60

Lowe North R4 Post-mining

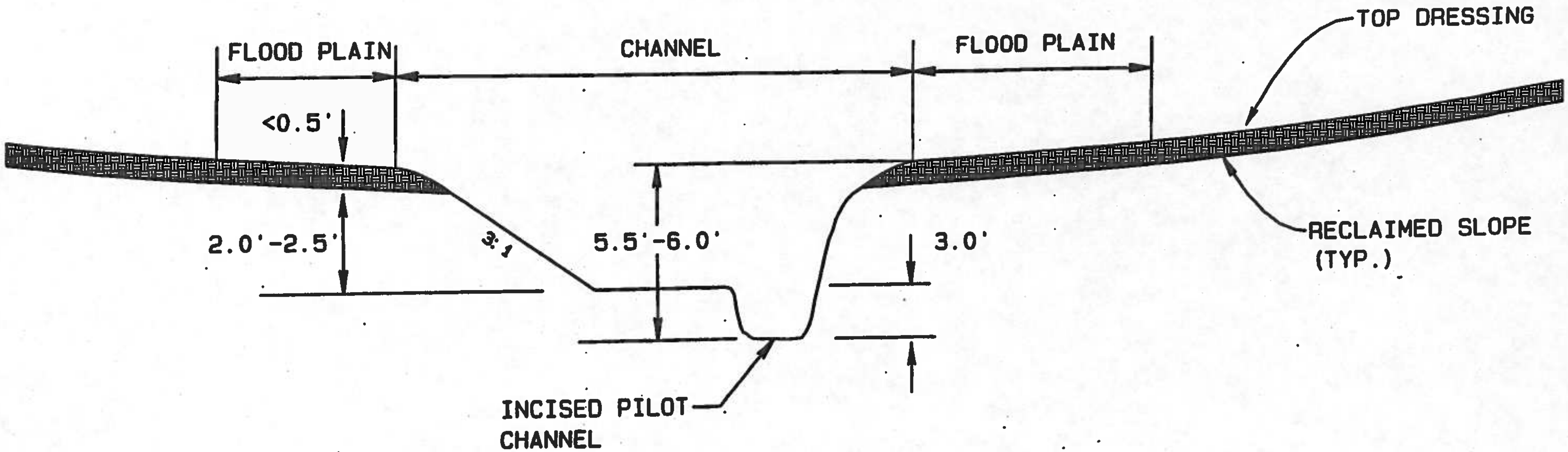
Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
11.71*	86.0	N/A	N/A	230.0	N/A	N/A	331.0	N/A	N/A	475.0	N/A	N/A

Lowe South Post-mining

Flow Change (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
258.72*	83	N/A	N/A	209	N/A	N/A	296	N/A	N/A	418	N/A	N/A
243.0	106	3.62	3.07	318	5.78	2.98	473	6.32	3.01	701	7.39	3.13
178.00	106	4.87	3.56	329	7.09	3.86	495	7.39	3.89	739	8.24	3.99
33.2*	106	N/A	N/A	490	N/A	N/A	755	N/A	N/A	1,156	N/A	N/A
15.95*	155	N/A	N/A	514	N/A	N/A	791	N/A	N/A	1,206	N/A	N/A

* For the flow change the entire reach is either undisturbed or riprapped.

FIGURE 11-29



TYPICAL RECLAIMED CHANNEL SECTION

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11.6.5.2 Ephemeral Stream Diversion Designs

All streams within the Navajo Mine Permit Area with the possible exception of Chinde Arroyo are hydrologically ephemeral streams. Nevertheless, OSM regulations classify all streams with drainage areas greater than one square mile as intermittent streams regardless of flow conditions. Therefore, this section provides information concerning design of permanent diversions for ephemeral streams and addresses low order stream segments with drainage areas less than one square mile. Reclamation structures will be designed in accordance with the Reclamation Surface Stabilization Handbook.

Design flows were developed using the SEDCAD+ computer model following the procedures and assumptions described in CHAPTER 7.

~~11.6.5.3 Area IV North Reclaimed Channels~~

~~All the drainage basins in post-mining topography are less than one square mile (640 acres). Per the Reclamation Surface Stabilization Handbook the channels for these drainage basins will not require detail designs. The detail designs will be developed during the final regrading and reclamation process.~~

11.6.5.4 Area I South Reclaimed Channels

There is one reclaimed channel in the Area I South FSC with a watershed larger than 640 acres, which requires detailed designs according to the Reclamation Surface Stabilization Handbook. The reclaimed channel is designated as the Doby North Channel. The alignment of the reclaimed channel is shown on EXHIBIT 11-85 and 12-5A.

In the vicinity of Doby Pit, the pre-mine surface sloped down towards the west with primarily sheet flow drainages and some small channels. The post-mine topography changed the pre-mine drainage pattern by diverting the westward drainages from the off lease undisturbed surface towards the south via a post-mine channel that runs north to south along the eastern lease boundary. The channel also collects surface runoff from a portion of the reclaimed surface to the west.

Since there was no main channel in the pre-mine surface, the pre and post-mine flow velocities cannot be compared. The design of the reclaimed channel was based on maintaining the flow velocity less than the erosive velocity of the channel bed material, which in this case is the spoil material. The spoil material is primarily composed of shale/clay with sandstone cobbles that has an erosive velocity of approximately 5 fps. Specifically, the design philosophy was to design a channel that is: 1) stable by demonstrating that the flow velocities are less than 5 fps, and 2) able to safely convey the flow from the 100-year, 6-hour event.

Analysis of Reclaimed Channels

The SEDCAD hydrology software was utilized to design the reclaimed channel. The hydrology for the Doby North Channel was modeled in SEDCAD to simulate the 2, 10, 25 and 100 year- 6 hour storm events. The channel was designed to retain the 10 year-6 hour peak flow without overflowing the banks. The watershed subdivisions used in the model is presented in Exhibit 11-85. The results from the SEDCAD runs are presented in Appendix 11-FF. During storms greater than the 10 year-6 hour, over bank flow will occur at the upper reach of the channel. For all the storm events simulated, the flow velocities are less than 5 fps, indicating that the channel will be hydraulically stable.

The profile of the Doby North Channel at the south end of the Doby reclamation area has a significant drop; this reach of channel will require a riprapped drop structure to control erosion. The drop structure will be designed for a 25-year, 6-hour stability and 100-year, 6-hour capacity. The design of drop structure is included in the SEDCAD hydrology model. Refer to Appendix 11-FF.

The location and design details for the Doby North Channel are presented on Exhibit 11-85.

11.6.6 Hydrologic Monitoring Reporting

Hydrologic monitoring reports will be submitted to OSM on a quarterly frequency and a detailed monitoring report will be submitted twice during the permit term. The quarterly monitoring report will consist of a summary of the data collected and events for the quarter, identification of anomalies, inconsistencies or non-compliances, and include an electronic copy of the raw analytical data on disk.

In addition to the quarterly hydrologic monitoring report, an in-depth hydrology report will be submitted twice during the permit term. This detailed hydrologic monitoring report will provide a detailed reduction, analysis and interpretation of surface and groundwater data collected to date, in addition to the raw data. The analysis will include plotting hydrographs, parameter concentration vs. time graphs, trilinear graphs and statistical summaries. The monitoring data is then compared against historical data trends and water quality standards to identify changes in water quality or quantity. Specifically for the detailed report, flow and water quality data will be provided as detailed below.

Flow: For the nearly perennial Chinde Wash stations, CD-1A and CD-2A, weekly hydrographs will be plotted. A comparison of the flow between the upstream and downstream stations will be provided.

Water Quality and Sediment: Stage and discharge corresponding to each sample will be reported along with the measured concentrations. For Chinde Wash, summary statistics will include water yield and sediment and analyte concentrations for each month. A comparison of water quality and sediment concentrations between the upstream and downstream stations will be provided.

A comparison will be made between surface water quality concentrations collected and the applicable water quality State of New Mexico for Interstate and Intrastate Streams standards and Navajo Nation Stream Standards for both the biannual report and the quarterly reports.

Discussion on requirements of the Clean Water Act, National Pollutant Discharge Elimination System (NPDES) is found in Section 11.2.6.

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