Cumulative Hydrologic Impact Assessment

Of the

BHP Billiton Navajo Coal Company

Navajo Mine

Prepared By

Office of Surface Mining Reclamation and Enforcement

Indian Program Branch, Program Support Division

Western Region Office – Denver, Colorado

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%RSD	Percent Relative Standard Deviation
AOC	Approximate Original Contour
APS	Arizona Public Service
AST	Above-Ground Storage Tank
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	Best Management Practice
BNCC	BHP Navajo Coal Company
CCB	Coal Combustion Byproduct
CFR	Code of Federal Regulations
CHIA	Cumulative Hydrologic Impact Assessment
CIA	Cumulative Impact Area
CWA	Clean Water Act
FCPP	Four Corners Power Plant
HUC	Hydrologic Unit Code
LOM	Life-of-Mine
MAD	Median Absolute Deviation
MSL	Mean Sea Level
NAPI	Navajo Agricultural Products Industry
NHD	National Hydrologic Database
NIST	National Institute of Standards and Technology
NMEMNRD	New Mexico Energy Minerals and Natural Resource Division
NNEPA	Navajo Nation Environmental Protection Agency
NPDES	National Pollution Discharge Elimination System
OSMRE	Office of Surface Mining Reclamation and Enforcement
PAP	Permit Application Package
PCS	Pictured Cliff Sandstone
PHC	Probable Hydrologic Consequences
SMCRA	Surface Mining Control and Reclamation Act of 1977
TDS	Total Dissolved Solids
TOJ	Termination of Jurisdiction
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VWP	Vibrating Wire Piezometer

1 INTRODUCTION

The Office of Surface Mining Reclamation and Enforcement (OSMRE) is the regulatory authority for coal mining operations on Indian Lands under the Surface Mining Reclamation and Control Act of 1977 (SMCRA) (U.S. Congress, 1977). As such, OSM is responsible for the review and decisions on all permit applications to conduct surface coal mining operations within the boundaries of the Navajo Nation Reservation. BHP Navajo Coal Company's (BNCC's) Navajo Mine permit area is located on Navajo Nation lands. By regulation, OSM must prepare a Cumulative Hydrologic Impact Assessment (CHIA) for this permit area. The CHIA determines whether the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area (30 Code of Federal Regulations (CFR) § 780.21(g)).

A CHIA is an assessment of the probable hydrologic consequences (PHC) of the proposed operation and all anticipated coal mining upon surface and groundwater systems in the cumulative impact area (CIA). The PHC is prepared by the applicant, as required by 30 CFR § 780.21(f), and approved by the regulatory authority. Congress identified SMCRA (U.S. Congress, 1977) that there is "a balance between protection of the environment and agricultural productivity and the Nation's need for coal as an essential source of energy" (SMCRA, 1977 Sec 102(f)). The hydrologic reclamation plan required by the rules at 30 CFR § 780.21(h) recognizes that disturbances to the hydrologic balance within the permit and adjacent area should be minimized, material damage outside the permit area should be prevented, applicable Federal, Tribal, and State water quality laws should be met, and the rights of present water users protected. Additionally, 30 CFR § 816.42 states "discharges of water from areas disturbed by surface mining activities shall be made in compliance with all applicable State and Federal water quality laws and regulations and with the effluent limitations for coal mining promulgated by the United States Environmental Protection Agency (USEPA) set forth in 40 CFR part 434." Discharges of disturbed area runoff at the Navajo Mine are conducted in accordance with the terms and conditions of a National Pollutant Discharge Elimination System (NPDES) permit issued by the USEPA and certified by the Navajo Nation and Hopi Tribe under the Clean Water Act (CWA).

OSMRE considered USEPA approved surface water quality standards for the Navajo Nation Environmental Protection Agency (NNEPA) as part of this assessment. Protection of existing and foreseeable water uses within the various delineated cumulative impact areas was a focus of this assessment. Additionally, potential impacts associated with the historic disposal of coal combustion by-products (CCB) at the Navajo Mine were specifically evaluated. This CHIA supersedes the CHIA written in February, 1984 (Kaman Temp 1984), and addendum from 1989 (OSMRE 1989). Findings with regard to material damage are summarized below (Table 1).

Table 1: Navajo Mine – Material Damage Summary

Water Resource	Assessment Approach	Hydrologic Balance Threshold Reached	Material Damage Limit Reached	Measures to Minimize Impact	Adequate Monitoring Program
Fruitland & PCS Quantity	Evaluation of potentiometric surface contour maps	No	No	Contemporaneous Reclamation	Yes
Alluvial Quantity	Comparison of water levels at individual wells over-time	No	No	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones	Yes
Surface Water Quantity	SEDCAD modeling-assessment of pre- and post-mining impacts; Percent of HUC12 Watersheds controlled with impoundments	**Yes**	No		Yes
Fruitland & PCS Quality	Comparison of baseline water quality to potentially impacted or non-baseline wells, including spoil and CCB wells	No	No	Contemporaneous Reclamation; mixing of overburden/ backfill materials	Yes
Alluvial Quality	Comparison baseline (upstream/pre-mining) water quality to non-baseline (post-mining/downstream) water quality	**Yes**	No	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones	Yes
Surface Water Quality		No	No	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones; Sedimentation Ponds	Yes

The finding that the mining operation is designed to prevent material damage to the hydrologic balance outside the permit area is supported by the following chapters. The Navajo Mine CHIA is organized as follows:

- Chapter 1 describes the regulatory environment and general background of Navajo Mine.

- Chapter 2
  - Assesses the cumulative impact potential with historical and active coal mines.
  - Delineates the surface water CIA.
  - Delineates the groundwater CIA.

- Chapter 3 identifies water resource uses and water use designations within the CIAs.

- Chapter 4 provides a description of baseline surface and groundwater quantity and quality within the CIAs.

- Chapter 5 contains an impact assessment of the BNCC operation on surface and groundwater quantity and quality, and includes a determination of:
  - The minimization of impacts within the lease area; and,
  - The adequacy of the monitoring program to assess potential impacts.

- Chapter 6
  - Establishes hydrologic balance thresholds and material damage limits; and,
  - Contains the summary CHIA findings statement.

1.1 Regulatory Environment

Surface coal operations within the Navajo Nation are managed through the coordinated collaboration of several regulatory agencies. Depending on the permitting action, several regulatory agencies may be involved in the review, comment, and public participation process. Regulatory agencies that may have a permitting action on the BNCC permit include:

- OSMRE (regulatory authority for coal mining operations within the Navajo Nation)
- Bureau of Indian Affairs (protect and improve trust assets of the Tribes)
- Navajo Nation Environmental Protection Agency (NNEPA) (develop and administer water quality standards)
- Navajo Nation Minerals Department (represent Tribal mineral interests)
- Navajo Nation Water Management Branch (implement Navajo Nation's Water Code)
- USEPA (issue and administer NPDES permits)
- U.S. Fish and Wildlife Service (ensure protection of threatened and endangered species)
- Bureau of Land Management (ensures maximum resource recovery)
- U.S. Army Corps of Engineers (issue permits and associated impact assessments for the discharge of fill material into waters of the United States, including wetlands under section 404 of the CWA)

The 2012 Navajo Mine CHIA has been peer reviewed by the Bureau of Indian Affairs (BIA), Navajo Nation Environmental Protection Agency (NNEPA), Navajo Nation Minerals Department (NNMD), U.S. Army Corps of Engineers (USACE), and OSM technical staff. Additionally, separate face-to-face discussions were conducted with the aforementioned organizations to review the assessment approach, and to identify any potential major concerns prior to finalization of the assessment. BIA, NNMD, and USACE concurred that the assessment approach for the 2012 Navajo Mine CHIA was reasonable, and the conclusions were appropriate. NNEPA found that the process used to determine water quantity impact was appropriate and that comparison between baseline and post-mining results was acceptable.

OSM developed a use impact assessment approach, specific to the evaluation of potential impacts from Navajo Mine. This approach developed by OSM in part referenced and used NNEPA water quality standards for comparison and also considered Baseline (background) water quality as well as research supported water quality criteria for livestock. OSM did not use NNEPA guidance for assessing the quality of Navajo Nation surface waters to determine impairment because OSM has no authority to implement 303d impaired stream listing protocols. For this reason NNEPA cannot concur with OSM's conclusions without first assessing water quality impairment using NNEPA guidance. NNEPA has expressed future plans to conduct analysis on the available data set using NNEPA guidance.

1.1.1 CHIA Revision Rationale

The CHIA is not updated at a specified interval. 30 CFR § 780.21(g)(2) states "an application for permit revision shall be reviewed by the regulatory authority to determine whether a new or updated CHIA shall be required." A revision to the BNCC life-of-mine (LOM) permit application package (PAP) was submitted to OSMRE in March 2011. Revision updates include additions to the groundwater resources information (PAP, Chapter 6) and probable hydrologic consequences (PAP, Chapter 11). The revision was approved by OSMRE in March 2012. The factors below describe the major differences from the previous CHIA.

The 2012 CHIA for BNCC operations:

- Provides a definition for "Material Damage to the Hydrologic Balance",
- Identifies material damage limits and hydrologic balance thresholds,
- Updates hydrologic monitoring data sets through 2010,
- Includes background baseline information for Mine Areas IV and V,
- Considers NNEPA 2007 surface water use designations and water quality standards,
- Evaluates the effects of Morgan Lake,
- Considers the effect of the Navajo Agricultural Product Industry (NAPI),
- Evaluates the impact of CCB placement within the permit area,
- Updates the methodology for impact assessment,
- Refines the surface water CIA, and
- Expands the groundwater CIA.

1.1.2 Cumulative Impact Area

A CIA is defined at 30 CFR § 701.5 as, ". . . the area, including the permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated mining on surface- and ground-water systems." The CIA is an area where impacts from the coal mining operation, in combination with additional coal mining operations, may cause material damage (OSMRE 2002). The size and location of a given CIA will depend on the surface water and groundwater system characteristics, the hydrologic resources of concern, and projected impacts from the operations included in the assessment (OSMRE 2007). For this CHIA, one surface water CIA and one groundwater CIA are delineated to assess impacts associated within these distinct hydrologic resource areas.

1.1.3 Material Damage to the Hydrologic Balance

Sections 507(b) (11) and 510(b) (3) of SMCRA, and 30 CFR § 780.21 (g) require OSMRE to determine if a mining and reclamation operation has been designed to prevent material damage to the hydrologic balance outside the permit area. "Hydrologic balance" is defined at 30 CFR § 701.5 as, "the relationship between the quality and quantity of water inflow to, water outflow from, and water storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake or reservoir. It encompasses the dynamic relationships among precipitation, runoff, evaporation, and changes in ground and surface water storage."

"Material damage to the hydrologic balance" is not defined in SMCRA or at 30 CFR § 701.5. The intent of not developing a programmatic definition for "material damage to the hydrologic balance" was to provide the regulatory authority the ability to develop a definition based on regional environmental and regulatory conditions. Therefore, for the purpose of this CHIA;

> Material damage to the hydrologic balance outside the permit area means any quantifiable permanent adverse impact from surface coal mining and reclamation operations on the quality or quantity of surface water or groundwater that exceeds the identified material damage limits and that would preclude any existing or reasonably foreseeable use of surface water or groundwater outside the permit area.

SMCRA recognizes that coal mining will have some hydrologic impacts; therefore, differentiates between impacts within the permit area and outside the permit area. Disturbances to the hydrologic balance within the permit and adjacent area should be minimized, and material damage outside the permit area should be prevented (30 CFR 780.21). The Navajo Mine CHIA evaluates the entire lease area (Figure 1). The lease area includes BNCC coal mining areas prior to the enactment of SMCRA north of the permit area, and includes lease areas IV south and V. In an effort to evaluate historical CCB disposal north of the permit area, and to include baseline information from areas IV south and V, the assessment includes the entire lease area.

1.1.4 Material Damage Criteria

Except for water quality standards and effluent limitations established at 30 CFR § 816.42, the determination of material damage criteria is the discretion of the regulatory authority (48 FR 43972-43973, 1983 and 48 FR 43956, 1983). Material damage criteria for both groundwater and surface water quality should be related to existing standards that generally are based on the maintenance and protection of specified water uses such as public and domestic water supply, agriculture, industry, aquatic life, and recreation (OSMRE, 1998). A CHIA also can include material damage standards for parameters of local significance to water use (OSMRE, 1998). The 2012 Navajo Mine CHIA establishes hydrologic balance thresholds and material damage limits (Ch. 6).

1.2 Background

Navajo Mine was originally an asset of Utah International, beginning operation in 1963. Utah International was acquired by GE in 1977, and then by BHP in 1984. Navajo Mine became part of BHP Billiton with the merger of BHP and Billiton in 2001, and is currently operated by BNCC. Navajo Mine operates under Permit NM-0003(A-F). Permit NM-0003 was renewed in 1991, 1993, 1994, 1999, 2004, and 2010; pursuant to 30 CFR 774.15(c).

The Navajo Mine is located 18.6 miles southwest of Farmington, New Mexico, on a contiguous lease within the northeastern portion of the Navajo Nation (Figure 2). The Navajo Mine permit is 24,211 acres (BNCC 2011, Appendix 1-C); the original permit covered 12,092 acres. The permit area was extended in 1991, 1993, and 1994 to 12,921, 13,429, and 13,430 acres respectively (OSMRE 1994). The Navajo Mine lease area is divided into five areas (I-V) (Figure 1) (USEPA n.d.). These lands are divided into Pre-Law, Interim, Termination of jurisdiction (TOJ), and Permanent Program land classifications (Figure 1) (BNCC 2011, Ch. 11). BNCC is currently conducting surface coal mining operations, including reclamation, in permit Areas I, II and III (USEPA n.d.), and has applied to begin operations in Area IV North.

The Navajo Mine supplies approximately 8.5 million tons of coal a year to the Four Corners Power Plant (FCPP) (BNCC 2011, Ch. 11). The coal produced is transported via the Navajo Mine Railroad up to 14 miles to the FCPP (USEPA n.d.). FCPP is a five-unit, 2,040-megawatt facility, located on the Navajo Nation west of Farmington, New Mexico, and adjacent to the Navajo Mine lease area. FCCP is operated by Arizona Public Service (APS) and owned by APS and five other utilities in the Southwest (Arizona Public Service n.d.).

Navajo Mine uses strip mining as the primary mining method in the permit area for multiple coal seam mining (BNCC 2011, Ch. 11). Strip mining involves the removal of overburden material covering the coal using blasting and large draglines. The coal is then removed by truck shovels or front-end loaders and transported to coal preparation facilities using haulage trucks. Coal seams are exposed in pits ranging in depth from 5 feet to 240 feet, mine pit lengths from 1,000 feet to 15,000 feet (BNCC 2011, Ch. 11). After the coal is removed, the overburden material is regraded to the approved topography and drainages to support the approved post-mining land uses. Stockpiled topsoil and other suitable material are spread on top of the graded overburden material to support the re-establishment of approved post-mining vegetation. BNCC must then demonstrate the persistence of reestablished vegetative cover sufficient to support post-mining land use in accordance with 30 CFR 816.116.

1.2.1 Climate

The lease area ranges in elevation from 5,000 feet to 5,600 feet above sea level (BNCC 2011, Ch. 4). The climate at Navajo Mine varies from arid to semi-arid based on Navajo Mine precipitation records (BNCC 2011). Navajo Mine has collected climatological data from two onsite meteorological monitoring stations since 1991, designated Met Station I and II. Met Station I is located in Area I, and Met Station II is located at an area referred to as “the Neck” between Area II and Area III.

Temperatures at Navajo Mine are characterized by cold winters and warm summers, with wide variations in diurnal and annual temperature (URS 2009). Summer days are typically warm (90-95°F) and dry, while nights are cool (55-60°F). During the winter months of December and January, air temperatures commonly fall below 20°F in early morning, while daytime highs typically range from 35 to 45°F. The frost-free period averages 162 days from early May to mid-October (Smeal, et al. 2006).

The average relative humidity at the Navajo Mine ranges from 33 percent in July to 65 percent in January, with an annual average of 45 percent relative humidity (BNCC 2011, Ch. 4). The area receives precipitation during the summer months, when afternoon showers form as a result of moist air from the Gulf of Mexico moving over the area, and in the fall and winter, when cold fronts moving to the east and southeast from the Pacific Ocean create steady, usually light rain and snow showers across the area (URS 2009). The majority of precipitation occurs during monsoon season (July-October), when prevailing winds shift to the southwest and carry sub-tropical moisture into the area, resulting in localized, high intensity, short duration thunderstorms (BNCC 2011, Ch. 4) (Smeal, et al. 2006) (URS 2009). However, considering the entire year, most precipitation events are of short duration and deposit less than 0.10 inch of rain per event (Smeal, et al. 2006). During the winter, snows are infrequent and light. Snow accumulations melt or sublimate within a few days, and snow depths greater than 6 inches are uncommon (Smeal, et al. 2006) (URS 2009).

1.2.2 Regional Geology

The area of interest for this CHIA is within the Colorado Plateau physiographic province of the Western United States, geographically west of the 100th meridian west longitude (BNCC 2011, Ch. 4). The Colorado Plateau covers approximately 130,000 square miles (mi^2) and includes parts of Arizona, Colorado, New Mexico, and Utah (Hereford, Webb and Graham 2005). The Navajo Mine is located on the western flank of the San Juan Structural Basin in northwestern San Juan County approximately 15 miles southwest of Farmington, New Mexico (Figure 3). This basin is an asymmetric, structural basin with a northwest trending axis parallel to the Hogback Monocline in northwest New Mexico. The basin is bounded on the northwest by the Hogback Monocline and on the north by the San Juan Uplift. The eastern rim is formed by the Brazos Uplift and the Nacimiento Uplift. The Zuni Uplift and the Chaco Slope form the southern margin of the basin while the Defiance Uplift and Four Corners Platform complete the northwestern basin rim (Figure 3) (BNCC 2011, Ch. 5). The San Juan Watershed lies on the eastern edge of the Colorado Plateau and extends from northwestern New Mexico into portions of northeastern Arizona along the New Mexico/Arizona border, southwestern Colorado, and the southeastern most corner of Utah. The San Juan Watershed is approximately 140 miles wide by 200 miles long, and covers a total area of 21,600 square miles (URS 2009).

The rock strata in the southern part of the lease area strike north-south while the strata in the northern part strike northeast-southwest (BNCC 2011, Ch. 5). The geologic formation dips gently to the east toward the center of the San Juan Basin at an angle of one to two degrees, and steepens toward the outcrop areas where the fairly abrupt monocline (Hogback) can be observed (BNCC 2011, Ch. 6). The stratigraphic section in the lease area reflects the Late Cretaceous transition of shallow marine depositional environment to a terrestrial fluvial depositional environment (BNCC 2011, Ch. 5). During the late

Cretaceous geologic period, the shoreline of a vast shallow inland sea shifted back and forth across the basin and ultimately receded, depositing alternating marine and nonmarine sediments (BNCC 2011, Appendix 6.D). The strata in the lease area have not been intensively folded, and faults in the strata have limited displacement and extent (BNCC 2011, Section 11.6). The mine lease area surface, and adjacent areas, are comprised of the Lewis Shale, Pictured Cliffs Sandstone Formation, Fruitland Formation, Kirtland Shale and unconsolidated alluvial deposits in the valleys of the San Juan River, Chaco River, and the Chaco River tributaries (BNCC 2011, Ch. 6). A generalized stratigraphic section and geologic map of the lease area are presented in Figures 4 and 5.

Legend

Mine Lease Boundary

- Pre-Law
- Interim Program
- Permanent Program
- TOJ Lands

Meterological Station

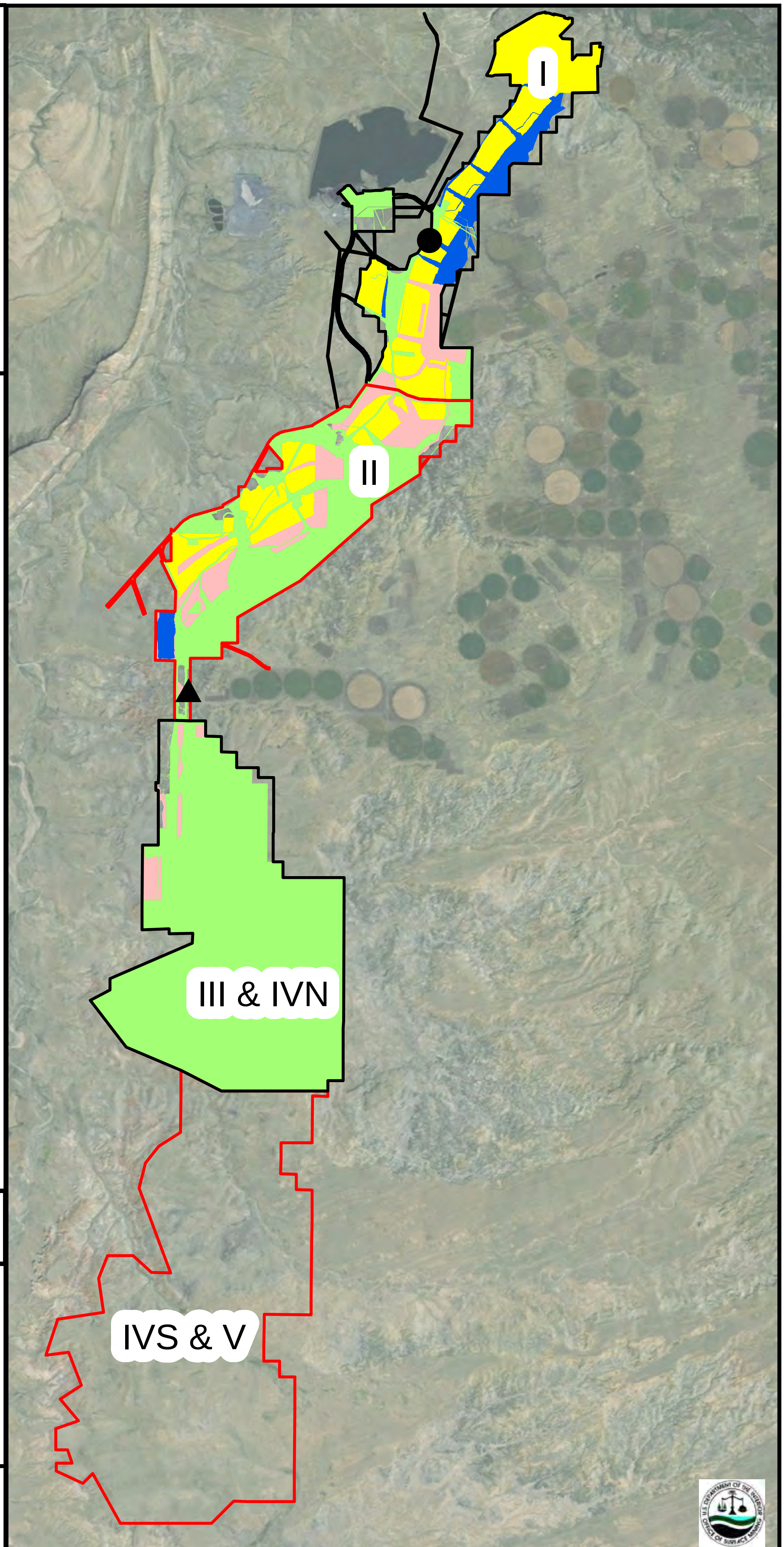
- ● 1
- ▲ 2

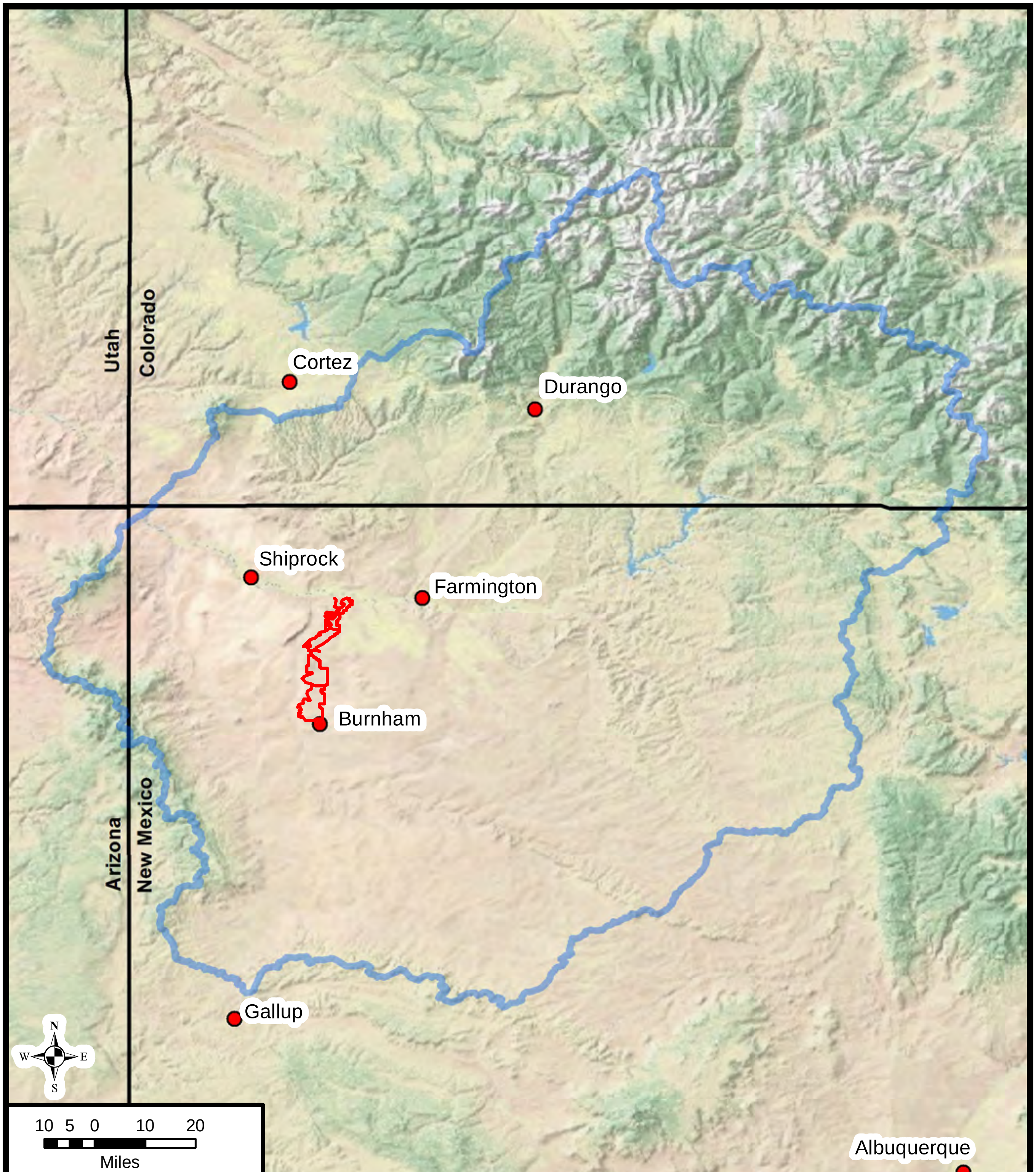
1 0.5 0
Miles

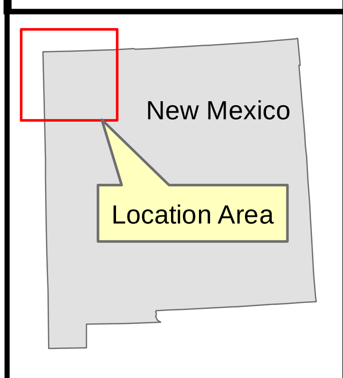
N

BNCC Navajo Mine Areas

Figure 1

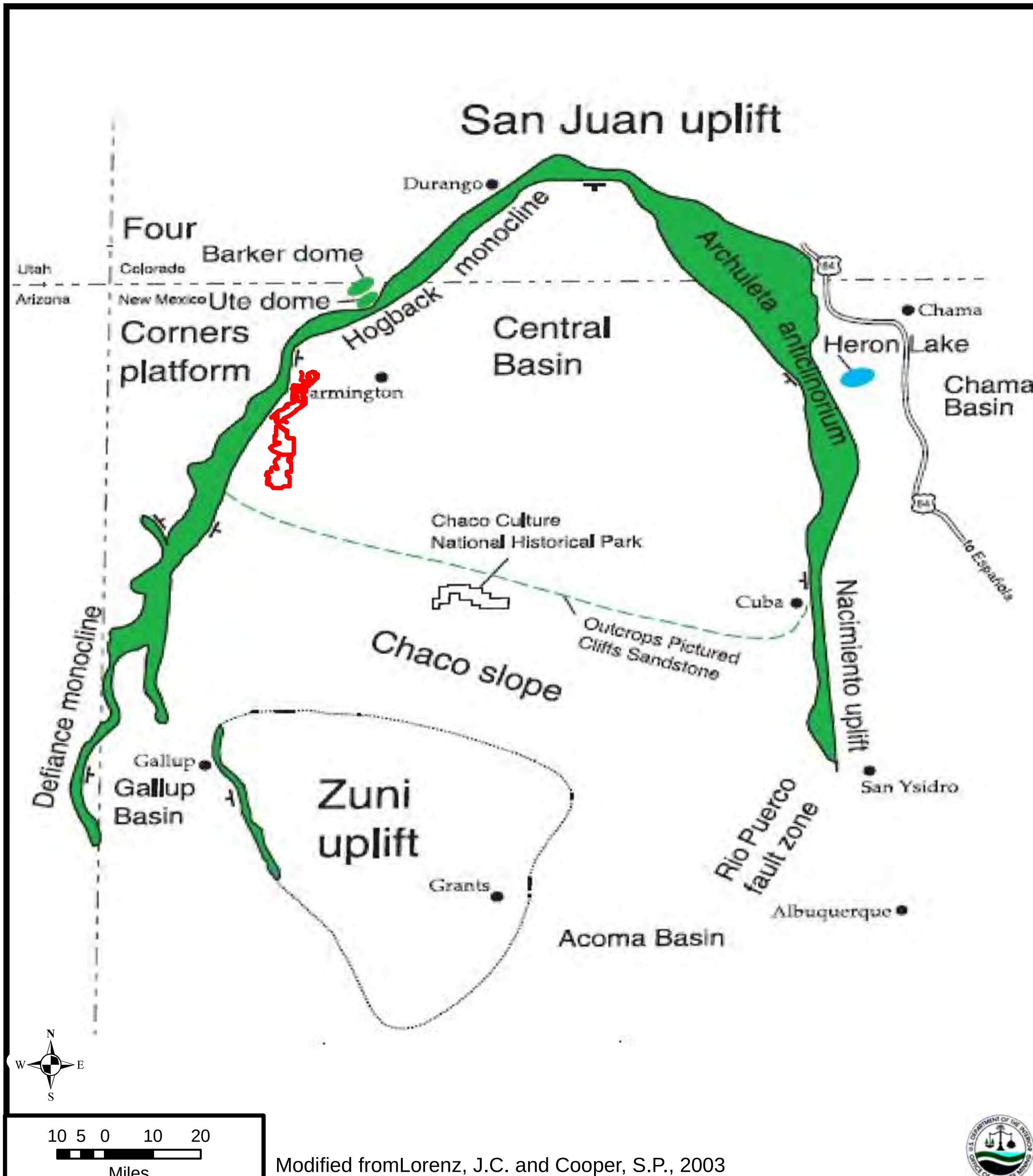






Navajo Mine Location Map

Figure 2



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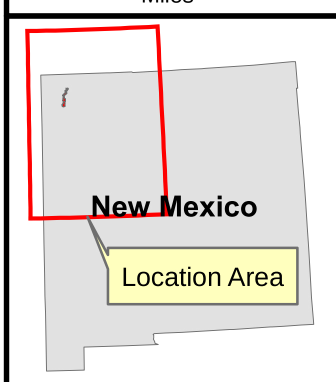


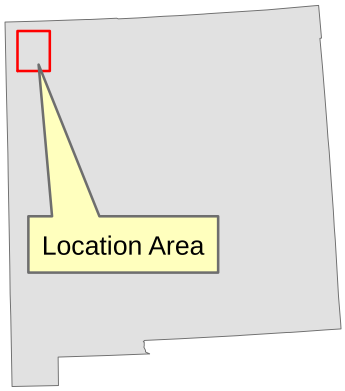
Legend

Navajo Mine Lease Boundary

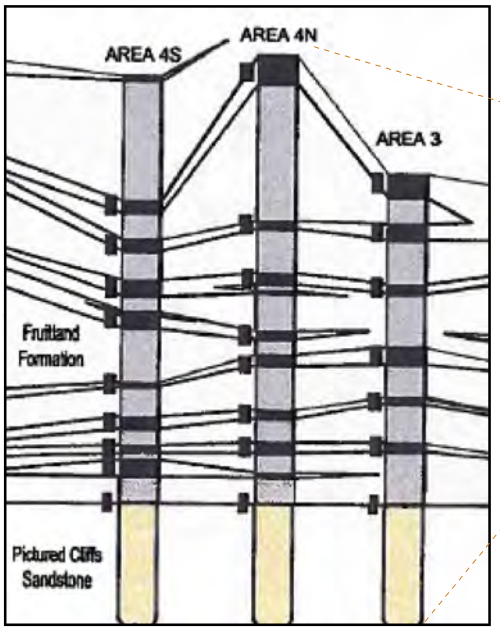
Areas of steep dip; strike and dip symbols show direction of dip

San Juan Basin Structural Geology NW New Mexico

Figure 3



Navajo Mine Area Lithology



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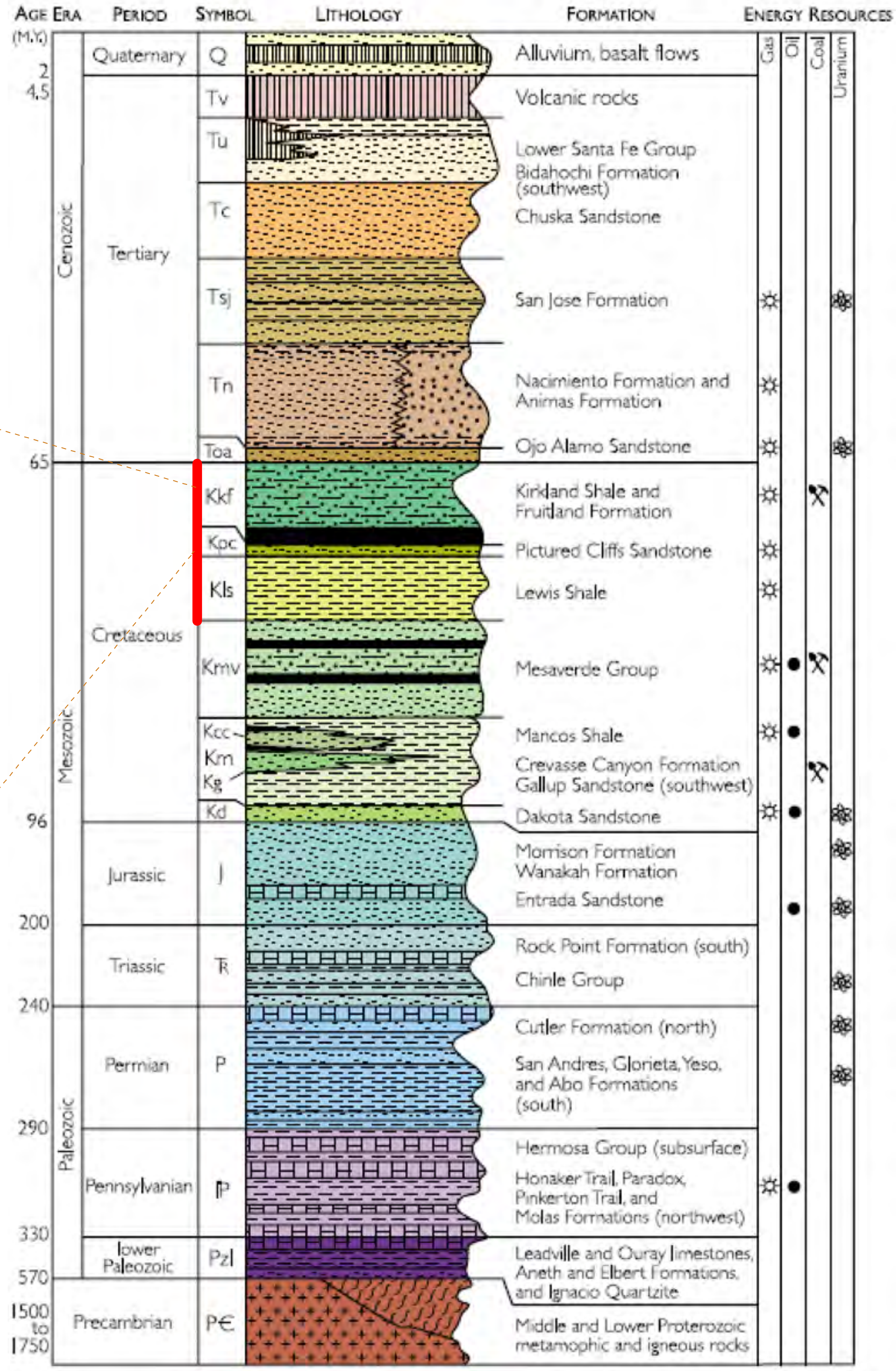
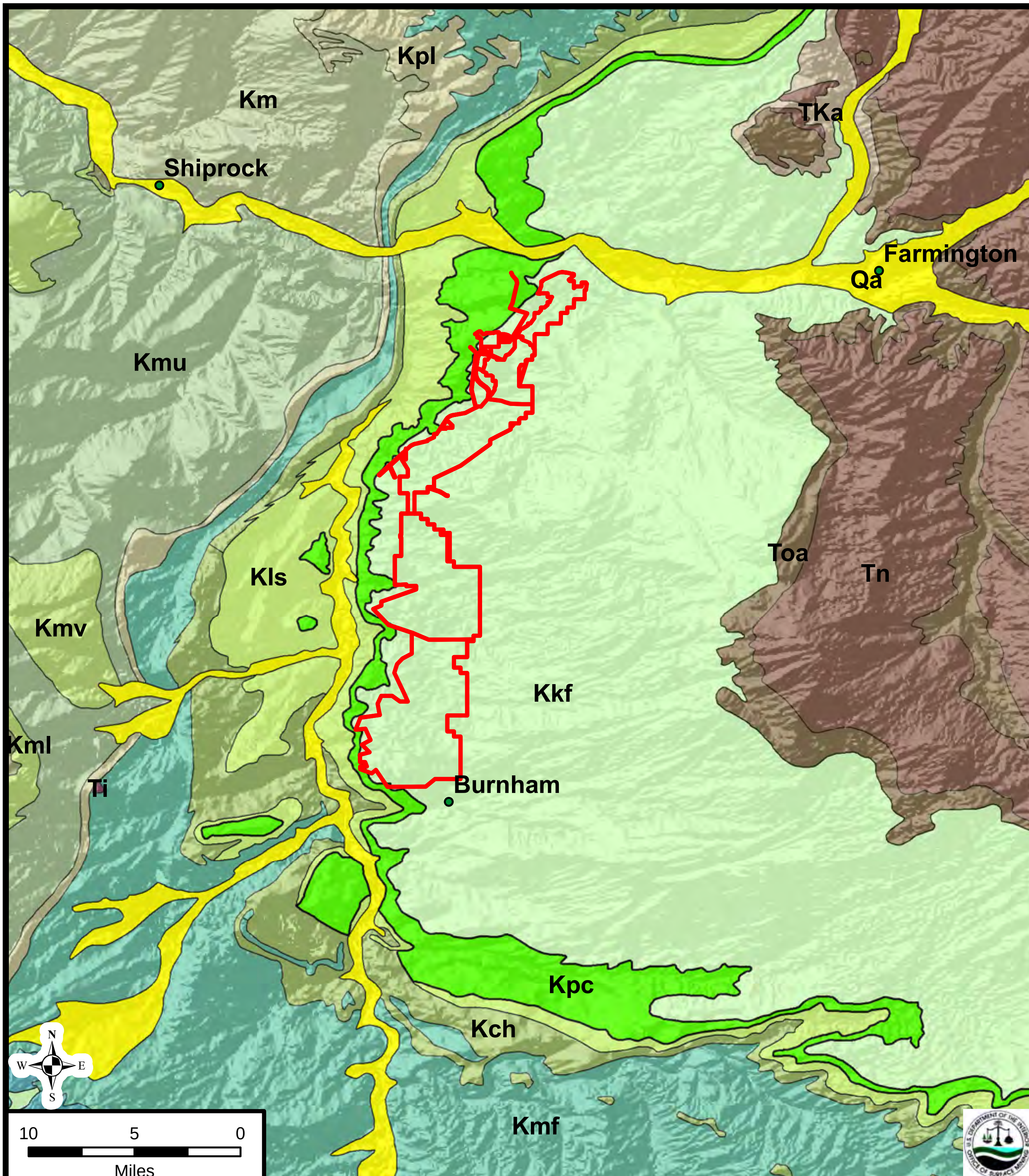
Fassett, J. E. (1977),
USGS Prof. Paper 1625-B

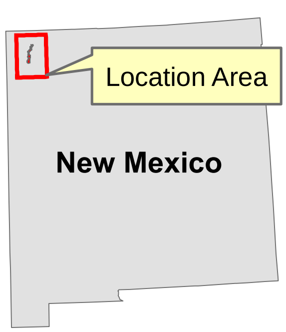


Navajo Mine and Surrounding Area Stratigraphy

Figure 4

From: Brister, B. S. and Price, L. G., 2002





Legend

Navajo Mine Lease Boundary

Navajo Mine Geology

- Qa - Quaternary Alluvium
- Kkf - Kirtland Shale - Fruitland fm.
- Kpc - Pictured Cliffs Sandstone
- Kls - Lewis Shale

Navajo Mine Area Geologic Map NW New Mexico

Figure 5

2 DELINEATION OF CUMULATIVE IMPACT AREA

A CIA is defined in 30 CFR 701.5 as the area, including the permit area, within which impacts resulting from the proposed operation may interact with impacts of all anticipated mining on the surface and groundwater system. CIA delineation for the Navajo Mine consists of both surface and ground water delineations, with specific impact areas delineated for both surface and ground waters based upon the resource extent and potential use impacts.

2.1 Surface Water Cumulative Impact Area

The Navajo Mine lease covers all or part of the drainage areas of the Bitsui, Chinde, Hosteen, No Name, and Barber Washes, and the Neck, Lowe, Cottonwood, and Pinabete Arroyos (Figure 6).

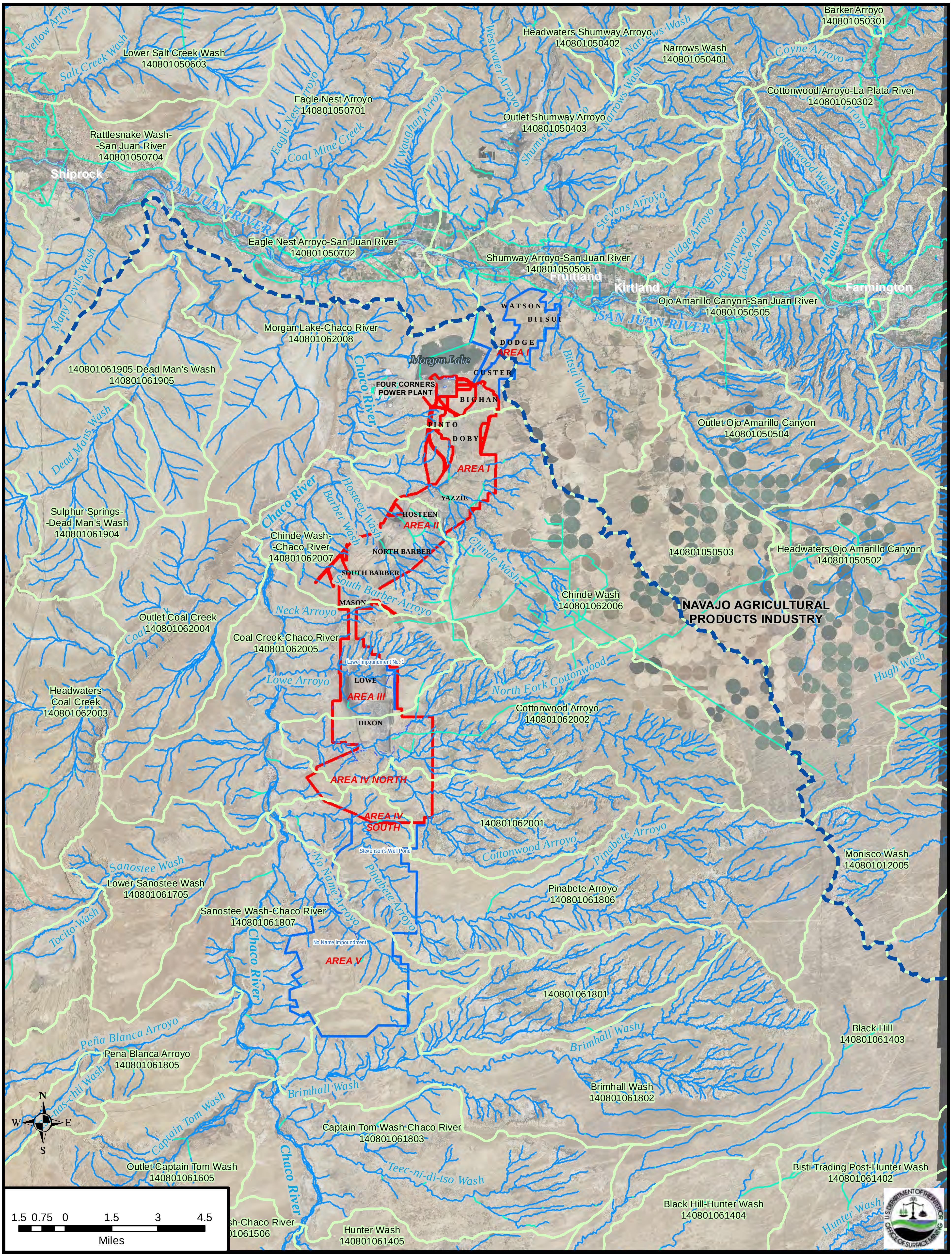
Since mining operations at the Navajo Mine are the only SMCRA regulated operations in the above mentioned drainage basins, surface water impacts cannot be cumulative with other SMCRA operations unless the impacts extend farther downstream. Bitsui Wash discharges directly to the San Juan River, all other washes and arroyos discharge to the Chaco River, which in turn discharges to the San Juan River. The San Juan River and Chaco River channels and flood plains will not be directly impacted by active mining activities. Therefore, potential coal mining impact on these rivers would be through the discharge of surface or groundwater from the mine area or from reclaimed surface and backfill (BNCC 2011, Section 11.6). OSM will assess (1) the cumulative surface water impact potential of all SMCRA mining operations on the Chaco and San Juan watersheds, and (2) the potential for cumulative surface water quality and quantity impacts of the Navajo Mine on either the Chaco or San Juan Rivers.

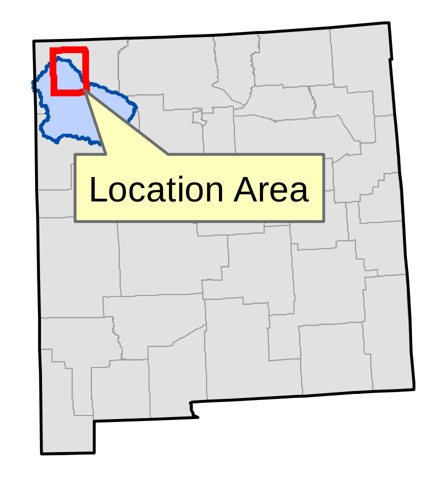
2.1.1 Cumulative Surface Water Impact Potential

Surface coal mining and reclamation activities are required to minimize disturbance to the hydrologic balance within the permit and adjacent areas, prevent material damage to the hydrologic balance outside the permit area, to assure the protection or replacement of water rights, and to support approved post-mining land uses and conditions (30 CFR 816.41(a)). Surface water quality protection of the hydrologic balance is accomplished, to the extent possible, by using the best technology currently available to minimize acidic or toxic drainage and additional contribution of suspended solids to streamflow outside the permit area (30 CFR 816.41(d)(l)).

The 1984 Navajo Mine CHIA (with addendum in 1989) was prepared considering the entire San Juan Watershed as the CIA (Kaman Temp 1984) (OSMRE 1989). Therefore, this delineation considers the cumulative surface water impact potential of all SMCRA regulated activities in the San Juan Watershed. The San Juan Watershed contains the following historical or existing coal mines: Chimney Rock Mine, Coal Gulch Mine, Carbon Junction Mine, Peacock Mine, National King Coal Mine, La Plata No. 1 Mine, Blue Flame Mine, La Plata Mine, Black Diamond Mine, San Juan Mine, Navajo Mine, Burnham Mine, De-Na-Zin Mine, Gateway Mine, and El Segundo Mine (Figure 7). Lee Ranch Mine, which began surface coal operations in 1984, is identified on Figure 7 for illustration purposes only. Existing and planned operations boarder but are not within the San Juan Watershed; therefore, Lee Ranch Mine will not be included in the potential cumulative impacts discussion at this time.

The Chimney Rock, Coal Gulch, Gateway, De-Na-Zin, and Black Diamond Mines were surface coal mines (Table 2). Mining was completed at each of these mines, as well as final bond release. The Blue Flame and La Plata No. 1 Mines were underground mines, which began operation in 1950 and 1905 respectively. Mining was completed at each in 1991 and 1988 respectively; final bond release occurred in 2008 and 2004 respectively. The Peacock Mine was on underground coal mine, which began mining in 1905, and reclamation was completed in 1996.





Legend

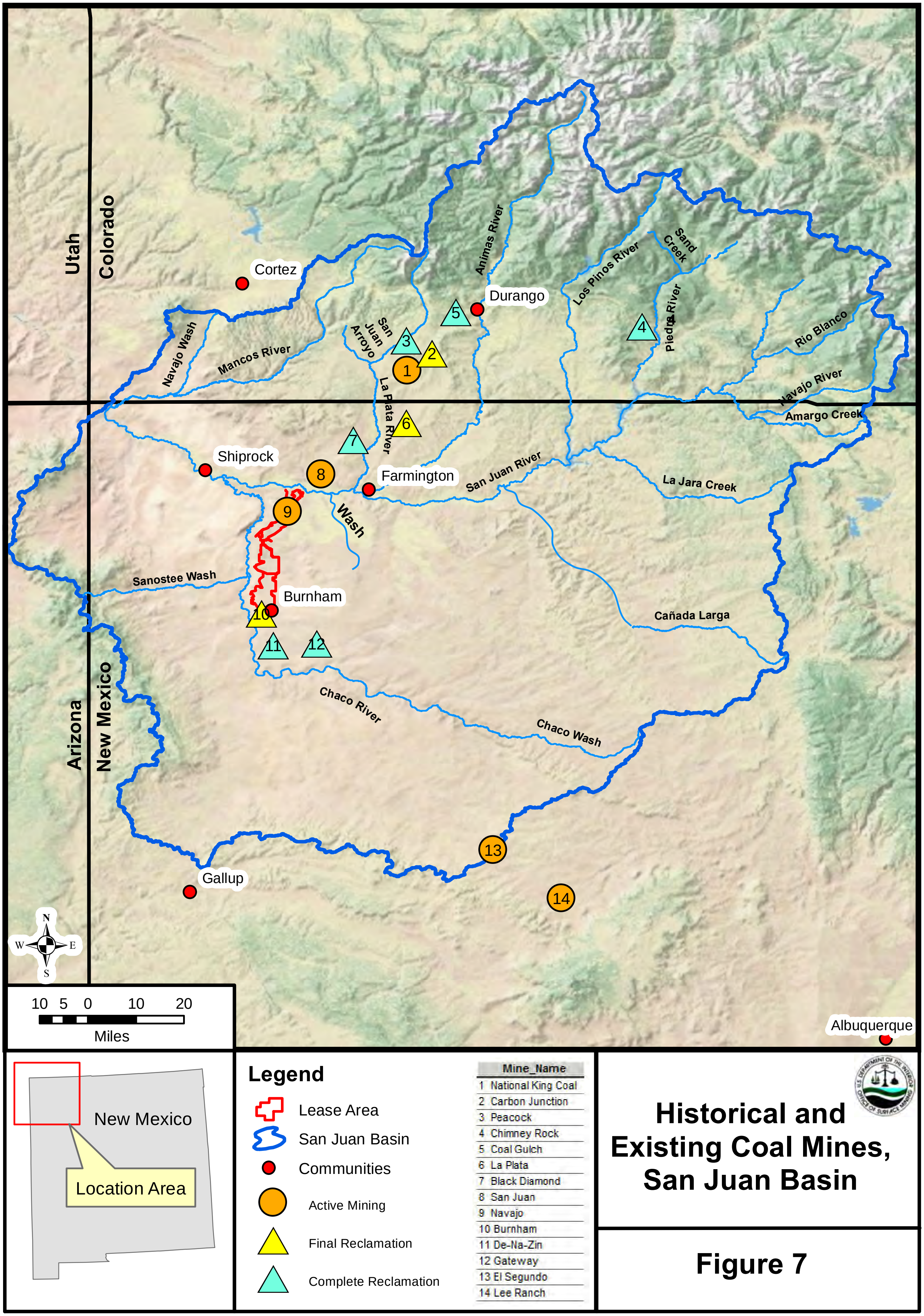
- HUC12 Watersheds[1]
- Ponds
- Natural Stream[1]
- Artificial Canal/Ditch[1]
- Surface Water CIA
- Coal Lease Area
- Permit Area
- PIT NAMES

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA

HUC12 Watersheds

Figure 6



Historical and Existing Coal Mines, San Juan Basin

Figure 7

The Carbon Junction, La Plata and Burnham mines are surface mines, which have not achieved final bond released. The Carbon Junction Mine achieved final reclamation in 2008. Phase II bond release was achieved for the entire La Plata Mine site, and the location is now in final reclamation. The Burnham Mine was conditionally approved for the initial seven years of operation; however, was never issued a permit under the Permanent Program, and the location is currently under reclamation. The King Coal Mine is an underground operation, which began in 1941, and is currently active. The San Juan Mine is both a surface and underground mine operation, which began in 1973 and 2000 respectively. Both the San Juan surface and underground mines are currently active. El Segundo Mine is a surface mine, which began in 2008, and is currently active. The Navajo Mine has operated since 1963, and is the subject of this assessment.

Table 2: Mining History in the San Juan Watershed

Mine	Type	Start of Mining	End of Mining	Status
Chimney Rock	Surface	1976	1985	Final Bond Release 2005
Coal Gulch	Surface	1978	1998	Final Bond Release 2010
Gateway	Surface	1982	1990	Final Bond Release 2004
De-Na-zin	Surface	1980	1992	Final Bond Release 2003
Black Diamond	Surface	1983	1993	Final Bond Release 2007
Blue Flame	Underground	1950	1991	Final Bond Release 2008
La Plata No. 1	Underground	1905	1988	Final Bond Release 2004
Peacock	Underground	1905	1981	Reclamation Completed 1996
Carbon Junction	Surface	1983	1990	Reclamation Completed 2008
La Plata	Surface	1986	2003	In Final Reclamation
Burnham	Surface	1980	1984	Under Reclamation
King Coal Mine	Underground	1941	NA	Active
San Juan Mine	Surface/Underground	1973/2000	NA	Active
El Segundo	Surface	2008	NA	Active
Navajo	Surface	1963	NA	Active

Generally, Phase I bond release requires submission and approval of all documentation for permanent drainage control structures. Phase II bond release generally requires documentation that the permittee or the landowner has provided for sound future maintenance of all approved permanent impoundments in accordance with 30 CFR 800.40(c)(2). Phase III bond release requires a demonstration in accordance to 30 CFR 816.41 that all surface mining and reclamation activities have been conducted to minimize disturbance of the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the lease area, to assure quantity and quality are suitable to support approved postmining land uses, the water rights of other users have been protected or replaced, and in accordance with terms and conditions of the approved permit.

All mines approved for final bond release are eliminated from the potential impact discussion since a determination has been made that material damage to the hydrologic balance has been prevented. Peacock mine is also excluded from the potential impact discussion, since reclamation has been completed to the satisfaction of the Colorado Department of Mining and Safety. Inactive operations, and permit areas currently under reclamation, especially those further along in the bond release process, will most likely not have a cumulative impact; however, they are considered in the potential impacts discussion. All currently active mines are also considered in the potential impact discussion. Therefore, mines which are considered in the potential impact discussion are Carbon Junction, La Plata, Burnham, King Coal, San Juan, El Segundo, and Navajo Mine.

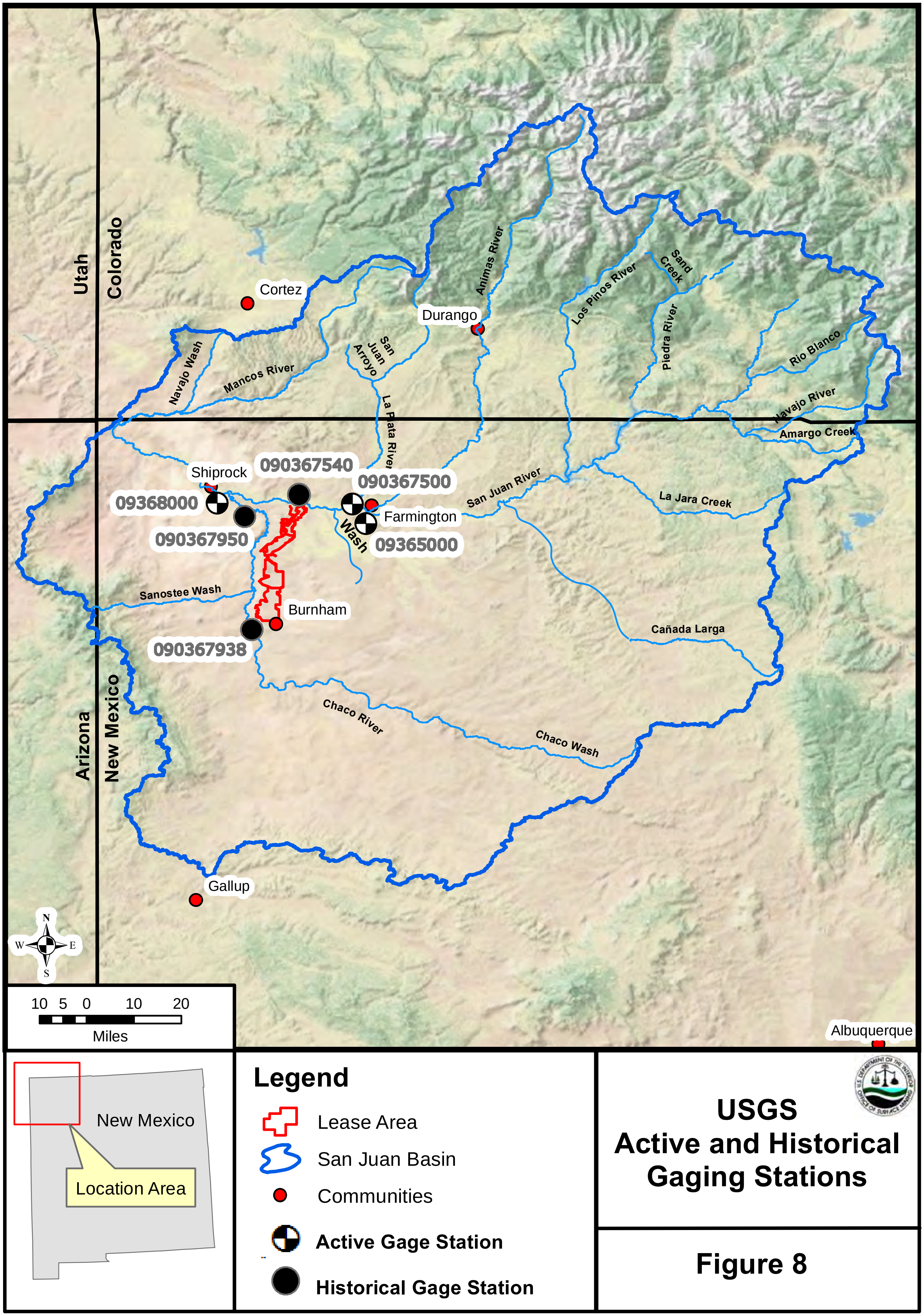
2.1.2 **Impact Potential to the San Juan River**

The San Juan River is a major tributary to the Colorado River, with a drainage area of 24,900 square miles. The San Juan River Watershed is within New Mexico, Arizona, Colorado, and Utah. Originating on the western slope of the Continental Divide in southwestern Colorado, the San Juan River flows perennially from the San Juan Mountains north of Pagosa Springs, Colorado, and enters northwestern New Mexico through the Navajo Reservoir in Rio Arriba County, west of the Jicarilla Apache Reservation and the Carson National Forest. The course of the San Juan River turns westward for approximately 140 miles through New Mexico and southern Utah to its confluence with the Colorado River.

The United States Geologic Survey (USGS) located three stream gaging stations along the San Juan River within the general area of the Navajo Mine (Figure 8). These stations were assigned the following site numbers by the USGS; 09368000, 09367540, and 09365000. Station 09368000 is active and located on the San Juan River approximately 0.9 miles south of Shiprock New Mexico, and 2 miles west of the Chaco River confluence. Station 09367540 is not active, and located approximately 0.4 miles west of Fruitland New Mexico, 13.8 miles east of the Chaco River confluence, and 8.3 miles west of the La Plata confluence. Station 09365000 is active, and located approximately 0.9 miles southwest of Farmington New Mexico, 1.7 miles southeast of the La Plata River confluence, and 0.7 miles northwest of the confluence with the Animas River (Figure 8).

The San Juan River is perennial, and part of its flow originates from groundwater discharge. The historic average mean annual flow at USGS station 09368000 near Shiprock is 2024 ft^3/sec, with a historical low of 657 ft3/sec in 2002. BNCC holds Surface Water Permit Number 2838, issued by the New Mexico Office of the State Engineer in October 1958, and supplies water to the Four Corners Generating Station, the San Juan Generating Station, and the Navajo Mine under this permit. Permit number 2838 provides BNCC a total diversionary right of 51,600 acre-feet annually (~71 ft3/second), with a consumptive right of 39,000 acre-feet annually (~54 ft3/second), for waters drawn from the San Juan River. BNCC typically diverts 825 acre feet per year (~1.14 ft3/second) for use at the Navajo Mine (United States of America 2011, Table L-1), or less than 0.2% of the San Juan River historic low flow rate from 2002. Therefore, diversion from the San Juan River for use at Navajo Mine is not expected to result in material damage to the surface water quantity of the San Juan River given the ratio of the diversion to the total flow of the San Juan River.

The San Juan alluvial aquifer is estimated to have an average flow of approximately 30,000 ft^3/day (BNCC 2011, Section 11.6), or approximately 0.02% of the historic average flow within the San Juan River. Approximately 1% of the alluvial aquifer flow, or 300 ft^3/day, is estimated to discharge from the backfilled mining areas to the San Juan River (BNCC 2011, Section 11.6). Leaching studies from overburden and spoil sample analysis indicate that the chemical quality expected from backfill leachate would be similar to baseline quality in coal seams. Therefore, groundwater discharge from the mine area will have a negligible effect on the water quantity or quality of the San Juan River due to low discharge estimates and water quality analysis comparison.



USGS
Active and Historical Gaging Stations

Figure 8

Figure 9 illustrates discharge data collected by the USGS at three stations San Juan River gaging stations from 1931 to 2010. The data demonstrates there has been consistent flow variability along the San Juan, with a general decreasing flow trend for the period of record. Although flows initially increased upstream to downstream along the San Juan during the monitoring period, this trend reversed, such that downstream flows were less than upstream flows. Based on linear trend lines, the tipping point at which this occurred was around 1972. However, the general trend of decreasing flows, and the difference in the rate of decrease between the downstream and upstream stations, was apparent before mining, and appears unrelated to the changing mining activity in the San Juan Watershed.

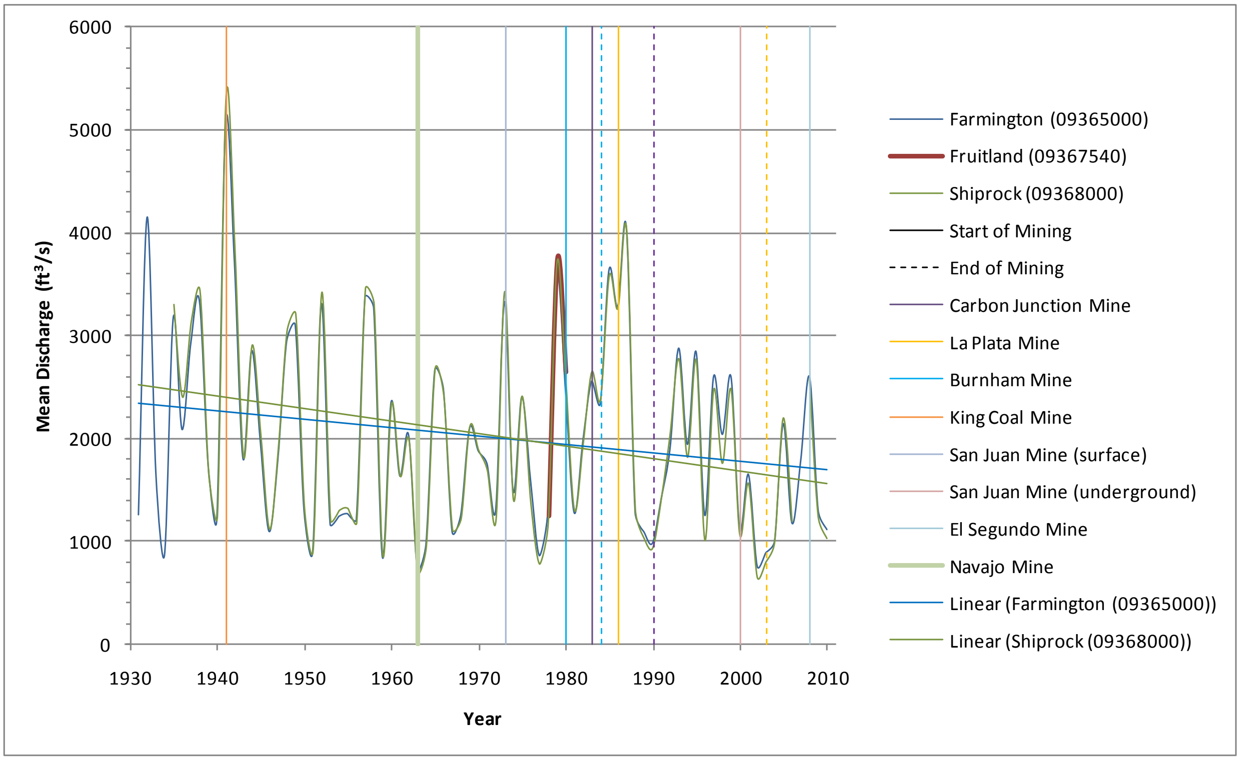


Figure 9: San Juan River Discharge and Mine Operational Period Comparison (1931-2010)

Historic data was analyzed for over 20 constituents collected by the USGS along the San Juan River at the three stations from 1958 to 2010 (Appendix A). Analysis indicates high variability, generally increasing pH, and generally decreasing or relatively unchanged concentrations in constituents of interest over time. Additionally, changes in data trends do not show correlation with mining activities.

For instance, the measured Total Dissolved Solids (TDS) concentrations indicate variability in concentrations along the San Juan River, with a general trend of decreasing concentration throughout the duration of monitoring. TDS increases from upstream to downstream along the San Juan River, and is consistently higher at downstream monitoring stations. Based on linear trend lines, TDS concentrations are decreasing at downstream locations, and the general trend appears to be unrelated to the changing mining activity in the San Juan Watershed (Figure 10).

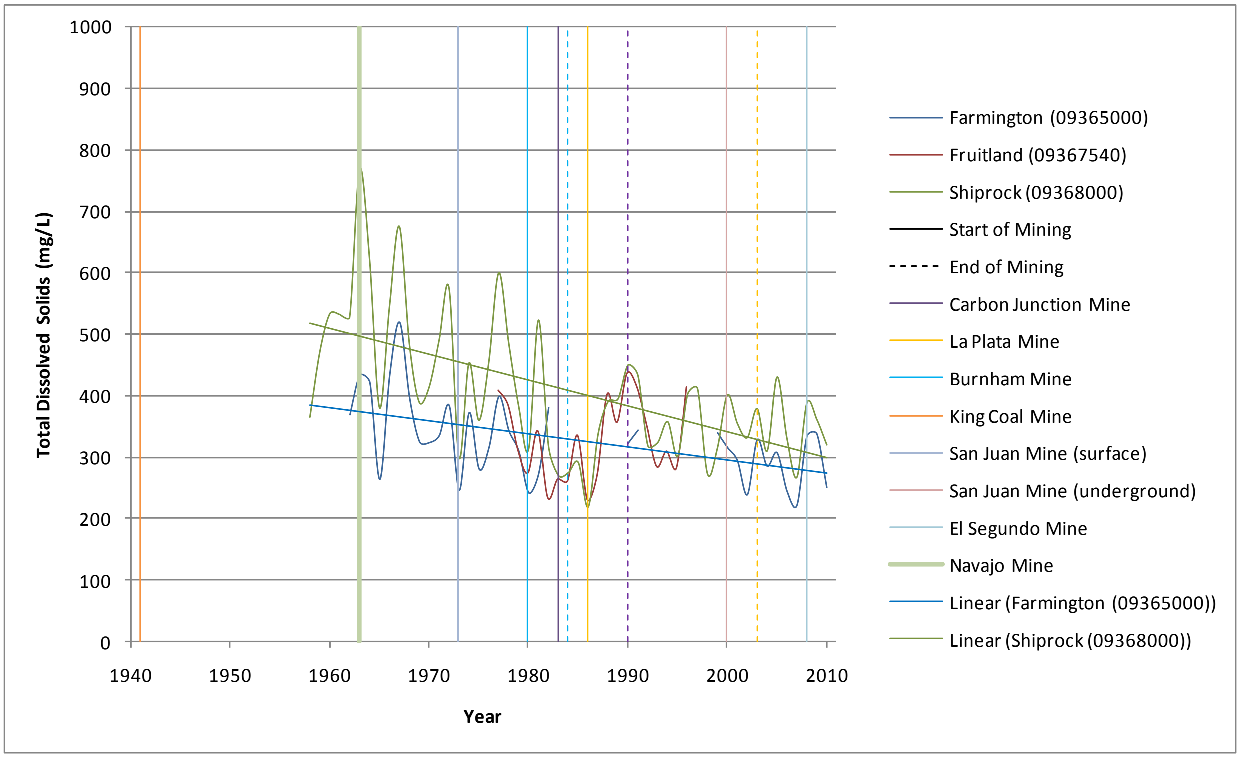


Figure 10: San Juan River TDS and Mine Operational Period Comparison (1957-2010)

Assessment of historic USGS data suggests that cumulative surface water quality impacts from mining are not distinguishable from baseline surface water quality for the San Juan River. All surface water drainages that traverse the Navajo Mine discharge into the Chaco River, which in turn discharges into the San Juan River, except Bitsui Wash. Bitsui Wash is located near the northernmost portion of the lease area, flows intermittently, and discharges directly to the San Juan River (Figure 6). Bitsui Wash drains an area of 7,835 acres. Approximately 17.5% of the Bitsui watershed, or 1,371 acres, were disturbed by historical mining at Navajo Mine. All mining disturbance within the Bitsui watershed predates the establishment of SMCRA in 1977, and is consider pre-law (BNCC 2011, Ch.7). Bitsui receives drainage from pre-law jurisdictional lands on the northern area of the mine lease, but receives no drainage from the reclaimed areas from the Navajo Mine permanent program permit area (BNCC 2011, Section 11.6). Historically, Bitsui Wash would flow ephemerally in response to precipitation; however, the development of NAPI causes Bitsui Wash to flow intermittently. Surface water monitoring was conducted along the Bitsui Wash from 1986-1992. Comparison of median water quality monitoring data to the 2007 NNEPA numeric standards for designated uses indicated exceedances of the aquatic and wildlife standards for cadmium, chromium, and selenium. However, median concentrations are only slightly elevated, and impact to the hydrologic balance is not expected to be significant. The San Juan River is the closest surface water body which could be impacted by Bitsui Wash outside the lease area. Analysis of USGS data indicates concentrations of cadmium, chromium, and selenium have all been decreasing with time in the San Juan River. Therefore, material damage to the San Juan River uses is not expected. Since discharge from Bitsui Wash is not expected to result in material damage to the hydrologic balance, and since the Bitsui Wash area was mined and reclaimed prior to the jurisdiction of SMCRA, it is excluded from the surface water CIA.

Additionally, the Mining and Minerals Division of the New Mexico Energy, Minerals and Natural Resource Division (NMEMNRD) completed CHIAs for both the La Plata and San Juan Mines. La Plata CIA, as determined in the 1999 La Plata CHIA, was found to be entirely contained within the La Plata

Watershed, and potential impacts from the La Plata Mine were not found to extend to the San Juan River. The northern boundary of the La Plata mine CIA is the Colorado-New Mexico border, which is downstream of the King Coal Mine, indicating impacts were not found to be cumulative between the King Coal and La Plata mines along the La Plata River (NMEMNRD 1999). The 1999 San Juan Mine CIA includes the Shumway Arroyo and Stevens Arroyo, which are both tributaries to the San Juan River, but does not extend to the San Juan River (NMEMNRD 1999). Considered in conjunction with hydrologic assessments completed by the NMEMNRD, impacts from the King Coal, La Plata and San Juan mines will have a negligible cumulative potential with the Navajo Mine impacts.

Based on historical quantity and quality data along the San Juan River and CHIA analysis completed by the NMEMNRD, the San Juan River will not be included in the Navajo Mine surface water CIA.

2.1.3 **Impact Potential to the Chaco River**

The Chaco River has a watershed area of approximately 4,350 square miles, of which, the Navajo Mine lease area occupies approximately 0.6-percent. The Chaco River lies to the west of the lease area, and flows north to the San Juan River, downstream of the Navajo Mine. Flow in the Chaco River is ephemeral except for the last 12.5 miles near the confluence of the Chaco and San Juan rivers. The surface expression of the Chaco River is approximately 0.1 mile wide. The Chaco River is subject to high sediment loadings. The Bureau of Land Management (BLM) Farmington Field Office estimated an average sediment yield from the Chaco watershed at 5.8 tons per acre per year (URS 2009). The only coal mining activities in the Chaco Watershed that have not achieved final bond release, other than Navajo Mine, are the Burnham Mine and the El Segundo Mine.

The Burnham Mine is located in Burnham, New Mexico approximately 15 miles east of U.S. Highway 491 on BIA Road 5 in San Juan County, New Mexico (Golder Associates Inc. 2008). In 1978, Consol proposed mining 6,831 acres at Burnham Mine. OSM conditionally approved Burnham Mine for 7 years, and mining operations commenced in 1980. However, the mine only produced coal for 4 years, and production ceased in 1984. Consol submitted an application under the permanent program as a result of the approval of the Federal Program for Indian Lands (30 CFR § 750) in 1984. However, prior to OSM completing review of the application, lease negotiations between Consol and the Navajo Nation failed resulting in lease termination in 1990. For this reason in 1991 OSM rejected the Permanent Program application, returned the application, and requested Consol reclaim the disturbed lands of about 140 acres. Consol submitted the "Plan for the Reclamation of the Burnham Mine" to OSM and it was approved in 1994 (Blake 1994).

The existing Burnham Mine site encompasses approximately 203 acres; containing a former pit area, reclamation areas, and the main facility. The main facility area contains an office building, abandoned guard house, abandoned trailer, and two 500 gallon above ground storage tanks (ASTs). In 1992 a release of diesel fuel was confirmed from an AST system that provided fuel to a generator. The product lines from two 8,000 gallon ASTs to the generator leaked an unknown volume of diesel fuel, and the site is currently under reclamation. The release affected the subsurface soil and shallow groundwater. The majority of soil contamination present at the site is present at the air-water interface between 16 and 26 feet below ground surface not exceeding four feet in thickness. The extent of soil contamination roughly mirrors the extent of non-aqueous phase liquid (NAPL) and is present south of the former ASTs and extends south to the office building. There is approximately 6,500 total cubic yards of diesel contaminated soil at the Burnham Mine. Results of groundwater monitoring indicate that dissolved phase contamination has not migrated extensively ahead of the NAPL contamination. The nearest major surface water is the Chaco River located approximately seven miles west of the site, with the Brimhall Wash a tributary feature to the Chaco River located 0.5 miles south of the site (Golder Associates Inc. 2008).

A draft reclamation plan was prepared by Golder Associates and submitted by Consol to the NNEPA in 2008; it was approved without changes and became the final reclamation plan in 2009 with cleanup standards for diesel contaminates of 500 mg/kg for soil and 100 mg/L for groundwater. The plan currently under action identifies the need for excavation and land farming of contaminated soils, and control and treatment of groundwater from the excavated area. Reclamation on the site is was completed by the end of 2011. This contamination is not expected to affect surface water quantity or quality in the area since the contamination is well below the surface and is not expected to extend laterally to the nearest surface water features before completion of reclamation. For these reasons, the impacts associated with Burnham mine will not be considered further in this surface water CIA.

There are two historic United States Geologic Survey (USGS) stream reach stations along the Chaco River. These stations were assigned the following site numbers by the USGS; 09367950 and 09367938. Station 09367950 is located on the Chaco River approximately 6 miles southwest of Waterflow New Mexico and 4.6 miles southeast of the San Juan River confluence. Station 09367938 is located on the Chaco River approximately 15 miles southwest of Burnham New Mexico and 0.7 miles north of the Brimhall Wash confluence. Discharge data was collected from 1977 to 1994, and water quality data was collected from 1969 to 1989. The period of record does not sufficiently cover the more recent mining activity in the watershed, and therefore cannot be used to rule out cumulative SMCRA related surface water impacts along the Chaco.

In addition to the USGS data, the Mining and Minerals Division of the NMEMNRD has completed a CHIA assessment for the El Segundo Mine. El Segundo coal mine is located in the eastern end of the Standing Rock Cleary Coal area which is located in the southern part of the San Juan Watershed in an area known as the Chaco Slope. The Chaco Slope is a broad, gently dipping part of the San Juan Watershed extending from the edge of the Zuni uplift on the south, northward to the central area of the basin. The proposed lease area straddles the continental divide at elevations approximating 7,000 feet above mean sea level (MSL) in an area that is crossed by several unnamed ephemeral, arroyos. The continental divide separates the lease area into two surface watersheds; only the western section is included as part of the Chaco watershed. There are no named drainages to the west of the continental divide within the proposed lease area. The main drainage through the western mine area has the National Hydrologic Database (NHD) reach code of (14080106000944) and is identified as ephemeral as it leaves the lease area. The drainage area for the main western drainage as it leaves the lease area is approximately 24.7 square miles of which about 6.1 square miles (25%) of the total watershed are proposed to be disturbed by mining (NMEMNRD 2005).

Cumulative surface water quantity and quality impacts from the Navajo Mine with other mining operations in the Chaco River Watershed cannot be ruled out based solely on historical quantity and quality data along the Chaco River and analysis from the Mining and Minerals Division of the NMEMNRD.

2.1.4 Surface Water Impact Area

The Surface water CIA for assessing cumulative impacts of the Navajo and El Segundo mines will be the entire Chaco River watershed (Figure 11). However, the BNCC lease area covers a relatively small percentage of the entire Chaco Watershed. Therefore to insure adequate protection of water uses adjacent to the lease impacts will also be assessed using smaller evaluation areas. Impact of surface water quality will be assessed for the Chaco River within the immediate vicinity of BNCC and the primary washes and arroyos traversing the lease area; Pinabete Arroyo, No Name Wash, Cottonwood Arroyo, and Chinde Wash, as these washes are representative of the water quality conditions of the lease area. Impacts on surface water quantity are analyzed using Hydrologic Unit Code (HUC) 12 watersheds. The USGS has divided and sub-divided the United States into successively smaller hydrologic units and assigned each a HUC number. HUC 12 watersheds are among the smallest of these hydrologic units and represent 6 levels of divisions (USGS 2012). HUC 12 watersheds are used rather than individual drainage basins in order to standardize the analysis as flow is heavily impacted by watershed size which varies significantly between drainages. The Navajo Mine lies primarily within five HUC12 watersheds that either intersect or contain portions of the lease area (Figure 6). Impacts on surface water quantity were analyzed using the following HUC 12 watersheds; Morgan Lake-Chaco River (140801062008), Chinde Wash (140801062006), Chinde Wash-Chaco River (140801062007), Coal Creek-Chaco River (140801062005), and Cottonwood Arroyo (140801062002)

2.2 Ground Water Cumulative Impact Area

Based on drilling and excavation activities, the Quaternary Alluvium, the coal seams and inter-bedded lithologic units of the Fruitland Formation, and the Pictured Cliffs Sandstone (PCS) bear appreciable amounts of water within the mine area. All coal seams at Navajo Mine are within the Fruitland Formation, and the majority of water within the Fruitland Formation is concentrated within these lenticular coal strata, therefore the Fruitland Formation will be assessed in this CHIA with an emphasis on the coal strata. The Kirtland Shale is relatively impermeable, contains no coal seams and was not found to contain appreciable amounts of water within the mine area; it will therefore not be considered for impact assessment in this CHIA (BNCC 2011, Ch. 6). The potentiometric gradients in Fruitland Coal and in the PCS trend north to northwest towards the San Juan River (BNCC 2011, Appendix 6.D), with localized gradients toward the topographic lows along the Chaco tributaries. Ground water in the Fruitland coals and Pictured Cliffs Sandstone may discharge at a very low rate at some locations within the topographic lows along arroyos, where it is removed by evapotranspiration. These discharges are insufficient to sustain baseflow, although they may be sufficient to enhance localized vegetation growth (URS 2009). Alluvial groundwater will also be included in this groundwater CIA. Ground water recharge of the bedrock is thought to be enhanced along the select channels and at existing pond locations where water is available for recharge from storm runoff and pond storage. Recharge water, although limited, is thought to move predominantly downward through the overburden and coal units of the Fruitland Formation and into the PCS. For this reason the PCS will also be assessed in this CHIA. The Lewis Shale underlies the PCS; however, the Lewis Shale is relatively impermeable and does not receive significant discharge from the PCS and will not be considered for impact assessment in this CHIA. Therefore, potential groundwater quality and quantity affects on the Fruitland and Picture Cliffs Sandstone (PCS) Formations and valley alluvium in the permit and adjacent area will be evaluated in this CHIA.

2.2.1 Ground Water Impact Area

A single groundwater CIA will be used to encompass all three groundwater resources (Figure 12); Fruitland Formation, PCS and alluvium. The CIA will be bounded on the north by the San Juan River. Both the PCS and the Fruitland outcrop in the vicinity of the San Juan River, and given that the San Juan is perennial and receives groundwater baseflow, it is expected that the groundwater potentiometric elevation is close to the elevation of the San Juan River channel bottom. The San Juan River can therefore be assumed to act as a hydrologic barrier.

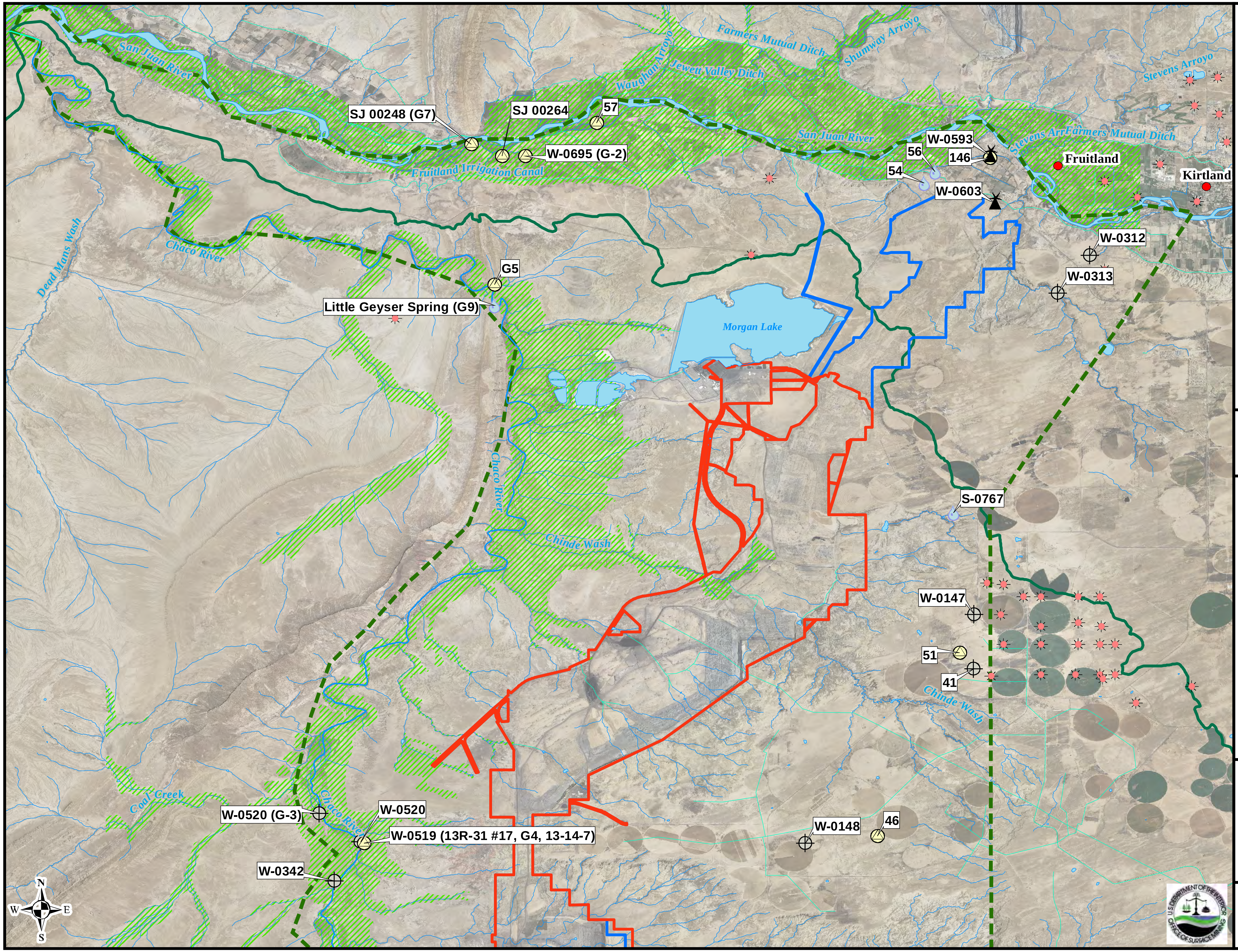
The San Juan alluvial aquifer is estimated to have an average flow of approximately 30,000 ft^3/day, of which 1% or 300 ft^3/day is estimated to be discharged from the backfilled mining areas (BNCC 2011, Section 11.6). Leaching studies of overburden and spoils indicate that the chemical quality expected from backfill leachate would be very similar to baseline quality in coal seams (BNCC 2011, Section 6.5). Consequently, groundwater discharge from the mine area will have a negligible effect on the water quantity or quality of the San Juan River alluvium.

Both the PCS and Lewis Shale outcrop to the west of the Lease area, serving as a physical barrier to groundwater impact for the PCS. In this area the PCS potentiometric surface is above the base of the coal layers and should therefore also serve as in impact boundary for the Fruitland formation. However, in order to address all potential impact to the alluvial system the western boundary of the CIA will be extended beyond the outcrop of the PCS/Lewis shale stratigraphic interface to the western boundary of the Chaco River alluvium.

Both the southern and eastern CIA boundaries are based on groundwater model boundaries developed by Norwest Corporation for BNCC, and presented in the PHC. Two distinct models were developed by Norwest one for the southern mine area (Areas IV and V) and one for the northern mine area (Area I). The southern CIA boundary is the southern boundary developed for the model of Areas IV and V. The eastern CIA boundary is a composite of the eastern boundaries of both models extended correspondingly north and south to their natural intersection. Current and historic water level monitoring data from wells, drainage and outcrop locations, and previously conducted studies in the area, were used to generate a potentiometric surface for the PCS. This potentiometric surface was then used to establish boundaries at a sufficient distance to the east and south of the coal lease where the required assumptions about hydrogeologic conditions at the boundary were expected to have minimal influence on the predicted changes in the groundwater system. The models represent the most comprehensive compilation and evaluation of geologic and hydrologic data in the area, and are therefore appropriate tools for assessing BNCC hydrologic impacts. Figure 12 illustrates the boundaries of the groundwater CIA for this CHIA.

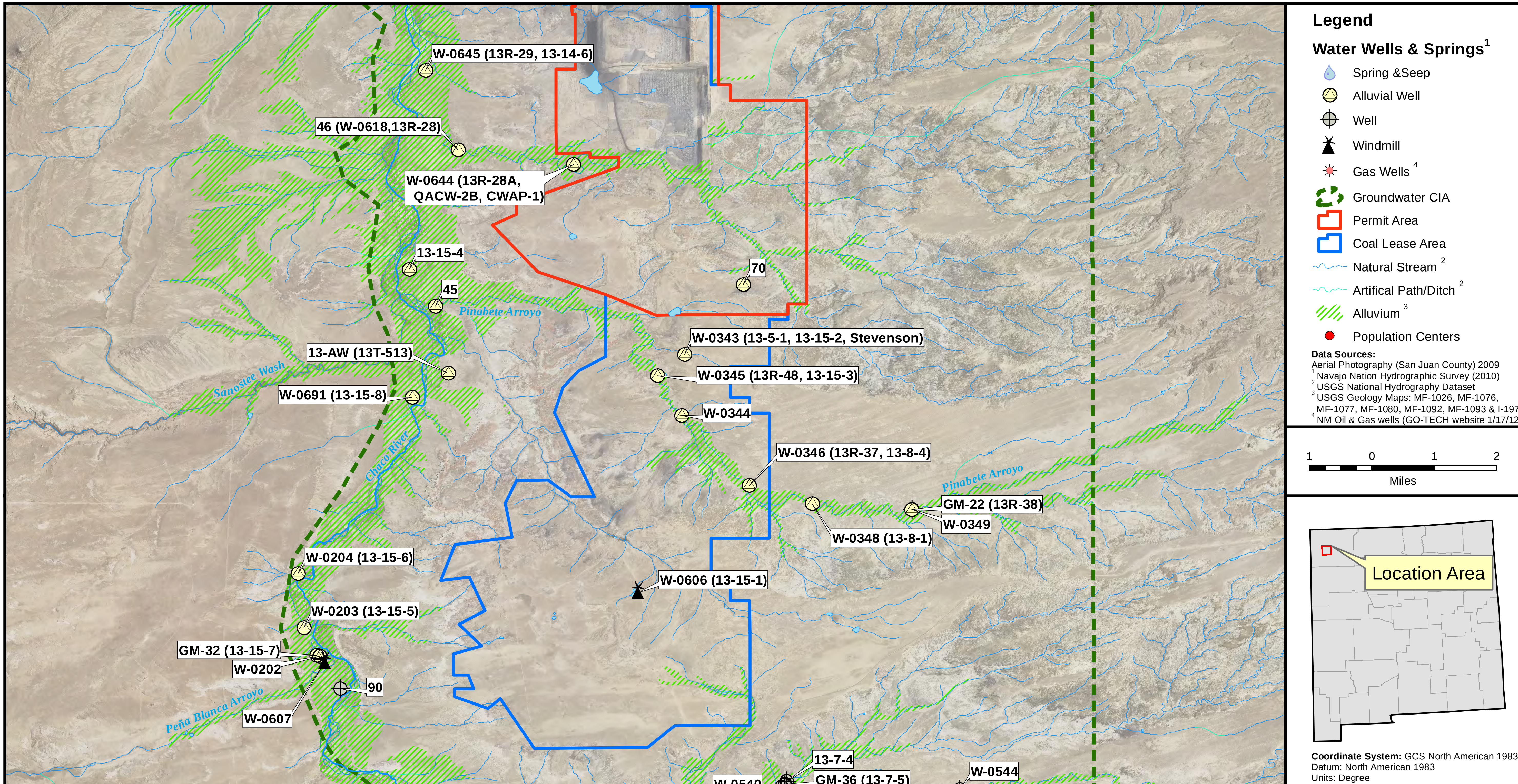
It should be noted that this groundwater CIA extends south of the Burnham Mine. The depth to groundwater at Burnham Mine ranges from approximately 16 to 30 feet below ground surface. Hydrologic monitoring at Burnham Mine indicates groundwater is moving to the southeast away from the Navajo Mine site. Additionally, the area has a low hydraulic gradient and reclamation is expected to be complete before degraded water quality has significantly migrated (Golder Associates Inc. 2008). Therefore, the groundwater contamination at Burnham is not expected to result in cumulative groundwater affects with the Navajo Mine, and the groundwater impacts associated with Burnham mine will not be considered further in this CHIA.


Legend
Impoundments [1]
Water Body [2]
Streams [3]
Permit Area
Coal Lease Area
Surface Water CIA
Counties
El Segundo Mine
Population Centers
Data Sources:
Aerial Photography (Bing Mapping Service)
[1] Navajo Nation Hydrographic Survey (2010)
[2] USGS National Hydrography Dataset
[3] ESRI USA Base Data (2010)
5 0 5 10 15
Miles
Location Area
Coordinate System: GCS North American 1983
Datum: North American 1983
Units: Degree
San Juan
Rio Arriba
Sandoval
McKinley
New Mexico
Beclabito
Shiprock
Rattlesnake
Fruitland
Kirtland
Upper Fruitland
Farmington
Spencerville
Aztec
Flora Vista
Lee Acres
Bloomfield
Blanco
Alcatraz
Turley
Archuleta
Navajo Dam
Navajo City
Fivemile Crossing
Huerfano
Little Water
Sanostee
Tocito
Newcomb
Toadlena
Two Grey Hills
Sheep Springs
Naschitti
Crystal
Buffalo Springs
Navajo
Tohatchi
Mexican Springs
Coyote Canyon
Brimhall Nizhoni
Twin Lakes
Tse Bonito
Yah-ta-hey
Rock Springs
Pinedale
Mariano Lake
Smith Lake
Standing Rock
Shillingburg (hist.)
Crownpoint
White Rock
Lake Valley
Tsaya
Kimbeto
Nageezi
Lybrook
Counselor
Pueblo Pintado
Ojo Encino
Whitehorse
Seven Lakes
Hospah
El Segundo Mine
Voght Place
Piedra de la Aguila
Leon
El Dado
Red Wash
Little Shiprock Wash
Shiprock Wash
Dead Mans Wash
La Plata River
Farmington Glade
Animas River
San Juan River
Sanostee Wash
Tocito Wash
Pinabete Arroyo
Brimhall Wash
Chaco River
Captain Tom Wash
Sheep Springs Wash
Hunter Wash
Alamo Wash
De-na-zin Wash
Coal Creek
Gallegos Canyon
Kimbeto Wash
Betonnie Tsosie Wash
Escavada Wash
Canada Alemita
Blanco Wash
Kim-me-ni-oli Valley
Indian Creek
Kim-Klizhin Wash
Fajada Wash
Chaco Wash
Standing Rock Wash
Coyote Wash
Red Willow Wash
Dry Brush Wash
Pinetree Canyon
Seven Lakes Wash
Sand Springs Arroyo
North Fork Arroyo Chico
Arroyo Chico
Canada Marcelina
Voght Draw
Puerco River
Burned Death Wash
Crystal Creek
Bonito Creek
Frances Creek
La Jara Canyon
Gobernador Canyon
Cereza Canyon
Canon Largo
Tapicito Creek
Canada Larga
N
E
S
W
Surface Water
CIA and Non-BNCC
Impoundments
Figure 11



Ground Water Cumulative Impacts Area
San Juan County, NM

Figure 12
(pg 1 of 2)



Ground Water Cumulative Impacts Area San Juan County, NM

Figure 12
(pg 2 of 2)

3 WATER RESOURCE USES AND DESIGNATIONS

As the regulatory authority, OSM has the responsibility of assessing the potential impacts of the mining operation on the hydrologic balance, and to provide a determination for the potential to materially damage the hydrologic balance outside the lease area. Material damage implies that a quantifiable adverse degradation or reduction of surface or ground waters outside the lease area has occurred, resulting in the inability to utilize water resources for existing and foreseeable uses. Therefore, it is necessary to identify the existing and foreseeable water uses within the CIA's.

Surface and ground water within the CIA's will be evaluated for the following existing and foreseeable uses:

- Direct human use (including domestic and municipal water supply),
- Industrial water supply,
- Irrigation supply water,
- Livestock watering, and
- Aquatic and wildlife habitat

Multiple uses may be present at some locations. Tables summarizing use information within the surface Water and groundwater CIA’s can be found in Appendix B, additionally Figure 12 shows all groundwater wells identified in the groundwater CIA and Figure 11 shows all surface water impoundments identified in the surface water CIA.

3.1 Direct Human Use

Within the surface water CIA Morgan Lake and the Chaco River from its mouth to the mouth of Dead Man’s Wash are the only water bodies designated by the NNEPA for Primary Human Contact; all surface waters within the CIA are designated by the NNEPA for Secondary Human Contact. Primary Human Contact means use of water that causes the human body to come into direct contact with the water, typically to the point of submergence in the water body, or probable ingestion of the water, or contact by the water with membrane material of the body. Examples include ceremonial uses, swimming and water-skiing. Secondary Human Contact means the use of water which may cause the water to come into direct contact with the skin of the body but normally not to the point of submergence, ingestion of the water, or contact of the water with membrane material of the body, such contact would occur incidentally and infrequently, examples include boating and fishing (NNEPA 2007). Both Primary and Secondary Human Contact may occur during ceremonial or other cultural uses. Based on currently available information no cultural use waters have been identified within the vicinity of BNCC.

The Chaco River and all tributaries including the Chinde Wash and Cottonwood Arroyo are designated by the NNEPA for Fish Consumption. Fish Consumption means the use of water by humans for harvesting aquatic organisms for consumption. Harvestable aquatic organisms include, but are not limited to, fish, shell-fish, turtles, crayfish, and frogs. The lease does not contain any streams or ponds with fish, and Morgan Lake is the closest water body within the surface water CIA that provides a fishing habitat.

The closest surface water body to the mine designated by the NNEPA for domestic water supply is the San Juan River, which is outside of the surface water CIA. There are no surface water sources for municipal supply water within the CIA, however, the San Juan River, downstream of the BNCC lease area, is used as a municipal water source for Shiprock, NM. A hydrographic survey was conducted as part of an ongoing water rights settlement agreement between the State of New Mexico, the United States Federal Government, and the Navajo Nation. The survey did not distinguish between historic and current uses. The survey identified 59 impoundments within the surface water CIA that are used for municipal waste water treatment. These impoundments are supplied by local sewer systems and used for waste settling. Of the 59 impoundments, 56 are west and/or south of the Chaco, and 3 are north of the Chaco and east of the Permit (United States of America 2011, Appendix D).

Within the groundwater CIA, the Burnham chapter was identified as a community whose water supply may be included for groundwater impact assessment. However, while the Burnham Chapter used to get their water from a nearby well, they currently have water piped in from the Carson/Huerfano area to the east, outside of the groundwater CIA. Additionally, the water withdrawn from the Carson/Huerfano area is from the Ojo Alamo aquifer, located well above the Fruitland formation. Therefore, although the Burnham Chapter is within the groundwater cumulative impact area, a specific water quantity assessment related to Burnham water use is not warranted since water used at this location is derived from a source outside the CIA. BNCC identified well #90 located west of Area V and the Chaco River completed in the PCS (BNCC 2011, Addendum 12-D-A). The hydrographic survey identified W-0312 east of the permit just south of the San Juan River, it is owned by the Navajo Tribal Utility Authority and W-0349 east of Area IV South along the Pinabete Arroyo (United States of America 2011, Appendix D). New Mexico State Engineer's Office Records and the USGS have identified SJ 00248 (G7, #6) in the alluvium of the San Juan River Northwest of the BNCC lease (Thorn 1993). BNCC also provides the community potable water at two locations, one near the Navajo North facilities and the other near the Area III facilities (BNCC 2011, Exhibit 11-168). These three community potable water locations are illustrated on Figure 12.

3.2 Industrial Supply Water

The Arizona Public Service (APS) Four Corners Power Plant (FCPP) and BNCC are the primary industrial water users within the CIA's. FCPP is a 2040-megawatt coal fired power plant, which has been operating since 1963. In addition to APS and BNCC, significant oil and gas extraction occurs within the San Juan Basin, including the Chaco Watershed. Oil and Gas extraction wells use groundwater and not surface water resources within the vicinity of the mine. A few gas wells were identified within the GW CIA just north and east of the BNCC permit. Gas extraction is the only industrial use of groundwater within the groundwater CIA.

Both APS and BNCC hold water rights on the San Juan River, and neither entity withdrawals groundwater for industrial uses. BNCC holds Surface Permit Number 2838 issued by the New Mexico Office of the State Engineer in October 1958 and supplies water to the Four Corners Generating Station, the San Juan Generating Station, and the Navajo Mine under this permit. This permit provides BNCC a total diversionary right of 51,600 acre-feet annually (~71 ft3/second), with a consumptive right of 39,000 acre-feet annually (~54 ft3/second), for waters drawn from the San Juan River. BNCC typically diverts and consumes 825 acre-feet annually (~1.14 ft3/second) at the Navajo Mine; APS typically diverts 35,421acre-feet and consumes 28,611 acre-feet annually (United States of America 2011, Table L-1).

Water diverted from the San Juan River is diverted to Morgan Lake [P-0016], which is the primary source of industrial water in the area, and is used by both BNCC and APS. NNEPA has designated Morgan Lake for primary and secondary human contact, fish consumption, aquatic wildlife and habitat, and livestock watering. Morgan Lake is a manmade reservoir approximately 1.2 miles wide and 2.2 miles long; it has a maximum depth of about 100 feet and a surface area of 1,260 acres at its maximum storage. Built in 1961 and operated by APS, Morgan Lake holds approximately 39,200 acre-feet of water at normal storage and 42,800 acre-feet of water at maximum storage. Water from Morgan Lake is used as cooling water at the Four Corners Generating Station and also for use in dust suppression and reclamation irrigation activities associated with the BNCC Lease Area. APS uses an ultra-filtration system to purify the water before using it to cool the turbines, and diverts a small portion for drinking water within the plant.

APS manages 11 impoundments west of BNCC which are supplied by industrial water from the power plant and used for industrial purposes [P-0430 through P-0440]. There are an additional 3 impoundments supplied by industrial sources just south of Morgan Lake [P-0022 through P-0024] (United States of

America 2011, Table K-1). BNCC manages several impoundments on the current lease area, as outlined in PAP Section 11.5.4 and summarized in Appendix C, from which they extract water for use in dust suppression. In addition to impoundments operated by APS and BNCC, 6 impoundments supported by the Navajo Indian Irrigation Project (NIIP) irrigation channel are used as a fish hatchery east of the Neck section of Area II of the BNCC permit [P-1430 through P-1435] (United States of America 2011, Table K-1). Although El Segundo Mine is partially within the surface water CIA, the water supply for the mine is from a groundwater well outside of the groundwater CIA. All of these impoundments within the immediate vicinity of the BNCC lease area can be seen on Figure 13.

3.3 Irrigation Supply Water

Groundwater is not used for irrigation within the groundwater CIA. However, there is significant use of surface water for irrigation within the surface water CIA. The closest surface water body to the mine to be designated by the NNEPA for agricultural water supply is the San Juan River. Water from the San Juan River is used for irrigation by NAPI, BNCC and Navajo Nation Fruitland-Cambridge irrigation projects within the vicinity of the mine site. The Fruitland-Cambridge project is just north of BNCC and has a diversion right of 18,180 acre feet per year and depletion right of 7,970 acre feet per year, however all fields on the southern edge of the San Juan drain into the San Juan and do not extend south into the Chaco watershed. Therefore, this project does not extend into the surface water CIA. BNCC operates an irrigation pipeline (initiated in 1975), which provides water from Morgan Lake for the irrigation of revegetation plots as part of the approved reclamation plan (BNCC 2011, Ch. 11). NAPI withdrawals water from the Navajo Reservoir. The Navajo Reservoir is approximately 33 miles east of Farmington, NM and well outside of the surface water CIA.

NAPI is part of the Navajo Indian Irrigation Project (NIIP). On June 13, 1962, Congress authorized the NIIP to furnish irrigation water to 110,630 acres of land with an average annual diversion of 508,000 acre feet of water. The initial 1962 project authorization allowed for development of 77,543 acres of land east and 33,087 acres west of the Chaco River. On September 25, 1970, following a reevaluation of the project, the site descriptions authorized by the original 1962 Act were amended to exclude the proposed irrigated lands west of the Chaco River and include additional townships east of the river such that all proposed irrigated 110,630 acres were east of the Chaco River (United States of America 2011). NAPI was created by the Navajo Tribal Council on April 16, 1970 (Moore 2006). NAPI has developed in stages and by blocks; eleven blocks of approximately 10,000 acres each were created (United States of America 2011). On April 10, 1976 Farm Block I received its first release of water (Moore 2006).

Today, the project is still under construction. Blocks 1 through 8 and the first six fields of Block 9 of NIIP have been completed and are operational. Since 1962, of the acres authorized for development, 79,760 acres have been developed and are subject to project irrigation. Blocks 1, 2 and 4 are east of Gallegos Canyon and outside of the surface water CIA. Block 3 is just east of Area I and II and well within the surface water CIA. Block 2 is just north and east of Block 3, and while part of it drains into the Bitsui watershed it is outside of the Chaco watershed (surface water CIA). Block 7 is just east of Block 3 and partially contained within the CIA. Block 8 and 9 are south of Block 7 and also partially contained in the CIA (United States of America 2011, Appendix E).

In addition to NAPI and BNCC impoundments, 77 impoundments are supplied by surface water sources, other than the San Juan River, which are used for irrigation within the surface water CIA. The 77 impoundments include diversions, in-channel impoundments, and off-channel impoundments. All 77 of these impoundments drain into the Chaco from the opposite side of the basin from BNCC and are located either west or south of the Chaco. Additionally there are 15 impoundments used for irrigation within the SW CIA that are supplied by groundwater or spring sources, all drain into the Chaco from the opposite side of the basin from BNCC and are located either west or south of the Chaco (United States of America 2011, Appendix F).

The hydrographic survey also identifies acreage associated with tributary irrigation project lands that utilize water from sources other than the Mainstem of the San Juan River (Figure 14). One project which irrigates by diversion of surface flows from the No Name Wash is just South of Area IV North, and east of the Chaco River. Two projects which also irrigate by diversion of surface flows from the Teec-ni-di-tso Wash are southwest of Area V and east of the Chaco River. None of these tributary irrigation projects have associated impoundments. The fourth tributary irrigation project is the R.L. Tanner project located north of the Chaco River and southeast of BNCC in the Lower De-na-zin Wash HUC-12 Watershed. The project has an associated reservoir and irrigates by diversion of surface flows from the De-na-zin Wash. All other tributary irrigation project lands are located either west or south of the Chaco on the opposite side of the basin from BNCC (United States of America 2011, Appendix E).

3.4 Livestock Supply Water

Livestock grazing has been and is currently the largest land use on Navajo Lands. Within the San Juan Watershed a variety of water sources exist to meet the demands of livestock. Surface water from the mainstem of the San Juan River and its tributaries has been, and continues to be, used for livestock purposes. In addition, groundwater sources are also utilized to meet livestock demands. On Navajo Lands within the San Juan Watershed, there are 650 wells and 138 springs that have been identified as serving livestock purposes. Finally, on Navajo Land, stock impoundments have been built or maintained to create an additional source of water for livestock. These stock impoundments are supplied with water and are filled and refilled annually to the extent that water is available. The United States has identified that the reserved water right associated with livestock grazed on the lands held in trust for the Navajo Nation is 304 acre feet per year (afy) of depletion (486 afy diversion). Additionally, the Navajo Nation water rights associated with stock impoundments on trust lands amount to 12,693 acre-feet of storage with the associated right to fill and refill these stock impoundments as water is available (United States of America 2011).

BNCC has completed an inventory of wells and springs within the permit and adjacent area (BNCC 2011, Appendix 6-E). The inventory was extended several miles beyond the Navajo Mine permit boundary and includes wells completed in the alluvium of the Chaco River and the San Juan River. The hydrographic survey conducted as part of the ongoing water rights settlement agreement also identified wells and springs used for livestock watering within the groundwater CIA (United States of America 2011).

All together thirty-nine wells used for stock watering were identified within the groundwater CIA. Three wells are located along the San Juan River north of the BNCC lease, two of these are specifically identified as alluvial wells [W-0695 (G-2), SJ 00264 (#7)], and the other well [W-0593] does not have an identified completion level. There are fifteen wells along the Chaco, nine of which are identified to be alluvial [W-0202, W-0607, W-0203, W-0204, W-0519, W-0645, 13-AW, GM-32], one is identified to be in the PCS [#90], and the other four [W-0342, W-0520, W-0538, W-0539] have unidentified completion levels. Two wells are located along Bitsui Wash, one east [W-0313] and one north [W-0603] of the lease, both have unidentified completion levels. One improved spring [S-0767] is located adjacent to the Chinde Wash east of the lease area. Two wells used for stock watering are located west of the lease area within the Cottonwood Arroyo alluvium [W-0618, W-0644]. Seven wells are identified along Pinabete Arroyo, 4 within the lease area [W-0343, W-0345, W-0344, W-0346] and 3 west of the lease boundary [W-0348, W-0349, GM-22], six are identified to be in the alluvium, and one has no identified completion level. There is one well within the lease area along No Name Wash which has no identified completion level [W-0606]. Six wells have been identified as used for stock watering along Brimhall Wash, none of which have identified completion levels [W-0314, W-0537, W-0540, W-0544, W-0545, W-0624]. There are an additional seventeen wells identified within the groundwater CIA with no identified use. Livestock watering is the primary use of groundwater within the CIA. The location of all referenced wells can be found in Appendix B and Figure 13.

All surface waters within the CIA are designated by the NNEPA for livestock watering use, including Morgan Lake. Surface water flows are used opportunistically by sheep or other livestock which might be in the vicinity when the channels are carrying water. However, livestock normally use stock watering ponds which have been constructed to catch surface flows. Surface water use adjacent to the El Segundo mine is confined to opportunistic use by ranchers for livestock watering (NMEMNRD 2008).

BNCC has conducted an inventory of the stock watering ponds within the permit and adjacent area (BNCC 2011, Exhibit 10-3). The inventory found 11 pre-mine stock ponds, which have been disturbed, or will be disturbed by mining. BNCC also identified 4 ponds west of Area II, 3 east of Area II, 2 west of Area III, and 11 east of Area III.

The hydrographic survey conducted as part of the ongoing water rights settlement agreement also identified stock ponds within and adjacent to the lease area (United States of America 2011). One in-channel impoundment [P-5378] was indentified east of Area II slightly south of Area I. Five impoundments were identified east of the Chaco, west of the Areas II and III, three in Chaco tributaries north of the Cottonwood [P-5358, P-5354, P-5305], one in a Cottonwood tributary south of the main fork [P-5294], and one in a Chaco tributary south of Cottonwood [P-0384]. Fourteen in-channel stock impoundments were identified east of Area II and III, six in the Chinde [P-0365, P-1769, P-0366, P-5352, P-0367, P-0354], two in the north fork of Cottonwood [P-5306, P-5318], one in the South Barber Arroyo [P-5344], and five in Lowe Arroyo [P-5325, P-5324, P-5323, P-5320, P-5316]. All referenced impoundment locations can be found in Appendix B and page 1 of Figure 13.

Additionally, twelve in channel impoundments were identified east of Areas III and IV North, in Cottonwood Arroyo and Cottonwood Arroyo tributaries [P-5318, P-0382, P-0355, P-0356, P-5311, P-0695, P-0691, P-0690, P-5280, P-5357, P-0700, P-0692]. South of Area IV North, 41 stock impoundments were identified; sixteen in-channel impoundments are within Pinabete Arroyo and Pinabete Arroyo tributaries [P-5274, P-5261, P-5233, P-5232, P-0350, P-0349, P-0348, P-5241, P-0346, P-0345, P-5262, P-0685, P-0688, P-0687, P-5250, P-0689], two in No Name Wash [P-0332, P-0342], and 23 in Brimhall Wash and Brimhall Wash tributaries [P-0337, P-0339, P-5192, P-5184, P-0341, P-5187, P-5190, P-5209, P-0343, P-5213, P-0344, P-0813, P-5180, P-0608, P-5183, P-0610, P-0611, P-0594, P-0593, P-5195, P-5189, P-0593, P-0591] (United States of America 2011, Appendix M). All referenced impoundment locations can be found in Appendix B and Figure 13.

Outside of the permit and adjacent area, 242 stock impoundments were identified northeast of the Chaco River on the same side of the watershed as BNCC; 205 are in-channel, two are off-channel, three are NIIP supplied, and one is a diversion. 791 stock impoundments were identified southwest of the Chaco River; 767 are in-channel, nine are off-channel, and fifteen are diversions (United States of America 2011, Appendix M). Additionally, BNCC provides water to local permitees in tanks for livestock use in areas around the lease, when requested (BNCC 2011, Section 11.6). Given the total number of stock impoundments, it is evident that livestock watering is the primary use of surface water within the CIA.

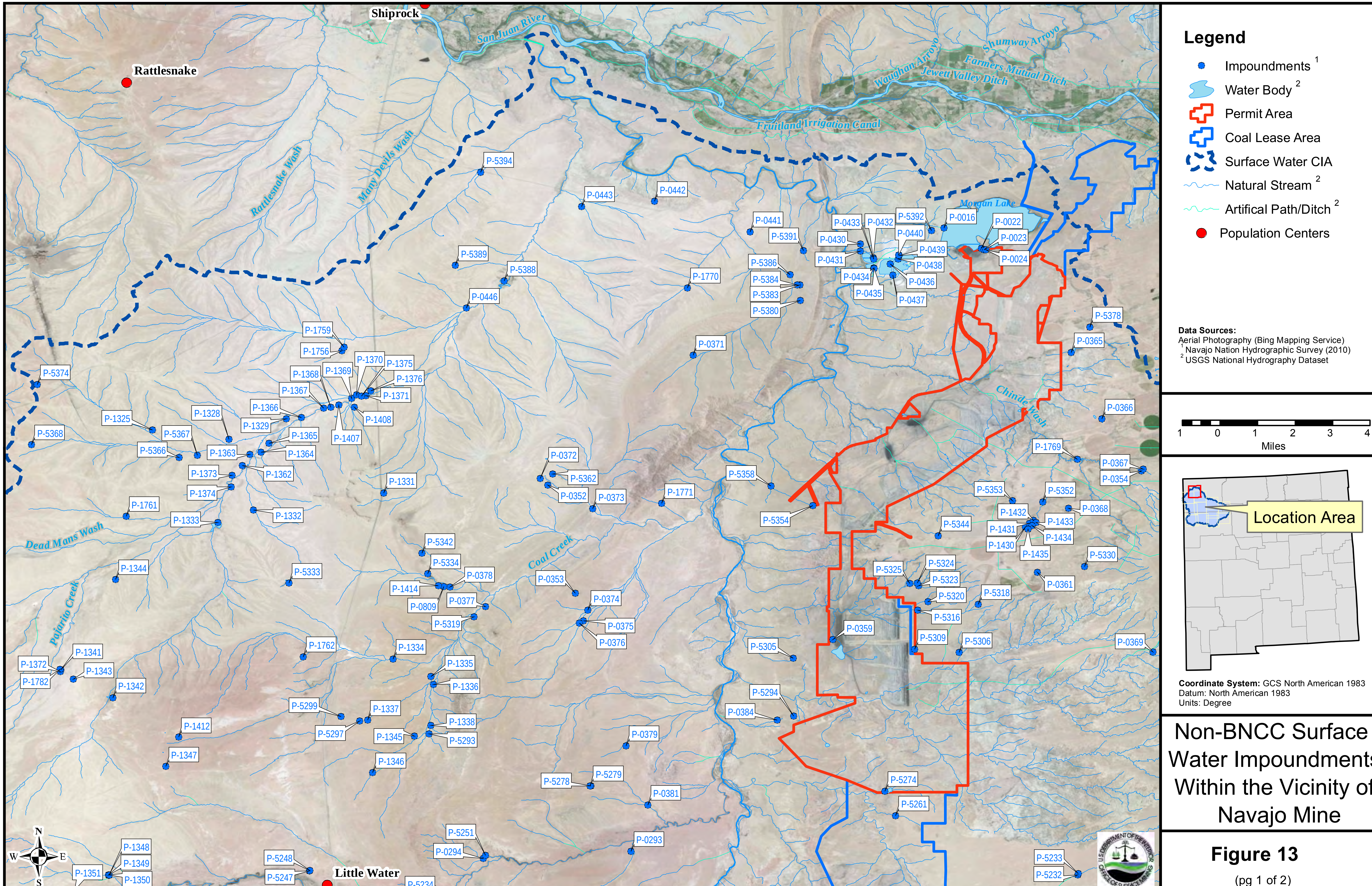
3.5 Aquatic and Wildlife Habitat Water Supply

The Chaco River and all tributaries including the Chinde Wash and Cottonwood Arroyo are designated by the NNEPA for Aquatic & Wildlife Habitat use. The Aquatic and Wildlife Habitat designated use indicates that the water body supports use by animals, plants or other organisms, including salmonids and non-salmonids, and non-domestic animals (including migratory birds) for habitation, growth or propagation (NNEPA 2007).

All water sources are considered wildlife habitats, particularly in the arid region within which the Navajo Mine lease occurs. The vegetation around water sources may be more vigorous or comprised of different species than found in the surrounding area. The predominant wildlife water sources are ponds and impoundments on the lease and nearby areas. Of particular interest are three ponds located on pre-law lands at the french drain discharge point in Area II, based on observations the ponds appear to be permanent year long features. Other small ponds only contain water after precipitation events and are dry most of the time; off lease stock ponds depend on runoff for their water supply. Wildlife and their habitats on and adjacent to the Navajo Mine lease have been surveyed during several studies conducted at various times since 1973 through 1987 and 1989. The lease does not contain any streams or ponds with fish, and Morgan Lake is the closet water body within the surface water CIA that provides fishing habitat. The scarcity of suitable water sources on the lease limits the potential habitat for amphibians. The lesser earless lizard, western whiptail, and sagebrush lizard were the most frequently observed reptiles on the lease (BNCC 2011, Ch. 10).

Waterfowl in the area use water sources such as stock ponds and impoundments on the lease opportunistically as they migrate through the area. Morgan Lake, which is located off lease but within the surface water CIA, provides more suitable waterfowl habitat than is available on the lease. Horned larks are by far the most abundant passerine bird species throughout the year. Other common breeding birds are mourning doves and rough-winged swallows. Mourning doves were the most frequently observed game bird, and mourning dove and waterfowl hunting is provided at Morgan Lake. Blue-winged or cinnamon teal were the most common species observed using the small ponds. White-faced ibis migrate through the region and are occasionally observed at stock ponds or other water sources. Raptors nesting within the lease and adjacent buffer zone during 1987 were ferruginous hawk, red-tailed hawk, American kestrel, and burrowing owl. One active ferruginous hawk nest was located on the lease and several were located within approximately one-quarter mile of the lease boundary. Three red-tailed hawk nests were located on the lease during 1987. Burrowing owls nested on several of the active and abandoned prairie dog colonies on the lease. Additional raptors nesting beyond the one-quarter mile buffer include ferruginous hawk, red-tailed hawk, golden eagle, prairie falcon, and barn owl (BNCC 2011, Ch. 10).

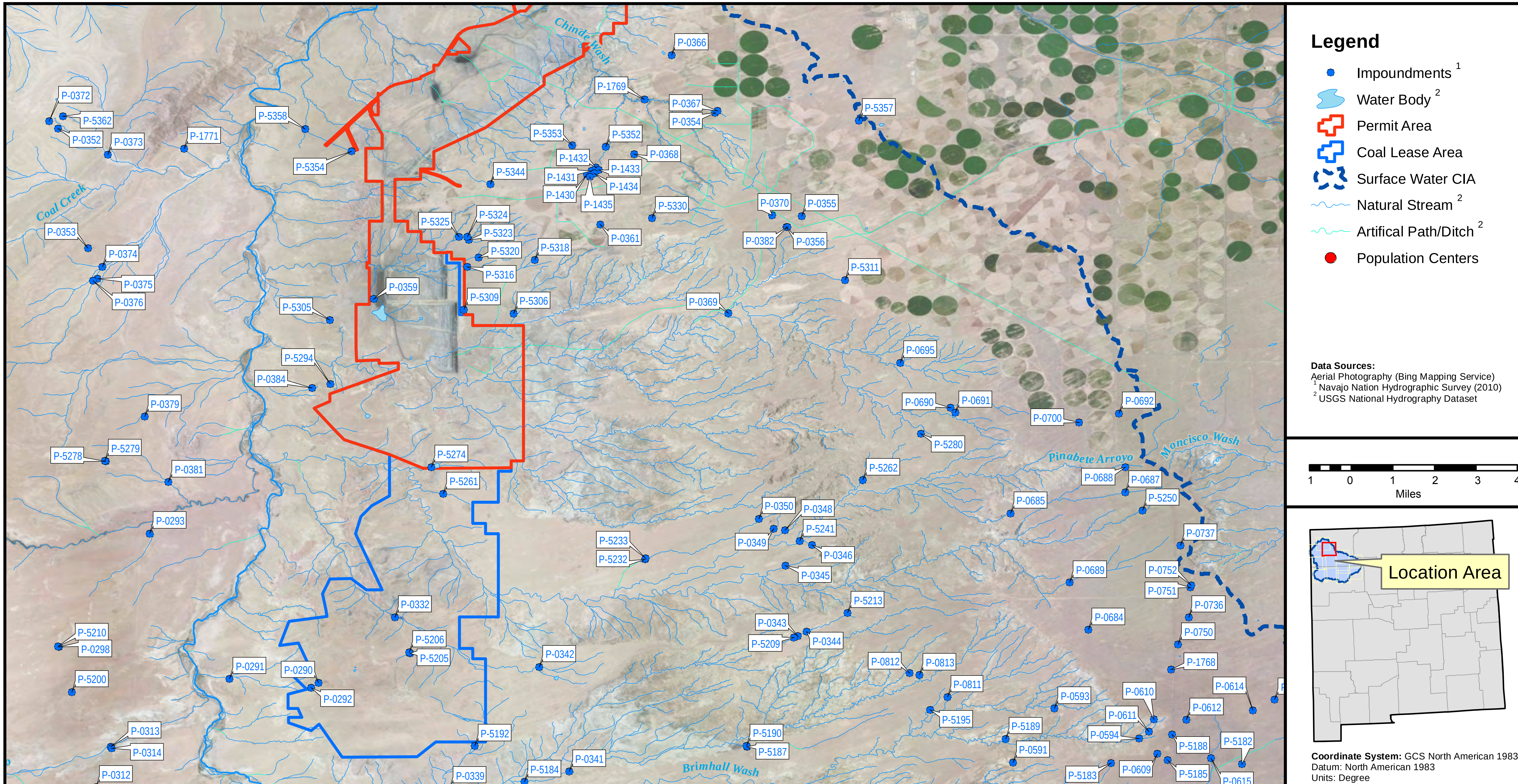
Mule deer are the only big game animal that has been reported on the lease, though they are infrequently observed. Deer mice and silky pocket mice are the most abundant small mammals throughout most of the habitats on the lease. Prairie dogs and kangaroo rats are relatively common on the upland habitats on the lease. Blacktailed jackrabbits and cottontails are common medium-sized mammals. Common predators include red fox, kit fox, coyote, and badger. The prairie dog colonies on the lease provide potential habitat for the endangered black-footed ferret, however, no black-footed ferret has been found during over 1000 hours of night spotlight surveys conducted on the lease. Other endangered species that may use the area are bald eagle and peregrine falcon. Neither of the species nests on the lease and no suitable nesting habitat for either of them occurs on the lease. Both species may occasionally use the area during the migration or winter periods. Other species of high interest that breed on the lease are ferruginous hawk and mountain plover (BNCC 2011, Ch. 10).



Non-BNCC Surface Water Impoundments Within the Vicinity of Navajo Mine

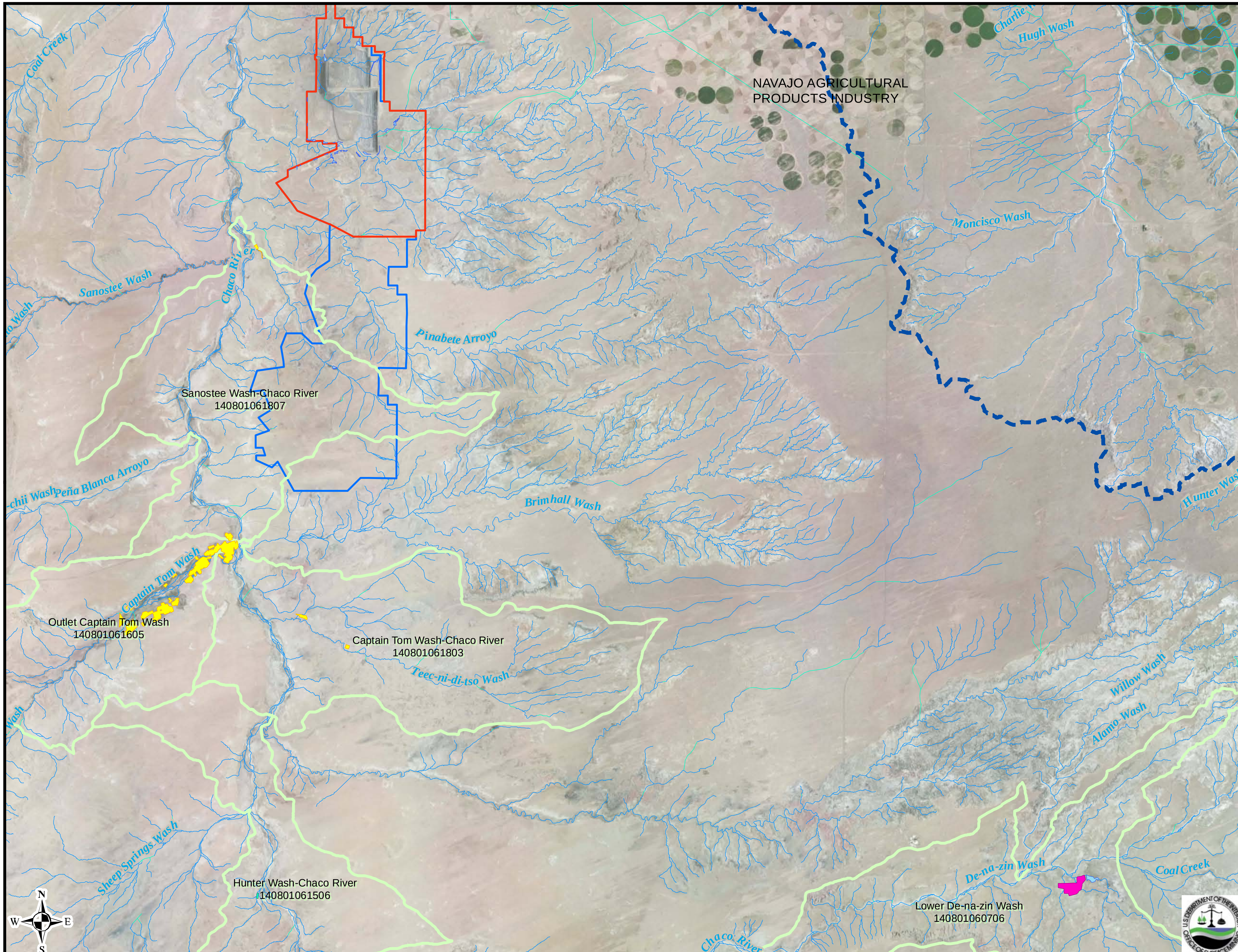
Figure 13

(pg 1 of 2)



Non-BNCC Surface Water Impoundments Within the Vicinity of Navajo Mine

Figure 13
(pg 2 of 2)



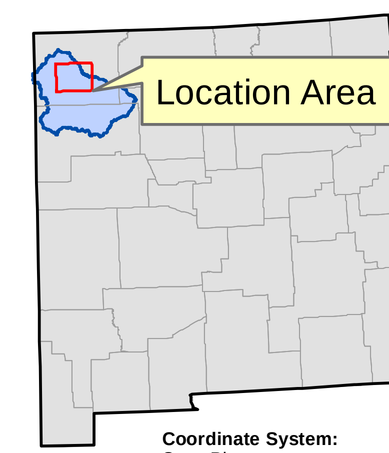
Legend

Irrigation Type:

- Diversion with Reservoir[1]
- Diversion[1]
- Floodwater[1]
- Ponds & Reservoirs
- Natural Stream [2]
- Artifical Path/Ditch [2]
- HUC12 Watersheds[2]
- Surface Water CIA
- Permit Area
- Coal Lease Area

Data Sources:
Aerial Photography (Bing Mapping Service)
[1] Navajo Nation Hydrographic Survey (2010)
[2] USGS National Hydrography Dataset

2 0 2
Miles



Coordinate System:
State Plane
North American Datum 1927
New Mexico West (FIPS 3003)
Feet

Navajo Mine CHIA
Select Tributary
Irrigation Project Lands

Figure 14

4 BASELINE HYDROLOGIC CONDITIONS

The issuance of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) established that surface coal mining operations are to be conducted as to protect the environment, and to assure that a balance between the protection of the environment and the production of coal as a source of energy is maintained (SMCRA, Section 102(d) and (f), 1977). Therefore, as presented in OSMRE's guidance document for the preparation of PHC's and CHIA's, the goals in establishment of baseline hydrologic conditions are to characterize the local hydrology, understand the regional hydrologic balance, and identify any water resource or water use that could be affected by the mining operation (US DOl, 2002). The guidance document is consistent with 30 CFR 780.21: Hydrologic Information. However, mining operations at BNCC commenced prior to the issuance of SMCRA, making quantification of baseline conditions for impact assessment challenging for some hydrologic resources due to the absence of pre-mining information since it was not required prior to 1977.

In compliance with the issuance of SMCRA, in the late 1970's BNCC initiated an extensive hydrologic monitoring program documenting the interaction between the surface water system and alluvial and Fruitland ground water systems within the lease area. Although the large majority of hydrologic information was collected after mining operations began at BNCC, the substantial data sets developed over the last 30 years of monitoring provide insight regarding baseline conditions based on observed water quality and quantity trends. These data sets provide more information related to the hydrologic balance than was available for the initial BNCC CHIA issued in 1984; therefore, some assessments of predictive impacts in this document may differ from the 1984 CHIA.

The general approach for hydrologic impact assessment is similar to the 1984 CHIA. Chapter 3 of this document identified the water resource uses and designations within the surface and ground water CIA's delineated in Chapter 2. The following discussion on the baseline hydrologic conditions will consider available surface and ground water information to characterize both regional and local hydrologic quantity and quality in the assessment areas. Chapter 5 will utilize the characterization of regional and local hydrologic quantity and quality to facilitate hydrologic impact analysis related to the existing and foreseeable water uses, and Chapter 6 make hydrologic determinations of the potential for the mining operation to result in material damage outside the lease area.

4.1 Surface Water

The drainages in the surface water CIAs are considered ephemeral, intermittent and perennial based on OSMRE definitions at 30 CFR 701.5. An ephemeral stream is when a stream flows only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice, and which has a channel bottom that is always above the local water table. An intermittent stream is considered a stream, or reach of a stream, that is below the water table for a least some part of the year, and obtains its flow from both surface runoff and groundwater discharge. OSMRE further defines intermittent at 30 CFR 701.5 as a stream, or reach of stream, that drains a watershed of a least one square mile. A perennial stream is defined as a stream or part of a stream that flows continuously during all of the calendar year as a result of ground-water discharge or surface runoff.

4.1.1 Surface Water Regulatory Requirements

Water Quality

Surface water runoff from areas disturbed by mining operations is required to be managed in a manner that prevents additional contribution of suspended solids to stream flow outside the lease area to the extent possible with the best technology currently available, and otherwise prevents surface water pollution (30 CFR 816.41(d)). BNCC ensures compliance of surface water protection by designing, constructing, and maintaining siltation structures, impoundments, diversions, and designating stream buffer zones within the lease area.

BNCC is required to submit a monthly report to the USEPA regarding NPDES Permit No. NN0028193. The NPDES monthly reports document the water quality and quantity of discharge to the washes when high runoff events exceed the storage capacity design of the structure and surface water discharge to the wash occurs. Additionally, BNCC may dewater ponds in order to ensure sufficient design capacity by either transferring water to nearby ponds with available capacity, or by discharging water into the downstream wash in accordance with the NPDES permit.

Water Quantity

BNCC is required to reclaim lands disturbed by mining so the lands may be returned to the appropriate land management agency in a condition compatible with and capable of supporting the approved post-mining land uses. Therefore, the reclamation plan has been designed by BNCC to produce lands which will be compatible with and will support livestock grazing. The approved post-mining land use is livestock grazing, which is consistent with the pre-mining land use. In order to support the livestock grazing post-mining land use, and after consultation with the Navajo Nation and the Bureau of Indian Affairs (BIA), BNCC proposed to replace the 11 livestock ponds impacted by mining as part of reclamation to ensure a greater viability of post-mining land use success. All the reconstructed ponds will be built to accommodate a similar volume to estimated pre-mining volumes and in the vicinity of the pre-mining locations. The reclamation plan has been previously agreed to by the BIA and the Navajo Nation.

4.1.2 Surface Water Regime

The surface water CIA flow regime is influenced by the duration, intensity, and extent of the precipitation events and the transmission loss rates to the alluvium along the channels. BNCC has conducted several field investigations to better understand these intricate influences of the surface water regime within the lease area. Additionally, the surface water monitoring program continues to provide information necessary for hydrologic evaluation and compliance with SMCRA regulatory requirements. The continued collection and analysis of hydrologic data is utilized to continually assess and update probable hydrologic consequences to the surface water regime.

4.1.3 El Segundo Mine

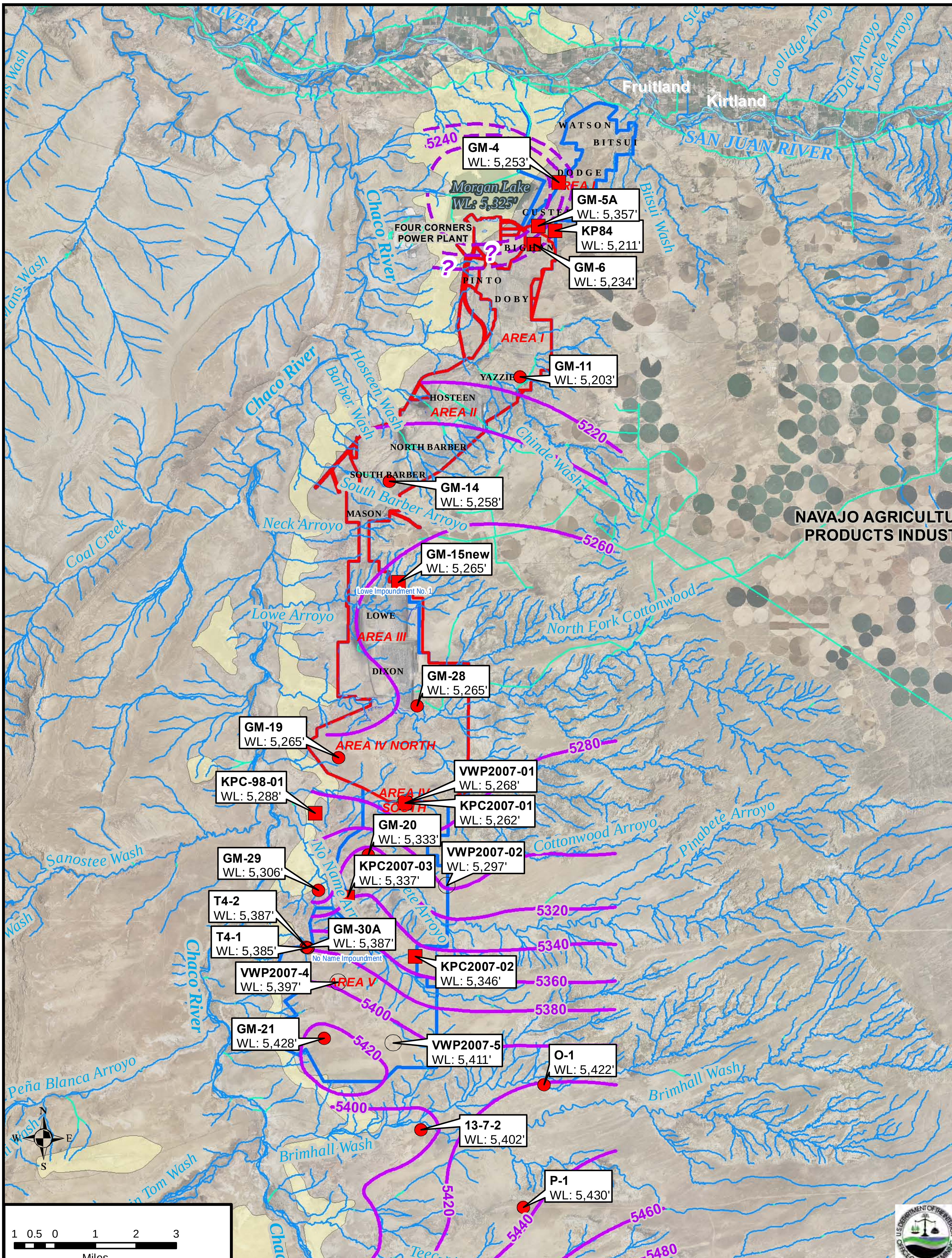
El Segundo coal mine is located approximately 70 miles southeast from the southern tip of the Navajo Mine permit boundary. The proposed lease area is divided into two subwatersheds by the continental divide and is crossed by several unnamed ephemeral, arroyos. The western portion of the lease area drains into the Chaco River through an unnamed, ephemeral channel that drains to Laguna Castillo before flowing into a named drainage, Kim-me-ni-oli Wash, and into the Chaco River. The USGS maintained a gaging station on Kim-me-ni-oli wash from October 1981 to September of 1983. The utility of this station is questionable due to a baseflow discharge to the wash from the proposed Phillips Petroleum, Nose Rock Uranium Mine at that time period. The 2 year data set indicates that surface flows in the ephemeral channel are highly variable, ranging from zero to 1060 cfs. The ephemeral arroyos passing through the lease area flow only in direct response to storm events and have channel bottoms that are above the local water table. The drainage area for the main western drainage as it leaves the lease area is approximately 24.7 square miles of which about 6.1 square miles (25%) of the total watershed are proposed to be disturbed by mining (NMEMNRD 2008) . In the western unnamed Arroyo drainages bicarbonate is the dominant anion and calcium is the major cation followed by sodium. Additionally, total suspended solids and possibly aluminum concentrations exceed various New Mexico water quality standards under baseline conditions (NMEMNRD 2008).

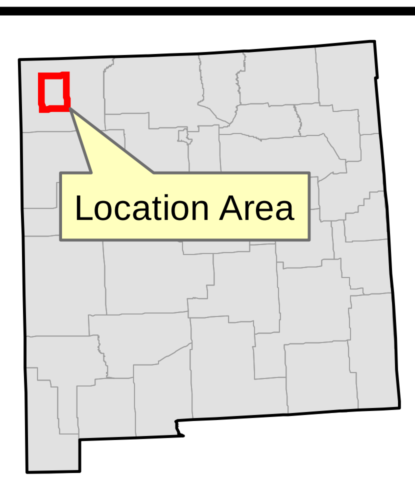
4.1.4 Morgan Lake

Built in 1961, Morgan Lake is a manmade reservoir and perennial surface water body, west of Area I (Figure 15). It was constructed to supply water to mining and power generation activities in the area. Morgan Lake is approximately 1.2 miles wide and 2.2 miles long with a maximum depth of about 100 feet and a surface area of 1,260 acres at its maximum storage. Morgan Lake has a volume of approximately 39,200 acre-feet of water at normal storage and 42,800 acre-feet of water at maximum storage.

Morgan Lake has influence on baseline conditions of Navajo Mine areas I, II, and III. It has had a significant impact to baseline conditions with respect to both surface water quantity and groundwater quantity in the area. One of the principal impacts in which Morgan Lake has affected surface water is at its outflow point where it discharges into the Chaco River. Flow in the Chaco River is ephemeral except for the last 12.5 miles of the river, where perennial flow is the result of spillway overflows from Morgan Lake. It has also had an effect on the groundwater regime in the area, specifically within the PCS. The PCS potentiometric surface in Figure 15 shows how Morgan Lake has likely affected groundwater quantity around its perimeter and within the Navajo Mine lease area.

Water from the San Juan River is pumped to Morgan Lake for use as cooling water at the APS Four Corners Generating Station and also for use in dust suppression and reclamation irrigation activities associated with the BNCC Lease Area. Therefore, baseline water quality in Morgan Lake is most likely similar to that found in the San Juan River. The San Juan River has a better water quality compared to water within the Chaco River Watershed; specifically a comparison of water quality from USGS stations along the San Juan and Chaco Rivers shows that TDS concentrations within the Chaco River are approximately three times more than TDS concentration within the San Juan River. Morgan Lake is designated for the following uses by the NNEPA; livestock watering, aquatic and wildlife habitat, secondary and primary human contact and fish consumption (NNEPA 2007).





Legend

- Abandoned PCS Monitoring Well
- Existing PCS Monitoring Well
- Nested Vibrating Wire Piezometer
- PCS Potentiometric Contour
- PCSPotentiometric Contour - Inferred
- Ponds
- Natural Stream[1]
- Artificial Canal/Ditch[1]
- Coal Lease Area
- Permit Area
- Pictured Cliffs Formation (Kpc)
- PIT NAMES

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA Pictured Cliffs Potentiometric Surface

and Outcrop Location

Figure 15

4.1.5 Chaco River

4.1.5.1 Surface Water Quantity

The Chaco River is an ephemeral drainage up until the last 12.5 miles of the stream where runoff from Morgan Lake has caused it to be perennial. All of the primary drainages of interest at the Navajo Mine except for Bitsui Wash drain into the Chaco River. Water monitoring historically occurred along two USGS gage stations along the Chaco River, station #09367950 near Waterflow, NM and station #09367938 near Burnham, NM. The locations of these two water monitoring stations are illustrated in Figure 8. The stations were actively monitored for stream flow and select water quality parameters from 1977-1994 and from 1977-1982, respectively. Station #09367938 exhibits the original ephemeral nature of the Chaco River, which existed prior to the construction of Morgan Lake. USGS station 09367938 is considered to be representative of baseline conditions within the Chaco River relative to mining impacts as it is upstream of the Navajo Mine lease. Flow at USGS station 09367938 is shown in Figure 16. All of the large flow events occur in response to precipitation.

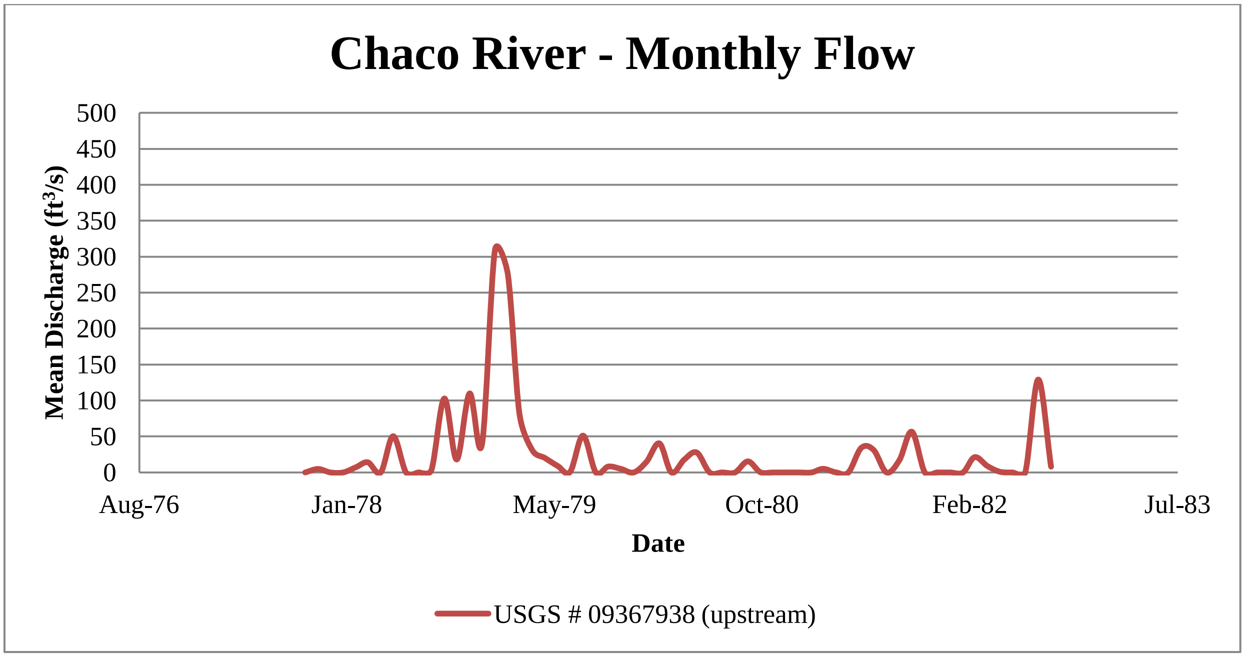


Figure 16: Baseline Monthly Flow along the Chaco River

4.1.5.2 Surface Water Quality

The Chaco River within the vicinity of the BNCC lease area is designated for the following uses by the NNEPA; livestock watering, aquatic and wildlife habitat, secondary human contact and fish consumption. Additionally, the Chaco River from its mouth to the mouth of Dead Man's Wash is designated by the NNEPA for Primary Human Contact (NNEPA 2007). The principal use of surface waters near the lease area is for stock watering ponds (BNCC 2011, Section 11.6).

4.1.5.2.1 Methodology

Surface water quality analysis, where data was available, has been done for all constituents for which there are NNEPA criteria, as these constituents have been identified by NNEPA to have potential impact on use (NNEPA 2007). Additionally, analysis has been conducted on TDS, sulfate, chloride, and fluoride as these are generally considered to be harmful to livestock at elevated concentrations (Lardy, Stoltenow and Johnson 2008). Select surface water use criteria are presented in Table 3 below. Analysis was also conducted for dissolved iron based on the water quality definition referenced in SMCRA at 30 CFR §

816.42, which for western alkaline mining is defined in 40 CFR § 434.81 to be a drainage effluent maximum of 10mg/L. No manganese criteria is defined for western alkaline mining in 40 CFR § 434.81.

Table 3: Surface Water Criteria

Constituent	Livestock	Aquatic & Wildlife Habitat (Acute)	Aquatic & Wildlife Habitat (Chronic)	Secondary Human Contact	Fish Consumption
Aluminum	NNS	0.75	0.087	NNS	NNS
Arsenic	0.2	0.34	0.15	0.28	0.08
Barium	NNS	NNS	NNS	98	NNS
Boron	5	NNS	NNS	126	NNS
Cadmium[1]	0.05	.0041	.00041	0.47	0.008
Chloride	600**	NNS	NNS	NNS	NNS
Chromium (III+IV)	1	NNS	NNS	NNS	NNS
Chromium III	NNS	.00061	.035	1400	75
Chromium IV	NNS	.016	.011	2.8	0.15
Copper[1]	0.5	.027	.017	9.33	NNS
Fluoride	2*	NNS	NNS	56	NNS
Lead[1]	0.1	.14	.0056	0.015	NNS
Mercury	NNS	0.0024	0.000001	0.28	0.00015
Nitrate	500*	NNS	NNS	1493.33	NNS
pH	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	NNS
Radium 226+228	30	NNS	NNS	NNS	NNS
Selenium	0.05	0.033	0.002	4.67	0.67
Silver[1]	NNS	.012	NNS	4.67	8
Sulfate	1000*	NNS	NNS	NNS	NNS
TDS	3000*	NNS	NNS	NNS	NNS
Zinc[1]	25	.0375	.0378	280	5.1

Note all values are NNEPA 2007 criterion unless otherwise specified
NNS = No Numeric Standard
[1] Aquatic & Wildlife Criterion are hardness dependent and calculated for a hardness of 210 mg/L as CaCO3, which is the median across all surface water samples
*Lardy, Stoltenow and Johnson 2008
**NNEPA 2004 Criterion

Several statistical parameters were run during the analysis of surface water quality including, average and standard deviation, median and median absolute deviation (MAD), third quartile (Q3), and ninety-fifth percentile. Variability of surface water quality data in the area was found to be high with the Percent Relative Standard Deviation (%RSD) across all parameters at all sites ranging from 44% to 126% with a median of 85%. Therefore, given the high variability in the data, the use of medians and MAD as compared to other parameters was considered more appropriate for characterization, as it is a more robust measure of variability of a data set and more resilient to the influence of outliers (NIST 2010). The median and MAD are therefore used throughout the characterization of baseline within this CHIA; however, all statistical values can be found in Appendix D.

4.1.5.2.2 Analysis

Surface water quality data is available on the Chaco at two historic USGS monitoring stations, which bracket all Chaco River tributaries traversing the lease area; station 09367950 downstream of the Morgan Lake discharge point and station 09367938 upstream of No Name Wash confluence (Figure 8). USGS station 09367938 is considered representative of baseline conditions within the Chaco River since it is upstream of the Navajo Mine lease. Water quality data was collected by the USGS at this site from July of 1977 to August of 1982.

Baseline data has a high variability, with a calculated median percent relative standard deviation for all constituents of 44 percent. There were no exceedances of NNEPA and other relevant livestock watering criteria or NNEPA secondary human contact criteria. However aluminum, cadmium, copper, mercury, selenium and zinc exceeded NNEPA chronic aquatic and wildlife habitat criteria for 50%, 100%, 57%, 100%, 67% and 17% of all samples respectively. Chromium, copper, mercury and zinc levels also exceeded NNEPA acute aquatic and wildlife criteria for 100%, 14%, 31%, and 17% of all samples respectively. Mercury also exceeded NNEPA fish consumption standards for 100% of all samples. Additionally, the median aluminum, cadmium, copper mercury and selenium values were 2, 1.2, 1.2, 2100, and 1.5 times greater than the NNEPA chronic aquatic and wildlife habitat standards. The median chromium value was 12 times the NNEPA acute aquatic and wildlife habitat standard. The median mercury value was also 14 times the NNEPA fish consumption criteria. Baseline surface water quality within the Chaco River as compared to NNEPA and other relevant criteria is appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of aluminum, cadmium, chromium, copper, mercury, and selenium were found relative to aquatic and wildlife habitat and fish consumption NNEPA criteria. There were no exceedances of the SMCRA dissolved iron standard.

4.1.6 Historic Mining Area North of the BNCC permit

Prior to mining and before the development of up gradient agricultural lands, surface flows in channels traversing this area were predominantly ephemeral. The ephemeral surface flows carry high sediment loads. The increased application of surface water from NAPI has impacted the area hydrology and water quality. NAPI impacts in this area consist of indirect discharges from irrigation return flows. The indirect NAPI related discharges are a result of return flows caused by infiltrating irrigation water. The impacts of the NAPI activities on the baseline channel hydrologic balance are expressed as highly variable increases in flow and discharge. The indirect NAPI related discharges result in leaching of the unconfined geologic surface formations and soils. NAPI impacts increase the already highly variable hydrologic balance and further decrease the potential for changes to the hydrologic balance as a result of mining (BNCC 2011, Section 11.6).

The historic mining area north of the BNCC permit area includes the Watson, Bitsui, Dodge, and Custer pits, of these only the Custer pit area is within the surface water CIA. The Custer Pit area is within the Morgan Lake-Chaco River HUC12 watershed along with the Bighan Pit area. The Bighan Pit area is within the BNCC permit area therefore the characterization of the baseline water quantity for the Morgan Lake-Chaco River HUC12 watershed is included below in Section 4.1.2.1.5.1. There are no major tributaries to the Chaco River which traverse this area, and no baseline surface water data is available for this area within the surface water CIA.

4.1.7 Navajo Mine

4.1.7.1 Surface Water Baseline Quantity

Prior to mining and before the development of up gradient agricultural lands, surface flows in channels traversing the permit area were predominantly ephemeral. The ephemeral surface flows carry high sediment loads. Stock watering ponds are the principal use of surface water on or near the lease area, and these are not located on the larger tributaries where pond embankments are susceptible to failure due to flash floods.

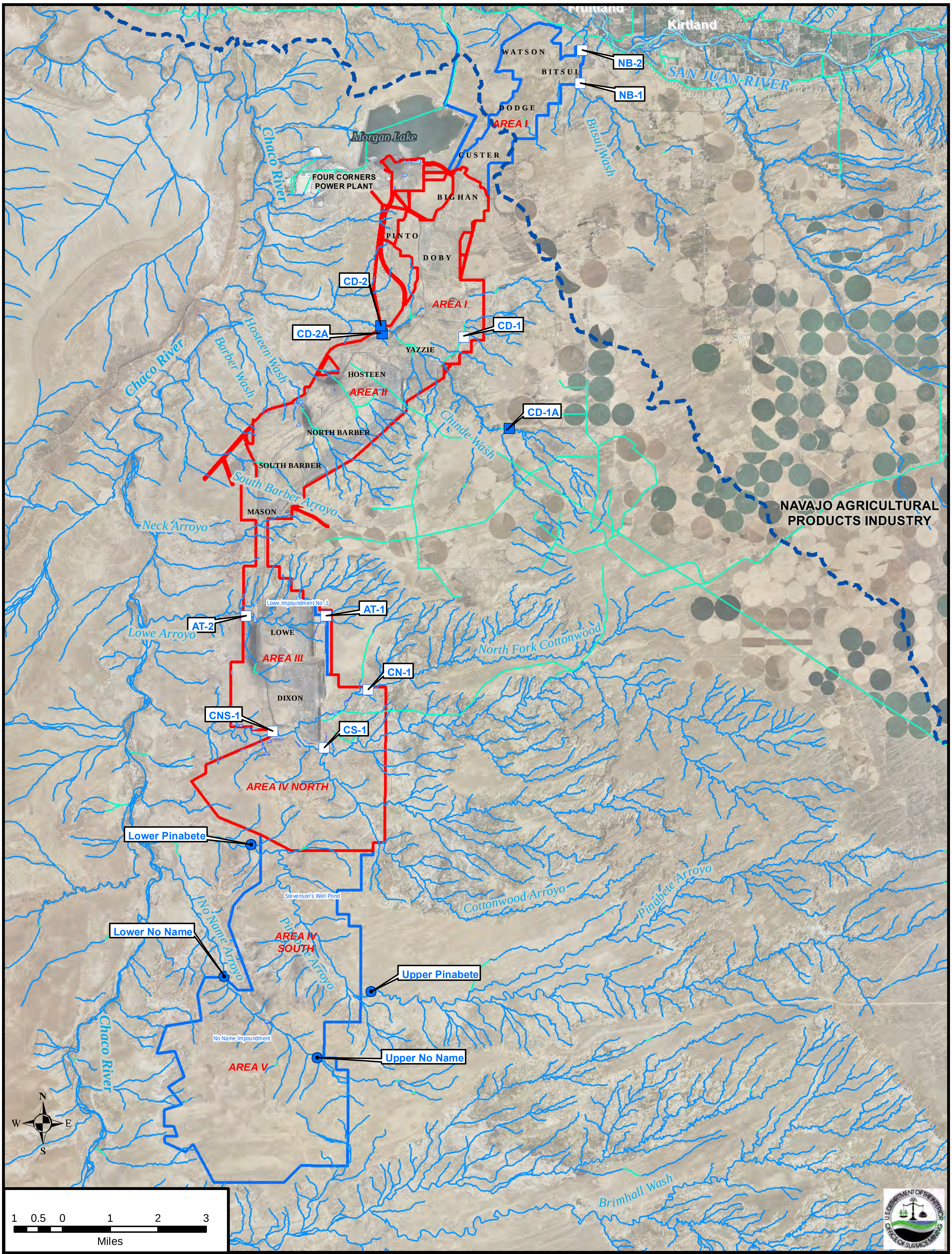
The increased application and discharge of surface water from NAPI has impacted the permit area hydrology. NAPI impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. NAPI direct discharges are a result of an oversupply of water in the canal that is released directly to a wash. Discharge events for the streams are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel (BNCC 2011, Section 11.6). The indirect NAPI related discharges are a result of return flows to the wash caused by the infiltrating irrigation water. The impacts of the NAPI activities on the baseline channel hydrologic balance are expressed as highly variable increases in flow and discharge.

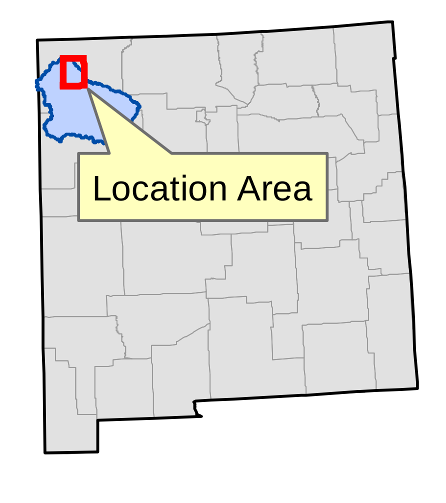
The irrigation return waters have changed the Chinde Wash into a perennial stream. Cottonwood Arroyo is not impacted by perennial flows. Water quantity impacts of NAPI activities on the baseline hydrologic balance of the Cottonwood Arroyo will be highly variable increases in the flow and discharge. Moreover 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 and qualitative data to characterize the NAPI impacts to these drainages is being collected as part of the surface water monitoring plan. Although there is certainly some contribution of flow to the Chaco River from the drainages that pass through the Navajo Mine site, historic monitoring of flow along these drainages is not available for assessment. Historically, fifteen surface water monitoring stations were established on drainages that pass through the Navajo Mine lease area, of which thirteen are within the surface water CIA (Figure 17). The stations within the CIA cover the Chinde, and No Name Washes along with Lowe (only one sample was taken along this wash before the stations were abandoned), Cottonwood, and Pinabete Arroyos. All of the monitoring stations north of station CS-l have been impacted by irrigation activities derived from the NAPI project located to the east of the permit (BNCC 2011, Section 11.6). There is little to no flow that passes through the lease area along Hosteen Wash, Barber Wash and Lowe Arroyo. The combination of upstream check dams, the present mining topography, and higher soil infiltration rates in the case of reclaimed areas causes surface water flow to be attenuated as it passes through the lease area along these drainages.

The Navajo Mine lies primarily within four HUC12 watersheds that either intersect or contain portions of the lease area (Figure 6). The watersheds include the Morgan Lake-Chaco River, Chinde Wash-Chaco River, Coal Creek-Chaco River, and Cottonwood Arroyo watersheds. Each major tributary to the Chaco River are described by watershed in the following sections.

Modeling using SEDCAD 4 was implemented to assess peak flows in response to the 10-year, 6-hour storm events within each HUC 12 watershed. BNCC built SEDCAD models for all major drainages which traverse the lease area. The Chinde Wash and Cottonwood Arroyo Watersheds are both representative of HUC 12 range, as they were modeled directly in the PHC, and models have been reviewed by OSMRE; this modeling was not duplicated for purposes of this CHIA, rather results of BNCC models presented in the PHC are used. The PHC SEDCAD modeling only evaluated specific parts of the Coal Creek and Chinde-Chaco River HUC12 watersheds within the lease area where mining has occurred. Therefore for these HUC 12 watersheds information from the PHC on the pre-mining and post-mining SEDCAD inputs (curve numbers, runoff volumes, etc.) were integrated into simplified larger watershed scale models for the purpose of this evaluation. Excerpts from the OSMRE-generated SEDCAD models showing specific routing details, curve numbers, and other pertinent information are located in Appendix E. Figure 18 shows SEDCAD subwatersheds used in OSMRE modeled HUC 12 watersheds.





Legend

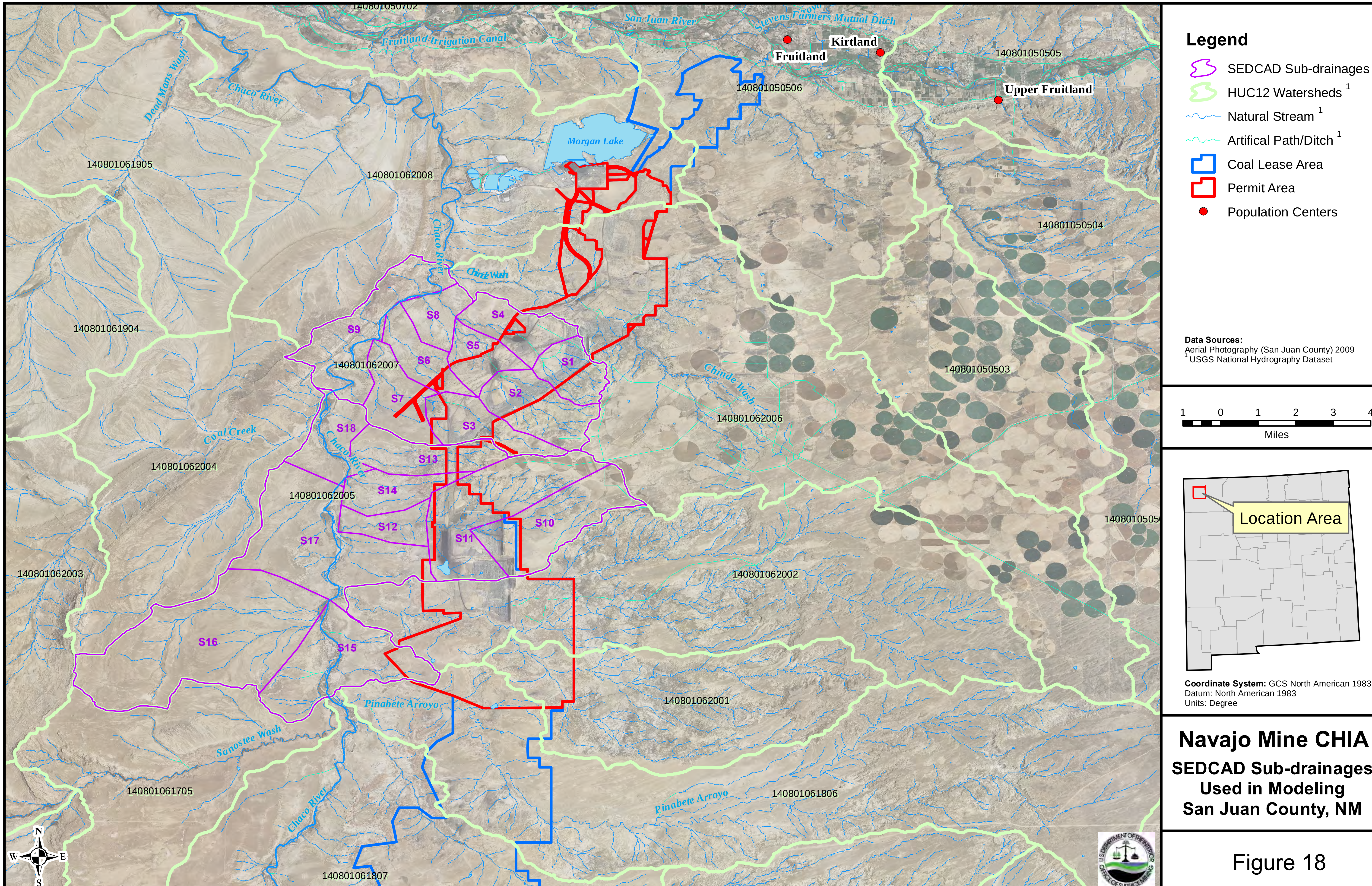
- Active Monitoring Station
- Historic Monitoring Station
- Non-SMCRA Surface Water Monitoring
- Surface Water CIA
- Ponds
- Natural Stream[1]
- Artificial Canal/Ditch[1]
- Permit Area
- Coal Lease Area

PIT NAMES

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA Surface Water Monitoring Locations

Figure 17



Navajo Mine CHIA

SEDCAD Sub-drainages Used in Modeling San Juan County, NM

Figure 18

4.1.7.1.1 Morgan Lake-Chaco River Watershed

The Morgan Lake-Chaco River Watershed (HUC 12 number 140801062008) is located north of the Chinde Wash and Chinde Wash-Chaco River watersheds and comprises part of the northern section of the Navajo Mine. The surface area of the entire watershed is about 32,600 acres, and about 1,400 acres of the Navajo Mine permit area is within this watershed. The entirety of the permitted area that overlaps with this watershed is in the Area I section of the mine. Conditions within this watershed are dominated by the presence of Morgan Lake, which has significantly altered baseline conditions from what they might have been before the mine. SEDCAD modeling was not implemented on the watershed due to the small contribution that activities within the permit area would have on the total watershed, because of the effect that contributing perennial flow to the watershed outfall (Chaco River) from Morgan Lake would have on the model, and because most of the permit area present in this watershed is either pre-law or termination of jurisdiction land.

4.1.7.1.2 Chinde Wash Watershed

Chinde Wash (HUC 12 number 140801062006) has been disturbed by mining since before SMCRA was passed in 1977, so it is difficult to estimate pre-mining conditions along the stream reach. Little data was collected prior to this time period that characterized pre-development conditions along the Chinde Wash. Therefore, advanced techniques involving iterative modeling (SEDCAD) were utilized by BNCC in the PHC, to address pre-mining conditions. The present watershed area of Chinde Wash is about 27,130 acres. An area of an additional 7,000 acres initially contributed to the present Chinde watershed but was diverted by NAPIs Ojo Amarillo canal into Cottonwood Arroyo. The baseline estimate of peak runoff for the entire drainage from the 10 year, 6-hour precipitation event is 715 cubic feet per second. Model details including SEDCAD subwatersheds can be found in the PHC. (BNCC 2012).

4.1.7.1.3 Chinde Wash-Chaco River Watershed

The Chinde Wash-Chaco River watershed (HUC 12 code 140801062007) is approximately 14,225 acres, of which the Navajo Mine permit area is 4,200 acres. It is composed of 3 principal sub-watersheds, namely Hosteen Wash, Barber Arroyo, and South Barber Arroyo. SEDCAD modeling was utilized to determine pre-mining estimates for peak flow from a 10 year, 6 hour storm event for the entire watershed. Figure 18 and Table 4 outline the details of the sub-watersheds for the area. Hosteen Wash is represented by the S1, S2, S4, and S5 sub-watersheds in the model and comprises a total of 5,860 acres, comparable to the 5,833 acres of the pre-mining area stated in the PHC model. South Barber Arroyo is represented by the S3 and S7 sub-watersheds and Barber Arroyo is represented as the S6 watershed. All of these watersheds collectively drain into the Chaco River, contributing runoff that is attenuated, to an extent, as it moves through each stream reach towards the ultimate discharge point in the HUC 12 watershed. The baseline estimate of peak discharge for the entire watershed is about 2,100 cubic feet per second for the 10 year, 6 hour rain event.

Table 4: Chinde-Wash Chaco River Sub-Watershed Details

Chinde Wash-Chaco River Watershed	
Subwatershed	Area (acres)
S1	1210
S2	2010
S3	1565
S4	1540
S5	1100
S6	1235
S7	1650
S8	980
S9	2930
Total	14220

4.1.7.1.4 Coal Creek-Chaco River Watershed

The total watershed area for Coal Creek-Chaco River Watershed (HUC 12 code 140801062005) is 28,235 acres; of which approximately 2,900 acres is Navajo Mine lease area. The lease area-portion of the watershed is comprised of 2 separate sub-watersheds, the Neck Arroyo and Lowe Arroyo. The Lowe Arroyo is the larger of the two, approximately 7,700 acres, and is represented in SEDCAD as S10, S11, and S12. The Neck Arroyo is smaller in comparison, about 1,700 acres, little of which is disturbed by mining related impacts. Both the Lowe and the Neck Arroyo drain into the Chaco River, which ultimately exits the watershed to the northwest of its tributaries. To determine peak flows from the pre-mining surface configuration in the Coal Creek Watershed, SEDCAD modeling was utilized using a 10 year, 6 hour storm event as a basis of comparison. The area of each subwatershed is displayed in Table 5. Although the surface area of this watershed is quite large, the peak flow for the 10 year 6 hour storm event at the exit point of the watershed was estimated to be about 1,720 cubic feet per second.

Table 5: Coal Creek Sub-Watershed Details

Coal Creek Watershed	
Subwatershed	Area (acres)
S10	2860
S11	3930
S12	940
S13	1740
S14	1280
S15	3530
S16	7300
S17	5060
S18	1590
Total	28230

4.1.7.1.5 Cottonwood Arroyo Watershed

Cottonwood Arroyo is a major sand bed ephemeral drainage that passes through the southern portion of the lease area. The HUC 12 watershed number 140801062002 is 29,845 acres and the ultimate outlet of the watershed is from Cottonwood Arroyo itself just before it drains into the Chaco River. Approximately 10 percent of the drainage area of the Cottonwood Arroyo watershed lies within the lease area. The total drainage area of the watershed includes 7,000 acres of the Chinde Wash drainage that is diverted by the NAPI Ojo Amarillo canal into the Cottonwood drainage. About 49 percent of this watershed is occupied by badlands that account for the high discharge and flow intensities observed in this drainage.

The total watershed area that was modeled in the PHC includes the 7,000 acres diverted from the Chinde Watershed, the Cottonwood Arroyo HUC12 Watershed, and an additional unnamed HUC12 number 140801062001 watershed directly south of the Cottonwood Arroyo watershed. The total of these three areas, as modeled in the Navajo Mine PHC, is 51,269 acres.

The modeled flow response in Cottonwood Arroyo is characterized by a rapid increase in discharge from a dry channel to peak discharge, followed by a recession to a low discharge over several hours. The pre-mining estimate of peak flow in response to the 10-year, 6-hour storm event is 1,551 cubic feet per second. Model details including SEDCAD subwatersheds can be found in the PHC (BNCC 2011, Section 11.6).

4.1.7.2 Surface Water Baseline Quality

All surface waters which cross the lease area are designated for the following uses by the NNEPA; livestock watering, aquatic and wildlife habitat, secondary human contact and fish consumption (NNEPA 2007). The principal use of surface waters on or near the lease area is for stock watering ponds (BNCC

2011, Section 11.6). Surface water quality analysis, where data was available, has been done using the same methodology used for analysis of the Chaco River as described in Section 4.1.5.2.1 above.

Prior to mining and before the development of up gradient agricultural lands, surface flows in channels traversing the lease area were predominantly ephemeral. Under baseline conditions, these tributary channels carry very high concentrations of suspended solids and bed loads during storm runoff (BNCC 2011, Section 11.6). Generally surface waters within the northern lease area, specifically Chinde watershed, are of the sodium sulfate type while surface waters in the southern lease area, specifically Cottonwood watershed, are of the sodium sulfate/sodium bicarbonate type. This difference might be explained by different salts being present in the soils of the different watersheds (BNCC 2011, Appendix 7-E).

Monitoring of tributaries to the Chaco River that traverse the lease area has revealed a range of surface water conditions that are considered representative of similar tributaries traversing the lease area, on which there has been no monitoring. Historically, fifteen surface water monitoring stations were established on drainages that pass through the Navajo Mine lease area, of which thirteen are within the surface water CIA (Figure 17). The stations within the CIA cover the Chinde, and No Name Washes along with Lowe (only one sample was taken along this wash prior to the station being abandoned), Cottonwood, and Pinabete Arroyos. All of the monitoring stations north of station CS-l have been impacted by irrigation activities derived from the NAPI project located to the east of the permit (BNCC 2011, Section 11.6). Since the effects of NAPI discharge are not attributable to the mine, the changes brought about by NAPI will be treated as baseline conditions. For this reason the baseline surface water quality discussion of Chaco River tributaries is divided into two sections: a discussion of baseline with NAPI impacts in the northern lease area, and a discussion of baseline without NAPI impacts in the southern lease area. Baseline water quality for the Chaco River and its major tributaries as they cross the lease area from north to south are described in the following sections. A complete summary of water quality data including tables and graphs can be found in Appendix D.

4.1.7.2.1 Baseline with NAPI

NAPI impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. Direct discharge events are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel (BNCC 2011, Section 11.6). The indirect NAPI related discharges result in leaching of the unconfined geologic surface formations and soils. NAPI impacts increase the already highly variable hydrologic balance and further decrease the potential for changes to the hydrologic balance as a result of mining. Quantitative data to characterize NAPI impacts is being collected as part of the surface water monitoring plan. For the purpose of this CHIA analysis, the results of NAPI discharges are taken into account when evaluating baseline surface water conditions for Chinde Wash and Cottonwood Arroyo.

A comparison of median baseline values at NAPI influenced stations on Chinde Wash and Cottonwood Arroyo to median baseline values at stations without NAPI influence on Pinabete Arroyo and No Name Wash showed that values were relatively consistent for aluminum, pH, and selenium. Aluminum and total iron values were relatively higher at non-NAPI influenced stations, where as values were higher at NAPI influenced stations for barium, boron, cadmium, chloride, chromium, fluoride, lead, nitrate, silver, sulfate, TDS, zinc, conductivity, and manganese. Total Suspended Solids (TSS) was highest along Cottonwood Arroyo and lowest along Chinde Wash.

4.1.7.2.1.1 Chinde Wash

Surface water quality data is available on Chinde Wash at four monitoring stations which bracket the lease area; CD-2 and CD-2A downstream of the mine and CD-1 and CD-1A upstream of the mine (Figure 17). Water quality data was collected at CD-1 and CD-2 from 1986 to 1997 and at CD-1A and CD-2A from 1996 to present. There is no pre-mining data on Chinde Wash, however, CD-1 and CD-1A can be considered as baseline as they are upstream of the mine. It is important to note that while upstream of mining, CD-1 and CD-1A are both downstream of NAPI activities, and there is no pre-NAPI data on Chinde Wash. Chinde Wash is subject to both direct and indirect NAPI influences. Direct discharge events for the 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, and most likely result in the continuous baseflow within Chinde Wash. TSS values are most likely lowest along Chinde Wash as some samples are taken during baseflow, whereas all TSS values for other drainages correspond to periodic high flow events. NAPI irrigation return waters leach the unconfined surface formations resulting in greater dissolved solids concentrations in base flow (BNCC 2011, Section 11.6).

Baseline water quality data at CD-1 and CD-1A was found to have a relatively higher variability than that of Chaco River where the median percent relative standard deviation for all constituents was 85. Baseline water quality within Chinde Wash occasionally exceeded NNEPA and other relevant livestock watering criteria. Specifically fluoride, TDS, sulfate, lead, and selenium exceeded livestock criteria for 16%, 4%, 16%, 0.35%, and 0.29% of all samples respectively. Cadmium, chromium, lead, selenium, silver and zinc exceeded NNEPA acute aquatic and wildlife habitat standards for 4, 100, 0.3, 1, 2, and 64 percent of all samples respectively. Aluminum, cadmium, chromium, lead, selenium, and zinc exceeded NNEPA chronic aquatic and wildlife habitat standards for 27, 100, 2, 65, 76, and 64 percent of all samples respectively. Lead exceeded NNEPA secondary human contact criteria for 4% of all samples and arsenic exceeded NNEPA fish consumption criteria for 35% of all samples. Median cadmium, lead, selenium and zinc concentrations were 6, 2, 1.4, and 2 times greater than NNEPA chronic aquatic and wildlife habitat criteria. Median chromium and zinc concentrations were 16 and 2 times greater than NNEPA acute aquatic and wildlife habitat criteria. Arsenic, aluminum and selenium median values are below all criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Therefore baseline surface water quality within the Chinde Wash as compared to NNEPA and other relevant criteria is considered generally appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of cadmium, chromium, lead, and zinc were found relative to aquatic and wildlife habitat and fish consumption NNEPA criteria. One sample or approximately 0.5 percent of all samples exceeded the SMCRA dissolved iron standard; however, the median dissolved iron concentration of 0.2 mg/L is fifty times smaller than the criterion.

4.1.7.2.1.2 Cottonwood Arroyo

Surface water quality data was collected on the Cottonwood Arroyo from 1990 to 1999 at three monitoring stations CN-1 along the North Fork upstream of the mine, CNS-1 downstream of mining, and CS-1 along the main stem within the mine lease area (Figure 17). All data was collected prior to mining in the area. It is important to note that while data is pre-mining there is no pre-NAPI data along the Cottonwood Arroyo. Cottonwood Arroyo is not subject to indirect NAPI irrigation return flows, but NAPI does directly discharge from irrigation canals into the North Fork, therefore monitoring station CN-1 and the downstream monitoring station CNS-1 are both influenced by NAPI, whereas station CS-1 is not. Direct discharge events are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel. These recurrent higher flow NAPI discharges could be the cause of higher TSS levels in Cottonwood Arroyo as compared to non-NAPI influenced drainages to the south. The Cottonwood Arroyo is geochemically impacted by NAPI as evident through the increased mineralization deposited on the stream banks as a result of seeps in the upper reaches, resulting in highly variable increases in water quality parameter concentrations.

Baseline data at CN-1, CNS-1, and CS-1 was found to have a relatively higher variability than that of the Chaco River or Chinde Wash where the median percent relative standard deviation for all constituents was 108. Baseline water quality pH within Cottonwood Arroyo dropped below the NNEPA criteria range once at both CN-1 and CNS-1. Arsenic exceeded NNEPA criteria for all five categories for 0.5% of all samples. Cadmium exceeded NNEPA fish consumption criteria for 0.4% of all samples, and lead exceeded NNEPA livestock and secondary human contact criteria for 0.3% and 20% of all samples respectively. Additionally, nitrate, sulfate and TDS exceeded livestock criteria for 38%, 3%, and 4% of all samples respectively. NNEPA acute aquatic and wildlife habitat criteria where exceeded for arsenic, cadmium, chromium, lead, silver, and zinc for 0.5, 2, 100, 1, 1, and 77 percent of all samples respectively. NNEPA chronic aquatic and wildlife habitat criteria where exceeded for arsenic, cadmium, chromium, lead, selenium, and zinc for 0.5, 100, 5, 78, 64, and 77 percent of all samples respectively. Median concentrations for chromium and zinc were 16 and 3 times greater respectively than NNEPA acute aquatic and wildlife habitat criteria. Median concentrations for cadmium, lead, selenium and zinc were 6, 2, 1.25, and 3 times greater respectively than NNEPA chronic aquatic and wildlife habitat criteria. All other median values are below all criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Therefore baseline surface water quality within the Cottonwood Arroyo, as compared to NNEPA and other relevant criteria, is considered generally appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of cadmium, chromium, lead, selenium and zinc were found relative to aquatic and wildlife habitat NNEPA criteria. Thirty samples or approximately 15 percent of all samples exceeded the SMCRA dissolved iron standard; however, the median dissolved iron concentration of 0.5 mg/L is twenty times smaller than the criterion.

Comparison of median concentrations at each station showed that barium, cadmium, chromium, lead, nitrate, pH, selenium, silver, zinc and manganese concentrations were approximately equal across all stations. Arsenic, boron and total iron were all lowest on the North Fork (CN-1). Arsenic was approximately equal on the main fork within the mine lease (CS-1) and downstream of the lease area (CNS-1), boron was highest downstream of mining (CNS-1), and iron was highest along the main fork within the lease area (CS-1). Chloride, sulfate, TDS, TSS and conductivity were all highest along the North Fork (CN-1) upstream of the lease area.

4.1.7.2.2 Baseline without NAPI

Surface water quality data was collected on Pinabete Arroyo and No Name Wash at upper and lower stations in 1998 and from 2007 to 2008, where all stations are within the mine lease area (Figure 17). All data is pre-mining in the area and neither drainage is impacted by NAPI activities. Baseline data on Pinabete and No Name was found to have a relatively higher variability than that of the Chaco River where the median percent relative standard deviation for all constituents was 86 for Pinabete Arroyo and 77 percent for No Name Wash. This places Pinabete Arroyo at roughly the same variability as Chinde Wash and No Name Wash at a relatively lower variability. Both Pinabete Arroyo and No Name Wash express less variability in water quality than Cottonwood Arroyo.

There were no exceedances of NNEPA secondary human contact criteria. Aluminum, cadmium, copper, lead, mercury, selenium and zinc exceeded NNEPA chronic aquatic and wildlife habitat criteria for 41, 23, 7, 3, 100, 56, and 7 percent of all samples respectively. Aluminum, cadmium, chromium, and zinc exceeded NNEPA acute aquatic and wildlife criteria for 7, 8, 46, and 7 percent of all samples respectively. Cadmium and zinc NNEPA fish consumption standards were also exceeded for 8% and 3% of all samples respectively. Cadmium also exceeded NNEPA livestock criteria for 4% of all samples and TDS exceeded criteria for 7% of all samples. Median concentrations for mercury and selenium were 100 and 1.25 times greater respectively than NNEPA chronic aquatic and wildlife habitat criteria. All other median values are below all criteria indicating that the criteria exceedances for these parameters are generally more characteristic of the high variability in the data set as compared to the general water quality. Therefore baseline surface water quality within Pinabete and No Name as compared to NNEPA and other relevant criteria is considered generally appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of mercury and selenium were found relative to aquatic and wildlife habitat NNEPA criteria. There were no exceedances of the SMCRA dissolved iron standard along No Name Wash. One sample along Pinabete Arroyo or approximately 4 percent of all samples exceeded the SMCRA dissolved iron standard; however, the median dissolved iron concentration of 0.12 mg/L is 80 times smaller than the criterion.

Cadmium, pH, and selenium were relatively consistent across Pinabete Arroyo. Chloride and pH were relatively consistent across No Name Wash. Aluminum and copper median values were higher at upper stations, whereas barium, boron, lead and manganese median values were all higher at lower stations for both Pinabete Arroyo and No Name Wash. Along Pinabete Arroyo arsenic, chloride, fluoride, nitrate, sulfate, TDS, TSS and conductivity median values were higher at upper stations; whereas chromium, silver, zinc and iron median values were all higher at lower stations. Along No Name Wash cadmium, chromium, silver, zinc, and iron median values were higher at upper stations; whereas arsenic, fluoride, nitrate, selenium, sulfate, TDS, TSS and conductivity median values were all higher at lower stations.

4.2 Ground Water

Since mining at the Navajo Mine started long before SMCRA became law, baseline hydrologic monitoring data generally does not exist for Area I and portions of Area II of the Navajo Mine. Nevertheless, the “GM-“ monitoring wells installed in the late 70’s provide baseline information for Areas III, IV, V, and portions of Area II. Many of the GM wells have been mined through or abandoned and additional monitoring wells were installed during the mid 80’s. Monitoring wells were installed in 1998 and in 2007 for baseline characterization of Areas IV South and V. Groundwater monitoring locations can be seen on Figure 19.

4.2.1 Ground Water Regulatory Requirements

30 CFR 816.41(h) states that a water supply of an owner of interest used for domestic, agricultural, industrial, or for other legitimate use that is adversely impacted by contamination, diminution, or interruption proximately resulting from surface mining activities shall be replaced. However, there is very little significant use of groundwater resources surrounding the Navajo Mine. The Fruitland and PCS formations are utilized in oil production west of the lease area, and the alluvial aquifer has limited use as a livestock watering supply.

4.2.2 Chaco River Alluvium

Data was collected along the Chaco River alluvium from 1974 to 1977 at GM-24 located between the No-Name and Pinabete confluences, GM-25 located upstream of No Name Wash, and GM-34 located upstream of the BNCC lease. The Chaco River alluvium is mostly saturated across the length of the lease area and provides limited stock water supply at several dug wells as shown in Figure 12. The Chaco River alluvium had water for all sampling events at GM-34 upstream of the lease area, for 67% of all sampling events downstream of No Name Wash, and for 87.5% of sampling events at GM-24 between No Name Wash and Pinabete Arroyo. The characterization of Chaco River alluvial quantity was limited to the percent of dry sampling events as no water elevation data was available.

Groundwater use in the groundwater CIA is limited in extent and is mostly derived from wells completed within surficial valley-fill deposits of Quaternary age, or alluvium. Water derived from alluvial wells is predominantly used for livestock watering. Given the predominant use of alluvial waters for livestock watering and the designated post-mining land use of livestock grazing, alluvial baseline quality will be evaluated in part by comparison to applicable livestock watering criteria (Table 3). The criteria are not enforceable standards with respect to groundwater and are included only as a reference for the suitability of the groundwater quality for livestock use.

Baseline alluvial quality data was found to have a higher variability compared to surface water quality where the median %RSD for all constituents was 127 or 2.9 times greater than the surface water %RSD. A general comparison of median concentrations across different wells within the alluvial systems showed the following. The Chaco River alluvium pH was relatively consistent across all sites. Moving downstream along the Chaco River, selenium and nitrate tended to increase while arsenic, copper, mercury and zinc tended to decrease, and other constituents did not show any apparent trend.

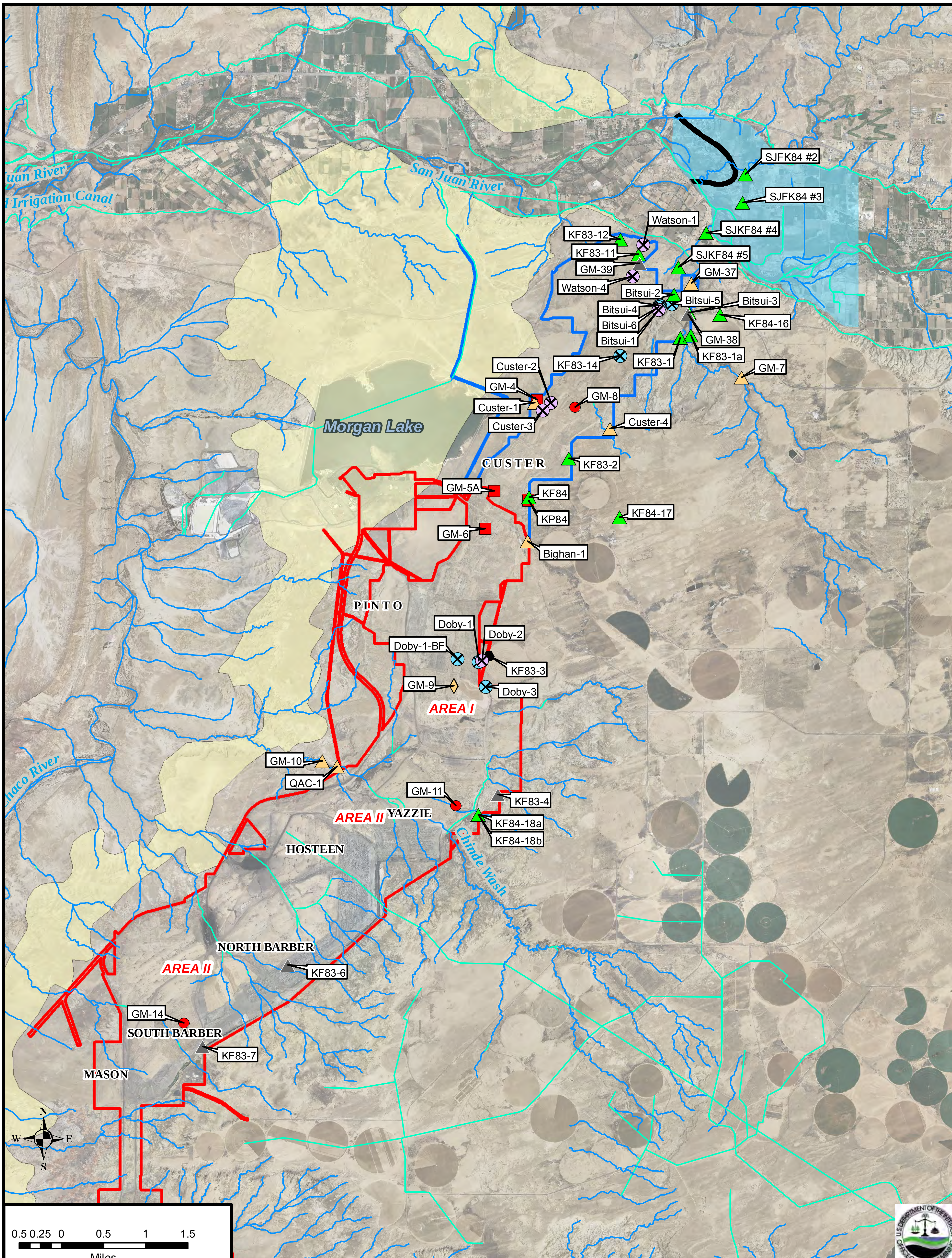
All pH values for all other Chaco River alluvial samples were within the appropriate range. Arsenic, lead, selenium, chloride, fluoride, sulfate, and TDS exceeded livestock criteria for the Chaco River for 21%, 5%, 16%, 11%, 6%, 67% and 72% of all samples respectively. Median values for arsenic, lead, selenium, chloride, and fluoride were below the criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Median sulfate and TDS values exceed the livestock criteria. Based on these relevant use criteria, the water in the alluvium systems is a poor source of supply for livestock watering use. This is especially apparent when considering sulfate and TDS concentrations. These water quality parameters often exceed relevant criteria for livestock use, although the alluvium has been historically and is currently used for this purpose.

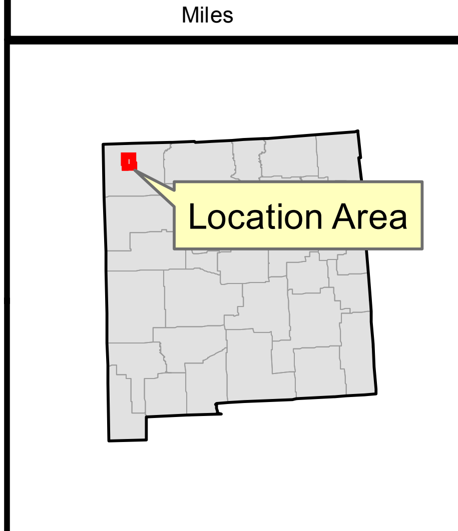
4.2.3 Historic Mining Area North of the BNCC permit

Two alluvial wells exist along drainages that are tributary to Morgan Lake; data was collected from 1996 to 2000 at Custer-1 located along the western lease boundary, and Custer-4 located within the BNCC lease area close to the eastern lease boundary. The Custer wells were not monitored prior to mining impact in the area and can therefore not be used for baseline characterization. Two additional alluvial wells exist along Bitsui Wash; data was collected from GM-7 from 1975 to 1976 and no data is available at GM-37. GM-7 is located upstream of mining and can therefore be used for baseline characterization. The Bitsui Wash alluvium had water for all sampling events at GM-7 upstream of the lease area. No water elevation data was available for characterization of Bitsui Wash alluvial quantity.

Only four samples were collected at GM-7 from 1975 to 1976. Baseline alluvial quality data was found to have a lower variability compared to surface water quality where the median %RSD for all constituents was 70% less than the surface water %RSD. All pH values for all other Bitsui Wash alluvial samples were within the appropriate range. Arsenic, selenium, chloride, fluoride, sulfate, and TDS exceeded livestock criteria for the Chaco River for 25%, 25%, 25%, 100%, 75% and 25% of all samples respectively. Median values for arsenic, selenium, chloride, and TDS were below the criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Median fluoride and sulfate values exceed the livestock criteria. Based on these relevant use criteria, the water in the alluvium systems is a poor source of supply for livestock watering use. This is especially apparent when considering fluoride and sulfate concentrations. These water quality parameters often exceed relevant criteria for livestock use, although the alluvium has been historically used for this purpose.

No pre-mining Fruitland data is available in this area. However, there is post-mining data for the #8 coal seam. The Fruitland formation outcrop is located to the north of this area and this is the point of discharge to the San Juan alluvium. No pre-mining PCS data is available in this area. However, there is limited post-mining data for the PCS. Post-mining data along with modeling efforts has been made by the coal operator and OSMRE to assess post-mining conditions and impact potential for this area. This analysis is completed in section 5.3.5





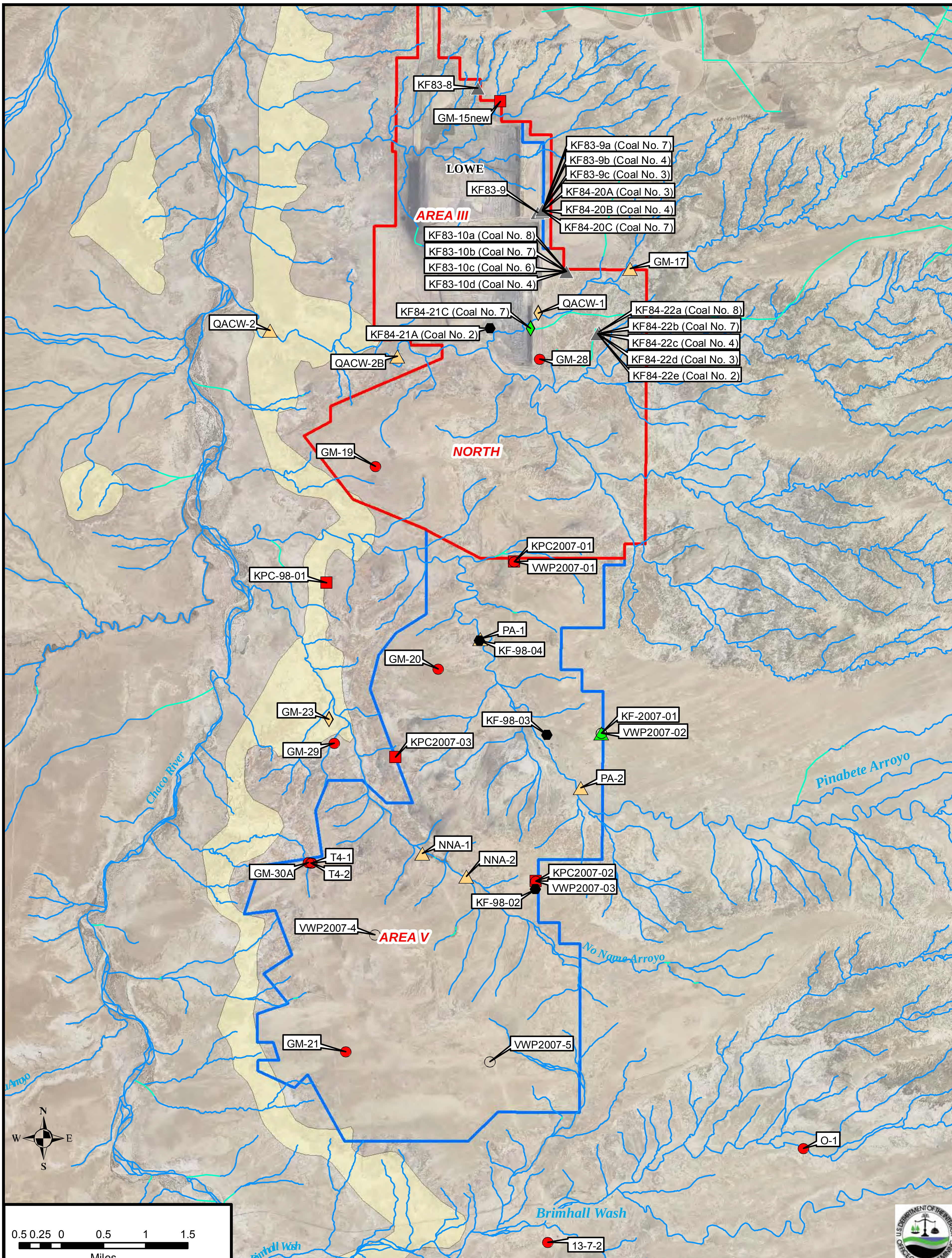
Legend

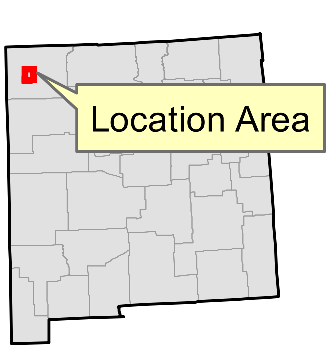
- Permit Area
- Coal Lease Area
- San Juan Alluvium above Fruitland Formation Outcrop
- Approximate Coal Subcrop[2]
- Pictured Cliffs Formation (Kpc)
- Abandoned Alluvial Monitoring Well
- Existing Alluvial Monitoring Well
- No. 2 Coal Monitoring Well
- No 3. Coal Monitoring Well
- No. 4 Coal Monitoring
- No. 6 Coal Monitoring Well
- No. 7 Coal Monitoring Well
- No. 8 Coal Monitoring Well
- Fruitland Well or Nested Wells
- Abandoned PCS Monitoring Well
- Existing PCS Monitoring Well
- Backfill Monitoring Well
- CCB Monitoring Well
- Nested Vibrating Wire Piezometer
- Natural Stream[1]
- Artificial Canal/Ditch[1]

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset
[2] NMBMMR RM-19 Beaumont 1998

Navajo Mine CHIA Groundwater Monitoring Locations

Figure 19
(pg 1 of 2)





Legend

- Permit Area
- Coal Lease Area
- San Juan Alluvium above Fruitland Formation Outcrop
- Approximate Coal Subcrop[2]
- Pictured Cliffs Formation (Kpc)
- Abandoned Alluvial Monitoring Well
- Existing Alluvial Monitoring Well
- No. 2 Coal Monitoring Well
- No 3. Coal Monitoring Well
- No. 4 Coal Monitoring
- No. 6 Coal Monitoring Well
- No. 7 Coal Monitoring Well
- No. 8 Coal Monitoring Well
- Fruitland Well or Nested Wells
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- Natural Stream[1]
- Artificial Canal/Ditch[1]

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset
[2] NMBMMR RM-19 Beaumont 1998

Navajo Mine CHIA Groundwater Monitoring Locations

Figure 19
(pg 2 of 2)

4.2.4 **Navajo Mine**

4.2.4.1 **Alluvial Baseline Quantity**

Alluvial quantity was assessed using two methods, the percent of all sampling events which were dry and the water elevation in feet above Mean Sea Level (MSL). Water elevation was not collected for all samples; however, inference of water presence was based on the presence of water quality data. Therefore the total number of samples used to calculate the percent of dry sampling events is often higher than the number of samples used for the water elevation comparisons. Given data availability baseline quantity could only be characterized for the Chaco River, No Name Wash, Pinabete Arroyo and Cottonwood Arroyo.

One alluvial well, Bighan-1, exists along drainages that are tributary to Morgan Lake within the permit area; data was collected from 1995 to 2001 at this location along the eastern lease boundary just south of the permit boundary. The location of Bighan-1 along the eastern mine permit boundary suggests that the well would be representative of baseline; however, it was installed after mining impact in the area. For these reasons it is unclear if this well should be included as baseline, and it will be analyzed in Ch. 5 of this CHIA assessment.

Along Chinde Wash alluvial data was collected from 1979 to 1980 at GM-9 within the BNCC lease, from 1985 to present at QAC-1 at the western mine lease boundary, and from 1975 to 1982 at GM-10 just downstream of QAC-1. Wells along Chinde Wash were not monitored prior to mining impact in the area and can therefore not be used for baseline characterization.

Alluvial data was collected along Cottonwood Arroyo, from 1975 to 1982 at GM-17 along the North Fork at the eastern lease boundary, from 1985 to 1998 at QAC-1 along the North Fork downstream of GM-17 in Area III, during 1975 at GM-16 along the North Fork just upstream of the confluence with the Main Fork, from 1986 to 1999 at QACW-2B just downstream of the western lease boundary, and from 1974 to 2008 at QACW-2 downstream of QACW-2B. Cottonwood Arroyo alluvium was found to be variably saturated, and is known to provide limited stock water supply at wells shown in Figure 12, specifically W-0644 (QACW-2B), which is not owned by BNCC and has been used for stock water supply. QACW-2B and GM-17 had water for all sampling events, QACW-2, QACW-1, and GM-16 had water for 66%, 54%, and 50% of all sampling events.

Data was collected along No Name Wash alluvium during 1975 at GM-23 located just upstream of the Chaco River confluence, and during 1998, 2007 and 2008 at NNA-1 and NNA-2 located within the BNCC lease where NNA-1 is downstream of NNA-2. No Name Wash alluvium was found to be mostly dry where both NNA-2 was found to be dry for all sampling events; however, NNA-1 had water for 27% of all sampling events.

Along Pinabete alluvial data was collected from 1974 to 1977 at GM-22 located upstream of the BNCC lease, and during 1998, 2004, 2007 and 2008 at PA-2 located just west of the eastern lease boundary, and PA-1 located within the lease downstream of PA-2. Pinabete alluvium was found to be mostly saturated, and is known to provide limited stock water supply at wells shown in Figure 12. PA-2 and GM-22 had water for all sampling events and PA-1 had water for 96% of all sampling events. Estimated hydraulic conductivities based on aquifer test results for the Pinabete Arroyo alluvium are 51.3 ft per day (ft/day) (1.8 x 10-2 cm per second (cm/sec)) at PA-1 and 10.7 ft/day (3.8 x 10-3 cm/sec) at PA-2. Both are within the range expected for clean sand and considerably higher than the bedrock values in the area. Well yields from the alluvium, however, are limited by a very low saturated thickness of about 5 ft or less (BNCC 2011, Appendix 6.G).

Water elevation data was available for Cottonwood Arroyo, Pinabete Arroyo and No Name Wash, although not at any of the GM historic monitoring locations. The percent relative standard deviation for water elevation data showed that Cottonwood had the highest variability where the %RSD was 6 times greater than that of No Name and 2.5 times greater than that of Pinabete. The relatively higher variability of water elevation levels in Cottonwood Arroyo may in part be due to NAPI discharges which have generated high variability in surface water flows. Under baseline conditions the alluvial systems of both Cottonwood and Pinabete Arroyos have decreasing water levels as you move downstream. No Name however, had no water for any sampling events for the upstream well but had water for 27% of sampling events at the downstream well. This could in part be due to the influence of tributary drainages which confluence with the main channel in between the two wells. More detailed alluvial quantity data including graphs and tables can be found in Appendix F.

4.2.4.2 Alluvial Baseline Quality

Groundwater use in the vicinity of the Navajo Mine is limited in extent and is mostly derived from wells completed within surficial valley-fill deposits of Quaternary age, or alluvium. Water derived from alluvial wells is predominantly used for livestock watering. Given the predominant use of alluvial waters for livestock watering and the designated post-mining land use of livestock grazing, alluvial baseline quality will be evaluated in part by comparison to applicable livestock watering criteria (Table 3). The criteria are not enforceable standards with respect to groundwater and are included only as a reference for the suitability of the groundwater quality for livestock use. Alluvial quality data was not collected at GM-23 and NNA-2 along No Name Wash and at GM-16 and QACW-1 along Cottonwood Arroyo as they were either dry or had insufficient water for sampling during baseline monitoring. Generally the alluvial systems are of sodium-sulfate type with variable TDS concentrations.

Baseline alluvial quality data was found to have a higher variability compared to surface water quality for all drainages except No Name Wash, where the median relative percent standard deviations for all constituents was 142, and 121 for the Pinabete Arroyo and Cottonwood Arroyo respectively or 1.7, and 1.1 times greater than their respective surface water %RSDs. The median %RSD for all constituents for No Name Wash alluvium was 68 or roughly 10% less than the respective surface water %RSD. A general comparison of median concentrations across different wells within the alluvial systems showed the following. The Pinabete Arroyo alluvium pH was relatively consistent across all sites. Moving downstream along Pinabete Arroyo, iron and mercury tended to increase while arsenic, boron, cadmium, copper, lead, selenium, zinc, and nitrate tended to decrease, and other constituents did not show any apparent trend. Moving downstream along the Cottonwood Arroyo alluvium pH, selenium, and fluoride tended to increase while boron, manganese, mercury, nitrate, sulfate and TDS tended to decrease, and other constituents did not show any apparent trend. No comparison was made along the No Name Wash alluvium as only one well had sufficient water for sampling.

Baseline water quality pH within the Cottonwood Arroyo alluvium dropped below the livestock criteria range once at GM-17, however, all other pH values for all other alluvial samples were within the appropriate range. Arsenic, selenium, chloride, fluoride, sulfate and TDS exceeded livestock criteria for the Cottonwood Arroyo alluvium for 6%, 4%, 3%, 26%, 91% and 55% of all samples respectively. All median values for arsenic, selenium, chloride and fluoride were below the criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. The median sulfate and TDS values exceed the livestock criteria. Based on these relevant use criteria, the water in the Cottonwood Arroyo alluvium system is a poor source of supply for livestock watering use. This is especially apparent when considering sulfate and TDS concentrations. These water quality parameters often exceed relevant criteria for livestock use, although the alluvium has been historically and is currently used for this purpose.

All pH values for all samples within the Pinabete Arroyo alluvium were within the appropriate range. Arsenic, selenium, chloride, fluoride, sulfate and TDS exceeded livestock criteria for the Pinabete Arroyo alluvium for 5%, 4%, 4%, 86%, 75% and 46% of all samples respectively. All median values for arsenic, selenium, and chloride were below the criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. The median fluoride, sulfate and TDS values exceed the livestock criteria. Based on these relevant use criteria, the water in the Pinabete Arroyo alluvium system is a poor source of supply for livestock watering use. This is especially apparent when considering fluoride, sulfate and TDS concentrations. These water quality parameters often exceed relevant criteria for livestock use, although the alluvium has been historically and is currently used for this purpose.

All pH values for all samples within the No Name Wash alluvium were within the appropriate range. Sulfate and TDS exceeded livestock criteria for the No Name Wash alluvium for 100% and 100% of all samples respectively. The median sulfate and TDS values exceed the livestock criteria. Based on these relevant use criteria, the water in the No Name alluvium system is a poor source of supply for livestock watering use. This is especially apparent when considering sulfate and TDS concentrations. These water quality parameters often exceed relevant criteria for livestock use, although the alluvium has been historically and is currently used for this purpose.

4.2.4.3 **Fruitland Formation Baseline Quantity**

Only a small amount of groundwater is found in the coal units of the Fruitland Formation and in the PCS, which underlies the Fruitland Formation at the Navajo Mine site. The geologic strata within the permit and adjacent area dip gently to the east toward the center of the San Juan Watershed at an angle of 1 to 2 degrees. Based on both regional and site-specific information, the Fruitland Formation and associated coal units, and the PCS are unsaturated or partially saturated near the outcrop of these units on the western side of the Navajo Mine lease area but become saturated to the east and down dip of the outcrop.

The Fruitland Formation has been mined extensively throughout the history of the Navajo Mine. Most of the wells that were present at one time or another have been mined through or abandoned, making the monitoring program inconclusive with respect to the finer details of how groundwater flow has been affected at the mine site. Modeling efforts and other estimates have been made by the coal operator to determine (1) what the pre-mining groundwater flow conditions were like in the Fruitland Formation and (2) what the post-mining conditions will likely be for this aquifer.

Based on baseline information obtained from water level elevations measured in the wells and piezometers, the general groundwater flow directions in the Fruitland Formation within Areas III, IV and V of the BNCC coal lease are vertically downward through the interbedded shale and coal units of the Fruitland Formation and into the PCS and laterally within individual coal seams toward the north-northeast with some localized flow toward the topographic lows along Cottonwood and Pinabete Arroyos (BNCC 2011, Appendix 6-G).

Direct recharge rates measured by chloride mass balance methods on undisturbed areas at the Navajo Mine ranged from 0.002 to 0.09 in/yr (Stone, Phase-III Recharge Study at the Navajo Mine - Impact of Mining on Recharge 1987). The highest recharge rate of 0.09 in/yr was for valley terraces while the lowest recharge rate of 0.002 in/yr was for badland areas. Recharge from upland flats averaged 0.03 in/yr. Recharge is expected to be higher from saturated alluvium and surface water impoundments. Although Stone's research (1986 and 1987) did not include recharge estimates for surface impoundments, it does provide an estimate of an average recharge rate of 0.16 in/yr from depressions within reclaimed mine areas at the Navajo Mine (BNCC 2011, Appendix 6-G).

Baseline potentiometric elevations measured in the wells in Areas IV and V were recorded by BNCC. The potentiometric surface for the No. 3 coal seam is provided in Figure 20. This potentiometric surface was constructed from the baseline potentiometric elevations for the No. 3 coal seam presented in Appendix 6.G of the PAP and the July 1989 baseline potentiometric elevations measured in the No. 3 coal wells located within Area III. The modeled baseline potentiometric surface for the No. 3 coal was also used to estimate the potentiometric contours beyond the limits of the monitoring data. The potentiometric gradient in the No. 3 coal seam indicates groundwater flow components toward the north-northeast with local gradients toward Pinabete Arroyo and Cottonwood Arroyo. The lower coal seams pinch out and do not extend north of Area III. The groundwater moving perpendicular to the potentiometric gradients to the northeast flows through the undifferentiated Fruitland Formation into either the upper coal units or into the underlying PCS (BNCC 2011, Appendix 6.G).

Potentiometric gradients in the other coal seams within Areas III, IV, and V of the BNCC coal lease are expected to be generally toward the northeast, similar to the gradients shown for No. 3 coal. However, the upper coal seams (No. 6, No. 7, and No. 8) outcrop to a greater extent within the valleys of Pinabete Arroyo, No Name Wash, and Cottonwood Arroyo within the BNCC coal lease. The groundwater associated with these upper coal seams is expected to show greater local influence from the topographic lower elevations along the arroyos. The local influence of topography on potentiometric gradients was greatest for the shallowest coal, the No. 8 seam. Field observations of salt deposits and enhanced vegetation production also indicate that local discharge may occur from the No. 8 coal at the coal outcrop along Pinabete Arroyo. Baseline groundwater model simulations and potentiometric elevations at wells within the No. 8 coal seam were used to prepare the potentiometric surface in Figures 21. The modeled baseline potentiometric surface for the No. 8 coal was also used to estimate the potentiometric contours beyond the limits of the monitoring data. Higher hydraulic conductivities are characteristic of the higher coal units (No. 7 and No. 8) relative to the lower coal units (No. 2, No. 3, and No. 4-6) (BNCC 2011, Appendix 6-G).

4.2.4.4 **Fruitland Formation Baseline Quality**

Groundwater use in CIA is limited in extent, and water derived from the Fruitland formation has no known use within the vicinity of BNCC other than for oil and gas extraction to the west of the lease area. This is in part due to the very low well yields within the Fruitland system within the general area of the mine lease, which do not tend to support beneficial use. However, given the designated post-mining land use of livestock grazing, Fruitland baseline quality will be evaluated in part by comparison to livestock watering criteria (Table 3). The criteria are not enforceable standards with respect to groundwater and are included only as a reference for the suitability of the groundwater quality for livestock use. Fruitland water quality will only be evaluated for pH, conductivity, boron, total iron, manganese, selenium, chloride, fluoride sulfate, and TDS, as these parameters most generally define water quality and tend to be of concern within the region as evident in both the surface water and alluvial analysis. Generally water quality monitoring data from Fruitland Formation coal wells show that baseline groundwater in the coals is very saline (BNCC 2011, Appendix 6-G).

Fruitland water quality data has been collected at several historic and current locations as seen on Figure 19. All data collected from Areas IV and V and all data collected prior to 2001 within Area III and II is considered to be baseline relative to quality because during mining gradients within the Fruitland were towards the mine pits therefore impact to water quality would be minimal. This data used to characterize baseline Fruitland quality within the lease area consists of samples collected at 12 well locations from 1984 to 2008 as follows; KF2007-01 from 2007 to 2008, KF98-02 from 1998 to 2008; KF84-21A, KF84-22B, and KF84-20A from 1984 to 2001; KF84-21C, KF84-22D, and KF84-22E during 1984; KF84-22A from 1991 to 2001; KF84-20C and KF84-18A from 1985 to 2001; KF84-18B from 1984 to 2000.

Baseline Fruitland quality data was found to have a lower variability compared to alluvial water quality, and the median relative percent standard deviations for all constituents was 58 for the baseline coals within the lease area. Comparison of median concentrations across wells within the Fruitland baseline within the lease area showed a general trend where moving towards the northeast from Area V to II; conductivity, TDS, chloride, manganese and iron tended to increase, whereas sulfate, fluoride, selenium, and pH tended to decrease. The TDS concentrations in the coal units at the Navajo Mine also typically increase from shallow to deep, whereas sulfate tends to decrease from shallow to deep, which could in part due to sulfate reduction in the groundwater (BNCC 2011, Appendix 6-G).

Baseline Fruitland water quality within the lease area showed that pH, fluoride, and sulfate were not within the range of acceptable criteria for 4%, 16%, and 11% of all samples respectively. Baseline Fruitland quality exceeded the chloride and TDS criteria for 85% and 88% of all samples respectively, where the median concentration for chloride and TDS were 6 times and 2.5 times greater than the criteria, respectively. Based on comparison to livestock criteria, the water in the Fruitland systems would be a very poor source of supply for livestock watering use, specifically because of elevated chloride and TDS concentrations, which are well above livestock criteria.

4.2.4.5 **Pictured Cliffs Sandstone Aquifer Baseline Quantity**

The PCS is a well-cemented, low-permeability, marine sand and is the first water-bearing unit below the Fruitland Formation. The PCS is approximately 110 to 120 ft thick and follows the structure of the Fruitland Formation, dipping to the east at approximately 2 degrees, although the structure varies locally. The PCS conformably overlies the Lewis Shale, with the contact marked by a zone of interbedded sandstones and mudstones in the lower part of the PCS (Stone, Hydrogeology and Water Resources of San Juan Basin, New Mexico 1983). It outcrops just west of the mine lease and east of the Chaco River. The PCS is a marginal water resource due to low permeability, poor water quality, gas production, and low yields. The PCS is also a natural gas reservoir in the San Juan Watershed. Stone et al. (1983) state that the PCS cannot be considered a major aquifer and it is important only because it is the water-bearing horizon immediately underlying the coals in the Fruitland Formation.

The PCS has neither been used as a groundwater source nor has it been extensively affected by the mining activities at the Navajo Mine. BNCC modeled the potentiometric surface and came to some conclusions regarding both baseline and mine-impacted conditions within the PCS. Although the modeling done by BNCC focuses primarily on the areas proposed for mining under the new permit revision, the baseline quantity information for the PCS aquifer in this area sufficiently reflects prevalent conditions in other areas of the Navajo Mine.

Well KPC-98-01 was installed in 1998 near the PCS outcrop at the location shown in Figure 19. In 2007, wells KPC2007-01, KPC2007-02, and KPC2007-03 were completed in the PCS at locations around the perimeter of Area IV South. Vibrating Wire Piezometers (VWPs) were installed in the PCS at four of the five locations as shown in Figure 19. A VWP was not installed in the PCS at the VWP2007-03 location because monitoring well KPC2007-02 was installed in the PCS at this location.

The modeled baseline potentiometric surface for the PCS together with the baseline potentiometric elevations from the PCS wells and VWPs were used to prepare the PCS potentiometric surface provided in Figures 15. The measurements of the baseline potentiometric elevations for the abandoned GM wells were obtained in June 1989. The potentiometric surface for the PCS shows overall gradients to the north. The highest potentiometric elevations for the PCS correspond with a structural high in the PCS located within the southeast portion of Area V of the BNCC coal lease. There are also local gradients toward the topographic lows along No Name Wash, Pinabete Arroyo and Cottonwood Arroyo.

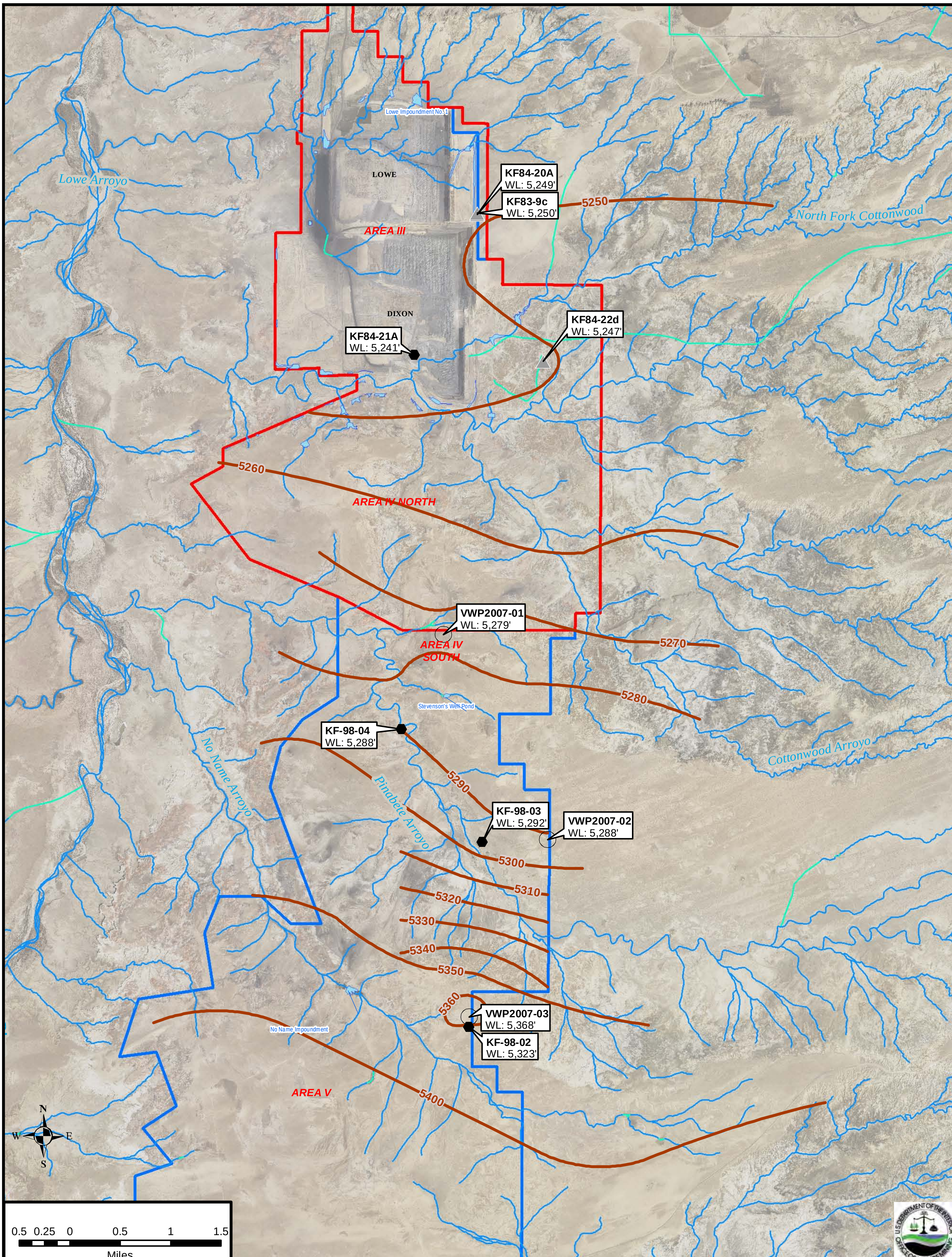
Water yields are quite low from the PCS monitoring wells completed around BNCC lease Area IV South. Two of the PCS wells were quickly pumped or bailed dry during conventional sampling. The yield from one of the PCS wells was sufficient to sustain a rate of about 0.4 gallons per minute (gpm) during a constant rate pumping test. The fourth PCS monitoring well was pumped dry after about 140 minutes during a constant-rate pumping test at a rate of about 1 gpm.

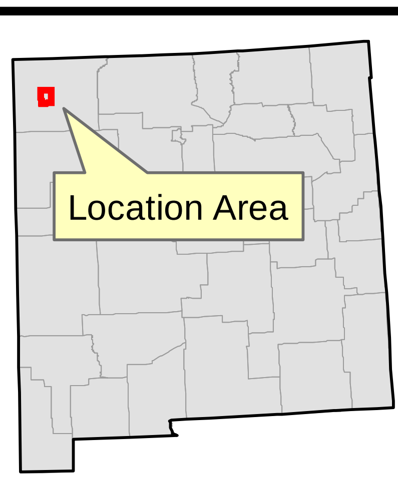
4.2.4.6 **Pictured Cliffs Sandstone Aquifer Baseline Quality**

Groundwater use in the vicinity of the Navajo Mine is limited in extent, and water derived from the PCS has no known use within the vicinity of BNCC other than for oil and gas extraction to the north and west of the lease area. This is in part due to the very low well yields within the PCS system within the general area of the mine lease, which do not tend to support beneficial use. However, given the designated post-mining land use of livestock grazing, PCS baseline quality will be evaluated in part by comparison to livestock watering criteria (Table 3). The criteria are not enforceable standards with respect to groundwater and are included only as a reference for the suitability of the groundwater quality for livestock use. PCS water quality will only be evaluated for pH, conductivity, boron, total iron, manganese, selenium, chloride, fluoride sulfate, and TDS, as these parameters most generally define water quality and tend to be of concern within the region as evident in both the surface water and alluvial analysis. Generally water quality monitoring data from PCS show that baseline groundwater is sodium-sulfate type with high TDS concentrations (BNCC 2011, Appendix 6-G).

PCS water quality data has been collected at several historic and current locations as seen on Figure 19. All data collected from Areas IV and V and all data collected during the mid-1970s from the GM series of wells is considered to be baseline relative to quality. This data used to characterize baseline PCS quality within the lease area consists of samples collected at 13 well locations from 1974 to 2008 as follows; KPC-2007-01 from 2007 to 2008, KPC-98-01 in 1998,2007, and 2008; GM-14, GM-15, and GM-8 from 1975 to 1976; GM-19, GM-20, and GM-21 from 1974 to 1979; GM-11 and GM-5 from 1975 to 1977; GM-6 from 1976 to 1977; GM-28 from 1974 to 1976; GM-30A from 1976 to1979. Baseline PCS quality data was found to have a lower variability compared to alluvial water quality, and a higher variability compared to Fruitland water quality, where the median relative percent standard deviations for all constituents was 76.

Comparison of median concentrations across wells within the PCS baseline showed that pH and TDS were relatively consistent across the lease area, other constituents were much more variable, and fluoride and boron tended to increase moving towards the northeast from Area III to I. Baseline PCS water quality showed that pH, boron, selenium, chloride, fluoride, sulfate and TDS were not within the range of acceptable criteria for 19%, 2%, 12%, 61%, 23%, 82% and 98% of all samples respectively. Additionally the median concentration for chloride, sulfate and TDS were 1.6, 2.5 and 2 times greater than the criteria, respectively. Based on comparison to livestock criteria, the water in the PCS would be a very poor source of supply for livestock watering use, specifically because of elevated chloride, sulfate and TDS concentrations, which are well above livestock criteria.





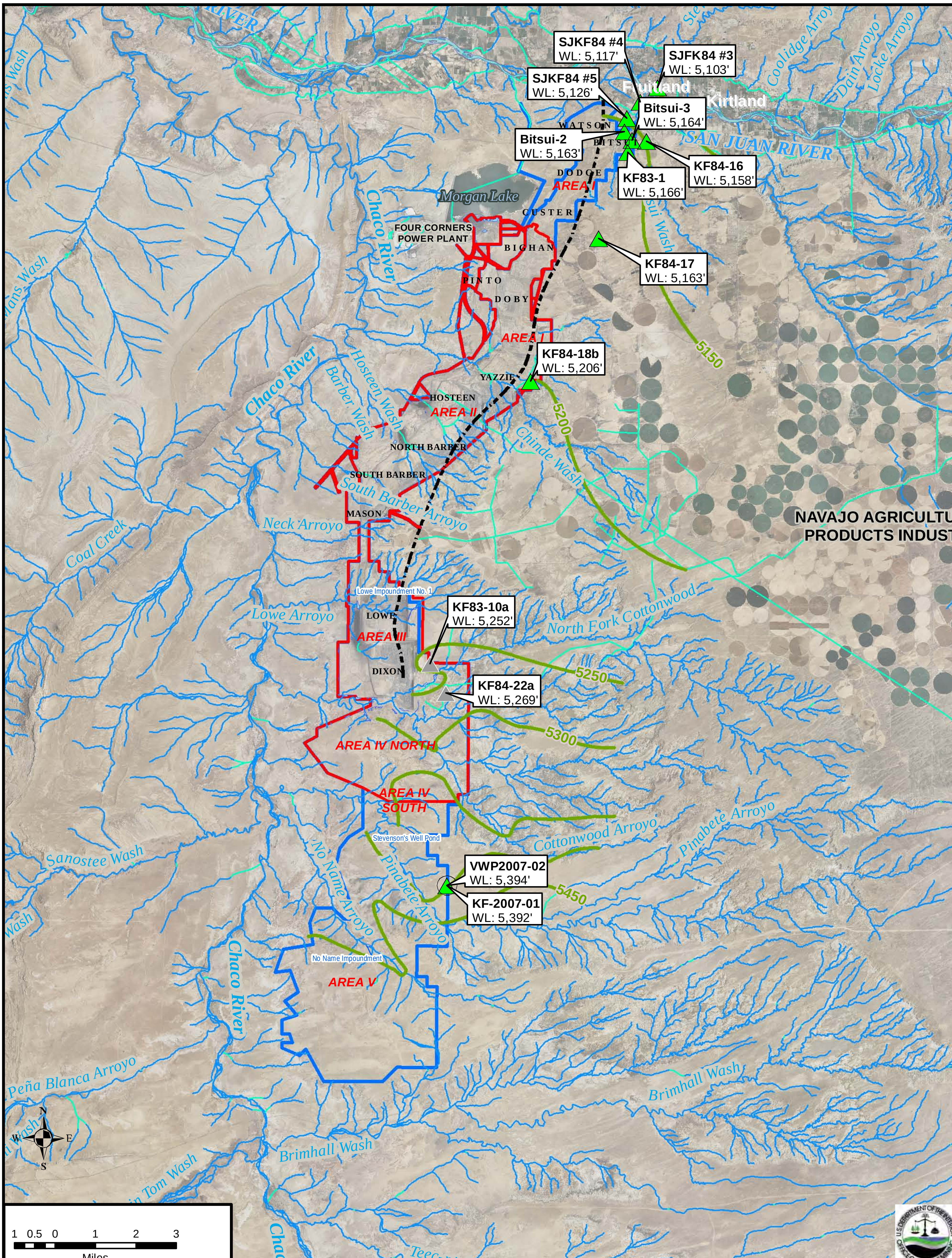
Legend

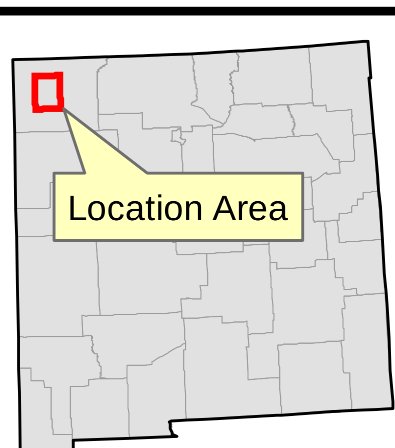
- Coal 3 Potentiometric Contour
- No 3. Coal Monitoring Well
- Fruitland Nested Wells
- Nested Vibrating Wire Piezometer
- Ponds
- Natural Stream[1]
- Artificial Canal/Ditch[1]
- Coal Lease Area
- Permit Area
- PIT NAMES

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA Coal Seam No. 3 Potentiometric Surface

Figure 20





Legend

- No 8. Coal Monitoring Well
- Fruitland Nested Well
- Nested Vibrating Wire Piezometer
- Coal 8 Potentiometric Contour
- Coal 8 Potentiometric Contour - Inferred
- Saturated/Unsaturated Boundary
- Ponds
- Natural Stream[1]
- Artificial Canal/Ditch[1]
- Coal Lease Area
- Permit Area
- PIT NAMES

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA Coal Seam No. 8 Potentiometric Surface

Figure 21

5 HYDROLOGIC IMPACT ASSESSMENTS

Required by 30 CFR 780.21(g), as the regulatory authority, OSMRE shall provide an assessment of the probable cumulative hydrologic impacts of the mining operation upon surface water and groundwater systems in the cumulative impact area. OSMRE must make a determination that the BNCC operation has been designed to minimize impact within the permit area and prevent material damage outside the permit area. OSMRE must also evaluate that the monitoring program has been appropriately designed to provide the surface water quantity and quality information necessary to assess potential impacts per 30 CFR 780.21(g).

5.1 Minimization of Impact

BNCC outlines impact minimization procedures in the Hydrologic reclamation plan (BNCC 2011, Section 12.11). Minimization of impacts to the hydrologic balance is focused on reducing the disturbance footprint to the extent practical via contemporaneous reclamation. Additionally, local areas of acid forming material are managed through proper chemical characterization and placement, including blending and mixing, of overburden materials. The amount of upgradient surface water commingled with disturbed area drainage is limited utilizing best management practices (BMPs) to contain or divert upgradient flows. Upgradient flows diverted around active mining pits and into downgradient natural channels or upgradient impoundments have been established to contain upstream water runoff. Migration of sediment during storm events is limited utilizing BMPs to contain or treat flows via impoundments downgradient of the mine site. BNCC also minimizes potential effects to the surface water and alluvial groundwater quantity by instituting stream buffer zones when practical to limit disturbances in channel reaches unaffected by mining. OSMRE finds that the mining operation has been designed to minimize impacts within the permit boundary.

5.2 Monitoring Program

A surface water monitoring plan is provided in the PAP, Chapter 7, Section 7.4. BNCCs surface water monitoring program was established to monitor surface water quantity and quality at locations where major watercourses enter and leave the permit area. The monitoring program provides the basis for assessment of the impact of mining on the surface water resource and has been developed to collect water quantity and quality information for use in the identification of potential impacts to the prevailing hydrologic regime. The plan identifies the parameters to be monitored, sampling frequency, and site locations. The permit application also complies with NPDES Permit No. NN0028193 (BNCC 2011, Section 7.4). Current surface monitoring locations can be seen on Figure 17. A list of surface water sampling parameters is found in Navajo Mine PAP, Chapter 7, Table 7-10, and includes pH, TDS, TSS, conductivity, settleable solids, total sediment, aluminum, arsenic, boron, calcium, cadmium, chloride, fluoride, total and dissolved iron, lead, total and dissolved manganese, nitrate, potassium, selenium, sulfate, sodium, bicarbonate, and carbonate (BNCC 2011). Additionally, each sample is accompanied with a cation/anion balance for quality assurance. OSMRE finds that the surface water monitoring program has supplied sufficient information to support the required evaluation for material damage potential in this CHIA.

A groundwater monitoring plan is provided in the Navajo Mine PAP, Chapter 6, Section 6.6. BNCCs groundwater monitoring program was established to monitor groundwater quantity and quality in alluvial systems, the Fruitland formation, and the PCS. The monitoring program provides the basis for assessment of mining impact on groundwater resources and has been developed to collect water quantity and quality information for use in the identification of potential impacts to the prevailing hydrologic regime. The plan identifies the parameters to be monitored, sampling frequency, and site locations (BNCC 2011, Section 6.6). Current groundwater monitoring locations are illustrated on Figure 19. A list of groundwater sampling parameters is found in the Navajo Mine PAP, Chapter 6, Table 6-4, and includes TDS, conductivity, pH, water level, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, fluoride, and selenium. Additionally, each sample is accompanied with a cation/anion balance for quality assurance. Additional monitoring parameters, are only used if the reference criteria are exceeded, and are found in the Navajo Mine PAP, Chapter 6, Section 6.6.13.2 and footnote 1 of Table 6.5 Additional monitoring parameters include iron, manganese, nitrate, and boron. Table 6.5 lists the reference criteria. OSMRE finds that the groundwater monitoring program has supplied sufficient information to support the required evaluation for material damage potential in this CHIA.

5.2.1.1 Monitoring Program Updates

Monitoring programs are periodically updated to enhance the available data sets for predictive analysis. OSMRE recently approved enhancements to the hydrologic monitoring program proposed by BNCC. Monitoring program enhancements are outlined below (BNCC 2012):

Surface Water:

1. Chinde Wash
    a. One continuous flow gauge will be installed upstream, off lease in the proximity of agricultural fields.
    b. One continuous flow gauge will be installed on-lease, downstream of the "big fill"
2. Cottonwood Arroyo
    a. Four upstream flow gauges will be installed (one each) along the North Fork, Middle Fork and two branches of the South Fork
        i. Above mentioned upstream gauges will be installed at the outfall of culverts along the proposed Burnham Road re-route
    b. One downstream flow gauge will be installed on an already existing cable structure across the channel; periodic channel surveys will confirm accurate channel cross section
    c. All stations will consist of flow meters to sample flow quantity and water samplers for water quality analysis
3. Implementation Schedule
    a. Chinde gauges upon approval of off-lease monitoring
    b. Cottonwood upstream gauges dependent on permit approval and construction schedule of Burnham Road re-route; proposed for June 2012 (North Fork) and October 2012 (Middle and South Fork)
    c. Cottonwood downstream monitoring scheduled for completion in May 2012

Groundwater:

1. Bitsui Area – used on part to evaluate the Area I groundwater model
    a. Existing well Bitsui-2 will be used for #8 seam groundwater level monitoring and for groundwater sampling.
    b. Existing wells KF84-16 and KF83-1 will be used for monitoring #8 seam groundwater levels.
2. Chinde Wash Area
    a. One off-lease, upstream pre-packed well (CA-1) will be installed via hand augur
    b. CA-2 will be installed near the lease boundary as a well to monitor water quality of Chinde Arroyo up gradient of mining activities.
    c. One off-lease, downstream pre-packed well (CA-6) may be installed via hand augur; this will be replaced by a drilled well once final approvals have been acquired
    d. Three piezometers (CA-3, CA-4, CA-5) will be installed in the "big fill" wetland area
    e. All Chinde wells and piezometers will be monitored quarterly for a period of two years, followed by an assessment of continued monitoring frequency.
3. Cottonwood Arroyo Area
    a. A new alluvial well (proposed CWA-4) will be installed to replace the hand-dug, dry well QACW-2B along the main Cottonwood Arroyo just south of Dixon.

b. A new alluvial well (proposed CWA-1) will be installed to replace the abandoned well GM-17 along the North Fork of the Cottonwood Arroyo just inside the lease boundary.
c. Two new alluvial wells (proposed CWA-2 and CWA-3) will be installed along the Main Fork and South Fork, respectively, of the Cottonwood Arroyo near the lease boundary.
d. Two new Fruitland wells (proposed KF-1 #3 and KF-1 #8) will be installed on the northwest side of Area IV North near the lease boundary. These will be used to evaluate Area IV north groundwater model predictions of drawdown, recharge and TDS transport. Monitoring of the No. 3 and No. 8 coal seam should provide information about potential impacts prior to influences on the alluvial water system, which will be protective of downstream alluvial users on the Cottonwood and Chaco.

4. Groundwater Reference Criteria
   a. Criteria will be recalculated using the entire set of baseline data from *10/17/2011*
   b. Reference criteria will be established for QACW-2
   c. QACW-2B is a dry, unsuitable hand-dug well and will be replaced by well CWA-4; new reference criteria will be developed for well CWA-4
   d. GM-17 well will be replaced by proposed well CWA-1; local variation in natural soil properties precludes comparing these two wells as being chemically equivalent so new reference criteria will be developed for CWA-1
   e. Reference criteria are based on the median + 2 median absolute deviations for the baseline monitoring data through year 2001; detection values are calculated as the product of 0.5 and the detection limit
   f. Reference Criteria have been established for well QACW-2 as requested; detection values were calculated as the product of 0.5 and the detection limit.
5. Implementation Schedule
   a. All replacement wells, with the exception of CA-6, are scheduled to be installed during April and May of 2012
   b. Chinde downstream drilled well CA-6 will be installed when necessary approvals are acquired
   c. Well development is scheduled to be completed during June, 2012
   d. The monitoring plan revision to the permit is planned for submittal in August, 2012

Modifications to the Chinde alluvial monitoring are particularly important in light of the potential mining related impacts to this system discussed in section 5.3.7.1.2.2. The objective of these new monitoring locations is to characterize and monitor hydrogeologic conditions of the Chinde Alluvium as follows:

The first monitoring location would be a drive point well that would be installed down-gradient of the NAPI fields and up-gradient of the wetland east of the mine lease. The purpose of this monitoring location would be to assess the groundwater quality immediately down-gradient of NAPI.

- The second monitoring location would be a well installed adjacent to the wetland east and up-gradient of the mining activities. The purpose of this well would be to monitor water quality immediately up-gradient of mining activities.
- The third monitoring location would be a well installed in the Chinde Wash down-gradient of existing well QAC-1. The purpose of this well would be to monitor water quality down-gradient of the mine. Since this monitoring location is located off-lease it is anticipated that installation will be delayed due to the approvals that must be obtained. BNCC is proposing that a drive point be installed prior to well installation to expedite the collection of data. Once the necessary approvals are acquired for the monitoring location, the drive point will be removed and replaced with a monitoring well.
- The remaining three new monitoring locations would be installed in the wetland immediately up-gradient of the Big Fill. The purpose of these is to monitor potential impacts of the wetland on

alluvial water quality, and to monitor groundwater elevations and enable groundwater flow direction to be determined.

BNCC proposes to sample these six new monitoring locations for a period of two years, after which BNCC will discuss with OSMRE the efficacy of continued monitoring of the new monitoring wells. These proposed additions are outlined in Table 6 and approximate locations are shown in Figure 22.

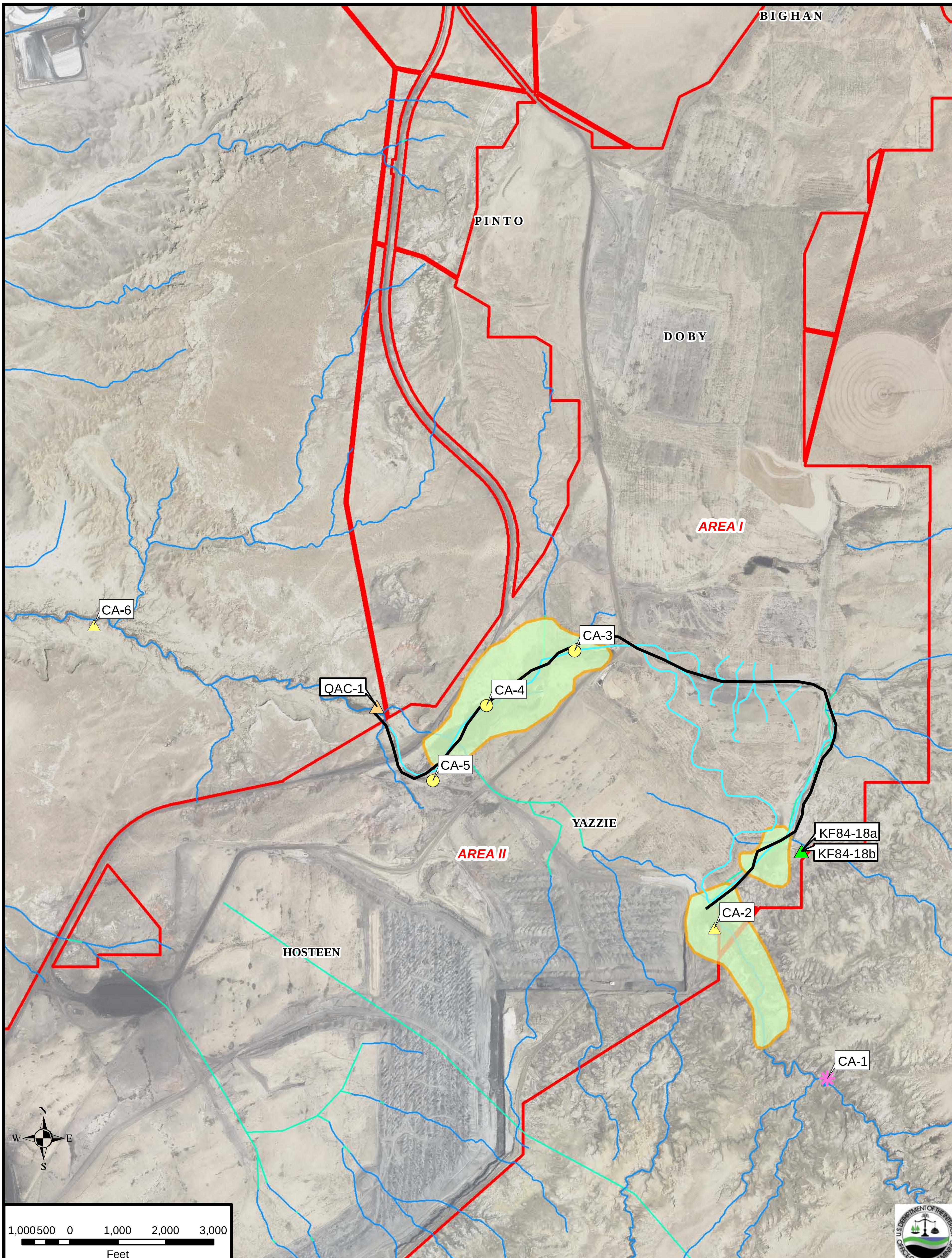
Table 6: Proposed Chinde Alluvium Monitoring (BNCC 2012)

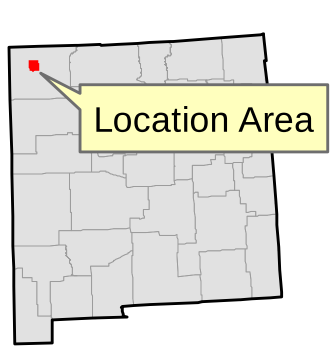
Target Unit	Well Designation	General Location	Monitoring Type	Screen Interval	Sampling Frequency
Top of competent bedrock	CA-1	Chinde Wash – downgradient of NAPI	Drive Point	Dependent on refusal	Quarterly
Alluvium	CA-2	Chinde Wash – adjacent to wetland east of mine lease	Monitoring Well	Varies – 5' above the water table plus thickness of aquifer	
	CA-3*	Chinde Wash – wetland on lease			
	CA-4*				
	CA-5*				
	CA-6	Chinde Wash – downgradient of mine lease	Drivepoint/ Monitoring well	Dependent on refusal/ Varies – 5' above the water table plus thickness of aquifer	

*Water level measurements only

5.3 Impact Assessment

The assessment presented in Chapter 5 of this document considers available quantity and quality information related to surface water and groundwater potentially affected by BNCC operations. The assessment approach used for each resource is outlined in Table 7. Impact assessment relied upon analysis of monitoring data, several models, relevant published and unpublished reports and papers, experience from past mining and reclamation operations at Navajo Mine and other mines located along the western rim of the San Juan Watershed, as well as observations made by BNCC and OSMRE staff during the day-to-day operations and regulation of the mine. Impacts are designated as negligible, minor, moderate or major as defined in Table 7. Table 7 also outlines current minimize techniques and updates to the BNCC monitoring program.





Legend

- Existing Alluvial Monitoring Well
- Existing Fruitland Well
- Proposed Monitoring Well
- Proposed Piezometers
- Proposed Drive Point
- Wetlands
- Original Diversion
- Natural Stream Channel Design
- Permit Area
- Coal Lease Area
- Natural Stream[1]
- Artificial Canal/Ditch[1]

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA Chinde Diversion and Monitoring Locations

Figure 22

Table 7: Impact Assessment and Designation Methodology

Water Resource		Fruitland & PCS Quantity	Alluvial Quantity	Surface Water Quantity	Fruitland & PCS Quality	Alluvial Quality	Surface Water Quality
Assessment Approach		Evaluation of potentiometric surface contour maps	Comparison of water levels at individual wells over-time	SEDCAD modeling- pre- and post-mining; Percent of HUC12 Watersheds controlled with impoundments	Comparison of baseline water quality to potentially impacted or non-baseline wells, including spoil and CCB wells	Comparison baseline (upstream/pre-mining) water quality to non-baseline (during and post-mining/downstream) water quality and comparison to applicable Water Quality Standards	
Impact Designation	**Major**	Changes in water level contours that are significantly less than baseline levels	Changes in water levels that are consistently (>60% of the time) below baseline fluctuations as Characterized by the Median minus 2 MAD	Impounded areas relative to HUC 12 watersheds or change in peak flows relative to baseline are >60%	Changes in water quality that consistently (>60%) exceed baseline fluctuations as Characterized by the Median plus 2 MAD		
	Moderate	Changes in water level contours that are moderately less than baseline levels	Changes in water levels that are regularly (30%-60%) below baseline fluctuations as Characterized by the Median minus 2 MAD	Impounded areas relative to HUC 12 watersheds or change in peak flows relative to baseline are between 30% and 60%	Changes in water quality that regularly (30-60%) exceed baseline fluctuations as Characterized by the Median plus 2 MAD		
	Minor	Changes in water level contours that are slightly less than baseline levels	Changes in water levels that are occasionally (10%-30%) below baseline fluctuations as Characterized by the Median minus 2 MAD	Impounded areas relative to HUC 12 watersheds or change in peak flows relative to baseline are between 10% and 30%	Changes in water quality that occasionally (10%-30%) exceed baseline fluctuations as Characterized by the Median plus 2 MAD		
	Negligible	Impacts to Groundwater that is not capable of providing a sustainable water supply for use or that are similar to baseline fluctuations		Impounded areas relative to HUC 12 watersheds or change in peak flows are <10% (considered within baseline)	Impacts to water quality that are within baseline fluctuations (<10%) as Characterized by the Median plus 2 MAD or Impacts to Groundwater that is not capable of providing a sustainable water supply for use or that are similar to baseline fluctuations		
Impact Mitigation		Contemporaneous Reclamation	Contemporaneous Reclamation; reclamation of approximate original contour (AOC); mining limited to ephemeral channels; stream buffer zones		Contemporaneous Reclamation; mixing of overburden/ backfill materials; material classification and handling procedures	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones; Sedimentation Ponds
Monitoring Program Updates		Submittal of 5 yr Potentiometric Surface Contour Maps	Addition of new monitoring stations	Addition of new monitoring stations	Additional coal seam well in area IV north	Addition of new monitoring stations	Addition of new monitoring stations

5.3.1 Potential Cumulative Impact between BNCC and El Segundo Mine

El Segundo coal mine is located approximately 70 miles southeast from the southern tip of the Navajo Mine lease boundary. The proposed lease area is divided into two subwatersheds by the continental divide, and is crossed by several unnamed ephemeral arroyos. The western portion of the lease area ultimately drains into the Chaco River through an unnamed, ephemeral channel that drains to Laguna Castillo before flowing into a named drainage, Kim-me-ni-oli Wash, and into the Chaco River. The ephemeral arroyos passing through the lease area flow only in direct response to storm events, or discharges derived from NAPI. The drainage area for the main western drainage as it leaves the lease area is approximately 24.7 square miles of which about 6.1 square miles (25%) of the total watershed are proposed to be disturbed by mining. The effects of mining relative to surface water quantity is limited to the interception of surface flows, which has potential to impact the stock watering capability of rangelands (NMEMNRD 2008).

The El Segundo mine lies approximately 70 miles away from the Navajo Mine and the Chaco River is an ephemeral, losing stream. Therefore, only under tremendous regional storm conditions is it possible for surface water flows from the El Segundo Mine to reach the Chaco River in the vicinity of the Navajo Mine and comingle with surface waters that have crossed the BNCC lease. Overall, El Segundo Mine covers less than one percent of the total Chaco Watershed. The surface water runoff generated from the small percentage of the Chaco Watershed is imperceptible relative to the total runoff volume generated from the entire Chaco Watershed. Therefore, OSMRE concludes that surface water cumulative impacts to the Chaco River from the El Segundo Mine are negligible.

5.3.2 Potential Impact of BNCC operations on NAPI

NAPI uses surface water sourced from the San Juan River upstream of BNCC mining operations. Additionally, NAPI operations are located upstream of BNCC operations. Therefore, given the surface water flow directions, BNCC operations are determined to have negligible surface water impacts on NAPI operations.

However, NAPI operations have been documented to have significant impact on BNCC operations. NAPI impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. NAPI direct discharges are a result of an oversupply of water in the canal that is released directly to a wash. Discharge events for the streams are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel (BNCC 2011, Section 11.6). The indirect NAPI related discharges are a result of return flows to the wash caused by the infiltrating irrigation water. The indirect NAPI related discharges result in leaching of the unconfined geologic surface formations and soils. The impacts of the NAPI activities on the baseline channel hydrologic balance are expressed as highly variable increases in flow and discharge.

5.3.3 Potential Impact of BNCC Operations on Morgan Lake and APS

Water from the San Juan River is pumped to Morgan Lake for use as cooling water at the APS Four Corners Generating Station and also for use in dust suppression and reclamation irrigation activities associated with the BNCC permit area. BNCC typically diverts and consumes 825 acre-feet annually; APS typically diverts 35,421acre-feet and consumes 28,611 acre-feet annually (United States of America 2011, Table L-1). The total volume of water in Morgan Lake is approximately 39,200 acre-feet at normal storage and 42,800 acre-feet at maximum storage. Variation between normal storage and maximum storage in Morgan Lake encompasses a difference of 3,600 acre-feet, or 10% of the normal storage. A comparison of total (BNCC and APS) diversion and consumption to the Morgan Lake volume shows that at normal storage roughly 90% of the Morgan Lake volume is diverted every year, of which roughly 75% is consumed. Of these total diversion and consumption percentages only 2% is due to BNCC operations. BNCC annual diversion and consumption from Morgan Lake is less than the difference between normal and maximum storage of Morgan Lake, therefore, the impact of BNCC operations on Morgan Lake water quantity is negligible. The contribution to Morgan Lake from tributaries which traverse the BNCC permit is also considered to be negligible.

Given the total (BNCC and APS) diversion rate from the San Juan River into Morgan Lake, which results in approximately 90% of the normal storage volume being replaced on an annual basis, and the negligible flow contribution to Morgan Lake from tributaries which traverse the BNCC permit, quality impacts associated with these tributaries are considered to be negligible. BNCC diversion and consumption is roughly 2% of the total APS diversion and 3% of the total APS consumption, therefore BNCC operations are not expected to adversely impact the water availability for APS operations. Quality impacts to Morgan Lake associated with BNCC operations are considered to be negligible, and BNCC operations should not impact Morgan Lake water quality, such that, it would not be suitable for use in APS operations.

5.3.4 **Chaco River**

There are periods when precipitation runoff from the drainages that normally flow across the areas intersected by mining will not make it to the Chaco River during operations, but will either be intercepted by the mine pits or captured in temporary pit protection ponds (highwall impoundments) located up gradient of mining. Once reclamation is completed within the mining area, precipitation runoff from these reclaimed areas will flow through channels in the reconstructed topography and then to the Chaco River.

5.3.4.1 **Surface Water Quantity**

The Chaco River is an ephemeral drainage up until the last 12.5 miles of the stream where runoff from Morgan Lake has caused it to be perennial. All of the primary drainages of interest at the Navajo Mine except for Bitsui Wash drain into the Chaco River. Water monitoring historically occurred along two USGS gage stations along the Chaco River, station #09367950 near Waterflow, NM and station #09367938 near Burnham, NM. The locations of these two water monitoring stations are illustrated in Figure 8. The stations were actively monitored for stream flow and select water quality parameters from 1977-1994 and from 1977-1982, respectively. Station #09367938 exhibits the original ephemeral nature of the Chaco River, which existed prior to the construction of Morgan Lake, whereas Station #09367950 is downstream of the confluence with the Morgan Lake drainage where the river flows perennially. USGS station 09367938 is considered to be representative of baseline conditions within the Chaco River as it is upstream of the Navajo Mine lease.

Precipitation runoff from reclaimed areas may be reduced somewhat from pre-mine levels due to any of the following factors: lower slopes, enhanced vegetative growth, engineered traditional or geomorphic drainage designs, and the use of sediment-control BMPs that operate to retain water in the reclaimed areas reducing storm-water runoff to the channels. Although some perennial flow occurs along the final stretch of the river, all of the large flow events occur in response to precipitation. From Figure 23, it is apparent that the flow in response to these heavy precipitation events increases as you move downstream in nearly all cases, therefore there is not a substantial loss in surface water flows within the Chaco River downstream of mining and impacts of the BNCC mining operation on Chaco River surface water quantity is considered to be negligible.

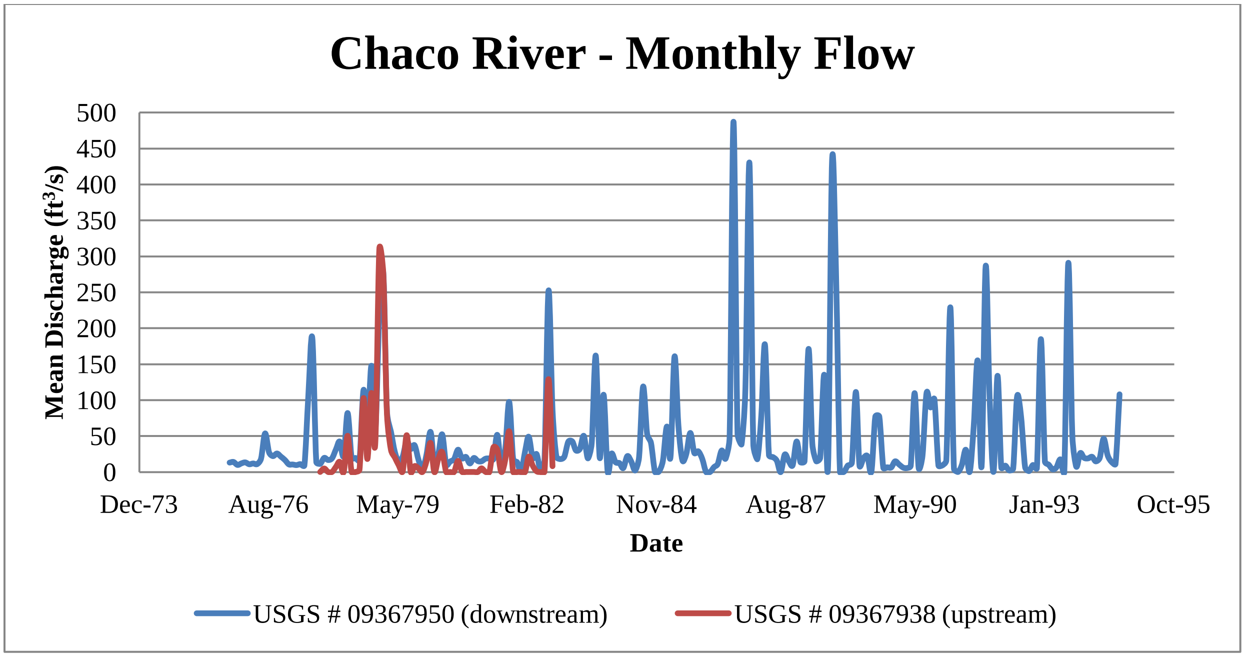


Figure 23: Monthly Flow along the Chaco River

5.3.4.2 Surface Water Quality

Surface water quality data is available on the Chaco at two historic USGS monitoring stations which bracket all Chaco River tributaries traversing the lease area; 09367950 downstream of the Morgan Lake discharge point and 09367938 upstream of No Name Wash confluence (Figure 8). USGS station 09367938 is considered to be representative of baseline conditions within the Chaco River as it is upstream of the Navajo Mine lease. Water quality data was collected by the USGS at 09367938 from July of 1977 to August of 1982.

USGS station 09367950 is used to assess the non-baseline or downstream, conditions within the Chaco River as it is downstream of the Navajo Mine lease, however it is not necessarily considered to be representative of mining impacts as it is also downstream of the Morgan Lake discharge point, which is known to have significant impact on the Chaco River quantity turning the normally ephemeral drainage into a perennial drainage at this point. Additionally, between 2 USGS stations the Chaco river moves from traveling over an established Quaternary Alluvium Deposit to running over the outcrop of the Mesa Verde Aquifer (Cliff House Sandstone, Menefee Formation, Point Lookout Sandstone formation) before discharging into the San Juan River (Figure 5). The Chaco River is a known discharge area for the Mesa Verde Aquifer within the San Juan Watershed. There is very sparse water quality data for this aquifer in the San Juan Watershed, specifically within the discharge zone to the Chaco River adjacent to the Navajo Mine. However, the data available to the west of the Navajo Mine indicate that the dissolved-solids concentration ranges from about 1,000 to over 4,000 milligrams per liter (Robson and Banta 1995). However, despite these potential non-mining impacts, in light of the fact that no other downstream data exists on the Chaco River data from USGS 09367950 will be used for the assessment. Water quality data was collected by the USGS at 09367950 from October of 1969 to August of 1989.

While USGS 09367950 is downstream of the BNCC permit, it is also downstream of the APS operations and the Morgan Lake discharge; therefore it is impossible to differentiate BNCC impact from these other potential sources. Nevertheless, analysis will be done using data from this station as data collected upstream of the APS operation and Morgan Lake discharge is not available.

Downstream data was found to have relatively high variability relative to baseline data where the median percent relative standard deviation for all constituents was 96 percent as compared to 44 percent. The NNEPA criterion for pH was exceeded for 1 sample where the pH was 11.3. Mercury exceeded the NNEPA fish consumption criteria for 85 percent of all samples. Cadmium exceeded NNEPA secondary human contact, fish consumption, and livestock criteria for 8 percent of all samples. NNEPA acute aquatic and wildlife habitat criteria were exceeded for cadmium, chromium, copper, mercury, selenium, and zinc for 8, 100, 25, 17, 8, and 8 percent of all samples respectively. NNEPA chronic aquatic and wildlife habitat criteria were exceeded for cadmium, copper, mercury, selenium, and zinc for 100, 25, 100, 85, and 8 percent of all samples respectively. Livestock criteria for boron, chloride, fluoride, sulfate and TDS were exceeded for 23, 1, 46, 24, and 5 percent of all samples. The median cadmium, mercury and selenium concentrations were 1.2, 300, and 3 times greater than NNEPA chronic aquatic and wildlife habitat standards. The median chromium concentration was 1.6 times greater than NNEPA acute aquatic and wildlife habitat standards. The median mercury value also exceeds the NNEPA fish consumption criteria. All other median values are below all criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Therefore surface water quality within the Chaco River as compared to NNEPA and other relevant criteria is appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of cadmium, chromium, mercury, and selenium were found relative to aquatic and wildlife habitat and fish consumption NNEPA criteria. There were no exceedances of the SMCRA dissolved iron standard.

The comparison to baseline median plus 2 MAD from the upstream station USGS 09367938 showed the following; minor impacts for manganese where 15% of all samples exceeded baseline; moderate impacts for barium, cadmium, fluoride, radium, and selenium where 35, 31, 54, 1, 38, and 58 percent of all samples exceeded baseline; major impacts for boron, sulfate, TDS and conductivity where 96, 94, 100, and 96 percent of all samples exceeded baseline. Of these the median concentrations of boron, chloride, fluoride, nitrate, selenium, sulfate, TDS, and conductivity all exceeded the baseline median plus 2 MAD. The median concentrations for all of these criteria except selenium and nitrate, however, were below the relevant use criteria. Impacts for all other constituents were determined to be negligible. Therefore while the impact designation can be considerable for certain constituents it does not appear to transfer to a significant impairment of use. Surface water quality within the Chaco River is generally appropriate for the designated post-mining land use of livestock grazing, except for possible concerns over nitrate concentrations. Additional potential concerns exist regarding selenium concentrations relative to aquatic and wildlife habitat use.

5.3.4.3 Chaco River Alluvium

Groundwater use in the groundwater CIA is limited in extent and is mostly derived from wells completed within surficial valley-fill deposits of Quaternary age, or alluvium. Water derived from alluvial wells is predominantly used for livestock watering. Baseline alluvial water quality was found to be a poor source for livestock watering use. This is especially apparent when considering sulfate and TDS concentrations. No downstream alluvial data is available for comparison.

5.3.5 Historic Mining Area North of the BNCC permit

5.3.5.1 Surface Water

The increased application of surface water from NAPI has impacted the area hydrology and water quality. NAPI impacts in this area consist of indirect discharges from irrigation return flows. The indirect NAPI related discharges are a result of return flows caused by infiltrating irrigation water. The impacts of the NAPI activities on the baseline channel hydrologic balance are expressed as highly variable increases in flow and discharge. The indirect NAPI related discharges result in leaching of the unconfined geologic surface formations and soils. NAPI impacts increase the already highly variable hydrologic balance and further decrease the potential for changes to the hydrologic balance as a result of mining (BNCC 2011, Section 11.6).

The historic mining area north of the BNCC permit area includes the Watson, Bitsui, Dodge, and Custer pits, of these only the Custer pit area is within the surface water CIA. The Custer Pit area is within the Morgan Lake-Chaco River HUC12 watershed along with the Bighan Pit area. The Bighan Pit area is within the BNCC permit area therefore the characterization of impact to water quantity for the Morgan Lake-Chaco River HUC12 watershed is included below in Section 5.3.7.1.1. There are no major tributaries to the Chaco River which traverse this area, and no surface water data is available for this area within the surface water CIA.

5.3.5.2 **Alluvium**

There are not any current uses of the alluvium in this area; however, there have been historic uses of alluvium in the area for livestock watering (BNCC 2011, Section 11.6). Within this area two alluvial wells exist along drainages that are tributary to Morgan Lake; water quantity data was collected from 1996 to 2000 at Custer-1 located along the western lease boundary, and Custer-4 located within the BNCC lease area close to the eastern lease boundary. Two additional alluvial wells exist along Bitsui Wash; data was collected from GM-7 from 1975 to 1976 and no data is available at GM-37. Data collected at GM-7 represents the only alluvial quality data available for this area, however, it is located upstream of mining and was used for baseline characterization. Therefore no assessment of alluvial quality is presented in this discussion.

The Custer wells were not monitored prior to mining impacts in the area, and can therefore not be used for baseline characterization. Therefore, alluvial quantity assessment at these locations cannot rely upon comparison of pre to post mining conditions. Alluvial quantity was assessed using two metrics: the percent of all sampling events which were dry and the water elevation in feet above Mean Sea Level (MSL). Water elevation was not collected for all samples; however, inference of water presence was based on the presence of water quality data. Therefore the total number of samples used to calculate the percent of dry sampling events is often higher than the number of samples used for the water elevation comparisons. Alluvium at Custer-1 and 4 was found to be dry for 75% of all sampling events, and only two water elevation data points are available for each well as shown in Figure 24. While data in the area is limited it is reasonable to assume that changes in groundwater levels will not preclude use as they are steadily increasing over time, therefore the impact is designated to be negligible.

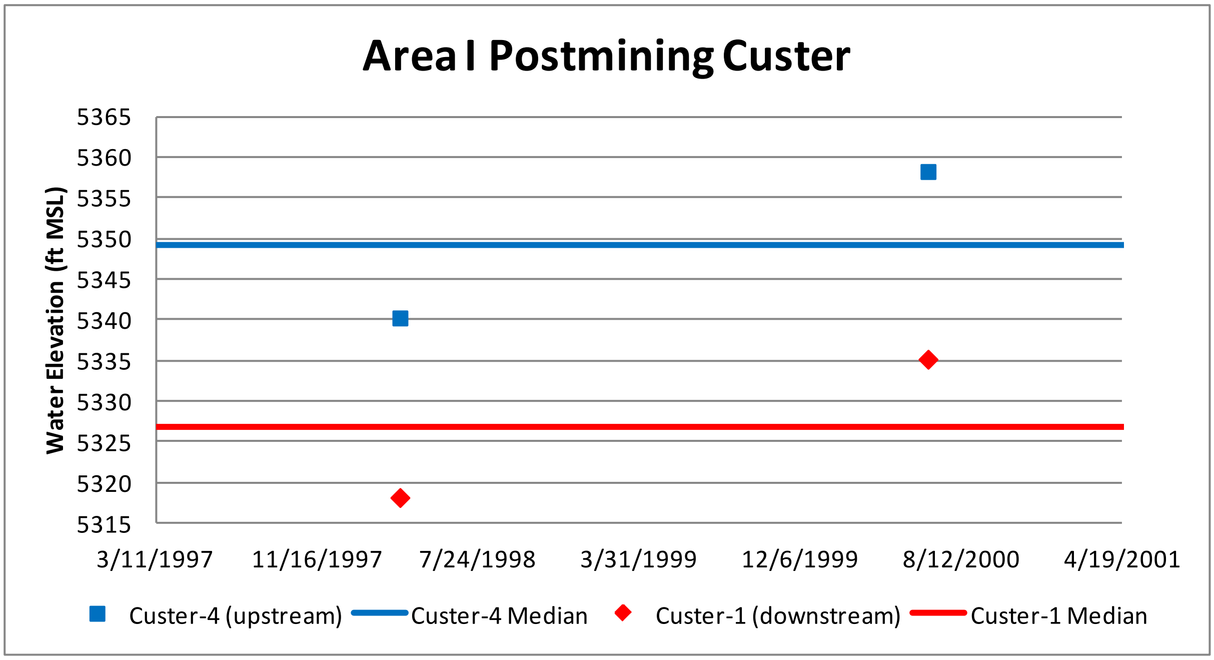


Figure 24: Custer Water Elevations

5.3.5.3 Fruitland Formation and PCS

The mine pits remained dry throughout this area except on rare occasions when surface flows were captured. Groundwater seeps were rarely observed along highwalls as any groundwater in the Fruitland overburden and coals was most likely consumed by evaporation (BNCC 2011). The few seeps that were observed during mining were at locations where the highwall was near NAPI irrigation plots. The projected and observed impacts to the water quantity within the Fruitland Formation and the coal seam aquifers resulting from coal mining have been minimal to date. There are no current uses for the Fruitland formation in or adjacent to this area and no foreseeable uses other than oil and gas extraction, therefore impacts to the Fruitland formation resulting from the historic mining activity are not expected to disturb water users. Additionally, the observed impacts to the Fruitland do not extend outside of the immediate areas surrounding the mine pits and subsequent reclaimed areas and the unit is generally not capable of providing a sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the Fruitland groundwater quantity are considered to be negligible.

Spoil leaching tests were performed in support of the PHC assessment for the Navajo Mine SMCRA permit revision. The spoil leaching test results show a considerable range in the concentrations of TDS and sulfate, which are the primary constituents of concern with respect to spoil leachate. The leaching test results are fairly consistent with the results for the Bitsui #5 spoil well completed in the mine spoils in the Bitsui Pit, located in this historic mining area. The Bitsui Pit was backfilled in the 1980s and is the only pit where saturation of mine spoils has been observed. Arsenic and selenium were below detection in most of the leaching test results and in the Bitsui 5 spoil well. Fluoride is also lower in the spoil water leachate than in the coal water and is attenuated in flow through mine spoil. Boron and manganese concentrations are also elevated in mine spoil water (BNCC 2011, Section 11.6). A post-reclamation increase in TDS and sulfate concentrations in mine spoil backfill may result in increased TDS and sulfate concentrations in the coal seams adjacent to the historic mining areas. Spoil leaching test results found an increase in TDS concentrations in spoil water leachate ranging from 400 to 2,700 mg/l and an increase in sulfate concentrations in spoil water leachate ranging from 630 to 2,580 mg/l (BNCC 2011, Appendix 11-

VV). Spoil data within this area is generally consistent with spoil data within the BNCC permit area, for a detailed assessment of spoil data relative to baseline within the permit area see Section 5.3.7.2.2.

The PCS is a well-cemented, low-permeability, marine sand and is the first water-bearing unit below the Fruitland Formation. The PCS is approximately 110 to 120 ft thick and follows the structure of the Fruitland Formation, dipping to the east at approximately 2 degrees, although the structure varies locally. The PCS conformably overlies the Lewis Shale, with the contact marked by a zone of interbedded sandstones and mudstones in the lower part of the PCS (Stone, Hydrogeology and Water Resources of San Juan Basin, New Mexico 1983). It outcrops just west of the mine lease and east of the Chaco River. The PCS is a marginal water resource due to low permeability, poor water quality, gas production, and low yields. The PCS is also a natural gas reservoir in the San Juan Watershed. Stone et al. (1983) state that the PCS cannot be considered a major aquifer and it is important only because it is the water-bearing horizon immediately underlying the coals in the Fruitland Formation. There is no non-baseline PCS data available in the area; therefore there will be no comparison of non-baseline PCS quality to baseline conditions.

Since there are no current uses for the Fruitland or PCS formations in or adjacent to this historic mining area and no foreseeable uses other than oil and gas extraction, impacts are not expected to disturb water users. Additionally, the observed impacts do not extend outside of the immediate areas surrounding the reclaimed areas and the units are generally not capable of providing sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the Fruitland groundwater quantity are considered to be negligible.

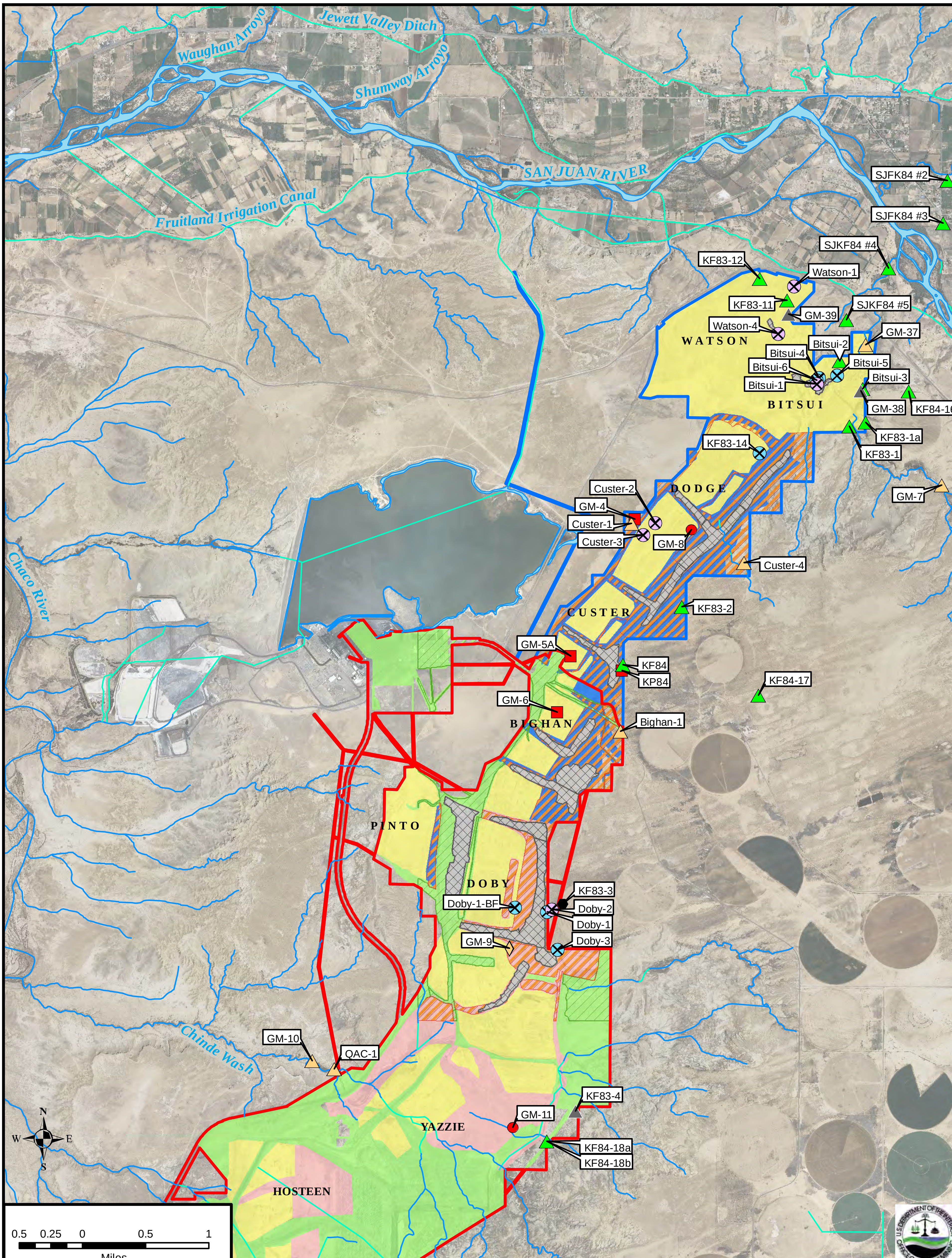
5.3.5.3.1 CCB Disposal

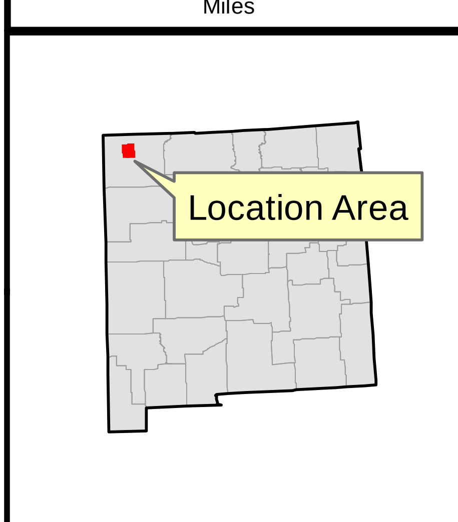
Under the Navajo Mine's fuel supply contract with Arizona Public Service, the Navajo Mine accepted CCBs from the Four Corners Power Plant units 4 and 5 for disposal in final pits and ramps from 1971 to 2008. CCBs disposed of at Navajo Mine included: fly ash, scrubber sludge, and bottom ash. CCBs from the Four Corners Power Plant were placed in mined-out pits and ramps of the Navajo Mine to help achieve approximate original contours (AOC) (BHP Billiton 2010, Ch. 11). The CCB disposal designs considered the natural conditions prevalent in the area and precautions were taken when engineering the disposal and reclamation.

CCB disposal predominantly occurred within this historic mining area north of the BNCC permit, and can be seen on Figure 25. Additionally, the only saturated CCB pit, Bitsui, is located within this historic area, therefore CCB analysis is discussed under this section. No baseline Fruitland coal data is available for this area, however, baseline Fruitland data from upgradient wells located within the BNCC lease area is used for comparison.

The variability of CCB data is relatively similar to that of the baseline Fruitland coal within the permit where the median %RSDs was 46. A comparison of CCB wells to the Median + 2MAD for baseline Fruitland coals within the BNCC lease showed the following; negligible impact for chloride; minor impacts for conductivity and manganese where 20 and 26 percent of all samples exceeded baseline respectively; moderate impacts for total iron and TDS where 40 and 59 percent of all samples exceeded baseline respectively; major impacts for pH, boron, selenium, fluoride and sulfate were 70, 100, 82, 63 and 100 percent of all samples exceeded baseline respectively. Of these the median concentrations for boron, selenium, fluoride, sulfate, and TDS exceeded the baseline Median + 2MAD where they were 13, 4, 1.1, 150 and 1.25 times larger respectively. Median pH was within the livestock criteria range, and no individual sample was below 6.5. However, 16 percent of pH samples were above 9. The median concentrations for selenium were below the livestock criteria; however, median concentrations for boron, fluoride, sulfate, and TDS exceeded livestock criteria where they were 2, 1.3, 6 and 5 times larger respectively. Therefore, within CCB disposal areas boron, fluoride, sulfate and TDS are all considered to be of concern relative to baseline and livestock criteria.

While high levels of constituents of concern exist within the CCB wells in the historic mining area, there are no current uses for the Fruitland formation in or adjacent to this area and no foreseeable uses other than oil and gas extraction. Therefore in order for the historic CCB disposal to have significant impact to use, CCB leachate would need to have sufficient mobility to reach alluvial users within the vicinity of the historic disposal sites at significant concentrations. Modeling was conducted by OSMRE and BNCC to assess the impact of historic CCB placement relative to nearby alluvial systems, which could have impact to current and reasonably foreseeable uses. Modeling showed that it is unlikely that any significant future effects will ensue from the CCB disposal at the Navajo Mine because of the very slow groundwater movement and the attenuation of contaminants of concern as they migrate through the subsurface. Detailed CCB analysis can be found in Appendix G, including CCB placement locations, CCB leachate studies and groundwater modeling. Based on analysis found in Appendix G, OSMRE concludes that potential impacts to water users from CCB disposal at the Navajo Mine are negligible.





Mine Areas

- CCB Placement [1][2]
- Interim [2]
- Permanent Program [2]
- Interim [3]
- Permanent Program [3]
- Pre-Law [3]
- TOJ [3]
- Permit Area
- Coal Lease Area
- Natural Stream[1]
- Artificial Canal/Ditch[1]

- Abandoned Alluvial Monitoring Well
- Existing Alluvial Monitoring Well
- No 3. Coal Monitoring Well
- No. 8 Coal Monitoring Well
- Fruitland Well or Nested Wells
- Abandoned PCS Monitoring Well
- Existing PCS Monitoring Well
- Backfill Monitoring Well
- CCB Monitoring Well

PIT NAMES

Mine Area:
[1] Bitsui and Watson CCB disposal.docx
[2] EXH 11-149 CCB Placement_032008.pdf
[3] Fig2_BNCC Navajo Mine Areas.pdf

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA Approximate Historic Coal Combustion Byproduct (CCB) Placement

Figure 25

5.3.6 Navajo Mine

5.3.6.1 Surface Water Quantity

Changes in peak flows due to the presence of upstream containment berms, diversions and highwall impoundments, coupled with retention of water within pits and down gradient sediment ponds will reduce peak flows downgradient of the mine during operations. As areas are reclaimed, it is predicted that there will be better retention of surface water runoff within the lease area compared with pre-mining conditions, due to lower slopes and the placement of topsoil materials with more permeable textures than occurred naturally in pre-mine conditions.

It is anticipated that post-mining flows will be ephemeral in all of the streams within the lease area due to the limited precipitation regime and the marginal development of alluvium as a water supply, unless activity from the upgradient NAPI continues to generate intermittent or perennial flows. NAPI impacts have resulted in the perennial and intermittent flows in Chinde and Cottonwood respectively. Future development of NAPI may continue further east and south of existing development into the headwaters of Cottonwood (BNCC 2011). The expanded NAPI irrigation plots would be far removed from mining within Area III or Area IV North.

There are periods when precipitation runoff from the drainages that normally flow across the areas intersected by mining will not make it to the Chaco River during operations, but will either be intercepted by the mine pits or captured in temporary pit protection ponds (highwall impoundments) located up gradient of mining. Precipitation runoff collected in the pits or in the pit protection ponds may be utilized for dust suppression and other mine needs, or will naturally diminish from evaporation and seepage. Once reclamation is completed within the mining area, precipitation runoff from these reclaimed areas will flow through channels in the reconstructed topography and then to the Chaco River. Precipitation runoff from reclaimed areas may be reduced somewhat from pre-mine levels due to any of the following factors: lower slopes, enhanced vegetative growth, engineered traditional or geomorphic drainage designs, and the use of sediment-control BMPs that operate to retain water in the reclaimed areas reducing storm-water runoff to the channels.

The PHC and CHIA analyses were developed with the support of site-specific data and modeling. Surface water and sediment modeling was performed using SEDCAD to model peak flows. The Navajo Mine lies primarily within four HUC12 watersheds that either intersect or contain portions of the lease area (Figure 6). The watersheds include the Morgan Lake-Chaco River, Chinde Wash-Chaco River, Coal Creek-Chaco River, and Cottonwood Arroyo watersheds. Each major tributary to the Chaco River are described by watershed in the following sections.

Surface water quantity impacts from the mine are measured according to percentages in which each watershed is affected according to two criteria:

1. Percentage of each watershed managed by surface water impoundments, diversions, and other mining related surface water management structures, and
2. The percentage that water management within the lease area affects the peak flows within each watershed (i.e. the difference between pre-mining and post-mining peak flow).

The PAP presents detailed information on BNCC water management structures, and removal of temporary structures. A summary of these structures and general hydrologic information is provided in Appendix C.

Modeling using SEDCAD 4 was implemented to assess peak flows in response to the 10-year, 6-hour storm events within each HUC 12 watershed. BNCC built SEDCAD models for all major drainages which traverse the lease area. The Chinde Wash and Cottonwood Arroyo Watersheds are both representative of HUC 12 range, as they were modeled directly in the PHC, and models have been reviewed by OSMRE; this modeling was not duplicated for purposes of this CHIA, but rather results of BNCC models presented in the PHC are used. The PHC SEDCAD modeling only evaluated specific parts of the Coal Creek and Chinde-Chaco River HUC12 watersheds within the lease area where mining has occurred. Therefore for these HUC 12 watersheds information from the PHC on the pre-mining and post-mining SEDCAD inputs (curve numbers, runoff volumes, etc.) were integrated into simplified larger watershed scale models for the purpose of this evaluation. Excerpts from the OSMRE-generated SEDCAD models showing specific routing details, curve numbers, and other pertinent information are located in Appendix E. Figure 18 shows SEDCAD subwatersheds used in OSMRE modeled HUC 12 watersheds.

5.3.6.1.1 Morgan Lake-Chaco River Watershed

As discussed previously in section 4.1.5.2.1, the impact assessment of the Morgan Lake-Chaco River watershed does not include modeling of peak flow changes due to the small contribution that activities within the permit area would have on the total watershed, because of the effect that contributing perennial flow to the watershed outfall (Chaco River) from Morgan Lake would have on the model, and because most of the permit area present in this watershed is either pre-law or termination of jurisdiction land. However, there are still a number of mine-related impoundments in this watershed that could potentially affect the hydrologic conditions.

The maximum percentage of the Morgan Lake-Chaco River watershed managed by surface impoundments at any given time is about 2.1%. As seen in Figure 26, no permanent post-mine impoundments will affect this particular watershed. All impoundments are projected to be removed by 2025. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Morgan Lake-Chaco River watershed are negligible.

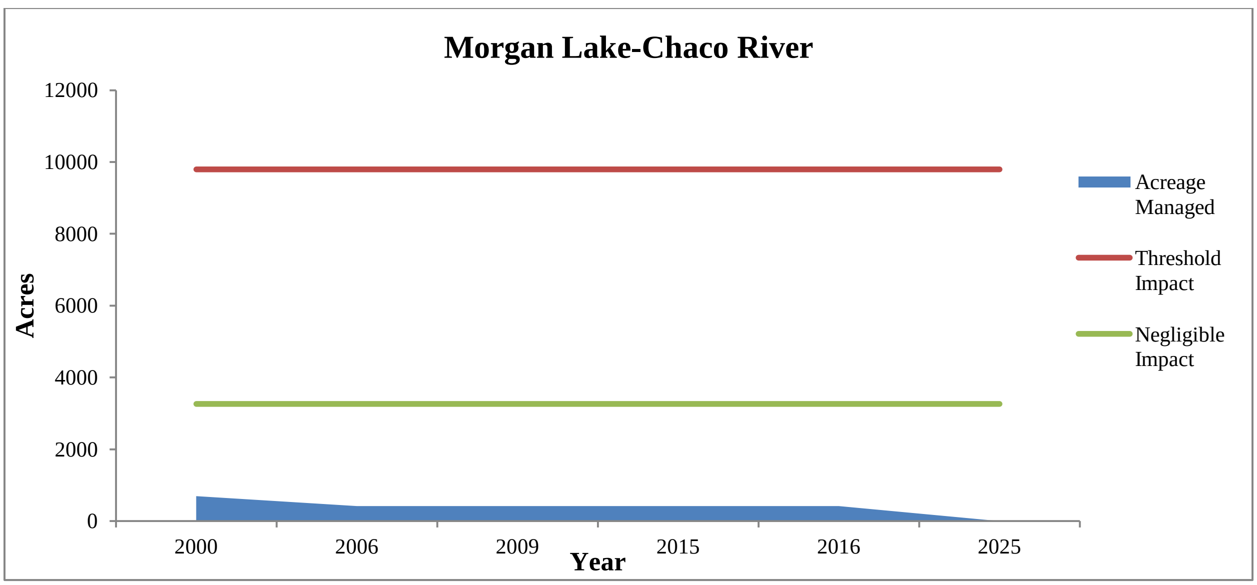


Figure 26: Percentage of the Morgan Lake-Chaco River Watershed Managed by Impoundments

5.3.6.1.2 Chinde Wash Watershed

About 3,100 acres of the Chinde Wash drainage basin is disturbed by mining activities. The post-mining Chinde Wash watershed increases in size by 1,124 acres within the lease area primarily because of changes in the drainage divide between Hosteen Wash and Chinde Wash, and the drainage divide between Dodge Diversion and Chinde Wash.

The largest hydrologic change to Chinde Wash is in the Doby reclamation area to the north, 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.

The peak flow resulting from a 10-yr 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 715 cubic feet per second (cfs) to a post-mining estimate of 705 cfs for Chinde Wash at the exit point of the watershed. Table 8 summarizes these findings. For the purpose of this assessment, this decrease in peak flow constitutes a negligible impact.

There are no impoundments within the Chinde Wash watershed, so the impacts to the hydrologic balance concerning the percentage of the watershed managed by impoundments, are negligible. Although significant activity occurred on the Chinde Wash before SMCRA was instituted in 1977, which probably impacted the stream significantly. The Chinde Diversion Channel was constructed in 1971 to divert surface water from the Chinde Wash around mining activities in Yazzie Pit. Additionally in 1973 the "Big Fill" was built for the rail crossing of the Chinde Wash. As this activity occurred prior to the issuance of a SMCRA permit, it was not subject to SMCRA regulations. The original Chinde diversion was constructed with a 1.5:1 slope or roughly twice as steep as current regulations dictate, in the 1990s the diversion channel was regraded to a 2:1 slope, still outside of current regulation standards but a significant improvement. Finally on 2009 a significant section of the Chinde diversion was replaced with a natural stream channel design which traverses the lease area to the south of the original diversion connecting the upstream and downstream wetlands. The Chinde Area has also experienced impacts from sources other than mining. Most notably in 1976 NAPI initiated commercial scale irrigation on lands adjacent to the BNCC mining lease (Moore 2006), and this has resulted in a significant change in the hydrology of the Chinde Wash. What was once an ephemeral dry arroyo is now a perennial stream due to NAPI irrigation return flows and releases of excess irrigation water. This combination of events in the Chinde Area has resulted in the development of two wetlands along the Chinde Wash. One of the wetlands is located up-gradient of the mine lease and the second is located on the mine lease, up-gradient of the Big Fill. The historic Chinde diversion and the new natural channel regrade can be seen in Figure 22.

Table 8: Comparison of Pre-Mine and Post-Mine Peak Flows in the Chinde Wash Watershed (BNCC 2011)

Sedcad 4.0 Watershed Designation		**Pre-Mine**		**Post Mine**		**Difference From Pre-Mine**	
Pre	Post	Area	Peak Flow (cfs)	Area	Peak Flow (cfs)	Area	Peak Flow (cfs)
S24	S24	27,130	715	28,254	705	1,124	-10
S17 SW1	S17 SW1	1,100	34	824	40	-276	6
S15 SW1	S15 SW1	595	43	600	26	5	-17
S11	S27	446	172	1,726	332	1,280	160
S18 SW1	S18 SW1	146	10	120	10	-26	0

5.3.6.1.3 Chinde-Chaco River Watershed

Notable changes to the watershed from the pre-mining model to the post-mining model occurred along Hosteen Wash, Barber Wash, and South Barber Wash. The surface area within Hosteen Wash decreased by approximately 1300 acres from the pre-mining to the post-mining scenario due to diversion of surface water into the adjacent Chinde Watershed. Curve numbers for certain areas within Hosteen wash were significantly reduced to reflect the impact of mining impoundments and higher infiltration rates on the area. The total peak flow reduction from a pre-mining to a post-mining scenario along Hosteen Wash is about 850 cfs. Impacts along North and South Barber wash were also integrated into the assessment. South Barber Wash lost approximately 850 acres in its sub watershed. The area lost from South Barber was subsequently added to the North Barber sub watershed through a diversion. Detailed assessment and modeling of the individual drainages can be found in the PHC (BNCC 2011, Section 11.6). For purposes of this CHIA analysis and modeling was conducted on HUC 12 watersheds. Although peak flow to South Barber Wash is thought to be reduced by about 120 cfs after mining is completed, minimal effects to the entire HUC12 watershed occurred through the changes in the Barber and South Barber Washes. A summary of this information is presented in Table 9.

The peak flow resulting from a 10-yr 6-hr precipitation event at the watershed outlet is predicted to decrease from a pre-mining estimate of 2,096 cfs to a post-mining estimate 1,331 cfs. The total peak flow reduction for the entire HUC12 watershed, pre-mining to post-mining, is about 36.5%. For the purpose of this assessment, this decrease in flow represents a moderate impact.

Table 9: Comparison of Pre-Mine and Post-Mine Peak Flows in Chinde-Chaco River Watershed

Sedcad Watershed Designation	Pre-Mine		Post-Mine		Decrease in Peak Flow
	Total Contributing Area	Peak Discharge	Total Contributing Area	Peak Discharge	
	(ae)	(cfs)	(ac)	(cfs)	Percent
#2	2,010.00	680.13	1,650,000	81.38	88
#5	3,110.00	929.94	2,400,000	262.42	72
#1	1,210.00	298.3	850,000	32.21	89
#4	2,750.00	609.87	2,100.00	307.04	50
#8	6,840.00	1,408.08	5,480,000	575.42	59
#3	1,565.00	221.37	1,140,000	161.25	27
#7	3,215.00	444.33	2,365,000	326.8	26
#6	1,235.00	253.21	1,985,000	406.98	-61
#9 (Outlet)	14,220.00	2,096.39	12,760.00	1,331.61	36

The maximum percentage of the Chinde-Chaco River watershed managed by surface impoundments at any given time is about 8.2%. As seen in Figure 27, no permanent post-mine impoundments will affect this particular watershed. All impoundments are projected to be removed by 2025. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Chinde-Chaco River watershed are negligible.

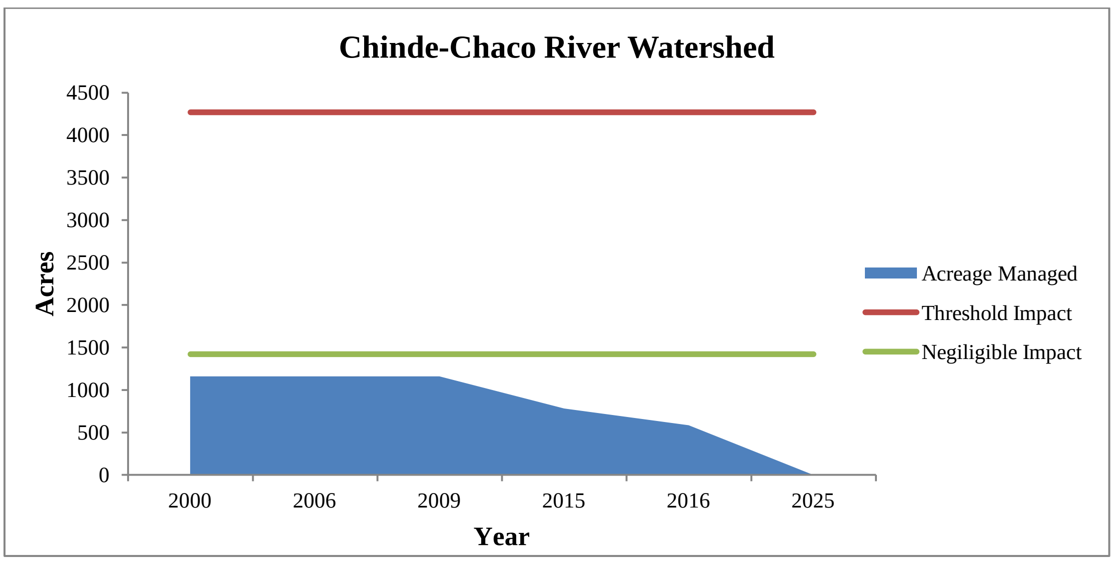


Figure 27: Percentage of the Chinde-Chaco River Watershed Managed by Impoundments

5.3.6.1.4 Coal Creek-Chaco River Watershed

The total peak flow reduction to the Coal Creek Watershed is much lower, as a percentage, than that of the Chinde-Chaco River Watershed. Although much of the runoff within the watershed area is generated in Lowe Arroyo due to the steeper slopes present in this area, the total impacts to the watershed are mitigated by the large geographical area of which it is comprised. Curve numbers were reduced significantly in order to model the post-mining changes along Lowe Arroyo. Detailed assessment and modeling of tindividual drainages can be found in the PHC (BNCC 2011, Section 11.6). For purposes of this CHIA analysis and modeling was conducted on HUC 12 watersheds.

The estimated pre-mining peak flow for the watershed, in response to the 10-year 6-hour rain event, is 1,719 cfs and the post-mining peak flow is 1335 cfs. The total peak flow reduction for the entire HUC12 watershed, pre-mining to post-mining, is about 22%. Results are presented in Table 10. For the purpose of this assessment, this decrease in flow represents a minor impact.

Table 10: Comparison of Pre-Mine and Post-Mine Peak Flows in Chinde-Chaco River Watershed

Sedcad Watershed Designation	**Pre-Mine**		**Post-Mine**		**Decrease in Peak Flow**
	Total Contributing Area	Peak Discharge	Total Contributing Area	Peak Discharge	
	(acres)	(cfs)	(acres)	(cfs)	Percent
#16	7300	467.26	7300	467.26	0
#15	3530	388.14	3530	388.14	0
#10	2860	370.9	2860	240.25	35
#11	6790	898.5	6790	500.47	44
#12	7730	933.82	7730	523.35	44
#17	23620	1827.86	23620	1471.57	19
#14	1280	261.33	1280	261.33	0
#13	1762	250.23	1762	250.23	0
#18	28252	1757.7	28252	1383.23	21
#19 (Outlet)	28252	1719.96	28252	1335.69	22

The maximum percentage of the Coal Creek-Chaco River watershed managed by surface impoundments at any given time is about 9.3%. As seen in Figure 28, permanent post-mine impoundments will affect 1,624 acres for this particular watershed under the current mine plan. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Chinde-Chaco River watershed are negligible.

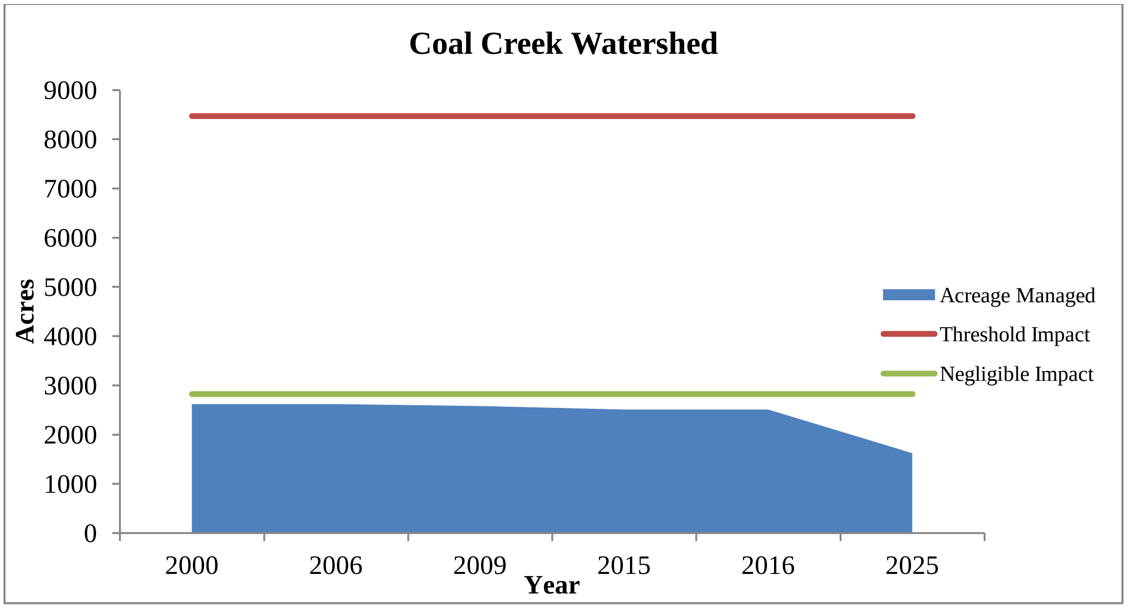


Figure 28: Percentage of the Coal Creek Watershed Managed by Impoundments

5.3.6.1.5 Cottonwood Arroyo Watershed

The primary hydrologic change to the Cottonwood Arroyo watershed is the disturbance of the North Fork of Cottonwood Arroyo. Approximately 10,662 feet of the North Fork will be permanently realigned from the pre-mine orientation due to reclamation (BNCC 2011). As noted in the discussion of Lowe Arroyo, the Cottonwood Arroyo watershed will slightly increase from the pre-mine scenario, but this increase will yield no appreciable hydrologic effects with respect to the evaluation method used in this CHIA.

Table 11 shows the comparison of peak flow for the 10-yr 6-hr precipitation event for the portions of Cottonwood tributaries that drain the proposed Area 4 North mine area. These results reflect disturbance conditions for the entire sub-watershed even though proposed mining affects only a portion of the sub-watershed. Yet the differences in peak flow are negligible between pre and post-mining at the lease line. The incrementally small change in peak flow reflects the small acreage 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 increase from a pre-mining estimate of 2,879 cfs to a post-mining estimate 2,903 cfs. For the purpose of this assessment, this is considered a negligible impact.

Table 11: Comparison of Pre-mine and Post-Mine Peak Flows in the Cottonwood Arroyo Watershed (BNCC 2011)

SEDCAD 4.0 WATERSHED DESIGNATION		Pre-Mine		Post-Mine		Difference From Pre-Mine	
Pre	Post	Area (acres)	Peak Flow (cfs)	Area (acres)	Peak Flow (cfs)	Area (acres)	Peak Flow (cfs)
S21	S21	13,492	1,551	13,532	1,546	40	-5
S34	S34	18,191	674	18,279	665	88	-9
S36 (lease line)	S36	49,060	2,879	49,184	2,903	124	24
S37(Outlet)	S37	51,269	2,842	51,477	2,855	208	13

The maximum percentage of the Cottonwood Arroyo watershed managed by surface impoundments at any given time is about 6.6%. As seen in Figure 29, permanent post-mine impoundments will affect 561 acres for this particular watershed under the current mine plan. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Cottonwood watershed are negligible.

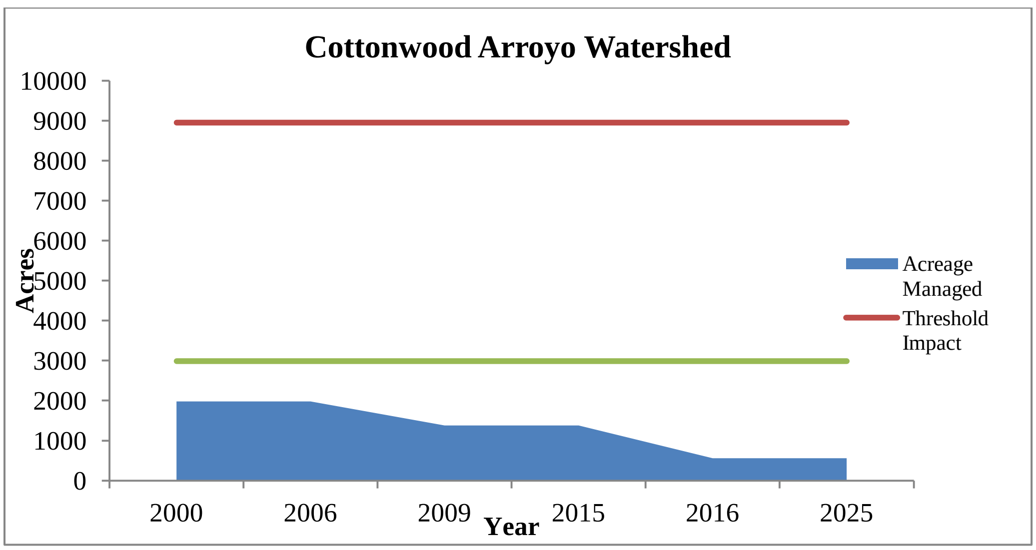


Figure 29: Percentage of the Cottonwood Arroyo Watershed Managed by Impoundments

5.3.6.2 Surface Water Quality

Several recharge mechanisms influence surface water quality within the permit and adjacent area. Precipitation and NAPI discharges generate runoff in the ephemeral washes, entraining sands, silts, and clays, inducing elevated concentrations of TSS. The elevated TSS concentrations influence the cation exchange capacity, and ultimately the chemical composition of the surface water. Recharge also occurs from baseflow in areas where NAPI has resulted in intermittent and perennial flows and rising of local groundwater tables increasing hydrologic communication between the Fruitland Formation and alluvial systems. The effect of runoff on spoil surface area influences the surface water quality. During mining and through bond release, surface water impoundments capture surface water runoff that was in contact with spoil material. The impounded surface water may discharge over the spillway during precipitation events exceeding the design capacity, or infiltrate through the bottom of the impoundments, entering the Fruitland Formation and alluvial and surface water systems.

Surface water quality impact assessment is conducted via comparison of upstream/pre-mining or baseline water quality to downstream or non-baseline water quality collected during and post-mining. This assessment is conducted on the primary drainages which traverse the BNCC permit area. As part of the ongoing BNCC surface water monitoring program, water quality has been assessed along the Chinde, Cottonwood, Pinabete, and No Name drainages at the location shown in Figure 17. The only drainage for which non-baseline surface water quality data exists is Chinde Wash.

Surface water quality impact assessment is also conducted via comparison to applicable water quality standards as outlined in Table 3, as well as the SMCRA dissolved iron standard of 10mg/L. The NNEPA water quality program is an integral component in the protection of the hydrologic balance and surface water quality. As such, OSMRE will work in partnership with the NNEPA if concentrations of chemical parameters have potential to change the present or potential use outside the lease area. The hydrologic balance is protected by the material damage definition, additionally; discharges to the surface water are reported to USEPA under point source permit No. NN0028193. If the appropriate CWA authority determines a water quality violation exists, OSMRE will evaluate the chemical parameter of concern to determine whether the mining operation caused the violation. If the mining operation is the cause of the violation, OSMRE will use the appropriate permitting and enforcement procedures to correct the water quality violation.

5.3.6.2.1 Chinde Wash

Surface water quality data is available on the Chinde Wash at four BNCC monitoring stations which bracket the lease area; CD-2 and CD-2A downstream of the mine and CD-1 and CD-1A upstream of the mine (Figure 17). Water quality data was collected at CD-1 and CD-2 from 1986 to 1997 and at CD-1A and CD-2A from 1996 to present. There is no pre-mining data on Chinde Wash, however, CD-1 and CD-1A were considered as baseline as they are upstream of the mine. It is important to note that while upstream of mining, CD-1 and CD-1A are both downstream of NAPI activities, and there is no pre-NAPI data on Chinde Wash, which is subject to both direct and indirect NAPI influences. Direct discharge events for the 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, and most likely result in the continuous baseflow within Chinde Wash (BNCC 2011, Section 11.6). Data from CD-2 and CS-2A will be used for the downstream analysis on Chinde Wash.

Downstream data was found to have slightly higher variability relative to baseline data where the median percent relative standard deviation for all constituents was 100 percent as compared to 85 percent. The NNEPA fish consumption criterion was not exceeded for any samples. NNEPA acute aquatic and wildlife habitat criteria were exceeded for cadmium, chromium, selenium, silver and zinc for 4, 100, 1, 2 and 60 percent of all samples respectively. NNEPA chronic aquatic and wildlife habitat criteria were exceeded for aluminum, cadmium, chromium, lead, selenium, and zinc for 46, 100, 3, 57, 70, and 60 percent of all samples respectively. Lead exceeded the NNEPA secondary human contact standard for 4 percent of all samples. Livestock criteria for boron, chloride, selenium, sulfate and TDS were exceeded for 0.5, 5, 23, 0.5 and 6 percent of all samples. The median cadmium, lead, selenium and zinc concentrations were 6, 2, 1.25 and 1.3 times greater than NNEPA chronic aquatic and wildlife habitat standards. The median chromium and zinc concentrations were 16 and 1.3 times greater than NNEPA acute aquatic and wildlife habitat standards. All other median values are below all criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Therefore surface water quality within the Chinde Wash as compared to NNEPA and other relevant criteria is appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of selenium were found relative to chronic aquatic and wildlife habitat NNEPA criteria. One sample or approximately 6 percent of all samples exceeded the SMCRA dissolved iron standard; however, the median dissolved iron concentration of 0.1 mg/L is 100 times smaller than the criterion.

The comparison to baseline median plus 2 MAD from the upstream stations CD-1 and CD-1A showed the following; minor impacts for boron, selenium, sulfate, TDS, conductivity, and manganese where 15, 24, 21, 22, 22, and 10 percent of all samples exceeded baseline respectively; moderate impacts for aluminum, arsenic, chloride, nitrate, TSS, and total iron where 50, 50, 39, 35, 32, and 32 percent of all samples exceeded baseline respectively. Of these the median concentrations of aluminum and arsenic exceeded the baseline median plus 2 MAD. The median concentrations for all of these criteria except selenium, however, were below the relevant use criteria. Impacts for all other constituents were determined to be negligible. No major impacts have occurred within Chinde Wash and water quality is generally appropriate for the designated post-mining land use of livestock grazing. Potential concerns do, however, exist regarding selenium concentrations relative to aquatic and wildlife habitat use.

5.3.7 Groundwater

OSMRE will evaluate groundwater quantity and quality related to the overall hydrologic balance and potential impact of BNCC on groundwater uses, specifically livestock watering as this is the primary use of groundwater within the CIA, and considering livestock water quality criteria. OSMRE must also evaluate that the operation has been appropriately designed to provide the groundwater quantity and quality information necessary to assess potential impacts per 30 CFR 780.21(g). Minimization of impacts to the hydrologic balance relative to groundwater is focused on reducing the disturbance footprint to the extent practical via contemporaneous reclamation. Additionally, local areas of acid forming material are managed through proper blending and mixing of overburden materials. BNCC also minimizes potential effects to the alluvial groundwater quantity by instituting stream buffer zones to limit disturbances in channel reaches unaffected by mining.

5.3.7.1 Alluvium

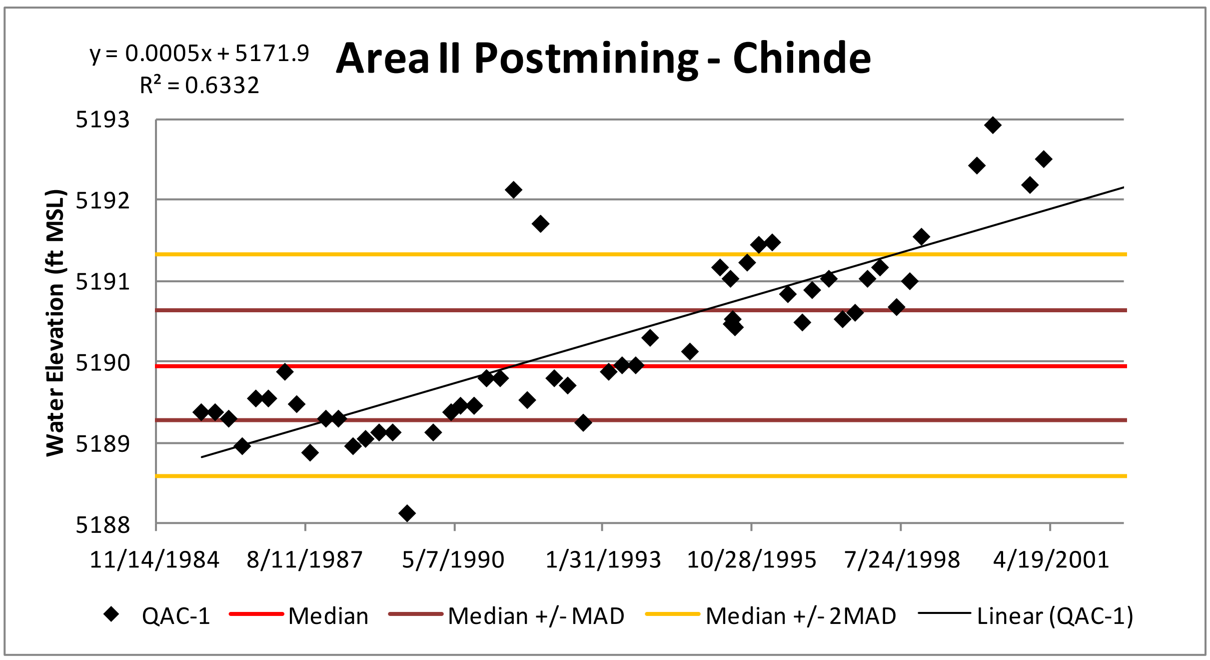
Alluvium is the most used groundwater resource within the CIA, and is primarily used for livestock watering. OSMRE will evaluate the potential impact of BNCC to the existing and foreseeable uses outside the permit area related to alluvial water quantity and quality. Non-baseline, i.e. downstream and/or postmining, alluvial wells exist within Areas I and II of the BNCC permit. Along Chinde Wash alluvial data was collected from 1979 to 1980 at GM-9 within the BNCC lease, from 1985 to present at QAC-1 at the western mine lease boundary, and from 1975 to 1982 at GM-10 just downstream of QAC-1. One alluvial well, Bighan-1, exists along drainages that are tributary to Morgan Lake within the permit area; data was collected from 1995 to 2001 at this location along the eastern lease boundary just south of the permit boundary. The location of Bighan-1 along the eastern mine permit boundary suggests that the well would be representative of baseline; however, it was installed after mining impact in the area and is therefore discussed below and not in baseline assessment. Monitoring well locations can be seen in Figure 19.

5.3.7.1.1 Alluvial Quantity

There are no current uses of the alluvium in Area I or II of the BNCC lease, however, there have been historic uses of the alluvium for livestock watering (BNCC 2011, Section 11.6). The wells along Chinde Wash and Morgan Lake tributaries were not monitored prior to mining impacts in the area, and can therefore not be used for baseline characterization. Therefore, the alluvial quantity assessment at these locations cannot rely upon a comparison of pre mining alluvial groundwater quantity to post mining conditions. The potential for impacts to alluvial groundwater quantity was assessed using two metrics: the percent of all sampling events which were dry and the water elevation in feet above Mean Sea Level

(MSL). Water elevation was not collected for all samples; however, inference of water presence was based on the presence of water quality data. Therefore the total number of samples used to calculate the percent of dry sampling events is often higher than the number of samples used for the water elevation comparisons.

Alluvial groundwater monitoring data suggests the Chinde Wash alluvium is mostly saturated across the length of the lease area, where water was found for all sampling events at GM-9, GM-10 and QAC-1. Alluvium at Custer-1 and Custer-4 was found to be dry for 75% of all sampling events, whereas Bighan-1 had water for all sampling events. Water elevation data was, available at QAC-1 along Chinde Wash, and at Custer-1, Custer-4 and Bighan-1. Variability as characterized by the percent relative standard deviation (%RSD) for water elevation data showed that the Custer wells had the highest variability, where the median %RSD was 14 times greater than that of Bighan-1; and 11 times greater than that QAC-1 on Chinde Wash. The lower variability of water elevation levels in Chinde Wash may in part be due to perennial nature of the drainage as a result of NAPI agricultural irrigation discharges. Water levels at all four wells have been increasing over time (Figure 30), most likely as a result of infiltration of NAPI runoff and agricultural irrigation discharges. As water levels are steadily increasing in the alluvium of Area I and II it is reasonable to assume that groundwater levels are not below baseline fluctuations, and therefore the impact is negligible. More detailed alluvial quantity data can be found in Appendix F.



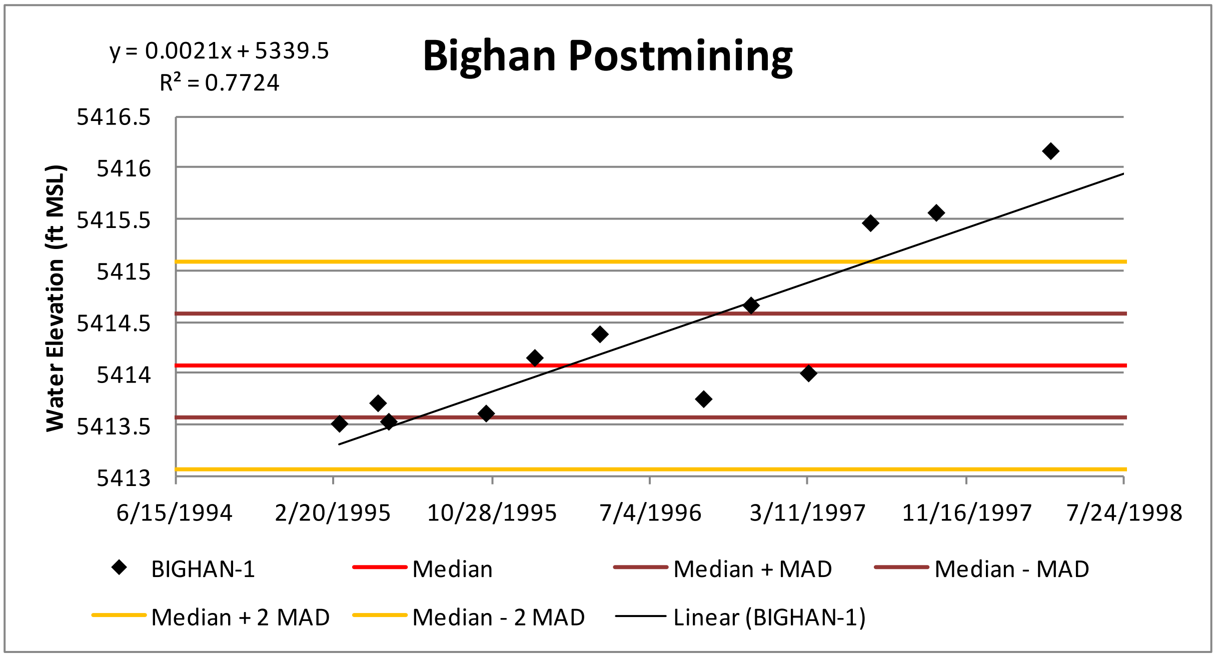


Figure 30: Chinde and Bighan Alluvial Water Elevations

While alluvial groundwater downstream of the Area IV North permit boundary has been monitored at QACW-2 since 2005 after mining began in the North Fork of the Cottonwood Arroyo, the well has been dry for all monitoring events. Dry periods of this length are not outside of the variability observed in the baseline quantity data at this well, therefore the dry period can be characterized as a negligible impact. Groundwater modeling of Area IV North conducted as part of the PHC assessment was used to help assess the approximate magnitude of changes in groundwater flow in the Cottonwood alluvium that might occur as a result of mining in Area IV North. The groundwater model predicted a steady-state post-reclamation alluvial groundwater flow at the mouth of Cottonwood Arroyo of about 4.6 gallons per minute (gpm) compared to the pre-mine alluvial groundwater flow estimate of 4.3 gpm (BNCC 2011, Section 11.6). However, baseline groundwater flows in the Cottonwood alluvium are never at steady state and vary considerably seasonally and from year to year and will continue to vary throughout mining and after reclamation. The model-predicted 0.3 gpm increase in groundwater flow in the Cottonwood alluvium. This prediction is quite low relative to the baseline variability in the Cottonwood alluvial groundwater. Thus, mining and reclamation within Area IV North is not expected to result in a long-term measurable change to the alluvial groundwater quantities or potential well yield from the alluvium. Groundwater quantities in the Cottonwood alluvium have historically been insufficient to sustain a reliable water supply at two of the three wells that were monitored for baseline conditions. This is not expected to change even with the modeled flow increase of 0.3 gpm. Impacts to the Cottonwood alluvial quantity are considered to be negligible because they are similar to fluctuations caused by natural processes (Ecosphere Associates Inc. 2011).

5.3.7.1.2 Alluvial Quality

Water quality data is available at all three wells (GM-9, GM-10 and QAC-1) along Chinde Wash, and at Bighan-1 along Morgan Lake tributaries. The wells along Chinde Wash and Morgan Lake tributaries were not monitored prior to mining impacts in the area and can therefore not be used for baseline characterization. Instead, baseline data collected along Cottonwood Arroyo was used as a surrogate for the area. Cottonwood Arroyo data was selected as representative of the alluvial systems in Areas I and II since it is also subject to NAPI influences. However, this is an imperfect representation as Cottonwood

Arroyo is only subject to NAPI direct discharges and not NAPI irrigation return flows, which leach water soluble constituents from the unconfined surface formations. This difference in source water type suggests that Cottonwood Arroyo baseline alluvial water quality dissolved concentrations would most likely be lower than the baseline concentrations along Chinde Wash and in Area I. Therefore impacts assessed by this method may be overestimated.

5.3.7.1.2.1 Bighan Alluvium

The location of Bighan-1 along the eastern mine permit boundary suggests that the well would be representative of baseline; however, it was installed after mining impact in the area and is therefore discussed below and not in baseline assessment. It is important to note that there is ambiguity surrounding this well specifically as to whether it is truly representative of potential mining impact or of baseline conditions.

The variability of Bighan-1 data is relatively low where the median %RSD is 31, significantly lower than that of the Cottonwood baseline which has a median %RSD of 121. At Bighan-1 arsenic, selenium, chloride, sulfate, TDS and fluoride exceeded livestock criteria for 4, 4, 4, 13, 6 and 100 percent of all samples. Of these Median fluoride concentrations exceed livestock criteria where the median fluoride concentration was 5 times larger than criteria.

A comparison to the Cottonwood baseline Median + 2MAD showed the following; moderate impacts for total iron where 50 percent of all samples exceeded baseline respectively; major impacts for arsenic, fluoride, selenium, and nitrate where 95, 100, 100, and 100 percent of all samples exceeded baseline respectively. Impacts for all other constituents were found to be negligible. Of these the median concentrations of arsenic, boron, selenium, fluoride, and nitrate exceeded the Cottonwood baseline Median + 2MAD where they were 5, 6, 3, 4, and 21 times larger respectively. The median concentrations for all of these criteria except fluoride, however, were below the relevant livestock use criteria. Therefore, while the impact designation can be considerable for certain constituents it does not appear to transfer to a significant impairment of use. Alluvial water quality at Bighan-1 is generally appropriate for the designated post-mining land use of livestock grazing, although there are possible concerns over fluoride concentrations. The fluoride exceedance may indicate impacts to the alluvial system or may also be indicative of general alluvial quality in the area, as Cottonwood is not a perfect surrogate baseline since it is only impacted by NAPI direct discharges. In contrast, the Bighan area is impacted by indirect NAPI irrigation return flows which leach the unconfined surface formations and may have significant quality impacts. Additionally, based on spoil leachate data and observations in spoil wells located in the historic mining area north of the BNCC permit, fluoride is lower in spoil water leachate than in the coal water and is attenuated in flow through mine spoil. There are no apparent trends over time in the Bighan-1 fluoride concentrations.

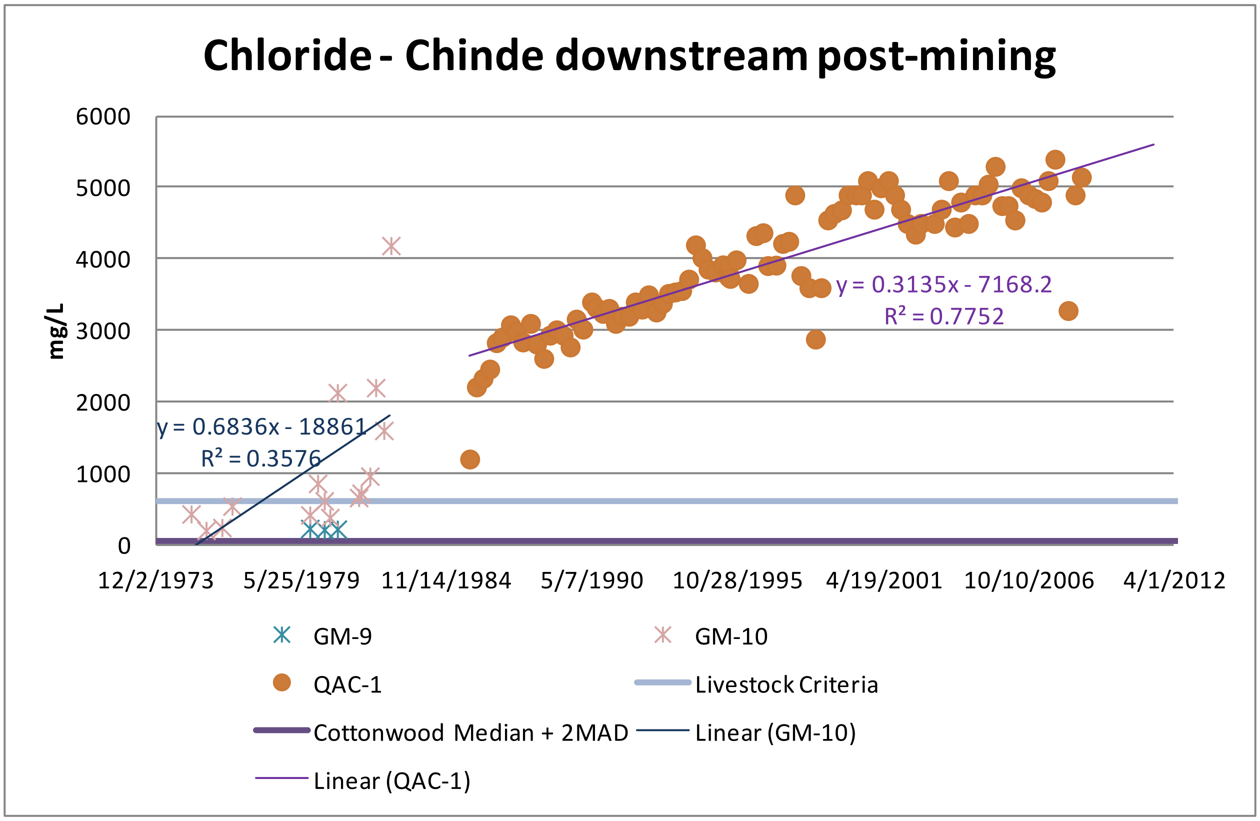
5.3.7.1.2.2 Chinde Wash Alluvium

The variability of Chinde Wash alluvium water quality is greater than that of the Bighan-1 where the median %RSDs were 114 and 31 respectively, and both show lower variability than Cottonwood Wash baseline alluvium water quality which had a median %RSD of 121. Additionally, Chinde Wash alluvium water quality is more variable than Chinde surface water quality which had a median %RSD of 100.

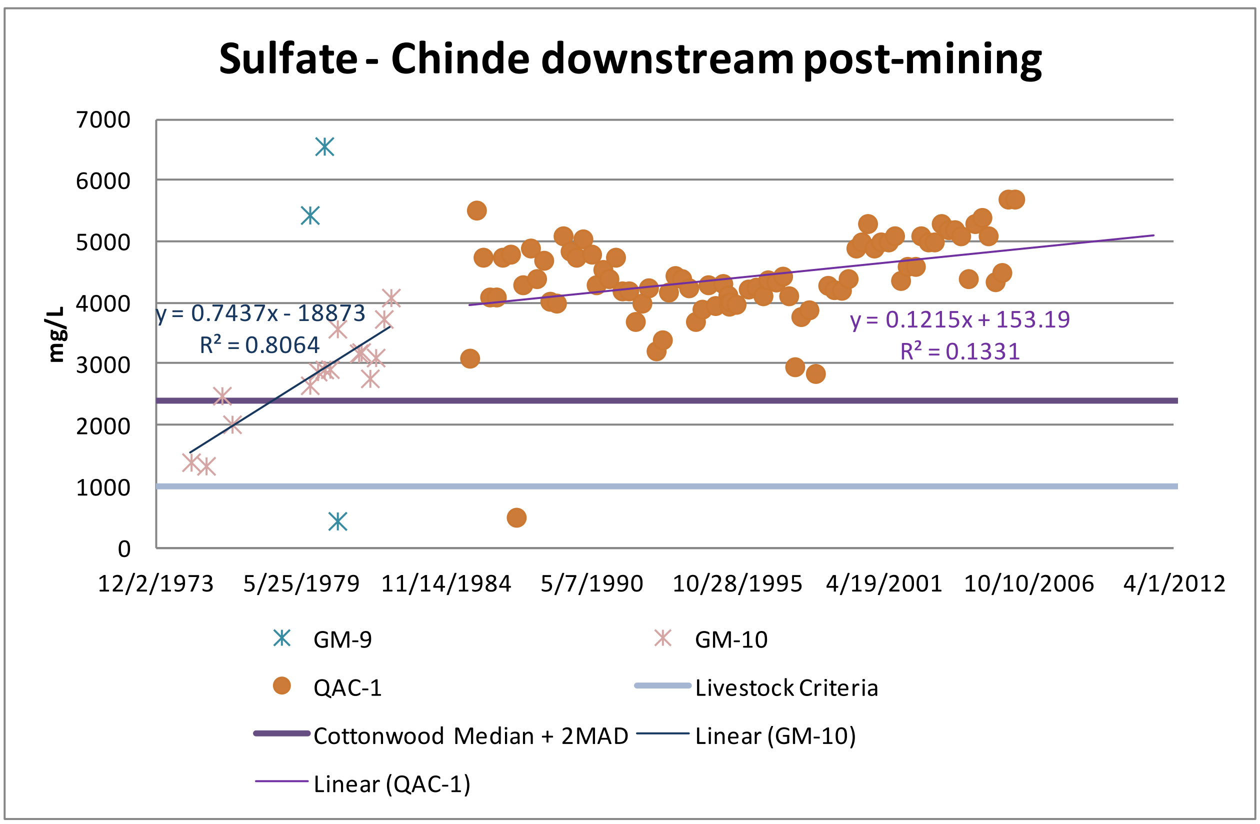
Along Chinde Wash the pH was below the NNEPA standard range for one sample where the pH was 6.45. Arsenic, cadmium, lead, selenium, chloride, fluoride, nitrate, sulfate and TDS exceeded livestock criteria for 1, 1, 8, 7, 92, 11, 3, 98 and 98 percent of all samples respectively. The median concentrations for chloride, sulfate, and TDS exceeded livestock criteria and concentrations were 6, 4, and 4 times larger than the applicable criteria respectively.

A comparison to the Cottonwood baseline Median + 2MAD showed the following; moderate impacts for total iron where 50 percent of all samples exceeded baseline respectively; minor impacts for pH, cadmium, copper, selenium, fluoride and nitrate where 24, 16, 19, 25, 11 and 18 percent of all samples exceeded baseline respectively; moderate impacts for arsenic, chromium, lead and radium where 43, 51, 52 and 47 percent of all samples exceeded baseline respectively; major impacts for conductivity, boron, total iron, manganese, chloride, sulfate and TDS where 94, 98, 74, 88, 100, 95 and 97 percent of all samples exceeded baseline respectively. Impacts for all other constituents were found to be negligible. Of these the median concentrations of conductivity, boron, chromium, total iron, lead, manganese, chloride, sulfate, and TDS exceeded the Cottonwood baseline Median + 2MAD where they were 4, 6, 2, 2, 2, 15, 22, 2 and 3 times larger respectively. The median concentrations for all of these criteria except chloride, sulfate, and TDS, however, were below the relevant livestock use criteria. Therefore, while the impact designation can be considerable for certain constituents it does not appear to transfer to a significant impairment of use. Alluvial water quality along Chinde is generally appropriate for the designated post-mining land use of livestock grazing, except for concerns over chloride, sulfate and TDS concentrations.

These exceedances relative to baseline may indicate mining related impacts to the alluvial system or may be indicative of general alluvial quality in the area, as Cottonwood is not a perfect surrogate baseline. Cottonwood is only impacted by NAPI direct discharges, whereas Chinde Wash is impacted by both NAPI direct discharges and indirect NAPI irrigation return flows which leach water soluble constituents from the unconfined surface formations and may have significant water quality impacts. However, elevated sulfate and TDS concentrations at BNCC are associated with water quality from backfilled spoil and CCB disposal areas as characterized in section 5.2.2.1 below. Additionally, the concentrations of chloride, sulfate, and TDS have been steadily increasing within the Chinde Wash alluvium over time, as illustrated in Figure 31. More detailed alluvial quality data can be found in Appendix F.



Chloride - Chinde downstream post-mining
mg/L
6000
5000
4000
3000
2000
1000
0
12/2/1973
5/25/1979
11/14/1984
5/7/1990
10/28/1995
4/19/2001
10/10/2006
4/1/2012
y = 0.6836x - 18861
R² = 0.3576
y = 0.3135x - 7168.2
R² = 0.7752
GM-9
GM-10
QAC-1
Livestock Criteria
Cottonwood Median + 2MAD
Linear (GM-10)
Linear (QAC-1)



Sulfate - Chinde downstream post-mining
mg/L
7000
6000
5000
4000
3000
2000
1000
0
12/2/1973
5/25/1979
11/14/1984
5/7/1990
10/28/1995
4/19/2001
10/10/2006
4/1/2012
y = 0.7437x - 18873
R² = 0.8064
y = 0.1215x + 153.19
R² = 0.1331
GM-9
GM-10
QAC-1
Livestock Criteria
Cottonwood Median + 2MAD
Linear (GM-10)
Linear (QAC-1)

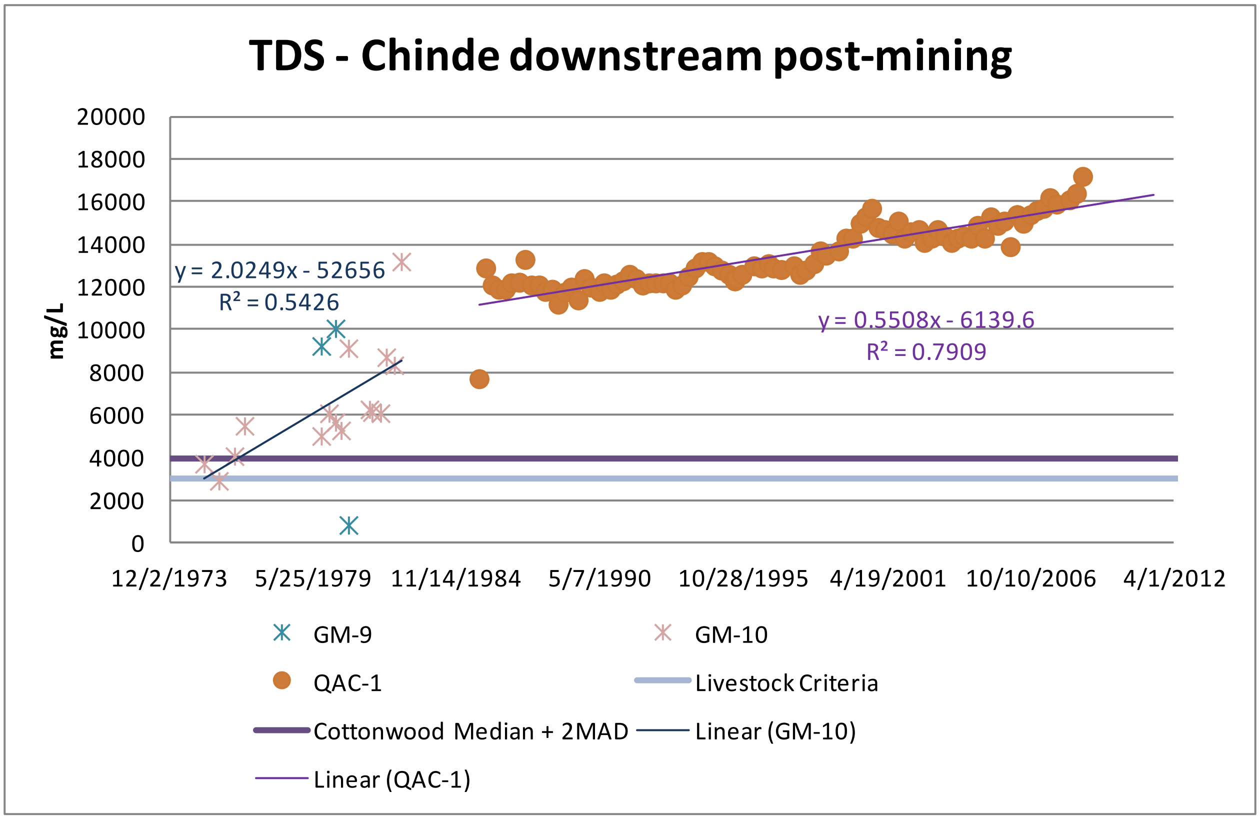


Figure 31: Chinde Alluvium Concentrations over Time

5.3.7.1.2.3 Cottonwood Arroyo Alluvium

While QACW-2 has been monitored since 2005 after mining began in the North Fork of the Cottonwood Arroyo, it has been dry for all monitoring events; therefore no water quality data has been collected for comparison to baseline. Impacts to alluvium in Area IV North are not expected to be significant as there is a stream buffer zone around the main stem of the Cottonwood Arroyo including the alluvial deposit.

Long-term (500 years) TDS transport modeling simulations within Area IV North were performed using a lower bound source TDS concentration of 3,550 mg/l and an upper bound TDS concentration of 11,850 mg/l (BNCC 2011, Section 11.6). Based on these results, the long-term post-reclamation TDS concentrations in the groundwater in the Cottonwood alluvium may be expected to increase down gradient of the Area IV North mine area. The results indicate a delayed long-term increase in the TDS concentrations in the Cottonwood alluvium that may be within a magnitude of 0 to 22 percent near the mouth of Cottonwood after more than 500 years. A 22 percent increase would result in a predicted TDS concentration of 3687 mg/L. TDS concentrations between 3000 and 5000 mg/L may not cause adverse effects to adult livestock, however, growing/young livestock could be affected by looseness or poor feed conversion (Lardy, Stoltenow and Johnson 2008).

The natural variability in the baseline TDS concentrations in the Cottonwood alluvium is comparable to or greater than the magnitude of the model-predicted changes in TDS concentrations. For example, the median plus one median absolute deviation of the TDS concentrations measured in baseline samples at Cottonwood alluvial wells QACW-2 and QACW-2B are 22 percent and 10 percent higher than the median respectively, indicating large natural variation in TDS concentrations in the alluvium water quality. Cottonwood Arroyo alluvial monitoring at QACW-1 had insufficient water for sampling so it is not possible to assess the variability in TDS concentrations at this location. The median plus one median absolute deviation of the TDS concentrations measured in baseline samples at alluvial well GM-17 on the North Fork of Cottonwood was 3 percent higher than the median. However, the median TDS concentration in baseline samples from this well was 15,210 mg/l, making the alluvial groundwater at this location on the North Fork of Cottonwood unsuitable for use. In summary, the baseline median plus one median absolute deviation ranges from 3 to 22 percent higher relative to the medians (Ecosphere Associates Inc. 2011).

While the predicted TDS change of 0 to 22 percent could result in TDS concentrations above livestock criteria, the predicted change is within the variability of 3 to 22 percent observed in baseline fluctuations. Thus, the impact of the model predicted changes in TDS concentrations in the Cottonwood alluvium are considered to be negligible as the predicted long-term changes in water quality are within the variability observed in the baseline fluctuations. Additionally, changes unrelated to mining could result in a greater magnitude of change in TDS concentrations in the Cottonwood Arroyo alluvium, within the 500 year modeled timeframe. Any changes in alluvial groundwater quality are not expected to affect surface water quality or potential ecological receptors, as alluvial groundwater is not a source of base flow and generally does not discharge to the surface (Ecosphere Associates Inc. 2011).

5.3.7.2 **Fruitland Formation Quantity**

Based on mining experience at the Navajo Mine, the coals, the overburden, and the interburden in the Fruitland Formation are not expected to yield much water during mining in Area IV North. The mine pits have remained dry throughout the lease area except on rare occasions when surface flows are captured. Groundwater seeps are rarely observed along the highwall as any groundwater in the Fruitland overburden and coal is consumed by evaporation along the highwall (BNCC 2011). The few seeps that have been observed during mining were at locations within Area I where the highwall was near NAPI irrigation plots. Groundwater flow rates through the Fruitland coals within Area III are believed to be extremely low because of the low hydraulic conductivities of the coal and the relatively flat hydraulic gradients. For a long period following mining within Area III gradients will be toward the mine backfill. As the mine spoils begin to saturate over the long-term, the buildup of heads in the mine spoil will increase, reversing the gradients with respect to the mine spoils. Based on model estimates of Area IV North it could take as long as 80 years for gradient reversal to occur (BNCC 2011). Transport directions for mine spoil water at that time would be laterally down dip in the Fruitland Formation, toward the outcrop areas to the south and west of Area III, and vertically into the PCS. Lateral flow from the mine spoils through the Fruitland Formation and vertically into the PCS will be very low due to the low hydraulic conductivity of these units and due to the relatively flat gradients that can be expected based on pre-mine conditions. Most discharge to the PCS and Fruitland Formation outcrops to the south and west of Area III is expected to be removed by evapotranspiration, although a portion of this groundwater discharge could reach the Cottonwood Arroyo alluvium.

Potentiometric gradients in the other coal seams within Areas III, IV, and V of the BNCC coal lease are expected to be generally toward the northeast, similar to the gradients for No. 3 coal seam. However, the upper coal seams (No. 6, No. 7, and No. 8) outcrop to a greater extent within the valleys of Pinabete Arroyo, No Name Wash, and Cottonwood Arroyo within the BNCC coal lease. The groundwater gadients within these upper coal seams are influenced by outcrop discharge along the arroyos. The baseline hydrogeologic model generated to support the PHC assessment simulated local potentiometric gradients toward the Pinabete Arroyo, No Name Wash, and Cottonwood Arroyo in all of the Fruitland coal units. The local influence of topography on potentiometric gradients was greatest for the shallowest coal, the No. 8 seam (Norwest Corporation 2011). Field observations of salt deposits and enhanced vegetation production also indicate that local discharge may occur from the No. 8 coal at the coal outcrop along Pinabete Arroyo. Baseline groundwater model simulations and potentiometric elevations at wells

KF-2007- 01, KF84-22A, and KF83-10A were used to prepare the potentiometric surface of the No. 8 coal seam provided in Figure 21.

The open mine pit acts as a drain for drawdown of any groundwater in the overburden/interburden, in the coal seams. Model simulations of the advance of proposed open pit mining in Area IV North have been performed to provide estimates of drawdown and recovery in the Fruitland coals during mining and reclamation. It is estimated that mining in Area IV North will cause around 5 feet of drawdown by the time of completion of mining in both the No.3 and the No. 8 coal seams (BNCC 2011). The groundwater model developed for the PHC was also applied to simulate the rate of recovery of water levels in mine backfill and in the Fruitland coals adjacent to the mining block. Maximum drawdown is less than 17 feet, occurring approximately 30 years following the start of mining (BNCC 2011). Upward gradients of groundwater movement from the PCS to the mine backfill do not occur until about 85 years after the start of mining. After that time, the recovery of the potentiometric surface in the backfill is complete and gradients are vertically downward from the backfill to the PCS.

These results together with the estimated 5-foot drawdown contour maps at the end of mining show that the hydrogeologic effects of proposed mining within Area IV North are localized and occur over a long time period. The long-term change resulting from the removal of the interbedded coal, shales, mudstones, and sandstone strata and replacement with a relatively homogeneous and isotropic mine backfill will be an increase in the rate of vertical flow into the PCS from the mine backfill compared with the vertical flow into the PCS from the Fruitland formation prior to mining.

Cumulative effects of drawdown are determined to be negligible because there are no wells completed in the Fruitland Formation and the PCS that could be impacted and these units are not capable of providing a sustainable water supply (BNCC 2011a).

The projected and observed impacts to the water quantity within the Fruitland Formation resulting from coal mining at the Navajo Mine have been minimal to date. Since there are no current uses for the Fruitland formation in or adjacent to the Navajo Mine and no foreseeable uses other than oil and gas extraction, impacts to the Fruitland formation are not expected to preclude current or foreseeable uses. Additionally, the predicted and observed impacts to the Fruitland Formation do not extend outside of the immediate areas surrounding the mine pits and reclaimed areas; and the Fruitland Formation is generally not capable of providing a sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the groundwater quantity of the Fruitland Formation are considered to be negligible.

5.3.7.3 **Fruitland Formation Quality**

Spoil leaching tests were performed in support of the PHC assessment for the Navajo Mine SMCRA permit revision. The spoil leaching test results show a considerable range in the concentrations of TDS and sulfate, which are the primary constituents of concern with respect to spoil leachate. Spoil leaching test results found an increase in TDS concentrations in spoil water leachate ranging from 400 to 2,700 mg/l and an increase in sulfate concentrations in spoil water leachate ranging from 630 to 2,580 mg/l (BNCC 2011, Appendix 11-VV). The leaching test results are fairly consistent with the results for the Bitsui #5 spoil well completed in the mine spoils in the Bitsui Pit, located at the north end of the BNCC Navajo Mine. The Bitsui Pit was backfilled in the 1980s and is the only pit at Navajo Mine where saturation of mine spoils has been observed. Arsenic and selenium were below detection in most of the leaching test results and in the Bitsui 5 spoil well. Fluoride is also lower in the spoil water leachate than in the coal water and is attenuated in flow through mine spoil. Boron and manganese concentrations are also elevated in mine spoil water (BNCC 2011, Section 11.6).

During active mining, hydraulic gradients and groundwater flow directions in the Fruitland Formation are towards the mine pits and backfill areas. Thus, it is expected that there would be little change in the quality of groundwater beyond the limits of the mine pit and mine backfill during mining and reclamation operations. These results show that in addition to increases in concentrations of TDS and sulfate, concentrations of boron and manganese may also increase relative to the baseline coal water (BNCC 2011, Section 11.6).

A comparison of baseline water quality to livestock criteria found that water in the Fruitland Formation is a very poor source of supply for livestock watering use, specifically because of elevated chloride and TDS concentrations, which are well above livestock criteria. There are no livestock watering wells completed in the Fruitland Formation that could be impacted and the aquifer is generally not capable of providing a sustainable water supply for this use. The only documented current and historic use of the Fruitland Formation in the area is for oil and gas extraction, which does not have protective use criteria designations since water quality is not particularly significant for this use. Therefore, analysis of post mining groundwater quality in the Fruitland Formation including adjacent Fruitland Formation coal aquifers, CCB disposal areas and the backfilled spoil will be evaluated against baseline Fruitland Formation groundwater quality as well as livestock use criteria. A complete comparison to livestock use criteria can however be found in Appendix F. An analysis of constituents generally associated with backfill spoil and CCB leachate including pH, conductivity, boron, total iron, manganese, selenium, chloride, fluoride, sulfate and TDS is presented below.

The variability of groundwater quality data from backfill spoil, and non-baseline Fruitland Formation coal aquifers is similar to that of the corresponding baseline groundwater quality data within the coal lease where the median %RSDs are 68 and 67 respectively. A comparison of spoil wells to the Median + 2MAD for baseline Fruitland coals within the BNCC lease area showed the following; negligible impacts for conductivity, chloride, and fluoride; minor impact for total iron where 27 percent of all samples exceeded baseline; moderate impact for selenium where 33 percent of all samples exceeded baseline; major impacts for pH, boron, manganese, sulfate and TDS where 64, 98, 64, 100 and 93 percent of all samples exceeded baseline respectively. Of these the median concentrations for boron, manganese, sulfate, and TDS exceeded the baseline Median + 2MAD where they were 2, 10, 187 and 1.3 times larger respectively. No pH values were outside of the livestock criteria range. There is no livestock criterion for manganese, and median boron concentrations were below the livestock criterion; however, median concentrations for sulfate and TDS exceeded livestock criteria where they were 8 and 5 times larger respectively. Therefore, within spoil wells sulfate and TDS are all considered to be of concern relative to baseline and livestock criteria. It is important to note that impact to boron and fluoride concentrations is lower in spoil wells relative to CCB wells.

A comparison of non-baseline Fruitland Formation coal aquifer wells to the Median + 2MAD for baseline Fruitland Formation coal aquifer wells within the BNCC lease showed the following; negligible impacts for pH, conductivity, total iron, manganese, chloride, and TDS; minor impacts for selenium and fluoride where 20 and 13 percent of all samples exceeded baseline respectively; major impacts for boron and sulfate where 92 and 64 percent of all samples exceeded baseline respectively. The median concentrations for boron and sulfate exceeded the baseline Median + 2MAD and concentrations were 1.3 and 6 times larger respectively. When compared against livestock water quality criteria, median boron and sulfate concentrations were below the livestock criteria. Therefore, within non-baseline Fruitland coal wells no constituents are considered to be of concern relative to baseline and livestock criteria, although boron and sulfate have major impacts relative to baseline. It is important to note that impact to non-baseline Fruitland coal wells within the BNCC lease is significantly reduced relative to impacts in CCB and spoil wells.

Since there are no current uses for the Fruitland formation in or adjacent to the Navajo Mine and no foreseeable uses other than oil and gas extraction, impacts to the Fruitland formation are not expected to preclude water uses. Additionally, the predicted and observed impacts to the Fruitland Formation do not extend outside of the immediate areas surrounding the mine pits and reclaimed areas and the aquifer is generally not capable of providing a sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the Fruitland Formation groundwater quantity are considered to be negligible.

5.3.7.4 **Pictured Cliffs Sandstone Quantity**

The PCS is a marginal water resource due to low permeability, poor water quality, gas production, and low yields. The PCS is also a natural gas reservoir in the San Juan Watershed. Stone et al. (1983) state that the PCS cannot be considered a major aquifer and it is important only because it is the water-bearing horizon immediately underlying the coals in the Fruitland Formation.

Lateral flow through the PCS within Area II is expected to be generally toward the northeast as indicated by the potentiometric surface provided in Figure 15. There could also be a component of flow west toward the PCS outcrop located east of the Chaco River. Groundwater flow rates through the PCS will be very low due to the very low hydraulic conductivity of the PCS. Any discharge along the PCS outcrop to the west of Area II will likely be removed by evapotranspiration. Based on pre-mine observations along the PCS outcrop adjacent to Areas III and IV North, flow rates in the PCS are expected to be insufficient to sustain flow at seeps and into the alluvial aquifer.

It is estimated that a 5 foot drawdown will be present in the PCS at the completion of proposed mining in Area IV North. The layer of shale separating the bottom of the lowest coal seam and the PCS serves to restrict groundwater inflow from the PCS during mining. The thickness of shale layer between the No. 2 coal and the PCS averages about 8.7 feet over the Area IV North mine block but is absent in some places. This variation in the shale thickness has been accounted for in the estimates of drawdown within the PCS. Artesian pressures in the PCS occur in the eastern portion of the Area IV North mine block where the shale thickness separating the coal from the PCS is greater. Accordingly, any drawdown in the PCS is dampened, particularly in these locations where the shale thickness is greater.

The model simulated steady-state post mining potentiometric surface in the PCS is provided in Figure 32. This surface is similar to the pre-mining PCS potentiometric surface in Figure 15, except for the localized increase in the heads in the PCS below the mine backfill within Area IV North. The higher head in the PCS below the mine backfill is due to the higher heads at the base of the mine backfill. Very little change in heads is predicted at locations away from mine backfill, including at the former PCS wells GM-19 and GM-28, located within the lease area at distances of about 3,500 and 3,000 feet from the Area IV North mine pit. This localized increase in heads in the PCS results in an increase in gradients toward the northwest and toward the northeast.

There is one identified livestock watering well completed in the PCS located along the western side of the Chaco River west of Area V which may be influenced by alluvial waters of the Chaco River and it is not known if the well is actively being used. The unit is known to have very low yields in the vicinity of BNCC and is generally not capable of providing a sustainable water supply for this use. The primary documented current and historic use of the PCS in the area is for oil and gas extraction, which is not particularly sensitive to water quantity loses within the extraction zones. Therefore impacts to the PCS are not expected to disturb water users. Additionally, the predicted and observed impacts to the PCS do not extend outside of the immediate areas surrounding the mine pits and subsequent reclaimed areas. Therefore for the purpose of this assessment, the impacts to the PCS groundwater quantity are considered to be negligible.

5.3.7.5 **Pictured Cliffs Sandstone Quality**

Comparison of baseline water quality to livestock criteria found that water in the PCS is a very poor source of supply for livestock watering use, specifically because of elevated chloride, sulfate, and TDS concentrations, which are well above livestock criteria. However, there is one identified livestock watering well completed in the PCS located along the western side of the Chaco River west of Area V which may be influenced by alluvial waters of the Chaco River. It is not known if the well is actively being used. The unit is known to have very low yields in the vicinity of BNCC and is generally not capable of providing a sustainable water supply for this use. The primary documented current and historic use of the PCS in the area is for oil and gas extraction, which does not have protective use criteria designations, as water quality is not particularly significant for this use. Therefore, impacts to the PCS are not expected to disturb water users. The only non-baseline PCS monitoring well KP-84 did not have sufficient water for sampling during the historic monitoring period from 1990 to 1998. Therefore there will be no comparison of non-baseline PCS quality to baseline conditions.

Direct intermediate-term impacts to the groundwater quality beyond the active mine area are not expected to occur during mining and reclamation operations. During active mining, hydraulic gradients and groundwater flow directions in the PCS would be toward the mine pits and backfill areas. Thus, it is expected that there would be little change in the quality of groundwater beyond the limits of the mine pit and mine backfill during mining and reclamation operations. However, over the long term as these gradients reverse post-reclamation increase in TDS and sulfate concentrations in mine spoil backfill may result in increased TDS and sulfate concentrations in the PCS adjacent to mining (Ecosphere Associates Inc. 2011). Additionally, the predicted and observed impacts to the PCS do not extend outside of the immediate areas surrounding the mine pits and subsequent reclaimed areas and are not expected to disturb water users. Therefore for the purpose of this assessment, the impacts to the PCS groundwater quantity are considered to be negligible.

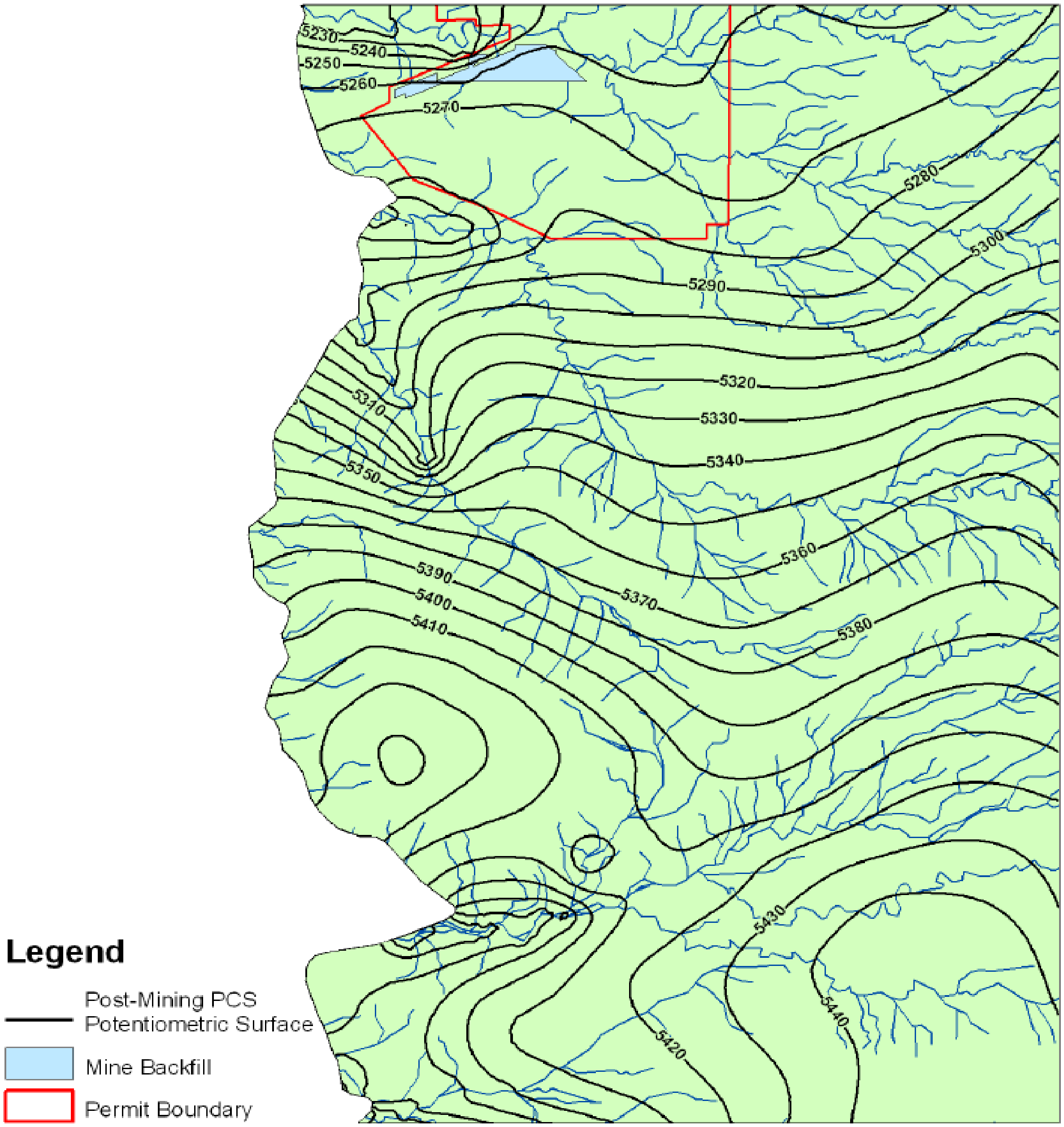


Figure 32: Post-Mining Potentiometric Surface in the PCS Aquifer (BNCC 2011)

6 MATERIAL DAMAGE

Sections 507(b) (11) and 510(b) (3) of SMCRA, and 30 CFR § 780.21 (g) require OSMRE to determine that a mining and reclamation operation has been designed to prevent material damage to the hydrologic balance outside the permit area. "Hydrologic balance" is defined at 30 CFR § 701.5 as, "the relationship between the quality and quantity of water inflow to, water outflow from, and water storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake or reservoir. It encompasses the dynamic relationships among precipitation, runoff, evaporation, and changes in ground and surface water storage."

"Material damage to the hydrologic balance" is not defined in SMCRA or at 30 CFR § 701.5. The intent of not developing a programmatic definition for "material damage to the hydrologic balance" was to provide the Regulatory Authority the ability to develop a definition based on regional environmental and regulatory conditions. Therefore, for the purpose of this CHIA;

> Material damage to the hydrologic balance outside the permit area means any quantifiable permanent adverse impact from surface coal mining and reclamation operations on the quality or quantity of surface water or groundwater that exceeds the identified material damage **limits** and that would preclude any existing or reasonably foreseeable use of surface water or groundwater outside the permit area.

The hydrologic impact assessment presented in Chapter 5 of this document considers available quantity and quality information related to surface water and groundwater resources potentially affected by the Navajo Mine. Chapter 5 contains definitions for impact designation of negligible, minor, moderate, and major (Table 7). Detailed discussion of the monitoring program, impact minimization, and impact designation determinations can be found in Chapter 5. The material damage assessment determines if material damage to the hydrologic balance has occurred, or the has the potential to occur, due to the mining operation.

6.1 Cumulative Impact of BNCC and El Segundo Mine

OSMRE has concluded that surface water quantity and quality cumulative impacts relative to the Chaco River from the El Segundo are negligible. Additionally, the State of New Mexico Mining and Minerals Division has determined that all anticipated mining within the El Segundo Mine has been designed to prevent material damage to the hydrologic regime outside the permit area (NMEMNRD 2008).

6.2 BNCC Impact on NAPI

OSMRE has determined that BNCC operations have negligible impacts on NAPI operations.

6.3 BNCC Impact to Morgan Lake and APS

OSMRE has determined that flow contribution to Morgan Lake from tributaries which traverse the BNCC permit is negligible, and quality impacts associated with these tributaries are also negligible.

BNCC operations are not expected to adversely impact the water quantity or quality necessary for APS operations, and OSMRE has determined that BNCC operations will have a negligible impact on APS operations.

6.4 Chaco River

OSMRE has determined that impacts of the BNCC mining operation on Chaco River surface water quantity is considered to be negligible. Relative to the Chaco River surface water quality, although the impact designation may be considerable for certain constituents, it does not appear to translate to a significant impairment of use. OSMRE finds that surface water quality within the Chaco River is generally appropriate for the designated post-mining land use of livestock grazing.

6.5 Historic Mining North of the BNCC Permit

OSMRE finds that changes in alluvial groundwater quantity will not preclude use; therefore, the impact is designated to be negligible. Relative to Fruitland formation and PCS quantity and quality, impact designation is *negligible,* since observed impacts do not extend outside of the immediate areas surrounding the reclaimed areas and the hydrologic units are generally not capable of providing sustainable water supply. OSMRE's assessment has concluded that potential impacts to use from historic CCB disposal are *negligible*.

6.6 Navajo Mine

OSMRE has identified both **hydrologic balance thresholds** and **material damage limits** for the Navajo Mine (Table 2).

- A **material damage limit** is a long-term coal mining effect on the hydrologic balance by the mining operation that permanently precludes an existing or reasonably foreseeable designated use outside of the permit boundary, and specifically pertains to the designated post-mining land use within the permit area. Such an effect cannot be effectively mitigated or replaced by the coal operator.
- A **hydrologic balance threshold** constitutes changes to the hydrologic balance caused by the mining operation that are short-term and can be effectively mitigated by reclamation or by water supply replacement, or changes to the hydrologic balance that do NOT preclude existing or reasonably foreseeable uses.

For the purpose of this material damage assessment, short-term impacts are defined as impacts that occur to the hydrologic balance during mining, but are not projected to persist after the reclamation liability period. Long-term impacts are defined as impacts that are projected to persist after the reclamation liability period. The reclamation liability period ends after the permittee has met all of the requirements at 30 CFR 750, including those at 30 CFR 800.13. At a minimum an application for final (Phase III) reclamation liability release would not be considered by the regulatory authority until the reclaimed (back filled, re-graded and top soiled) lands have been revegetated for ten years.

The intent of determining a hydrologic balance **threshold** is to alert BNCC and OSM of potential water resource impacts of concern, such that BNCC may take appropriate actions to prevent material damage. The exceedance of a material damage **limit** would result in a finding that material damage to the hydrologic balance outside the permit area had occurred. At the time of final bond release OSMRE must make a determination that material damage to the hydrologic balance outside of the permit area has been prevented. Final bond release shall not be granted until such a determination is made.

The distinction between long-term and short-term impacts is supported in research. Various studies have determined that a number of requirements that must be met by a coal operator in order to achieve final bond release can restore water quality and quantity. Appropriate reclamation has been found to restore the seasonal variation rainfall-runoff watershed processes (Bonta, et al. 1997). Reclaiming diversions and re-vegetation have been shown to considerably improve water quality (Bonta and Dick 2003). Additionally, drastic decreases in suspended sediment concentrations, load rates, and yields have been documented to occur at surface coal mines subsequent to reclamation (J. V. Bonta 2000).

Table 12: Material Damage Limits and Hydrologic Balance Thresholds

Category			Definition
General	Quantity	Limit	irretrievable loss of the water resource to support existing or reasonably foreseeable uses outside of the lease area that cannot be provided by alternate water supplies
		Threshold	long term loss of the water resource that does not preclude the current or potential future use potential of the resource or short term loss of the water resource to support existing uses that can be mitigated by reclamation or by provision of alternate water supplies
	Quality	Limit	long-term changes in water quality outside the lease area that preclude existing or reasonably foreseeable uses that cannot be provided by alternate water supplies
		Threshold	long term changes in water quality that occasionally exceed the water quality observed in the baseline fluctuations but that do not preclude the current or potential future use potential of the resource or short term changes in water quality that consistently exceed the water quality observed in the baseline fluctuations but that do not preclude the current use or can be mitigated by reclamation or by provision of alternate water supplies
Criteria Applied to the Navajo Mine		Limit	**Long-term** (impact remains after final reclamation and bond-release) Impact Designation of **Major** as defined in Table 7, and which **Preclude** Existing or Reasonably Foreseeable **Uses Outside** of the Lease area that **Cannot be Mitigated** by Reclamation or Provision of Alternate Water Supplies
		Threshold	**Long-term** (impact remains after final reclamation and bond-release) Impact Designation of **Moderate or Major** as defined in Table 7 **Outside of the Lease area** that **Does NOT Preclude** Existing or Reasonably Foreseeable **Uses** **OR** **Short-term** (impact occurs only during active mining and reclamation prior to final bond release) Impact Designation of **Major** as defined in Table 7, which **may Preclude** Existing or Reasonably Foreseeable **Uses Outside of the Lease area** that **Can be Mitigated** by Reclamation or Provision of Alternate Water Supplies

A summary of OSM's material damage assessment and findings is presented in Table 13 and further discussed below. For clarity in the discussion hydrologic balance **threshold** and material damage **limit** will be bolded, and the impact designations of *negligible*, *minor*, *moderate*, and *major* will be italicized.

Table 13: Assessment of Material Damage for the Waters of the Navajo Mine

Water Resource	Assessment Approach	Hydrologic Balance Threshold Reached	Material Damage Limit Reached	Impact Mitigation	Adequate Monitoring Program
Fruitland & PCS Quantity	Evaluation of potentiometric surface contour maps	No	No	Contemporaneous Reclamation	Yes
Alluvial Quantity	Comparison of water levels at individual wells over-time	No	No	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones	Yes
Surface Water Quantity	SEDCAD modeling-assessment of pre- and post-mining impacts; Percent of HUC12 Watersheds controlled with impoundments	**Yes**	No		Yes
Fruitland & PCS Quality	Comparison of baseline water quality to potentially impacted or non-baseline wells, including spoil and CCB wells	No	No	Contemporaneous Reclamation; mixing of overburden/ backfill materials	Yes
Alluvial Quality	Comparison baseline (upstream/pre-mining) water quality to non-baseline (post-mining/downstream) water quality	**Yes**	No	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones	Yes
Surface Water Quality		No	No	Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones; Sedimentation Ponds	Yes

6.6.1 Material Damage Assessment

6.6.1.1 Surface Water

Surface water quantity impacts are assessed as a relative percentage of the watershed controlled through the use of sediment impoundments compared to the corresponding Hydrologic Unit Code (HUC) 12 watershed delineation. Hydrologic balance **thresholds** and material damage **limits** have not been reached for any of the assessed HUC 12 watersheds, since all impact designations are *negligible* or *minor*.

When modeled pre-mining peak flows are compared to-post-mining peak flows, the comparison indicates that hydrologic balance **thresholds** and material damage **limits** have not been reached for the Chinde Wash Watershed, Coal Creek-Chaco River Watershed, or Cottonwood Arroyo Watershed.

In the Chinde-Chaco River Watershed a long-term impact designation of *moderate* has been determined for the area outside of the permit boundary. This *moderate* impact designation is due to a reduction in post-mining peak flow. Therefore, the hydrologic balance **threshold** has been reached for this watershed. The material damage **limit** has not been reached since the impact designation has not been determined to be *major* current designated water uses are not expected to be precluded. BNCC and OSM are currently discussing modifications to the reclamation plan that may be needed for this area to ensure material damage to the hydrologic balance is prevented outside of the permit area over the long-term.

Relative to Chinde Wash surface water quality, the hydrologic balance **threshold** and material damage **limit** have not been reached, since impacts are not long-term, not determined to be *major*, and will not preclude designated water uses.

6.6.1.2 Alluvium

The material damage assessment for alluvial water quantity confirms that hydrologic balance **thresholds** and material damage **limits** have not been reached, since all impact designations are *negligible*.

It has also been determined that the alluvial water quality hydrologic balance **threshold** has been reached in the Chinde Wash alluvium, since a short-term *major* impact designation has been assigned, which may preclude designated water use. The material damage **limit** has not been reached since impacts are not considered long-term. BNCC is enhancing the existing alluvial monitoring plan in this area to further assess and verify the duration of coal mining impacts in the Chinde Wash alluvium outside the permit area.

Relative to Cottonwood alluvial water quality, the hydrologic balance **thresholds** and material damage **limits** have not been reached since all impact designations are *negligible*.

6.6.1.3 Fruitland Formation and PCS

Relative to Fruitland formation and PCS quantity and quality, hydrologic balance **thresholds** and material damage **limits** have not been reached since impact designation is *negligible* and designated water use is not expected to be precluded. See Section 6.2 Historic Mining North of the BNCC Permit for CCB disposal determination.

6.6.2 Conclusion

OSMRE finds that the Navajo Mine operation monitoring program has supplied sufficient information for this CHIA and finding. OSMRE finds that the Navajo Mine operation has been designed to minimize impacts within the permit area and to prevent material damage to the hydrologic balance outside of the permit area.

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