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**

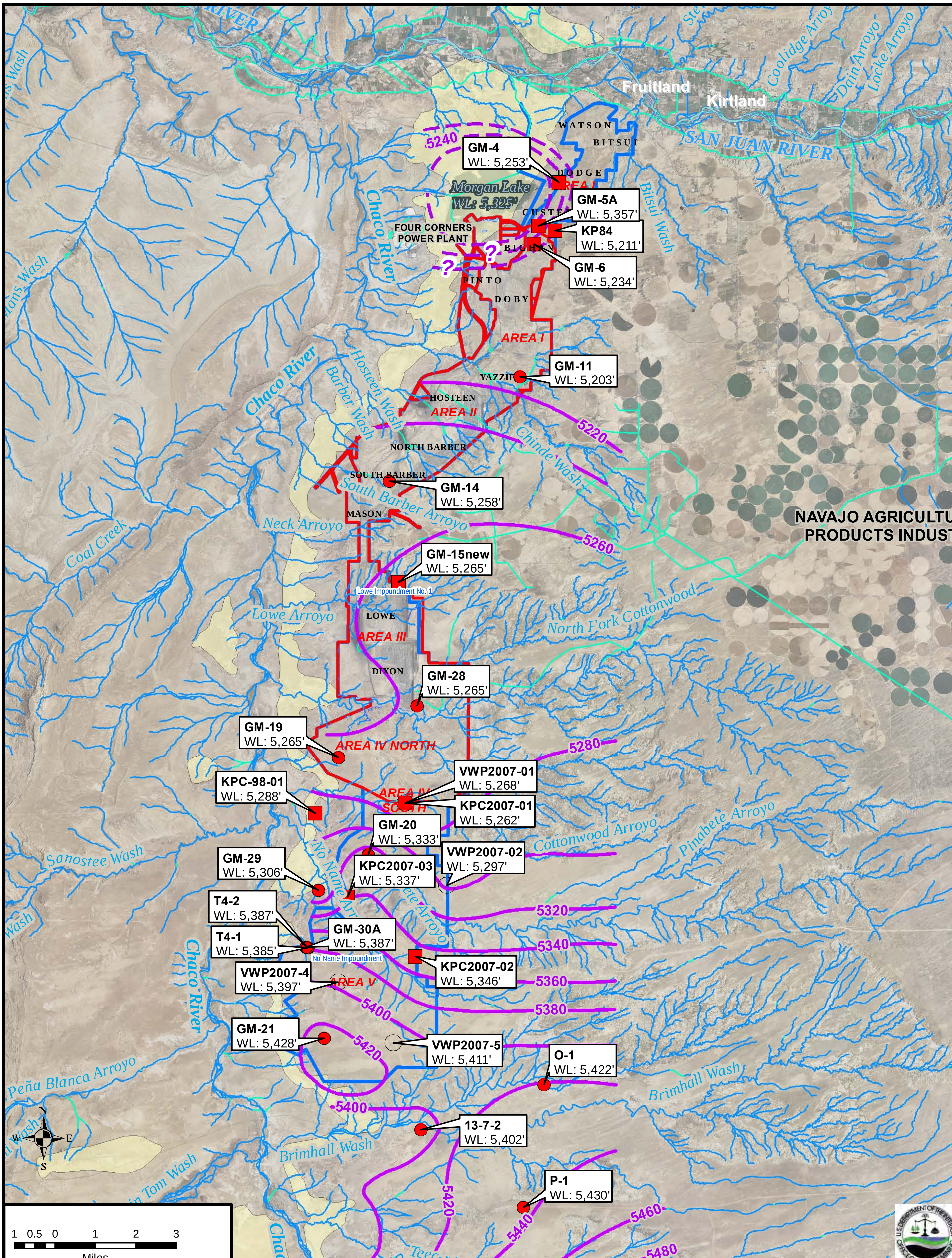
El Segundo coal mine is located approximately 70 miles southeast from the southern tip of the Navajo Mine permit boundary. The proposed lease area is divided into two subwatersheds by the continental divide and is crossed by several unnamed ephemeral, arroyos. The western portion of the lease area drains 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).



Location Area

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.

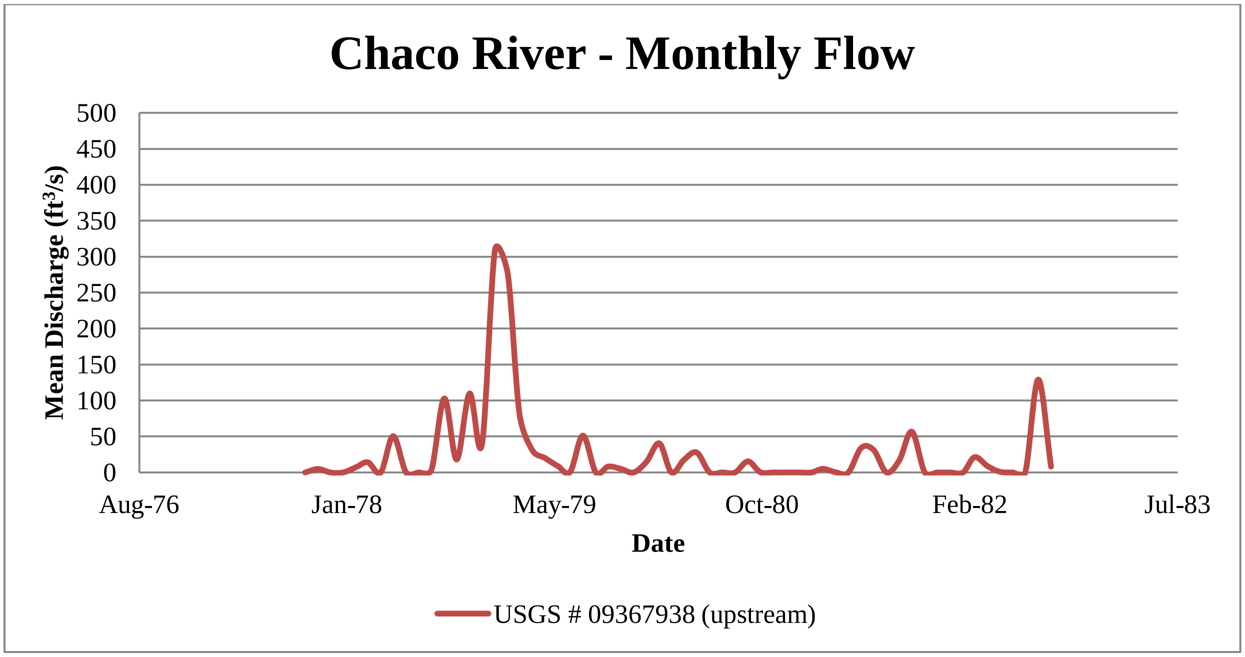


Figure 16: Baseline Monthly Flow along the Chaco River

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 $CaCO_3$, 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.

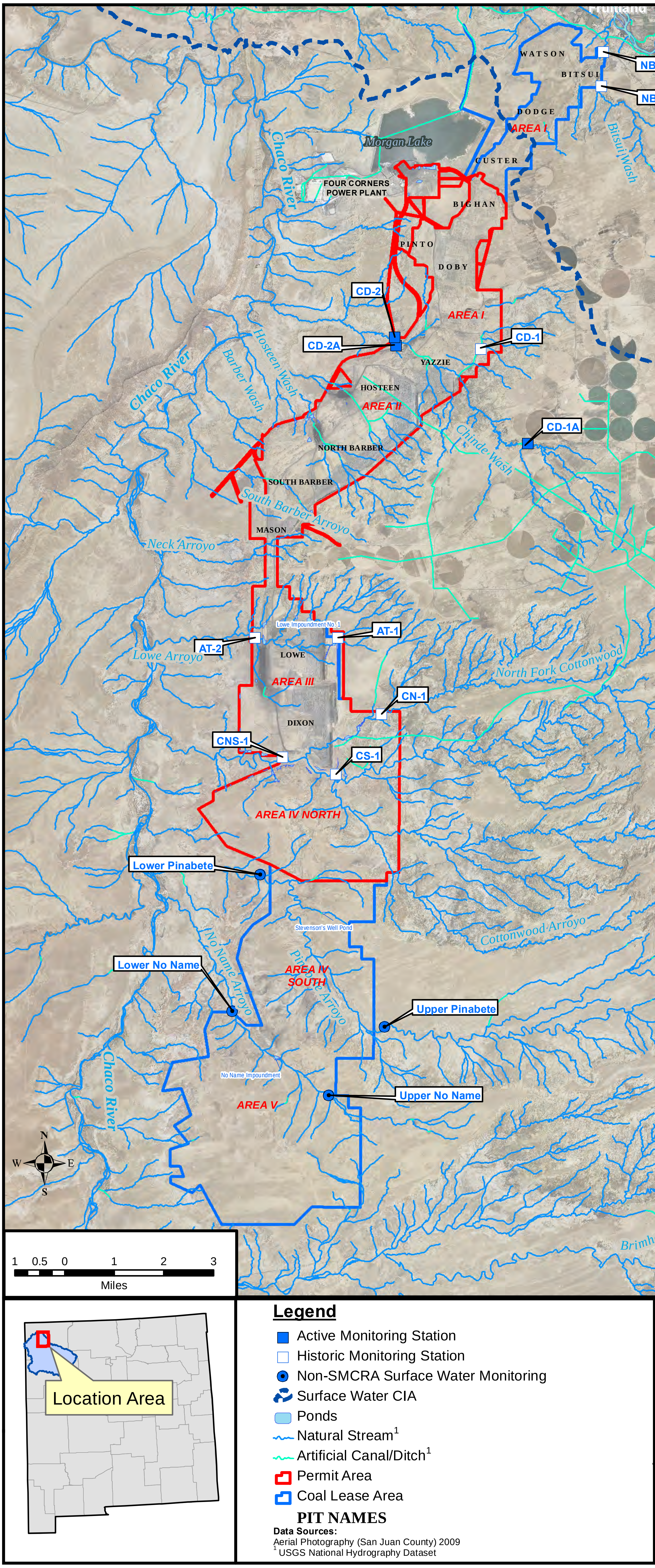
The increased application and discharge of surface water from NAPI has impacted the permit area hydrology. NAPI impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. NAPI direct discharges are a result of an oversupply of water in the 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.

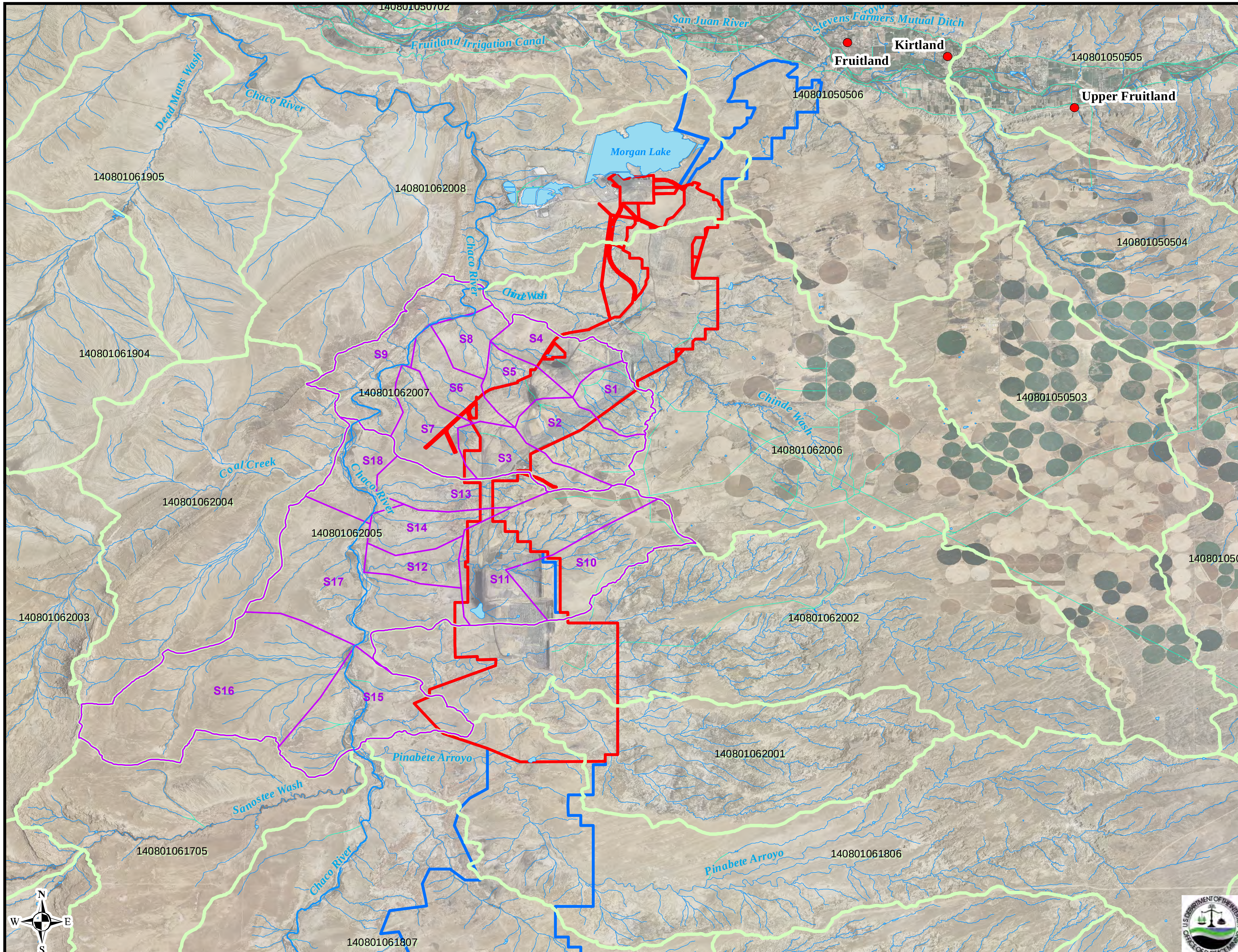
The Navajo Mine lies primarily within four HUC12 watersheds that either intersect or contain portions of the lease area (Figure 6). The watersheds include the Morgan Lake-Chaco River, Chinde Wash-Chaco River, Coal Creek-Chaco River, and Cottonwood Arroyo watersheds. Each major tributary to the Chaco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



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.

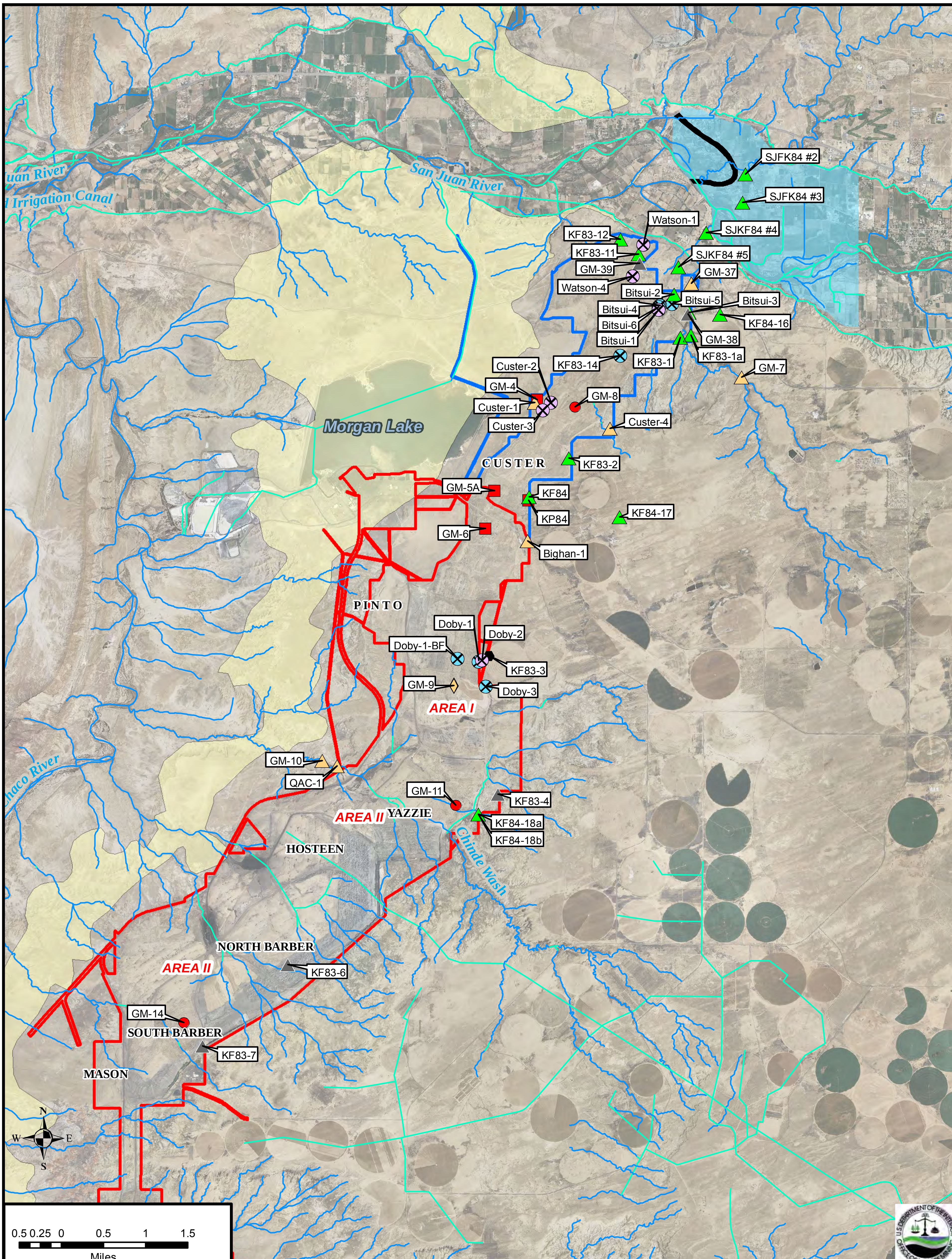
All pH values for all other Chaco River alluvial samples were within the appropriate range. Arsenic, lead, selenium, chloride, fluoride, sulfate, and TDS exceeded livestock criteria for the Chaco River for 21%, 5%, 16%, 11%, 6%, 67% and 72% of all samples respectively. Median values for arsenic, lead, 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.

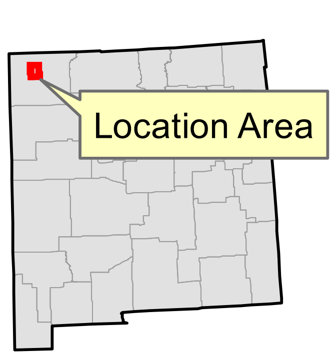
No pre-mining Fruitland data is available in this area. However, there is post-mining data for the #8 coal seam. The Fruitland formation outcrop is located to the north of this area and this is the point of discharge to the San Juan alluvium. No pre-mining PCS data is available in this area. However, 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

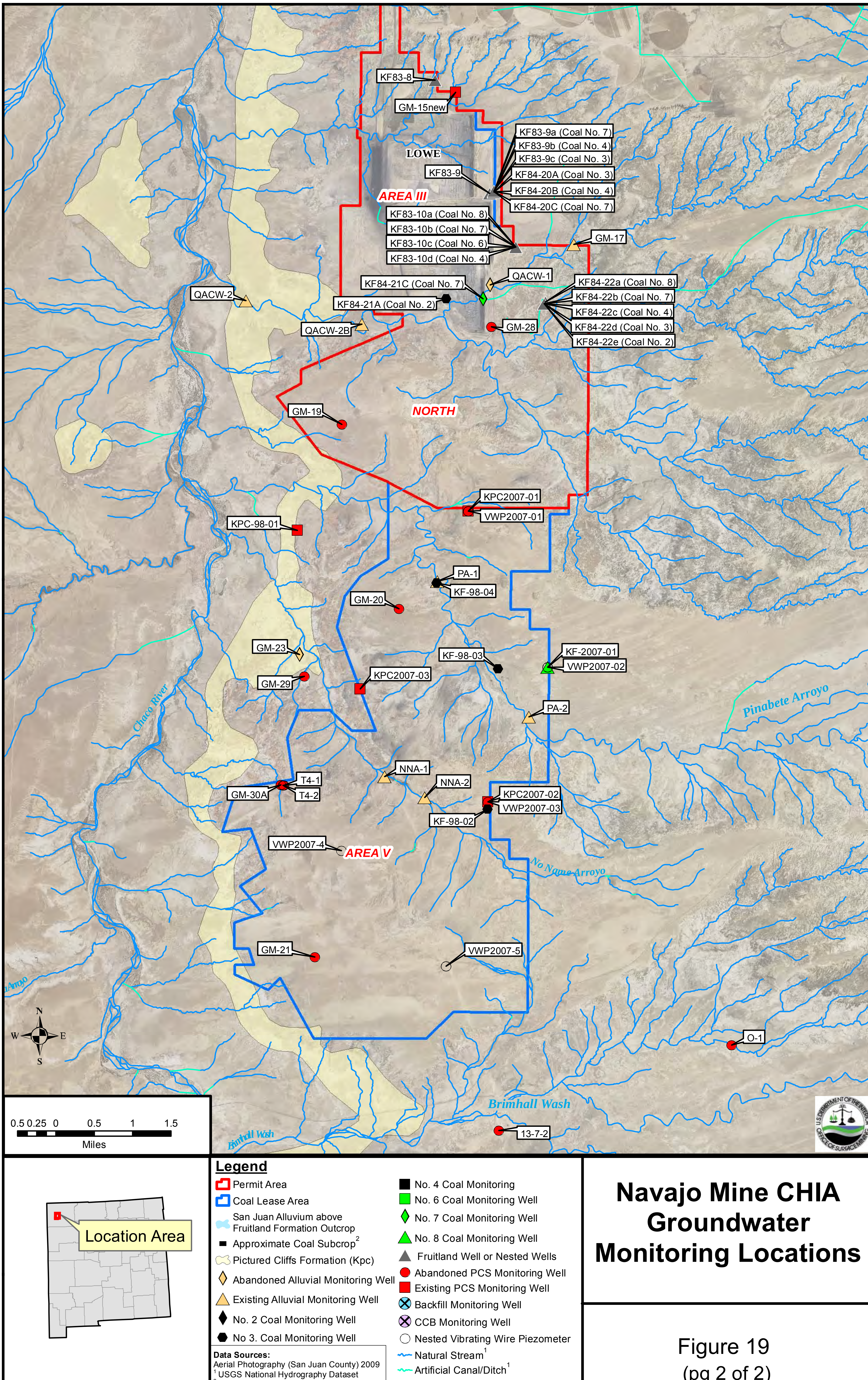
- Permit Area
- Coal Lease Area
- San Juan Alluvium above Fruitland Formation Outcrop
- Approximate Coal Subcrop[2]
- Pictured Cliffs Formation (Kpc)
- Abandoned Alluvial Monitoring Well
- Existing Alluvial Monitoring Well
- No. 2 Coal Monitoring Well
- No 3. Coal Monitoring Well
- No. 4 Coal Monitoring
- 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)



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.

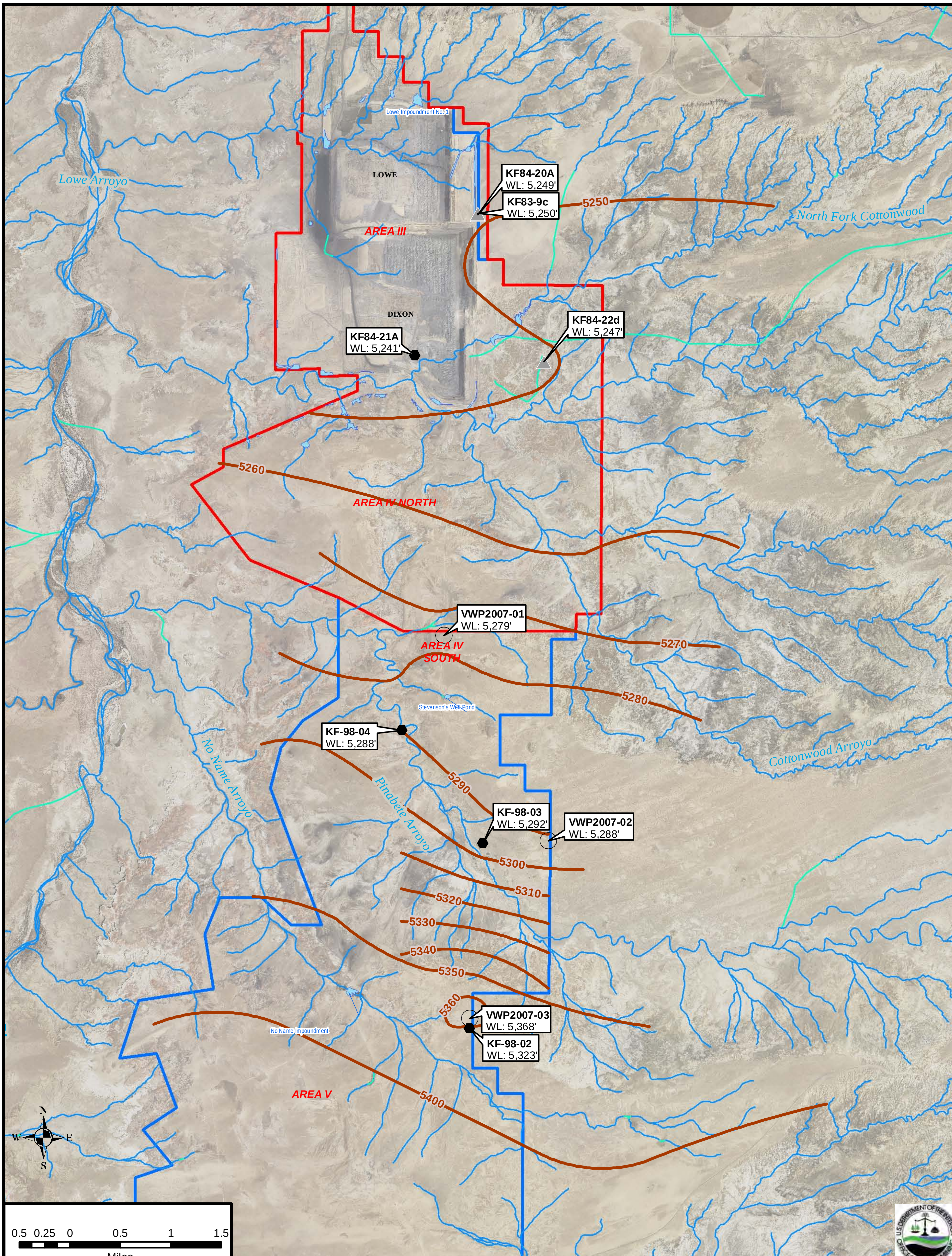
Water yields are quite low from the PCS monitoring wells completed around BNCC lease Area IV South. Two of the PCS wells were quickly pumped or bailed dry during conventional sampling. The yield from one of the PCS wells was sufficient to sustain a rate of about 0.4 gallons per minute (gpm) during a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

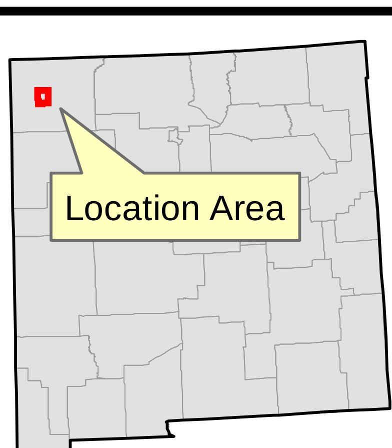
4.2.4.6 **Pictured Cliffs Sandstone Aquifer Baseline Quality**

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.





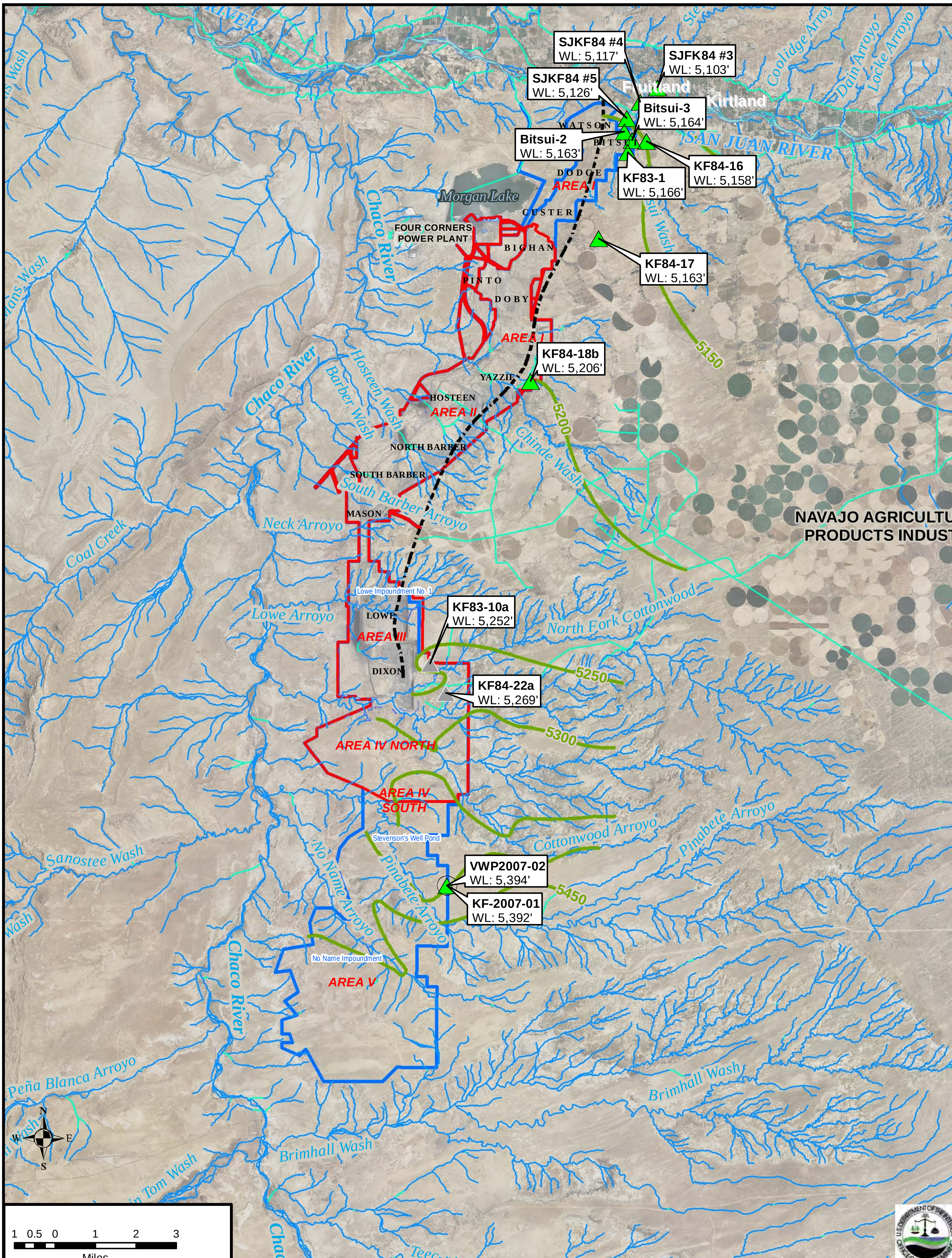
Legend

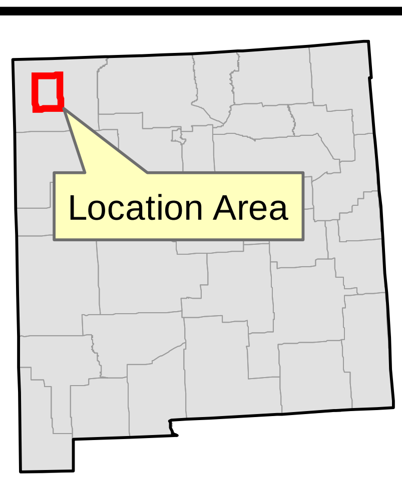
- Coal 3 Potentiometric Contour
- No 3. Coal Monitoring Well
- Fruitland Nested Wells
- Nested Vibrating Wire Piezometer
- Ponds
- Natural Stream[1]
- Artificial Canal/Ditch[1]
- Coal Lease Area
- Permit Area
- PIT NAMES

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