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March 26, 2012

Mr. Fernando Martinez, Director
Mining and Minerals Division
Energy, Minerals and Natural Resources Department
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Re: Cebolleta Mine Permit Application

Dear Mr. Martinez:

Enclosed is the Sampling and Analysis Plan (SAP) prepared by Neutron Energy Inc. for the Cebolleta Mine project in accordance with the requirements of NMAC 19.10.6.602D.(12)(a). The Cebolleta SAP, in conjunction with this transmittal letter and attachments listed below, constitutes the first phase of Cibola Resources, LLC's application for a new permit to mine for the proposed Cebolleta uranium mine on the Cebolleta Land Grant. Neutron Energy Inc. (Neutron) is the operating entity of the applicant which is Cibola Resources LLP. Listed below are responses to the permit application requirements set forth in 19.20.6.602 NMAC parts A through D that are not integral to the SAP itself.

NMAC 19.10.6.602A. – Six hard copies and one digital version of the application are submitted herewith.

NMAC 19.10.6.602B. - None of the information contained in this application or the appurtenant SAP is considered confidential. Information contained in the Cultural Resources reports described in the SAP is considered confidential and should be treated accordingly.

NMAC 19.10.6.602C. - The applicant certification is attached to this letter as Attachment A.

All information required by **NMAC 19.10.6.602D. (1) through D.(7)**, is provided in Section 1.0 of the enclosed Cebolleta Mine SAP.

NMAC 19.10.6.602D.(8) – A copy of the proposed form of notice required by 19.10.9 NMAC is provided as Attachment B to this letter. Once MMD has approved the notice for publication, it will be translated into Spanish and published in both English and Spanish as required by NMAC 19.10.2.201B.

NMAC 19.10.6.602D.(9) - A permit application fee ("base fee") in the amount of $5,000 is included with this letter.

NMAC 1910.6.602D.(10) – The Cebolleta Mine project proposes physically separate but interrelated mining operations located in close proximity to each another, with a central facilities and administrative services area, all under the control of the same owner and operator (including common management of all operations). It is therefore requested that one permit be issued for all of the operations as provided in this section of the Part 6 Rules. See Section 1.4 of the Cebolleta SAP for additional discussion of how the project will be developed and managed as one cohesive entity with multiple mining operations.

NMAC 1910.6.602D.(11) – A list of other state and federal permits that may be required for the proposed operations is in Table 1 on the following page. Note that some of the permits listed may not be required, depending on final mine design and facilities layout.

Table 1 Possible State and Federal Permits and Registrations		
Permit or Registration	**Agency**	**Activity Authorized**
Exploration Permit	NM Mining & Minerals Division	Exploration or confirmation drilling. Note that MMD Permit No. CI014ER was issued for this project on 1/19/2011 and is in timely renewal.
Groundwater Discharge Permit(s)	NM Environment Dept. (NMED), Groundwater Bureau	Potential discharges from ore stockpiles, overburden piles, ponds or water catchments.
Stormwater Pollution Prevention Plan	NMED, Surface Water Quality Bureau	Diversion, storage and treatment of storm water runoff.
Air Quality Permits	NMED, Air Quality Bureau	Hazardous Air Pollutant emissions; New Sources (construction & operation).
Mine Dewatering Permit	NM Office of State Engineer (OSE)	Mine dewatering and discharge.
Surface Water Appropriation	NM OSE	Only required for dams > 10 feet high or impoundments > 10 acre-feet.
Mine Registration	NM MMD	Informs MMD of location, commodity, operator, type of operation and changes in registration information.
Radioactive Materials License	NM Radiation Control Bureau	Licensable quantities of special nuclear material not regulated by NRC (e.g. nuclear density gauges).
Emergency Notification Plan	NM State Mine Inspector	Notify of accident events.
Tank Registration	NMED Petroleum Storage Tank Bureau	Register new above or below ground petroleum storage tanks.
404 Permit	US Army Corps of Engineers	Filling or construction in drainage channels or wetlands; Nationwide permits for maintenance, construction.

As provided for in NMAC 19.10.6.602D.(12)(c), Neutron would like to have a conference with you and staff assigned to review the SAP as soon as possible and prior to any determination of completeness regarding this SAP. We look forward to cooperating with MMD staff as we work through the application process. If there are any questions regarding this permit application or the Cebolleta SAP, please don't hesitate to call me.

Sincerely,

Michael Neumann

Michael R. Neumann
Vice President, Environment

Cc:Dave Clark, MMD
Rick Karlson, Neutron Energy Inc.

Attachments: A- Certification Statement
B- Proposed Public Notice
Enclosures: Six (6) Copies of Cebolleta Sampling & Analysis Plan
One disk copy of Cebolleta Sampling & Analysis Plan
Check No. 10424 in the amount of $5,000.00

Attachment A
Part 6 New Mine Permit Application
Cebolleta Mine Project

CERTIFICATION

I certify that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals responsible for obtaining the information, I believe the submitted information is true, accurate, and complete.

Michael R. Neumann
Authorized Representative of the Permittee

Vice President, Environment
Title

Neutron Energy Inc.
Company

Subscribed and sworn to before me this 26th day of March, 2012

STEPHANIE A. JAMIESON
Notary Public
State of Colorado
My Commission Expires March 05, 2013

Stephanie A. Jamieson
Notary Public

My Commission Expires

3/5, 2013

Attachment B

Proposed Public Notice- Cebolleta Mine Permit Application
(3/26/12)

Cibola Resources, LLC has submitted a new mine permit application for developing and operating a uranium mine on the Cebolleta Land Grant pursuant to the New Mexico Mining Act of 1978, as amended, and New Mexico Administrative Code (NMAC) regulations (NMAC 19.10.6). The proposed 4,475 acre permit area is located in portions of Sections 23, 24, 25 and 26, in T11N, R5W, and portions of Sections 19, 20, 29 and 30, T11N, R4W, all in Cibola County, New Mexico. The proposed mine area is located in an historic uranium mining area approximately 4 miles east of the village of Seboyeta which is approximately 17 miles north of Laguna and I-40. United Nuclear Corporation (a subsidiary of General Electric Corporation) and Sohio Western Mining Company (a subsidiary of Rio Tinto Corporation) are responsible for reclamation of the existing mine operations within the proposed permit area.

As the operator for Cibola Resources, Neutron Energy Inc. (NEI) plans to develop multiple conventional (i.e. underground or open pit) mining operations near the existing St. Anthony Mine on the Cebolleta Land Grant. Up to 200 acres of previously disturbed and undisturbed land could be affected by new mining and reclamation activities over a 10 to 15 year time period. Cibola Resources LLC has submitted a Sampling and Analysis Plan (SAP) to the Mining and Minerals Division of the New Mexico Energy, Minerals, and Natural Resources Department that describes in detail the baseline resource and site characterization studies that are underway or will be completed to support mine planning, development, and reclamation.

Copies of the SAP are on file and available for viewing during normal business hours at:

New Mexico Energy, Mineral and Natural Resources Department
Mining and Minerals Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Copies of the SAP are also available at New Mexico State Campus Library, and the Chamber of Commerce Mining Museum in Grants, New Mexico.

Or on-line at: http://www.emnrd.state.nm.us/mmd/.

Written comments may be submitted to the Director, Mr. Fernando Martinez, at the above address within 30 days after the newspaper publication date of this notice.

CEBOLLETA MINE SITE
SAMPLING AND ANALYSIS PLAN

Submitted to:

NEUTRON ENERGY, Inc.
9000 E. Nichols Avenue, Suite 225
Englewood, Colorado 80112
Telephone: (303) 531-0470; Fax: (303) 531-0519

Submitted by:

SWCA ENVIRONMENTAL CONSULTANTS
5647 Jefferson Street NE
Albuquerque, New Mexico 87109
Telephone: (505) 254-1115; Fax: (505) 254-1116

KLEINFELDER

TRINITEK SERVICES, Inc.

INTERA

CLASS ONE TECHNICAL SERVICES

SWCA Project No. 20506

March 2012

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1.0 INTRODUCTION

Neutron Energy, Inc. (Neutron), on behalf of Cibola Resources, LLC (Cibola), has prepared this Sampling and Analysis Plan (SAP) as the first step in applying for a new permit to mine for the proposed Cebolleta uranium mine (Cebolleta Mine Site). The proposed mine will be developed in an inactive uranium mining district on private land owned predominantly by the Cebolleta Land Grant (CLG) approximately 4 km (2.5 miles) east-northeast of the Village of Moquino in Cibola County, New Mexico, as shown in Figure 1.1.

The proposed Cebolleta Mine permit boundary covers approximately 4,475 acres (1,811 ha) encompassing both platted and unplatted land within the CLG. No township and range data are available for the northern part of the permit area, but the southern part of the permit area consists of parts of Sections 23, 24, 25, and 26, Township 11 North, Range 5 West and parts of Sections 19, 20, 29, and 30, Township 11 North, Range 4 West. All but approximately 1,068 acres (432 ha) of the surface within the entire proposed permit area is owned in fee by the CLG. All minerals within the proposed permit boundary are owned by the CLG. Cibola has an exclusive mining lease with the CLG granting access to all CLG-leased land for mineral exploration and development.

There are dormant existing mines with associated workings and extensive disturbed areas within the proposed new mine permit area. United Nuclear Corporation (UNC) (a subsidiary of General Electric Company) and Sohio Western Mining Company (Sohio) (a subsidiary of Rio Tinto Corporation) are respectively responsible for reclamation of the St. Anthony and the JJ No. 1 mines, which are within the proposed permit area. Both companies are engaged in closure planning or reclamation of the existing mines and associated disturbances pursuant to requirements of the New Mexico Mining and Minerals Division (MMD) and the New Mexico Environment Department (NMED). Considerable useful resource data is available to Cibola from site characterization work completed by these companies in support of closure planning.

This SAP has been prepared in accordance with the requirements of New Mexico Administrative Code (NMAC) 19.10.6.602.D and describes how existing data will be used or new data collected to characterize and document existing resource conditions within the proposed mine permit area. In addition, the August 2010 *Guidance Document for Part 6 New Mining Operation Permitting Under the New Mexico Mining Act* (*Part 6 Guidance Document*) was used extensively to make sure that all elements of the SAP will meet MMD expectations for a new mine permit application. In keeping with the *Part 6 Guidance Document*, the SAP is organized by resource category with detailed descriptions within each category of exactly what data will be collected and how it will be collected to ensure that all information and data meet applicable data adequacy standards.

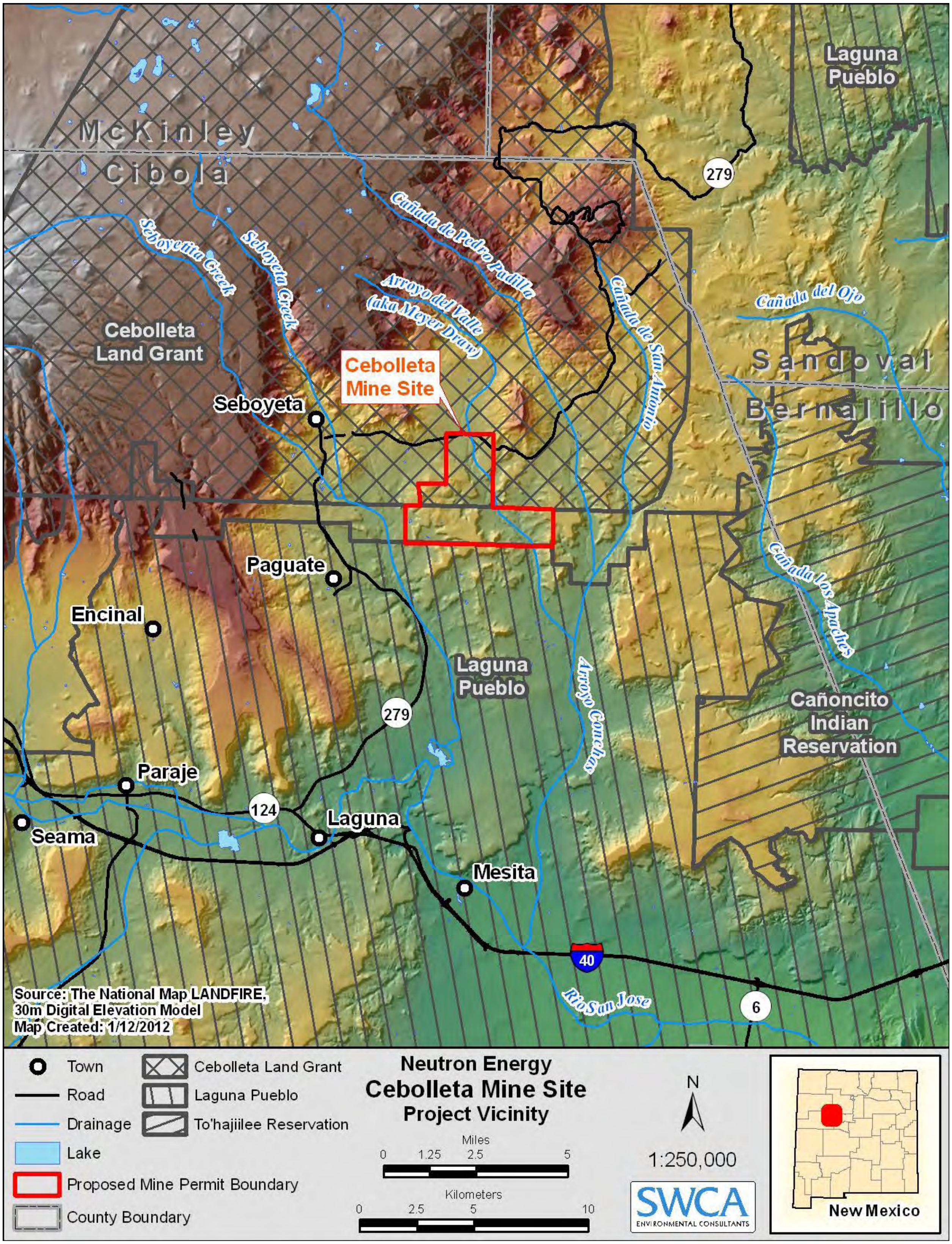

Figure 1.1. Project Area Vicinity

1.1 APPLICANT INFORMATION

1.1.1 NAME OF APPLICANT

Cibola Resources, LLC, is the applicant, with Neutron Energy, Inc., being the manager of Cibola Resources, LLC.

1.2 MAP OF PROPOSED PERMIT AREA

Figure 2.1 shows the proposed permit area drawn on a topographic map of the project area at a scale of 1:24,000.

1.3 LIST OF SURFACE AND MINERAL ESTATES

As noted, all minerals within the proposed permit area are owned by the CLG. The CLG also owns the majority of the surface estate within the proposed permit area, except as shown on Figure 2.1. Owners of the surface estate are:

La Merced Del Pueblo de Cebolleta (aka Cebolleta Land Grant)
c/o Lee Maestas, President, Board of Trustees
HC 77, Box 6
Seboyeta, NM 87014

Everest Holdings (aka Sayland Farms LLC, aka Lobo Partners LLC)
7373 North Scottsdale Road
Suite B-250
Scottsdale, AZ 85253

United Nuclear Corporation
c/o Roy S. Blickwedel
General Electric Company
640 Freedom Business Center
King of Prussia, PA 19406

1.3.1 MAP SHOWING SURFACE AND MINERAL OWNERS

Figure 2.1 shows all surface owners within and immediately adjacent to the proposed mine permit area and the exploration areas previously permitted under MMD Permit No. CI014ER. All minerals within the proposed permit area are owned by the CLG.

1.4 GENERAL DESCRIPTION AND MINE PLAN

1.4.1 LOCATION AND ACCESS

The proposed mine will be developed in an inactive, sparsely populated uranium mining district on private land owned by the CLG approximately 4 km (2.5 miles) east-northeast of the Village of Moquino in Cibola County New Mexico. Access to the proposed mine site is via New

Mexico Highway 279 (NM 279) north from Interstate 40 (I-40) through the villages of Laguna and Paguate and a portion of the CLG as shown in Figure 2.1. Entry into the mine site is through private land with locked gates so there is no public access.

1.4.2 MINE FACILITIES

The proposed permit area of 4,475 acres (1,811 ha) would include new surface disturbance areas totaling approximately 200 acres (81 ha), not including the existing disturbed areas that UNC or Rio Tinto are responsible for. The new mines will be developed as conventional underground operations, so the largest new surface disturbances will be associated with material stockpiles and a central infrastructure area consisting of administrative and maintenance facilities to serve multiple mine areas over the life of the project. Figure 2.1 shows the probable new disturbance areas encompassing all surface facilities.

Exact locations and dimensions for the buildings, ore pads, stockpiles, and support facilities are undetermined at this time but they will be located within areas fully characterized through implementation of this SAP. At this stage of project development, the Mine Operations Plan is conceptual, as provided for in NMAC 19.10.6.602(12)(a)(viii) and the *Part 6 Guidance Document*. As mine planning and design proceed, more specific locations and accurate footprints of probable disturbed areas will be identified and described in detail in the Mining, Operations, and Reclamation Plan (MORP) required as part of the Permit Application Package (PAP).

The intent of conducting environmental studies over the relatively large permit area described in this SAP is to ensure good characterization of all resources within the proposed permit area and identify possible avoidance areas or areas requiring special management. Within the proposed disturbed area footprints, more detailed studies will be completed to fully characterize existing conditions and constraints. Specifically, cultural resource surveys, radiation surveys, soil sampling, and sensitive species searches will fully cover the potential disturbed area footprints, including a buffer to allow flexibility in facility design as the MORP is developed. Before submitting a PAP as the next step in the mine permitting process, Neutron will also delineate exact boundaries of those existing mine and disturbed areas that would be excluded from Neutron's proposed permit area. In addition to disturbances from past mining, several thousand holes were drilled within the proposed permit area 30 to 50 years ago. Although many of the drill sites have been naturally reclaimed over the ensuing years, evidence of previous drilling is abundant.

1.4.3 DEVELOPMENT PLANS

Preliminary mine development plans at this time are to access the Area I ore deposit via a drift (tunnel) driven near the bottom of the existing St. Anthony pit approximately 0.6 km (0.4 mile) to the northwest. Ore will likely be removed using conventional room and pillar methods with excavated material stockpiled within mined-out areas and on the surface within the perimeter of Area I as shown. In addition to the surface facilities area shown there will be two or three ventilation shafts located in the general area. Ore will be stored for short time periods on lined pads designed to contain the ore and any runoff and prevent potential seepage. The ore will be removed from the ore pads and transported by truck to the mill at Marquez. Development (or waste) rock brought to the surface will also be stored in fully designed surface areas within the infrastructure area until final reclamation. Final reclamation of development rock piles will consist of sloping and contouring the piles to prevent erosion and facilitate revegetation. Minimal, if any, surface subsidence over the underground mine workings is anticipated as the rock overlying the deposits is very competent and previous underground mining at Cebolleta (Willie P underground mine, JJ No. 1 mine) has not caused obvious surface subsidence.

Area III will also be mined using conventional underground methods, with access to the deposit most likely via a decline (sloping tunnel) driven from the west within the infrastructure area shown in Figure 2.1 (use Area III layout on photo base). The common infrastructure facilities area will include the mine offices, shop facilities, power lines and substation, vehicle and truck parking areas, water treatment facilities, helipad (for MedEvac), truck wash, wheel wash, security office, and truck scales. The production decline for Area III, ore stockpiles, and development rock storage areas will also be within the probable disturbed area footprint shown in Figure 2.1. Additional surface disturbances at Area III will be limited to approximately three ventilation shaft locations and their associated access roads.

Current plans are to develop the Area I and Area III mines simultaneously, with construction expected to take about 18 months for each mine. At a projected annual production rate increasing from about 284,000 tons per year initially to a peak of about 831,000 tons per year, it is expected that mining will occur over a period of 16 years. Ore produced from the mines will be loaded into highway trucks, tightly covered, and hauled approximately 24 km (15 miles) on existing NM 279 to the mill site at Marquez. Truck wheels and undercarriages will be washed before leaving the mine site, surveyed for external radiation levels, and weighed. Trucks will again be weighed upon arrival at the mill site and all shipping records carefully checked on a regular basis to make sure all material is accounted for. Empty trucks will be washed again prior to leaving the mill site. Although NM 279 will need some upgrading, it was substantially improved in the 1970s specifically to serve as a haul road and is still in excellent condition. Once Area III is mined out, it will be reclaimed in accordance with the detailed reclamation plan required as part of the PAP. In general, reclamation will be planned and implemented to eliminate or minimize the potential for erosion, prevent release to the environment of any contaminants resulting from mining, and achieve a self-sustaining ecosystem within an acceptable time period as required by NMAC 19.10.6.603. Contemporaneous reclamation will include contouring and revegetating all surface disturbances as soon as practical, controlling runoff from operations and disturbed areas, stabilizing all development rock piles, and directly placing excavated waste rock into mined out areas underground where ever feasible.

As the Area I and Area III mines are being developed and produced, exploration and confirmation drilling will occur within the proposed permit boundary in areas adjacent to active mining. Neutron anticipates that additional ore bodies will be identified or confirmed, thereby extending the mine life and/or increasing production rates. The base case mine plan will be presented in the MORP and the appropriate permit modifications or revisions obtained from the MMD if changes from the base case become warranted. As described in following sections of the SAP, broad coverage baseline studies of such areas will be included in the initial surveys and be followed up with more site-specific studies as needed to support subsequent permit revisions or modifications.

1.4.4 RIGHT OF ENTRY

Cibola's right to enter and conduct mineral exploration, development, and mining on the CLG is granted via a lease by La Merced to Neutron in 2007. Documents describing the history of land and mineral ownership within the land grant and Cibola's rights under the lease, including the Memorandum of Lease, Surface Use Rights Memorandum, and Instrument of Transfer are presented in Appendix A.

1.5 LIST OF ALL PARTIES WITH OWNERSHIP INTEREST IN OPERATIONS

As the operator for Cibola, Neutron is the only party with any ownership or controlling interest in the project. Addresses and phone numbers for Cibola and Neutron are:

Cibola Resources LLC
c/o Neutron Energy Inc.
9000 E. Nichols Ave.
Suite 225
Englewood, CO 80112
(303) 531-0470

1.6 STATEMENT OF ALL MINING OPERATIONS

Neither Cibola nor Neutron own, operate, or control any mining operations in the United States. Neutron and Cibola do hold exploration permits issued by the MMD as follows:

- Cibola Resources, LLC – Permit No. CI014ER, approved 1/19/2011
- Neutron Energy Inc. – Permit No. MK023ER, approved 3/30/2009; Permit No. MK028EM, approved 9/4/2009

1.7 CONTACT INFORMATION

The designated agent for this permit application is:

Michael Neumann
Vice President
Neutron Energy Inc.
9000 E. Nichols Ave., Suite 225
Englewood, CO 80112
(303) 531-0492 office
(970) 620-0749 mobile

1.8 PERMIT FEES

A check in the amount of $5,000 as specified by NMAC 19.10.2.203.B accompanies this permit application.

2.0 TOPOGRAPHIC MAPS

A topographic map illustrating the Cebolleta Mine Site project area, surface ownership within the project area, and the facilities footprint is found in Figure 2.1

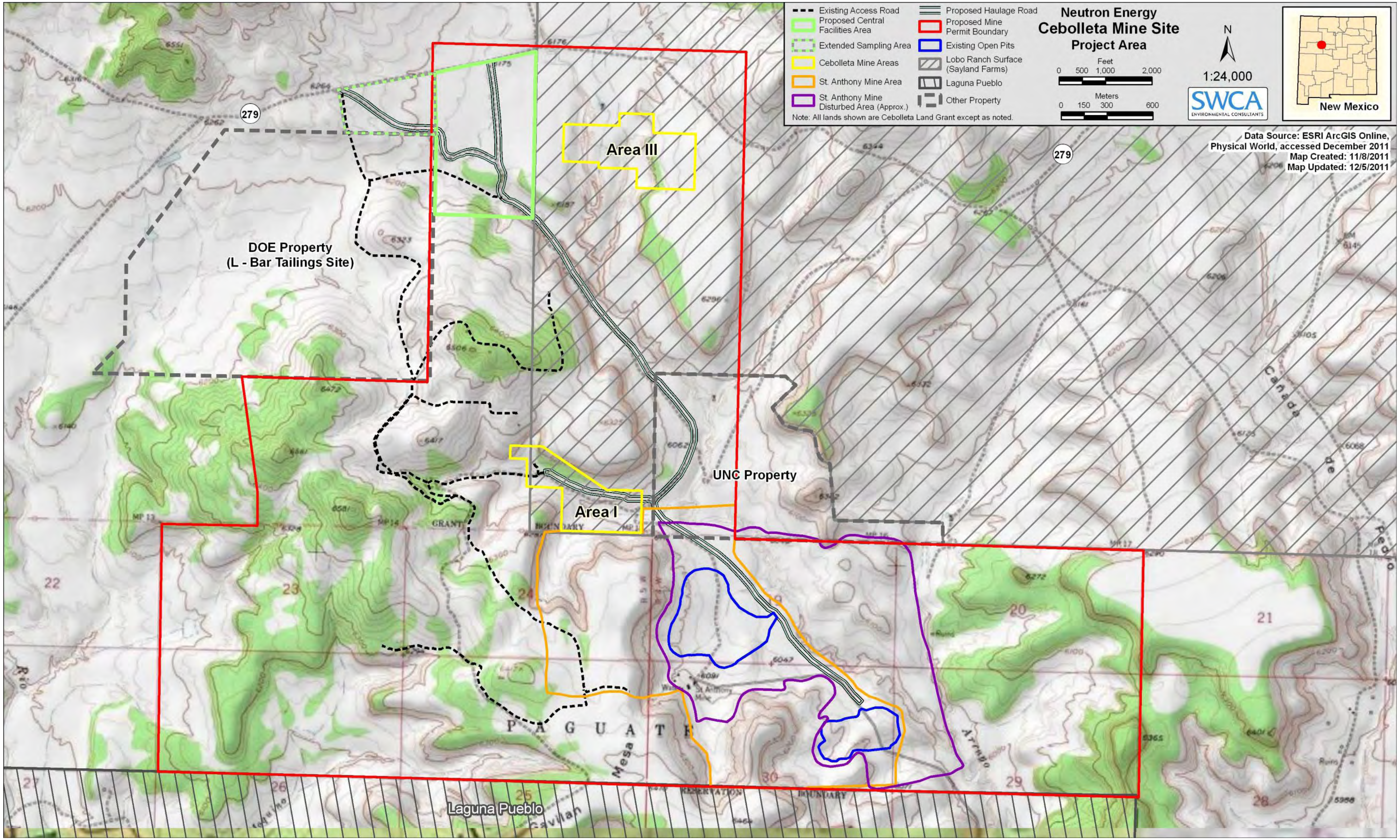

Figure 2.1. Topographic map of the Cebolleta Mine Site project area.

3.0 LAND USE

3.1 INTRODUCTION

The proposed mine will be developed in an inactive uranium mining district on private land owned by the Cebolleta Land Grant (CLG) and Everest Holdings approximately 4 km (2.5 miles) east-northeast of the Village of Moquino in Cibola County New Mexico, as shown in Figure 2.1. The Cebolleta Mine Site permit area covers approximately 4,475 acres (1,811 ha), with all but approximately 1,068 acres (432 ha) of the surface within the entire proposed permit area owned in fee by the CLG (see Figure 2.1). All minerals within the proposed permit boundary are owned by CLG. Cibola has an exclusive mining lease with the CLG granting access to all CLG-leased land for mineral exploration and development (see List of Surface and Mineral Estates, page 8).

3.2 DETERMINATION OF EXISTING LAND USES

The project area is a remote, dry, sparsely populated rangeland of New Mexico formerly part of the 200,000 acre Cebolleta Land Grant. Observations by Neutron staff over literally thousands of hours on and in the immediate vicinity of the Cebolleta project area over the last several years confirm that existing land uses within the privately owned lands comprising the proposed permit area are limited to historic uranium mining, livestock grazing, and sparse wildlife utilization. There are no public lands within the proposed permit area, or access to the public. All surface lands are controlled by either the CLG or Everest Holdings. There are no residences, croplands, recreational facilities, or permanent buildings within the proposed permit area boundary.

Documenting historic and past land uses within and around the proposed project area will consist of acquiring relevant available records from the Cibola County Assessor, in Grants, New Mexico. The next step will be to review historic and current topographic maps from the US Geological Survey (USGS) and US Department of Agriculture/ Natural Resources Conservation Service (NRCS). The records from the county Assessor's office will be reviewed alongside the topographic maps to provide an initial background on the land uses and land use capabilities in the area.

Additional information regarding past and present land uses within the general project area will be obtained from written CLG histories, public resource reports, and interviews with land owners, managers, leaseholders, or tenants within and around the proposed permit area. Information from this process will confirm current land uses and provide at least some quantification of livestock grazing practices, previous mining activities, population trends, future land use plans and similar data.

Public records including most recently available census data, tax records, county Master Plans, land use plans, traffic studies, school enrollment records, historic photos, etc. will also be reviewed as part of the land use documentation process. However, because most of the land (and all of the minerals) within the proposed permit area is owned by the CLG, and has been under its control since 1800 A.D., information from the CLG will likely be the most useful in describing present and historic land uses.

3.3 Method for Delineating Prior Mining Operations Within the Permit Area

The New Mexico Mines Database (NMMD), maintained by the New Mexico Bureau of Geology and Mineral Recourses (NMBGMR) will be a primary source of public information to be used in delineating the existing mines within the proposed permit boundary. This source would supply both information and photographs specific to mines within this area. In addition, Neutron has obtained recent satellite photo coverage of the project area which can be used to map the surface extent of existing disturbances including currently un-reclaimed mines within the proposed permit area. Neutron has also obtained much relevant information from UNC and Sohio including some maps showing the historic underground mine workings that can be used to delineate prior mining activities within the permit area.

The New Mexico MMD and Environment Department will also be consulted regarding information pertinent to the mines within the proposed permit area. Neutron has been deeply involved with the evaluation of close-out alternatives for the St. Anthony mine and has held several discussions with UNC regarding coordination of mine reclamation and development plans. Neutron is also quite familiar with the recent reclamation work completed on the JJ No. 1 mine by Sohio Corporation and again has access to proprietary information that will be used to accurately delineate the extent of mining and reclamation operations associated with prior mining activities. Appropriate maps and aerial photos will be included in the Baseline Date Report (BDR) to clearly illustrate the extent of prior mining activities within the proposed permit area.

4.0 CLIMATOLOGICAL FACTORS

4.1 INTRODUCTION AND BACKGROUND

The closest weather station with publically available data is located in the Village of Seboyeta, approximately five miles west of the project area. In order to provide site-specific climatological data representative of the proposed permit area, Neutron began operation of a 10-m (33-foot) meteorological tower near the southeastern boundary of the proposed mine permit area on June 10, 2011. The tower is instrumented with wind direction, wind speed, temperature, precipitation, pan evaporation, and relative humidity. A summary of the data collected from inception through September 30, 2011, can be found in Table 4.1 through Table 4.3 and Figure 4.1. Details on collected parameters, instrument specifications, and site location appear in Section 4.6. The data collection procedures described in this document apply to the historical data that are presented in this section. The tower operations are ongoing as of the date of this document.

The following tables and graphic summarize the meteorological characteristics of the project study area for June 10 through September 30, 2011. Given a data capture rate of 99%, the data are representative without any systematic bias due to missing values for the summer months of June through September. The precipitation and temperature statistics follow expected monthly and seasonal patterns based on site elevations, terrain, and geographic location. The predominate wind direction is bimodal from the northwest and west southwest following prevailing wind patterns in north central New Mexico, the local terrain influence of canyon drainages, and the higher terrain to the west and north. Based on data collected to date, monthly average wind speeds are low to moderate ranging from 2.6 to 4.5 m (8.5–14.8 feet) per second. Precipitation totals are consistent with the summer rain pattern with 15.98 cm (6.29 inches) total during this period. Evaporation rates peak in the early summer months with warm daytime temperatures and prior to the onset of the summer rains.

Table 4.1. Cebolleta Meteorological Tower Data Summaries for June–September 2011

Month	Temperature 2 Meter (C)			Relative Humidity (%)			Wind Speed (m/s)	
	Max	Min	Average	Max	Min	Average	Max	Average
June	35.5	9.3	25.2	54.1	4.0	15.0	13.3	4.5
July	35.1	14.6	25.1	95.9	9.1	39.0	12.3	3.2
August	34.9	14.7	24.8	99.0	6.6	43.4	13.6	2.8
September	31.7	8.4	18.8	96.1	9.0	49.8	12.4	2.6

Table 4.2. Cebolleta Meteorological Tower Monthly Precipitation and Evaporation Totals for June–September 2011

Month	Precipitation (inches)	Evaporation (inches)
June	0.08	11.38
July	1.34	11.20
August	2.50	8.44
September	2.37	4.96
Totals	**6.29**	**35.98**

Table 4.3. Cebolleta Meteorological Tower Monthly Data Capture in Percent

Month	Excluding Evaporation	Including Evaporation
June	100	94
July	100	99
August	100	99
September	100	99

Note: Evaporation parameter reduces overall data capture percentage due to the daily pan water refill event. Validity of evaporation pan data is not necessarily affected.

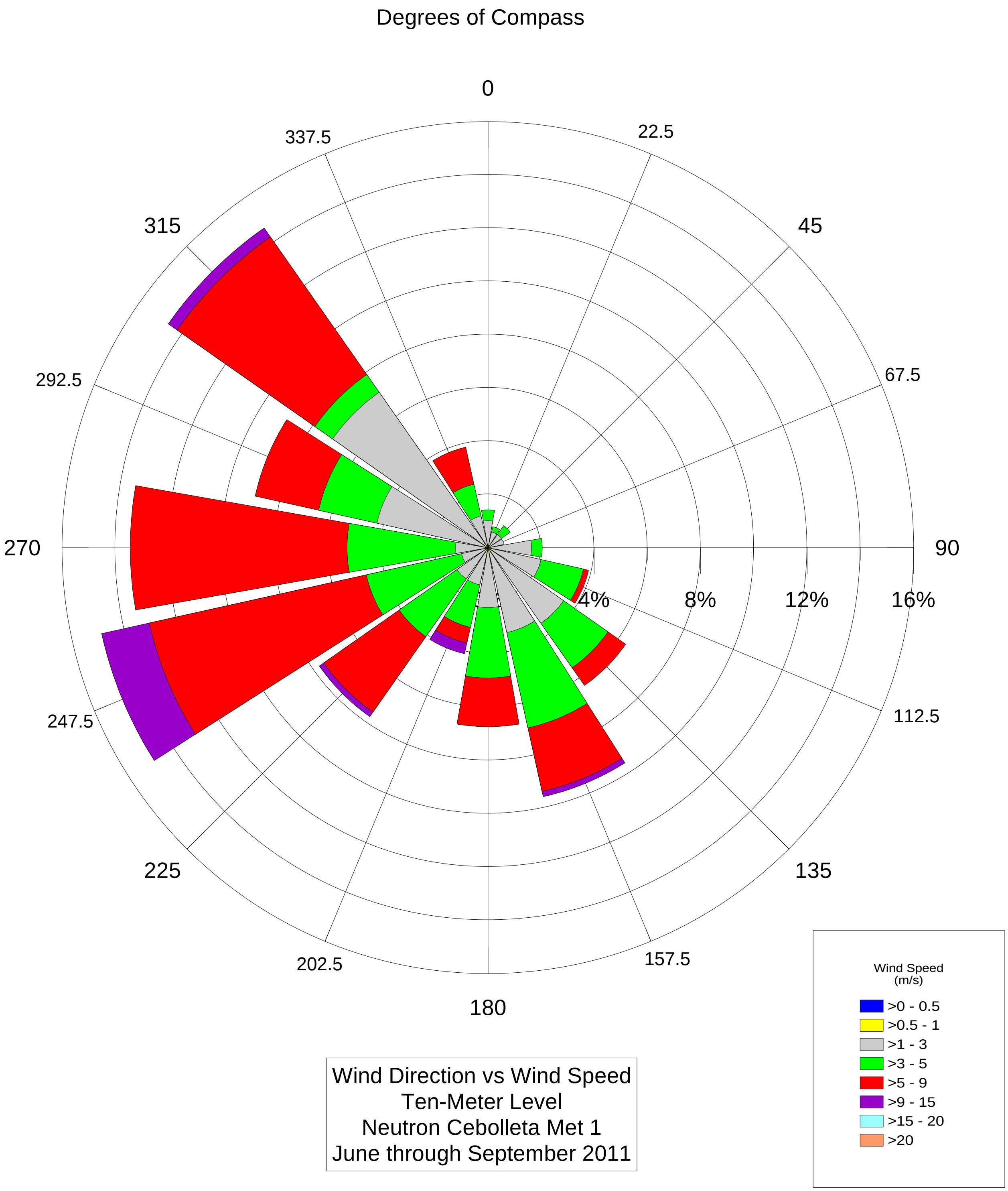

Figure 4.1. Wind direction vs. wind speed, Cebolleta meteorological tower, June–September 2011.

4.2 SAMPLING OBJECTIVES

4.2.1 METEOROLOGICAL

The current monitoring program consists of a single meteorology station initiated on June 10, 2011. The purpose of the monitoring program is to collect baseline climatological data representative of the project area that satisfy the criteria of the New Mexico Surface Mining Act and provide solid data for project planning and design. The equipment and monitoring criteria specified in these documents also satisfy long-term project needs for climate characterization and impact analysis on ambient air quality and climatology. The listed criteria meet or exceed the National Weather Service Measurements Quality Objectives as published in the U.S. Environmental Protection Agency (EPA) *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements*; Table 0-11 (March 2008).

4.3 METEOROLOGICAL MONITORING PROTOCOL

Class One Technical Services installed a 10-m (33-foot) meteorological tower (Mill Site 1) on June 10, 2011, to acquire data in support of climate characterization needs. The site is located near the southeastern boundary of the mine area at an elevation of 1,859 m (6,100 feet). Figure 4.2 illustrates the proposed mine areas, haul and access roads, the central facilities area, and the Mine Site 1 tower location.

The terrain in the general project area is characterized as complex, consisting of broad flat mesas incised with shallow valley drainages trending north to south. The predominate terrain feature in the region is the Mt. Taylor caldera with associated ridges and mesas extending to the northwest of the study area and the mountain rising to approximately 3,353 m (11,000 feet) in elevation. The proposed Cebolleta Mine Site includes a previous surface mining operation located within one of these drainages. The canyon section (Meyer Draw) containing the existing mine area trends from north-northwest to the southeast. The elevation at the lowest point of the mine area is approximately 1,844 m (6,050 feet). The west and east slopes ascend to elevations of approximately 1,950 m (6,400 feet) and terminate in broad, flat mesa-type terrain. The rim and sides of the valley are irregular in shape and broken by arroyos flowing into Meyer Draw. Immediately north and west of the existing mine area the canyon broadens further into open valleys where future mining is planned in Areas I and III. The existing St. Anthony mine area is characterized by open pits interspersed with piles of waste rock. The meteorological tower is centrally located near the southern boundary of the proposed permit area at an elevation of 1,859 (6,100 feet).

Ground cover on the mesa surfaces and valley and canyon floors is sparse. The mesa tops are predominately desert grassland with few low juniper (*Juniperus* sp.) trees and cholla cactus (*Cylindropuntia* sp.) providing low surface roughness. The valley and canyon vegetation is desert grassland and sparse desert scrub.

The primary emissions due to mining and related activities will be fugitive particulate matter due to ground disturbance, light vehicle traffic, emissions from ore and waste rock stockpiles, ore transport, and mine vents. The releases will be predominantly ground level with low vertical velocity.

The Mine Site 1 will provide representative meteorological data for the air drainages of Arroyo del Valle (aka Meyer Draw), tributaries, and adjacent mesa lands. The Mine Site 1 tower site collects representative meteorological data due to the following factors:

- The tower is located within the pre-existing and proposed mine project area.
- The tower base elevation approximates the average elevations of the mine areas and the hauling and facilities area in the broad drainages where future mines will be developed.
- The tower collects wind speed and wind direction data at the 10-m (33-foot) level to represent air flow through the valley drainages as well as regional meteorological conditions.
- Arroyo del Valle forms the predominant air drainage from the mine site and surface operations trending north to south. The tower base elevation combined with wind measurements at the 10-m (33-foot) level provides a regional representation of meteorological wind patterns across the project area.
- Vegetative ground cover and surface characteristics are similar to a large portion of the project area with no obstructions to bias either the tower or ground based measurements.

4.4 SAMPLING FREQUENCY

4.4.1 METEOROLOGICAL STATION

Meteorological sensors are to be scanned once each second. The data are compiled as averages and totals at 15- and 60-minute intervals.

4.5 LIST OF DATA TO BE COLLECTED

4.5.1 METEOROLOGICAL

Data validations will be performed on a monthly basis with data reported and summarized quarterly and annually. A minimum of one year of continuous baseline data will be collected. The meteorological data will provide input to characterize the following climatological factors:

- Wind direction;
- Wind speed;
- Temperature;
- Precipitation;
- Relative humidity; and
- Evapotranspiration.

The data capture goal will be 90% or greater, on an annual basis, for each meteorological parameter. Averages and totals of the data are output at 15- and 60-minute intervals. The project currently has over six months of data collected with data capture rates exceeding 90%. See Table 4.4 for the meteorological data that will be collected and the instruments that will be used.

Table 4.4. Meteorological Data to be Collected – Mine Site 1

Parameter	Tower Level (m above ground surface)			Equipment Manufacturer and Model
	0	2	10	
Horizontal Wind Direction			x	Climatronics F460
Horizontal Wind Speed			x	Climatronics F460
Ambient Temperature		x		Vaisala Naturally Aspirated
Pan Evaporation	x			NovaLynx
Relative Humidity		x		Vaisala Naturally Aspirated
Precipitation	x			Hydrological Services TB06 Tipping Bucket

Although not required by the MMD for mine permit applications, Neutron is also collecting air quality data at two sites, one located upwind of proposed mining operations and another located generally downwind near the meteorology station. The location of these air particulate samplers is also shown on Figure 4.2.

4.6 METHODS OF COLLECTION

4.6.1 METEOROLOGICAL MONITORING

Data will be collected and stored on a Campbell Scientific CR800 datalogger. Data will be downloaded every two weeks to a portable laptop PC directly from the datalogger. Remote communications will not be available for the tower. The datalogger will have the capacity to store approximately two months of data on-site. Table 4.5 contains the operating specifications for each model of meteorological sensor.

Table 4.5. Cebolleta Equipment Sensor Specifications

Sensor	Manufacturer	Model	Range	Accuracy
Wind Speed	Climatronics	F460	0–145 mph (0–65 m/s)	0.15 mph (+/- 0.07 m/s) or +/- 1.0% of true air speed (whichever is greater)
Wind Direction	Climatronics	F460	0–360 degrees – mechanical	+/- 2 degrees
Temperature	Vaisala	HMP60	-40^{o}C–60^{o}C (-40^{o}F–140^{o}F)	+/- 0.6^{o}C (+/- 1.1^{o}F)
Relative Humidity	Vaisala	HMP60	0%–100%	+/- 3%RH, 0-90%Range (0 to 40^{o} C) +/- 5%RH, 0-90%Range (-40 to 0^{o} C)
Precipitation	Hydrological Services	TB06	0.001 inches per tip (0.254 mm per tip)	+/- 3%
Pan Evaporation	NovaLynx	255-100	0–9 inches water	0.25% Evaporation gauge with pan and pipes +/- 0.25% over 10-inch range

4.7 PARAMETERS TO BE ANALYZED

4.7.1 METEOROLOGICAL PARAMETERS

The meteorological tower will report 15- and 60-minute averages for the following parameters:

- Horizontal wind direction;
- Horizontal wind speed;
- Sigma theta of the wind direction;
- Temperature at 2 m (6.6 feet) (T2);
- Relative humidity; and
- Pan evaporation.

In addition, the meteorological tower will report 15- and 60-minute totals for precipitation and evaporation.

The map provided in Figure 4.2 shows the location of the meteorological monitoring stations. Coordinates for the station location are provided in Table 4.6.

Table 4.6. Cebolleta Proposed Monitoring Sites

Site	Lat/Lon	UTM (Zone 13, NAD83)
PM10 Site 1	35°11'16.06"N	288,365 E
	107°19'27.69"W	3,896,344 N
PM10 Site 2	35°9'22.78"N	291,860 E
	107°17'6.33"W	3,892,770 N
Met Tower	35°9'10.85"N	291,552 E
	107°17'18.18"W	3,892,409 N

4.8 MAPS SHOWING PROPOSED SAMPLING LOCATIONS

Figure 4.2 shows location of the proposed meteorological monitoring tower sites in relation to the proposed mine and mine permit boundaries. Note that the map scale used makes it appear that the station is located outside the proposed permit area, but is in fact located on the CLG within the permit boundary.

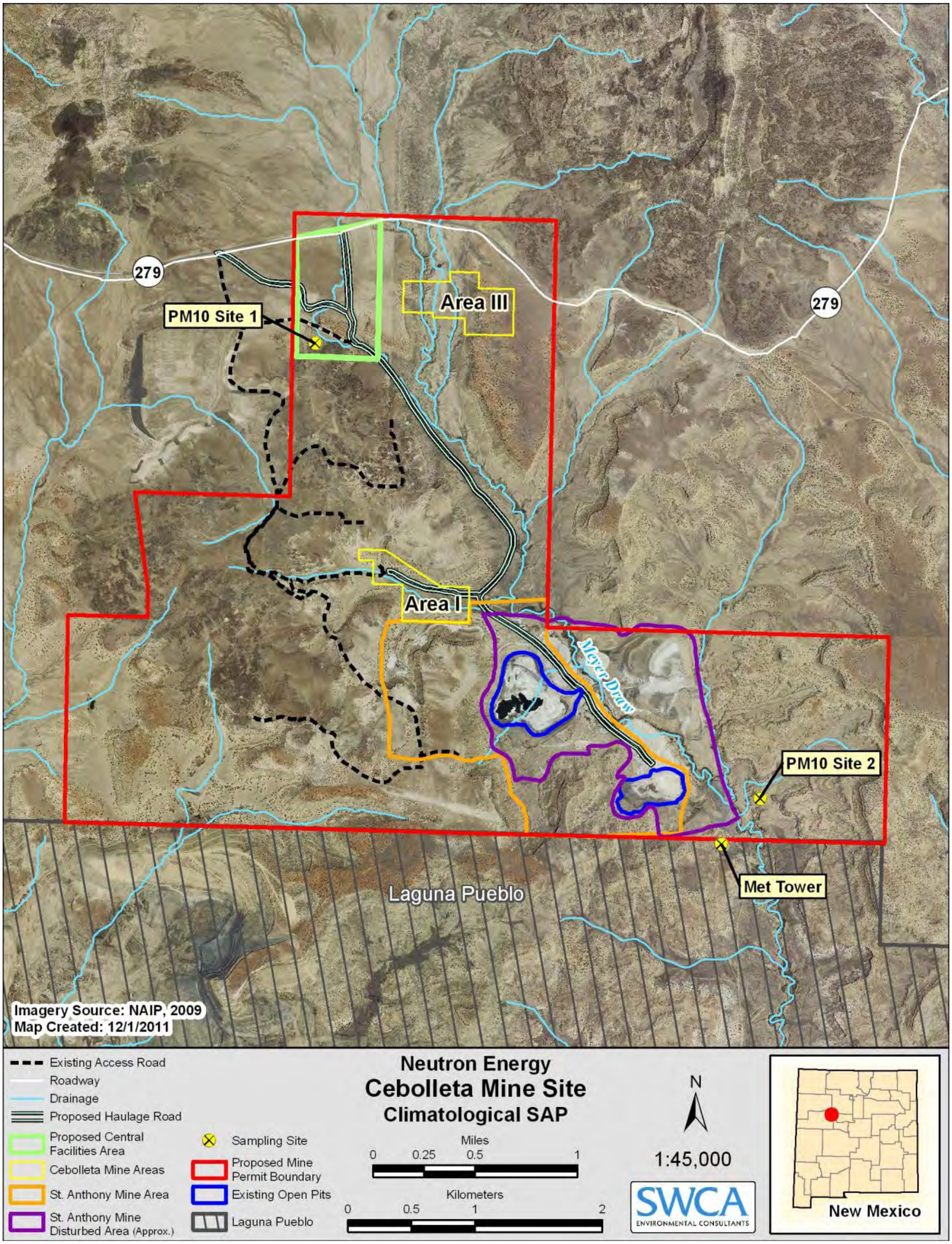

Figure 4.2. Cebolleta Mine Site meteorological monitoring sites.

4.9 LABORATORY AND FIELD QUALITY ASSURANCE PLANS

4.9.1 DATA VALIDATION AND REPORTING

All data will be reviewed by a senior air quality professional retained by Neutron as information is received from the field. Any problems detected during the data review will be immediately communicated to the field technicians and then to the data reduction specialists. Air quality specialists will compile the data and document validation actions taken on a monthly basis. Once validations are complete, a report file listing of each parameter with time stamp and headers will be generated and accompanied by statistical summaries. The statistical summary reports will include frequency distribution tables by parameter, reporting maximums, minimums, and averages by hour and day for the month. Wind patterns will be summarized as a joint frequency distribution of wind speed and wind direction resulting in a graphical wind rose. Parameters such as precipitation and evaporation will be summarized with daily and monthly totals including time of occurrence and duration. The individual monthly summaries will be compiled into quarterly and annual reports. The quarterly and annual reports will follow the data listings and summary statistics described for the monthly summaries. All procedures for calculation and reporting of data capture and determination of compliance will be performed in general accordance with the following, as relevant and appropriate:

- Paragraph 13 of Subsection D of 19.10.6.602 NMAC – Baseline Data.
- EPA: *On-Site Meteorological Program Guidance for Regulatory Modeling Applications, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Specific Methods* (Appendix D), and *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements* (EPA 2000, 2008a, 2008b).
- U.S. Nuclear Regulatory Commission (NRC): *Regulatory Guide 1.23, Revision 1* (March 2007), As referenced in Regulatory Guide 3.8
- NRC: *Regulatory Guide 3.8, Preparation of Environmental Reports for Uranium Mills, Revision 2* October 1982
- NRC: *Regulatory Guide 3.63, Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Reporting*, March 1988 and Reviewed September 2009.

4.9.2 QUALITY ASSURANCE/QUALITY CONTROL

The quality assurance/quality control (QA/QC) audits will be conducted with personnel and equipment completely independent from the routine field operators and their chain of supervision. The tower-based meteorological sensors will be audited every six months. Problems encountered during the audits will be corrected at the time of the audit or immediately referred to the station operator. All audit results will be summarized in a separate report to be issued following each field visit. All audit procedures and equipment will conform to the federal regulations and guidelines listed above.

4.10 DISCUSSION IN SUPPORT OF PROPOSAL

The Mine Site 1 Tower is located within the boundary of the proposed mine operation. The site is situated near the southern boundary at an elevation approximating the average elevation of the active mining areas and pre-existing overburden piles. The selected site is undisturbed by previous mine activities providing natural ground and soil conditions for the area. The tower monitors temperature and relative humidity at 2 m (6.6 feet) with precipitation and evaporation at ground level. This combination of parameters will provide a representative data set of moisture evaporation rates and precipitation levels for the surrounding region including the multiple mine sites. Additionally, the tower instrumentation and quality assurance procedures will document and validate exceptional meteorological events such as heavy rains, high winds, extreme temperatures, and unusually dry conditions, that may occur during the baseline study period.

The 10-m (33-foot) wind direction, wind speed, and sigma theta provide a regional representation of short term and long term climatological conditions. Additionally, these data provide meteorological dispersion parameters for future emissions analysis.

4.11 LITERATURE CITED

Environmental Protection Agency (EPA), 2000, On-site Meteorological Program Guidance for Regulatory Modeling Applications, EPA document EPA-454/R-99-005 February 2000.

Environmental Protection Agency (EPA), 2008a, On-Site Meteorological Program Guidance for Regulatory Modeling Applications, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Specific Methods

Environmental Protection Agency (EPA), 2008b, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, EPA document EPA/454/B-08-002.

U.S. Nuclear Regulatory Commission: Regulatory Guide 1.23, Revision 1 (March 2007), as referenced in Regulatory Guide 3.8

U.S. Nuclear Regulatory Commission: Regulatory Guide 3.8, Preparation of Environmental Reports for Uranium Mills, Revision 2 October 1982

U.S. Nuclear Regulatory Commission: Regulatory Guide 3.63, Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Reporting, March 1988 and Reviewed September 2009.

Title 40 CFR Part 58 Appendix B: Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring

5.0 VEGETATION SURVEY

5.1 INTRODUCTION AND BACKGROUND

This document proposes methods and protocols for a quantitative baseline biological survey of the Cebolleta Mine Site (see Figure 2.1), as part of the permitting process for the proposed mine. The information obtained from this vegetation SAP will meet the *Part 6 Guidance Document*, (EMNRD, August 2010), specifications for vegetation studies and analysis.

Existing literature information on the flora and fauna of the Cebolleta Mine Site region, including previous studies done on the site, was reviewed and compiled by SWCA Environmental Consultants (SWCA) to support this vegetation SAP. The literature search provided information on the potential presence of U.S. Fish and Wildlife Service federally listed threatened or endangered plant species that may occur at the site in Cibola County or in adjacent Bernalillo, McKinley, and Sandoval counties. The Zuni fleabane (*Erigeron rhizomatus*) is the only known protected plant species known to occur in the general region (Table 5.1). However, the species is known from western, not eastern, McKinley County and is not known to occur in the immediate region of the Cebolleta Mine Site (New Mexico Rare Plant Technical Council [NMRPTC] 2011).

Table 5.1. Threatened or Endangered Plant Species Known to Occur in Cibola, McKinley, and Sandoval Counties, New Mexico

Common	Scientific	Federal Rank/ County	State Rank/ County
Zuni fleabane*	*Erigeron rhizomatus*	Threatened McKinley	Endangered McKinley

Source: U.S. Fish and Wildlife Service (2011) and NMRPTC (2010).

The entire proposed Cebolleta Mine Site permit area encompasses approximately 4,500 acres situated in sandstone table lands composed of mesas and stream/arroyo drainage systems that feed into Arroyo del Valle (aka Meyer Draw). Exposed sandstone rim-rock areas are scattered along edges of the mesa top areas, while other portions of the mesa tops gradually slope down into arroyo drainages. A soils map of the site prepared by the Natural Resources Conservation Service (NRCS 2010) reveals several predominant soil types at the site: primarily Poley-Pojoaque very cobbly loams on mesa tops, Skyvillage-Rock outcrop-Bond complex on escarpments, and Sparank-San Mateo complex and Penistaja fine sandy loams in drainage bottoms. Knowledge of the presence and geographic distribution of soil types contributed to the classification of principal vegetation/habitat types appropriate for this Cebolleta Mine Site vegetation survey.

The Southwest Regional Gap Analysis Project (SWReGAP) (U.S. Geological Survey [USGS] 2004; Lowry et al. 2005) mapped vegetation communities or formations over much of the Southwest, including the proposed Cebolleta Mine Site, using interpretation of satellite images at 30 × 30–m pixel resolution. Thirteen vegetation types identified as occurring at the Cebolleta Mine Site (Figure 5.1) are listed, in order by amount of landscape coverage, as follows:

1) Colorado Plateau Pinyon-Juniper Woodland (dominates upland mesa tops)
2) Inter-Mountain Basins Mixed Salt Desert Scrub (dominates lowland drainage bottoms)
3) Inter-Mountain Basins Semi-Desert Shrub Steppe
4) Inter-Mountain Basins Semi-Desert Grassland
5) Inter-Mountain Basins Juniper Savanna
6) Inter-Mountain Basins Greasewood Flat
7) Inter-Mountain Basins Big Sagebrush Shrubland,
8) Colorado Plateau Mixed Bedrock Canyon and Tableland
9) Rocky Mountain Lower Montane Riparian Woodland and Shrubland
10) Inter-Mountain Basins Shale Badland
11) Southern Rocky Mountain Pinyon-Juniper Woodland
12) Colorado Plateau Mixed Low Sagebrush Shrubland
13) Rocky Mountain Alpine-Montane Meadow

Lowry et al. (2005) acknowledged that errors in mapping may occur from incorrect interpretation of spectral data. Initial field surveys of the site by SWCA personnel revealed that the proposed Cebolleta Mine Site is generally dominated by vegetation characteristic of juniper savanna and semi-desert shrub/steppe vegetation communities. Based on preliminary surveys, some of the SWReGAP vegetation types reported to be at the site, such as Rocky Mountain Alpine-Montane Meadow and Inter-Mountain Basins Big Sagebrush Shrubland, do not appear to exist within the project area. Knowledge of the presence and geographic distribution of SWReGAP vegetation types contributed to the classification of principal vegetation/habitat types and provided a basis to stratify the number and distribution of vegetation sampling locations appropriate for this vegetation SAP. The detailed vegetation sampling plan presented below will be stratified to reflect the extent and overall landscape vegetation/habitat patterns.

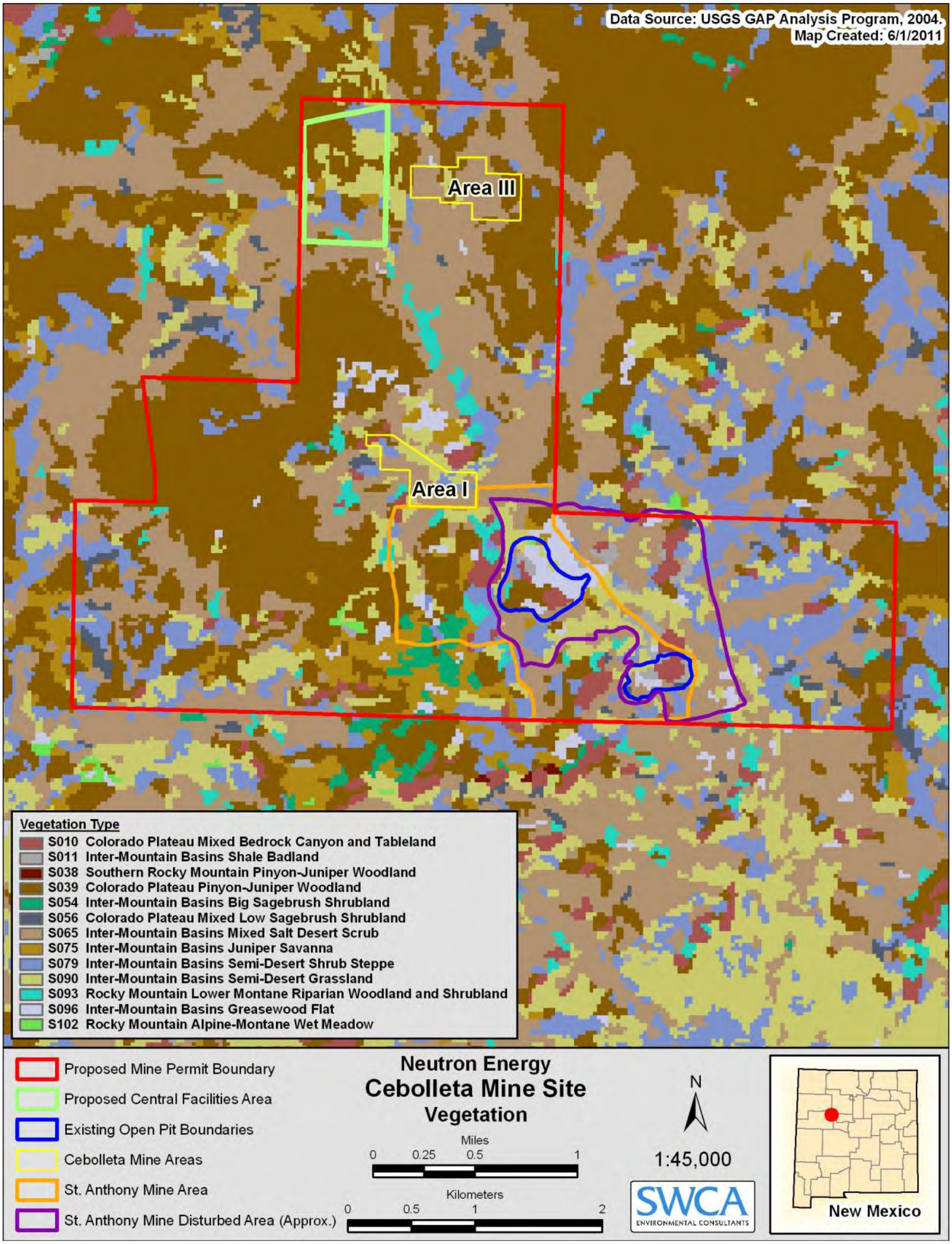

Figure 5.1. SWReGAP vegetation map of the proposed Cebolleta Mine Site (USGS 2004).

As evident from Figure 5.1 and field observations, two principal vegetation communities or types at the Cebolleta Mine Site dominate most of the project area and are therefore considered most important for vegetation and other biological surveys:

1) Upper Mesa/Rimrock/Piedmont Slope Juniper Savanna, consisting largely of Intermountain Basins Juniper Savanna, Colorado Plateau Pinyon-Juniper Woodland, Inter-Mountain Basins Semi-Desert Grassland, and Semi-Desert Steppe, and North American Warm Desert Bedrock Cliff and Outcrop; and

2) Drainage Bottom Shrub/Steppe, consisting largely of Inter-Mountain Basins Mixed Salt Desert Scrub, Semi-Desert Grassland and Semi-Desert Steppe.

   Figure 5.2 provides a map of the Cebolleta Mine showing geographic distribution of the principal vegetation/habitat types as defined here. Large disturbed areas are present within the Cebolleta Mine project area due primarily to previous St. Anthony mining activities and widespread overgrazing by domestic livestock. Figure 5.3 provides an image of typical Upper Mesa/Rimrock/Piedmont Slope Juniper Savanna in the distant center and the left right sides of the photograph, and Drainage Bottom Shrub/Steppe in the middle foreground of the photograph. The photograph was taken on May 11, 2011 near the center of the project area, view facing west.

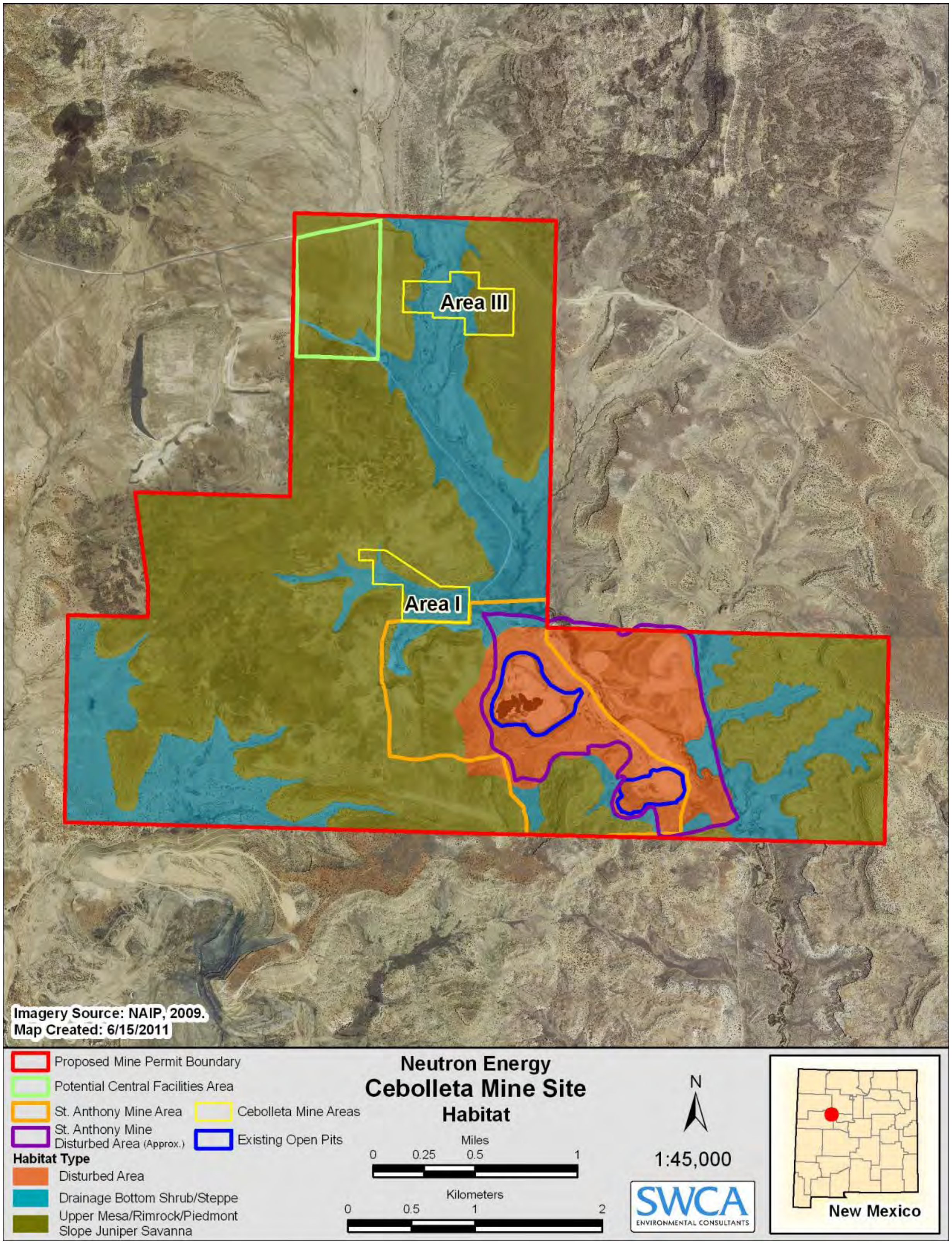

Figure 5.2. Aerial image of the Cebolleta Mine Site showing the distribution of principal vegetation/habitat types.

Figure 5.3. Cebolleta Mine Site project area facing west showing Upper Mesa/Rimrock / Piedmont Slope Juniper Savanna and Drainage Bottom Shrub/Steppe.

5.2 SAMPLING OBJECTIVES

The primary objective of a quantitative biological baseline survey of the proposed Cebolleta Mine Site is to survey the existing vegetation as part of an overall characterization of existing baseline resource conditions within the proposed mine permit boundary as required for a new mine permit application. Specific objectives for vegetation sampling are to inventory the species and quantify the composition and canopy cover of plant species across the site. Any species that are considered to be ecologically important to the overall ecosystem of the site, including threatened and endangered species, will be identified and their relative abundance, habitat associations, relationships with other species, and potential response to mine construction will be addressed. Additionally, the successional stages and productivity or annual yield of major vegetation communities will be determined.

The specific locations of mine facilities and associated disturbed area footprints are not completely known at this time. Therefore, this baseline survey will sample dominant vegetation types to obtain statistically representative data of the entire proposed mine permit area and to identify potential reference areas for reclamation comparisons. In order to sample principle landscapes or habitats, sampling locations will be subjectively located within each of the major landform/vegetation types present at the project area and within areas where surface disturbances are anticipated based on conceptual mine plans. Field measurements of vegetation will be conducted during the spring (April/May) and fall (September/October).

General pedestrian qualitative surveys of the flora of the Cebolleta Mine Site will be conducted as part of the overall baseline flora inventory to develop a complete listing of plant species found at the site and will continue concurrently with the quantitative sampling.

5.3 SAMPLING FREQUENCY

Vegetation field sampling will occur in the late spring (April/May) for winter/spring flowering perennial plants and annual plants, and again in the late summer or fall at the end of the growing season (September/October) for all plants. Both the late spring and late summer sampling periods will include qualitative pedestrian surveys for all plant species, plant species of conservation concern and exotic invasive species. , Quantitative measurements of plant species composition and annual aboveground plant biomass production will also be obtained over a minimum of one growing season.

5.4 LIST OF DATA TO BE COLLECTED

The following vegetation parameters will be measured at the Cebolleta Mine Site:

1) Landscape vegetation type or plant community map for the entire project area (evaluate and possibly modify Figure 5.1) including identification of special or unique wildlife habitat features as required by NMAC 19.10.6.602D(13)(d) and NMDGF June 2010 *Baseline Wildlife Study Guidance*.
2) Vascular plant species inventory for the entire project area:
   a) All plant species.
   b) Plant species of conservation concern.
   c) Non-native invasive plant species.
3) Vegetation attributes:
   a) Relative (percent) foliage canopy cover by vascular plant species per unit area.
   b) Annual aboveground biomass production or yield of vegetation per unit area.
   c) Vegetation condition resulting from former domestic livestock grazing using NRCS (2003) pasture condition scores.
   d) Photo points to visually characterize vegetation and to serve as baseline photographs for any future studies at all sampling locations.

5.5 METHODS OF COLLECTION

5.5.1 VEGETATION COMMUNITY MAP FOR THE ENTIRE PROJECT AREA

The initial overall project area vegetation community map (see Figure 5.4) was produced as discussed above using existing NRCS soils and SWReGAP maps, and from conducting pedestrian surveys across the project area. Those vegetation communities are based on dominant plant species and geomorphology, resulting in observable principal vegetation types or communities across the landscape. Further ground-truthing will be conducted during field surveys, and the overall vegetation map may be refined as more is learned about the flora of the project area. Photo points associated with vegetation measurement transects will provide visual records of vegetation type composition and structure across the project area. Initial photographs will be taken during the late summer when most plants are present and have maximum seasonal foliage canopies.

5.5.2 VASCULAR PLANT SPECIES INVENTORY FOR THE ENTIRE PROJECT AREA

GENERAL PLANT SURVEYS

Pedestrian surveys will be conducted in the spring and fall when other vegetation measurements are being collected at the site. A list of all vascular plant species, including rare or uncommon plant species, observed along with habitat associations will be prepared. Plant names and taxonomic classification will follow the U.S. Department of Agriculture PLANTS Database (http://plants.usda.gov/java/).

PLANT SPECIES OF CONSERVATION CONCERN

A survey for plant species of conservation concern, Zuni fleabane (see Table 5.1), will be conducted along with the general plant inventory survey. Surveys for the Zuni fleabane will be given special attention in appropriate habitats (clay slopes in piñon-juniper woodland) encountered in the project area, although the Cebolleta Mine Site is below the typical elevation where the Zuni fleabane is known to occur and the plant has not been identified during previous surveys of the project area.

NON-NATIVE INVASIVE PLANT SPECIES

A survey for non-native invasive plant species will be conducted along with the general plant inventory survey. Surveys for and documentation of invasive plants will also receive priority attention where they may be most likely to be encountered in the project area.

5.5.3 VEGETATION ATTRIBUTES

RELATIVE CANOPY COVER BY PLANT SPECIES AND GROWTH FORM

The point-line intercept method for measuring vegetation species composition and relative abundance will be used to measure the relative abundance of plant species based on foliage canopy cover (Elzinga et al. 2001; Herrick et al. 2005). Vegetation measurement locations will be subjectively established across the project area, in such a way as to maximize measuring vegetation attributes among the different vegetation types and habitats, with the total number to be proportional to each of the main habitat types that are relatively equal in acreage. Thirty-five vegetation measurement transects will be located across the project area and stratified by major plant community/habitat types (Figure 5.4), including:

- 12 transects located in the Drainage Bottom Shrub/Steppe (at vegetation transects 1, 2, 4, 6, 9, 12, 14, 17, 18, 20, 29, 35), and
- 23 transects located in the Upper Mesa/Rimrock/Piedmont Slope Juniper Savanna (at vegetation transects 3, 5, 7, 8, 10, 11, 13, 15, 16, 19, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34).

Point-line-intercept measurements will be taken from a 50-m (164-foot) transect established at each vegetation measurement location. The transect locations will be documented by use of GPS units in the field, the ends of each transect marked with an orange fiberglass rod, and each transect will be given a unique code number and the number marked on the rods. A 50-m (164-foot) measuring tape will be extended between each transect end point, and 50 measurement points will be situated at each 1-m (3-foot) interval along each transect. A narrow wire rod (1 mm diameter, 1 m [3 feet] long) will be positioned vertically on the soil surface at each of the 50 points along the measuring tape, and contact between the rod and each plant species will be recorded for each point following the point-line intercept protocols of Elzinga et al. (2001) and Herrick et al. (2005). Overlapping canopy layers will be recorded by documenting the sequence of each overlapping canopy per point from top to bottom. Vegetation will be measured during the spring (for winter/spring annual plants only) and fall (all perennial plants and summer annual plants at the end of the summer growing season). Data will be recorded in the field in specially designated data books and later entered into Microsoft Excel spreadsheet files. Each plant species will be categorized by growth form: grass, forb, shrub, tree, or succulent.

Common and dominant plant species will be characterized by the point-line-intercept method, while rare or uncommon plant species may be missed by point-line-intercept sampling. These species will be documented as a part of the general plant surveys discussed above. Overall plant diversity and estimated canopy cover for larger and more widely spaced (relative to herbaceous vegetation) woody shrubs and trees will be recorded from a 2-m-wide by 50-m-long (6.6-foot-wide by 164-foot-long) belt transect along each point-line-intercept transect. All vascular plant species observed within each belt transect will be recorded, along with overall canopy cover estimates for woody species, assigned to rank cover values in increments of 10% (equivalent to the expected error rate level of accuracy for visual estimates) for each entire 100-m² (50 × 2–m [164 × 6.6–foot]) belt transect. An additional field data form will be used to record the belt transect species composition data.

Trees such as juniper and piñon pine (*Pinus edulis*) are scattered across the landscape at larger spatial scales than appropriate for 50-m (164-foot) transect sampling. Tree densities will be determined using aerial images and geographic information system (GIS) measurements to determine the average tree densities on a per hectare basis.

ANNUAL VEGETATION YIELD

Vegetation annual yield or aboveground biomass production will be measured as standing aboveground live, dry plant biomass per unit area (Elzinga et al. 2001; NRCS 2003) during the fall sampling period. Quadrats 1 m^2 in size will be located within 1 m (3 feet) from the start point of each vegetation transect, for a total of 35 annual vegetation yield measurement quadrats located across the project area and stratified by the two major plant community/habitat types as previously described and shown on Figure 5.4. The sample size is believed to be adequate to characterize the aboveground biomass production due to the low diversity of dominant herbaceous species found on the site.

Each vegetation production quadrat will be enclosed in a screen cage in late spring or early summer to prevent domestic livestock from consuming the plant biomass. All live-standing, aboveground vegetation foliage will be clipped from each 1-m^2 quadrat and placed in a labeled paper bag. All bagged samples will be taken to the laboratory, dried and living tissue separated from dead, and weighed to the nearest gram to provide total live dry plant biomass per sample. Sample biomass will be partitioned by growth form. These samples will provide end of the growing season standing live vegetation biomass, by growth form, on a grams/m^2 basis. Mean or average values will be reported for each of the two principal habitat types.

VEGETATION CONDITION

The condition of vegetation resulting from historic and recent domestic livestock grazing and wildlife utilization will be evaluated using NRCS (2003) pasture condition scores to assess the degree of departure from the reference state for the ecological site.

VEGETATION PHOTO POINTS

Photographs will be taken of each vegetation transect and plant biomass quadrat in the fall of 2011, providing a view from the start point to the end point of each transect along with the biomass quadrat. These photographs will provide visual documentation of the environmental conditions of each transect and serve as a baseline or possible reference area should future comparisons be necessary.

The vegetation condition of the two principal habitat types will be assessed using the NRCS pasture condition scoring method (Cosgrove et al. 2001). This method rates range condition within the area of interest on a scale of 1 to 5 based on the current pasture (area of interest), productivity, and stability of its plant community, soil, and water resources. This evaluation will be conducted during the fall sampling period at the end of the 2011 growing season.

5.6 PARAMETERS TO BE ANALYZED

Data from qualitative field surveys, quantitative point-line intercepts, and belt transects will be used to compile a listing of all vascular plant species in the two principal habitat types, focusing specifically on the spring annual plants or summer annual and all perennial plants. A complete list of taxonomic species found at the project area will be produced. Other non-vegetation ground cover such as leaf litter, bare soil, or bare rock will also be reported from quantitative line-intercept data. The relative abundance or percent cover of each plant species, leaf litter, and bare soil or rock per habitat type also will be calculated by habitat type using the methods of Elzinga et al. (2001) and Herrick et al. (2005). Plant biomass data will be summarized as averages of grams/m^2 over the 15 samples per habitat type and partitioned by growth form.

5.7 Maps Showing Sampling Locations

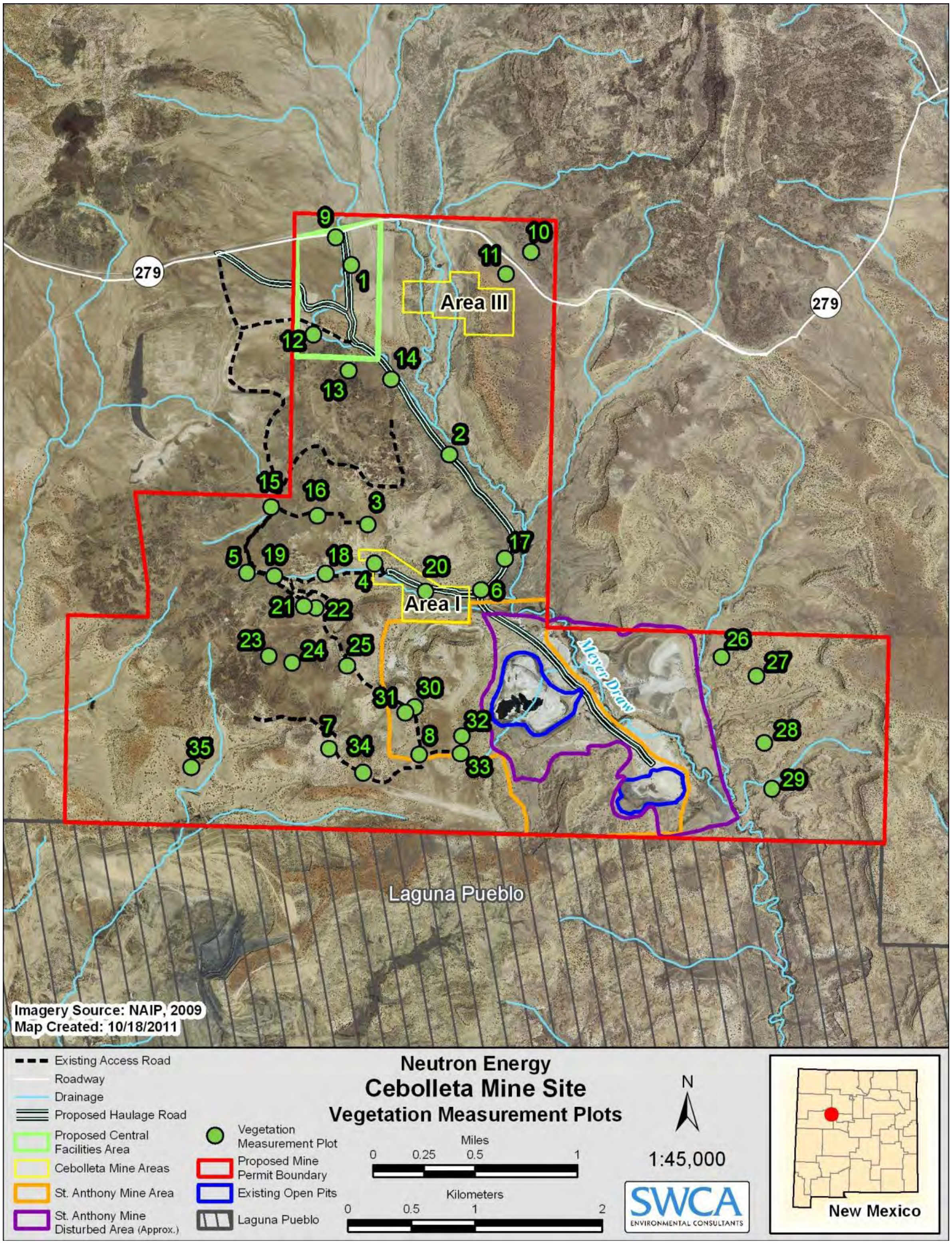

Figure 5.4. Aerial image of the Cebolleta Mine Site showing the locations of vegetation sampling points numbered 1–35. See text for habitat type designations of these transects.

5.8 LABORATORY AND FIELD QUALITY ASSURANCE PLANS

5.8.1 PERSONNEL

All field measurements, data collection, data analysis, and interpretation of findings will be conducted only by qualified biologists who have experience conducting these proposed field measurement and analysis protocols, and who are familiar with the plant species occurring in the region. Only experienced and qualified personnel will be employed for other aspects of the vegetation sampling and analysis, including data entry, data verification, data analysis, and interpretation of results and reporting.

5.9 SAMPLING PROTOCOLS

Standardized and widely used sampling protocols from Elzinga et al. (2001) and Herrick et al. (2005) will be used for all vegetation measurements. All data will be entered onto predesigned standard data forms and entered in to Microsoft Excel data files representing each data type file (line-intercept transect, belt transect, vegetation yield quads). Each vegetation transect will be measured the same way by the same qualified personnel. Each vegetation yield quadrat will be harvested the same way by the same qualified personnel. Standardized and widely recognized U.S. Department of Agriculture PLANTS Database names and taxonomic classification will be used. Samples of any plants that cannot be identified to the species level in the field will be collected and brought to the lab for positive identification. Photographs will only be taken in the field of any plants identified as or suspected to be threatened or endangered species.

5.10 DATA QUALITY ASSURANCE/QUALITY CONTROL

Standard data entry and data analysis protocols will be used, and only experienced data entry/management qualified personnel will conduct data entry and management. Data analysis will be conducted only by personnel experienced with statistical data analysis software and statistical theory, and with the ability to interpret the results of data analysis.

5.11 DISCUSSION IN SUPPORT OF SAMPLING PROPOSAL

The proposed field data collection protocols are standard and widely used methods for characterizing vegetation species composition, relative canopy cover, and annual aboveground net primary production (annual vegetation yield) (Elzinga et al. 2001; Herrick et al. 2005). These methods will provide the data needed to address the objectives for this vegetation SAP.

The results of the vegetation surveys will be incorporated into the BDR. The vegetation survey report will include the combined findings of both the qualitative and quantitative spring and fall vegetation surveys, and will be partitioned to address the major vegetation community/habitat types represented across the project area. The report will contain:

- Lists of all plant species found at the site over the study period, identification of important species, spatial and temporal distributions, and habitat associations of all species with an emphasis on important species.

- Data summaries and any comparative analyses will be reported from all quantitative sampling, including:
    - Data on relative abundance (counts and percentages of species found across the site, and
    - Aboveground plant biomass productivity.
- Photographs of landscapes and sampling locations.
- An evaluation of rangeland condition resulting from past and recent livestock grazing.

5.12 Literature Cited

Cosgrove, D., D. Undersander, and J. Cropper. 2001. Pasture condition score sheet. Natural Resources Conservation Service, Grazing Lands Technology Institute.

Elzinga, C.L., D.W. Salzer, J.W. Willoughby, and J.P. Gibbs. 2001. Monitoring Plant and Animal Populations. Malden, Massachusetts: Blackwell Science, Inc.

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2005. Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems. Quick Start. Design, Supplementary Methods and Interpretation, 1 and 2. U.S. Department of Agriculture, Agricultural Research Service Jornada Experimental Range, Las Cruces, New Mexico. Tucson: University of Arizona Press.

Lowry, J.H, Jr., R.D. Ramsey, K. Boykin, D. Bradford, P. Comer, S. Falzarano, W. Kepner, J. Kirby, L. Langs, J. Prior-Magee, G. Manis, L. O'Brien, T. Sajwaj, K.A. Thomas, W. Rieth, S. Schrader, D. Schrupp, K. Schulz, B. Thompson, C. Velasquez, C. Wallace, E. Waller, and B. Wolk. 2005. Southwest Regional Gap Analysis Project: Final Report on Land Cover Mapping Methods. Logan, Utah: RS/GIS Laboratory, Utah State University.

Natural Resources Conservation Service (NRCS). 2003. National Range and Pasture Handbook. Grazing Lands Technology Institute. Available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/. Accessed December 9, 2011.

———. 2010. Custom Soil Resource Report for McKinley County Area, New Mexico, and Parts of Cibola and San Juan Counties. (online application, map produced June 2010).

New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division (EMNRD). 2010. Guidance Document for Part 6 New Mining Operation Permitting under the New Mexico Mining Act. Santa Fe: New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division.

New Mexico Department of Game and Fish (NMDGF). June 2010. Baseline Study Guideline. http://www.wildlife.state.nm.us/conservation/habitat_handbook/documents/WildlifeBaselineStudyGuidelinesand%20Appendix.pdf. Accessed January 13, 2012.

New Mexico Rare Plant Technical Council (NMRPTC). 2010. New Mexico Rare Plants. Albuquerque: New Mexico Rare Plants Homepage. Available at: http://nmrareplants.unm.edu (latest update: December 6, 2010). Accessed July 7, 2010.

Nuclear Regulatory Commission (NRC). 1982. Regulatory Guide 3.8. Preparation of Environmental Reports for Uranium Mills. Revision 2, October, 1982.

U.S. Department of Agriculture. 2011. The PLANTS Database. Available at: http://plants.usda.gov/java. Accessed November 2, 2011.

U.S. Fish and Wildlife Service. 2011. Endangered, Threatened, Proposed, and Candidate Species in McKinley County, New Mexico. Southwest Region Ecological Services. Available at: http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm. Accessed May 24, 2011.

U.S. Geological Survey (USGS). 2004. Southwest Regional GAP Analysis Project Final Report. Logan, Utah: RS/GIS Laboratory, College of Natural Resources, Utah State University. Available at: http://earth.gis.usu.edu/swgap/. Accessed July 7, 2010.

6.0 WILDLIFE

6.1 INTRODUCTION AND BACKGROUND

The Cebolleta Mine Site has been previously surveyed for wildlife, including efforts to document use by any sensitive, threatened, and endangered species. Most of the previous environmental studies have focused on three specific locations; Areas I and III, and the area around the St. Anthony mine (Figure 6.1). Vegetation and wildlife was surveyed in St. Anthony area in 2005 by United Nuclear as support for possible revegetation and "closeout" of the existing mine. The revegetation plan provided information on flora and fauna covering 430 acres in the vicinity of the mine and evaluated conditions and habitat quality in the permit area.

In May 2008, original baseline studies were initiated by Neutron in Areas I and III that included surveys for wetlands, songbirds, raptors, and general wildlife using six and seven north-south transects (see Figure 6.1), respectively, established across each area (Hawks Aloft 2008a, 2008b). The 0.4-km (0.25-mile) buffer added around the perimeter of each area expanded the survey area to 437 acres (177 ha) (Area I) and 442 acres (179 ha) (Area III). The transects were resurveyed in July 2009, and additional searches for threatened and endangered species and of known raptor nesting locations were conducted (Hawks Aloft 2009). Raptor and songbird surveys were completed between May 1 and July 15, 2010, at Areas I and III with a focused effort to document loggerhead shrike (*Lanius ludovicianus*) nesting and to determine whether breeding gray vireo (*Vireo vicinior*) might be present (Hawks Aloft 2010). Only raptor surveys were conducted at the St. Anthony mine area in 2010, and any active raptor nests were monitored at least three times during the survey period. Subsequent documentation of wildlife at the site was completed in February 2011 and included the entire Cebolleta mine area (Permits West 2011). Forty-two stations were established consisting of a combination of transects to survey for furbearing mammals and circular plots to sample for large mammal sign (e.g., scats, scrapes, bones, burrows) across an area comprising 3,397 acres (1,375 ha) (Permits West 2011) (see Figure 6.1).

6.1.1 EXISTING HABITAT

The proposed Cebolleta Mine Site Areas I and III consist of primarily heavily grazed high desert grassland with scattered one-seed juniper (*Juniperus monosperma*), Rocky Mountain juniper (*J. scopulorum*), and occasional piñon pine. Grasses and annual forbs dominate with shrubs such as rabbitbrush (*Chrysothmnus* sp.), big sagebrush (*Artemisia tridentata*), fourwing saltbush (*Atriplex canescens*), and winterfat (*Eurotia lanata*).

The site has varying topography with elevation ranging from approximately 1,828 m (6,000 feet) in the St. Anthony mine pit and in the large open canyons bisecting the area to nearly 2,011 m (6,600 feet) on the highest ridges of the adjacent mesas.

6.2 SAMPLING OBJECTIVES

Sampling objectives are to thoroughly identify the vertebrate fauna at the Cebolleta Mine Site by using observational and specific inventory techniques to describe the baseline species composition, density, distribution, and habitat preferences prior to initiating new mining activities. The data collected will help assist in the evaluation of the potential short- and long-term impacts and cumulative effects of the proposed mines. In addition, the data will provide the basis for future mitigation and reclamation plans and the evaluation of their effectiveness. The results of the wildlife surveys will be incorporated into the BDR, which will be submitted as part of the PAP.

6.3 PREVIOUS DATA COLLECTION

To meet the objectives identified in Section 6.2, collection methodology will be selected to supplement observational data previously collected. Hawks Aloft (2008a, 2008b) established 13 north-south transects to survey for wetlands, songbirds, raptors, and general wildlife. The transects were resurveyed in July 2009, at which time additional searches for threatened and endangered species and known raptor nesting locations were conducted (Hawks Aloft 2009). Raptor and songbird searches were again conducted in 2010 at Areas I and III with a focused effort to document loggerhead shrike nesting and to determine whether breeding gray vireo might be present (Hawks Aloft 2010). Raptor surveys were conducted in the St. Anthony mine area in 2010. Permits West (2011) established 42 random sampling sites in the Cebolleta Mine Site project area to estimate the presence of big game and furbearing mammals. Figure 6.1 illustrates the Hawks Aloft transect lines and the Permits West large mammal sampling sites.

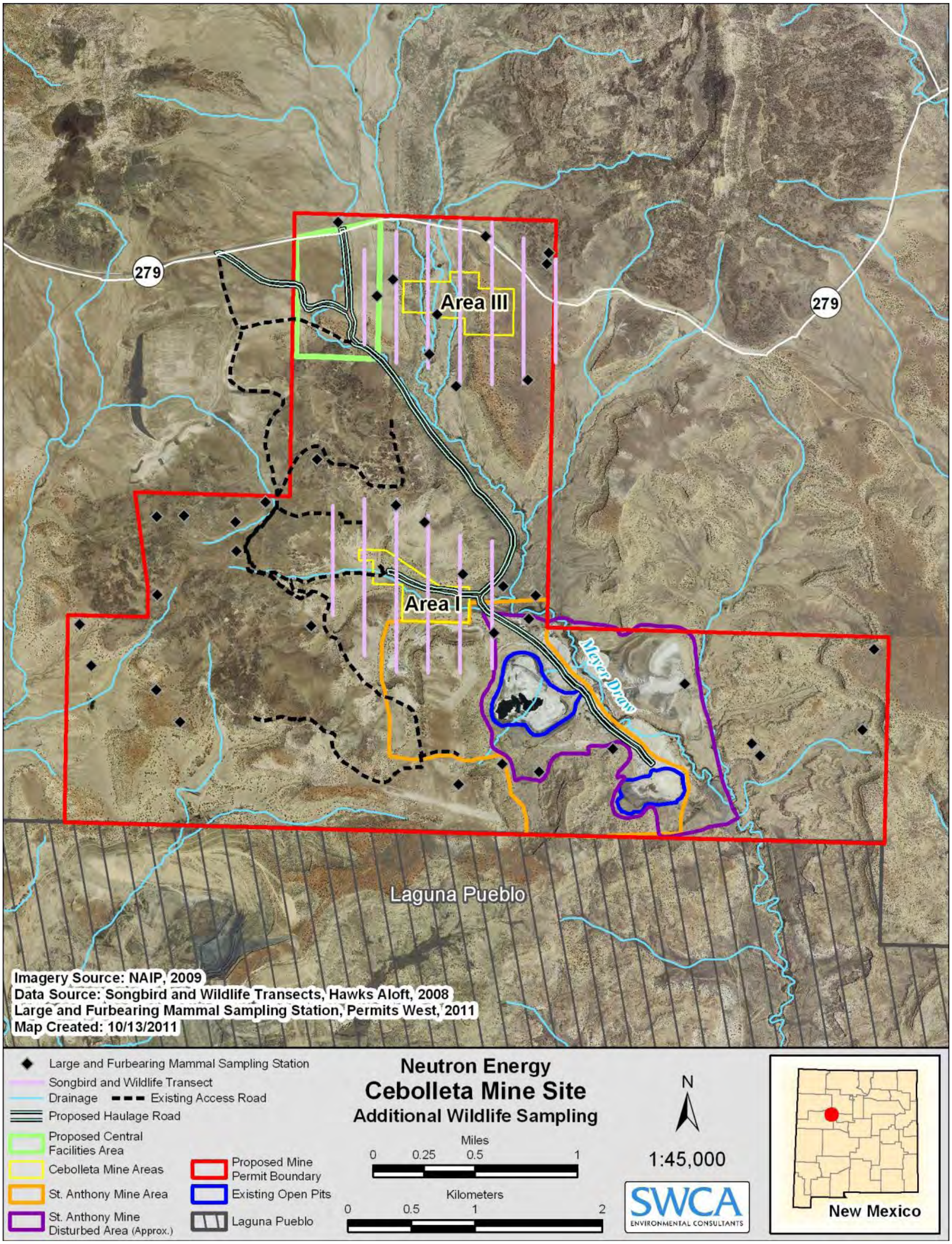

Figure 6.1. Hawks Aloft transects and Permits West large mammal sampling sites.

6.4 SUPPLEMENTAL DATA COLLECTION

A review of previously collected data identified several data gaps needing to be addressed. In general, the presence of birds and medium-sized and large mammals has been well documented; however, the use of observation and signs of small mammals, especially rodents may be inefficient to accurately document their presence, status, and distribution. Many desert dwelling species are nocturnal, and therefore trapping and spotlighting may be necessary survey techniques. Some herpetofauna may also be nocturnal, relatively scarce, or difficult to detect. Therefore, pitfall trapping may be necessary to supplement observational surveys. Bats are another group of nocturnal animals that are likely to be present in the area but are difficult to detect. This group includes one state listed threatened species, the spotted bat (*Euderma maculatum*), that is typically found at higher-elevation sites in the vicinity of cliffs or rock outcroppings. The Cebolleta Mine Site may be too low in elevation to support breeding populations of this species, but the steep cliffs contain numerous crevices that could provide roosting or maternity sites for other bat species. Table 6.1 below identifies the gaps in data collection that were identified and the proposed methods to address those deficiencies.

Table 6.1. Data Collection Gaps and Proposed Methodology

Additional Data Needs	Proposed Methodology
Identify species composition and relative abundance of small mammals, including nocturnal species.	Set up small mammal sampling arrays of 25 Sherman live traps to represent each distinctive habitat type.
Document presence and distribution of nocturnal wildlife species.	Set up trapping for small mammals as described above. Conduct road spotlight surveys.
Determine species composition and relative abundance of herpetofauna.	Set up herpetofauna arrays consisting of pitfall and snake traps to represent each distinctive habitat type.
Identify species of bats using the project area.	Set up an AnaBat detector at the pond to sample bat species present on the project site.
Continue documenting general wildlife use.	Record all animal signs or direct observations while completing vegetation transects and other general work at the site.
Follow up on documenting potential presence of sensitive species.	Continue avian surveys to document raptor use and repeat targeted surveys where gray vireo and loggerhead shrike have been observed.
Evaluate species distribution and map any potential critical habitat or range.	Use all survey data to complete a comprehensive review of spatial (range) and temporal (seasonal) habitat use.

6.5 METHODS OF COLLECTION

6.5.1 WILDLIFE INVENTORIES

General surveys for wildlife species at the Cebolleta Mine Site will be initiated to supplement the data previously collected by Hawks Aloft during the 2008–2010 field efforts, and additional mammal surveys conducted in 2011 by Permits West. These data sources and new surveys will provide a thorough list of species and habitat associations and fulfill MMD requirements for baseline data collection. Focused surveys will be conducted for any federally listed or State of New Mexico threatened, endangered, or species of concern that have the realistic potential to occur on the project site.

6.5.2 SPECIES AND HABITAT RELATIONSHIPS

Surveys designed to sample the various habitat types located at the project site will provide an evaluation of wildlife communities and facilitate an examination of the potential impacts of the proposed mining operation, as well as subsequent mitigation and reclamation efforts. Habitat maps showing special or unique wildlife habitat features or key habitat areas as required by NMAC 19.10.6.602D(13)d and the NMDGF June 2010 *Baseline Wildlife Study Guidelines* will be created and field verified prior to initiating wildlife surveys. By reviewing the proposed new mining operation plans relative to the species habitat lists, both short- and long-term effects on wildlife can be assessed. Seasonal surveys will provide additional data on temporal use and distribution relative to habitats present on the project site.

DATA COLLECTION

Several website sources will be used to determine the potential presence of any federally or state listed species, including the U.S. Fish and Wildlife Service (2011) and the New Mexico Department of Game and Fish (NMDGF) Biota Information System of New Mexico (BISON-M 2011). Additional information may be obtained through requests to New Mexico Natural Heritage and further consultation with NMDGF. Existing literature information on the flora and fauna of the Cebolleta Mine Site region was reviewed and compiled by SWCA to support the overall baseline inventory of the site. The literature search provided information on the potential presence of animal species at the site, and a list of those species of conservation concern that may occur in Cibola County was developed.

Wildlife surveys will attempt to sample all categories of wildlife that potentially use the site. The categories include big game (elk [*Cervus canadensis*] and mule deer [*Odocoileus hemionus*]), mammals, small mammals (including bats), birds, and herpetofauna (reptiles and amphibians). Methodology will be standardized so that the surveys can be repeated for future comparisons.

SAMPLING DESIGN

Medium-sized and Large Mammals

Although previously surveyed, the presence and distribution of large mammals will continue to be monitored through general observation, wildlife sign recorded along vegetation transects, and spotlight counts. Thirty-five 100-m (328-foot) transects (see Figure 6.3 below) have been located at the vegetation sampling locations to adequately sample the habitat types present. Diurnal medium-sized to large mammals (e.g., rabbits [Leporidae], coyotes [*Canis latrans*], mule deer, Rocky Mountain elk [*Cervus canadensis nelsoni*]), and/or tracks and scat of those animals, will be observed and recorded along the same wildlife transects that will be used for vegetation monitoring. One observer will walk each transect during the morning hours, recording all opportunistic mammal sightings observed within 100 m (328 feet) perpendicular to each side of each transect and all tracks and scat within the 1-m (3-foot) area perpendicular to each side of each transect, by species. The perpendicular distance of each animal from the center of each transect line will be estimated and recorded. Surveys for mammals and their sign will be conducted along transects during the spring and fall.

In addition, a spotlight survey route has been established (see Figure 6.3 below) on the main access roads to inventory nocturnal use by medium-sized to large mammals (Wilson et al. 1996; Thompson et al. 1998).

Small Mammals

Small mammals (i.e., species generally less than 300 grams in body weight) are generally inventoried and monitored by using small box traps that capture animals alive so they may be released again (Wilson et al. 1996; Thompson et al. 1998; Morrison et al. 2001). The traps have a spring plate mechanism that causes the door to close when an animal enters the trap. Oatmeal is placed inside each trap to attract rodents. White polyvinyl chloride (PVC) roofing gutter cut into 0.3-m (1-foot) lengths will be placed over each trap to protect the traps from rain and overheating by the sun. Traps are opened each evening before sunset and checked the next morning. The traps are closed during daytime hours during the trapping session and removed from the site during the non-trapping period to avoid any inadvertent trapping and animal mortality.

Each animal captured will be identified to species. If identification is uncertain, standard measurements will be taken (ear, hind foot, tail, body, weight), and the animal will be photographed to make a subsequent positive identification. Voucher photographs will be taken of all rodent species captured. Each animal captured will be marked with a colored Sharpie marking pen to distinguish between animals trapped on consecutive nights.

The objective of this trapping design is to document the presence and relative abundance of rodent species at the site. Trapping will be accomplished in each habitat type by setting the traps adjacent to pitfall trap arrays to sample for herpetofauna. Traps will be placed at 10-m (33-foot) intervals in a grid pattern, with 25 traps per grid. Trapping will be conducted for two consecutive nights during each of the spring, summer, and fall sampling periods.

Data including species composition and total numbers of individuals captured by species will be recorded in a Microsoft Excel database. Relative abundance data will be estimated for each habitat type for comparison.

Herpetofauna

Day-active (diurnal) and night-active (nocturnal) amphibians and reptiles will be sampled by using pitfall trap arrays (Thompson et al. 1998). Pitfall trap arrays will be subjectively located to sample representative habitat types. Each pitfall trap array will consist of four 5-gallon plastic utility buckets dug into the ground so that the open tops are level with the soil surface, modified from Thompson et al. (1998). Three of the buckets will be positioned into an equilateral triangle arrangement, each positioned 5 m (16 feet) from the center of the triangle (Figure 6.2). The fourth bucket will be positioned at the center of each triangle array. Silt fencing measuring 1 m (3 feet) high will be stretched between each of the three end buckets to the center bucket of each array. The silt fence will be vertical to the ground surface and buried several centimeters into the soil surface along each bottom edge. A 50 × 50–cm (20 × 20–inch) piece of 3/8-inch plywood will be placed over the opening of each bucket, elevated approximately 10 cm (4 inches) above the bucket on small rocks placed under each of the four corners. Two snake traps with cover boards will be positioned along the north silt fence line in attempt to catch large snake species that otherwise would be able to enter and exit bucket traps without being recorded. Plastic lids will be placed on the tops of the buckets during intervals between sampling periods. The pitfall trap buckets will be opened for sampling during each of the spring, summer, and fall sampling periods. The buckets will be checked once each day to sample for both nocturnal and diurnal animals for three consecutive days during the spring, summer, and fall sampling periods. Reptiles are not likely to be active during the winter period. All amphibians and reptiles found in the buckets will be recorded by species and count, and all individuals will be removed and released near (20 m [66 feet] away) each array. Any amphibians and reptiles observed while conducting other wildlife surveys will be recorded as incidental and will be added to the overall species list. All data will be entered into a Microsoft Excel database.

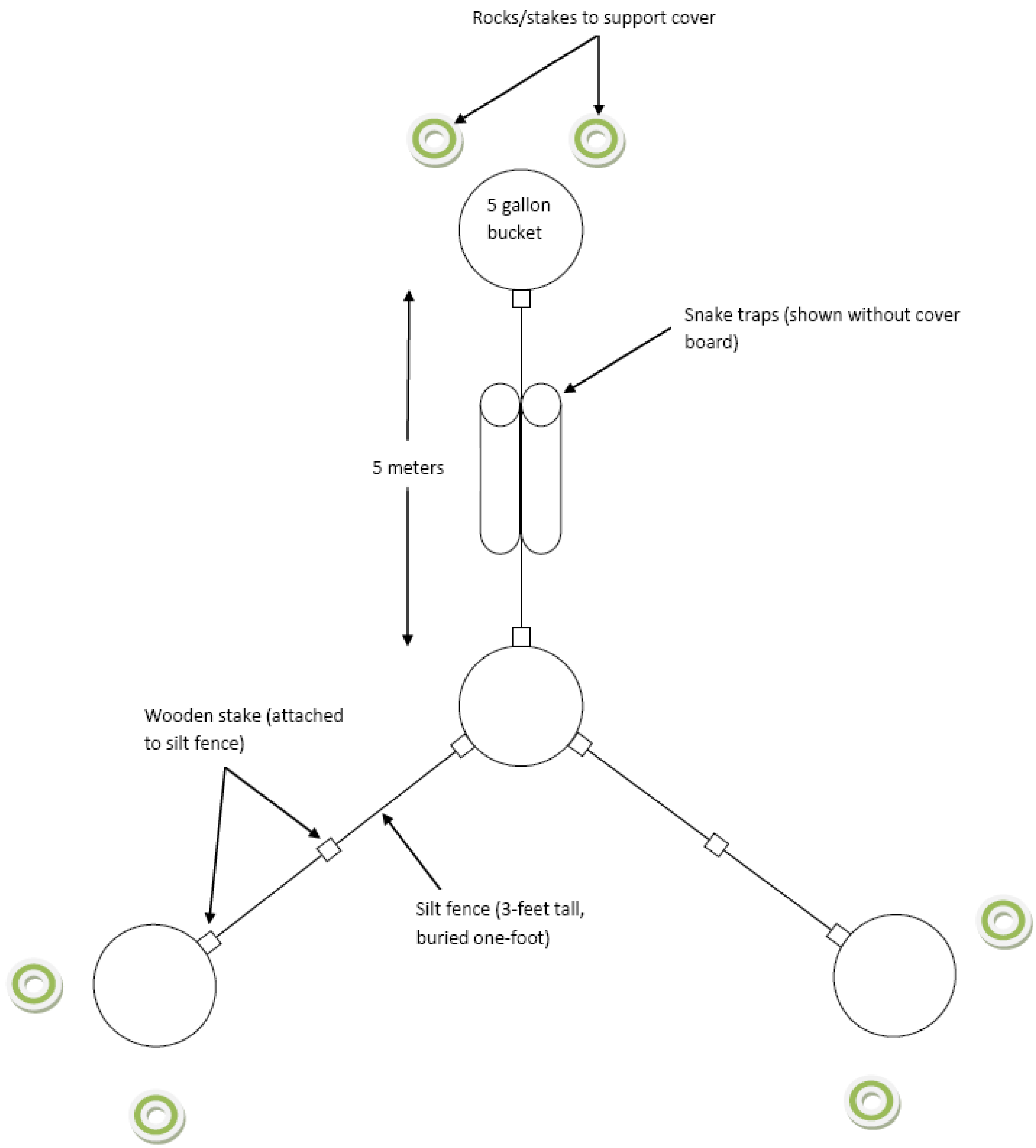

Figure 6.2. Diagram of herpetofauna pitfall trap array (modified from Thompson et al. 1998).

Bats

One bat detector system was installed at a location near the permanent stock tank a couple hundred yards west of Area I (see Figure 6.3). The monitoring system consists of an AnaBat II ultrasonic bat detector, a ZCAIM storage unit with a compact flash card, a 4.5-amp-hour charge controller, and a 12-volt, 2.2-amp-hour battery enclosed in a weatherproof housing, with a 45 degree reflector plate. The reflector plate enables calls to be detected on a horizontal plane without exposing the sensitive microphone to wind and rain. The unit is mounted approximately 3 m (10 feet) above ground. The system battery is charged via a south-facing, 5-watt solar panel. The receiver on the bat detector was placed at a 45 degree angle above a polycarbonate reflector. The detectors are programmed to monitor daily from 6:00 p.m. to 6:00 a.m. The calls are recorded to compact flash cards that can be switched as they become full of data. Each card can typically store about two months of data, but are changed at more frequent intervals.

The detection range for ultrasonic bat detectors is dependent on many variables, including the amount of moisture in the air, the strength and frequency of the bat calls, the direction of the calls in relation to the receiver, and the condition of the receiver and associated electronic components. Generally, the system described here has a detection range of about 30.5 to 53 m (100–175 feet), with relative humidity of 10% to 90%, respectively.

The data will be analyzed using various custom filters developed within the Analook software and by visual interpretation of the individual spectrographs. The first filter employed separates potential bat calls from definite non-bat "calls," such as those produced by insects, rain, wind, and general ultrasonic interference. All rejected calls are scanned visually to make sure the first-pass filter is working properly. Following this separation, other filters are applied to the accepted calls in an effort to identify them to the species level, where possible, or to assign them to groups based on call frequency or general known characteristics of a particular genus. As with the non-bat calls, all accepted bat calls are visually inspected.

Birds

Seasonal avian transects will provide an assessment of migratory and potential breeding populations, as well as winter populations. Initial avian transects were performed by Hawks Aloft in July 2008 to document songbird and raptor presence at the mine site (Hawks Aloft 2008, 2009, 2010). In order to maintain repeatable consistency in data collection, future avian surveys will occur along the same transect lines first established by Hawks Aloft (Figure 6.1). One modification to previous methodology will consist of the survey transects being confined to the Area I and Area III project boundaries, although observations of birds beyond the boundaries will be included. This modification is made because analysis of the previous data suggested that the additional effort would not compromise the assessment of songbird and raptor presence at the mine site. The transects are systematically positioned 250 m (820 feet) apart throughout the proposed mine site in a north-south direction using GIS location methods and include start and end points only within the proposed mine boundary. SWCA biologists will walk each transect during the morning hours, observing and recording all birds within an approximately 100-m (328-foot) perpendicular distance from the transect line. The perpendicular distance of each bird from the center of each transect line will be estimated and recorded. All data will be recorded in a specified data book and later entered into Microsoft Excel spreadsheet files.

All avian species identified by sight and sound along transects will be recorded. Observational data on birds will be analyzed by habitat type and summarized. Additionally, distance methods will be used to estimate bird densities using the analytical distance methods of Buckland et al. (1993) and the software program DISTANCE (Laake et al. 1993).

Additional surveys will be conducted to monitor any raptor nests, or if gray vireos are suspected or detected on the project area. Breeding by other bird species protected by the Migratory Bird Treaty Act, such as loggerhead shrike, will be recorded and locations of nesting mapped as described below.

6.5.3 Mapping

All data collected will include GPS coordinates to be used to generate maps for the project site that will depict an overview of wildlife use relative to habitat types. Within each habitat type the map will present spatial and seasonal distribution of species, where available. The locations of any nesting sites or other sensitive wildlife areas will be identified on the map for implementing avoidance during mining construction or operation. Special or unique habitat, if present, will be identified on the appropriate maps. Habitat typing and mapping will include the project area plus a one mile perimeter beyond the proposed permit boundary.

6.6 Parameters to be Analyzed

Data collection will focus on the representative habitat types present at the project site and document wildlife species presence, relative abundance, and seasonal distribution for big game (elk and mule deer), bats, small mammals, herpetofauna, and birds. Acreages for all habitat types and the total length of linear habitat will be computed from field observations and aerial photos.

6.7 Maps of Sampling Locations

Figure 6.1 provides sampling locations from surveys conducted in 2008, 2009, and 2010. Figure 6.3 and Figure 6.4 identify the survey and sampling locations to be established to address additional data needs and methodologies recommended in Table 6.1.

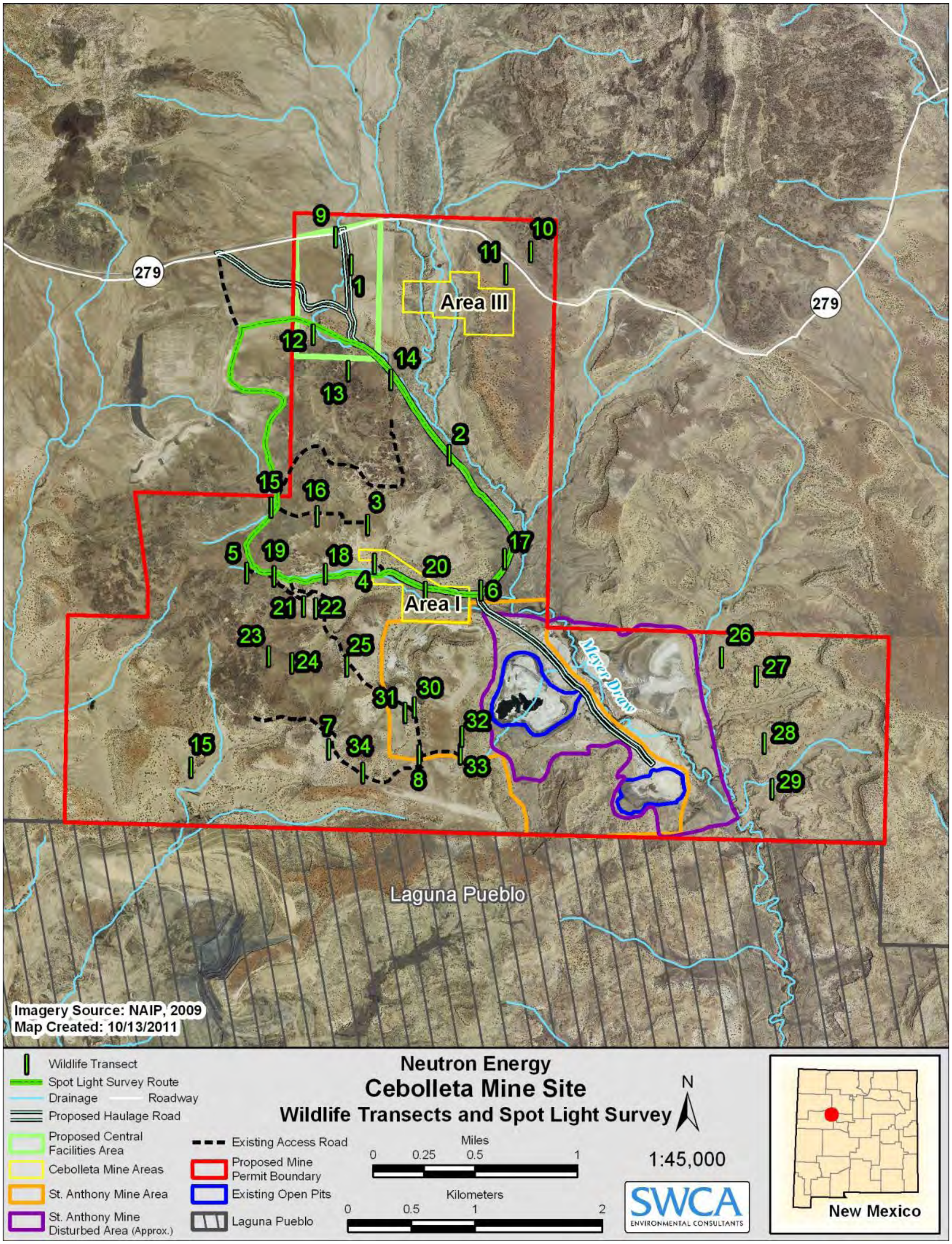

Figure 6.3. Wildlife transect sample locations and spotlight survey route.

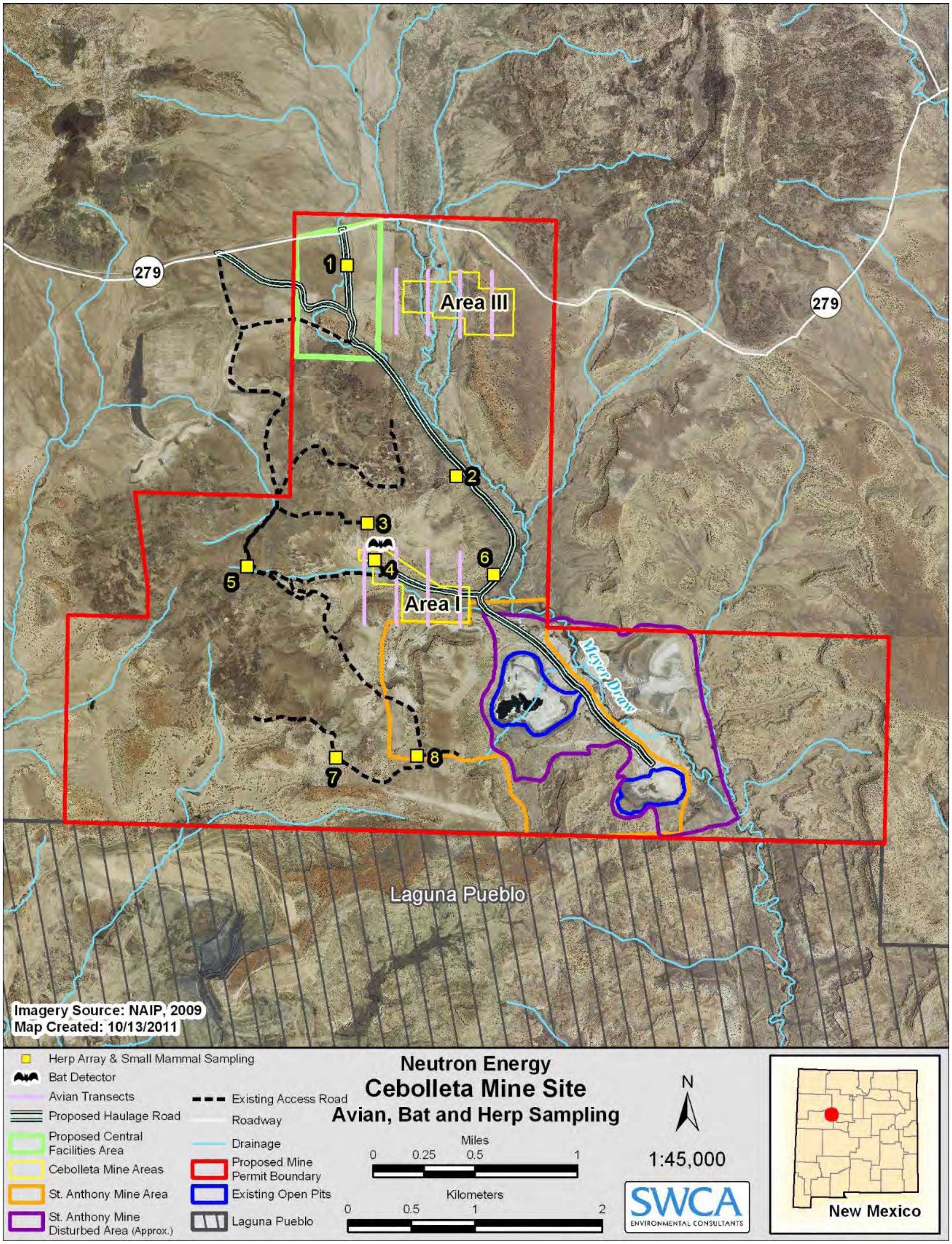

Figure 6.4. Locations of avian transects, herpetofauna pitfall arrays, and bat detectors.

6.8 SAMPLING FREQUENCY

Field survey methodologies have been developed using well-established techniques of various references cited in this report. Table 6.2 summarizes the sampling frequency for each of the additional data needs listed in Table 6.1. Surveys will be conducted a minimum of twice over a 12-month period as recommended in the *Part 6 Guidance Document (EMNRD 2010)*.

Table 6.2. Data Needs and Sampling Frequency

Additional Data Needs	Sampling Frequency
Identify species composition and relative abundance of small mammals, including nocturnal species.	Sampling periods in the spring and fall. Small mammal trapping completed in May, July, and October 2011.
Document presence and distribution of nocturnal wildlife species.	Sampling periods in the spring and fall for small mammals. Small mammal trapping completed in May, July, and October 2011. Spotlight counts completed in May and July.
Determine species composition and relative abundance of herpetofauna.	Sampling periods in the spring and fall. Herpetile trapping completed in May, July, and October 2011.
Identify species of bats present in the project area.	Continuous May through October. Bat detector installed in May 2011.
Continue documenting general wildlife use.	Sampling periods in the spring, fall, and winter. First surveys completed in February 2011. (Permits West 2011). Fall wildlife surveys completed in October 2011.
Follow up on documenting potential presence of sensitive species.	Sampling periods in the spring and summer. Surveys conducted in May and July.

6.9 LABORATORY AND FIELD QUALITY ASSURANCE PLAN

6.9.1 PERSONNEL

Using standardized and survey protocol accepted in the professional literature ensures that sampling methods to be used provide a statistically representative sample and can be repeated for future analysis. The field crew used for surveys should be highly trained with adequate experience using these methodologies in the field with sufficient knowledge of the life histories and characteristics of species likely to be encountered so that identification in the field, with photographs and measurements, is accurate. The field leader should have the necessary combination of education (B.S. or advanced degree in appropriate field) and field experience that would meet the standards of certification required to qualify as a Certified Wildlife Biologist as determined by the Wildlife Society. Project leaders and principal investigators should have a minimum of an M.S. degree and appropriate experience or be a Certified Wildlife Biologist. Resumes reflecting the qualifications of personnel involved in the data collection as reflected in this SAP will be provided with future reports.

6.9.2 SAMPLING PROTOCOL PLAN

The field leader will ensure that the sampling protocol plan is followed and that data collection is consistent. To further encourage consistency and reduce potential bias, continuity of field personnel will be maintained as practicable.

Observations will be recorded on established data sheets and all data entered into databases. Databases will be backed up on a regular basis to prevent data loss. Extra copies of data sheets will be made and filed. All databases will be reviewed by senior level staff and experienced principal investigators and checked for accuracy using the original data sheets for comparison. Final analysis of the methods, results, and conclusions will also be completed by the same senior staff member.

6.10 LITERATURE CITED

Biota Information System of New Mexico (BISON-M). 2011. BISON-M homepage. Version: July 7, 2010. Available at: http://www.bison-m.org. Accessed June 15, 2011.

Buckland, S.T., D.R. Anderson, K.P. Burnham, and J.L. Laake. 1993. Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, New York.

Hawks Aloft. 2008a. Resource Inventory of Area I Cebolleta Land Grant, Cibola County, New Mexico. Albuquerque: Hawks Aloft.

———. 2008b. Resource Inventory of Area III Cebolleta Land Grant, Cibola County, New Mexico. Albuquerque: Hawks Aloft.

______. 2009. Raptor, Gray Vireo, Loggerhead Shrike and T&E Vegetation Surveys Areas I and III Cebolleta Land Grant, Cibola County, New Mexico. Albuquerque: Hawks Aloft

———. 2010. 2010 Raptor and Songbird Surveys: St. Anthony and Cebolleta Areas 1 and 3 Preliminary Report. Albuquerque: Hawks Aloft.

Laake, J. L., S.T. Buckland, D.R. Anderson and K.P. Burnham. 1993. DISTANCE User's Guide. Fort Collins, Colorado: Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University.

Morrison, M.L., W.M. Block, M.D. Strickland, and W.L. Kendall. 2001. Wildlife Study Design. New York: Springer-Verlag New York, Inc.

New Mexico Department of Game and Fish (NMDGF). June 2010. Baseline Study Guideline. http://www.wildlife.state.nm.us/conservation/habitat_handbook/documents/WildlifeBaselineStudyGuidelinesand%20Appendix.pdf. Accessed January 13, 2012.

New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division (EMNRD). 2010. Guidance Document for Part 6 New Mining Operation Permitting under the New Mexico Mining Act. Santa Fe: New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division.

Permits West. 2011. Native Ungulate and Furbearing Mammal Report (February 2011 Fieldwork) Cebolleta Mine Site, Cibola County, New Mexico. Santa Fe: Permits West.

Thompson, W.L., G.C. White, and C. Gowan. 1998. Monitoring Vertebrate Populations. London: Academic Press.

U.S. Fish and Wildlife Service. 2011. Endangered, Threatened, Proposed, and Candidate Species in McKinley County, New Mexico. Southwest Region Ecological Services. Available at: http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm. Accessed June 15, 2010.

Wilson, D.E., F. Russell Cole, J.D. Nichols, R. Rudran, and M.S. Foster, eds. 1996. Measuring and Monitoring Biological Diversity: Standard Methods for Mammals. Washington, D.C.: Smithsonian Institution Press.

7.0 TOPSOIL

7.1 INTRODUCTION AND BACKGROUND

This section describes proposed methods to collect baseline soils information for the proposed Neutron Cebolleta Mine Site in Cibola County, New Mexico, as part of the permitting process for the proposed new mine. The information obtained from this topsoil sampling and analysis plan will constitute an Order 1 soil survey that meets the requirements of the *Part 6 Guidance Document* (EMNRD 2010).

SWCA reviewed soil mapping data from the NRCS Soil Survey Geographic Database (SSURGO), which delineates soils by associations and complexes of soil series (Figure 7.1). SWCA also reviewed detailed soil association and series descriptions provided in the NRCS (formerly SCS) soil survey for the Cibola area (SCS 1993) and NRCS official series descriptions (NRCS 2010). The areal extent of the soil types within the proposed mine permit boundary and facilities area footprint as mapped by NRCS is summarized in Table 7.1.

Table 7.1. Soil Map Units and Aerial Extent as Mapped by the NRCS

Map Unit Number	Map Unit Name/Description	Area (acres)	Proportional Extent (%)
200	Penistaja fine sandy loam, 2%–10% slopes	Area I: 2.7 Facilities: 49.3	0.8 14.1
251	Sky Village-Rock Outcrop-Bond complex, 3%–40% slopes	Area I: 8.2 Area III: 23.5	2.4 6.7
257	Sparank-San Mateo complex, 0%–5% slopes	Area I: 36.0 Area III: 35.4 Facilities: 114.5	10.3 10.2 32.9
262	Poley-Pojoaque very cobbly loams, 5 to 30 percent slopes	Facilities: 19.7	5.7
625	Hagerman-Bond association, 1%–10% slopes	Area I: 24.3 Facilities: 34.9	7.0 10.0
	TOTAL	**348.5**	**100.0**

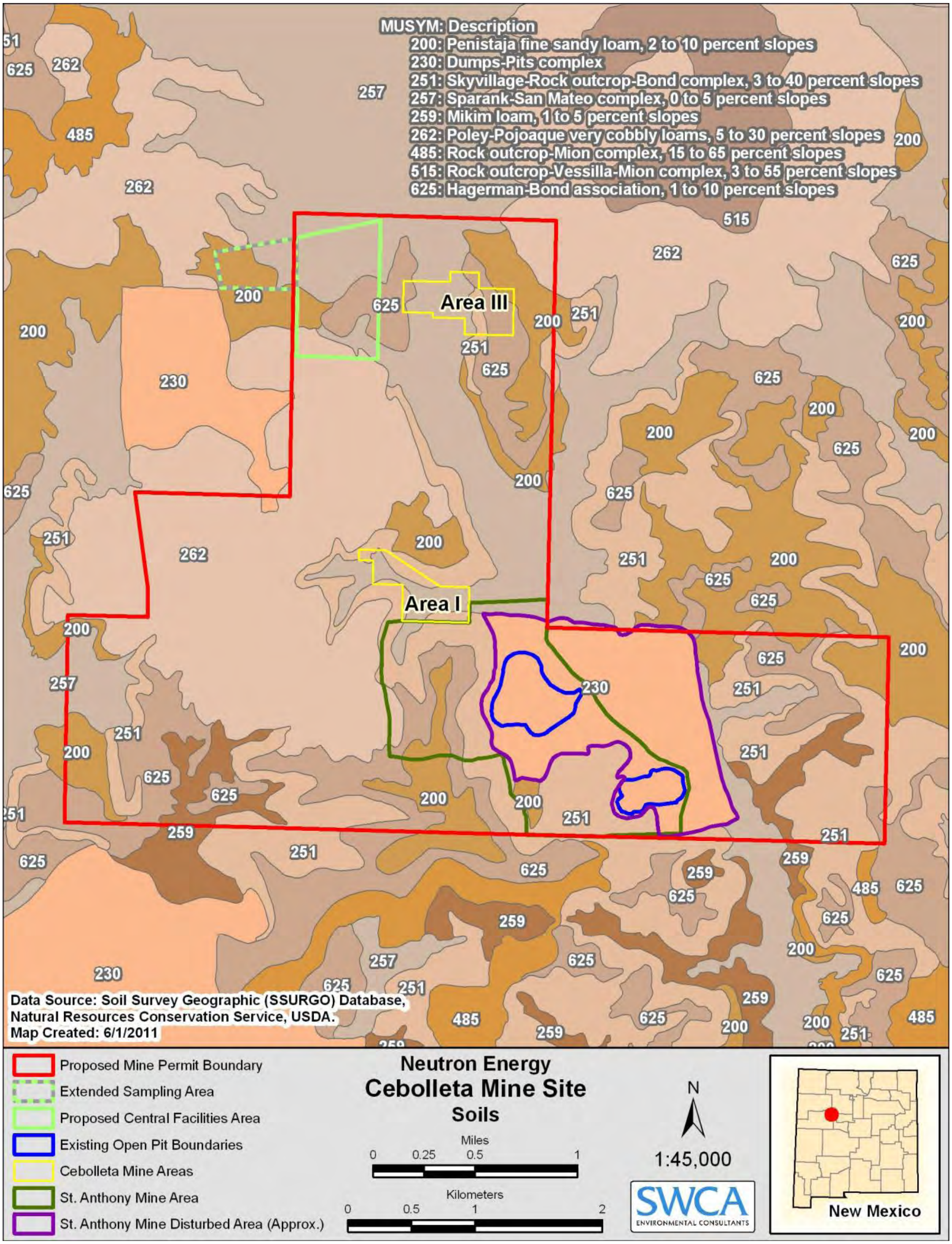

Figure 7.1. NRCS soils map of the Cebolleta Mine Site.

7.2 SAMPLING OBJECTIVES

Primary objectives of the soil baseline assessment are as follows: 1) to confirm the accuracy of previous soil mapping that has been conducted in the project area by NRCS and others (e.g. Cedar Creek Associates), 2) to provide information to support estimates of salvageable volume of suitable soil across the (planned) disturbed areas based on field sampling, and 3) to provide information to determine gross estimates of salvageable volume of suitable soil across the permit area based on previous mapping/descriptions that have been confirmed. This information can also be used to determine if soil borrow areas may be required and identify potentially suitable borrow areas based on soil types.

7.3 SAMPLING FREQUENCY

The proposed sampling frequency for the Cebolleta Mine Site is intended to provide representative samples for each of the major soil map units. A minimum of one representative location for a backhoe trench or hand-dug soil pit will be excavated for the purpose of observing the soil profile. Additional samples, either soil pits or hand auger samples, will be collected for the map units with the largest areal extent. For purposes of soil mapping confirmation, a soil scientist will traverse the project area and may perform additional sampling for observation of the soil profile, although soil samples for laboratory analysis may not be collected for these additional observation samples. One of the soil map units (200) occurs only in a small portion of Area III. A single soil pit is proposed to be sampled for this unit. Three samples are proposed to be collected for each of the other map units.

Proposed numbers of soil samples to be collected for laboratory analysis are summarized in Table 7.2 below.

Sample sites in rock outcrop map units may contain little or no soil for laboratory sampling. In such cases, soil depth (or lack of) by horizon will be noted, and as feasible soil will be collected for laboratory analysis.

Table 7.2. Proposed Number and Type of Soil Samples by Map Unit

Map Unit Number	Map Unit Name/Description	Number of Samples	Sample Type
200	Penistaja fine sandy loam, 2%–10% slopes	1 3	Backhoe trench /soil pit Soil pit/auger
251	Sky Village-Rock Outcrop-Bond complex, 3%–40% slopes	1 2	Backhoe trench /soil pit Soil pit/auger
257	Sparank-San Mateo complex, 0%–5% slopes	2 3	Backhoe trench /soil pit Soil pit/auger
262	Poley-Pojoaque very cobbly loams, 5 to 30 percent slopes	1	Backhoe trench /soil pit
625	Hagerman-Bond association, 1%–10% slopes	1 2	Backhoe trench /soil pit Soil pit/auger
	TOTAL	**15**	

7.4 LIST OF DATA TO BE COLLECTED

The following soil information will be collected, as described in further detail in Section 7.5:

- Confirmation of previous mapping through walking transects and spot sampling
- General observations on slope, rock outcrops, and vegetation type
- Depth, Munsell color, and field texture by horizon
- Overall depth to lithic contact
- Soil reaction
- Volume of rock by horizon
- Laboratory analyses as described in Section 7.6

7.5 METHODS OF COLLECTION

7.5.1 CONFIRMATION OF PREVIOUS SOIL MAPPING

A soil scientist will survey the proposed mine permit area to evaluate previous soil mapping. This survey will include walking transects across the permit area to observe surface and topographic features, and examination of soil profiles through backhoe or hand-dug soil pits, hand auger samples, and observations of soil profiles in existing arroyo cuts. Observation of soil profiles and sampling will be used to evaluate variability within map units for key parameters such as soil depth.

7.5.2 BACKHOE TRENCHING

Wherever feasible, soil profile observations and collection of soil samples will be conducted using backhoe trenching. Once the soil profile has been exposed, field scientists will clean the profile with a trowel and complete soil profile description forms for each sample site. The description will include horizon depths, field texture, color, volume of coarse fragments, and depth to bedrock or rocky layer. For soil types where calcium carbonate accumulation may be an indicator, a field effervescence test will be performed using hydrochloric acid. Soil samples will be collected by horizon, collecting the minimum sample volume needed to perform necessary laboratory analyses (approximately half of a gallon sample bag).

The soil collected from each horizon layer will be placed in a sample bag and labeled with soil type, sample identification number, horizon, and date collected. This information will also be recorded on chain-of-custody forms for submittal to the laboratory.

7.5.3 HAND AUGER SAMPLING

Hand auger sampling will be used to collect data on soil horizons and depth, and to collect soil samples. Auger samples will be separated into horizon layers (according to such factors as organic matter content, color, and texture), and soil profile description forms will be completed for each site noting horizon depths, field texture, color, volume of coarse fragments, and overall sample depth. For soil types where calcium carbonate accumulation may be an indicator, a field effervescence test will be performed using hydrochloric acid.

Soil samples will be collected from each horizon layer and bagged separately (approximately half of a gallon sample bag). Auger samples will be collected to the depth of lithic contact or other impenetrable layer or to a maximum depth of 152 cm (60 inches).

7.5.4 Soil Pit Sampling

Hand-dug soil pits will be used to observe representative soil profiles and collect soil samples. Soil pits will be approximately 0.6 m (2 feet) wide by 1.2 m (4 feet) long and dug to the depth of bedrock or other impenetrable layer. A hand trowel will be used to clean one wall of the soil pit to observe horizon layers, which are identified according to such factors as organic matter content, color, and texture. A soil profile description form will be completed for each site noting horizon depths, field texture, color, volume of coarse fragments, and overall sample depth. For soil types where calcium carbonate accumulation may be an indicator, a field effervescence test will be performed using hydrochloric acid. Soil samples will be collected from the pit wall for each horizon layer and bagged separately (approximately half of a gallon sample bag).

7.6 Parameters to be Analyzed

Soil samples will be packaged and shipped in accordance with laboratory recommendations and standard analytical procedures. Chain-of-custody forms will be completed and the samples submitted to the laboratory. Table 7.3 details the soil geochemical parameters and procedures proposed for the laboratory analysis.

Table 7.3. Soil Laboratory Analysis Parameters and Methods

Parameter	Extraction Method	Analysis Method
pH	Saturated paste ASA10-3.2	pH meter
Acid/base potential	USDA Handbook 60, 23c	Calculation
Texture (hydrometer)	ASA15-5	Hydrometer
Texture (medium, fine and very fine sands, #35, #60 and #140 sieves, respectively)	ASA15-5	Sieve
Salinity (electrical conductivity)	Saturated paste ASA 10-3	Conductivity meter
Sodicity (sodium absorption ratio) (paste Ca, Mg, and Na me/L)	Saturated pasteASA10-3.4	E6010.20
Organic matter content	Organic carbon ASA 29-3	Spectrophotometer
Cation Exchange Capacity	USDA Handbook 60, 19	E6010.20
Inorganic carbon (to nearest 0.1% $CaCO_3$ equivalent)	USDA Handbook 60, 23c	Titration
Boron (hot-water soluble)	ASA 25-9	E6010.20
Selenium (ABDPTA extractable)	ASA 3-5.2	E6010.20
Total uranium	ASA	E6010.20
Total radium (Ra 226)	SW3050B	E903.0
Iron	SW3050	E6010.20
Magnesium	SW3050	E6010.20
Manganese	SW3050	E6010.20

Parameter	Extraction Method	Analysis Method
Copper	SW3050	E6010.20
Cadmium	SW3050	E6010.20
Lead	SW3050	E6010.20
Mercury	SW7471	E6010.20
Molybdenum	SW3050	E6010.20
Nickel	SW3050	E6010.20
Arsenic	SW3050	E6010.20
Nitrate-nitrite	ASA 33-8.1	E353.2
Phosphorus	ASA 24-5.1	E365.1
Potassium	ASA 13-3.5	E6010.20

Method references: American Society of Agronomy (ASA) Monograph #9; U.S. Department of Agriculture Handbook 60; EPA Method SW 3050B.

Figure 7.2 illustrates proposed soil sampling locations. Under the direction of the project soil scientist, sampling locations may be modified based on field observations in order to collect representative samples.

7.7 Map Showing Sampling Locations

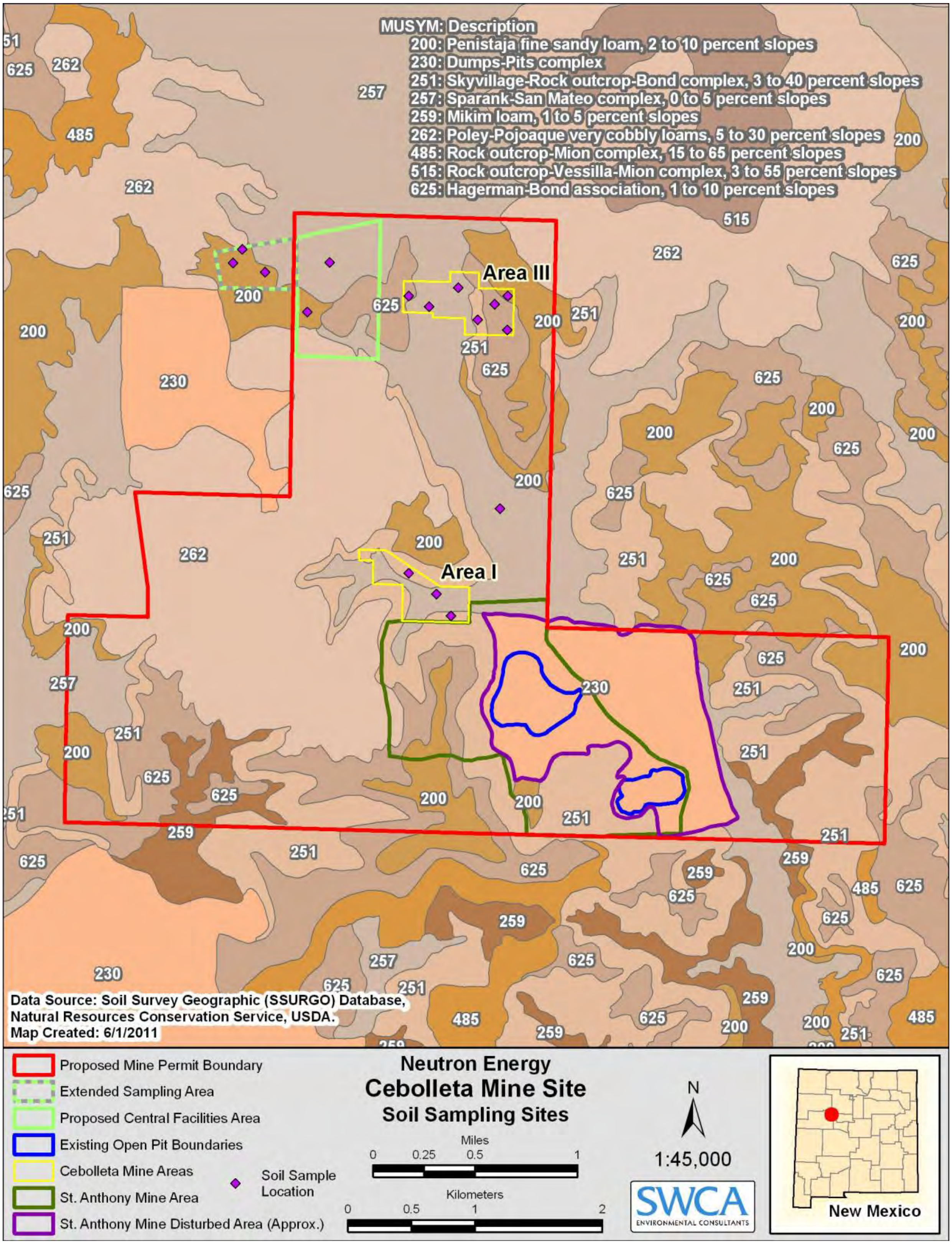

Figure 7.2. Proposed soil sampling locations.

7.8 LABORATORY AND FIELD QUALITY ASSURANCE PLANS

7.8.1 PERSONNEL

Soil sampling will be conducted by or under the direction of a professional soil scientist specializing in soil morphology and mapping and having familiarity with the project region. Only experienced and qualified personnel will be employed for other aspects of the sampling and analysis, including data entry, data verification, data analysis, and interpretation of results and reporting.

7.8.2 PROTOCOLS

Sample handling and chain of custody procedures will be followed for the preparation of soil samples for shipment to the analytical laboratory. Laboratory analysis will be conducted in accordance with methods described in *Methods of Soil Analysis, Parts 1 and 2* (American Society of Agronomy, Inc., and Soil Science Society of America, Inc. 1986 and 1982, respectively). Neutron will ensure that the laboratory operates under a quality program and has expertise and experience with the approved soil analytical methods. The laboratory QA/QC report (e.g., results of duplicate sample analyses) will be reviewed and submitted with the analytical results.

7.8.3 DATA QUALITY ASSURANCE AND QUALITY CONTROL

Standard data entry and data analysis protocols will be used, and only experienced data entry/management qualified personnel will conduct data entry and management. Data analysis will be conducted only by personnel experienced with statistical data analysis software and statistical theory, and the ability to interpret the results of data analysis.

7.9 DISCUSSION IN SUPPORT OF SAMPLING

The proposed field data collection and laboratory analyses for the soil baseline are designed to meet MMD requirements as described in NMAC 19.10.6.602D.(13)(e) and applicable recommendations of the *Part 6 Guidance Document* (EMNRD 2010), and the objectives of the plan as described in Section 7.2. The proposed SAP will enable MMD scientists to determine that sufficient soils data will be collected to provide estimates of salvageable volume of suitable soil for eventual successful reclamation of the areas proposed to be disturbed.

7.10 LITERATURE CITED

American Society of Agronomy (ASA) Monograph #9; US Department of Agriculture (USDA) Handbook 60.

Environmental Protection Agency (EPA). 2008. Method SW 846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Analytical Method 3050B: Acid Digestion of Sediments, Sludges, and Soils. January 2008.

Natural Resources Conservation Service (NRCS) 2010. Custom Soil Resource Report for McKinley County Area, New Mexico, and Parts of Cibola and San Juan Counties. (online application, map produced June 2010).

New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division (EMNRD). 2010. Guidance Document for Part 6 New Mining Operation Permitting under the New Mexico Mining Act. Santa Fe: New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division.

Soil Conservation Service. 1993. Soil survey of Cibola Area, New Mexico, parts of Cibola, McKinley, and Valencia counties. Issued March 1993.

8.0 GEOLOGY

This section of the SAP identifies sources to be used in compiling baseline data for the Geologic Sampling resource category identified in NMAC 19.10.6.602.D.(13).(f). Data sources include historic data from unpublished technical reports, published studies, contact with knowledgeable local operators and geologic experts, and consultation with Neutron technical staff. This section describes the history and scope of the proposed project (Section 8.1), the location and physiography of the site vicinity (Section 8.2), the regional geologic setting (Section 8.3), the general site geology (Section 8.4), including details of the site stratigraphy (Section 8.4.1), known ore deposits (Section 8.4.2), and overburden rocks (Section 8.4.3). Also included is a discussion of the SAP sub-categories identified in NMAC 19.10.6.602.D.(12).(a) that concern the Geologic Sampling resource category (Section 8.5). A list of references is included in Section 8.6.

8.1 INTRODUCTION

The Cebolleta Mine Site is located on private land located approximately 64 km (40 miles) west of Albuquerque. Neutron and the mineral owner, the CLG, have signed a lease covering surface and mineral rights for approximately 4,475 acres (1,811 ha) of land and minerals owned by the CLG. Approximately 1,068 acres (432 ha) within the proposed permit area are owned byEverest Holdings, LLC (aka Lobo Ranch), and UNC. However, the CLG owns all mineral rights within the lease and proposed mine permit area. The lease agreements convey the right to explore for, mine, and process uranium deposits known or subsequently discovered on the leased premises, and allow Neutron to use the water rights controlled by the CLG. A "Short Form Memorandum of Uranium Mining Lease and Agreement" has been filed and recorded with the offices of the County Clerks and Recorders for Cibola, McKinley and Sandoval counties, New Mexico.

The property is part of an established Spanish Land Grant (the owners of the property are heirs of the original grantees), and was never "sectionalized" under the United States section, township, and range survey system. Several surveys of the boundaries of the lands under lease have been completed, and the boundaries of the properties have been verified by the State of New Mexico District Court. The leased properties are held "free and clear" of any third-party interests.

The project area is presently known to contain several former underground, open pit, and unexploited uranium deposits. These primarily consist of the St. Anthony mine and Sohio Deposits I through V., which are reported to have produced approximately 4.7 million pounds of U_30_8 (Marquez 1979). Figure 8.1 shows the location of the St. Anthony and Sohio Deposits. Figure 8.2 shows the ore deposits in relation to lease boundary.

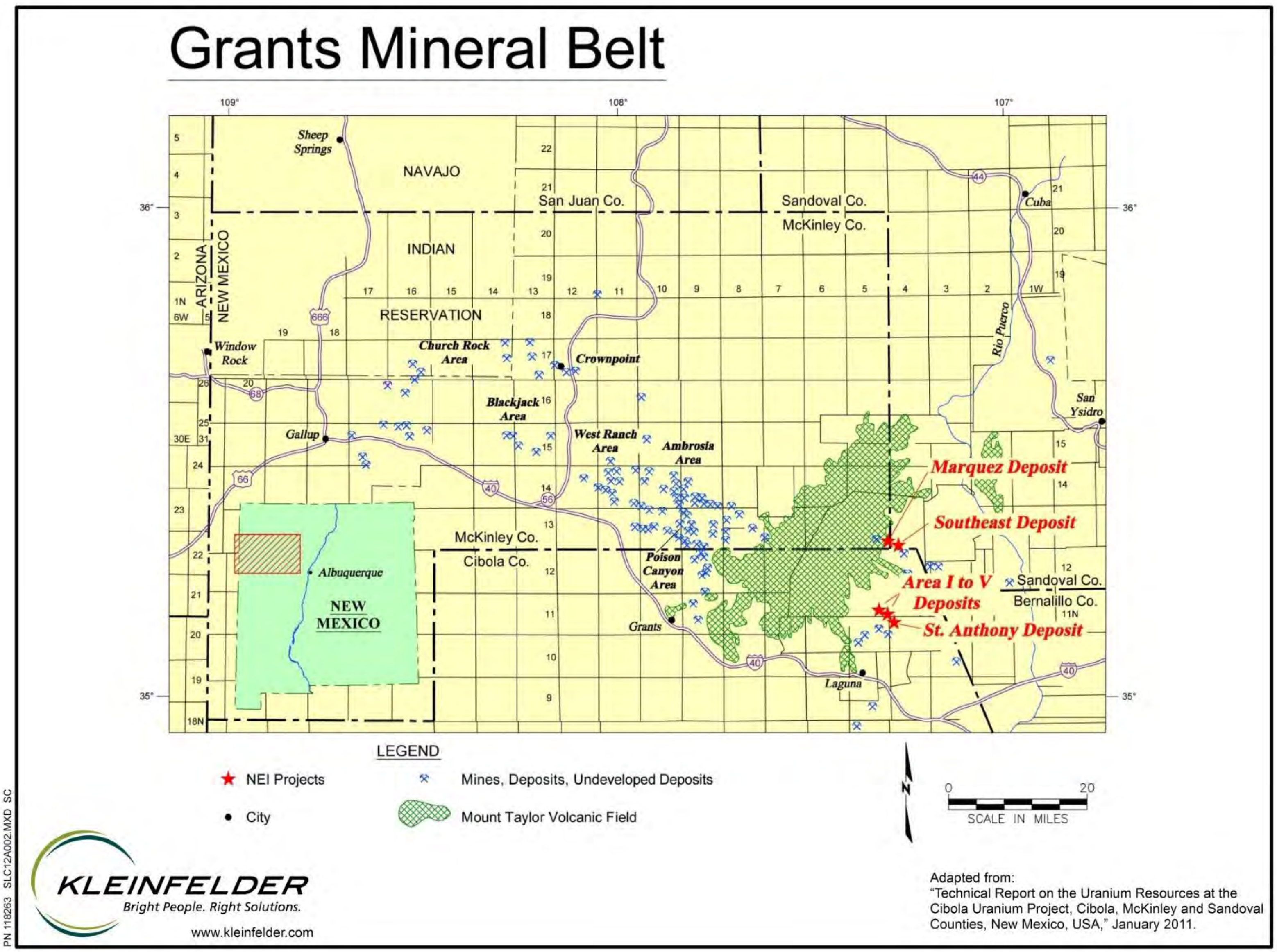

Figure 8.1. Map showing the location of the St. Anthony and Sohio uranium deposits of the Cebolleta Mine Site.

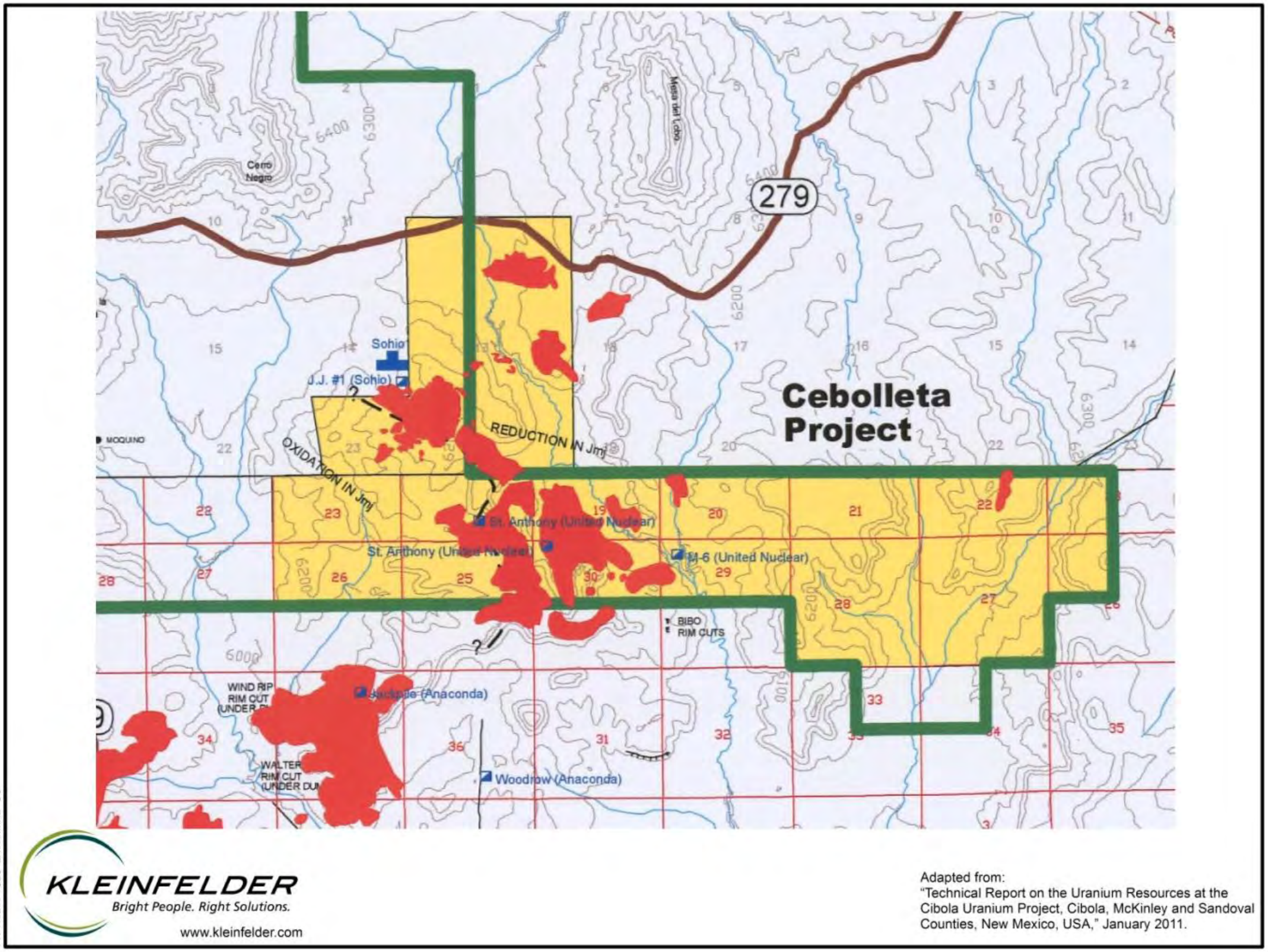

Figure 8.2. St. Anthony and Sohio ore bodies in relation to proposed permit boundary (in yellow).

The Cebolleta Mine Site area has been of considerable interest to the U.S. uranium industry since the original discovery of the nearby Jackpile uranium deposit (located immediately southwest of the southern boundary of the Cebolleta project) in late 1951. Early exploration was carried out by the Anaconda Company during the 1950s on the southern portion of the Cebolleta project area on what is now part of the lands Neutron has leased from CLG.

The first mining at the Cebolleta Mine Site was undertaken by the Climax Uranium Company (Climax), who developed an underground mine in the St. Anthony area in 1957. During the period of Climax's mining operation, which ended in 1960, approximately 321,000 pounds of U_30_8 were produced. At a later date UNC and its subsidiary Teton Exploration Drilling Company carried out an extensive exploration program in the area of the former Climax mine, and its vicinity. UNC subsequently developed two open pits and one underground mine on lands leased from the CLG, with its initial development commencing in 1975 (Baird et al. 1980). Ore from the St. Anthony mines was processed primarily at UNC's Church Rock mill near Gallup. Mining was suspended at St. Anthony in 1979, and the milling of stockpile material was completed in 1980. Mines at St. Anthony are reported to have produced approximately 2.5 million pounds of U_30_8 (McLemore and Chenoweth 1991).

Reserve Oil and Minerals, a New Mexico-based mineral resource company, purchased the Evans Ranch, which adjoins the St. Anthony mine area to the north. In 1968, Reserve sold an undivided 50% interest in the ranch, including the mineral rights, to Sohio (then a subsidiary of the Standard Oil Company of Ohio).The two companies formed a joint venture in 1969 to explore for and mine uranium deposits on the Evans Ranch (Melting 1980a, 1980b). Sohio, who operated the joint venture, discovered extensive uranium mineralization on the property and subsequently developed an underground mine and uranium mill complex (the Sohio mine and mill). In 1982 Sohio acquired Reserve's interests in the property, and after final closure of the Sohio mill and underground mine, deeded a portion of their property interests in the area to the CLG in 1989. The Sohio mine was reported to have produced 2.2 million pounds of U_30_8.

8.1.1 Site Description and Physiography

The project is located in west-central New Mexico and occupies the northeastern part of Cibola County. The site lies approximately 16 km (10 miles) northeast of the village of Laguna, which is adjacent to I-40. Access to the project area is over paved NM 279, as far as the village of Seboyeta. Several private roads of varying quality cross the project lands and provide access to nearly all parts of the project area. Rail service is available from the Burlington Northern Santa Fe Railroad at Grants and Milan.

The project area is situated on the southern margin of the San Juan Basin of west-central New Mexico. The leased property is located to the southeast of Mesa Chivato, a broad volcanic capped mesa that flanks the eastern and northern sides of Mount Taylor. Elevations within the project area range from 1,829 to 1,981 m (6,000–6,500 feet) above sea level. Topography is typical of the mesa-canyon form in this region of New Mexico, with sharp local variations in elevation, on the order of 61 to 122 m (200–400 feet) over short distances. A series of rounded hills, raising 61 to 91 m (200–300 feet) above the surrounding landscape, are present in the vicinity of the former Sohio uranium mine. Prominent canyons, developed along Meyer Draw and Arroyo Pedro Padilla, cut the southern part of the project area where the former St. Anthony mines are located. In spite of these variations in topography, access to essentially all of the project area is good (Carter 2011).

The vegetation is typical of a semiarid high desert climate, with sparse mixed grasses, shrubs, and scattered stands of pinion pine (see Section 5.0 of this SAP for additional information regarding the site vegetation). Temperatures at Grants (the nearest town with long term weather records) range from approximately 50 to 80 degrees F (10 to 27 degrees C) in the summer, and from approximately 10 to 40 degrees F (-12 to 5 degrees C) in the winter. The area receives about 279 mm (10–11 inches) of precipitation annually. Most precipitation comes in the form of afternoon thundershowers during the months of July through September, and may accumulate as much as 330 mm (13 inches) of snow during the winter months. Winter snows and summer thunderstorms may create muddy ground conditions that interrupt access for short periods of time. Other than during these short periods of muddy ground conditions, mineral exploration and mining activities normally can be conducted without interruption throughout the year (Carter 2011).

8.1.2 REGIONAL GEOLOGIC SETTING

The project lies within the Grants-Gallup Mineral Belt, along the southern flank of the San Juan Basin. The basin is part of the Colorado Plateau geologic province and forms a significant geological and topographic feature covering much of the northwest part of New Mexico. The Grants-Gallup Mineral Belt is an east-southeast trending zone of uranium deposits that extends eastward from the vicinity of the town of Gallup to the western edge of the Rio Grande Rift (west of Albuquerque), a distance of more than 161 km (100 miles).

The uranium deposits within the belt are concentrated in Jurassic-age sedimentary rocks, most notably within the fluvial sandstone beds of the Morrison Formation, including the Jackpile Sandstone (economic) unit of the Brushy Basin Member and the Westwater Canyon Member. The Grants-Gallup belt of uranium deposits encompasses several mining districts, including (listed from east to north and northwest) the Laguna, Marquez (the part of the Laguna District with uranium deposits hosted by the Westwater Canyon Member only), San Mateo, Ambrosia Lake, Smith Lake, Crownpoint, and Church Rock districts.

Collectively, the uranium deposits in these districts have provided more than 348 million pounds of U_30_8, or more than 37% of all uranium produced in the United States (Wright 1980). Sandstone-hosted uranium deposits in the Grants-Gallup Mineral Belt occur as either primary deposits (also known as “pre-fault” or “trend” deposits) or redistributed deposits (also known as “stack,” “secondary,” “post-fault,” or “roll” deposits). Both types of deposits are hosted in various sandstone units of the Morrison Formation in the region. Uranium mineralization in trend deposits was controlled by permeable host sandstones and the presence of chemical reductants (humates), which caused the precipitation of uranium minerals from groundwater. Redistributed uranium deposits are believed to have formed from trend deposits that were subsequently oxidized and redistributed by groundwater within the host sandstones.

8.1.3 General Site Geology

The project area is on the south flank of the San Juan Basin in an area known as the Chaco Slope. The regional dip of the sedimentary rocks in the area is to the north-northeast, into the basin, but strata have been locally modified by folding. Many of the structural features present in the project area are related to the Acoma Sag and Rio Puerco fault zone that mark the southeastern edge of the San Juan Basin (Livingston 1980).

Cross sections based on correlations of drill hole data prepared by Hogg (1977) and by Neutron staff depict only a small number of minor normal faults in the project area. Most of these faults terminate at the buried Jurassic-Cretaceous unconformity and do not cut the overburden section overlying the Jurassic strata. They are not evident in the Cretaceous or younger rocks on the land surface.

The surficial geology of the project area is capped by Tertiary volcanic rocks that occur atop Mesa Chivato to the northwest (but are outside the Cebolleta Mine Site area). Otherwise the landscape is dominated by Cretaceous-age sedimentary rocks, including (in descending order, from the high points on local mesas) the Point Lookout Sandstone, the Crevasse Canyon Formation (including the Gibson Coal, Dalton Sandstone, and Dilco Coal members), the Gallup Sandstone, and the Mancos Shale (Dillinger 1990).

In the lower portions of the Mancos, Neutron geologists follow the stratigraphy and nomenclature established by Herrick (1900), Hunt (1936), and Dane (1959) in referring to marker sandstone units in the lowermost Mancos as Tres Hermanos Sandstones. Rocks above the middle portion of the Mancos form the high-standing mesas in the project area, interfingering with the Tres Hermanos sand units and overlying the Cretaceous Dakota Sandstone. The Dakota Sandstone, in turn, unconformably overlies the Jurassic-age Brushy Basin Member of the Morrison Formation, which occurs above the Westwater Canyon and Recapture Members, respectively. The majority of the uranium mineralization occurs within the Jackpile Sandstone which is a local, yet distinct unit that is situated in the uppermost part of the Brushy Basin Member.

There are two published 7.5-minute geologic quadrangle maps that cover the surface geology of the project area. These maps are the Moquino and Arch Mesa Quadrangles. Neutron may develop new local (at very large, e.g. 1”=100’ scale) geologic and soil maps (on existing satellite or new aerial photography survey base maps) as project development and operations move forward. However, additional mapping is currently not planned in support of the BDR, as existing maps provide the information necessary to support mine permitting.

8.1.4 Stratigraphy Beneath the Permit Area

The regional stratigraphy of the Cretaceous and Jurassic sedimentary rocks in the vicinity of the Cebolleta Mine Site area is shown in Table 8.1. Geologic units are described below in descending order (youngest to oldest).

Table 8.1. Sedimentary Stratigraphy of the Cebolleta Mine Site

Age	Formation	Member	Thickness (Feet)	Description
Cretaceous	**Point Lookout Sandstone**	Main Body	120	Grayish orange fine to medium-grained sandstone
		Satan Tongue	50	Black to light gray shale and siltstone
		Hosta Tongue	100	Pale olive to medium-grained sandstone
	Crevasse Canyon Formation	Gibson Coal	300	Interbedded fine-grained sandstone, shale, and coal
		Dalton Sandstone	125	Fine-grained sandstone and intercalated siltstone
		Mulatto Tongue	350–400	Gray shale with some fine-grained sandstone
		Dilco Coal	85	Interbedded sandstone, siltstone, shale, and coal
	Gallup Sandstone		80	Pale orange fine-grained sandstone
	Mancos Shale	Main Body	600–650	Gray shale with some beds of yellowish gray sandstone
		Tres Hermanos Sandstones	225–325	Grayish orange fine to medium-grained sandstone and siltstones with interbedded gray and black shales
	Dakota Sandstone		40–70	Interbedded quartzose sandstone, siltstone, shale, and limestone
Jurassic	**Morrison Formation**	Jackpile Sandstone	0–120	Fine to coarse-grained quartzitic sandstone with sparse mudstone
		Bushy Basin	40–200	Grayish green bentonitic mudstone, local arkosic sands, and minor lacustrine limestone lenses
		Westwater Canyon	225–330	Grayish yellow fine to coarse-grained arkosic sandstone with interbedded mudstones
		Recapture	70–250	Reddish greenish gray mudstone, siltstone, and sandstone

ALLUVIUM

Quaternary alluvial material derived from local bedrock is present throughout the Chaco Slope area in the form of streambed alluvium along larger drainages, valley-fill alluvium in topographic lows, with colluvium and some talus on and at the base of larger slopes.

POINT LOOKOUT SANDSTONE

The Cretaceous age Point Lookout Sandstone is a regressive marine beach sandstone and generally consists of light gray, thick bedded, very fine- to medium-grained, locally cross-bedded sandstone. The Point Lookout Sandstone is as much as 82 m (270 feet) thick in the vicinity of the site, including intercalated shale and siltstone of the Satan Tongue of the Mancos Shale.

CREVASSE CANYON FORMATION

The Crevasse Canyon Formation consists of the following members, from youngest to oldest: Gibson Coal Member, Dalton Sandstone Member, and Dilco Coal Member. The Mulatto

Tongue of the Mancos Shale is known to insert itself below the Dalton Sandstone Member and above the Dilco Coal Member in this region.

The Gibson Coal Member is as much as 91 m (300 feet) thick in the area of interest, and the Dalton Sandstone Member, a regressive marine beach sandstone, is as much as 38 m (125 feet) thick. The Mulatto Tongue is 107 to 122 m (350–400 feet) thick in the site vicinity and is a marine deposit representing a transgression of the Western Interior Seaway. Its shale and silty sandstones crop out on gentle slopes and are covered in places by Quaternary alluvium and colluvium. The Dilco Coal Member has an average thickness of about 26 m (85 feet) and contains thin sandstone, shale, and discontinuous coal beds representative of a back-shore swamp environment associated with a regression of the Western Interior Seaway (Fassett 1989).

Gallup Sandstone

The Gallup Sandstone is a regressive marine beach sandstone that is fine- to medium-grained and is about 24 m (80 feet) thick. The Gallup Sandstone separates shale rocks of the overlying Crevasse Canyon Formation from similar rocks of the underlying Mancos Shale. The Gallup Sandstone is a productive aquifer unit in the Cebolleta area.

Mancos Shale

The main body of Mancos Shale represents the full transgression of the Western Interior Seaway. In the vicinity of the site its thickness is about 183 to 198 m (600–650 feet). The marine deposits of this formation consist mainly of dark gray to black silty shale with minor interbedded sandstones. In the site vicinity (being on the eastern side of Mount Taylor) the local convention has been to recognize the bottom part of the Mancos Shale as the Tres Hermanos Sandstones. This section contains a stacked sequence of three prominent sets of sandstones with siltstone and interbedded gray-black shales. Cumulatively, the Tres Hermanos Sandstones range from 69 to 99 m (225–325 feet) thick in the project area. They are likely correlative with more complicated inter-fingering within the upper Dakota and lower Mancos sand units that have been described by other authors in Ambrosia Lake and the western edge of the San Juan Basin.

Dakota Sandstone

Marine shore face and beach deposits of the locally distinct and recognizable Dakota Sandstone beds are composed mainly of fine-grained gray quartzose sandstone. In the subsurface in the permit area, the Dakota Sandstone ranges from less than 3 m to as much as 22 m thick (10–70 feet). Elsewhere in northwestern New Mexico, Dakota stratigraphy may be recognized as being composed of the following four units (in descending order): the Paguate Sandstone Tongue of the Dakota Sandstone, the Clay Mesa Shale Tongue of the Mancos Shale, the Cubero Sandstone Tongue of the Dakota Sandstone, and the Oak Canyon Member of the Dakota Sandstone (Landis et al. 1973).

The Dakota Sandstone is the lowermost Upper Cretaceous formation, and unconformably overlies the Upper Jurassic Morrison Formation. The unconformity between the Dakota and underlying Morrison Formation may mark a hiatus of as much as 40 million years in time.

BRUSHY BASIN MEMBER OF THE MORRISON FORMATION

The Brushy Basin Member of the Jurassic Morrison Formation unconformably underlies the Dakota Sandstone. The Brushy Basin Member is comprised of bentonitic mudstones, claystones, and very fine to coarse-grained sandstones, with some lacustrine limestone lenses. It ranges from 12 to 61 m (40–200 feet) in thickness.

The Jackpile Sandstone (of local and economic usage) is a local, yet distinct fluvial unit that occurs in the uppermost part of the Brushy Basin Member, immediately below the Cretaceous unconformity. This unit is the host for the significant uranium deposits at the Jackpile–Paguate, St. Anthony, and Sohio mines. The Jackpile Sandstone extends in a north-easterly-trending depositional belt that may be as much as 21 km (13 miles) wide and more than 105 km (65 miles) long (Jacobsen 1980). The unit may achieve a thickness of 61 m (200 feet). In the St. Anthony mine complex, the Jackpile was observed at 24 to 37 m (80–120 feet) thick by Baird et al. (1980), while at the adjoining Sohio mine it ranges from 24 to 30 m (80–100 feet) in thickness (Jacobsen 1980). Neutron geologists recognize Jackpile accumulations of approximately 46 m (150 feet) thick in drill hole data collected from the southeastern-most extent of the project area.

WESTWATER CANYON MEMBER OF THE MORRISON FORMATION

The Westwater Canyon Member is the principal unit of economic interest in the Juan Tafoya area (located approximately 16 km (10 miles) north of the Cebolleta Mine Site). The Westwater's fine to coarse-grained sandstone has been interpreted as having been deposited in a broad alluvial plain, which was formed by a complex braided stream system (Craig et al. 1955). It is also recognized as having characteristics of a meandering stream system. The unit averages 90 m (295 feet) in thickness, but is pinching out to a zero isopach between the Cebolleta Mine Site area and the I-40 corridor a few miles to the south.

Where optimally developed (such as at Juan Tafoya), the unit is primarily thick sandstone with interstratified mudstone breaks. Channel sandstones comprise approximately 70% of the total thickness of the Westwater Canyon (Livingston 1980). The Westwater is composed of upper and lower sandstone beds, separated by the so-called "K"-shale marker bed (Carter 2011).

The lower sandstone (below the "K"-shale) is the most economically important unit within the Westwater on the east side of Mount Taylor. It hosts nearly all of the known uranium mineralization located to the north of the Cebolleta Mine Site area (at the Juan Tafoya Project area). The Westwater is largely unexplored in the Cebolleta Mine Site area and may be another source of economic mineralization. The sandstones are fine to coarse grained, and are feldspathic to arkosic in composition. Calcite (as a cementing agent) comprises up to 30% of the sandstone and commonly replaces quartz and feldspar (Livingston 1980). The Westwater Canyon Member overlies the Recapture Member.

RECAPTURE MEMBER OF THE MORRISON FORMATION

The Recapture Member is most commonly recognized as the lower-most unit of the Morrison Formation (though recent geologic discussions are promoting inclusion of the underlying Bluff Sandstone). The unit ranges from 21 to 76 m (70 to 250 feet) in thickness, and averages 30.5 m (100 feet) in thickness. The Recapture Member is composed predominantly of mudstone and siltstone with minor, local sandstone lenses. The rocks are typically green to greenish gray, but may be maroon to brown in color. The uppermost part of the Recapture has lenses of sandstone that host minor uranium mineralization, occasionally in the vicinity of high-angle faults or fractures (Livingston 1980).

8.1.5 Description of the Ore Bodies

A significant number of important uranium deposits are located within the Cebolleta Mine Site area. These consist of the St. Anthony underground and open pit deposits and the Sohio complex (which includes five distinct mineral deposits: Areas I, II, III, IV, and V). Mining operations undertaken by Sohio were limited to the Area II and V deposit areas. However, data prepared by Sohio after the closure of the mines (Boyd 1981; Olsen and Kopp 1982; Boyd et al. 1984) indicate that substantial mineralization remains in both of those areas. Additional uranium mineralization is present in the St. Anthony area, contiguous with the north side of the North Pit and to the north of the St. Anthony Underground Mine (as observed by McLemore and Chenoweth 1991; McLemore 2000). Considerably more uranium resources are present in other areas within the proposed permit area. These uranium deposits share a common set of geological characteristics:

- Nearly all of the mineralization is hosted by the Jackpile Sandstone (of economic usage), although minor amounts of mineralization hosted in sands of the Brushy Basin Member of the Morrison Formation and the Dakota Sandstone are present in the St. Anthony area (Carter 2011) In addition, the Westwater Member is largely unexplored in the Cebolleta Mine Site and may be another source of economic mineralization.
- Most of the mineralization is hosted in medium- to coarse-grained sandstones that exhibit a high degree of large-scale tabular cross-stratification (Baird et al. 1980).
- Near the margins of the deposits the mineralization thins appreciably, although halos of low-grade mineralization surround the deposits (Carter 2011).
- Higher grade mineralization usually occurs in the core of the mineralized zones.
- Strong mineralization appears to be concentrated in the lowermost portions of the Jackpile Sandstone, although anomalous concentrations of uranium are present throughout the vertical extent of the unit (Jacobsen 1980).
- Most of the mineralization appears to be “reduced” with only isolated small pods (especially in the St. Anthony underground area) of discontinuous mineralization exhibiting oxidation (Baird et al. 1980).
- Individual deposits do not show a preferred orientation or trend, and while exclusively contained within it, do not fully reflect the southwest-northeast orientation of the main Jackpile Sandstone channel trend.
- Nearly all of the deposits show a strong spatial (and possibly genetic) relationship with carbonaceous material (Carter 2011).
- The deposits range in depth from approximately 10 to 91 m (30–300 feet) in the southern St. Anthony area, to nearly 213 m (700 feet) in the vicinity of Area II, and generally less than 153 m (500 feet) at the northerly Area III deposits at Sohio (Carter 2011).

In the Sohio area, mineralization occurs in tabular bodies that may be more than 305 m (1,000 feet) in length and attain thicknesses of 1.8 to 3.7 m (6–12 feet). The upper and lower boundaries of these mineralized bodies are generally quite abrupt (see Figure 8.3 through Figure 8.7, Cross Section Index and Area III Deposit Cross Sections for typical cross sections). There is some tendency for individual deposits to develop in clusters. Locally, these clusters may be related to the coalescence of separate channel sandstone bodies. In this instance, mineralization is often thicker and higher grade than adjoining areas, although Jacobsen (1980) suggests that the geologic controls on this type of mineralized occurrence are not known.

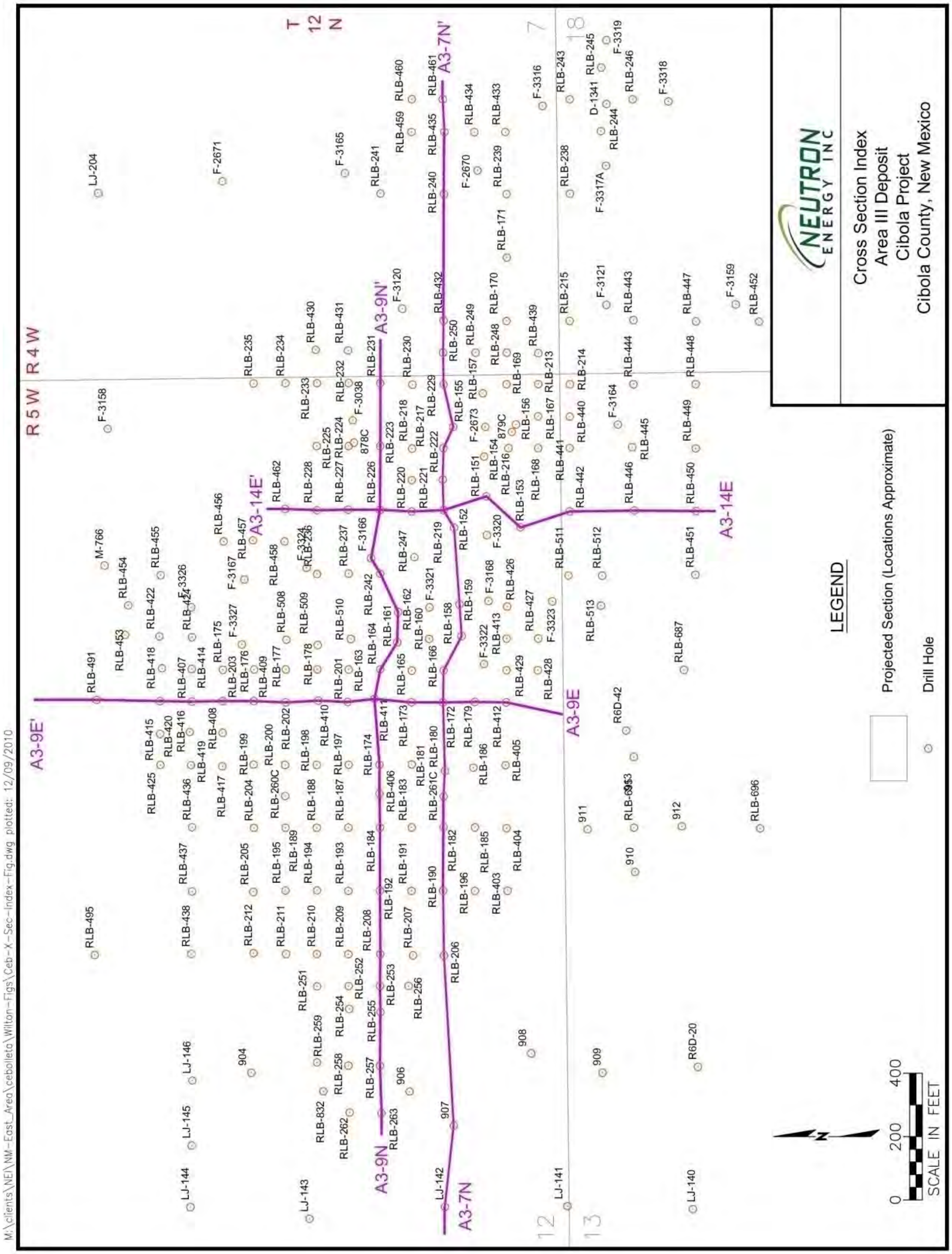

Figure 8.3. Cross section index map, Area III Sohio deposit.

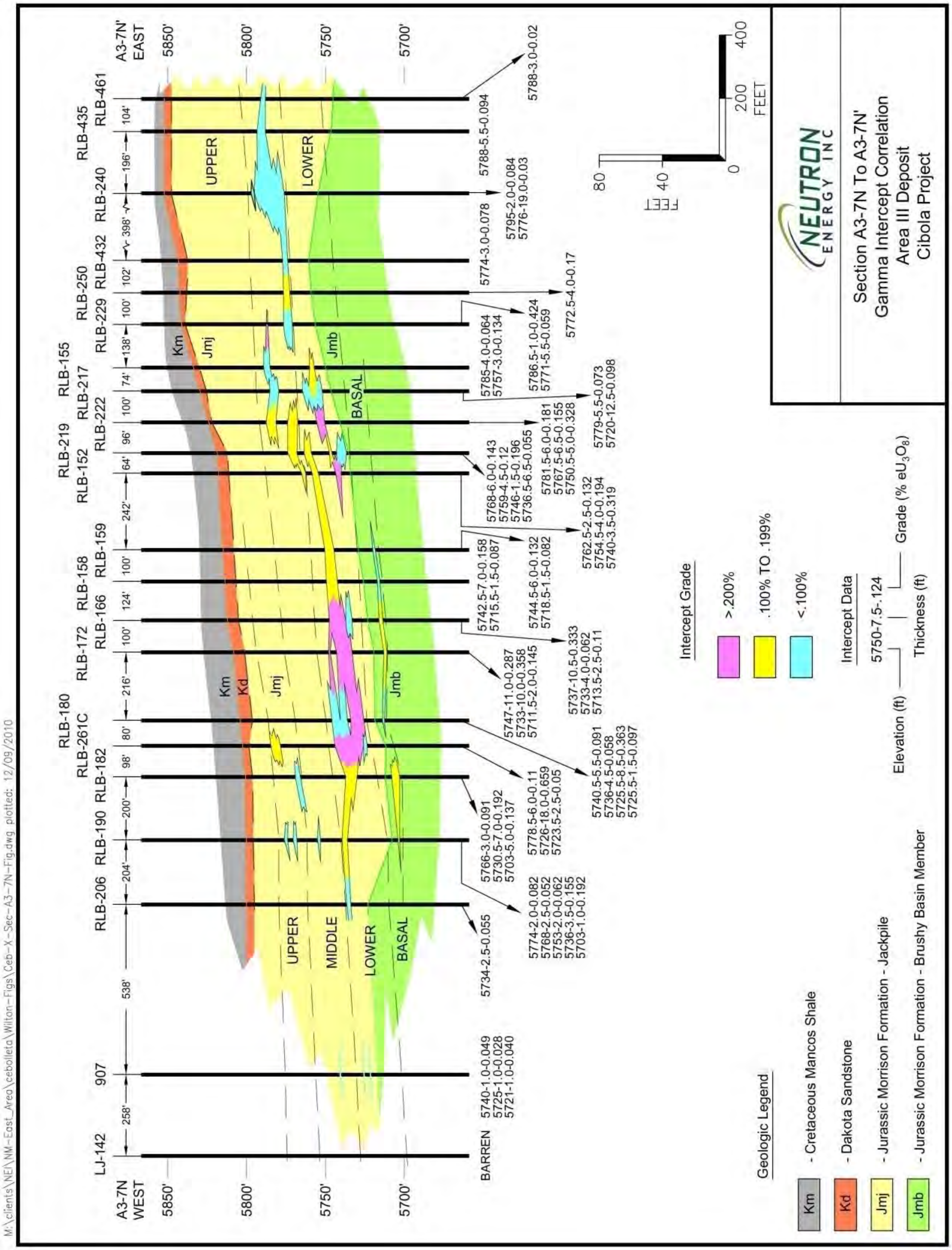

Figure 8.4. Cross-section (Area III Sohio Deposit), A3-7N to A3-7N'.

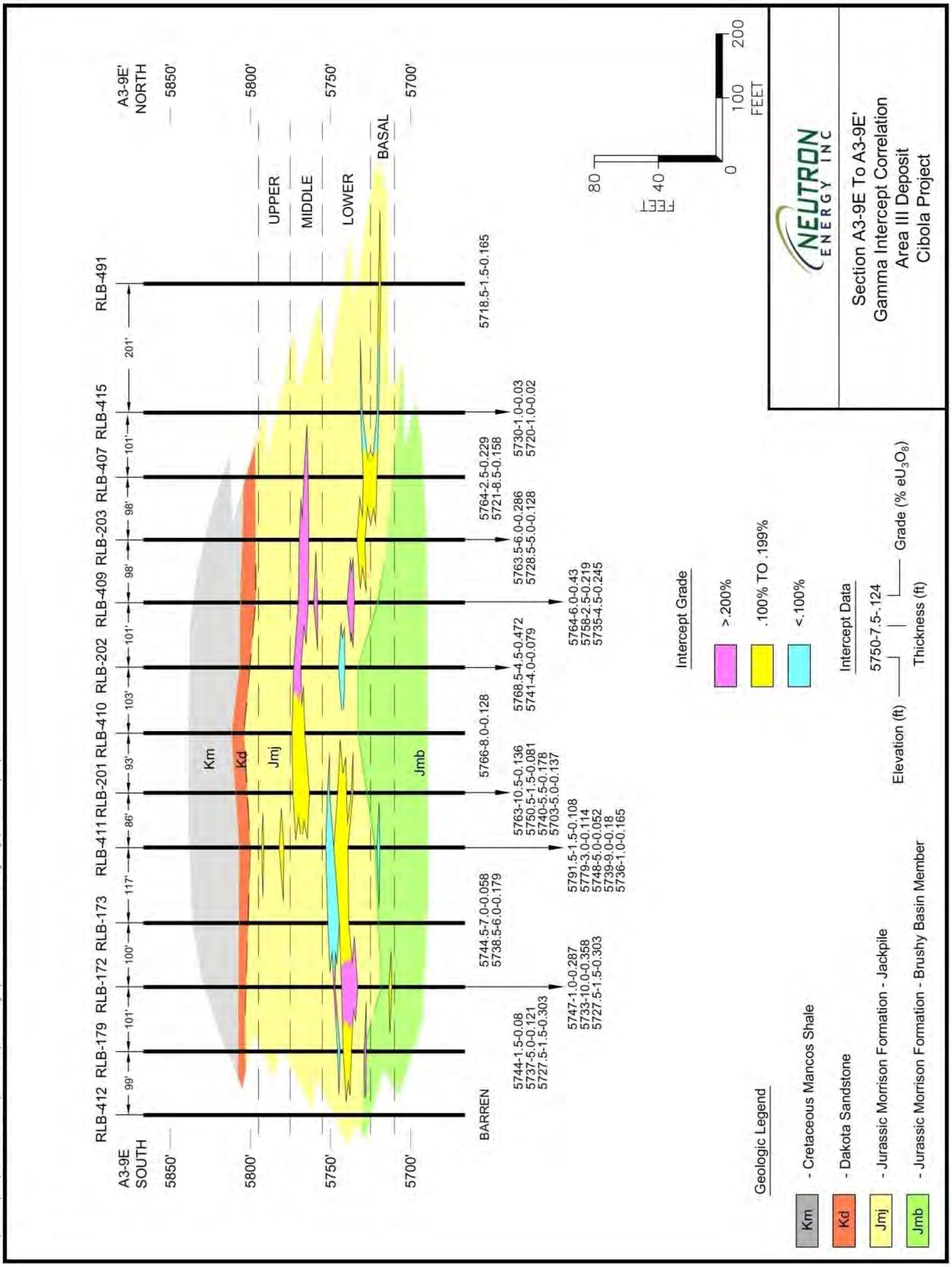

Figure 8.5. Cross-section (Area III Sohio Deposit), A3-9E to A3-9E'.

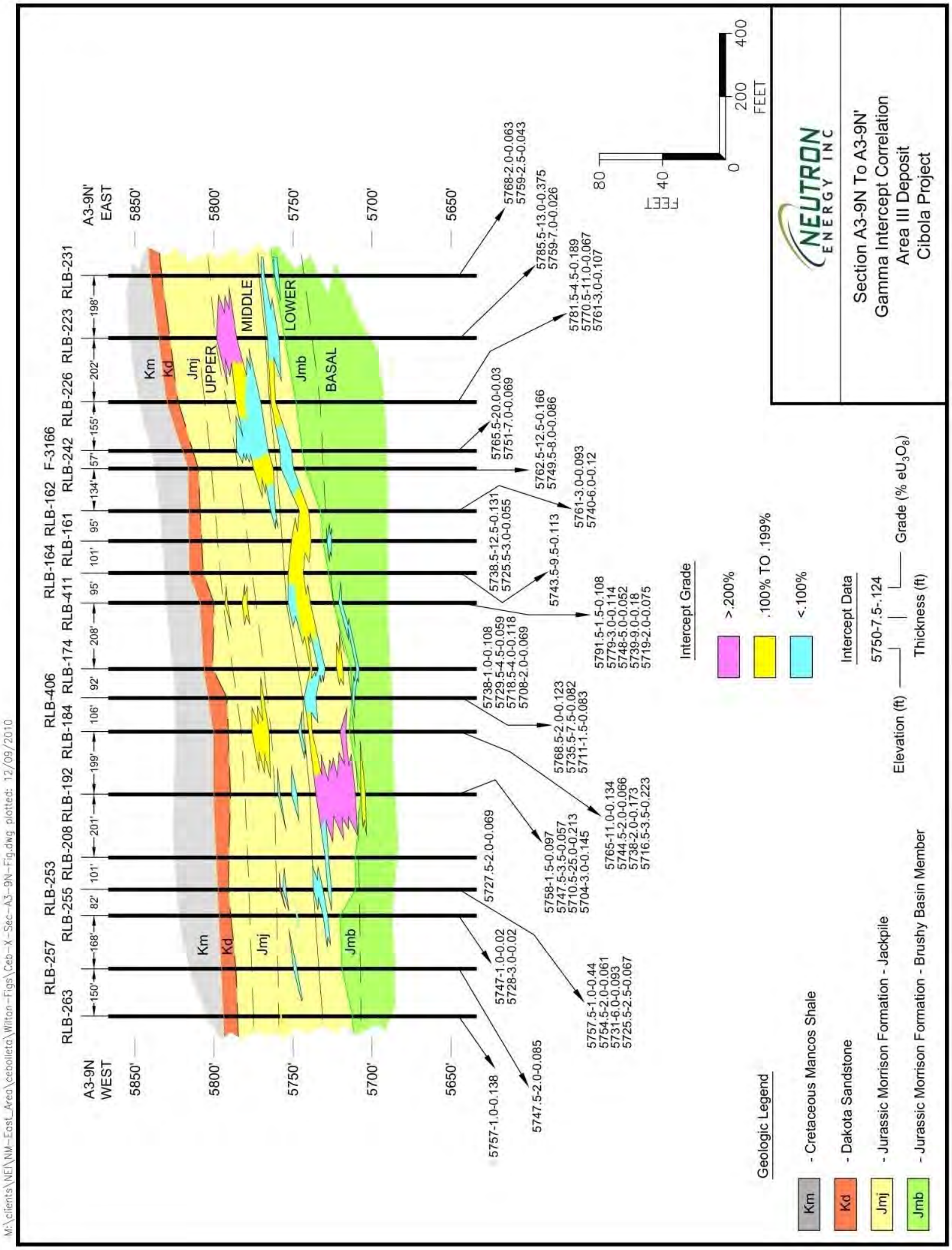

Figure 8.6. Cross-section (Area III Sohio Deposit), A3-9N to A3-9N'.

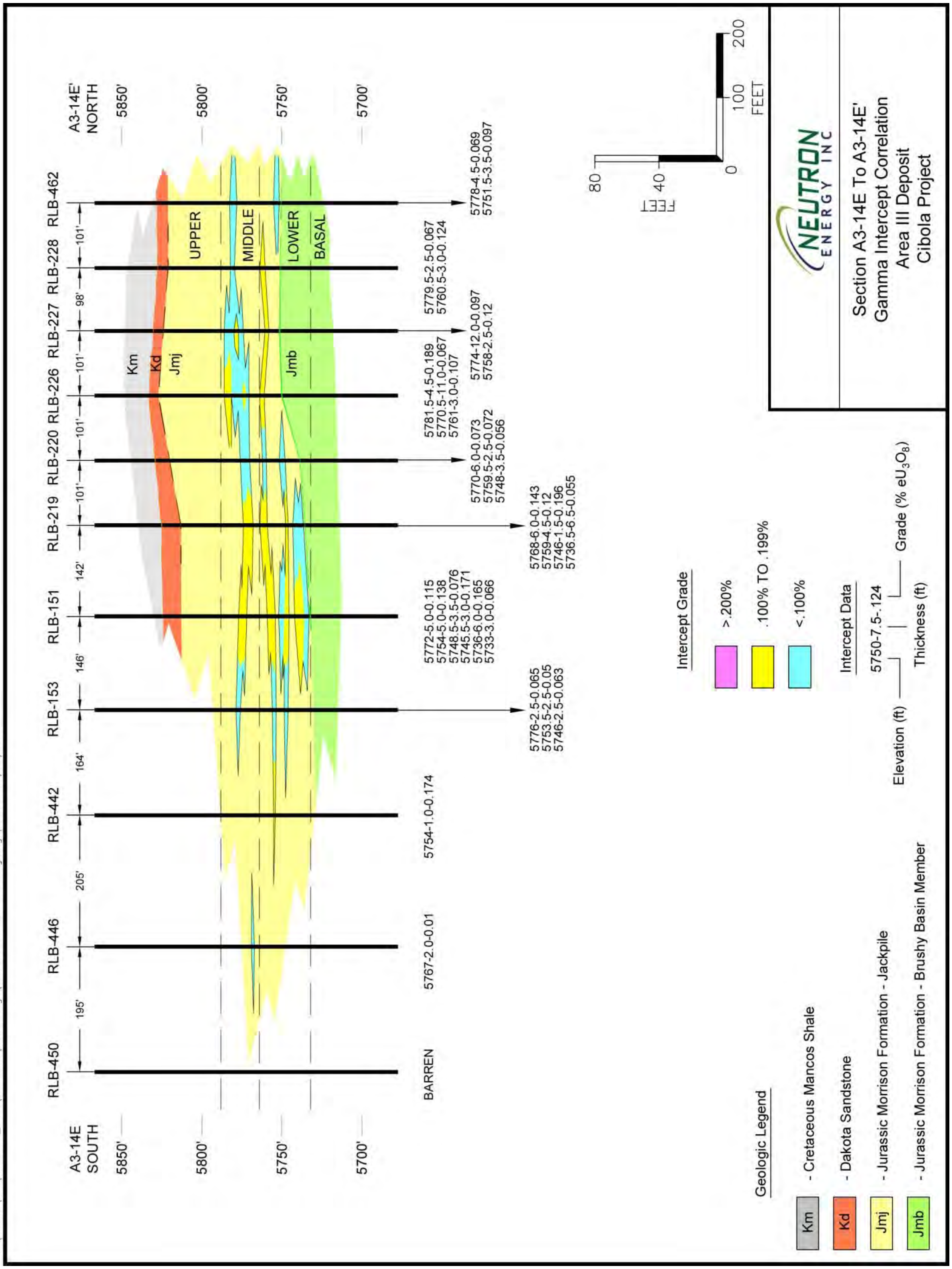

Figure 8.7. Cross-section (Area III Sohio Deposit), A3-14E to A3-14E'.

8.1.6 NATURE AND DEPTH OF OVERBURDEN

The overburden in the project area largely consists of a conformable sequence of Cretaceous sedimentary strata. At the very top of the stratigraphic section are the Mancos marine shales, containing the Tres Hermanos Units. The dark gray to black Mancos extends downward to the Dakota Sandstone that unconformably overlies the Morrison Formation. The Morrison Formation includes the ore-bearing Jackpile Sandstone and the bentonitic mudstones with interbedded sands and thin lacustrine limestone beds in the Brushy Basin Member (Carter 2011).

Overburden thickness ranges from about 9 m (30 feet) (in the St. Anthony pit area) to 213 m (700 feet) (in the Sohio Areas II and III) and is primarily controlled by topography and depth to the Jackpile (i.e., higher landscape elevation equals thicker overburden). The majority of the overburden is composed of quartzose sandstones, siltstone, mudstone, and marine shale lithologies that are relatively stable and resistant to chemical alteration (Carter 2011).

8.2 SAMPLING OBJECTIVES

Section 19.10.6.601(13)(f) of the NMAC requires that a discussion of substrata that are likely to create acid mine drainage and degrade surface and/or groundwater be provided (EMNRD 2010). Acid mine drainage from marine and continental sedimentary rocks in the Grants-Gallup Mineral Belt has not been a characteristic occurrence or problem. The previous mining operations of the St. Anthony and Sohio Area II and V deposits bear this out.

According to Dr. Virginia McLemore of the New Mexico Bureau of Geology and Mineral Resources (V. McLemore, personal communication, June 20, 2011), there are no recognized acid drainage problems associated with uranium mining from the geologic strata present at the site. This is supported by X-ray diffraction (XRD) results obtained from cores collected within the Jackpile Sandstone at the St. Anthony mine area (INTERA Incorporated [INTERA] 2007). Results of the XRD analyses do not indicate the presence of pyrite or other iron-containing minerals. Based on this, Neutron does not anticipate additional geologic sampling since acid mine drainage is not expected to be an issue in the project area.

A subsurface investigation was performed at the St. Anthony mine site to facilitate the preparation of a Stage 1 Abatement Plan (INTERA 2007). This study included the installation of alluvial and deep bedrock wells, hydraulic tests, surface and groundwater sampling, a gamma survey, and overburden pile sampling. This assessment was performed by INTERA for UNC to assess environmental impacts from previous mining operations. A summary of the results from this assessment is introduced here and discussed further in the Section 9.0 Surface Water and Section 10.0 Groundwater sections of the SAP. A more in depth discussion of the assessment and a copy of the report will be included in the forthcoming BDR.

The Stage 1 Abatement Plan assessment focused on potential impacts to surface and groundwater from the St. Anthony mine site. In particular, the assessment investigated possible impacts to surface and groundwater from the overburden piles located on the property. The potential impacts from an existing pond in the larger pit of the St. Anthony mine were also assessed. The presence of these ponds is a feature that is unique to the historic St. Anthony open pit mine and has no direct bearing on the local geologic setting discussed in this particular document. The Phase 1 investigation, with the important conclusions drawn from that work, will be discussed in depth as part of the forthcoming BDR.

A minor subset of the overburden piles that were evaluated contained “mixed economical” material that included low-grade to non-economical (at the time) mineralized rock that was mined from the Jackpile unit and stockpiled on the surface. The assessment included extensive sampling of the overburden piles and analysis of the samples using the Synthetic Precipitation Leaching Procedure (EPA Method 1312, SPLP). The results of the assessment concluded that:

- Stormwater sampling results indicated only a slight increase in uranium and gross beta content over background levels when comparing upstream and downstream water quality.
- There is a likelihood that minor rill and slope erosion of the overburden piles is occurring. However, groundwater samples collected from nearby wells completed in the shallow alluvium (approximately 18 m [60 feet] below ground surface) do not reflect metals impacts mobilized from the overburden piles.
- While there was preliminary evidence of leaching of soluble minerals from the overburden piles, groundwater quality in downgradient shallow alluvial wells did not show evidence of degradation caused by mining activities,
- Based on site-specific background water quality obtained from wells located on-site, there was no indication of groundwater impacts above undisturbed background ranges in the vicinity of the site.

Several interesting and pertinent observations were obtained from the study. In general, there are mechanisms that have helped mitigate reductive metal impacts to the groundwater at the site:

- Meteoric waters that mix into uranium mineralized aquifers may be sufficiently oxidizing to initially dissolve uranium and form solutions at concentrations greater than regulatory standards. However, the resultant mineralized groundwater is typically not capable of transporting the solubilized minerals over large distances. This is because these minerals precipitate out of solution as the groundwater migrates away from the recharge zones and conditions become more reducing. Natural attenuation of metals concentrations will occur as groundwater moves from areas of high to low dissolved oxygen concentrations (INTERA 2007).
- The arid nature of the New Mexico climate is a significant factor in the prevention of the migration of precipitation into and through the unsaturated zone. A conservatively estimated travel time for the migration of precipitation through a relatively thin section of overburden (15 m [50 feet]) was calculated to take over 1,200 years (INTERA 2007).
- Dissolved metals concentrations within the aquifer located in undisturbed portions of the ore body (background) were found to be higher than in wells located in mined areas downgradient of the ore body (INTERA 2007). Based on this, it can be concluded that in comparison to the uptake and transport of naturally occurring uranium mineralization, the previous mining operations did not contribute to groundwater impacts at the site.

The Stage 1 Abatement Plan (Intera 2006) assessment indicates that based on previous mining operations, it is unlikely that the currently proposed mining activities will cause detrimental impacts to groundwater or result in the formation of acid drainage at the Cebolleta Mine Site. Based on the data obtained from existing studies and assessment, additional geologic sampling is not proposed.

8.2.1 GEOLOGIC SAMPLING DISCUSSION: DRILLING AND SAMPLING DATA

Neutron has acquired an extensive data set for this portion of the Cebolleta Mine Site area, including several thousand gamma-ray/electrical logs for holes drilled by Sohio, Teton Exploration, and United Nuclear/UNC Resources, as well as numerous technical reports, drill hole maps, mineral resource estimates and studies, assay certificates, and mining and mineral processing data.

Previous exploration drilling carried out by Sohio and Teton/United Nuclear/UNC Resources at the Cebolleta Mine Site involved the use of conventional, or open-hole, rotary and “spot core” drilling to explore for and to sample zones of uranium mineralization on the properties. Drill holes were designed to penetrate the target horizons, which were the full Jackpile Sandstone section and the upper portion of the Brushy Basin Member of the Morrison Formation. Samples of the drill cuttings were collected at intervals of 1.5 or 3 m (5 or 10 feet) and the samples were examined by geologists who prepared lithologic logs describing rock types, alteration, presence and nature of carbonaceous material, accessory minerals (including pyrite, hematite, and/or limonite), oxidation state of the target sediments, and other geologic information.

The standard operating procedure (SOP) in the U.S. uranium industry during the time of the Cebolleta project exploration programs was to continuously log each drill hole with a down-hole probe that measured gamma radioactivity, S-P (self-potential), and single point resistivity values. Equivalent uranium (percent eU_30_8) grades, which are radiometric assays, were calculated from the resulting gamma ray logs using calculation methodologies that were considered “standard” in the uranium mining industry at the time the work was undertaken. These exploration and evaluation techniques remain valid, appropriate, and effective methods to explore for and develop sandstone-hosted uranium deposits and are regularly used in today’s uranium industry.

To provide a check against the radiometric assays obtained from the gamma ray logs of the drill holes, the project operators collected samples (Coltrinari 1977; Hogg 1977; Marquez 1979) from many core holes, which were also logged with gamma logging equipment. The uranium content of the samples was chemically determined via fluorimetric analytical methods. Individual radiometric assays were also determined at a commercial laboratory (Hazen Research, Inc. [Hazen Research]). Chemical assays of uranium content in the core samples were determined by Hazen Research, Charles O. Parker & Co., Root & Simpson, Inc., and the Grants Assay Office and Laboratory. A comparison of the radiometric grades (as determined from the corresponding gamma ray logs) was made with the chemical grades (Marquez 1979). This method of assaying was an SOP in the U.S. uranium industry in the 1970s and 1980s. It is still regarded as an effective technique for determining the equilibrium state of uranium mineral deposits.

Additionally, Neutron has acquired gamma-ray/electric logs and cores from two core holes recently drilled in the St. Anthony area by INTERA (see discussion in Section 8.5). Grade thickness and isopach maps have been prepared for several of these deposits, and gamma log and geologic cross sections have been constructed by Neutron's geologic staff as it undertakes a comprehensive review and analysis of the available information.

Neutron personnel have also recently completed a detailed channel sampling program on zones of the main mineralized horizons that are exposed in the north and south open pits in the St. Anthony area. They also sampled and assayed recently acquired drill core from two newly completed water monitoring boreholes located in the St. Anthony area. Collectively, these samples are fully representative of the nature and grade of the uranium deposits hosted in the Jackpile Sandstone at the St. Anthony and adjoining Sohio segments of the Cebolleta Mine Site.

The following are the procedures employed by Neutron's staff in the channel sampling program:

- Sampling locations were selected during radiometric traverses of the floor, slopes and high-walls of the open pits, and compared to the locations of adjacent and contiguous drill hole polygons. High radiometric anomalies (as outlined with a hand-held Radiation Solutions RS-125 "Super-Spec" spectrometer and a Delta Epsilon Instrument Co. SC-133 hand-held scintillometer) were marked with orange spray paint on the walls of the pits.
- Sample intervals were selected based in part on the radiometric anomalies and lithologic changes observed by the Neutron's geologists. Individual sample intervals were selected to include an unmineralized interval above and below the mineralized intervals (if accessible); varying mineralized lithologies were sampled separately, and no individual sample exceeded 0.76 m (2.5 feet) in vertical thickness.
- The weathered surfaces of the channel sample sites were "cleaned" with an electric chipping hammer to remove surface oxidized and leached material from the sample sites.
- Channels were cut into the sandstone faces with a handheld gasoline-powered diamond saw, and these vertical cuts were approximately 20 cm (8 inches) deep.
- Individual samples were removed from the channels with an electric chipping hammer, and the entirety of the removed material was placed in cloth sample bags. Sample weights ranged from 1.36 to 22.22 kg (3–49 pounds), and averaged 8.86 kg (19.5 pounds) in weight.
- Aluminum sample tags were inscribed with the sample numbers and affixed to steel spikes that were driven into the high-wall of the open pit at each sample site to provide semi-permanent markers.
- Samples were transported by a Neutron employee to the Elko, Nevada, sample preparation facility of American Assay Laboratories.
- After preparation (crushing, grinding, and splitting), the 83 individually numbered samples (several required more than one sample bag to deliver all the material harvested from a given targeted interval) were analyzed for U_30_8. Samples were analyzed by a 2 acid digestion followed by inductively coupled plasma optical emission spectrometry (ICP-OES), and all results exceeding 50 parts per million $U3O8$ were checked by X-ray fluorescence and a sodium peroxide/zirconium fusion ICP-OES. In addition to the total of 133 bags of samples submitted (for the 83 individual sampled intervals), the laboratory

randomly inserted four known "standards" and two "blanks" (nil value), and eight samples were selected for re-analysis ("re-runs").

- Results from this sampling program compare very favorably with mineralized intercept data indicated in the nearest-neighboring historic drill holes, and thus are also considered highly representative of the St. Anthony deposits.

8.2.2 HISTORIC METALLURGICAL TESTING

Although ore mined from the Sohio underground mine and St. Anthony open pit and underground mines was processed at the Sohio and Church Rock mills respectively, Bokum Resources Corporation conducted detailed laboratory tests of the mineralized material from all of the nearby operations at the Bokum mill's pilot facility (McCorkle, personal communication 2010) at Marquez.

The objective of this test work was to determine the amenability of this material to the process design of the Bokum mill (Reynolds et al. 1979; Kemp and Associates 1986). Test work conducted by Hazen Research (Reynolds et al. 1979) found "leach extraction under Bokum conditions ran about 94-96% with a head assay of 0.082% U_30_8. Acid consumption is lower than Marquez ore." Hazen Research went on to say that "solvent extraction was generally successful with good extraction and stripping behavior… In conclusion, the ore sample representing toll ore from St. Anthony responded to the Bokum mill design specifications with good extraction, low reagent consumption, and without significant solvent extraction problems" (Carter 2011). This confirms that Neutron's intent to process Cebolleta ore at the Marquez (Juan Tafoya) mill is viable from a metallurgical perspective.

8.2.3 ADDITIONAL DISCUSSION

Neutron is in possession of an extensive body of geochemical, geophysical, and geological data that serves as the basis for the technical aspects of this project. These data appear to meet the standards employed by the uranium exploration and mining industry in the United States at the time it was collected, and the firms that collected this technical information were highly experienced exploration and uranium production companies with long histories of work in the Grants Mineral Belt.

New processing of past data relating to the Cebolleta Mine Site follows Neutron's strict SOPs and QA/QC procedures. Data are scanned by electronic methods into digital images and entered into Neutron's database. Gamma-ray logs were first scanned, using electronic methods, and the various "curves" (gamma-ray, S-P, and resistivity) were then digitized, using NeuraLog commercial software. Data output from NeuraLog was exported in the form of text and log ascii standard (LAS) digital files and entered automatically and manually into the project database. Gamma-ray data were plotted in a graphical format in Microsoft Excel and visually compared against the original gamma-ray logs to check the accuracy of data entry.

All files entered manually into the project database were entered using the "double blind entry" method. The individual spreadsheets for each data set were then compared to determine if any entry errors were made. This method was employed for the drill hole collar coordinates, hole "drift" and deviation surveys, and other data.

Drill hole location data were also checked by plotting the boring locations on new maps and overlaying the recorded data on historic maps to check for any discrepancies. The data in these databases were randomly checked and found to be well assembled, and the double blind entry system enabled any errors in data entry to be corrected. The database was found to be sound. Based on the extensive information available for the project, Neutron does not anticipate performing any additional geologic sampling other than for geotechnical testing purposes. Consequently, no additional geochemical sampling is proposed.

8.3 SAMPLING FREQUENCY

No additional geologic sampling, other than for geotechnical purposes, is deemed necessary to complete the baseline geologic characterization of the Cebolleta Mine Site.

8.4 LIST OF DATA TO BE COLLECTED

No additional geologic data are needed to complete the baseline geologic characterization of the Cebolleta Mine Site. Since additional geologic sampling is not planned, a discussion on the methods of collection, parameters to be analyzed, and maps providing sampling locations, sampling frequency and laboratory and field QA/QC plan is not included in this SAP.

8.5 BRIEF DISCUSSION SUPPORTING PROPOSAL

The vast amount of geologic and mineralogical data that has been collected from previous investigations has provided Neutron with a significant database of pertinent information regarding the site. Based on the review of the existing data and extensive characterization of current site conditions, there do not appear to be significant data gaps that would hinder the understanding of either the surface or subsurface geology at the site. Based on this no additional geologic sampling is proposed.

8.6 LITERATURE CITED

Baird, Charles W., Kalvin W. Martin and Robert M. Lowry, 1980; Comparison of Braided-Stream Depositional Environment and Uranium Deposits at Saint Anthony Underground Mine; in Rautman, Christopher A., compiler, Geology and mineral technology of the Grants uranium region, 1979; New Mexico Bureau of Mines and Mineral Resources Memoir 38; p. 292-298.

Boyd, R. G., 1981; In-Place Ore Reserve Calculations Through June 30, 1981 (with a section "South L-Bar Geology Report Summary and Recommendations" by Cady, Gretchen W.); Internal Report, Sohio Western Mining Company, 29 pp.

Boyd, Ronald G., Lynn C. Jacobsen, Erwin K. Kopp and J. H. Olsen, Jr., 1984; South Sohio Operations Variable Ore Reserve Study & Revised Mine Plan, February, 1984; Internal Report, Sohio Western Mining Company, 38 pp. and 4 maps.

Carter, G.S., 2011; Technical Report on the Uranium Resources at the Cibola Project; Report for NI 43-101; on behalf of Neutron Energy, Inc.; 100 pp.

Coltrinari, E. L., 1977; Uranium Recovery From Marquez Canyon Ore Body by Acid Leach and Solvent Extraction Laboratory Studies; Private report from Hazen Research, Inc. to Bokum Resource Corporation, 17 pp, 12 tables and appendix (78 pp).

Craig, L.C., C.N. Holmes, R.A. Cadigan, V.L. Freeman, T.E. Mullens, and G.W. Weir, 1955; Stratigraphy of the Morrison and Related Formations, Colorado Plateau Region – A Preliminary Report; US Geological Survey Bulletin 1009-E, 43 pp.

Carter, G.S., 2011; Technical Report on the Uranium Resources at the Cibola Project; Report for NI 43-101; on behalf of Neutron Energy, Inc.; 100 pp.

Dane, C. H., 1959, Historical background of the type locality of the Tres Hermanos Sandstone Member of the Mancos Shale: New Mexico Geol. Soc. 10th Field Conf. Guidebook, p. 85-91.

Dillinger, J.K., 1990; Geologic Map of the Grants 30’ X 60’ Quadrangle, West-Central New Mexico; US Geological Survey Map C-118-C.

Fassett, J.E., 1989; Coal Resources of the San Juan Basin; *in* Southeastern Colorado Plateau, New Mexico Geological Society, 40th Field Conference Guidebook, p. 303–307.

Fitch, D.C., 1980; Exploration for Uranium Deposits, Grants Mineral Belt; *in* Rautman, Christopher A., compiler, Geology and mineral technology of the Grants uranium region, 1979; New Mexico Bureau of Mines and Mineral Resources Memoir 38, p. 40-51.

Hackman, R.J., 1967; Preliminary Photogeologic Map of the Laguna 2 Quadrangle, McKinley, Sandoval, and Valencia counties, New Mexico; US Geological Survey Open-file Report-1967; scale 1:62,500.

Herrick, C. L., and Johnson, D. W., 1900a, The Geology of the Albuquerque Sheet: Bull. of the Hadley Lab. of the Univ. of New Mexico, v. 2, no. 1, p. 1-67.

Hogg, G.M., 1977; A Report on the Bokum Resources Marquez Uranium Properties for Long Island Lighting Company; Private Report Prepared for Long Island Lighting Company, 34 pp., 3 appendices, 7 plates.

Hunt, C. T., 1936, Geology and fuel resources of the southern part of the San Juan Basin, New Mexico; the Mount Taylor Coal Field: U. S. Geol. Survey Bull. 860-B, p. 31-80.

Intera 2007; Stage 1 Abatement Plan, St. Anthony Mine Site, Cebolleta, New Mexico; Private Report Prepared for United Nuclear Corporation, Submitted to New Mexico Environment Department, Ground Water Quality Bureau, Mining Compliance Division, 40 pp.

Jacobsen, L. C., 1980; Sedimentary Controls on Uranium Ore at L-Bar Deposits, Laguna District, New Mexico; in Rautman, Christopher A., compiler, Geology and mineral technology of the Grants uranium region, 1979; New Mexico Bureau of Mines and Mineral Resources Memoir 38, p. 284-291.

Kemp, Emerson, and Associates, 1986; Technical Audit of Bokum, L-Bar and Quivira Uranium Mills, Production Capabilities and Costs; Private report prepared for Energy Fuels Nuclear, Inc., 55 pp.

Landis, E.R., C.H. Dane, and W.A. Cobban, 1973. Stratigraphic Terminology of the Dakota Sandstone and Mancos Shale, West-Central New Mexico; U.S. Geological Survey Bulletin 1372-J.

Livingston, B.A. Jr., 1980; Geology and Development of Marquez, New Mexico, Uranium Deposit; *in* Rautman, Christopher A., compiler, Geology and mineral technology of the Grants uranium region, 1979; New Mexico Bureau of Mines and Mineral Resources Memoir 38, pp. 252 – 261.

Marquez Development Corporation, 1979; Marquez Uranium Ore Reserves Report; Private Report, 5 pp. and tables.

McLemore, Virginia T., 2000: St. Anthony Mine; Unpublished memorandum, New Mexico Bureau of Geology and Mineral Resources, 3 pp.

McLemore, Virginia T. and Chenoweth, William L. 1991; Uranium Mines and Deposits in the Grants district, McKinley and Cibola Counties, New Mexico; New Mexico Bureau of Mines and Mineral Resources Open-file Report 353, 33 pp.

Melting, A. C., 1980; Reserve Oil and Mineral Corp.; Internal Memorandum, David S. Robertson & Associates, Inc., 4 pp.

Moench, R.H., and Puffett, W.P. 1963; Geologic map of the Arch Mesa Quadrangle, New Mexico; United States Geological Survey.

New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division (EMNRD). 2010. Guidance Document for Part 6 New Mining Operation Permitting under the New Mexico Mining Act. Santa Fe: New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division.

Olsen, J. H. Jr. and E. K. Kopp, 1982; South L-Bar Life-of-Mine Plan, October, 1982; Internal report, Sohio Western Mining Company, 10 pp., 8 tables, 6 appendices.

Reynolds, J. E., A. R. Williams, and R. J. Kuyvia, 1979; Uranium Recovery from St. Anthony Ore Acid Leach and Solvent Extraction – Laboratory Studies; Private report from Hazen Research, Inc. to Bokum Resources Corporation, 52 pp., 3 appendices.

Wright, R.J., 1980; Grants and World Uranium; *in* Rautman, Christopher A., compiler, Geology and Mineral Technology of the Grants Uranium Region, 1979; New Mexico Bureau of Mines and Mineral Resources Memoir 38, p. 22-35.

9.0 SURFACE WATER

9.1 INTRODUCTION AND BACKGROUND

The following subsections provide background, strategy, and methodology for evaluating baseline surface water conditions for the Cebolleta Mine Site.

9.1.1 SURFACE WATER CHARACTERISTICS OF SITE AND VICINITY

The Cebolleta Mine Site area falls within the Rio San Jose watershed, as defined by the USGS National Hydrography Dataset (USGS 2010). This watershed includes approximately 6,726 km^2 (2,597 square miles) in Catron, Cibola, McKinley, Socorro, and Valencia counties and is dominated by the Rio San Jose and its tributaries.

The regional surface topography is a combination of steep-sided mesas separated by broad, gently sloping valleys. These valleys are infilled with alluvial and colluvial deposits, with primary stream channels incised through previously deposited sediments. To the north and northwest, surface topography is dominated by the Mount Taylor volcanic field, which consists of broad, gently sloping basaltic flows with steep sides at flow edges. Numerous volcanic plugs occur in the area, similar to Cerro Negro to the northwest. The regional topography of mesas and valleys is dominant to the south and east (INTERA 2008a).

Regional drainage is to the east, first to Meyer Draw (aka Arroyo del Valle), then to Arroyo Conchas, and finally to the Rio San Jose to the south of the area shown in Figure 9.1. The drainage continues farther south and east into the Rio Puerco watershed along the Rio Puerco, eventually draining into the Rio Grande in central New Mexico. Although there are no perennial streams on the Cebolleta Mine Site, Rio Paguate is located about 4.2 km (2.6 miles) west of Area I and is perennial (USGS 2010).

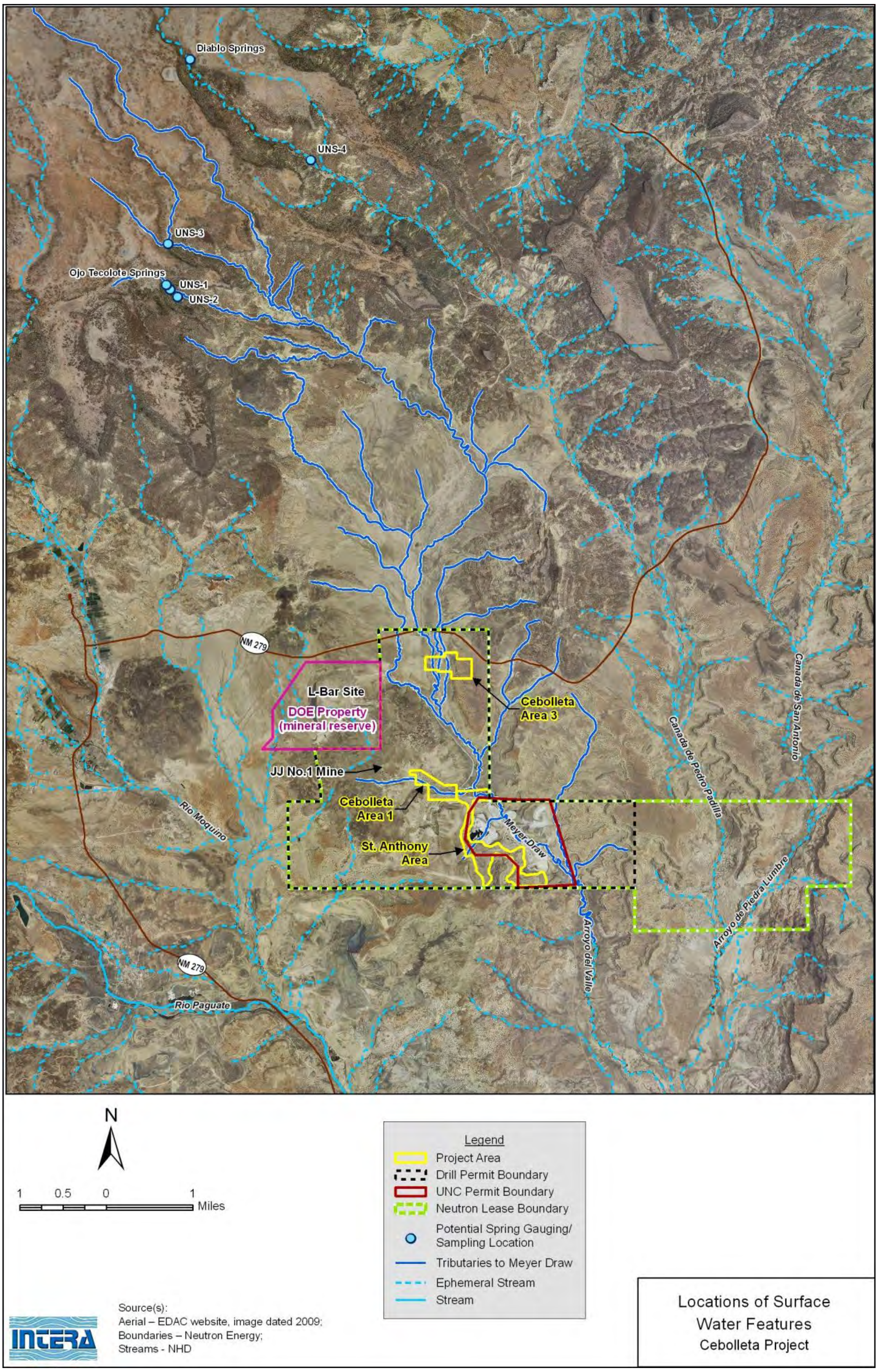

Figure 9.1. Surface water features location.

9.1.2 HISTORICAL DATA

Several studies have been completed for the Cebolleta Mine Site area, including the following:

- Stage 1 Abatement Plan, Revision 1, JJ No. 1/L-Bar Mine, Cibola County, New Mexico, prepared for Sohio Western Mining Company, prepared by INTERA, September 2006.
- Closeout/Mitigation Plan, JJ No. 1/L-Bar Mine, prepared for Sohio Western Mining Company, prepared by INTERA, October 2008a.
- St. Anthony Mine Stage 1 Abatement Plan, prepared for UNC, prepared by Montgomery, Watson, Harza, August 2002.
- Stage I Abatement Plan Investigation Report, St. Anthony Mine Site, Cebolleta, New Mexico, prepared for UNC, prepared by INTERA, submitted to the NMED, May 19, 2008b (Rev 2).
- St. Anthony Stage 2 Abatement Proposal, prepared for UNC, prepared by INTERA, submitted to the NMED, November 3, 2008c.
- St. Anthony Mine Close-Out Plan (draft), prepared for UNC, prepared by Montgomery, Watson, Harza (pending).

9.2 SAMPLING OBJECTIVES

The objective of sampling surface water is to characterize the volumetric flow and water quality of seeps, springs, and streams in the area of interest. Table 9.1 lists the frequency, location, and method for the proposed sampling program. Figure 9.2 below provides proposed sampling locations. Prior information exists for two of the locations (AS-N and AS-S) from ongoing site characterization activities performed by UNC. This information may be used for the following purposes:

- Develop the discharge plan application for water produced during mine dewatering.
- Determine baseline conditions.
- Describe the seasonal variations in surface water quantity and quality in the vicinity of the Cebolleta Mine Site.
- Determine the potential for impacts on the hydrologic regime, such as the quality and quantity of surface water systems in the vicinity, including dissolved and suspended solids under seasonal conditions.
- Meet the requirements set forth in the regulations in NMAC Title 19, Chapter 10, Part 6 for new mine permit applications.

Sources that could affect surface water quality in the general project area include the past disposal of mill tailings, drainage from existing mine stock piles, and erosion associated with potential reduced land cover and increased land disturbance. Dewatering activities and groundwater development for mine operations could affect surface water quantity. This plan outlines how, when, and where data will be collected to characterize baseline conditions in support of mitigating potential impacts to surface water quality and quantity.

9.3 SAMPLING FREQUENCY

As there are no perennial streams upgradient or within the Cebolleta Mine Site area, sampling will take place in ephemeral streams opportunistically after precipitation events. The frequency of sampling will be dependent on the frequency and intensity of precipitation events throughout the baseline study year. If there is not sufficient streamflow, it may not be possible to collect a sample. At least one soil sample will be taken at the surface water sampling locations illustrated in Figure 9.2 as provided in the NMED Surface Water Quality Bureau (SWQB) Standard Operating Procedures for Data Collection (NMED SWQB 2007) regardless of the presence or absence of water. The frequency of sampling by location is presented in Table 9.1.

Table 9.1. Proposed Surface Water Monitoring Locations, Sampling Frequency, and Method of Collection

Sample Location	Location Type	Likely Flow Type	Description of Location	Quarterly or Opportunistic Flow Measurement	Method of Collection	Quarterly Water Quality Sample
PAS-1	Auto-sampler	Ephemeral	Auto-sampler location upstream of Area III in Meyer Draw	Opportunistic	Automated and/or Grab Sampling	X
PAS-2	Auto-sampler	Ephemeral	Auto-sampler location downstream of Area III in Meyer Draw	Opportunistic	Automated and/or Grab Sampling	X
PAS-3	Auto-sampler	Ephemeral	Auto-sampler location downstream of Area III in Meyer Draw	Opportunistic	Automated and/or Grab Sampling	X
AS-N*	Auto-sampler	Ephemeral	Auto-sampler location downstream of Area I in Meyer Draw	Opportunistic	Automated and/or Grab Sampling	X
AS-S*	Auto-sampler	Ephemeral	Auto-sampler location downstream of Project in Meyer Draw	Opportunistic	Automated and/or Grab Sampling	X
Ojo Tecolote Springs	Spring	Intermittent	Upstream tributary of Meyer Draw	Quarterly	Grab	X
UNS-1	Spring	Intermittent	Upstream tributary of Meyer Draw	Quarterly	Grab	X
UNS-2	Spring	Intermittent	Upstream tributary of Meyer Draw	Quarterly	Grab	X
UNS-3	Spring	Intermittent	Upstream tributary of Meyer Draw	Quarterly	Grab	X
Diablo Spring	Spring	Intermittent	Spring in adjacent catchment to Meyer Draw	Quarterly	No Sample	
UNS-4	Spring	Intermittent	Spring in adjacent catchment to Meyer Draw	Quarterly	No Sample	
Rio Moquino	Gauging location	Perennial	Transect in perennial Rio Moquino west of Cebolleta Mine Site	Quarterly	No Sample	

*Prior data for sites is available.

9.4 LIST OF DATA TO BE COLLECTED

A variety of data needs are associated with surface water. These needs are provided in Table 9.2 along with a plan for how each need will be addressed through this SAP.

Table 9.2. Surface Water Resources Data Needs

Data Need	Plan To Address Data Need
Nature of flow and water quality in Rio Moquino.	One gauging location along a perennial reach is proposed to characterize streamflow if possible upstream of the permit area by collecting quarterly measurements of flow with Marsh McBirney, and sonde readings for pH, temperature, dissolved oxygen, and specific conductivity.
Potential of mine discharge to have a significant, quantifiable effect on flow in Meyer Draw.	Opportunistic streamflow and water quality sampling at four sites (PAS-1, PAS-2, AS-N, and AS-S) is proposed upstream, within, and downstream of the mine. Installation of auto-samplers along the ephemeral reach will enable opportunistic sampling.
Geochemical characteristics of sediment	Sediment samples will be collected concurrently with surface water samples collected from ephemeral reaches of streams. The list of sediment parameters to be analyzed is presented in Table 9.3.
Nature of flows from springs and seeps	Up to six springs are proposed to characterize spring flow by measuring discharge. Up to four springs are proposed to characterize water quality by collecting quarterly water samples and measurements. Four sites are located within tributaries to Meyer Draw, while two additional springs are in an adjacent catchment.

9.5 METHODS OF COLLECTION

In general, the methods used to collect surface water samples will follow the SOPs defined by the NMED SWQB (2007) for streamflow measurement and water quality sampling, as described below.

9.5.1 SURFACE WATER SAMPLES FROM SPRINGS AND DRAINAGES

VOLUMETRIC FLOW MEASUREMENTS

Streams. As there are no perennial streams on the Cebolleta Mine Site, quarterly volumetric flow measurements cannot be made. Given the unpredictable nature of flow in ephemeral reaches of streams, intermittent streamflow in many of these locations will be recorded using deployed, portable, automatic sampling devices (auto-samplers). An auto-sampler, such as the Global Water FSS Flow Sampling System (or similar), will be installed to collect streamflow during periods in which there is measurable flow. Each auto-sampler will consist of a pressure transducer, a pickup hose, a circuit board controller, a datalogger, a rechargeable gel cell battery, and an external pump trigger that will consist of either a float switch or a conductivity sensor that is placed in the stream channel. With the exception of the pressure transducer, the external pump trigger, and the pickup hose, the components are housed in a waterproof case mounted above ground next to the sampling location, which is outside the ordinary high water mark of the channel. Auto-samplers will be installed within Meyer Draw in the vicinity of the Cebolleta

Mine Site as listed in Table 9.1 and shown in Figure 9.2. The location of these auto-samplers will ensure that there is a sampling point up- and downgradient of the Cebolleta Mine Site area.

Springs and Seeps. Four springs/seeps are located upstream of the Cebolleta Mine Site on the CLG (USGS 2010). The springs/seeps are located along tributaries of Meyer Draw. One spring is identified as Ojo Tecolote Springs; the other three will be referred to as Un-Named Springs (UNS) 1–3. UNS 1 and 2 are located in the same general area as Ojo Tecolote Springs, discharging to the same tributary. UNS 3 is located in an adjacent tributary. In addition, there are two seeps/springs located in a nearby adjacent catchment: Diablo Springs, located about 4.3 km (2.7 miles) north of Ojo Tecolote Springs, and another spring referred to here as UNS 4, located about 3.5 km (2.2 miles) to the northeast of Ojo Tecolote Springs. While no discharge from these more distant springs will pass through drainages along the Cebolleta Mine Site, monitoring of the volumetric flow of these springs may be warranted due to their proximity to the project. The locations of the seeps/springs are shown on Figure 9.1. These springs may be gauged for flow quarterly, provided that land access is obtained and the springs are flowing.

The closest spring/seep downstream of the Cebolleta Mine Site is about 35 km (22 miles) downstream along the Rio San Jose and is not a good candidate for sampling or flow measurement, as water quality and quantity may be subject to many other influences between the Cebolleta Mine Site area and the downstream spring.

Volumetric flow from springs and seeps can be measured with a portable V-notch weir box or adjustable flume, if sufficient flow exists and channel conditions are appropriate. The V-notch weir box operates under the principle that discharge is related to the height of the water above the bottom of the V-shaped notch; the shape ensures that a small change in the discharge will effect a large change in the height of the water. Flow can be calculated from measurement methods defined for V-notch weirs by the U.S. Bureau of Reclamation (2001). Alternatively, flow can be measured using the same techniques employed for perennial streams, described in NMED SWQB (2007).

If flows are insufficient for the use of a flume or V-notch weir or flow-metering, e.g., <0.1 cubic feet per second (cfs) (44.8 gallons per minute [gpm]), volumetric flow will be estimated using the “timed fill” method, as described by NMED SWQB (2007). This method uses a stopwatch to measure the time it takes to fill a calibrated 5-gallon bucket by diverting the entire flow of the spring or seep into the bucket below a weir or waterfall (NMED SWQB 2007). To calculate flow using this procedure, 5 gallons per unit time may be converted to cfs using the following equation:

- **5 g = 0.6684 ft^3, thus 0.6684/elapsed time (seconds) = cfs**

WATER QUALITY SAMPLING

Streams. Individual samples collected over a period of 15 minutes or less (i.e., grab samples) will be obtained either as grab samples or by the auto-samplers (described in Volumetric Flow Measurements above), if possible, installed in the ephemeral stream locations illustrated in Figure 9.2. Each sample will represent water quality conditions at the time the sample was collected. The auto-sampler’s peristaltic pump is activated when a signal is received from the external float switch or conductivity sensor, pulling the 2.5-gallon sample into the sample container through the pickup hose. A shutoff switch prevents the pump from being activated once the sample container is filled. Stage measurements (i.e., depth of water in the stream channel) are recorded at 15-minute intervals in the datalogger and will be available for download onto a laptop computer. Neutron staff will be notified in real-time of a precipitation event by a cellular service that is part of the meteorological station installed on-site and will inspect the auto-sampler for a collected water quality sample following an event. Alternatively, Neutron environmental technicians living near the project area will obtain grab samples immediately following significant precipitation events if auto samplers are not used.

The sample will be retrieved by on-site mine staff, placed in a laboratory-provided sample container, and shipped overnight to the designated laboratory for analysis. All equipment preparation and cleaning, sample collection, and sample preservation will follow the SOPs defined by the NMED SWQB (2007).

Springs and Seeps. During quarterly measurements of flow from seeps and springs, water quality samples will be collected using non-isokinetic, open-mouth samplers following the USGS protocols for sample equipment selection described in Lane et al. (2003). Methods will follow the 2007 NMED/SWQB *Standard Operating Procedures for Data Collection,* Section 7.3 Routine Water Chemistry Sampling. Quarterly sampling and flow gauging may not be possible, depending on flow conditions of the springs and land access limitations.

Samples will be collected in clean polyethylene Cubitainer containers. Where water flows at sufficient depth, samples will be collected by immersing the container by hand or by rod beneath the surface. Otherwise, water will be collected in a plastic bucket or disposable bailer held with nylon rope or twine, if necessary. Care will be taken to avoid contamination with debris from the rope or twine and the sampling area. Buckets and bailers will be rinsed three times with source water and sampling personnel will rinse their hands with source water before collecting samples. Samples will be collected immediately following rinsing. Buckets will be rinsed with spring water following use, and cleaned with Liquinox and warm water prior to the next use.

Water will be transferred from the collection vessel to the sample container with a peristaltic pump or syringe, filtering as appropriate. Dissolved concentration samples will be filtered; total concentration samples will not be filtered. All samples for dissolved constituent analytes will be filtered with a 0.45-micron pore-size disposable inline filter cartridge. Prior to sampling, filters will be rinsed with sample water according to the manufacturer's recommendations.

Every effort will be made to take sonde readings in flowing water. Sonde readings will include pH, temperature, dissolved oxygen, and specific conductivity. When this is not possible, sonde readings will be made from the bucket or bailer after the sample has been collected and a note to this effect will be made on the field sheet.

SEDIMENT SAMPLING IN STREAMS

Sediment samples will be collected at each of the surface water sampling locations identified in Table 9.1. Sample collection methodology will depend on sample location. Field personnel will visit the locations and determine the best approach for ensuring collection of samples based on field reconnaissance and safety considerations (e.g., bank stability). The objective in selecting a sample site is to obtain recently deposited fine sediment. Depositional zones include areas on the inside bend of a stream; areas downstream from obstacles such as boulders, islands, or sand bars; or simply shallow waters near the shore. Where possible, fine-grained surficial sediments will be obtained from several depositional zones that represent various flow regimes within a stream reach and will be composited to yield a sample representing average conditions. However, depositional zones on small, ephemeral drainages may be limited in size, necessitating that a single zone be regarded as representative.

Samples will be collected following NMED SWQB *Standard Operating Procedures for Data Collection* (NMED SWQB 2007), as follows:

1. The sample will be collected in a plastic or Nalgene jar.
2. The sample will be composited from several representative depositional zones into an appropriate mixing container after decanting any excess water over the back of the scoop.
3. The sample will be mixed well.
4. An aliquot of the mixed material will be transferred to the final, labeled sample container (a 4-ounce, wide-mouthed glass jar) and placed on ice for transport to the analytical facility. If shipment cannot be accomplished in a timely manner, the sample will be frozen prior to shipment. (Sediment samples are not preserved.)

If water and sediment samples are to be collected at the same location, water samples will be collected 1) before collecting sediment samples, as sampling sediment will disturb the stream, and 2) downstream of sediment samples, as water sampling may disturb representative depositional zones. Personnel collecting samples will employ proper sample handling techniques, including wearing latex or nitrile gloves, avoiding hand contact with contaminating surfaces, and minimizing the number of sample handling steps. Sample containers will be covered while being moved to minimize the atmospheric input. All sample collection equipment will be rinsed as soon as possible after use and thoroughly rinsed with ambient water at each new sampling station before collecting a sample. Equipment used will be inert with respect to the analytes to be collected.

9.6 PARAMETERS TO BE ANALYZED

The samples will be analyzed for the suite of parameters and methods provided in Table 9.3.

Table 9.3. Analytical Parameters and Analysis Methods for Surface Water and Sediment Samples

Analytical Parameter	Analysis Method for Water	Practical Quantitation Limit (mg/L unless noted)	Analysis Method for Sediment	Lab Detection Limit for Sediments (mg/kg unless noted)
Anions				
Fluoride	EPA Method 300.0	0.1	NA	NA
Chloride	EPA Method 300.0	0.1	NA	NA
Nitrogen, Nitrite (as N)	EPA Method 300.0	0.1	NA	NA
Nitrogen, Nitrate (as N)	EPA Method 300.0	0.1	NA	NA

Analytical Parameter	Analysis Method for Water	Practical Quantitation Limit (mg/L unless noted)	Analysis Method for Sediment	Lab Detection Limit for Sediments (mg/kg unless noted)
Sulfate	EPA Method 300.0	0.5	NA	NA
Dissolved Metals				
Aluminum	EPA Method 200.7	0.02	EPA Method 200.7	1.0
Antimony	EPA Method 200.8	0.001	EPA Method 200.8	0.25
Arsenic	EPA Method 200.8	0.001	EPA Method 200.8	1.0
Barium	EPA Method 200.7	0.002	EPA Method 200.7	0.1
Beryllium	EPA Method 200.7	0.002	EPA Method 200.7	0.1
Boron	EPA Method 200.7	0.04	EPA Method 200.7	2.0
Cadmium	EPA Method 200.7	0.002	EPA Method 200.7	0.1
Calcium	EPA Method 200.7	0.50	EPA Method 200.7	5.0
Chromium	EPA Method 200.7	0.006	EPA Method 200.7	0.3
Cobalt	EPA Method 200.7	0.006	EPA Method 200.7	0.3
Copper	EPA Method 200.7	0.003	EPA Method 200.7	0.2
Iron	EPA Method 200.7	0.02	EPA Method 200.7	1.0
Lead	EPA Method 200.7	0.005	EPA Method 200.7	0.25
Magnesium	EPA Method 200.7	0.50	EPA Method 200.7	5.0
Manganese	EPA Method 200.7	0.002	EPA Method 200.7	0.1
Total Mercury[+]	EPA Method 7470/7471/245.2	0.0002	EPA Method 7471	0.03
Molybdenum	EPA Method 200.7	0.008	EPA Method 200.7	0.4
Nickel	EPA Method 200.7	0.01	EPA Method 200.7	0.5
Potassium	EPA Method 200.7	1.0	EPA Method 200.7	10
Selenium	EPA Method 200.8	0.001	EPA Method 200.8	1.0
Silicon	EPA Method 200.7	0.08	EPA Method 200.7	4.0
Silver	EPA Method 200.7	0.005	EPA Method 200.7	0.25
Sodium	EPA Method 200.7	0.5	EPA Method 200.7	5.0
Thallium	EPA Method 200.8	0.001	EPA Method 200.8	0.5
Uranium	EPA Method 200.8	0.001	EPA Method 200.8	0.5
Vanadium	EPA Method 200.7	0.005	EPA Method 200.7	0.25
Zinc	EPA Method 200.7	0.005	EPA Method 200.7	0.25
Solids				
Total Suspended Solids (TSS)	SM 2540D	1.0 µg/L	NA	NA
Total Dissolved Solids (TDS)	SM 2540C	10	NA	NA
Percent Solids	NA	NA	CLPSOW290 Part F, D-98	NA
Alkalinity				
Alkalinity, Total (as $CaCO_3$)	SM 2320B	20	NA	NA
Carbonate	SM 2320B	20	NA	NA
Bicarbonate	SM 2320B	20	NA	NA

Analytical Parameter	Analysis Method for Water	Practical Quantitation Limit (mg/L unless noted)	Analysis Method for Sediment	Lab Detection Limit for Sediments (mg/kg unless noted)
Radiochemistry*				
Gross Alpha Radioactivity	EPA Method 900.0	[-]	NA	NA
Gross Beta Radioactivity	EPA Method 900.0	[-]	NA	NA
Radium 226, 228	EPA Method 903.0/904.0	[-]	NA	NA
^{222}Radon	ASTM D5072-92	[-]	NA	NA
Isotopic Uranium (^{234}U, ^{235}U, ^{238}U)	EPA Method 907.0	[-]	NA	NA
Other				
pH	150.1	12.45	NA	NA
Specific Conductance	120.1	0.01 µS/cm	NA	NA
Cyanide	Kelada-01	0.005	M9012A	0.5
Turbidity	180.1			
Temperature	Measured in the field	NA	NA	NA

Notes:

NA = not applicable as sample will not be analyzed for a given parameter
ND = not determined or dependent on the instrument
$^{+}$Total concentration, not filtered prior to preservation.
*Sub-contracted to laboratory to be identified by INTERA/Neutron.
[-] = Defined by sub-contracted laboratory running radiochemistry analyses.
Sediment samples will be prepared using EPA Method 1312-SPLP, Synthetic Precipitation Leaching Procedure, to determine the concentrations of water-soluble constituents in the sediments.

9.7 MAPS SHOWING PROPOSED SAMPLING LOCATIONS

Proposed sampling locations for streams and springs are shown in Figure 9.2. These locations were selected to achieve the following objectives:

1. Develop the discharge plan application for water produced during dewatering.
2. Determine baseline conditions.
3. Describe the seasonal variations in surface water quantity and quality in the vicinity of the Site.
4. Determine the potential for impacts on the hydrologic regime, such as the quality and quantity of surface water systems in the vicinity, including dissolved and suspended solids under seasonal conditions.
5. Meet the requirements set forth in the regulations in NMAC Title 19, Chapter 10, Part 6 (19.10.6.602D(13)g) and the August 2010 *Guidance Document for Part 6 New Mining Operations* for new mine permit applications.

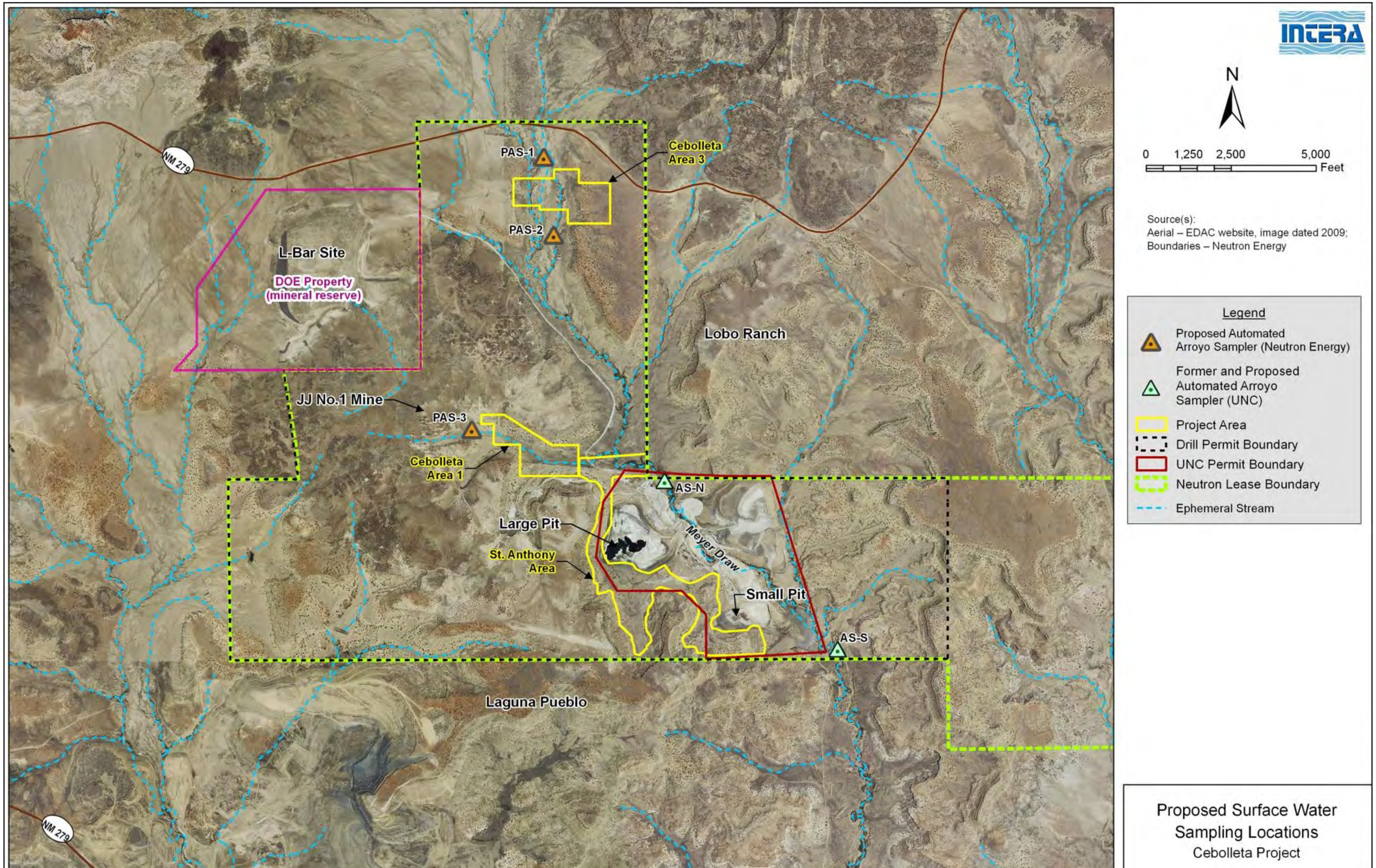

Figure 9.2. Surface water features sampling locations.

9.8 LABORATORY AND FIELD QUALITY ASSURANCE PLANS

Data collected to characterize the water quality and flow of surface water resources discussed in this section of the SAP will conform to the Standard Operating Procedures presented in Appendix C with respect to field methods, sampling procedures, and recording of field notes. If procedures for sampling or analysis are not specifically defined, by the sampling method, or by the analytical method, the NMED SWQB (2007) protocols for field data sampling, equipment calibration and cleaning, sample containment and handling, and photographic documentation will be followed as appropriate and/or applicable to the site conditions.

The samples for chemical analysis will be properly preserved and field filtered, if necessary, before shipment to an analytical laboratory accredited by the NMED and the New Mexico Department of Health. All samples will be shipped within the holding times defined by the analytical method to be used. In addition, containers specific to a given analytical method will be used as appropriate. To provide quality control, duplicates and/or equipment blanks will be collected/used. Analytical results will be stored in a project database that will be provided to the MMD electronically as well as in hard copy as an attachment to the BDR.

9.9 LITERATURE CITED

INTERA Incorporated (INTERA), 2006. Stage 1 Abatement Plan, Revision 1, JJ No. 1/L-Bar Mine, Cibola County, New Mexico, September.

———, 2008a, Closeout/Mitigation Plan, JJ No.1/L-Bar Mine, Cibola County, New Mexico, prepared for Sohio Western Mining Company, October.

———, 2008b, St. Anthony Mine Stage 1 Abatement Plan Investigation Report, prepared for United Nuclear Corporation. May 19.

———, 2008c, St. Anthony Stage 2 Abatement Proposal, prepared for United Nuclear Corporation, prepared by INTERA Incorporated, submitted to New Mexico Environment Department, November 3.

———, 2009, Stage 1 Abatement – Interim Report, JJ No. 1/L-Bar Mine, Cibola County, New Mexico, prepared for Sohio Western Mining Company. June.

Lane, S.L., Flanagan, S., and Wilde, F.D., 2003, Selection of equipment for water sampling (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A2, accessed July 2010 [http://pubs.water.usgs.gov/twri9A2/].

Marsh-McBirney, 1990, Flo-Mate™ 2000 portable flowmeter instruction manual.

Montgomery, Watson, Harza, 2002, St Anthony Mine Stage 1 Abatement Plan, prepared for United Nuclear Corporation, August.

———, pending, St. Anthony Mine Close-out Plan (draft), prepared for United Nuclear Corporation.

New Mexico Environment Department Surface Water Quality Bureau (NMED SWQB), 2007, The 2007 NMED/SWQB standard operating procedures for data collection, July 26, 186 p.

U.S. Bureau of Reclamation, 2001, Weirs, Chapter 7 in Water measurement manual, a water resources technical publication (3d ed.): U.S. Department of the Interior, Bureau of Reclamation, 2001 revised reprint edition, variously paged.

U.S. Geological Survey (USGS), 2010. National Hydrography Dataset, U.S. Geological Survey [Geodatabase], Version 2.0. U.S. Department of the Interior, U.S. Geological Survey. June.

10.0 GROUNDWATER

10.1 INTRODUCTION AND BACKGROUND

The following subsections provide background, strategy, and methodology for evaluating baseline groundwater conditions for the Site.

10.1.1 HYDROGEOLOGY

The hydrostratigraphic unit of primary interest to this SAP is predominately the Jackpile Sandstone. Investigation drilling activities conducted in 2004 by UNC showed that the Jackpile Sandstone unit is the first water-bearing unit beneath the ground surface in the vicinity of the St. Anthony mine. Other studies in the area indicate that there are discontinuous water bearing zones in the Tres Hermanos Sandstone lenses within the Mancos Shale and Dakota Sandstone (INTERA 2006), both overlying the Jackpile Sandstone.

The groundwater system, including the Jackpile Sandstone, is recharged primarily in the topographically high areas of the Zuni, Chuska, and Cebolleta mountains (Stone et al. 1983). Locally, recharge occurs in the San Mateo Mountains to the northwest of the Cebolleta Mine Site. Regional groundwater flow in the Morrison Formation, including the Jackpile Sandstone, in the vicinity of the Cebolleta Mine Site is to the south/southeast. Figure 10.1 presents regional groundwater contours developed by the New Mexico Office of the State Engineer (NMOSE 2002) that highlight groundwater recharge in the San Mateo Mountains and flow to the south/southeast in the vicinity of the Cebolleta Mine Site. The NMOSE water-level data set is based on a compilation of available water-level data in the region. Also illustrated on Figure 10.1 are the approximate locations of the St. Anthony and JJ No.1 mines within the Cebolleta Mine Site area.

The Dakota Sandstone is the shallowest aquifer used as a drinking water supply in the vicinity. The Dakota Sandstone, at a depth of about 91 to 107 m (300–350 feet), was used by the Village of Moquino, approximately 6 km (3.7 miles) west-northwest of the Cebolleta Mine. The Village of Moquino well was supplemented in approximately 1990 by a deeper well into the Westwater Canyon Sandstone.

Most of the water wells in the Cebolleta Mine area are completed in the Jackpile and Westwater Canyon members of the Morrison Formation. Wells have also been completed in the Brushy Basin Shale Member where sufficient thicknesses of sand have been encountered (INTERA 2006).

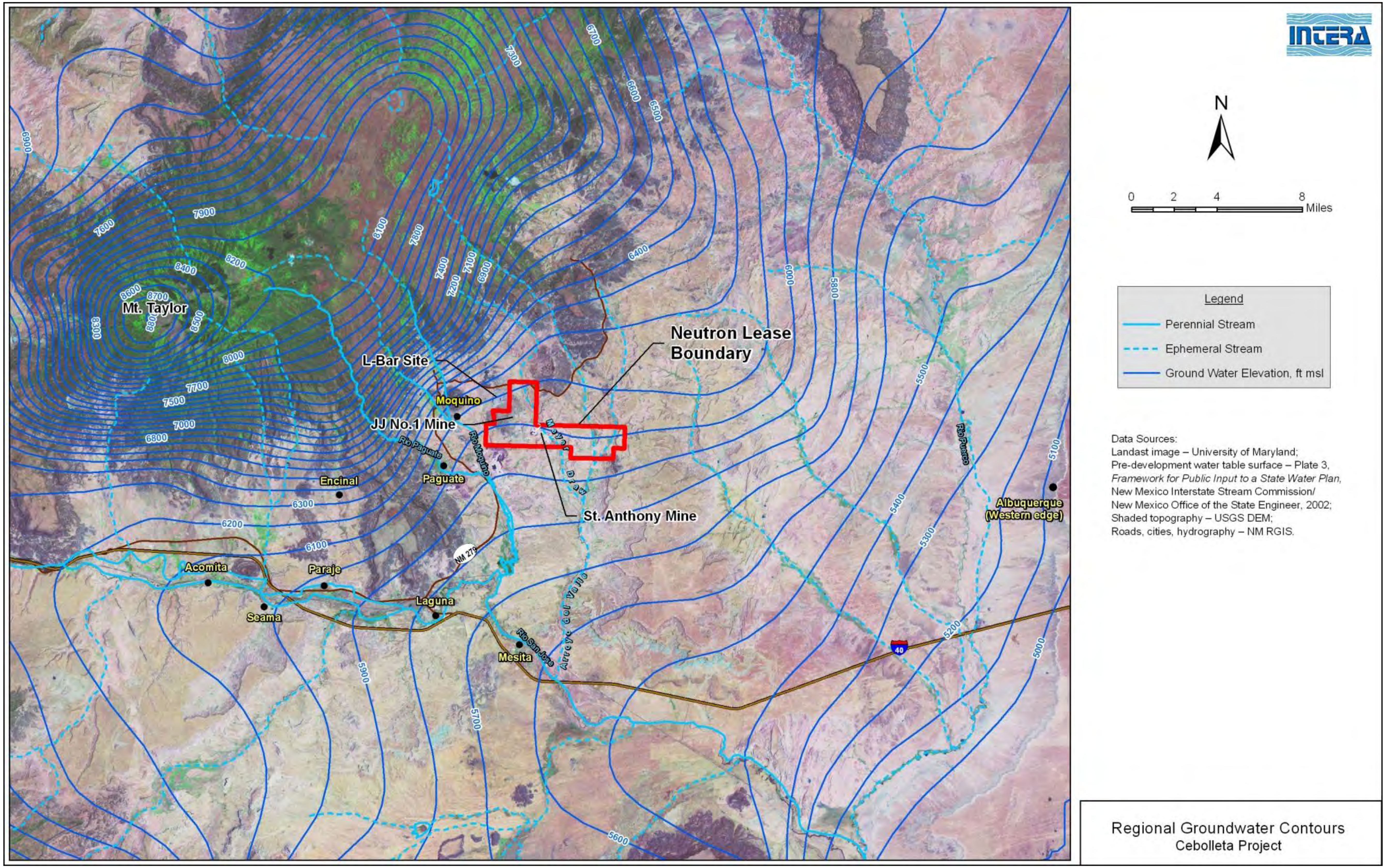

Figure 10.1. Regional Groundwater Contours.

The following description of regional trends is taken from a report prepared by Sohio (1980) and describes groundwater supply wells in the vicinity of the L-Bar site, which is about 1.6 km (1 mile) northwest of the Cebolleta Mine Site (Figure 10.1):

> The sandstone units of the Morrison Formation yield 5 to 10 gpm [gallons per minute] for stock and domestic wells on the Laguna Indian Reservation, in southeastern McKinley County, and in northeastern Valencia County. Primary recharge is probably at outcrops in the area, although some infiltration from the overlying Dakota Sandstone may occur, causing poor water quality locally. Sandstones near the top of the Morrison Formation yield 20 gpm near the Woodrow Mine, four miles south of the L-Bar site. Lateral lithologic changes in the Morrison Formation result in hydrogeologic characteristics that are difficult to predict.
>
> The Dakota Sandstone yields from 5 to 50 gpm to stock wells on the Laguna Indian Reservation. Yields from this formation in other areas, however, are generally small, and water quality is usually poor.
>
> Within the Mancos Shale Formation, the Tres Hermanos Unit reportedly is the only sandstone that yields water to wells. Several shallow stock and domestic wells in the area adjacent to the tailings impoundment and in McKinley County to the northwest yield 5 to 20 gpm. Water quality is generally fair to poor.
>
> Unconsolidated stream sediments (alluvium) a few inches thick to 150 feet thick form the flood plains of stream valleys throughout the region. These sediments constitute a principal aquifer along the Rio San Jose in the Laguna and Acoma Indian reservations and are moderately productive aquifers in the valleys of smaller flowing streams, such as the Rio Paguate and Rio Moquino. The water, however, is generally nonpotable in the lower reaches of those streams.
>
> A well drilled in the Rio Paguate (about four miles southwest of the site), which penetrated the alluvium, middle and lower sandstone units of the lower Mancos Shale, Dakota Sandstone and upper Morrison has yielded 10 gpm. This was mainly from the alluvium and Tres Hermanos Sandstone Member of the Mancos Shale. Another well near the town of Paguate has yielded 15 gpm from the alluvium. It is unlikely, however, that the alluvium could be used as a reliable source of water at any considerable distance away from flowing streams.

Regional groundwater flow patterns in the vicinity of the site are influenced by the occurrence of recharge areas, discharge areas, and hydrogeologic characteristics of the aquifer. In general, the potentiometric surface map indicates that groundwater enters the area from the north and northwest in the San Mateo Mountains and flows south and southeast toward discharge areas, which comprise the numerous arroyos (including Meyer Draw) that ultimately feed the Rio Puerco (Figure 10.2).

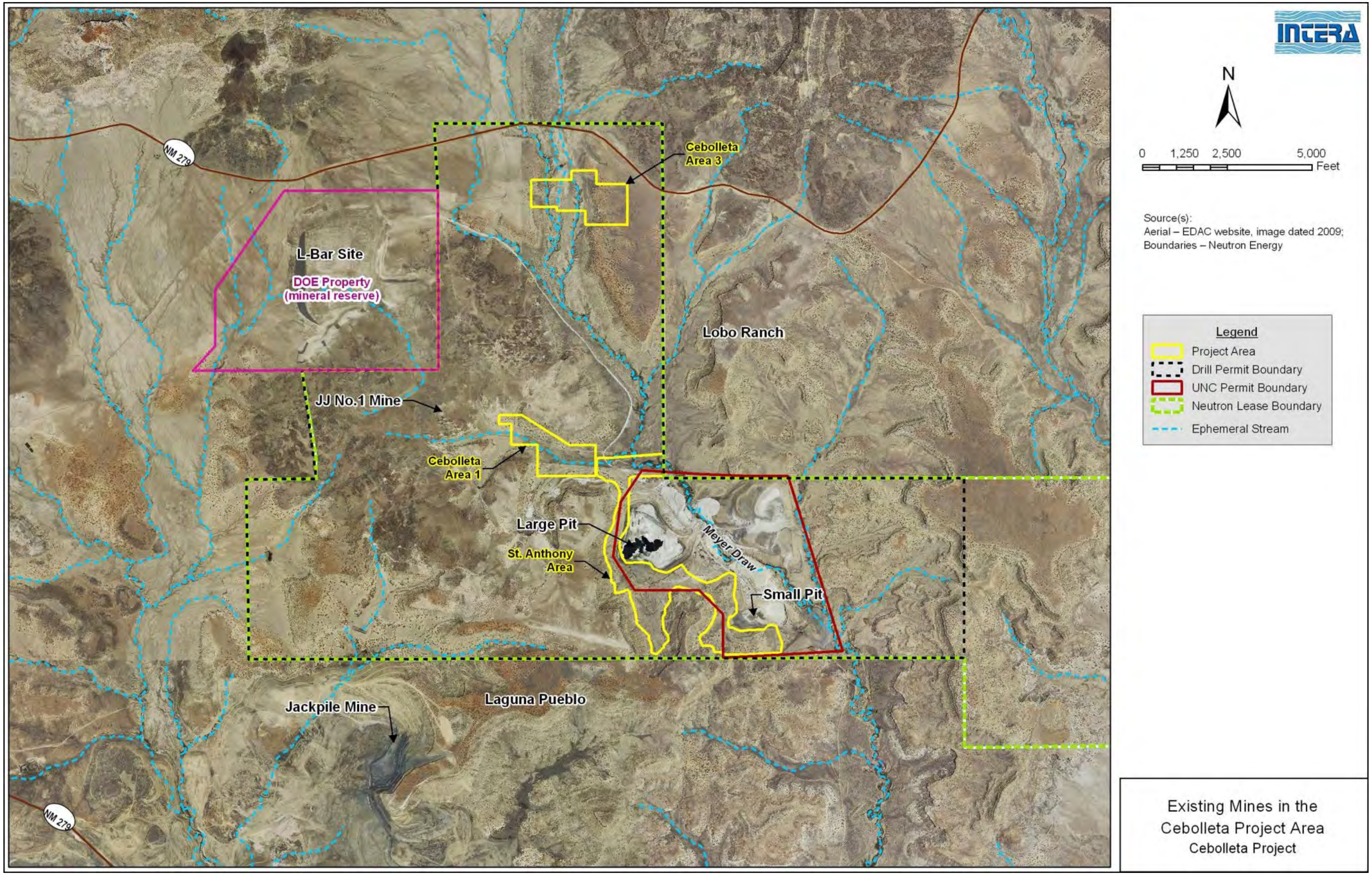

Figure 10.2. Existing Mines in the Cebolleta Project Area.

GROUNDWATER INVESTIGATIONS

As a result of abatement plan requirements from the NMED (NMAC 20.6.2.4103) and NRC closure requirements for the L-Bar tailings impoundment, numerous characterization studies have been completed for the Cebolleta Mine Site area, including the following:

- *Stage 1 Abatement Plan*, Revision 1, JJ No. 1/L-Bar Mine, Cibola County, New Mexico, prepared for Sohio Western Mining Company, prepared by INTERA, September 2006.
- *L-Bar Uranium Mine Reclamation and Closure Plan*, prepared for BP America, prepared by INTERA Technologies Inc., February, 1989; Modifications to October 1, 1986 Reclamation and Closure Plan.
- *St. Anthony Mine Stage 1 Abatement Plan*, prepared for UNC, prepared by Montgomery, Watson, Harza, August 2002.
- *Stage I Abatement Plan Investigation Report, St. Anthony Mine Site, Cebolleta, New Mexico*, prepared for UNC, prepared by INTERA, submitted to the NMED, May 19, 2008 (Rev 2).
- *St. Anthony Stage 2 Abatement Proposal*, prepared for UNC, prepared by INTERA, submitted to the NMED, November 3, 2008.

In 2008, on behalf of UNC, INTERA prepared a Stage 1 Abatement Plan Investigation Report for the St. Anthony mine site located near Cebolleta, New Mexico. The purpose of the Stage 1 Abatement Plan was to design and conduct a site investigation to adequately define site conditions and provide the data necessary to select and design an effective abatement option. Key observations from the groundwater monitoring and sampling activities included the following:

- A New Mexico Water Quality Control Commission (NMWQCC) numeric criterion for domestic water was exceeded in a few of the site monitoring wells (INTERA 2008b).
- Uranium concentrations exceeded the NMWQCC criterion (0.03 mg/L) and radionuclides radium-226 and radium-228 exceeded the NMWQCC criterion (30 pCi/L – combined concentrations) in a few of the monitoring wells (INTERA 2008b).
- Overall, the hydraulic conductivity of the Jackpile Sandstone is relatively low, between about 10^{-4} and 10^{-6} centimeters per second (cm/s) (INTERA 2008b).
- From the potentiometric surface maps, it is evident that the groundwater flow is generally toward the large pit over most of the Cebolleta Mine Site area. The pit acts as a groundwater sink because of evaporation, and therefore, all water within the large pit is contained on-site. Regional groundwater flow is to the southeast (Stone et al. 1983) (Figure 10.1).

In September 2006, INTERA produced a Stage 1 Abatement Plan (Rev. 1) for the JJ No. 1/L-Bar Mine for Sohio Western Mining Company (INTERA 2006). Following are key observations from this report:

- American Ground Water Consultants (AGW 1978) conducted several short-duration pump tests to evaluate the groundwater resource potential of wells penetrating primarily the Jackpile Sandstone and the Westwater Canyon members of the Morrison Formation. These wells provided the water supply for the Sohio milling operation and other surface facilities. Most of these wells are located about 1.6 km (1 mile) north and east of the mill area along Meyer Draw. The majority of the wells are multiple completion wells drawing groundwater from several geologic units. Two wells were tested by the USGS in 1971 and six wells were tested by AGW in 1978 (AGW 1978).
- Hydro-Engineering (1981) reported on pump tests performed in wells in the area of the tailings pile completed in the First Tres Hermanos Sandstone. The test results indicate the transmissivity of the First Tres Hermanos ranged from a low of 0.4 gpd/foot on the east side of the tailings impoundment to a high of 1,200 gpd/foot on the west side of the tailings impoundment. A storage coefficient of 3×10^{-5} was considered representative of the First Tres Hermanos in the northern area of the tailings impoundment (INTERA 2006).

In 2009, INTERA prepared the JJ No. 1/L-Bar Mine (JJ Mine) Stage 1 Abatement Interim Report on behalf of Sohio Western Mining Company, which included the following key observations:

- Groundwater samples from a few of the monitoring wells in the area exceeded NMWQCC standards for domestic water supply (INTERA 2009).
- Water level elevations indicated that the mine was continuing to recover from past dewatering (INTERA 2009).
- The 2009 potentiometric surface map suggested that the water in the mine had started to flow to the southeast with the natural gradient, even though the mine water levels were continuing to recover (INTERA 2009).

10.1.2 Aquifer Characteristics in the Permit Area

Alluvial Aquifers

Unconsolidated alluvial sediments that accumulate in the major drainage channels are locally and episodically saturated. Alluvial deposits are composed of permeable sands and gravel that allow for infiltration following storm events. Because of their dependence on infrequent recharge, these aquifers are not dependable water sources. As there are only ephemeral streams in the Cebolleta Mine Site area, it is unlikely that alluvial aquifers are extensive within the project area or a viable source of water supply.

Jackpile Sandstone

Aquifer characteristics of the Jackpile Sandstone have been characterized as a result of Stage 1 investigations for the St. Anthony and JJ No. 1 mines. These data are summarized in Section 10.1.1 above.

10.2 SAMPLING OBJECTIVES

The objectives of the baseline groundwater characterization program are as follows:

- Obtain necessary data to evaluate quantity and quality of all aquifers at the Cebolleta Mine Site that could be impacted by mining activities.
- Meet the requirements set forth in the regulations in NMAC Title 19, Chapter 10, Part 6.
- Meet the guidelines set forth in MMD's *Part 6 Guidance Document* (EMNRD 2010).

See Table 10.1 for the activities proposed to meet these objectives.

Table 10.1. Groundwater Sampling and Data Analysis Plan

Proposed Activity	Purpose of Activity
Perform a field verification survey of monitoring wells identified by previous investigators, measure depths to water and total depths of wells.	Confirm existing monitor well network in order to evaluate need for additional wells in key aquifers and finalize baseline monitoring well network.
Install background monitoring wells in alluvium, Tres Hermanos, and Dakota.	Establish background water quality for alluvium, Tres Hermanos, and Dakota, if sufficient yield to wells
Continue water level measurement and sampling of groundwater monitoring network.	Establish baseline (pre-mining) water quality and water levels for alluvium, Tres Hermanos, and Dakota.
Determine hydraulic parameters for alluvium, Tres Hermanos, and Dakota if sufficient yield.	Obtain necessary input for groundwater model to evaluate drawdown from mine dewatering and production well activities.

10.3 SAMPLING FREQUENCY

The *Part 6 Guidance Document* (EMNRD 2010) requires a minimum of two sampling events over the required 12-month period for baseline groundwater quality sampling. Quarterly groundwater quality sampling will be necessary to address the NMED's Discharge Plan requirements; therefore, the baseline groundwater quality sampling will be performed for a minimum of four quarters. Additionally, water levels will be obtained on a quarterly basis to evaluate baseline seasonal fluctuations. The locations for the existing and proposed wells are shown in Figure 10.3. These wells were selected because they provide up- and downgradient baseline data for the aquifers of interest for mine site permitting and because useful historical data exist for some of these well. Not all of the St. Anthony mine monitoring wells will be monitored on a quarterly basis. Evaluation of historical data will determine which wells will be included in the baseline characterization program.

Some of the proposed monitoring locations may have to be moved if access restrictions are not overcome. At this time, monitoring wells are planned for the Jackpile Sandstone aquifer only. If significant groundwater is encountered in the Dakota or Tres Hermanos sandstones during drilling, then a plan for characterizing these units will be implemented.

10.4 List of Data to Be Collected

The two categories of data to be collected for baseline groundwater characterization are groundwater quality and aquifer parameters. Further discussion of these data sets is included in the following subsections.

10.4.1 Groundwater Quality Parameters

The *Part 6 Guidance Document* (EMNRD 2010) lists specific groundwater quality parameters that are recommended to comply with the baseline characterization requirements. Table 10.2 incorporates those recommendations and shows the list of parameters to be analyzed for and the associated analysis methods and laboratory detection limits.

10.4.2 Aquifer Parameters

Water level measurements will be taken from all wells in the monitoring well network on a quarterly basis during the baseline characterization phase to evaluate the pre-mining potentiometric surface (i.e., steady-state condition). This potentiometric surface will form the basis for future modeling required to evaluate potential impacts from mine dewatering and production well pumping. In addition to water level monitoring, groundwater modeling requires hydraulic parameter data, specifically, hydraulic conductivity, transmissivity, and storativity for the key aquifers. As site-specific data for the aquifers of interest are limited, aquifer testing will be completed as described below.

10.5 Methods of Collection

Three major categories of data will be collected for the baseline groundwater characterization:

1. Well information (water levels and total depth).
2. Groundwater quality samples for general chemistry, metals, and radionuclides.
3. Aquifer parameters (hydraulic conductivity, transmissivity, and storativity).

General SOPs for water level and total depth measurements, groundwater sampling, aquifer testing, monitoring well installation and development, and decontamination are identified in the Quality Assurance Project Plan presented in Appendix C. Procedures will be modified as necessary to conform to site-specific requirements. In addition to conventional sampling methods (e.g., submersible displacement pumps), the following sampling methods are also being considered depending on well conditions and project requirements:

- Snap Sampler
- Rigid Porous Polyethylene Sampler (RPPS)
- Bladder pump with drop tube
- Hydrasleeve no-purge groundwater sampler

10.6 Parameters to be Analyzed

Samples will be tested for anions, dissolved metals, solids, alkalinity, radiochemistry, and other parameters. See Table 10.2 for proposed analytical parameters and analysis methods.

Table 10.2. Analytical Parameters and Analysis Methods for Groundwater Samples

Analytical Parameter	Analysis Method	Lab Detection Limit (mg/L unless noted)
Anions		
Fluoride	EPA Method 300.0	0.1
Chloride	EPA Method 300.0	0.1
Nitrogen, Nitrite (as N)	EPA Method 300.0	0.1
Nitrogen, Nitrate (as N)	EPA Method 300.0	0.1
Sulfate	EPA Method 300.0	0.5
Dissolved Metals		
Aluminum	EPA Method 200.7	0.02
Antimony	EPA Method 200.8	0.001
Arsenic	EPA Method 200.8	0.001
Barium	EPA Method 200.7	0.002
Beryllium	EPA Method 200.7	0.002
Boron	EPA Method 200.7	0.04
Cadmium	EPA Method 200.7	0.002
Calcium	EPA Method 200.7	0.50
Chromium	EPA Method 200.7	0.006
Cobalt	EPA Method 200.7	0.006
Copper	EPA Method 200.7	0.003
Iron	EPA Method 200.7	0.02
Lead	EPA Method 200.7	0.005
Magnesium	EPA Method 200.7	0.50
Manganese	EPA Method 200.7	0.002
Total Mercury^{+}	EPA Method 7470/7471/245.2	0.0002
Molybdenum	EPA Method 200.7	0.008
Nickel	EPA Method 200.7	0.01
Potassium	EPA Method 200.7	1.0
Selenium	EPA Method 200.8	0.001
Silicon	EPA Method 200.7	0.08
Silver	EPA Method 200.7	0.005
Sodium	EPA Method 200.7	0.5
Thallium	EPA Method 200.8	0.001
Uranium	EPA Method 200.8	0.001
Vanadium	EPA Method 200.7	0.005

Analytical Parameter	Analysis Method	Lab Detection Limit (mg/L unless noted)
Zinc	EPA Method 200.7	0.005
Solids		
Total Suspended Solids (TSS)	SM 2540D	1.0 µg/L
Total Dissolved Solids (TDS)	SM 2540C	10
Alkalinity		
Alkalinity, total (as $CaCO_3$)	SM 2320B	20
Carbonate	SM 2320B	20
Bicarbonate	SM 2320B	20
Radiochemistry*		
Gross Alpha Radioactivity	EPA Method 900.0	[-]
Gross Beta Radioactivity	EPA Method 900.0	[-]
Radium 226, 228	EPA Method 903.0/904.0	[-]
^{222}Radon	ASTM D5072-92	[-]
Isotopic Uranium (^{234}U, ^{235}U, ^{238}U)	EPA Method 907.0	[-]
Other		
pH	150.1	12.45
Specific Conductance	120.1	0.01 µS/cm
Cyanide	Kelada-01	0.005
Temperature	Measured in the field	NA

Notes:
NA = not applicable as sample will not be analyzed for a given parameter.
+Total concentration, not filtered prior to preservation.
*Sub-contracted to laboratory to be identified by INTERA/Neutron.
[-] = Defined by sub-contracted laboratory running radiochemistry analyses.

10.7 MAPS SHOWING PROPOSED SAMPLING LOCATIONS

Figure 10.3 illustrates the proposed groundwater monitoring network for the baseline characterization study. As stated earlier, at this time, the wells illustrated in Figure 10.3 will be screened in the Jackpile Sandstone only; however, if significant groundwater is encountered in the Dakota or Tres Hermanos sandstone units, a plan for characterization of these aquifers will be implemented.

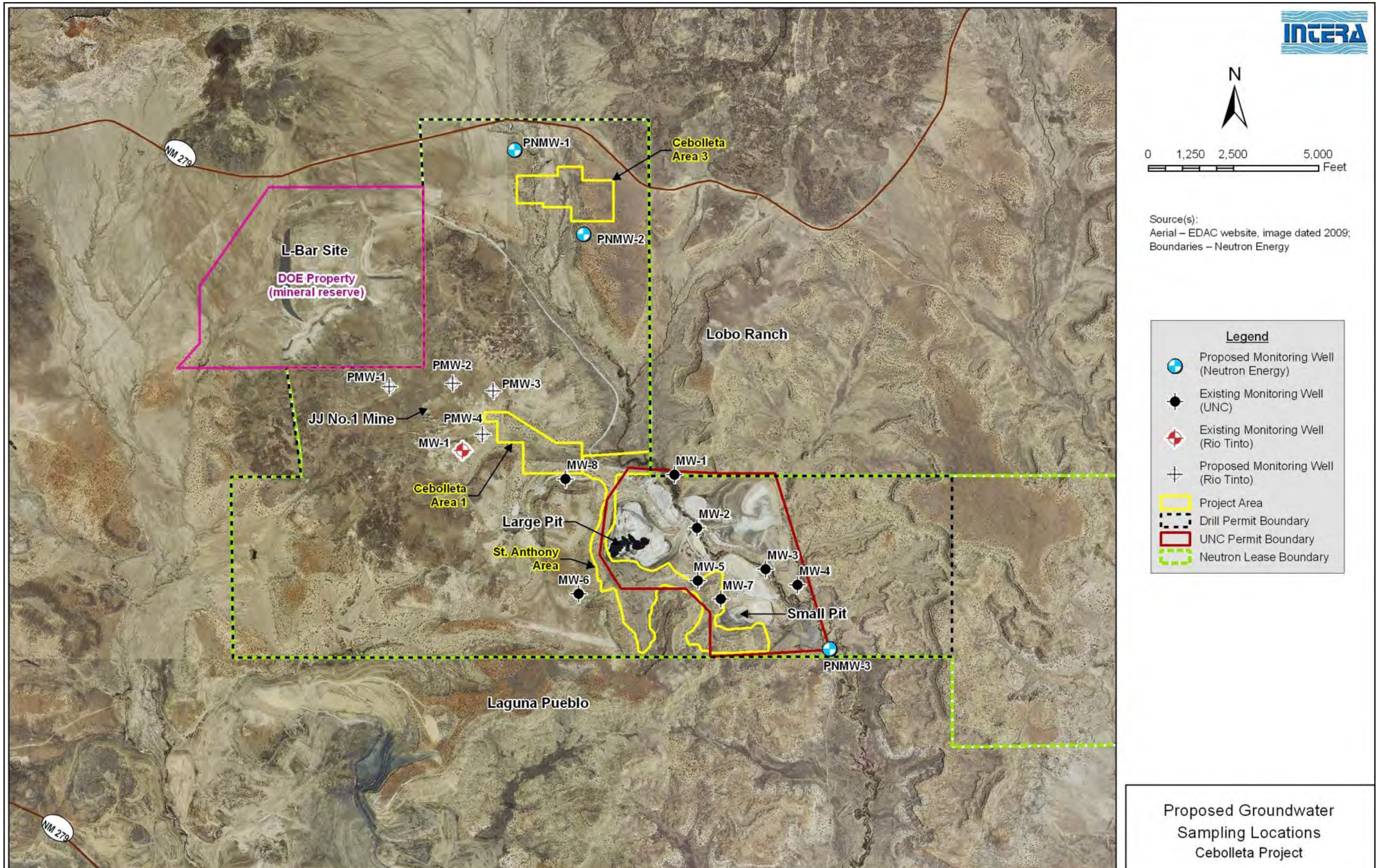

Figure 10.3. Proposed Groundwater Sampling Locations.

10.8 Laboratory and Field Quality Assurance Plans

The groundwater sample and data collection will be conducted in accordance with the Standard Operating Procedures listed in Appendix C. The samples will be properly preserved and sent to an accredited analytical laboratory. Water samples will be collected from site wells and private wells where appropriate. Fieldwork to determine which of these wells exist and can be sampled and measured is subject to owner approval. Comments made by the well users visited will be recorded in the logbook.

The parameters of pH, temperature, dissolved oxygen, turbidity, and specific conductivity will be measured in the field at the time of collection for each well. The field instruments will be calibrated by the manufacturer with calibration checks conducted by the user. The calibration certificates will be filed and the field checks will be recorded in the logbook. Groundwater quality control samples will include random duplicate samples.

The field leader for the aquifer pump test will be experienced and the field members will be trained in procedures to be used that have been developed by professionals in groundwater hydrology. The instruments used for pump tests will be calibrated by the manufacturer. A calibration certificate will be retained as a record. The main instruments used for the pump test are the pressure transducers, E-tape, vented cable, and barometric pressure gage. A preliminary step drawdown test a few days prior to the pump test will afford the field hydrologists a chance to verify that the meter, discharge system, transducers, and generator are working properly.

Water level measurements will be monitored manually with an E-tape as a check on transducer measurements and to ensure that a backup set of data is available in case of transducer failure. The E-tape and transducers will be compared several times before the pump test to determine the difference in readings. This difference will be recorded. During and after the pump test, several more checks will be made to compare the reading differences. The differences are typically minimal (inches), but will be used as an adjustment for the data interpretation. A similar comparison will be noted for the vented cable and the barometric pressure gage readings. Prior to installation, the transducer probe and cable will be inspected for damage, un-kinked, and cleaned.

The transducer data will be downloaded to a laptop computer on a regular basis. E-tape comparison readings will be taken often during the initial pumping and again during the initial recovery period, and numerous times during the days of pumping. For safety reasons, at least two people will be on-site during the entire pumping portion of the test.

Personnel will maintain a field logbook to record information about weather, field conditions, nearby pumping wells, and any circumstances which influence test results or would be useful to know during interpretation of test results.

10.9 LITERATURE CITED

American Ground Water Consultants (AGW), 1978, Results of Aquifer Performance Tests Using Wells Serving the Sohio L-Bar Mill, Valencia County, New Mexico, December 21, 1978.

Hydro-Engineering, 1981, Ground-Water Hydrology near the L-Bar Tailings Reservoir, prepared for Sohio Western Mining Company.

INTERA Incorporated (INTERA), 2006. Stage 1 Abatement Plan, Revision 1, JJ No. 1/L-Bar Mine, Cibola County, New Mexico, September.

———, 2008, St. Anthony Mine Stage 1 Abatement Plan Investigation Report, prepared for United Nuclear Corporation. May 19.

———, 2009, Stage 1 Abatement – Interim Report, JJ No. 1/L-Bar Mine, Cibola County, New Mexico, prepared for Sohio Western Mining Company. June.

INTERA Technologies, Inc., 1989, L-Bar Uranium Mine Reclamation and Closure Plan, prepared for BP America, prepared by INTERA Technologies Inc., February, 1989; Modifications to October 1, 1986 Reclamation and Closure Plan.

Montgomery, Watson, Harza, 2002, St Anthony Mine Stage 1 Abatement Plan, prepared for United Nuclear Corporation, August.

New Mexico Environment Department Surface Water Quality Bureau (NMED SWQB), 2007, The 2007 NMED/SWQB standard operating procedures for data collection, July 26, 186 p.

New Mexico Office of the State Engineer (NMOSE), 2002. "Statewide Water-Level Elevations." ESRI Shapefile format, data originally published in map plate 3 in the Framework for public input to a state water plan New Mexico Water Resource Atlas.

Standard Oil Company of Ohio (Sohio), 1980. "Environmental Report: L-Bar Uranium Project Valencia County, New Mexico." Prepared in Support of Radioactive Material License Renewal Application NM-SOH-ML.

Stone, W.J., Lyford, F.P., Frenzel, P.F., Mizell, N.H., and Padgett, E.T., 1983, Hydrogeology and water resources of San Juan Basin, New Mexico. Socorro, New Mexico Bureau of Mines and Mineral Resources Hydrologic Report 6, 70 p.

11.0 HISTORICAL AND CULTURAL PROPERTIES

11.1 INTRODUCTION AND BACKGROUND

Cultural resources surveys were conducted for the Cebolleta Mine Site from 1977 to 2009 in advance of commencing any activity on-site. The information required by NMAC 19.10.6.602.D(13)(i) regarding historic places and cultural resources was compiled. The information gathered, particularly the map identifying the locations of cultural sites, is considered confidential. Therefore, in order to protect the integrity of these sites and minimize the likelihood of their disturbance, the information is presented in separate cultural resources survey reports (see Section 11.1). Some of these reports were submitted to the New Mexico State Historical Preservation Office for review. The information will also be made available to others, as necessary.

11.1.1 CEBOLLETA MINE SITE

Cultural resources surveys have been conducted in the Cebolleta Mine Site at various times between 1977 and 2009. The information presented here summarizes the findings from these surveys. Prior to all field surveys discussed below, literature searches were conducted of the National Register of Historic Places (NRHP), the State Register of Cultural Properties (SRCP), and the Archaeological Records Management Section (ARMS). No cemeteries or unmarked burials were found during these surveys.

Records searches through the ARMS of the New Mexico Historic Preservation Division, the NRHP, and the SRCP show five previous cultural resources surveys have been conducted within a 500-m (1,640-foot) buffer around the project area (and all surveys partially intersect or are within the Cebolleta project area) (Figure 11.1). Fifteen archaeological sites were recorded within the project area. No additional archaeological sites were recorded within a 500-m (1,640-foot) buffer around the project area (Table 11.1–Table 11.3).

In 1977, a survey was conducted that intersected the project area. New Mexico Cultural Resource Information System (NMCRIS) Activity No. 323 was conducted from December 20, 1976, to November 30, 1977. The survey covered 1,000 acres (405 ha) and 16 sites were visited (Seaman 1977).

In 1979, a survey was conducted that intersected the eastern edge of the project area, though this may be a digitizing error and it is possible this previous investigation is adjacent and outside the project area. NMCRIS Activity No. 8277 was conducted from January 1 through December 31, 1979. The survey acreage covered was not listed in the ARMS database; five previously recorded sites were visited (Anschuetz 1979).

In 1980, a survey was conducted that intersected with the project area. A 368.48-acre (149.12-ha) survey, listed as NMCRIS Activity No. 8137, was conducted by the Laboratory of Anthropology. Six sites were visited during this survey (Condon 1980).

In 2006, Lone Mountain Archeological Services, Inc., conducted a 342-acre (138.5 ha) investigation immediately adjacent to and surrounding the St. Anthony mine disturbed area. Ten sites were documented (Allison 2006).

In 2008, Criterion Consulting conducted a 71.3-acre (28.85-ha) archaeological survey and inventory covering Areas I and III, entirely within the project area (Raymond and Lawrence 2008). NMCRIS Activity No. 110509 began June 12, 2008. Six sites were discovered during this survey (Carlson 2010), completed for Neutron Energy in conjunction with an exploration permit application.

A 1,625-acre (657.6) survey was conducted by SWCA in 2009 for wind farm access roads and turbine locations on private land; the southern end of this investigation intersects the northern edge of the Cebolleta project area. NMCRIS Activity No. 115670 from August 31, 2009, to August 12, 2010. Twenty-seven archaeological sites were identified.

All five of the reports detailing these surveys recommended that the NRHP eligible and undetermined sites be avoided while conducting project activities. If avoidance was not feasible, then full site recording via testing and/or data recovery was recommended.

Table 11.1. Surveys within 500 m (1,640 feet) of the Project Area

NMCRIS Number	Performing Agency	End Date of Investigation	Acres Surveyed	Number of Sites Visited	Relationship to Project Area
323	New Mexico Office of Cultural Affairs, Museum of New Mexico, Laboratory of Anthropology	30-Nov-1977	1,000.00	16	Intersects northern edge of project area
8137	New Mexico Office of Cultural Affairs, Museum of New Mexico, Laboratory of Anthropology	31-March-1980	368.48	6	Intersects northern edge of project area
8277	University of New Mexico Office of Contract Archaeol ogy	31-December-1979	Not Entered	5	Intersects eastern edge of project area
98419	Lone Mountain Archaeological Services	11-April 2006	342	10	Mostly within project area
110509	Criterion Consulting	14-August-2008	71.3	6	Entirely within project area
115670	SWCA Environmental Consultants	12-August-2010	1,625.00	27	Intersects northern edge of project area

Table 11.2. Archaeological Sites in and within 500 m (1,640 feet) of the Project Area

LA No.	Structural/Non-structural	Occupation Type	Maximum Length (m)	Relationship to Project Area
*15000	Structural	Historic/Prehistoric	327	Adjacent to project area
152218	Structural	Historic/Prehistoric	149	In project area
152219	Structural	Historic/Prehistoric	180	In project area
152220	Structural	Historic/Prehistoric	36	In project area
152221	Structural	Historic/Prehistoric	123	In project area
152222	Non-structural	Prehistoric	46	In project area
152223	Structural	Historic/Prehistoric	240	In project area
152224	Structural	Historic/Prehistoric	153	In project area
152225	Structural	Historic/Prehistoric	96	In project area
152226	Structural	Historic	17	In project area
159748	Non-structural	Prehistoric	155	In project area
159749	Non-structural	Prehistoric	68	In project area
159750	Non-structural	Prehistoric	124	In project area
159151	Non-structural	Prehistoric	121	In project area
159752	Structural	Historic/Prehistoric	370	In project area
159754	Structural	Historic	36	In project area

*LA 15000 is adjacent to the project area; the remaining sites in the table are within the project area.

Table 11.3. Eligibility Information for Archaeological Sites within the Project Area

LA No.	Structural/Non-structural	Occupation Type	Recommended Eligibility/Criterion	HPD Determination of Eligibility
152218	Structural	Historic/Prehistoric	Recommended Eligible/Criterion D	Not determined
152219	Structural	Historic/Prehistoric	Recommended Eligible/Criterion D	Not determined
152220	Structural	Historic/Prehistoric	Undetermined	Not determined
152221	Structural	Historic/Prehistoric	Recommended Eligible/Criterion D	Not determined
152222	Non-structural	Prehistoric	Undetermined	Not determined
152223	Structural	Historic/Prehistoric	Recommended Eligible/Criterion D	Not determined
152224	Structural	Historic/Prehistoric	Recommended Eligible/Criterion D	Not determined
152225	Structural	Historic/Prehistoric	Undetermined	Not determined
152226	Structural	Historic	Undetermined	Not determined
159748	Non-structural	Prehistoric	Recommended Eligible/Criterion D	Not determined
159749	Non-structural	Prehistoric	Recommended Eligible/Criterion D	Not determined
159750	Non-structural	Prehistoric	Recommended Eligible/Criterion D	Not determined
159151	Non-structural	Prehistoric	Recommended Eligible/Criterion D	Not determined
159752	Structural	Historic/Prehistoric	Recommended Eligible/Criterion D	Not determined
159754	Structural	Historic	Undetermined	Not determined

11.2 SAMPLING OBJECTIVES

The objectives of the cultural resources surveys are to locate all sites on or eligible for listing on either the NRHP and/or the SRCP and identify known cemeteries and unmarked human burials within the proposed project area. The surveys are intended to identify the baseline cultural resources within the permit area so that mitigation measures can be performed prior to commencing mining operations, as necessary. Neutron's preferred mitigation strategy is avoidance of eligible sites whenever possible.

11.3 SAMPLING FREQUENCY

Cultural resources are located and identified by walking the project area in transects no more than 15 m (49 feet) apart. These surveys have been previously completed for large portions of the project area (281.5 acres [114 ha]) by past investigators within the past 10 years. SWCA will complete the survey for the remaining 160-acre (65-ha) central facilities area and 66.8 acres (27 ha) paralleling the haulage road.

11.4 LIST OF DATA TO BE COLLECTED

Approximately 434 acres (175 ha) of the project area have been previously surveyed for the presence of archaeological and cultural resources of significance within the last 10 years; this portion of the project area will not require resurvey. The remaining 226-acre (27.0-ha) portion of the potential new disturbed areas within the project area that have had no previous surveys or surveys that took place more than 10 years ago will—depending on the scope of project activities—be surveyed by SWCA in compliance with NMAC standards. Cultural properties will be categorized with reference to chronology, cultural groups, and adaptive strategies.

11.5 METHODS OF COLLECTION

An archival review was conducted of the NRHP, the SRCP, and ARMS of areas within the project area, as well as a 500 m (1,640 feet) buffer around the project area. The results of these literature searches are summarized in Section 11.1.1 above. SWCA field personnel will conduct an intensive pedestrian survey of the portions of the project area likely to be disturbed that have had no previous surveys or surveys that took place more than 10 years ago. This cultural resources survey will evaluate existing archaeological sites identified from the literature search and identify and evaluate any new sites not previously recorded. Each archaeologist will walk linear transects in no more than 15-m (49-foot) intervals.

Recording of newly discovered cultural locations is typically initiated with the pin-flagging of artifacts and other cultural manifestations. Any cultural location is then evaluated in terms of artifact types, classes, quantity, and density to determine whether the location should be treated as a site or an isolated occurrence (IO). Cultural resources sites are defined as locations dating to an age or likely age of 50 years or more that contain 10 or more artifacts within a 10 × 10–m (33 × 33–foot) area, or as a feature or features in association with any artifacts meeting the 50-year age criterion. Other factors that influence designation of selected locations as archaeological sites include diversity of artifact materials and classes, presence of features or diagnostic artifacts, and high potential for intact buried cultural deposits. Cultural locations that are not classified as sites are categorized as IOs. Redeposited site material that lack significant locational context may also be determined to be an IO.

If sites are encountered, boundaries will be defined, a Laboratory of Anthropology site form will be completed, a sketch map will be drawn, and photographs will be taken showing the setting of each site and important or representative features. Sites will be plotted on USGS quadrangle maps, and GPS points will be taken. A datum will be placed on a tree at each site using a nail and aluminum tag. Each datum tree will be marked with white flagging, as will site boundaries. No artifacts will be collected during the survey.

If IOs are encountered, they will be recorded in the field and then plotted on a USGS quadrangle map.

11.6 PARAMETERS TO BE ANALYZED

Five previous field surveys identified 16 previously recorded archaeological sites within 500 m (1,640 feet) of the entire Cebolleta Mine Site project area. Of these 16 sites, 15 sites occur within the project area.

11.7 MAPS SHOWING PREVIOUS AND PROPOSED SAMPLING LOCATIONS

While the location of cultural resources is considered confidential—disclosure of site locations is prohibited under 36 CFR 296.18—a map showing the previously surveyed portions of the project area in 2006 and 2008is provided in Figure 11.1. Site locations can be found in the previous archaeological survey reports discussed in Section 11.1.1, as well as the ARMS database, and can be made available if necessary.

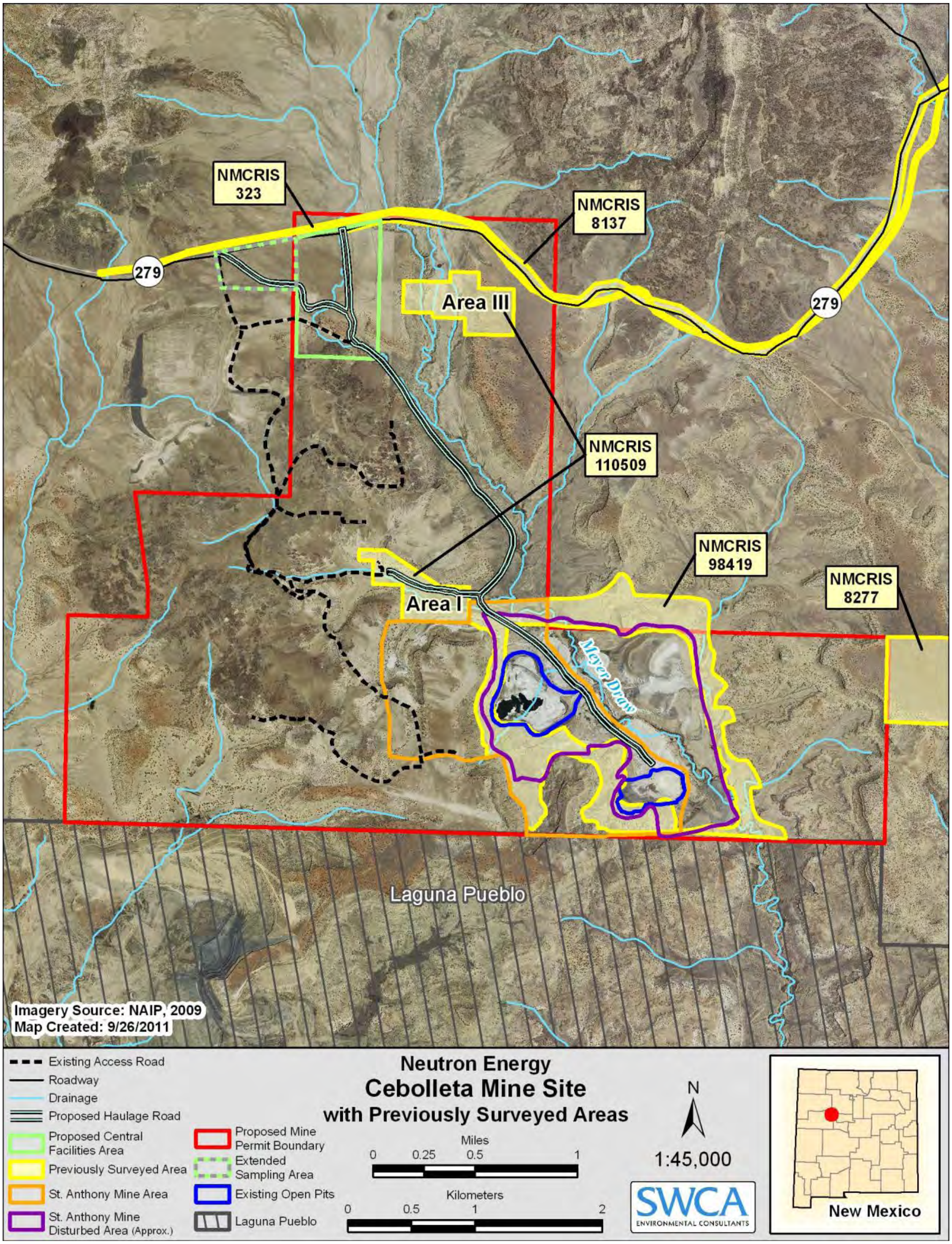

Figure 11.1. Cebolleta Mine Site showing previous cultural resources investigations.

11.8 LABORATORY AND FIELD QUALITY ASSURANCE PLANS

The contractor, SWCA, retained to perform the work is certified by the State of New Mexico to perform historic and cultural surveys. These experienced professionals will follow the accepted field procedures to conduct the surveys, mark and map the findings, and report the results.

11.9 DISCUSSION IN SUPPORT OF PROPOSAL

The objective of the cultural resources surveys is to locate all archaeological sites on or eligible for listing either on the NRHP and/or the SRCP and known cemeteries and unmarked human burials within the project area. The information generated will be used to comply with the requirements of NMAC 19.10.6.602D(13)(i) and develop mitigation strategies to protect or avoid archaeological and cultural resources that could potentially be impacted by mining operations.

11.10 LITERATURE CITED

Allison, P., D. Boggess, and Scott Walley. 2006 Cultural Resource Survey of 342 Acres for the St. Anthony Mine Reclamation, Cibola County, New Mexico. Lone Mountain Archeological Services, Inc.

Anschuetz, K.F. 1979 Approx 400 Acres near Cebolleta NM for Nuclear Assurance Corporation. Lone Mountain Archeological Services, Inc. University of New Mexico Office of Contract Archaeology. Report No. 185-040.

Archaeological Resources Management Section (ARMS). 2011. New Mexico Cultural Resources Information System. At https://nmcris.dca.state.nm.us. Accessed September 2011.

Carlson, Christopher A. 2010. A Cultural Resources Survey for an Access Road and Wind Farm near Seboyeta, Cibola County, New Mexico. SWCA Report No. 2009-390/SWCA Project No. 15883/NMCRIS No. 115670. SWCA Environmental Consultants, Albuquerque, New Mexico.

Condon, G.S. 1980. A Cultural Resource Inventory Along a Proposed Right-of-Way of N.M. 279, North of the Laguna Indian Reservation, Sandoval and Valencia Counties, New Mexico. New Mexico Office of Cultural Affairs-Laboratory of Anthropology Report No. 151.

Raymond, Gerry and H. Lawrence. 2008. A Cultural Resource Sruvey for the Cebolleta Area III Mineral Exploratory Project in Cibola County, New Mexico. Criterion Report No. 2008-13. Criterion Environmental Consulting. Albuquerque, New Mexico.

12.0 RADIOLOGY

12.1 INTRODUCTION AND BACKGROUND

This section of the SAP is a description of the scope of work proposed to characterize and document background radiological conditions at the planned mine disturbance areas within the Cebolleta Mine Site prior to any new mining disturbance. As appropriate, the characterization will also investigate prior exploration and development activities to the extent that they could reasonably affect the project.

Radiological surveys will be conducted in accordance with established practices. Baseline gamma radiation levels and soil sampling will be performed to determine the existing radiological conditions within the proposed permit boundaries. Suitably sized external Reference Areas may be used when appropriate to characterize radiological conditions in the permit area(s).

12.1.1 TERMS USED IN THIS SAP

- The term "anomaly" refers to gamma radiation exposure rates that exceed two times the ambient background.
- The term "background" refers to gamma radiation exposure rates and/or soil radionuclide concentrations in areas not influenced from prior uranium mining operations.
- The term "Reference Area" refers to a surrogate undisturbed land space where baseline radiological conditions are determined to represent the conditions within an actual mine permit area. Reference areas are proximal to proposed mine permit areas, with geologic, topographic, soil and vegetation characteristics similar to the permit areas.
- The term "stationary reading" refers to performing a gamma radiation exposure rate reading while standing still at a particular point.
- The term "survey" refers generically to: 1) exposure rate readings determined with an instrument and 2) soil sampling and analysis for radionuclide content.

12.2 SAMPLING OBJECTIVES

According to the *Guidance for Meeting Radiation Criteria Levels and Reclamation at New Uranium Mining Operations (Draft)*, issued by the MMD in May 2011, mine sites must be reclaimed to the following (post-reclamation) standards:

- Gamma exposure rates emanating from capped and uncapped surfaces cannot exceed 95th percentile values above the average pre-mining exposure rates.
- Cover material used for capping disposal cells cannot exceed 5 pCi/g radium-226 above background.
- Radium-226 concentration in uncapped waste cannot exceed 5 pCi/g above background averaged over the first 15 cm (6 inches) of soil below the surface and 15 pCi/g above

background averaged over 15-cm-thick (6-inch-thick) layers of soil more than 15 cm (6 inches) below the surface.

12.2.1 Horizontal and Vertical Characterization

Gamma radiation exposure rate surveys will be performed to determine the 95th percentile baseline values. The surveys will be reported in units of microroentgens per hour (µR/h). Vertical profiling of background radioisotopic concentrations will be performed to a depth of 15 cm (6 inches), although site specific conditions (e.g., anomalies, drainage features) may justify deeper investigative sampling. Soil samples will be analyzed for the following constituents: total uranium, radium-226, potassium-40, and gross alpha.

12.2.2 Cover Soil Characterization

Soil materials planned for reclamation cover will be analyzed for radium-226. Potential samples will be retrieved from intervals (typically 30.5 cm [12 inches]) throughout the depth of the borrow soil. The results will be reported in pCi/g. Surveys and sampling will be tied to the New Mexico State Plane Coordinate System and/or geodesic latitude and longitude coordinates. The coordinates will be determined using GPS units.

12.3 Sampling Survey Structure and Frequency

To demonstrate compliance with the above-listed standards, radiological surveys consisting of radiation instrument readings and soil samples analysis will be used to characterize background radiation and radioactivity levels both horizontally and vertically. Vertical characterization will consist solely of the analysis of soil samples.

12.3.1 Sampling Survey Structure

Subsequent to completing radiation instrument survey, the number of soil samples to be retrieved from the given planned disturbed area (PDA) will be determined by using the following formula:

$$N = \frac{t^2 s^2}{(0.1\bar{x})^2}$$

Where:

- N = number of samples to be collected from the given PDA (rounded to the nearest integer). A minimum N = 1 sample per PDA to a maximum of N = 1 sample per 1,000,000 ft^2 PDA surface area.
- t^2 = t-test value squared based on number of instrument readings collected (n); 95% confidence level; see the t-test values in Appendix C.
- s^2 = statistical variance (the standard deviation squared) of the instrument readings
- $\bar{x}$ = mean of instrument readings (i.e., µR/hr values)
- ν = degrees of freedom (i.e., number of survey readings minus 1)

12.3.2 Sampling Frequency

A minimum of one soil sample per PDA will be collected. A maximum of one sample per 1,000,000 square feet PDA surface area will be collected (equivalent to a 1,000-foot grid block). See Figure 12.1 below.

Radiation instrument survey samples will be collected at relatively equidistant locations on 500-foot grid points. Sample locations will be more closely spaced to investigate possible anomalies.

The planned disturbed areas, haul road, and reference location will be surveyed as listed in Table 12.1, below, and depicted in Figure 12.2 (refer to Section 12.7).

Table 12.1. Proposed Radiation Surveys within the Project Area

Description	Instrument Readings	Soil Sampling
PDAs	~500-foot grid points	See Section 12.3.1 above
Proposed Haul Road from the Mine to the Proposed Mill	~500-foot intervals	~1,000-foot intervals
Drainage Features	500-foot intervals	~1,000-foot intervals
Random Locations	At each location	As determined appropriate for investigation
Reference Location	Minimum of 1	One sample at each instrument reading location

12.3.3 Planned Disturbed Areas

Areas within PDAs will be surveyed on approximately 500-foot grid points. Instrument readings will also be monitored along the gridlines while moving between grid points; however, readings will be recorded only when anomalies are encountered.

Trintek Services Inc. performed limited radiation surveys in portions of the proposed permit area in 2011 as depicted in Figure 12.2 but soil sampling was not performed. These radiation surveys will be included as part of the radiological characterization described in the BDR. Soil samples will be taken and analyzed pursuant to this SAP.

12.3.4 Proposed Haul Road

Surveys will be performed on approximately 500-foot intervals along centerlines and borrow ditches of the proposed haul road or roads (see Figure 12.1)

12.3.5 Random Locations

Stationary and walkover radiation readings and soil sampling may be made at random locations within the proposed permit area to: 1) determine baseline (background) conditions, 2) investigate possible anomalies, and 3) investigate potential dispersal of radionuclides by prior mining operations.

INVESTIGATION OF ANOMALIES

Surveys in planned disturbed areas may reveal anomalies. The extent of these anomalies will be investigated and documented with instrument readings. Soil samples may be collected from the top 15 cm (6 inches) of soil to investigate the anomaly if no obvious explanations are evident. Additional sampling may also be performed in subsequent 15-cm (6-inch) intervals as appropriate.

12.3.6 REFERENCE AREA

The extreme southwesterly corner of the CLG will be used as a Reference Area throughout the project life, as provided for in the radiation guidance document (see Figure 12.1). The survey point(s) will be selected at random, and the location(s) will be documented for future comparison. This reference area was chosen based on a number of factors that will be fully discussed in the BDR and is thought to represent natural background levels unaffected from prior mining activities.

12.4 LIST OF DATA TO BE COLLECTED

In order to meet the requirements of MMD radiation guidance document (MMD 2011 draft), the following data will be collected:

- Gamma radiation exposure rates using unshielded instruments will be reported in microroentgens per hour (μR/h) and tied to the New Mexico State Plane Coordinate System.
- Concentrations of the following constituents from sample locations tied to the New Mexico State Plane Coordinate System: total uranium, radium-226, potassium-40, and gross alpha.

  Note that the MMD radiation guidance document (MMD 2011, draft) uses ambient dose rates from Ra-226 as a standard for compliance during reclamation; however, Ra-226 and K-40 are both gamma emitters and contribute to background gamma radiation at rates that vary according to soil composition. For example, shale formations tend to contain elevated concentrations of K-40. Therefore, the pre-mining concentrations of both Ra-226 and K-40 will be analyzed to aid in differentiating the respective ratios (Ra-226:K-40) contributed to the overall background exposure rates.

12.4.1 SURVEY LOGS

Pertinent information about the surveys and their locations will be recorded in bound survey logbooks. This information will include (among other things) dates, the names of persons performing the surveys, types, and serial numbers of instruments used for gamma surveys. This information may include a general description of the terrain and soil type. For random surveys, the information may also include the rationale for including the location(s) in the survey.

12.5 METHODS OF COLLECTION

12.5.1 RADIATION DETECTION INSTRUMENTS

Gamma exposure rates will be measured with meters having sufficient sensitivity to accurately quantify the range of 10 to 500 μR/h, such as the Ludlum Model 19 or the equivalent. The instruments will be calibrated by a qualified vendor. Calibration certificates will be maintained for inclusion in the final report. The instruments will be calibrated using cesium-137 because its gamma energy (0.661 MeV) is a good representative of the mid-range and higher range gamma energies common to radium-226 progeny. Daily performance checks will be performed using a 1 microcurie cesium-137 button source.

12.5.2 GLOBAL POSITIONING SYSTEM DATA

Trimble GPS unit(s) or equivalent GPS device(s) will be used to locate survey points. Readings from the instrument(s) will be recorded on data logger(s) with the data being directly correlated to the X, Y, and Z data provided by the GPS unit(s). These parameters will be stored and later downloaded for processing into visual interpretations using a computer drawing software package. Alternatively to data loggers, instrument readings and X, Y, and Z data may be recorded in paper survey logs for later transfer to an electronic database.

12.5.3 SOIL SAMPLING EQUIPMENT

- One-gallon Ziploc plastic bags (hard plastic containers may substitute).
- Digging tools will be selected using Table 7.1 "Soil Sampling Equipment" in NUREG-1575 (NRC 1997).

12.5.4 RADIATION SURVEYS

Areas within PDAs will be surveyed on reproducible, systematic grid points laid out on 500 foot spacings. Stationary instrument readings will be taken at these points. Readings will also be monitored along the gridlines while walking between grid points. Anomalies encountered during the walkover will be investigated.

Exposure rate readings will be acquired at sufficient length time intervals to ensure good data quality. Generally, instrument readings will be taken at approximately 1 m (3 feet) above ground and reported in μR/h.

12.5.5 SOIL SAMPLES

Surface samples will be collected from the top 15 cm (6 inches) of soil. Sampling may be performed in subsequent 15-cm (6-inch) intervals to investigate anomalies. The standard sample mass will be approximately 1,500 grams (about half of a 1-gallon Ziploc plastic bag). Each sample will be double-bagged.

Samples will be identified and marked as follows:

- Sample number (taken in sequence for the project sector)
- Coordinates
- Depth
- Date
- Technician initials

Following is an example:

- CB-002
- N: 586200 E: 1268300
- 0–15 cm (0–6 inches)
- 9/22/11
- XYZ

Note that "CB" in the sample number stands for the study area, which in this example denotes the Cebolleta Mine Site project area. Other study area abbreviations will be used; for example, "HR" will be used to denote haul roads.

After sample collection, the digging tool(s) will be wiped or brushed cleaned to prevent transferring contaminants to other samples. The survey crew will start a chain of custody (COC) form for each sample. (COCs provided by the laboratory may be used.) The field team leader will complete the COC form and will deliver or ship the samples to the analytical laboratory. Soil samples will require no field preparation or preservation. Replicate samples (if any are occur) will be homogenized in the field prior to separation into replicate sample containers.

12.6 PARAMETERS TO BE ANALYZED

Radionuclide concentrations in soil will be determined by laboratory analysis, as shown in Table 12.2, below.

Table 12.2. Laboratory Analysis Methods

Analyte	Analysis Method†	Description	Reporting Units
Total Uranium	EPA 6020	ICP-MS	µg/g
Radium-226	EPA 901.1	Gamma spectroscopy	pCi/g
Potassium-40	EPA 901.1	Gamma spectroscopy	pCi/g
Gross Alpha	EPA 900.0	Gas flow proportional	pCi/g

†Other appropriate EPA-approved analysis methods may be selected.

12.7 Maps Showing 2011 Sampling Locations

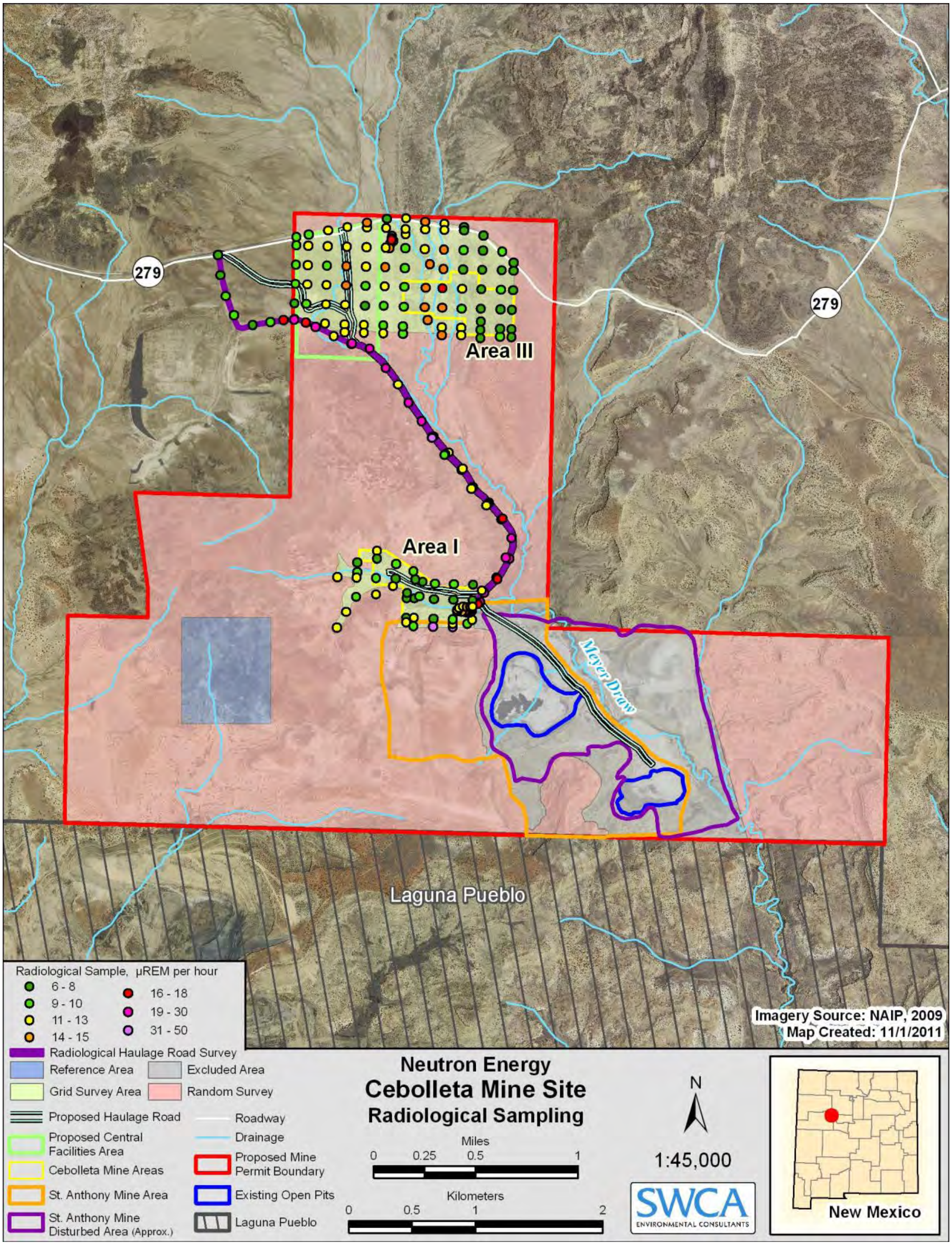

Figure 12.1. Radiological sampling grid locations.

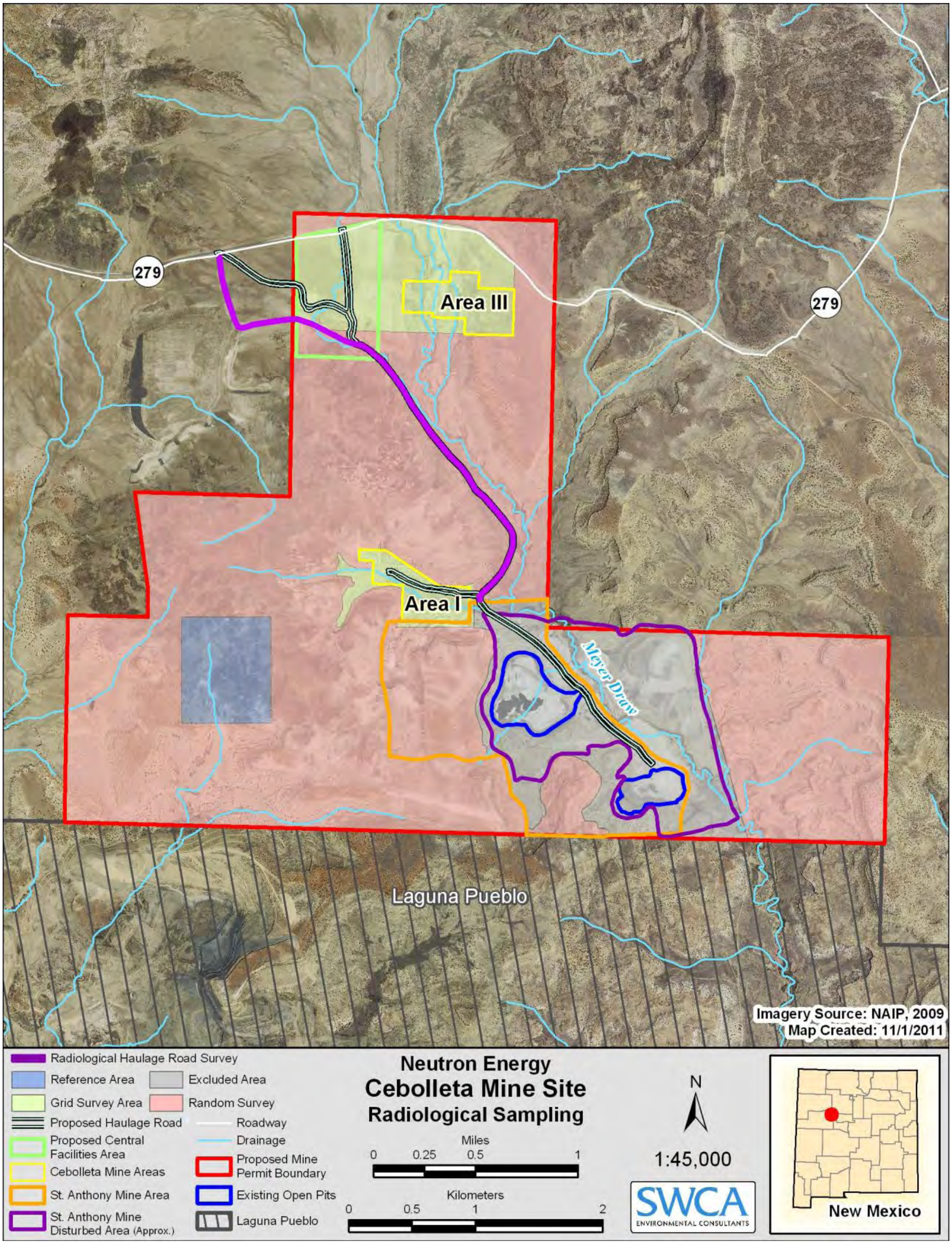

Figure 12.2. Planned disturbed areas, haul road, and reference locations.

12.8 LABORATORY AND FIELD QUALITY ASSURANCE PLANS

Gamma radiation surveys and soil sampling and analysis will be conducted in accordance the guidance provided in NUREG-1575 (NRC 1997) and EML HASL-300 (U.S. Department of Energy 1997) approved analysis methods. SOPs, plans, and manuals developed by Cebolleta Mine Site radiological consultants will be used to complete the survey.

The field team leader and each member of the survey team will be experienced in his or her particular area of expertise as verified by a current work resume. Additionally, each field member will have read this plan and the procedures and applicable manuals. A training session on this plan and procedures will be conducted by the field team leader or delegated individual.

Field data will be collected in a bound logbook. The field team leader will record daily activities, survey location, instrument performance checks, soil sampling identification information, handling and shipping information, and other information important for the data analysis. Survey data may be recorded in the logbook(s), then signed or initialed by the surveyor. If possible, a copy of all daily entries will be made and stored separately from the logbook. A copy of the logbook(s) will be kept at the Cebolleta Mine Site office when the survey is completed.

The calibration certificates for the instrumentation will be maintained for inclusion in the final report. Daily performance checks will be performed to ensure proper operation. Any improperly functioning instruments will be removed from service and replacements used.

The Trimble data recorder (or equivalent) will be downloaded to a computer daily if possible. The data quantity and quality will be reviewed to ensure it is usable and complete. This information will be reviewed by specialists to identify anomalies and ascertain the general site radiological characteristics.

The analytical laboratory(s) will be certified by the National Environmental Laboratory Accreditation Conference or equivalent. Only EPA-approved analytical methods will be employed.

12.9 BRIEF DISCUSSION SUPPORTING PROPOSAL

The objectives of the proposed radiological survey are to characterize and establish existing gamma radiation conditions and concentrations of naturally occurring radionuclides in soils associated with the proposed mine permit area. Data from the radiological surveys will be used to determine baseline gamma radiation levels, establish ranges of natural background conditions prior to surface disturbance activities and establish specific reclamation criteria to ensure that mined areas are returned to their approximate pre-mining state. The baseline study methods described herein are derived from the *Guidance for Meeting Radiation Criteria Levels and Reclamation at New Uranium Mining Operations (Draft)*, issued by the MMD in May 2011. To ensure high levels of quality and consistency, federal guidance, such as the *Multi-Agency Radiation Survey and Site Investigation Manual* (NRC 1997) and EPA-approved soil analysis methods will be used.

12.10 REFERENCES

New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division (EMNRD). 2010. Guidance Document for Part 6 New Mining Operation Permitting under the New Mexico Mining Act. Santa Fe: New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division.

———. 2011. Guidance for Meeting Radiation Criteria Levels and Reclamation at New Uranium Mining Operations (Draft). Santa Fe: New Mexico Energy Minerals and Natural Resources Department, Mining and Minerals Division.

EPA Method 900. Gross Alpha and Gross Beta Radioactivity in Drinking Water. U.S. Environmental Protection Agency, Washington, DC. August 1, 1980

EPA Method 901.1. Gamma Emitting Radionuclides in Drinking Water. U.S. Environmental Protection Agency, Washington, DC. August 1, 1980.

EPA Method 6020. Metals by Inductively Coupled Plasma – Mass Spectrometry. U.S. Environmental Protection Agency, Washington, DC. September 1, 1994

U.S. Department of Energy. 1997. The Procedures Manual of the Environmental Measurements Laboratory, 28th Edition (HASL-300). New York: U.S. Department of Energy.

U.S. Nuclear Regulatory Commission (NRC). 1997. Multi-Agency Radiation Survey and Site Investigation Manual, Rev. 1 (NUREG-1575). Washington, D.C.: U.S. Nuclear Regulatory Commission, U.S. Department of Energy, U.S. Department of Defense, and U.S. Environmental Protection Agency.

APPENDIX A
LAND AND MINERAL OWNERSHIP MEMORANDA

When recorded return to:

Mark K. Adams
Rodey, Dickason, Sloan, Akin & Robb
315 Paseo de Peralta
Santa Fe NM 87501

Memorandum of the Material Terms of a Mining Lease and Agreement

This is a Memorandum made pursuant to NMSA 1978, Section 14-9-1, of the Material Terms of a Mining Lease and Agreement effective as of April 6, 2007 (the "Effective Date") between LA MERCED del PUEBLO de CEBOLLETA, a political subdivision of the State of New Mexico, whose address is La Merced del Pueblo de Cebolleta, Attention: President, Board of Trustees, HC 77, Box 6, Seboyeta, NM 87014, as Lessor, and NEUTRON ENERGY, INC., a Wyoming corporation, whose address is Neutron Energy, Inc., Attention: Kelsey Boltz, President, 5320 North 16th Street, Suite 114, Phoenix, AZ 85016. This Memorandum is made pursuant to NMSA 1978, Section 14-9-1.

A. Lessor and Lessee entered into a Mining Lease and Agreement (the "Lease"), effective as of the Effective Date, in which Lessor granted Lessee certain rights and privileges with respect to the Property, which under the Lease means (i) the land owned by Lessor in fee located in Cibola County, New Mexico and described in Exhibit A to the Lease and to this Memorandum and (ii) any other fee interest in land within the exterior boundaries of the land described in Exhibit A acquired by Lessor after the Effective Date.

B. The Lease was affirmed on the Effective Date by Camille Martinez-Olguin, District Judge, Thirteenth Judicial District, Cibola County, New Mexico.

Memorandum of the Material Terms of a Mining Lease and Agreement - Page 1

200701563 Page 1 of 68 017 P:01769 Fri Apr 27 10:33:05 EDT 2007
Elloan R. Martinez, Cibola County, NM Clerk and Recorder

Doc CIBOLA000007

RODEY *Law Firm*

Memorandum

TO: Mike Neumann, Vice President-Environment, Neutron Energy, Inc.

FROM: Mark K. Adams

SUBJECT: Surface Use Rights of Cibola Resources LLC on a Tract of Land within the Cebolleta Land Grant Leased for Mining from La Merced del Pueblo de Cebolleta

DATE: January 8, 2010

I prepared this Memorandum at your request to evaluate and describe the rights of Cibola Resources LLC (Cibola) to enter and conduct mineral exploration and reclamation on a tract of land (the Tract) leased to Cibola's predecessor in title Neutron Energy, Inc. (Neutron) for mineral exploration, development and mining by La Merced del Pueblo de Cebolleta (La Merced). The Tract is shown on Attachment 1 to this Memorandum.

This Memorandum first discusses the history of the mineral and surface titles to the Tract. That history establishes that

- through a series of documents recorded in the public records of Cibola County, La Merced owns the mineral estate in the Tract;
- as the owner of the mineral estate, La Merced has the right to enter the Tract to conduct mineral exploration, development, mining and reclamation and has leased that right to Cibola; and
- Sayland Farms, LLC and its co-owners of surface interests in the Tract hold those interests subject to the right of La Merced and Cibola to enter and conduct mineral exploration, development, mining and reclamation on the Tract.

This Memorandum next discusses the rights of La Merced and Cibola under New Mexico law to enter and conduct mineral exploration, development, mining and reclamation on the Tract and concludes that under New Mexico law as well as under documents recorded in the public records of Cibola County, La Merced and Cibola clearly have such rights.

<u>History of Mineral and Surface Titles to the Tract</u>

Cibola holds the exclusive right to enter and conduct exploration, development, mining and reclamation for uranium and other valuable minerals (except oil and gas) on 6717 acres of land, more or less, in Cibola County, including the Tract, and to use so much of the surface of such lands "as may be necessary, useful or convenient in connection with" its exercise of those rights, under a Mining Lease

Rodey, Dickason, Sloan, Akin & Robb, P.A.
515 Paseo De Peralta | PO Box 1557 Santa Fe, NM 87104-1357
Offices in Albuquerque and Santa Fe | 505-954-3900 | fax 505-954-3942 | www.rodey.com
Established in 1885.
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NEI-

INSTRUMENT OF TRANSFER

URANIUM ENERGY CORP., a Nevada corporation ("**UEC**"), for and in consideration of its contemporaneous receipt from **NEUTRON ENERGY, INC.**, a Nevada corporation ("**Neutron**"), of U.S. $[redacted] in cash (the "**Consideration**"), the sufficiency and receipt of which Consideration is hereby acknowledged by UEC, hereby transfers and assigns to Neutron, and its successors and assigns, effective as of April 12, 2010 (the "**Effective Date**"), all of the following:

(i) UEC's entire Ownership Interest (as defined hereinbelow in this instrument of transfer (the "**Instrument**")) in Cibola Resources LLC, a Delaware limited liability company ("**Cibola Resources**");

(ii) any and all other rights, titles and interests of UEC in, to and under Cibola Resources; and

(iii) any and all rights, titles and interests of UEC in, to and under the Limited Liability Company Members' Agreement and the Limited Liability Company Operating Agreement (collectively, the "**LLC Agreements**"), both made as of April 26, 2007 by and between UEC and Neutron and both relating to the formation, operation and governance of Cibola Resources.

"**Ownership Interest**" as used in this Instrument has the same meaning as in the LLC Agreements.

This Instrument is the "Transfer Documentation" provided for in Article 2 of that certain Option Agreement made and entered into effective November 5, 2009 by and between UEC and Neutron, as amended by that certain First Amendment of Option Agreement made and entered into effective December 29, 2009 by and between UEC and Neutron, (collectively, the "**Option Agreement**"). The transfers and assignments made by this Instrument are subject to the matters set forth in Exhibit "A" to the Option Agreement. In accordance with Section 3.4 of the Option Agreement, the respective warranties and representations of UEC and Neutron set forth in Article 3 of the Option Agreement shall survive the execution, delivery and acceptance of this Instrument for a period of one year from the Effective Date hereof. In accordance with Section 4.1 of the Option Agreement, each of UEC and Neutron hereby releases the other as and to the extent provided in Section 4.1 of the Option Agreement.

Accepted and agreed to:

URANIUM ENERGY CORP.

By: ______________________

Name: AMIR ADNANI

Title: PRESIDENT & CEO

Date of Execution: APRIL 8, 2010

Neutron
3593851 2

APPENDIX B
QUALITY ASSURANCE PROCEDURES FOR METEOROLOGICAL STATION

The field quality assurance procedures and schedule for the meteorological tower are provided in Table B.1

Table B.1 Meteorological Station QA/QC Procedures

Task	Frequency
Perform general station check/visit	2 times per month
Review data on a real time basis	2 times per month
Audit meteorological tower instruments	Biannually
Check operation of meteorological sensors	Each visit
Check datalogger output against ambient conditions	Each visit
Ship data to Albuquerque (field logs)	Following each visit
Review data (field)	Each visit
Review data (home office)	As received from the field
Maintain documentation of all field activities	Each visit

The station operator will document the findings and actions taken during each station check on pre-printed and bound station log forms. A guidance document outlining the procedures and required corrective actions to maintain properly functioning instruments, if applicable, will accompany the station logbook.

Below is a summary of the meteorological field audit procedures to be followed by air quality personnel. Although characterized as a summary, the procedures described follow the intent of the published EPA QA/QC guidelines and satisfy the project monitoring obligations. The general guidelines to follow in preparation for a field performance audit are as follows:

1. List parameters to be audited. Include calculated parameters (e.g., delta T, temperature lapse, sigma theta).
2. List the model type(s) for sensors to be audited.
3. Compare the standard procedures below with the parameter/sensor model to be audited and prepare equipment and information lists.
    a. The equipment list should include:
        i. Actual test equipment.
        ii. Tools and spare parts.
        iii. A computer interface (laptop, keyboard, etc).
    b. The information list should include:
        i. Expected sensor output values.
        ii. Calibration factors for tower sensors and audit instrumentation (e.g., net radiation).
        iii. Programs and software (LoggerNet, copies of the datalogger program and channel outputs, an audit assistant spreadsheet, and look-up tables).

iv. Wiring diagrams for the datalogger and other connections, if available.

v. General data points and results from the previous audit, if available.

vi. Instruction manuals, including Campbell Scientific CR800 and sensor manuals as required.

vii. A field QA/QC binder.

Each meteorological sensor is evaluated based on the comparison of performance against EPA guidelines and manufacturer specifications. If performance values are outside the recommended ranges, the results are reported to field personnel so that field repair and/or recalibrations can be performed expeditiously. The Baseline Summary Report will include these results for documentation purposes.

Each meteorological sensor is calibrated using procedures specifically designed to test its accuracy of response. General descriptions are given below. These procedures reflect the requirements described in the *Quality Assurance Handbook for Air Pollution Measurement Systems* (EPA 2008b). Upon arrival at the site, each variable is observed for reasonableness by a trained technician. Next, the audit manipulations to each sensor are conducted. The datalogger outputs are recorded and compared to the audit input values. If the bias between the audit and Site values exceeds the prescribed limits described below, the appropriate troubleshooting is conducted to determine the cause of the discrepancy. At the conclusion of the audit, the sensors are put back online and are again checked for reasonableness. See Table B.2 for a summary of meteorological audit criteria.

Table B.2. Summary of Meteorological Audit Criteria

Parameter Tested	Acceptable EPA Deviation or Satisfactory Criteria
Wind Direction	
Vane Orientation	± 3° from reference
Sensor Linearity	±3° at any of the 12 points checked
Starting Torque	See manufacturer specifications
Horizontal Wind Speed	
Sensor Calibration	± 0.25 m/s at speeds < 5 m/s 5% at speeds > 5 m/s (max. error 2.5 m/s)
Starting Torque	See manufacturer specifications
Temperature	± 0.5°C at all 3 points checked
Precipitation	± 10% difference
Relative Humidity	± 3%
Evaporation	± 10% difference

SENSOR HEIGHTS

The height of each sensor above ground is measured with a standard tape measure or using trigonometric methods and a surveyor's transit. The measured heights are then compared to those stated in the air monitoring program plan.

WIND DIRECTION

Vane Calibration: Two factors must be checked to assure the wind vane is accurately measuring the wind direction: the azimuth as stated on the wind vane (orientation) and the ability of the wind vane to measure winds from all directions.

The preferred method for checking the wind vane orientation marker's stated azimuth is the solar azimuth angle technique, which is used to determine a known direction (solar azimuth). This measurement is made using a surveyor's transit mounted either on a field tripod or directly onto the wind direction sensor mounting plate. A measurement to a local topographical marker is then taken and the difference between that value and the known solar azimuth is used to determine a calculated azimuth angle for the reference marker. The resultant azimuth for the reference marker is used in a like manner to determine the orientation of the sensor cross-arm (ideally set at 180 degrees). The solar azimuth check is normally done only once per site to establish a known direction for measurement of the orientation of the reference marker. A minimum of three bearings will be taken for this test. If the solar azimuth angle technique cannot be used, the azimuth angles will be measured with compass or global positioning system (GPS) bearings.

A substitute (and second preference) for using the solar angle method is to measure the reference point azimuths from a topographic map. The sensor outputs, when aligned to the chosen reference points, are compared to the azimuths determined from the topographic map. This methodology requires accurate interpretation of the angles from the topographic map and knowledge that the chosen reference points are visible from the tower site. Additionally, at least one of the reference points needs to be greater than 10 km (6 miles) from the tower site.

Regardless of which azimuth determination technique is used, the following should be adhered to by the field staff:

- Select reference points with as great a distance as possible from the tower site. The preferred approach is to have at least one point that is a minimum of 10 km (6 miles) distant. If points of this distance are not available, extra care must be taken during the visual alignments.
- Always prepare the basic field data before leaving for the site (solar angle tables, azimuth to reference points, etc.).
- Complete all preliminary data on the audit log forms. These data include calibration constants of all audit instrumentation (as applicable) and expected output values for each test (as applicable).
- Always run an equipment checklist prior to leaving for the site. The content of the equipment list depends on the methodologies to be used.

The ability of the wind sensor to measure winds from any direction is tested by visually aligning the sensor with the reference markers established above, recording the output from the datalogger, and comparing the previously determined azimuths. To ensure accuracy, the wind vane is aligned with the crossarm and the corresponding output is recorded.

Sensor Linearity and Overall Accuracy: Sensor linearity is checked by removing the wind vane and replacing it with a protractor and angle fixture. Wind direction readings will be taken at 30 degree intervals for a total of 12 readings. This is the preferred method.

In the event a calibrated protractor is not available for a given type of sensor, the linearity will be checked by approximating 45 or 90 degree turns. A volt or ohm meter may be also be used for the alignments. As with the calibrated protractor, readings will be taken at approximately 30 degree intervals.

Sigma Theta Test: The wind direction sigma theta check is a test of the datalogger sigma theta calculation. System errors attributable to the program algorithm and/or the signal from the sensors are detected in the outputs at the datalogger. The theta test is conducted by fixing the wind vane at a given direction for a given period of time and then moving the vane 30 degrees and leaving it at this setting for the same time period. The time interval is selected to correspond to one averaging period of the datalogger. During the selected time interval, the wind speed sensor is held stationary to prevent the vector averaging routine from interfering with the sigma theta audit. Sigma theta, average wind direction, and average wind speed are recorded from the datalogger and compared to the expected values.

The following items are important for the accuracy of this test:

- Compare the theta test data to the averaging interval on the datalogger. Most systems calculate the sigma theta over a sub-interval period of either 10 or 15 minutes. Whenever a sub-interval period is in use, the averaging period of the datalogger (i.e., final output instruction) should be modified to correspond to this interval. Remember to reset changes made to the program before proceeding to the next audit parameter.
- Synchronize the timing for the test to the datalogger clock, not necessarily with the auditor's watch. Repositioning of the wind vane (for the second half of the averaging interval) must occur as closely as possible to the midpoint of the time interval. For example, the wind vane will be moved after 5 minutes for a 10-minute test and after 7.5 minutes for a 15-minute test.
- Record the start and end values for time, wind directions, wind speeds, and protractor settings (when applicable).
- Perform the sigma theta test on each datalogger within a monitoring network. On towers with multiple levels of sigma theta, perform the test on the level of the most significant interest.

Starting Threshold Torque: The wind vane's starting threshold torque is measured using a National Institute of Standards and Technology (NIST)-calibrated torque gauge. The gauge is applied to the wind vane shaft at the center of rotation and a constant force is applied. The test is repeated six to eight times beginning at different points for a 360-degree rotation. The value recorded is the highest value observed during the test.

If a calibrated torque watch is not available, the Jonard leaf torque gauge will be employed. This method requires a ruler (capable of measuring 10 cm [4 inches]) and a protected area where the sensor can be set up and leveled free from air disturbance.

A manual, qualified bearing check is acceptable only in combination with the above procedures for the purpose of a QA/QC audit.

HORIZONTAL WIND SPEED

Sensor Calibration: The sensor is audited by removing the anemometer cups and applying a constant rate of rotation in the normal direction of spin using synchronous motors. This is done by connecting the shaft of the synchronous motor to the anemometer shaft using a non-rigid, non-slip connector. Using the anemometer specifications, revolutions per minute (rpm) are converted to wind speed and compared to the resulting instantaneous datalogger outputs. The following precautions will be taken during the calibration procedure:

- Avoid applying excessive pressure to the sensor shaft during the motor test. Excessive pressure will slow the rate of rotation.
- Be certain all connections between the motor shaft and the sensor shaft are secure. Slippage can cause erroneous readings on the sensor.
- Always have the expected output values and audit criteria recorded on the audit log.

Starting Threshold Torque: The starting threshold torque measurement of the anemometer shaft follows the same procedure as that described for the horizontal wind vane. Due to the lower resistance, a more sensitive torque watch is used.

TEMPERATURE

The tower-mounted temperature sensor is audited by collocation at three points with a NIST-traceable thermometer in constant temperature water baths. The field thermometer has a range of at least -1°C to 51°C in 0.1°C graduations and will be compared to a NIST-certified thermometer. The tests are conducted in the following temperature ranges: 0°C to 5°C, 20° to 30°C, and 40° to 50°C. The equilibrated thermometer reading is compared to the datalogger output. Finally, the temperature probe aspirator is checked for proper ventilation by inspecting operation of the fans, if applicable, and checking the air pathway for obstructions.

When a water bath test is not possible, the temperature probes will be checked by collocation with the NIST thermometer. The field (NIST) thermometer is to be collocated under ambient conditions in proximity to the tower sensor. If possible, the temperature probe will be placed inside the aspirator shield. Be certain not to contact any nearby surfaces with the field probe while conducting this test and keep in mind the following considerations:

- In addition to recording readings from the field thermometer and individual tower probes, record the delta temperature and temperature lapse values, as calculated by the datalogger, simultaneously for each of the three water baths.
- Note that small temperature differences within the water bath tests can induce large differences in the measured lapse rates. The passing criterion is 0.1°C.

PRECIPITATION

The precipitation gauges are checked using a 100-mL graduated burette (within 1% accuracy). Two types of tests are conducted: a 10-tip test and a bucket test. The 10-tip test is conducted before disturbing the outer housing of the gauge. To conduct the 10-tip test, the burette is opened to deliver water at the approximate rate of five seconds per cubic centimeter (cc) of water and allowed to flow until 10 tips are identified. The delivered amount of water is converted to equivalent inches of precipitation and the result compared to the datalogger output. During the 10-tip test, it is important that the bucket does not overflow on the final tip (the tenth tip). Carefully monitor the flow rate following the ninth tip and quickly close the stop cock on the final tip of the bucket. The error introduced at this point can be minimized with careful control of the water flow rate and should not have a significant effect on the 10-tip average.

In the bucket test, water is delivered until the bucket tips one time. The delivered water is compared to the theoretical amount of precipitation needed for 0.01 inch of rain in each bucket. The bucket test is repeated at least three times for each bucket. Following the bucket tip tests, the sensor is checked for level and cleanliness.

RELATIVE HUMIDITY

The relative humidity sensors are audited by collocation under ambient conditions using an aspirated psychrometer or digital relative humidity meter. Both thermometers used in the psychrometer are certified using the procedures cited above for temperature. The equilibrated dry bulb and wet bulb thermometer readings and the datalogger output values are recorded. The audit relative humidity value is calculated from formulas contained in the Smithsonian Meteorological Tables, corrected for the measured ambient barometric pressure. The audit relative humidity is compared to the datalogger output and the result is considered satisfactory if the difference between the two is ±3 percent relative humidity or less.

When conducting the relative humidity audit, it is important that the following considerations be observed:

- Position the tower sensor as close to the inlet to the psychrometer thermometers as possible.
- Be certain to shield the tower sensor and the psychrometer from direct sunlight.
- Allow two or three minutes for the psychrometer to stabilize at the beginning of the test.
- Perform at least two tests, preferably three.

Station Locations and Orientation

During the field portion of the audit activities, the integrity of the station reference marker is checked by determining the azimuth angle with respect to true north and comparing that value to the value used by the station operator for the meteorological tower. This is accomplished by field measurement of the solar azimuth using a leveled surveyor's transit. The solar azimuth angle is previously calculated from a computer program and available to the auditor in tables at five-minute intervals. Once the known azimuth angle of the sun is established, it is used to determine the azimuth of station reference marker(s). These values are compared to values determined by the station operator using other orientation methods.

Station Sampling Environs

Part of the system audit is to document instrument fetch and local effects on data. The site area obstructions, field of view, and local topography are examined. Nearby obstructions are located on the azimuth scale, heights are determined (when possible), and the distance from the tower is measured. All local environs data are evaluated, compared to regulatory guidance, and submitted with the audit report for inclusion in site documentation files.

Meteorological Data Validation Criteria and Report Contents

The following criteria will be used in preparing the quarterly summaries for the Cebolleta Mine Site meteorological data for this report:

- Temperature Summaries (10-m temperature, 2-m temperature, delta temperature, and temperature lapse rate)

The mean, maximum, and minimum temperatures (in degrees Celsius) are reported for each day in the quarter. The maxima and the minima are based on on-hour averages. For a 24-hour mean value to be valid, at least 18 hourly values must have been recorded during the 24-hour period. If less than 18 hours of valid data are available, the mean is calculated, but data may not be representative and should be used with care. Similarly, maxima and minima are included for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data was for the hottest or coldest part of the day.

For each month in the quarter, the mean temperature is calculated from the hourly data. This includes days that did not have sufficient data to calculate a 24-hour mean. Monthly averages are calculated for months with less than four valid 24-hour means. The monthly maximum and minimum are also reported. Although four days of valid data are considered enough to report a mean, months with less than 18 days of valid data may not be representative and should be used with care.

A quarterly mean, maximum, and minimum are reported if there is at least one valid month of data in the quarter. However, these values may not be truly representative of the entire quarter if significant amounts of data are missing. The validity of the quarterly values depends on their intended use, and care should be taken with quarters with low data capture.

- Wind Speed Summary

The 24-hour mean wind speed and the maximum hourly wind speed are reported for each day of each month (in meters per second). The criterion for a valid 24-hour means is the same as that described above for mean temperatures.

The monthly mean and maximum wind speed are also reported. The criteria for determining the monthly values are the same as those described above for monthly temperature values. Likewise, the mean for the entire quarter and the maximum hourly value in the quarter are reported, using the criteria described above for quarterly temperature values.

- Wind Data Summary

The wind data summary report gives a joint frequency distribution (JFD) for wind direction and wind speed. Wind direction is divided into 16 sectors, each representing 22.5 degrees. The north sector covers 348.75 degrees to 11.25 degrees (i.e., its axis of symmetry is zero degrees). Wind speeds are divided into eight categories. The data in each wind speed/wind direction category are given as a fraction of the total month to the nearest 1%. The total fraction for each wind direction sector and each wind speed category is also given.

A quarterly JFD is printed if at least one valid month of data existed in the quarter. However, the quarterly JFD may not be truly representative of the full quarter if only one month of data is available.

- Precipitation Summary

The total daily precipitation in inches is reported for each day in the quarter, along with a running precipitation total beginning on the first day of the quarter. Daily precipitation is reported if at least one hour of data is available during that day.

The total quarterly precipitation is reported along with the total number of hours during which precipitation occurred. A quarterly precipitation value is reported if there is any valid precipitation data during the quarter. Care must be taken when using quarterly precipitation values if there were significant missing data during the quarter.

- Relative Humidity Summaries

The daily mean, maximum, and minimum relative humidity (in percent) are reported for each day in the quarter. The maxima and minima are based on one-hour averages. For a 24-hour mean value to be valid, at least 18 hourly values must have been recorded during the 24-hour period. If less than 18 hours of valid data are available, the mean is calculated, but data may not be representative and should be used with care. Similarly, maxima and minima are included for these periods. However, the maxima and minima may be misleading if the missing data were for the hottest or coldest part of the day.

The monthly mean relative humidity is calculated from all of the hourly data, including that from the days without sufficient data to calculate a 24-hour mean. Monthly averages are calculated for months with less than four valid 24-hour means in the month. The monthly maximum and minimum are also reported. Although four valid days are considered sufficient to report a mean, monthly means based on less than 18 days of valid data may not be representative and should be used with care.

A quarterly mean, maximum, and minimum are reported if there is at least one valid month of data in the quarter. However, these values may not be truly representative of the entire quarter if significant amounts of data are missing.

- Data Capture Summary – All Meteorological Parameters

The percent of valid data, based on hourly values, is reported for each month and each parameter; the average data capture for the entire month is also reported. In addition, the percent of valid data for the quarter for each parameter and the average data capture for the quarter are provided.

- Evaporation Summary

The total, minimum, and maximum evaporation values are reported in inches for each day of the quarter. Minima and maxima are based on one-hour averages. Positive values indicate evaporation, or loss of water from the evaporation pan, whereas negative values indicate precipitation or addition of water to the evaporation pan for other reasons.

For a 24-hour total value to be valid, at least 18 hourly values must have been recorded during the 24-hour period. If less than 18 hours of valid data are available, the total is calculated, but data may not be representative and should be used with care. Similarly, the maximum and minimum are included for these periods, but may be misleading if the missing data occurred in the hottest or coldest part of the day or during a precipitation event.

The total monthly evaporation is calculated from all the hourly data for each month in the quarter, including the data from days with insufficient data to calculate a 24-hour total. The monthly maximum and minimum are reported as well.

Validated data includes natural precipitation events. Scheduled and manual refilling events are removed from the reported data set. The evaporation pan operates seasonally. During the colder months when freezing of the pan is likely to occur there is no attempted data collection. At the Cebolleta Mine Site data collection generally spans the period April into November.

APPENDIX C
SURFACE WATER AND GROUNDWATER STANDARD OPERATING PROCEDURES

Water Level and Total Depth Measurements SOP

This SOP is concerned with the measurement of water levels in monitoring wells and the total depth of wells. Step-by-step procedures are outlined in the following sections.

Groundwater Level Measurement

If necessary, a plastic sheet can be placed around the well, creating a clean surface onto which the measurement and sampling equipment can be positioned. Do not place meters, tools, equipment, etc., on the sheet unless they have been cleaned first. After unlocking and/or opening a monitoring well, water level measurements will be made using an electric water level meter.

Equipment

- Socket wrenches and/or open-end wrenches
- Screw driver
- Key or combination for monitoring well lock
- Electric water level meter
- Decontamination equipment (buckets, brushes, Alconox™, distilled or deionized water, brushes, and paper towels)
- Safety equipment (sample gloves and other Personal Protective Equipment [PPE] as required for the job)
- Air monitoring equipment as required

Groundwater Level Measurement Procedures

- Unlock and/or open the monitoring well.
- Check for the measuring point at the top of the well. The measuring-point location should be clearly marked on the innermost casing or identified in previous sample-collection records. If no measuring point can be determined, a measuring point should be established. Typically, the top (i.e., the highest point or the north-facing point) of the innermost well casing will be used as the measuring point. The measuring-point location should be described on the monitoring-well gauging data form and should be the same point used for all subsequent sampling efforts.
- Obtain a water level measurement by lowering the probe of the electric water level meter into the monitoring well. Take care that the probe and electric line hang freely in the monitoring well and do not adhere to the wall of the well casing. Lower the probe into the well until the sound and light (if present) on the meter are activated. At this time, the precise measurement should be determined (to a hundredth of a foot) by repeatedly raising and lowering the tape to converge on the exact measurement. The water level measurement should be entered on an appropriate field form (i.e., monitoring-well gauging data form).

- Verify that the water level measurement is indicative of a static water level. The initial water level measurement may not be indicative of static conditions if groundwater pumping recently occurred in this vicinity or if the well is screened in a confined aquifer and the well casing does not have a vent hole permitting equilibrium with the atmosphere. A second water level measurement a few minutes after the initial measurement can be used to verify static water level conditions.
- Decontaminate the electric water level meter after use. Generally only the probe and the portion of the tape that enters the well will be cleaned. Ensure that the measuring tape is not placed directly on the ground surface.

Total Depth Measurement

If necessary, a plastic sheet can be placed around the well, creating a clean surface on which the measurement equipment can be positioned. Do not place tools, equipment, etc., on the sheet unless they have been cleaned first. Total-depth measurements will be made using a stainless-steel weighted tape.

Equipment

- Socket wrenches and/or open-end wrenches
- Screw driver
- Key or combination for monitoring well lock
- Stainless steel weighted tape
- Decontamination equipment (buckets, brushes, Alconox™, distilled or deionized water, brushes, and paper towels)
- Safety equipment (sample gloves and other PPE as required for job)
- Air monitoring equipment as required

Total Depth Measurement Procedures

- Unlock and/or open the monitoring well.
- Check for the measuring point of the well. The measuring-point location should be clearly marked on the innermost casing or identified in previous sample-collection records. If no measuring point can be determined, a measuring point should be established. Typically, the top (i.e., the highest point or the north-facing point) of the innermost well casing will be used as the measuring point. The measuring-point location should be described on the water level data form and should be the same point used for all subsequent sampling efforts. Obtain a total-depth measurement by lowering a weighted calibrated tape into the monitoring well. Take care that the weighted tape hangs freely in the monitoring well and does not adhere to the wall of the well casing. Lower the weighted tape into the well until the bottom of the well is reached. This can be determined when the weight can no longer be felt and there is slack in the tape. A

precise measurement of the total depth of the well should be determined (to a hundredth of a foot) by repeatedly raising and lowering the tape to determine the exact measurement and then adding the probe tip length (e.g., 0.10 ft) that extends below the 0.00-foot mark on the tape/probe. The total-depth measurement and condition of the well bottom (i.e., hard, soft) should be entered on an appropriate field form or field logbook (i.e., water level data form).

- Decontaminate the measurement device after each use. Generally only the portion of the tape that enters the well will be cleaned. Ensure that the measuring tape is not placed directly on the ground surface.

Monitoring Well Sampling for Groundwater SOP

Collection of Field Parameters – Temperature, pH, Electrical Conductivity, Dissolved Oxygen, and Oxidation-Reduction Potential

Field parameters of temperature, pH, and electrical conductivity should be collected at the time of groundwater sampling. The purpose of collecting these parameters is to determine the field parameters of the aquifer water and the adequacy of the purge. If the bladder pump sampling method is used, these parameters should be measured using parameter probes in a flow-through cell that is connected directly to the pump discharge line such that the groundwater does not contact the atmosphere. The parameters should be recorded periodically during the purge of the drop tube (8 to 10 gallons). Dissolved oxygen and oxidation-reduction potential (ORP) may also be measured in the flow-through cell.

Sampling Method

Bladder pump with drop tube:

- Upon arrival at the well head, measure depth to groundwater and record.
- Calculate the amount of water present in the drop tube based on the depth of the pump and the depth of the drop tube intake within the well screen (this may have already been done and will not change after installation of the pump and drop tube).
- Activate the bladder pump either by air from an air compressor or by air or nitrogen gas from a compressed gas bottle. Attach the air or gas line hose to the well head fittings and begin to purge the water from the drop tube. Measure the flow rate and estimate the expected time to purge the required volume. Direct the purge water through a flow-through cell for parameter measurements.
- Measure groundwater field parameters periodically as described in section 2.6.2.1.
- Containerize the discharge (up to 10 gallons) for future disposal, after analysis of water chemistry.
- After purge of the drop tube, collect the samples in the labeled, laboratory-prepared sampling containers.
- Store the containers on ice in a cooler for delivery to the analytical laboratory with chain-of-custody forms.

Collection of Samples from Groundwater Monitoring Wells

Groundwater samples are collected and analyzed to determine the presence, absence, or quantity of various constituents as part of Site characterization, remediation, and/or monitoring activities.

Equipment

The following list identifies the types of equipment that may be used for a range of groundwater sampling applications. A project-specific equipment list will be selected from this list based on project objectives and well conditions.

- Bailer with rope or string
- Pump with tubing and power source
- pH meter
- Specific conductance meter
- Temperature meter
- Dissolved oxygen meter
- eH (ORP) meter
- Turbidity meter
- Flow-through cell
- Water level measurement equipment
- Water sampling data form
- Filtration apparatus (project-dependent)
- Personal protective equipment
- Decontamination equipment
- Permanent pens
- Field logbook
- Sample coolers
- Sample containers and laboratory-supplied preservatives (if any)
- Sample labels
- Custody seals (if required by Sampling & Analysis Plan/Work Plan)
- Chain-of-custody forms
- Sample control logs

Well Purging

Prior to sample collection, purging must be performed for all groundwater monitoring wells to remove stagnant water from within the well casing and/or to ensure that a representative sample is obtained.

Standard Well Purging

Monitoring wells will be purged of at least three well casing volumes (moderate- to high-yield formations) or at least one well casing volume for low-yield formations unless micropurge methodology is followed (method described below). To determine the volume of water to be removed, the first step is to measure the depth to water (DTW) and the total depth (TD) of the well casing. DTW measurements should be made within 48 hours of purging and sampling wells.

Once these measurements have been obtained, the well casing volume is determined using the following equation:

$$V_{WC} = \frac{\pi D^2 h}{4}$$

Where:	V_{WC} (ft^3)	=	well casing volume
	D (ft)	=	internal diameter of the well casing
	h (ft)	=	length of the water column in the well casing (TD-DTW)

As a conservative measure or because of project-specific requirements, total well volumes may be required for purging rather than well casing volumes. Total well volume differs from well casing volume in that it includes the volume of water in the filter pack. Total well volume is calculated using the equation:

$$\text{Total Well Volume} = V_{FP} + V_{WC}$$

Where: V_{FP} = volume of water in the filter pack

The volume of water in the filter pack is determined by calculating the volume of the water in the borehole less the well casing volume. Compensation for the porosity of the filter pack is included in the equation, and this relationship is expressed as follows:

$$V_{FP} = \left\lfloor \frac{\pi D^2 h}{4} - V_{WC} \right\rfloor (n)$$

Where:	V_{FP} (ft^3)	=	filter pack volume
	D (ft)	=	diameter of the borehole
	h (ft)	=	lesser of (a) length of filter pack, or (b) length of water column in the casing
	n	=	filter pack porosity (assume 30%)
	V_{WC} (ft^3)	=	well casing volume

Useful conversions:	1 ft^3	=	7.48 gal
	1 gal	=	0.134 ft^3

Indicator parameters (pH, temperature, and conductivity) will be monitored and recorded during purging. Generally, well purging will continue until the pH is stable within 0.2 standard units, temperature is stable within 1° C, and electrolytic conductivity is stable within 10% in three consecutive measurements.

Low-yield wells are considered purged after a minimum of one well volume is removed. If possible, low-yield wells should be purged at a rate slow enough so as not to purge the well dry. If a well is purged dry, the well should be sampled as soon as it has recovered enough to have sufficient water volume for the sample. The time between purging and sampling should not exceed 24 hours.

For medium- or high-yield wells, samples should be collected within two hours of purging if possible. Under no circumstances should there be more than 24 hours between purging and sampling.

Please note that purging and sampling of a well can be done within 12 hours of well installation (i.e., just after well development), if necessary. However, the greater the time lapse between well installation and well sampling, the more representative the sample will be of formation water. It is recommended that, when project schedules and budget allow, wells should be allowed to stand for 24 hours or greater prior to purging and sampling.

Micropurging

Micropurging is an alternate method for purging wells that is distinctly different from the above-mentioned purging methodology. With micropurging, also referred to as low-flow purging, water is withdrawn directly from the screened interval at low enough pumping rates to ensure that the water sampled is formation water just recently entering the screen. As with traditional sampling, the groundwater is not sampled until the water-quality parameters (pH, temperature, and conductivity) have stabilized. Micropurging does not require a certain volume of water to be evacuated from the well. The intake point of the pump or tubing should be close to the middle of the screen, so the monitoring-well construction details must be known. Micropurging criteria include the following:

- The intake point of the pump or tubing is in the center of the screen.
- Return water is clear and free of debris and has evacuated all major air bubbles in the tubing and flow-through cell.
- The pumping rate does not exceed 1 liter per minute (L/min) (0.1 to 0.5 L/min is usually optimum).
- Drawdown in the well is minimized and does not exceed 10% of the screen length.
- Three consecutive measurements of pH, temperature, conductivity, redox potential, and dissolved oxygen have been taken and show changes in value no more than 0.1 for pH, 1°C for temperature, 3% for conductivity, 10 millivolts for redox potential, and 10% for dissolved oxygen.

Well-Purging Methods

Monitoring wells may be developed using either bailers or pumps. It is not recommended that bailers be used for purging, although in many cases bailing may be the most practical method.

Four general types of equipment are used for well purging:

1. Grab samplers (including bailers, Kemmerer samplers, and syringe samplers)
2. Suction-lift pumps (including peristaltic pumps, surface centrifugal pumps, and vacuum pumps)
3. Electric submersible pumps (including centrifugal submersible pumps, helical rotor pumps, and gear pumps)
4. Positive displacement pumps (including gas-drive pumps, piston pumps, inertial-lift pumps, and bladder pumps)

Once the type of pump or bailer is selected, the purge rate should be set low enough to avoid turbulent flow that causes entrainment of fines in the sand pack (over development of the well) and potentially causes stripping of volatile organic compounds. As a rule of thumb, the purge rate should not exceed the pumping rate or bailing rate used for well development. In addition, the purge rate should not exceed the recovery rate for the well. Typically, purging rates should not exceed 0.2 to 0.3 L/min.

Bailing

In many cases, bailing is the most convenient method for well purging and sampling. Bailers are constructed using a variety of materials such as PVC, stainless steel, polyethylene, and Teflon®. Care must be taken to select a specific type of bailer that suits a study's particular needs. Teflon® bailers are generally the most "inert," while PVC bailers are less expensive and sufficiently resistant to small-term exposure to most common contaminants. Bailers that are not chemically inert and easily decontaminated should not be used to purge and/or sample more than one well. Typically, a bailer can be dedicated to one well and can be hung in the well for subsequent purging and sampling events Disposable bailers, usually made of polyethylene, are sometimes more practical to use when decontamination time, expense, and the number of sampling events are considered.

Bailing presents three potential problems with well purging and sampling. First, increased suspended solids may be present in samples as a result of the turbulence caused by raising and lowering the bailer through the water column. High solids concentrations may require that total suspended solids (TSS) and the chemical character of the solids be evaluated during sample analyses. In addition, rapid bailing could cause the stripping of volatile organic compounds from the groundwater as a result of bailer agitation and/or groundwater cascading down the sides of the well screen.

Second, bailing may not be practical for wells that require that more than 20 gallons be removed during purging or for wells that are deeper than 50 ft bgs. Such bailing conditions mandate that long periods be spent during purging and sample collection, or that centrifugal pumps be used.

Third, bailing typically withdraws water from the top of the water column in the well and this water has already been exposed to the atmosphere. Exposure to the atmosphere can cause volatilization and reactions with carbon dioxide which cause subsequent lowering of the water's pH.

Suction-Lift Pumps

Suction-lift pumps are used to purge and sample groundwater from less than 30 ft bgs. Suction-lift pumps include peristaltic pumps, surface centrifugal pumps, and vacuum pumps. Vacuum pumps and surface centrifugal pumps (to a lesser extent) are not as appropriate as peristaltic pumps when collecting volatile-sensitive water samples.

Electric Submersible Pumps

Electric submersible pumps are commonly used to purge and sample groundwater from a variety of depths. Electric submersible pumps include centrifugal submersible pumps, helical rotor pumps, and gear pumps. The centrifugal submersible pumps are most commonly used, yet cause considerable water agitation due to the movement of the impeller(s). The gear pumps are the best-suited electric submersible pumps for groundwater purging and sampling and one of the best overall pumps for minimizing volatilization of groundwater samples.

Positive Displacement Pumps

Positive displacement pumps are widely available pumps often useful for groundwater purging and sampling. Positive displacement pumps include gas-drive pumps, piston pumps, inertial-lift pumps, and bladder pumps. The bladder pump is generally considered the best overall type of pump to collect groundwater samples for inorganic and/or organic analyses. Inertial-lift pumps are ideal for well development, but should not be used to collect volatile-sensitive groundwater samples.

Purging and Sample-Collection Procedures — Method Specific

Once purging is complete, samples can be collected with either bailers or pumps. In many cases, a well may be purged using a pump and sampled using a bailer. This section discusses specific procedures for collecting samples using bailers and pumps.

Bailer Sampling

Obtain a decontaminated or new bailer and rope or cord made out of nylon, polypropylene, or other equivalent material. Tie a bowline knot or equivalent through the bailer loop. Test the knot for security and the bailer itself to ensure that all parts are intact before inserting the bailer into the well. Remove the protective wrapping from the bailer. Lower the bailer to the bottom of the monitoring well and cut the cord at a proper length. Bailer rope should never touch the ground surface at any time during purging and sampling.

Raise the bailer by grasping a section of cord using each hand alternately in a “windmill” action. This method requires the sampler’s hands to be kept approximately 2 to 3 ft apart and the bailer rope to be alternately looped onto or off each hand as the bailer is raised and lowered. Alternate methods may be used to raise the bailer including use of a reel or a plastic-lined bucket into which the rope is manually fed. Bailed groundwater is poured from the bailer into a graduated container to measure the purged water volume.

For slowly recharging wells, the bailer is generally lowered to the bottom of the monitoring well and withdrawn slowly through the entire water column. If possible, the water should be bailed at a rate slow enough so that it does not cascade down the sides of the well screen, which causes stripping of volatile organic compounds. Groundwater should be allowed to recover to 70% or greater of its static volume before a sample is collected.

Typically, water samples should be collected at or near the midpoint of the well screen. To collect a groundwater sample using a bailer, slowly lower the bailer into the water column, allowing the bailer to fill slowly from the bottom. Once the bailer has been lowered to approximately the mid-point of the screen, slowly raise the bailer to minimize creating turbulence in the well and minimize drawing fine-grained sediment into the well. Gently empty water directly from the full bailer into sample containers, taking care not to allow contact between the bailer and the sample container.

Pump Sampling

When selecting the appropriate pump to use for purging and sampling a well, there are two criteria that must be considered. First, the construction material of the pump and tubing should not contain materials that interact with the constituents of interest and/or contain constituents that may cause the sample to have a false positive analysis. Second, if the sample is to be analyzed for volatile organic compounds, a pump that minimizes sample agitation and subsequent volatilization should be used. As noted previously, the most appropriate pumps under these conditions are the gear pump or the bladder pump.

Prior to inserting a pump into a monitoring well, it should be thoroughly decontaminated by pumping an Alconox™ or equivalent potable water mixture through the pump followed by pumping potable water, followed by a distilled or deionized water rinse. Tubing should be dedicated to a single well and should not be re-used.

During the collection of samples, the pumping rate should be approximately 0.1 L/min. If a greater pumping rate is used for purging, the pumping rate should be reduced during sampling. Groundwater should be pumped directly into the sample containers.

Sample Collection Procedures — Method Independent

The following are method-independent sample collection procedures:

- Collect samples intended for volatile organic analysis (VOA) first.
- Fill sample containers quickly and smoothly to avoid agitation, aeration, and loss of volatile components.

- To further avoid loss of volatile components, completely fill samples so that no headspace is present and cap securely with a Teflon®-lined lid.
- Collect samples for semivolatile, metal, or other analyses in the proper sample containers.
- Collect duplicate samples when quality assurance/quality control (QA/QC) samples are needed for VOA. VOA samples typically consist of two sample vials, referred to as the sample set. Alternating between the primary sample set and the replicate sample set, completely fill each vial and cap immediately in the order shown below:
  - Fill vial #1 - primary sample set
  - Fill vial #1 - replicate sample set
  - Fill vial #2 - primary sample set
  - Fill vial #2 - replicate sample set
- Collect duplicate samples when QA/QC samples are required for sample analyses other than VOA by alternately filling the sample containers as in the VOA procedure, but fill containers incrementally instead of completely, continuing the filling procedure until the sample containers are full.
- Label all sample containers with the following information:
  - Project name and/or number
  - Field sample number
  - Depth interval (if applicable)
  - Initials of collector
  - Date and time of collection
  - Sample type and preservative (if any)

  Replicate and duplicate sample labels require only project name and/or number, field sample number, and sample type and preservative (if any).
- Place samples in coolers as soon as possible and, if required, store and transport them at <4°C (39°F), using frozen ice packs or double-bagged ice.
- Use protective packaging as dictated by the mode of transport.
- Record sample information in the field logbook and on the sample control log as soon as possible after sample collection, in accordance with the procedures set forth in the Quality Assurance Project Plan.
- Complete chain-of-custody forms and place them in the cooler for shipment to the laboratory.
- If required by the SAP, place custody seals across cooler lids so that coolers cannot be opened without breaking the custody seal. Include the following information on the custody seals:
  - Collector's signature or initials
  - Date of sampling

- Ship samples to the laboratory for analysis, carefully observing all minimum holding-time requirements for degradable constituents.
- Set up a decontamination station near the sampling location to decontaminate equipment that will be reused at the next sampling location.

Aquifer Testing and Analysis SOP

All monitoring wells added to the monitoring well network will be installed and completed in accordance with the NMED Monitor Well Construction Guideline.

General

A pumping test is used to determine hydraulic properties of an aquifer by pumping one well for a specified length of time while collecting periodic water level measurements. Aquifer properties that can potentially be estimated using a pumping test include transmissivity (i.e., hydraulic conductivity multiplied by aquifer thickness), horizontal or vertical hydraulic conductivity, coefficient of storage, specific yield, and confining layer leakage. The two types of pumping tests most useful in determining aquifer hydraulic properties are the constant rate pumping test and the step-drawdown pumping test. The latter is best suited to determining the well's reduction in specific capacity (i.e., specific yield per unit of drawdown) with increasing yields, while the former is the most widely used pumping test in determining the transmissivity and storage values for an aquifer.

A pumping test can be performed using only the pumping well; however, specific information such as aquifer storage will not be obtainable. The use of observation wells in obtaining additional drawdown and/or recovery data over time is recommended whenever possible, especially when information on aquifer storage, anisotropy, vertical leakage, or the distance to a recharge or no-flow (i.e., barrier) boundary is needed.

In comparison to a slug test, a pumping test is representative of a much larger area and is therefore a better estimation of the hydraulic parameters of an aquifer. Conversely, a pumping test requires a greater commitment of resources (time, money, and equipment) and produces large volumes of water that usually need to be containerized during the test.

Several analytical solution methods are available. Two of the most widely used are the Theis (1935) equation and the Cooper and Jacob (1946) equation (often referred to as the Jacob straight-line method). A multitude of pumping test analysis software is available, though users are cautioned to be sure to understand all model or spreadsheet inputs as well as the assumptions of the governing equations. Far more extensive information on the design and analysis of pumping tests is covered in texts including, to name a few, Driscoll (1986), Kruseman and de Ridder (1991), Dawson and Istok (1991), Osborne (1993), and Fetter (1988).

Analyses of pumping tests require the following assumptions:

1. The water-bearing formation is homogeneous, isotropic, uniform in thickness, and infinite in areal extent.
2. The formation receives no recharge from any source.
3. The pumping well (i.e., the screened section) is fully penetrating the entire thickness of the water-bearing formation.
4. The water removed from storage is discharged instantaneously when the head is lowered.
5. The pumping well is 100% efficient.
6. All water removed from the well comes from aquifer storage.
7. Laminar flow exists throughout the well and aquifer.
8. The water table or potentiometric surface has no slope.

In reality, most pumping tests violate many of the above-mentioned assumptions to some degree or another. It is important to take all feasible measures to limit the extent of these violations whenever possible. Certainly, discussing these assumptions and any possible violations to them is important to any pumping test report.

Design Considerations

Prior to performing an aquifer pumping test, all available site and regional hydrogeologic information should be assembled and evaluated. If retrievable, such data should include groundwater flow direction(s), hydraulic gradients, other geohydraulic properties, site stratigraphy, well-construction details, regional water level trends, and the performance of other pumping wells in the vicinity of the test area. This information is used to select test duration, proposed pumping rates, and pumping well and equipment dimensions.

The precise location of an aquifer test is chosen to be representative of the area under study. In addition, the location is selected on the basis of numerous other criteria, including:

- Size of the investigation area.
- Uniformity and homogeneity of the aquifer.
- Distribution of contaminant sources and dissolved contaminant plumes.
- Location of known or suspected recharge or barrier boundary conditions.
- Availability of pumping and/or observation wells of appropriate dimension and screened at the desired depth.
- Requirements for handling discharge.

The dimensions and screened interval of the pumping well must be appropriate for the tested aquifer. For example, the diameter of the well must be sufficient to accommodate pumping equipment capable of sustaining the desired flow rate at the given water depth. In addition, if testing a confined aquifer that is relatively thin, the pumping well should be screened for the entire thickness of the aquifer. For an unconfined aquifer, the wells should be screened at least in the bottom one- to two-thirds of the saturated zone and they may be screened throughout the entire thickness of the saturated zone.

Any number of observation wells may be used. The number chosen is contingent upon both cost and the need to obtain the maximum amount of accurate and reliable data. If at least three observation wells are to be installed and there is a known boundary condition, the wells should be configured such that water levels can be monitored both perpendicular and parallel to the boundary, with the pumping well at the intersection of the two well lines. If two observation wells are to be installed, they should be placed in a triangular pattern, non–equidistant from the pumping well. If observation wells are placed at 90-degree angles from the pumping well, radial anisotropy can be easily calculated. When observation wells are installed for aquifer testing purposes, they should be located at distances and depths appropriate for the planned method for analysis of the aquifer test data. Observation well spacing should be determined based upon expected drawdown conditions that are the result of the studies of geohydraulic properties, proposed pumping test duration, and proposed pumping rate.

Equipment

The equipment necessary to conduct a pumping test includes:

- A pump (suited for site conditions and requirements of the test)

- Water-level measuring devices (pressure transducers and/or electronic water-level indicators) accurate to at least 0.01 feet
- A flow meter with totalizer (something as simple as a graduated bucket can also suffice, especially as backup)
- A digital watch with stopwatch function (used to keep time and to help determine discharge rate when using graduated containers)
- An electrical source (generator or electrical receptacle on site)
- An electronic data recorder programmed to suitable data collection intervals)
- A barometer
- Water quality meter(s) for noting changes as a function of capture zone
- Hose or pipe to route pumped water away from test area
- A gate valve
- An adequately sized tank/container for storing water
- A portable computer for preliminary analysis of data (optional)
- Field forms and log book
- Pen and paper
- Backup equipment (if feasible)

Pumping equipment should conform to the size of the well and be capable of delivering the estimated range of pumping rates. The selection of flow meter, gate valve, and water transfer lines should be based on anticipated rates of water discharge. Both the discharge rate and test duration should be considered when selecting a tank for storing discharge water if the water cannot be released directly to the ground, sanitary sewer, storm sewer, or nearby water treatment facility.

Pumping-Test Preparations

If feasible for the site, slug tests or preliminary pumping tests (constant-rate or step drawdown) should be performed on the pumping well prior to the actual test. The preliminary pumping should determine the maximum drawdown in the well and the proper pumping rate should be determined by step drawdown testing. If the discharge rate varied by less than 5% (i.e., a constant-rate pumping test), the time versus drawdown data from the pumping well can be used to estimate aquifer transmissivity. The preliminary pumping will also provide redevelopment of the pumping well by removing fines from the adjacent formation and from the filter pack. Redevelopment of the pumping well will improve well efficiency during the pumping test and thus will allow for a better estimation of the aquifer's hydraulic properties. The aquifer should then be given time to recover before the actual pumping test begins (as a rule of thumb, one day). A record should be maintained in the field logbook of the times of pumping and discharge of other wells in the area, and if their radii of influence intersect the cone of depression of the test well.

Barometric changes may affect water levels in wells, particularly in semiconfined and confined aquifers. Therefore, it is advisable to monitor (perhaps hourly) the barometric pressure and water levels in key wells at least 24 hours (if possible) prior to performing a pumping test. If a groundwater fluctuation trend is apparent, the barometric pressure should be used to develop curves depicting the change in water level versus time. These curves should be used to correct the water levels observed during the pumping test. Groundwater levels and barometric pressures in the background should continue to be recorded throughout the duration of the test. If data loggers with transducers are used, backup field measurements should be collected in case of data logger malfunction. All measurements and observations should be recorded in a field notebook or on appropriate field forms.

All equipment should receive calibration, function checks, and fresh or charged batteries if needed.

Conducting the Pumping Test

Prior to the start of the pumping test, the following checks should be made:

- Ensure all piping, valves, and flow meters are properly installed.
- Ensure that all containers are in place to capture all pumped water.
- Ensure that the energy needs (batteries, electricity, or gas) for all equipment are provided, including backup energy sources for key equipment.
- Verify all equipment is present and place it at locations where it will be needed most.
- Verify the pump intake is located at the proper interval in the pumping well.
- Verify all transducers are placed at the proper depth and are properly secured so they will not move or be susceptible to contact from site personnel.
- Verify the data logger is properly programmed to record (typically logarithmically).
- Lower electronic water level tapes to just above the water levels inside each well.
- Warm up all equipment (such as a generator) that performs better after initial operations.
- Ensure all personnel and field forms are in their start-of-test locations

Immediately prior to starting the pump, the water levels should be measured and recorded for all wells to determine the static water levels upon which all drawdowns will be based. Data loggers should be reset for each well to a starting water level of 0.00 foot. At this time, a pumping test is initiated by starting the data logger and then starting the pump. The data logger needs to be started at least a split second before the pumping begins. Immediately afterwards, the time pumping started needs to be recorded along with water-level readings, especially at or near the pumping well. A suggested schedule for recording water-level measurements made by hand is as follows:

- 0 to 10 minutes – 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, and 10 minutes. It is important in the early part of the test to record with maximum accuracy the time at which readings are taken.
- 10 to 100 minutes – 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, and 100 minutes.
- 120 minutes to end of test – every 1 hour (60 minutes).

At least 10 measurements of drawdown for each log cycle of time should be made both in the test well and the observation wells. Data loggers can be set to record in log time, which is very useful for data analysis. When logging data by hand, there should initially be sufficient field personnel to station one person at each well used in the pumping test. After the first two hours of pumping, two people are usually sufficient to complete most simplistic tests. It is advisable for at least one field member to have experience in the performance of pumping tests, and for all field personnel to have a basic familiarity with conducting the test and gathering data.

The discharge rate should be measured frequently throughout the test with a flow meter equipped with a totalizer and controlled to maintain a constant pump. This can be achieved, in part, by using a control valve. If used properly, the flow control valve can be pre-set for the test and will not have to be adjusted during pumping. When the pumping is complete, the total gallons pumped are divided by the time of pumping to obtain the average discharge rate for the test.

For a confined aquifer, the water level in the pumping well should not be allowed, if possible, to fall below the bottom of the upper confining stratum during a pumping test. The pitch or rhythm of the pump or generator provides a check on performance. If there is a sudden change in pitch, the discharge should be checked immediately and proper adjustments to the control valve or the generator engine speed should be made, if necessary. Do not allow the pump to break suction during the test. If the pump stops working during the test, make necessary adjustments and restart the test after the well has stabilized.

Water pumped from an aquifer during a pumping test should be disposed of in such a manner as to not allow the aquifer to recharge during the test. This means that the water must be piped away from the well and associated observation wells. Also, if contaminated water is pumped during the test, the water must be stored and treated or disposed of according to project specifications. The discharge water may be temporarily stored in drums, a lined and bermed area, or tanks. If necessary, it should be transported and staged in a designated secure area.

Field personnel should be aware that electronic equipment sometimes fails in the field. It is a good idea to record key data in the field logbook or on field forms as the data are produced. That way, the data are not lost should the equipment fail.

The total pumping time for a test depends on the type of aquifer and degree of accuracy desired. Economizing on the duration of pumping may yield less reliable results. It is always recommended to pump long enough to ensure the cone of depression achieves a stabilized condition. The cone of depression will continue to expand at an ever-decreasing rate until recharge of the aquifer equals the pumping rate, and a steady-state condition is established. The time required for steady-state flow to occur varies considerably from site to site. If steady-state conditions cannot be achieved in a reasonable time frame for the project, consider a test duration of at least 24 hours. A longer duration of pumping may reveal the presence of boundary conditions or delayed yield.

Use of portable computers allows time/drawdown plots to be made in the field. If data loggers are used to monitor water levels, the electronic data can be reviewed by scrolling with the data logger screen or via a portable computer. It is advisable to download the water level data before transporting the logger from the site.

References

Cooper, H.H., Jr., and Jacob, C.E., 1946. A generalized graphical method for evaluating formation constants and summarizing well-field history. Transactions, American Geophysical Union, Vol. 27: pp 526-534.

Dawson, K.J., and Istok, J.D., 1991. Aquifer testing: design and analysis of pumping and slug tests: Chelsea, Mich., Lewis Publishers, 344 pages.

Driscoll, F.G., 1986. Ground water and wells, 2nd Edition: St. Paul, Minn., Johnson Division, 1089 pages.

Fetter, C.W., 1988. Applied Hydrogeology, 2nd Edition: Columbus, Ohio, Merrill Publishing Company, 592 pages.

Kruseman, G.P., and de Ridder, N.A., 1991. Analysis and evaluation of pumping test data, 2nd Edition: Wageningen, The Netherlands, International Institute of Land Reclamation and Improvement, 377 pages.

Osborne, P.S., 1993. Suggested operating procedures for aquifer pumping tests. U.S.E.P.A. Office of Research and Development and Office of Solid Waste and Emergency Response, EPA/540/S-93/503, February, 23 pages.

Theis, C.V., 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground water storage. Transactions, American Geophysical Union, Vol. 16: pp 518-524.

Monitoring Well Installation SOP

Monitoring wells typically are installed to monitor groundwater and must therefore be installed in such a way that they provide representative groundwater samples. The wells will have a screen across the appropriate aquifer interval and the annulus around the well screen will be packed with granular material sized to reduce the migration of fines into the well.

Depending on the subsurface stratigraphy at the site, a two-stage drilling procedure may be utilized for monitoring wells. The upper soil/strata will be sealed from the aquifer using a cement-bentonite grout. Decontamination procedures, presented in Section 2.6.6 Decontamination SOP, will be adhered to during drilling, well installation, and well development.

The following sections present the monitoring-well design and installation procedures. The well-development procedures to be used during the field investigation are described in 2.6.5 Monitoring Well Development.

Monitoring-Well Construction

A schematic diagram of a typical well design for groundwater monitoring applications is presented in Figure A-1. The following procedures assume a 2-inch well installation completed using hollow-stem augers. Installation of wells of different sizes or into borings completed by other methods follows the same general procedures outlined below.

Soil borings intended for 2-inch well installation are typically advanced utilizing 4¼-inch ID hollow-stem augers with an 8 ¾-inch OD auger bit. If the well is 20 ft or greater in depth, the borehole may need to be reamed with 6-inch ID augers with a 10-inch OD auger bit. Installation of the well in larger hollow-stem augers reduces the problem of bridging of the filter pack or bentonite pellets.

When surface casing is required, care must be given to selecting the diameters of the surface casing, ream auger, and lead auger that will advance the boring to the desired depth. A 14-inch auger is utilized to ream the borehole for installation of a 10-inch surface casing. This allows for the later advancement of 4¼-inch ID by 8 3/4-inch OD hollow-stem augers. A 16-inch auger is utilized to ream the borehole for installation of a 12-inch surface casing. This allows for the later advancement of 6-inch ID by 10-inch OD hollow-stem augers.

Installation of Surface Casing

Surface casing is used as a means of isolating contaminated soil and providing a boundary, thus preventing downward migration of the contamination in the borehole. Surface casing is a secondary casing surrounding a borehole down to a desired depth. It serves as an additional annular seal by not allowing contaminated soil to come into contact with the drilling and sampling equipment, and therefore prevents cross contamination.

To isolate the upper portion of the borehole for installation of a 2-inch monitoring well, 10-inch diameter, Schedule 40 PVC casing is set to the desired depth to seal off the surface contamination. It is preferred that the base of the casing be seated in clay if the stratigraphy permits. A minimum 14-inch diameter borehole is required for installation of 10-inch surface casing.

The bottom of the casing will be sealed with a casing shoe in order to prevent entry of potentially contaminated water or soil into the casing during installation. The casing shoe can be made using PVC coupling half filled with plaster of Paris or Portland cement. The shoe can be anchored to the base of the surface casing using stainless-steel sheet metal screws or pop rivets. A stainless-steel centralizer will be placed on the lower portion of the casing to ensure alignment of the casing within the borehole.

Procedure

The procedure for installing a surface casing is as follows:

- Drill a borehole larger than the diameter of the surface casing down to the depth desired for the bottom of the surface casing.
- Set the surface casing in the borehole so that it extends from slightly above the ground surface through the contaminated zone and into the material separating the contaminated zone from the uncontaminated zone below.
- Grout the annulus between the borehole and the surface casing with a cement-bentonite slurry. The slurry can be mixed at a ratio of 6.5 gallons of potable water per 94-lb sack of Type I Portland cement. Bentonite powder should be added to the slurry at a ratio of 3% of the total Portland cement weight. The grout is typically tremied into place utilizing 1¼- to 1½-inch tremie pipe. At least 24 hours should be allowed for the grout to cure.
- Continue drilling and sampling through the cased section of the borehole. After drilling the boring scheduled for use as a monitoring well, the well casing and screen will be inspected and placed into the hollow stem of the auger pipe. Schedule 40 PVC or stainless steel, threaded, flush-joint casing is typically used for monitoring-well construction. Casing sections will typically be 5 or 10 ft long. Individual well-screen sections are also typically 5 or 10 ft long and often have 0.01-inch slot or 0.02-inch slot openings. A sufficient number of well screens will be assembled together to facilitate full penetration of the aquifer. However, to avoid dilution effects on sampling, screened intervals should be carefully evaluated before exceeding 20 ft in length.

If geologic conditions warrant, a 0.5- to 3-foot length of blank casing will be placed beneath each well screen to act as a sump or reservoir for fine material. All sections of casing and screen will be assembled on-site to allow inspection immediately before installation.

Stainless-steel centralizers will be attached, if needed, to the screen or casing to help center the well in each boring and facilitate the placement of the filter pack, the bentonite seal, and the grout in the annulus. When completed, the well casing should extend approximately 2 or 3 ft above the ground surface or be a few inches below ground surface depending on the type of surface completion preferred.

A filter pack (most commonly 16/30 or 20/40 silica sand, but dependent on the grain size of the geologic material), is placed in the annulus between the boring wall and the well screen. The purpose of the filter pack is to provide aquifer formation stability, minimize the entry of fine-grained material into the screen, and increase the effective well diameter and water-collection zone. Whenever possible, the filter pack will extend above the top of the screen for a distance equal to 10% of the screen length, or a minimum of 2 ft, to allow for settlement of the filter pack and prevent the migration of the overlying seal material into the intake zone. The filter pack will be placed in such a manner that bridging of the material in the annulus is prevented. Care should be taken not to damage the well screen or casing during placement of the filter pack using either agitation or the tremie pipe. If necessary, the filter pack material may be washed into the annular space with potable water to help prevent bridging.

At least 2 ft of bentonite pellets with no added polymers will be used to seal the monitoring well above the filter pack and isolate the aquifer interval from the upper zones. The bentonite pellets will be activated with potable water. An adequate amount of time will be allowed for the pellets to hydrate prior to grouting of the remaining annular space above the seal. One way of determining the appropriate amount of time for the pellets to hydrate is to fill a clear jar half full with a sample of the pellets delivered to the Site. The remaining headspace in the jar will then be filled with potable water. The time required to hydrate the pellets will be recorded. At a minimum, this will be the amount of time that the pellets in the borehole will be allowed to hydrate prior to grouting.

The annular space above the bentonite seal will be filled with an approved bentonite-based grout to within one foot of land surface leaving space for the surface completion. The grout will approximate Type I Portland cement (95%–97%) and powdered bentonite (3%–5%). One 94-cubic-pound sack of grout is typically mixed with 7 gallons of potable water. The grout mixture will be placed into the boring via the use of a tremie pipe, tubing, or direct pouring from the surface when appropriate. Pumps may be used to facilitate mixing of the grout and to fill the borehole with grout. After allowing the grout to set for at least 12 hours and preferably 24 hours, development of the well can begin.

An above-grade surface completion consists of a protective steel casing and locking cap that will be installed over the casing. Vent holes may be placed in the protective steel casing and in the riser pipe to allow the boring to communicate with the atmosphere. For protective casing, an approximately ¼-inch hole near the ground surface is recommended to facilitate gas venting and to prevent the accumulation of fluids in the annulus between the well casing and the protective casing. The well riser pipe may be vented with an approximately ¼-inch hole near the top of the pipe below the bottom of the protective cap. A flush-grade surface completion consists of a manhole cover or well box and a lockable well cap immediately below. Typically, a 3-foot-square or 4-foot-square concrete pad will be constructed at the base of the protective casing and protective bumper guards will be installed around the well, if necessary. The concrete pad will be constructed so that it slopes away at approximately 2% from the protective casing and thus directs run-off away from the well.

Monitoring Well Development SOP

Following is a description of the methods used to develop monitoring wells after original installation and before use of the well to obtain water-level measurements or water-quality samples. Development should not be confused with purging, the purpose of which is to yield groundwater that is as representative as possible to water still in the aquifer.

Monitoring-well development and/or rehabilitation is necessary to ensure that complete hydraulic connection is made and maintained between the well and the aquifer material surrounding the well screen and packing materials. Development is necessary after installation of a monitoring well to (1) reduce the compaction and intermixing of grain sizes produced during drilling; (2) increase the porosity and permeability of the artificial filter pack by removing the finer grain-sized fraction introduced near the screen by drilling and well installation; and (3) remove any foreign drilling fluids that coat the borehole or that may have invaded the adjacent natural formation.

This procedure also applies to monitoring wells in which siltation has occurred. After a well has been installed for some period of time (ranging from months to years), the accumulation of fine material in the bottom of the well casing may require rehabilitation or re-development of the well to re-establish complete hydraulic connection with the aquifer.

Procedure for Well Development

General Procedure

Water is moved in and out through the monitoring-well screen to move silt and clay particles out of the filter pack around the well screen and into suspension within the well. Water movement is effected using a surge block, bailer, or compressed gas. In some situations, pumping water may effect satisfactory development, but pumping alone is not generally recommended.

The sediment-laden water is removed from the monitoring well using a pump, bailer, or air compressor. Please note that well development procedures should not commence until at least 12 hours, and preferably 24 hours, has elapsed since well installation to allow for the annular seal and grout to properly set.

A well has been successfully developed when the following criteria are met:

- Five well-casing volumes have been removed, or a minimum of three well-casing volumes have been removed and the water is clear.
- Water-quality parameters (pH, temperature, and conductivity) have stabilized, i.e., pH is within 0.2 standard units, temperature is within 1°C, and electrolytic conductivity is within 10% over three consecutive determinations.

Any waste water and sediment produced during well development which may be contaminated will be properly containerized and stored on-site pending results of sample analysis.

Determination of Well Casing Volume

Well casing volume is determined using the following equation:

$$V_{WC} = \frac{\pi D^2 h}{4}$$

Where:

VWC (ft^3) = well volume
D (ft) = internal diameter of well casing
h (ft) = length of the water column in the well casing

In some instances, volume of the filter pack may also be of interest and may need to be calculated. The volume of the filter pack can be estimated by calculating the volume of the borehole filter pack less the casing volume.

Filter pack volume is calculated using the following equation:

$$V_{FP} = \left\lfloor \frac{\pi D^2 h}{4} - V_{WC} \right\rfloor (n)$$

Where:

VFP (ft^3) = filter pack volume
D (ft) = diameter of the borehole
h (ft) = lesser of (a) length of filter pack, or (b) length of water column in well casing
n = filter pack porosity (assume 30%)
VWC (ft^3) = well casing volume (see above)
Well Volume Total = VFP + VWC
Conversion: 1 ft^3 = 7.48 gal; 1 gal = 0.134 ft^3

Well-Development Equipment

The following list identifies the types of equipment that may be used to develop monitoring wells. Exact equipment needs will be well specific and will depend on the diameter of the well, the depth to the static water level, and other factors.

- **Surge Block.** A surge block consists of a rubber plunger attached to a rod or pipe of sufficient length to reach the bottom of the well. To avoid cross contamination of monitoring wells, the surge block and rod or pipe are decontaminated after use in each well in accordance with the decontamination procedures presented in Section 2.6.6 Decontamination SOP.
- **Pump.** A pump may be necessary to remove large quantities of groundwater or silt-laden groundwater from a well after using the surge block. Since the purpose of well development is to remove suspended solids from a well and its filter pack, the pump must be capable of moving some solids without damage. There are many varieties of pumps that can be used for well development including suction-lift pumps, electric submersible pumps, and positive displacement pumps. Suction lift pumps include peristaltic pumps, surface centrifugal pumps, and vacuum pumps. Electric submersible pumps include centrifugal submersible pumps, helical rotor (progressing cavity) pumps, and gear pumps. Positive displacement pumps include gas-drive pumps, piston pumps, inertial-lift pumps, and bladder pumps. Electric submersible pumps are commonly used for well development. Regardless of which type of pump is used, the pumping rate

should be low enough to avoid turbulent flow that causes entrainment of fines in the sand pack. Inertial-lift pumps are often preferred for wells less than two inches in diameter due to the surging action of the pumps and their low well-yield requirements.

- **Bailer.** A bailer may be used to purge silt-laden water from wells after using the surge block. In some situations, a bailer can be used to surge a well, but the use of a bailer for surging is not typically as effective as using a surge block. A bailer may be preferred in situations where silt loading is greater than that which can be handled by positive-displacement pumps.
- **Compressed gas,** generally nitrogen, can be used both to surge and to purge a monitoring well. A nitrogen tank is used to inject gas at the bottom of the water column, driving sediment-laden water to the surface. Compressed gas can also be used for "jetting" – a process by which the gas is directed at the slots in the well screen to cause turbulence (thereby disturbing fine materials in the adjacent filter pack). Compressed gas is not limited to any depth range.

  The hose or pipe that will be installed in the well for jetting should be equipped with a horizontal (side) discharge nozzle and one or more small holes in the bottom of the hose to enhance the lifting of sediment during jetting.

  Since the compressed gas will be used to "lift" water from the monitoring wells, provisions must be made for controlling the discharge from contaminated wells. This is generally accomplished by attaching a "tee" discharge to the top of the casing and providing containment of the discharged water. Gas-lifting must never be done in contaminated wells without providing a discharge control apparatus.

Selection of a Specific Procedure

The construction details of the well can be used initially to help define the method for developing a well, with due consideration being given to the level of contamination. The criteria for selecting a well-development method include well diameter, total well depth, static-water depth, screen length, the likelihood and level of contamination, and the type of geologic formation adjacent to the screened interval.

The limitations, if any, of a specific procedure are discussed within each of the following procedures.

Methods that involve placing water into the well may be objectionable to some state and federal agencies. In such cases, the surge block procedure may be preferable over the pumping procedure.

Specific Procedure: Surge Block

A surge block, in conjunction with a bailer or pump, effectively develops most monitoring wells. If the geologic layering in the screened interval includes permeable and impermeable layers (e.g., gravels and clays), it is possible that surging could remove fines from the impermeable layers and force them into the permeable layers. This problem can be minimized by using fewer surging cycles, using a surge block that is looser fitting, and/or increasing the purging volume or time of development.

To construct or obtain a surge block, the specific materials will depend on the diameter of the well to be developed. The diameter of the flexible rings must be sufficient to cause a tight seal within the well casing, and the rods must be of sufficient length to reach to the bottom of the monitoring well.

Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen, using the water column to transmit the surge action to the screened interval. A slow, initial surging, using plunger strokes of 3 to 5 ft, will allow material that is blocking the screen to separate and become suspended. Care should be exercised not to knock the bottom cap off the well casing or to damage the screen during surging procedures.

After a number (perhaps 5 to 10) of plunger strokes, remove the surge block and purge the well using a pump or bailer. The returned water should be heavily laden with suspended silt and clay particles. As development continues, slowly increase the depth of surging to the bottom of the well screen. For monitoring wells with long screens (greater than 10 ft), surging should be undertaken along the entire screen length in short intervals (2 to 3 ft at a time).

Continue this cycle of surging and purging until the well development criteria stated in Section 2.6.5.1 have been met.

Specific Procedure: Pump

Well development using only a pump is most effective in those monitoring wells that will yield water continuously. Effective development cannot be accomplished if the pump must be shut off to allow the well to recharge.

Set the intake of the pump in the center of the screened interval of the monitoring well. Pump a minimum of three well volumes of water from the well while using the intake hose of the pump as a plunger. The motion of the intake hose will act to a limited extent as a surge block.

Occasionally, where appropriate, use the pump to fill the monitoring well to the top of the casing and allow the water level to decline to the static level, thereby forcing water back into the formation. This action will cause water to exit the well screen and reduce the bridging of materials caused by water flowing in one direction through the well screen while pumping.

The water used to fill the monitoring well should be the same water removed from the well during the previous pumping cycle. The sediment previously pumped from the well must be removed from the water before being reintroduced to the well. A steel drum can be used as a sediment-settling vessel.

Continue pumping water into and out of the well until the well development criteria stated in Section 2.6.5.1 have been met.

Specific Procedure: Compressed Gas (Nitrogen)

Although the equipment used to develop a well using this method is more difficult to handle and use, well development using compressed gas for jetting is considered to be a very effective method. This method also is the most generally applicable because it is not limited by well depth, well diameter, or depth to static water, but caution must be exercised in highly permeable formations not to inject gas into the formation.

Lower the gas line from the gas cylinder into the well, setting it near the bottom of the screened interval. Install the discharge control equipment at the well head.

Set the gas flow rate to allow continuous discharge of water from the well. The discharge will contain suspended clay and silt material.

At intervals during gas-lifting, especially when the discharge begins to contain less suspended material, shut off the air flow and allow the water in the well to flow out through the screened interval to correct any bridging that may have occurred. Re-establish the gas flow when the water level in the well has returned to the pre-development level.

Jetting of the screened interval also can be done during gas lifting of water and sediment from the well. This is accomplished by using a lateral-discharge nozzle on the gas pipe or hose and slowly moving the nozzle along the length of the screened interval. Jetting should be done beginning at the bottom of the well screen and moving slowly upward along the screened interval. To enhance gas lifting of sediment, occasionally raise the discharge nozzle into the cased portion of the well and discharge sediment-laden water.

Continue gas lifting and/or jetting until the well development criteria stated in Section 2.6.5.1 have been met.

Specific Procedure: Bailer

Lower the bailer into the screened interval of the monitoring well. Using long, slow strokes, raise and lower the bailer in the screened interval, simulating the action of a surge block.

Periodically bail standing water from the well to remove silt and clay particles drawn into the well. Continue surging the well using the bailer and bailing water from the well until the well development criteria stated in Section 2.6.5.1 have been met.

Decontamination of Equipment

Equipment will be decontaminated according to the decontamination procedures presented in Section 2.6.6 Decontamination SOP.

Documentation

Well development and purging information will be completed on an appropriate field form and a field logbook will be maintained detailing any problems or unusual conditions that may occur during the development process.

All documentation will be retained in the project files following completion of the project.

Decontamination SOP

General

At sites with known hazardous materials or when deemed necessary, three zones/levels of contamination will be delineated at each site:

- A Clean Zone through which all access to the site will be routed.
- A Contamination Reduction Zone, which will be a buffer or intermediate zone where primary decontamination will be completed.
- An Exclusion Zone, which is the contaminated area or potentially contaminated area of the site.

Personnel and equipment in the Exclusion Zone will be decontaminated at the Exclusion Zone exit. Between the Exclusion Zone and the Clean Zone is the Contamination Reduction Zone, which provides a transition zone between the contaminated and clean areas of the site. Primary decontamination will take place at the boundary between the Exclusion Zone and the Contamination Reduction Zone. Personnel will decontaminate themselves and equipment before entering the Clean Zone from the Contamination Reduction Zone. The Clean Zone is an uncontaminated area from which operations will be directed. It is essential that all contamination from the site be kept out of the Clean Zone.

Personnel Decontamination

The most effective decontamination procedure is contamination avoidance when and where possible. All project personnel should avoid contact with contamination except when absolutely required, in which case they should utilize appropriate personal protective equipment.

Personnel will be decontaminated each time they leave the Exclusion Zone and whenever they are subjected to above-normal exposure to hazards or contaminated materials. Decontamination will take place in the Contamination Reduction Zone.

Some or all of the following steps may be taken for personnel decontamination depending on site conditions:

- Boots and reusable outer gloves will be washed using an appropriate soap (e.g., Alconox™) and potable water solution before being adequately rinsed with potable water.
- All disposable items (e.g., gloves, cover suits, tape, and etc.) will be removed and immediately placed in a container for proper disposal.
- Respirators will be removed and placed in plastic bags pending decontamination according to manufacturer instructions.
- Inner gloves and disposable outer gloves will be removed, turned inside out, and disposed of properly.
- Exposed skin areas such as the hands and face will be washed with soap and potable water.

Equipment Decontamination

Specific equipment decontamination procedures are described in the following paragraphs. Types of equipment decontamination that may occur at a given site include the following:

- Sampling-equipment decontamination between individual sampling locations to ensure that representative samples are collected.
- Drilling-equipment decontamination at the completion of each boring to ensure that boreholes are not cross contaminated.
- Tractor, forklift, backhoe and/or other heavy equipment decontamination to ensure that contamination is contained during site activities.

Sampling equipment will be decontaminated before leaving the Contamination Reduction Zone. Some or all of the following steps will be used to decontaminate this equipment:

- Hand-held equipment showing surficial-solid contamination will be placed in a wash tub (or other applicable container) and the contaminated material will be physically removed using scrapers, brushes, etc. Equipment will then be transferred to the designated container for the detergent wash. Contaminated solids will be drummed or otherwise containerized for disposal when necessary.
- The wash procedure will be followed by a double rinse. Equipment will typically be rinsed first in a wash tub with potable water followed by a spray rinse of distilled water.
- All wash and rinse solutions will be drummed for disposal when necessary.
- Equipment that may be damaged by water, such as instruments, will be carefully cleaned with a sponge and detergent water when necessary. Care will be taken to prevent equipment damage.
- Solvents such as methanol may be used on an as-needed basis to remove tar or other organics from equipment.
- Clean equipment will be air dried if possible or wiped dry with a clean material if needed for immediate reuse.
- Clean equipment will be stored and transported such that it is protected until used again for sampling. Plastic bags are commonly used to help protect many clean equipment items.

When practical, a sufficient quantity of clean, decontaminated sampling equipment will typically be available so that each sample can be taken with a separate sampling tool, and decontamination will be performed on all equipment at the end of the sampling effort, rather than between each sample.

Drilling-equipment decontamination will be conducted in the Contamination Reduction Zone. Drilling auger flights or direct-push probes will be dismantled and transported to the decontamination area between each boring. The following steps will be used to decontaminate the auger flights or direct-push probes:

- Gross soil, dirt, or waste contamination on the drilling augers will be removed at the drilling site. Contamination will be removed using blade scrapers or by other physical methods. Material removed from the augers or probes will be placed in drums or other dedicated containers.
- Augers or probes will be carried to the decontamination pad. Augers or probes will typically be placed on a rack in the decontamination area to ensure that water from the decontamination process does not reintroduce contamination to the cleaned equipment.
- A heated, high-pressure wash operating at a temperature of approximately 212°F and discharging 5 gallons per minute will typically be used to remove the contamination from the outside of each flight. Strongly adhered waste may require additional scrubbing using a wire or bristle brush. The inside of each auger or probe will also be cleaned with a pressure washer or steam cleaner and, if needed, scrubbed with a wire or bristle brush.

Any vehicle used to carry the auger flights or push probes will also receive a heated, high-pressure wash in all areas where the auger flights or push probes come into contact with the vehicle. Once the cleaned augers or push probes are placed into the transport vehicle, additional care will be given to ensure that the augers or probes remain clean by wrapping them in plastic when necessary.

All waste generated during decontamination activities will be contained using drums or other appropriate containers. Waste containers will be labeled properly and stored at the site temporarily pending proper disposal.