

Northeast Church Rock Mine Site Removal Action

Pre-Design Studies Work Plan

Church Rock Mill Site

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[UNOC Mill Site]

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
ARMS	Archeological Records Management Section
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
cm/s	Centimeters per second
CPT	cone penetration test
DOE	United States Department of Energy
EE/CA	Engineering Evaluation/Cost Evaluation
ET	Evapotranspirative
FSP	field sampling plan
GE	General Electric
HASP	Health and Safety Plan
IDW	Investigation Derived Waste
m	meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mg/kg	milligrams per kilogram
mm	millimeter
NECR	Northeast Church Rock
NMHPD	New Mexico Historic Preservation Division
NNHPD	Navajo Nation Historic Preservation Division
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
OU	Operable Unit
pCi/m ²	Picocurie per square meter
pCi/L	Picocurie per liter
pCi/g	Picocurie per gram
PDS	Pre-Design Studies
PPE	personal protective equipment
PTW	Principal Threat Waste
QAPP	Quality Assurance Project Plan
RA	Removal Action
RD	Removal Design
ROD	Record of Decision
RSE	Removal Site Evaluation
SOP	Standard Operating Procedure
SPT	standard penetration test
SWCC	soil-water characteristic curve
UNC	United Nuclear Corporation
USEPA	United States Environmental Protection Agency

1.0 WORK PLAN

1.1 INTRODUCTION

The Northeast Church Rock (NECR) Mine Removal Action (RA) is in the pre-design phase. This work plan identifies pre-design data needs, describes data collection activities necessary for RA design, and outlines a Field Sampling Plan (FSP) for data collection at the Mill Site to support RA design. This work plan has been prepared by MWH on behalf of General Electric Company and United Nuclear Corporation (GE/UNC) for submittal to the U.S. Environmental Protection Agency (USEPA), Region 9 in response to the *Action Memorandum: Request for Non-Time Critical Removal Action at the Northeast Church Rock Mine Site* ([Action Memo], USEPA, 2011) and the Record of Decision (ROD) (USEPA, 2013). MWH proposes conducting pre-design activities in accordance with the NECR Mine Site *Removal Site Evaluation Work Plan* (RSE Work Plan) (MWH, 2006) and any updated plans specific to the current activities or methods. An updated version of the *Quality Assurance Project Plan* (QAPP) from the RSE Work Plan is included in MWH (2013c, Volume III). A site-specific Health and Safety Plan (HASP) that covers field activities associated with pre-design data collection at the Mine Site and at the Church Rock Mill Site is included in MWH (2013d, Volume IV). This FSP, the QAPP, and the HASP constitute the Sampling and Analysis Plan in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).

This work plan describes data gaps and pre-design data needs and provides a FSP specific to the Mill Site. Pre-design data needs and a FSP related to the Mine Site are addressed in MWH (2013, Volume II). These work plans have been revised to incorporate responses to comments from the U.S. Nuclear Regulatory Commission (NRC) (NRC, 2013) and the U.S. Department of Energy (DOE) (DOE, 2013), provided to UNC on May 16, 2013 and May 17, 2013, respectively.

1.2 BACKGROUND AND OBJECTIVES

1.2.1 Background

The RA alternative selected by the USEPA in the Action Memo includes: (1) the removal of approximately 870,000 cubic yards of mine spoils and debris from the Mine Site, (2) restoration of the Mine Site, and (3) consolidation of the mine spoils and debris into a repository at Church Rock Mill Site. The Action Memorandum was issued following completion of a removal site evaluation (RSE) (MWH, 2007a) and USEPA's publication and public review and comment of the Engineering Evaluation and Cost Evaluation (EE/CA) (USEPA, 2009). The USEPA then issued the Proposed Plan (USEPA, 2012) that described the preferred plan of action for the site, along with a description of the alternatives considered. The Record of Decision (ROD), the decision document that addresses consolidation of the mine wastes into a repository at the Mill Site, was issued on March 29, 2013 by the USEPA Region 6 (USEPA, 2013). Because USEPA Region 6 oversees aspects of groundwater remediation at the UNC Mill Site under CERCLA (42 U.S.C. § 9601 et seq.), Region 6 prepared the Surface Soil Operable Unit (OU) Proposed Plan (Proposed Plan) for the Mill Site (USEPA, 2012) and the ROD (USEPA, 2013), which, consistent with USEPA Region 9, identifies the Preferred Alternative for permanent disposal of the NECR Mine Site waste within the Church Rock Mill Site. A complete site history, and information on prior investigations and removal actions are provided in these reports, as well as other documents available in the USEPA's NECR project public document repository.

The Site is located approximately 16 miles northeast of Gallup, in McKinley County, New Mexico. The NECR Mine Site and the Church Rock Mill Site, are located on adjacent sections of land less than one mile apart, as shown on Figure 1-1. A map of the Mill Site is shown in Figure 1-2. For purposes of the response action, the NECR Mine Site and the Church Rock Mill Site (Figure 1-1) will be treated as one site (USEPA, 2013).

Key components of the preferred alternative presented in the ROD (USEPA, 2013) are summarized as follows:

- Excavation of all mine waste materials at NECR that exceed the cleanup level for Radium-226 (Ra-226), which is 2.24 picocuries per gram (pCi/g).
- Consolidation of mine waste material into an above-ground repository on the UNC tailings impoundment.
- Construct a low permeability layer of natural materials between the NECR mine waste and the tailings currently disposed within the tailings disposal area.
- Construct a cover over the repository that will mitigate direct contact, limit water infiltration, and perform as a radon barrier.
- Offsite disposal or processing of principal threat waste (PTW), defined by the Action Memo to be "materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur." At the NECR Mine Site, USEPA has determined PTW to be all wastes containing either 200 pCi/g or more of Ra-226 and/or 500 milligrams per kilogram (mg/kg) or more of total uranium.
- Confirmation scanning, sampling and analysis to ensure that action levels are met in excavated areas consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM; USEPA, 2000).
- Site restoration including backfilling and regrading of excavated areas, erosion and sedimentation control measures, and revegetation of the repository cover and disturbed areas at the Mine and Mill Sites.

Mine waste materials will consist of mine spoils containing Ra-226 in excess of the cleanup level, as well as solid waste materials, such as scrap metal, concrete, and rubber from various locations at the Mine Site.

1.2.2 Objectives

This work plan was prepared to facilitate the Removal Design (RD) in accordance with the requirements and proposed performance standards listed above, as well as the final site ARARs. This report presents sampling and analysis plans for obtaining the identified data needs. There are data gathering or required procedural activities identified in this report that will be conducted concurrently with the RD effort. When this situation occurs, these items are not identified as data needs, but rather design components that will be addressed during the RD process.

The pre-design data needs and FSPs are described in Sections 2.2 and 3.1, respectively, and the anticipated schedule for data collection is presented in Section 2.3.

1.3 REMOVAL ACTION AND SITE STATUS

The Church Rock Mill Site is listed on the National Priorities List (NPL), and placement of waste materials from the NECR Mine Site at the Mill Site is contingent on an amendment of the Radioactive Materials License. UNC is addressing groundwater contamination at the Mill Site as called for in U.S. USEPA's Record of Decision / United Nuclear Corporation Groundwater Operable Unit (USEPA, 1988) (the ROD). UNC is also addressing source control and on-site surface reclamation at the Mill Site under the direction of the Nuclear Regulatory Commission (NRC), pursuant to the UNC Mill Site's NRC radioactive materials license.

1.4 SITE CHARACTERISTICS AND EXTENT OF CONTAMINATION

The Mill Site is composed of the former mill and ore-processing facilities (released by NRC for unrestricted use in 1993) and the tailings impoundment. The total area of the Mill Site is approximately 125 acres. Indian tribal trust land borders the Mill Site and the neighboring properties are sparsely populated. MWH (2013b, Volume II) presents a summary of the NECR Mine Site, including references to reports which include information on the materials to be placed in the proposed repository.

1.5 PERFORMANCE STANDARDS

The ROD (USEPA, 2013) sets the remediation goals and performance standards for the proposed waste repository at the tailings impoundment. These are summarized below.

- The repository will be designed to hold the contaminated mine material excavated from the NECR Mine Site. The design specifications will comply with CERCLA requirements, and specifically all Applicable or Relevant and Appropriate Requirements (ARARs). The repository design will also comply with applicable NRC requirements (including Appendix A of 10 CFR 40 and NUREG-1623). The ARARs are listed in the ROD (USEPA, 2013).
- The repository will include a cap designed and constructed to isolate the mine waste, reduce the potential for leachate development, and prevent contaminated runoff by minimizing flux of precipitation through the cap while minimizing erosion protection.
- The cap slope, shape and drainage will be designed and constructed to be stable and to minimize the effects of erosion.
- Amendments or top soil may be incorporated into the cap to facilitate vegetation growth on the repository cover. The surface of the repository will be seeded with native vegetation.
- The repository will include a low permeability layer constructed with the existing cover (radon barrier). The cover will be recompacted to provide a lower hydraulic conductivity layer at the base of the repository.
- Radionuclides and their daughter products in soil, mine waste, and tailings contained within the Tailings Disposal Area will not release radon-222 emissions from residual radioactive material to the atmosphere in exceedance of an average release rate of 20 picocuries per square meter per second ($\text{pCi}/\text{m}^2\text{s}$).
- Radionuclides and their daughter products in soil, mine waste, and tailings contained within the Tailings Disposal Area will not release radon-222 emissions from residual radioactive material to the atmosphere that will increase the annual average

concentration of radon-222 at or above any location outside the disposal site by more than one-half picocurie per liter (pCi/L).

- Migration of contaminants from the Tailings Disposal Area shall not result in ground water concentrations that exceed remediation goals established in USEPA's 1988 ROD for the Ground Water Operable Unit, including any amendment.
- The waste repository will be closed in such a manner that it will control, minimize or eliminate (to the extent necessary to protect human health and the environment) post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface water or to the atmosphere and be effective for one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years.

1.6 SUMMARY OF DESIGN STRATEGY AND BASIS OF DESIGN

This report was prepared to facilitate RA design in accordance with the performance standards, design criteria, and ARARs presented in the ROD (USEPA, 2013) and Action Memo (USEPA, 2011). A summary of the components of the preferred alternative is provided in Section 1.2.1. The repository will be designed to accommodate +/- 20 percent volume contingency to minimize design changes during construction. The repository design will include a cover designed to minimize flux into the underlying mine waste materials, thus minimizing the potential for leaching of radionuclides. Surface water controls will be implemented to eliminate run-on and provide long-term stability of the RA. The repository base layer will consist of soil from the existing tailings cell cap (the admixture will be removed and reused elsewhere), which will be recompacted to provide a barrier between the repository and the underlying tailings. The repository will be designed to limit disturbance of existing tailings, use existing site drainage features as practicable, and be of minimal visual impact to the site and surroundings. Slopes will be designed using soil/rock admixtures on surfaces as necessary for erosion protection, and to be consistent with the existing tailings cover and site aesthetics. The design will incorporate elements to minimize environmental and public health impacts during and after construction, as well as the use of currently accepted environmental control measures and technologies.

The repository on top of the existing tailings is designed to:

1. Reduce the emission rate of radon-222.
2. Eliminate the potential for ponding in localized areas where differential settlement has occurred, and enhance overall site drainage conditions.
3. Minimize meteoric water flux into the tailings.
4. Decrease the potential for burrowing activity and root intrusion into the underlying tailings.
5. Upgrade surface water controls

A summary of the basis of design for the RA is presented in Table 1-1. Table 1-1 includes individual design elements, performance criterion that guides each design element, site data currently available for RA design, and any additional data necessary to design the RA. Tables 1-2 and 1-3 are supplemental tables that list project documents and performance criteria references and guidance documents, respectively.

2.0 PRE-DESIGN STUDIES WORK PLAN

2.1 SUMMARY OF DATA NEEDS EVALUATION

As part of the pre-design data needs evaluation, MWH identified the major RA design elements and reviewed available data. The existing data were evaluated for completeness with respect to the level of detailed information necessary to design each element of the RA, as listed in Table 1-1. Procedural design elements that will be developed during the RD process were identified as such, and are not characterized as pre-design data needs. Procedural elements will be developed during the RD, including items such as creating a water balance analysis for the evapotranspirative (ET) cover, and practices for demolishing and placing debris to minimize void space and settlement.

Pre-design data needs identified for waste repository design are presented below. FSPs to collect the necessary data are presented in Section 3.1.

2.2 IDENTIFICATION OF SUPPLEMENTAL DATA NEEDS

The pre-design data needs for waste repository design are listed below. Each is summarized briefly in the following paragraphs, including the rationale and objectives of the FSPs described in Section 3.1.

- Geotechnical evaluation of tailings and underlying geologic units
- Borrow material investigation
- Volume and characteristics of on-site erosion protection materials
- Investigation of natural analog(s) for long-term moisture conditions for cover soils
- Visual inspection and survey of branch swales
- Repository and borrow area revegetation study
- Cultural resources survey
- Biointrusion evaluation
- Topographic survey of north and central cells and surrounding areas

2.2.1 Geotechnical Evaluation of Tailings Impoundment and Underlying Units

2.2.1.1 Characterization of Existing Tailings Cover Material for Design of Repository Base Layer

Conceptual design of the repository includes removal of the gravel admixture layer on top of the cover, and recompaction of the underlying cover layer to provide a low-permeability layer at the base of the new repository. Geotechnical and hydraulic properties of the existing cover soil must be determined in order to develop a construction specification for cover recompaction to construct the repository base layer. Furthermore, proposed repository cover construction will use existing on-site materials for erosion protection, if possible. In order to determine the suitability of the existing gravel admixture layer materials for use in the proposed repository cover, the admixture layer will be sampled and characterized.

The existing tailings cover will be sampled to 1) evaluate the gradation and volume of the gravel admixture layer of the current cover, and 2) evaluate hydraulic conductivity properties of the existing cover material, recompacted to target densities. A FSP describing collection and testing of cover samples is described in Section 3.1.1.1.

2.2.1.2 Geotechnical Characterization of Existing Tailings Impoundment

Requests have been made by NRC (2013) and DOE (2013) to collect site-specific tailings data to evaluate the potential impacts of construction of a waste repository over the existing tailings. The ROD (USEPA, 2013) for the site states that the south cell shall not be used for the placement of additional materials. Therefore, the FSP for characterization of the tailings impoundment is focused on the North Cell and Central Cell, which contains former Borrow Pits No.1 and No. 2.

Results of the impoundment characterization investigation will be used to update technical analyses and models, and to address NRC and DOE review comments. The objectives of the tailings impoundment characterization are as follows:

1. Evaluate the saturated hydraulic conductivity of the existing cover at anticipated levels of compaction;
2. Characterize the stratigraphy of the tailings impoundment where mine spoil loading is anticipated;
3. Characterize the subsurface material properties using in-situ test methods (CPT testing), sample collection and laboratory testing;
4. Characterize the strength properties of the existing embankment materials for confirmation of stability of the proposed repository;
5. Address specific NRC and DOE comments (NRC, 2013 and DOE, 2013).

The sampling plan has been developed to meet the objectives described above while (1) preventing the release of tailings or mixing of tailings into cover materials during and after sampling and testing; (2) preventing cross-contamination contact of the alluvium and sandstone layers by water from within the impoundment (if encountered); and (3) minimizing exposure to radioactive materials during sampling and testing.

In order to develop a sampling plan to supplement existing site data, MWH reviewed available information regarding the site geology, geotechnical data, geochemical properties of the alluvium and Gallup sandstone, and existing hydraulic and pump test data for the units underlying the impoundment. MWH also reviewed and summarized the existing and relevant geotechnical data for the tailings impoundment. Multiple investigations and testing programs were conducted between 1974 and 1992 in and around the tailings impoundment, including the advancement of hundreds of soil borings and test pits. A summary of the site geotechnical data is included in Appendix A. Summaries of the site geology, geochemistry, and hydraulic properties were prepared by Chester Engineers and are included in Appendix B.

The available information on the geotechnical, geologic, and hydraulic material properties provide a significant understanding of the materials in the vicinity of and underlying the proposed repository and existing tailings impoundment. The FSP for the characterization of the tailings impoundment has been specifically designed to augment the existing dataset of geotechnical, geologic and hydraulic material properties of the tailings and underlying materials, in specific areas where additional information is necessary for design. The supplemental information that will be obtained during the tailings characterization investigation includes 1) the stratigraphy of the tailings and the former borrow pits, 2) index, hydraulic, and consolidation properties of the tailings and underlying units, and 3) geotechnical parameters to use in the stability analyses and final design of the proposed repository. The soil boring and CPT locations

were selected to augment existing data, fill data gaps, and to meet the objectives of the impoundment characterization described above.

1. Two CPT and one borehole are proposed in Borrow Pit No. 2 to evaluate the backfill materials around and above the demolition debris in the pit, and to determine if, and at what depths, fine-grained tailings or perched water are present. If exploration can extend below the debris, the borehole samples will be tested to verify the index properties of the alluvium (if it exists) under the tailings, and/or used to verify the zone 1 sandstone contact.
2. Two CPT and one borehole are proposed in Borrow Pit No. 1 to confirm the depth of tailings in the borrow pit and further delineate the bottom of the pit. The CPT and boreholes will be used to:
 - Evaluate if, and at what depths, fine-grained tailings or perched water are present.
 - Test the tailings samples retrieved from the borehole for index, consolidation, strength, and hydraulic properties (laboratory hydraulic conductivity and SWCC), if quality samples are retrieved.
 - Evaluate the thickness and confirm the properties of the alluvium under the tailings, and evaluate the location of the contact between the alluvium and underlying Zone 3 sandstone.
 - Collect and test samples of the alluvium to confirm index properties and evaluate hydraulic properties (laboratory hydraulic conductivity and SWCC) of the alluvial materials.
 - Collect and test samples of the Zone 3 sandstone for hydraulic properties (laboratory hydraulic conductivity).
3. Two CPT and one borehole are proposed in the tailings storage area in the Central Cell to evaluate the depth of tailings in areas where borings have not been previously drilled through the tailings, and where the thickness of tailings underlying the proposed repository are anticipated to be greatest. The locations will be used to:
 - Evaluate if, and at what depths, fine-grained tailings or perched water are present.
 - Test the tailings samples obtained from the borehole to evaluate index, consolidation, strength, and hydraulic properties (laboratory hydraulic conductivity and SWCC), if suitable samples are retrieved.
 - Evaluate the thickness of the alluvium and confirm the properties of the alluvium under the tailings, and to evaluate the location of the contact between the alluvium and underlying Zone 3 sandstone.
 - Confirm index properties of the alluvium and evaluate hydraulic properties (laboratory hydraulic conductivity and SWCC) of the alluvial materials.
 - Collect samples of the Zone 3 sandstone and test for hydraulic properties (laboratory hydraulic conductivity).

4. Three CPT and one borehole are proposed in the tailings storage area in the North Cell in areas where borings have not been previously drilled through the tailings, and where the thickness of tailings underlying the proposed repository is anticipated to be greatest. The location of the former North Pond was considered in the selection of these locations. These locations will be used to:
 - Evaluate if, and at what depths, fine-grained tailings or perched water are present.
 - Test the tailings samples obtained from the borehole to evaluate index, consolidation, strength, and hydraulic properties (laboratory hydraulic conductivity and SWCC), if quality samples are retrieved.
 - Evaluate the thickness of the alluvium and confirm the properties of the alluvium under the tailings.
 - Evaluate the location of the contact between the alluvium and underlying Zone 3 sandstone.
 - Collect samples of the alluvium to test and confirm index properties and evaluate hydraulic properties (hydraulic conductivity and SWCC). Collect samples of the Zone 3 sandstone to test for hydraulic properties (laboratory hydraulic conductivity).
5. To collect data for stability analyses and to confirm stability of the proposed repository, during design; two CPT and two boreholes are proposed through the existing embankment to:
 - Confirm the index properties and obtain strength parameters of the embankment materials and the underlying alluvium near the proposed repository.
 - Test the embankment materials for swell/collapse potential.

2.2.2 Borrow Material Investigation

MWH identified a series of borings previously drilled in, or near, two of the proposed borrow areas (East and West). Relevant geotechnical information from these borrow area borings is summarized in Appendix A. A preliminary borrow investigation was conducted in 2008 to locate and characterize nearby materials potentially suitable for construction of the cover layer of the repository. The preliminary borrow investigation consisted of excavation and sampling of two borrow areas, as well as limited geotechnical testing to generally characterize the potential borrow materials. The preliminary borrow investigation is summarized in MWH (2012).

Results of the laboratory testing indicate the soils encountered in the borrow areas consisted of clay loam and sandy clay loam with values of saturated hydraulic conductivity ranging from 1.4×10^{-4} to 4.1×10^{-4} cm/s. A design-level borrow investigation is required to determine the volume, lateral and vertical heterogeneity, geotechnical, hydraulic, and agronomic properties of potential borrow area soils for construction of the repository cover. The characterization plan involves characterization of the following:

- 1) Two previously sampled borrow areas (East Borrow and West Borrow, previously referred to as Borrow Areas 1 and 2, respectively),
- 2) The Dilco Hill, and
- 3) Two alternative borrow areas (North and South Drainage Borrow Areas) which are available for use, if additional materials are required.

The FSP for the borrow investigation is included in Section 3.1.2. Supplemental borrow locations will be evaluated at a later date if additional materials are needed.

2.2.3 Volume and Characteristics of On-site Erosion Protection Materials

Construction of the repository cover will use existing, on-site materials for erosion protection and bedding material as much as possible. Erosion protection materials will be required for the rock/soil admixture surface layer of the cover, as well as for the drainage channels. Two types of erosion protection materials are available on site for use in the proposed repository, the rock from the existing cover, and the 1.5-in and 3-in diameter rock stockpiled at the Mill Site that were previously used during construction of the existing cover. Confirmation of the volume gradation and durability of the stockpiled erosion protection materials will be conducted. The FSP for sampling and testing the existing bedding and erosion protection materials is described in Section 3.1.3.

2.2.4 Investigation of Natural Analog for Long-term Moisture Conditions

The repository will be designed to be effective for one thousand years to the extent reasonably achievable, and, in any case, for at least 200 years, consistent with the requirements of NRC Title 10 Code of Federal Regulations, Appendix A to Part 40 (NRC 10 CFR 40 Appendix A). In order to be effective long-term, the cover should emulate long-term moisture characteristics of similar soils in the same climate. Therefore, identification and evaluation of a natural soil analog is planned to assess long-term conditions and develop a water balance for the ET cover analysis.

As part of the water balance evaluation for the proposed cover, a sensitivity analysis of key parameters is warranted. The cover material properties will be determined during the borrow investigation described in Section 3.1.2. Since constructed cover systems' soil parameters change toward a long-term natural state over time, and given the performance life of over 200 years, the critical cover soil parameters include the long-term saturated and unsaturated soil properties.

The likely cover soil borrow sources will be used to investigate these properties. Soils will be tested at representative locations within two of the proposed borrow sources (e.g., the East Borrow and the South Drainage Borrow areas); the final locations will be selected in the field based on observed ground conditions. A tension infiltrometer or similar instrumentation will be used to measure the in-situ moisture retention properties of the soil proposed for use in the repository cover. Similarly, a Guelph permeameter or double ring infiltrometer will be used to measure the in-situ saturated hydraulic conductivity. These measurements will be made at the soil surface, as well as at depth. The approximate measurement depths will be (1) surface, (2) 1-ft depth, (2) 2-ft depth, and (3) 3-ft depth. Data obtained with the tension infiltrometer will be one set of data used in the cover water balance model. Laboratory testing data of remolded samples will also be used. This input data set for modeling will be supplemented with the tension infiltrometer data for both saturated hydraulic conductivity and moisture retention parameters.

2.2.5 Visual Inspection and Survey of Branch Swales

The proposed repository will likely be designed to tie into the existing branch swales on the tailings impoundment. The ability of these swales to convey the design storm event shall be

verified prior to design. The as-built reports for the reclamation of the current tailings impoundment (Canonie Environmental, 1994, 1995; Smith Environmental Technologies, Corp., 1996a, 1996b, 1997) present detailed information regarding construction of the existing branch swales, including geotechnical properties of the materials used for construction and typical as-built construction details. The current condition of the branch swales that may be included in the repository design will be evaluated. The evaluation will include surveying the current swale geometry and cross-sections, qualitative evaluations of the physical condition of the rock, and evidence of siltation in the swales, as described in Section 3.1.5.

2.2.6 Repository and Borrow Area Revegetation Study

Assessment of existing vegetation on and in the vicinity of the borrow areas will be performed to develop a revegetation plan that establishes long-term, self-sustaining species at the borrow areas and on the repository cover surface. A vegetation analog survey will be conducted to evaluate the local vegetation on undisturbed ground near the borrow areas and tailings impoundment. A baseline vegetation evaluation will be conducted to determine 1) current floral and faunal conditions extant in the vicinity of the project area, 2) quality of habitat for indigenous wildlife, and 3) revegetation potential.

The baseline vegetation sampling procedures will include metrics for (1) ground cover (canopy cover), (2) species richness or diversity, (3) vegetative production (biomass) and (4) woody plant density. Information collected during the baseline evaluation of analog sites for the borrow areas and tailings impoundment will be used to develop future ecological scenarios for design. The various potential vegetative communities can be projected using local revegetation monitoring results from similar projects. Once potential plant communities are identified, the cover design can account for these ecological scenarios. Revegetation study results will be used to develop the revegetation design and to model the revegetation parameters in the water balance model.

A noxious weeds survey will also be conducted at each of the borrow areas and on the existing impoundment cover to evaluate the presence of invasive weeds that could contaminate the cover.

2.2.7 Cultural Resources Survey

A cultural resources inventory will be performed in the borrow areas and areas at or adjacent to the Tailings Impoundment that may be disturbed during sampling and construction activities, in order to identify any significant archeological sites and determine requirements for working in close proximity to those sites. The FSP for the Cultural Resources Survey is presented in Section 3.1.7.

2.2.8 Biointrusion Evaluation

A biointrusion evaluation will be conducted at the Mill Site to assess the potential for animal or plant intrusion into the tailings underlying the proposed repository. These evaluations will be conducted within adjacent habitats and at analog sites near the existing tailings impoundment. The purpose of the biointrusion evaluations is discussed below.

2.2.8.1 Animal Intrusion

The Environmental Report (UNC, 1975) presents the results of a visual survey and sampling of the small mammal population present on the mine and mill site. The survey results indicate the presence of some burrowing animals and prey species for larger burrowing predators in the general site vicinity. In order to aid in development of revegetation metrics and the cover design, as well as to determine the potential for animal intrusion into the tailings below the proposed repository, the presence and habitat of burrowing animals and predators in the vicinity of the Mill Site will be further evaluated. Animal biointrusion evaluation will determine the presence of burrowing animals and the potential for future colonization of the proposed repository, based on the local populations' existing habitat and the various scenarios for long-term vegetated cover and communities. The animal intrusion evaluation is described in Section 3.1.8.1.

2.2.8.2 Plant Intrusion

Vegetative root density and depth will be characterized through field sampling and verified through literature research. Rooting depth and root biomass of plants which have the potential to inhabit the cap will be measured directly using proven sample collection and handling techniques, as described in Section 3.1.8.2.

2.2.9 Topographic Survey of North and Central Cells and Surrounding Areas

A supplemental topographic survey will be conducted of the area around the proposed repository, in order to provide topographic elevation data with sufficient detail for design and construction. The survey will be conducted by either conventional or aerial survey methods, as described in Section 3.1.9.

2.3 SCHEDULE

MWH proposes to begin work in fall 2013, when weather and site conditions are suitable. It is anticipated that the field work will take approximately four weeks to complete. Final geotechnical laboratory results will be received within approximately twelve weeks of sample submittal to the laboratory.

2.4 REPORTING

Technical calls – GE/UNC and their consultants will hold at least two technical calls with the NRC, DOE, and USEPA prior to and during implementation of the field activities. Additional calls will be held as necessary. The Agencies will be contacted at least 14 days prior to commencing any field activities at the Mine Site associated with this work plan.

Laboratory reports and electronic files – Copies of the laboratory reports will be provided to the Agencies with the Final Report described below or sooner, if requested. The USEPA will also be provided with electronic copies of relevant tabular and spatial data as Excel® and ArcGIS® shape files. Maps will also be provided in PDF format.

Pre-Design Studies Report – a Pre-Design Studies (PDS) Report will be prepared to summarize the sampling activities and results. The PDS report will be submitted to the

Agencies no later than 90 days after field work is completed and final copies of all validated laboratory data are received. The PDS report will include the following information:

- A summary of the investigations performed and results of the investigations
- A narrative interpretation of data and results
- Resultant design parameters and design criteria
- Conclusions and recommendations for the repository design
- A summary of validated laboratory test data
- Data validation reports and laboratory data reports
- Results of statistical and modeling analyses
- Copies of field notes and log books
- Photographs documenting the work conducted

3.0 FIELD SAMPLING PLANS

3.1 SAMPLING RATIONALE AND OBJECTIVES

This section presents the FSPs to collect the pre-design data needs and satisfy the objectives identified in Section 2.2. The equipment, procedures and methods that will be used to collect the field data are included in Sections 3.1.1 through 3.1.8. The Health and Safety Plan (HASP) (MWHd, 2013 Vol. IV) covers the activities described below. Additionally, Standard Operating Procedures (SOPs) specific to this work are referenced below and included in Appendix C.

3.1.1 Geotechnical Evaluation of Tailings Impoundment and Underlying Units

The impoundment evaluation will consist of backhoe excavation of the existing cover for bulk samples of the cover admixture and radon barrier layers, as well as both CPT and hollow-stem auger drilling within the impoundment and on the embankment. The CPT investigation will be conducted at select locations, following temporary removal of the cover layer, to confirm the existing stratigraphic data in the area of interest. Based on the CPT results and the conditions encountered during the CPT exploration, borehole locations will be selected to complement the CPT locations. The sampling locations will be located in the field using a GPS prior to beginning the field sampling.

Proposed sampling locations are shown on Figures 3-1 and 3-2. Figures 3-3 and 3-4 describe the existing subsurface conditions and geology. Table 3-1 provides a summary of the anticipated subsurface profile and exploration depth for the proposed CPT and borehole locations. The geotechnical sampling plan was developed to obtain the material properties outlined in Table 3-2, using the sample types proposed. The number and specific type of samples retrieved will depend on the conditions encountered. A decision tree outlining the proposed scenarios for sampling methods and locations based on conditions encountered during the CPT and drilling operations is included as Figure 3-5.

3.1.1.1 Existing Tailings Cover

Samples of the cover materials will be submitted for laboratory testing to determine geotechnical and hydraulic properties, as specified in Table 3-3.

1. An excavator or hand shovels will be used to scrape a 5-ft by 5-ft area of admixture layer from the top surface of the tailings cover. The material will be stockpiled near the sampling location on plywood or similar material to separate the stockpiled material from the undisturbed cover surface.
2. A bulk sample of the admixture layer material will be obtained and labeled in accordance with SOP-06.
3. The thickness of the soil cover layer varies from approximately 18 to 21 inches in the North and Central cells within the area anticipated to be overlain by the waste repository. A backhoe or a hand shovel will be used to collect samples within this zone of cover material. Bulk samples will be collected from a range of approximately 0 to 12 inches below the bottom of the admixture layer, in order to avoid exposing any of the underlying tailings. A bulk sample and a small bag sample of the cover material will be collected from each sample location. The bag sample will be double-bagged in resealable bags or containers to preserve in-situ moisture content.

4. Materials encountered during sampling will be logged in accordance with SOP-17. General field conditions will be logged and photographs will be taken in accordance with SOP-14. The sample handling and shipping will be performed as described in SOP-06.
5. If sampling is to be followed by drilling or a CPT investigation, those activities will commence as described in Sections 3.1.1.2 and 3.1.1.3. Following the cover sampling, drilling, or CPT investigation, the stockpiled cover materials will be replaced over the excavated area to match surrounding grades and cover profile, and compacted by wheel tracking with the backhoe.
6. The excavator, hand shovels, and any support vehicles will be decontaminated and surveyed prior to leaving the Mill Site. The decontamination procedures are described in SOP-31.
7. The cover sampling locations will be staked and surveyed in accordance with SOP-10.

3.1.1.2 CPT Soundings

1. Twelve CPT soundings will be conducted at selected locations within the North and Central Cells including three locations within the North Cell, seven within the Central Cell, and two through the embankment. Figures 3-1 and 3-2 show the proposed CPT locations. Three will be located in or near Borrow Pit No. 1, two within Borrow Pit No. 2, two through the impoundment, and the remaining five in tailings storage areas.
2. A truck-mounted CPT rig will be used to advance the CPT probe through the existing cover and into the tailings in accordance with SOP-01. The equipment will be capable of measuring cone resistance, sleeve friction, and dynamic pore pressures. Equipment will include the CPT rig and support vehicles. General field conditions will be logged and photographs will be taken in accordance with SOP-14.
3. The CPT probe will be advanced into the subsurface vertically, at a constant rate, to the target (maximum) probe depths shown on Figures 3-3 and 3-4. Cone resistance, sleeve friction, and dynamic pore pressure measurements will be made at 8-inch maximum intervals during continuous pushing.
4. If saturated conditions are encountered, pore pressure dissipation tests will be performed to estimate water levels and pore pressure dissipation rates at select depths, during soundings. The decision tree included in Figure 3-5 provides additional information for variable conditions encountered during the CPT investigation.
5. The CPT probe will be advanced to refusal, which is expected to occur in the upper 5 feet of the alluvium or sandstone underlying the tailings.
6. Much of the hole created during CPT soundings is expected to cave after retraction of the probe. Upon completion of the CPT soundings, any remaining open hole will be backfilled to the top of the radon barrier using bentonite grout placed from the ground surface.
7. Following the CPT investigation, the stockpiled cover admixture materials will be replaced over the excavated area to match surrounding grades and cover profile, and compacted by wheel tracking with the backhoe.

8. The excavator, CPT rig, hand shovels and any support vehicles or equipment will be decontaminated and surveyed prior to leaving the tailings impoundment. The decontamination procedures are described in SOP-31.
9. The CPT locations will be staked and surveyed in accordance with SOP-10.

3.1.1.3 Hollow-stem Auger Drilling and Sampling

1. A minimum of six boreholes will be drilled at locations within the North and Central Cells, as shown on Figures 3-1 and 3-2. Each borehole will be located adjacent to (within 3 feet of) one of the completed CPT locations, in order to correlate the CPT data to the borehole samples. One borehole each will be drilled in Borrow Pit No. 1, Borrow Pit No. 2, the North Cell, and the Central Cell. Two boreholes will be drilled through the western embankment.
2. An excavator or hand shovels will be used scrape a 5-ft by 5-ft area of admixture layer from the top surface of the tailings cover. The material will be stockpiled near the sampling location on plywood or similar material to separate the stockpiled material from the undisturbed cover surface.
3. A truck-mounted drill rig equipped with hollow-stem augers and continuous sampling equipment (and/or sonic drilling capability) will be used to collect the samples. The auger drilling and sampling will take place in general accordance with SOP-01. The continuous samples will be collected in five-foot intervals for the full depth of each borehole. Acrylic liners (30 inches long) will be used to collect samples of the tailings within the continuous core sample barrel. Between each five-foot interval, modified standard penetration tests (SPT) will be conducted using a 2.5-inch outside diameter California-type sampler, driven into the soil with blows of a 140-pound hammer falling 30 inches, in accordance with SOP-07. Shelby tubes may be substituted for continuous core samples for additional sample collection, as needed to obtain relatively undisturbed samples.
4. The boreholes will be advanced to the approximate depths shown on Figures 3-3 and 3-4.
5. If the CPT indicates that water will be encountered while drilling, separate augers and sampling equipment will be used within the impoundment and within the underlying materials to minimize cross-contamination of the underlying materials. Per the decision tree presented in Figure 3-5, if perched water is encountered within the tailings, a temporary casing will be set to the bottom of the tailings and grouted in place, and clean equipment will be used to sample the underlying materials. If perched water is not encountered, drilling and sampling will proceed with one set of augers.
6. An MWH engineer or geologist will log the boreholes in the field and record the pertinent field test data in accordance with SOP-17. General field conditions will be logged and photographs will be taken in accordance with SOP-14.
7. Samples selected for testing will be sealed for transport to the laboratory in accordance with SOP-06. All samples will be scanned for alpha radiation (in total counts per minute) prior to being removed from the Mill Site. A preliminary sampling and testing plan is shown in Tables 5-1 and 5-2. The remaining samples, not selected for testing, will remain at the Mill Site. After the laboratory testing is complete, the samples will be

returned to the Mill Site for incorporation back into the tailings impoundment. An alternative being explored is to conduct the geotechnical testing onsite and not take any samples offsite.

8. Upon completion of the holes, the augers will be removed and the holes will be sealed with bentonite grout. The bentonite grout will extend up through the radon barrier layer of the cover. The stockpiled cover materials will be replaced over the grouted hole and excavated area to match surrounding grades and cover profile, and compacted by wheel tracking with the backhoe.
9. The excavator, drill rig, hand shovels, and any support vehicles or equipment will be decontaminated and surveyed prior to leaving the Mill Site. The decontamination procedures are described in SOP-31.
10. The completed borehole locations will be staked and surveyed in accordance with SOP-10.

3.1.1.4 Geotechnical Laboratory Testing

The geotechnical laboratory testing program in Table 3-3 has been developed to provide sufficient numbers of test results based on the sampling plan and parameters identified in Table 3-2. Laboratory testing will be conducted according to applicable American Society for Testing and Materials (ASTM) standards. This laboratory testing program will be modified based on a review of the actual samples collected during the investigation. After completion of the geotechnical laboratory testing, the samples will be returned to the Mill Site for disposal, if required.

3.1.2 Borrow Material Investigation

The borrow material investigation will consist of auger drilling in the potential borrow areas. The locations of the boreholes in the North and South Drainage Borrow Areas are shown on Figure 3-6. The locations of boreholes in the East Borrow and West Borrow Areas are shown on Figure 3-7. The approximate locations of boreholes in the Dilco Hill Borrow Area are shown on Figure 3-8. The proposed geotechnical, hydraulic, and agronomic testing is specified in Table 3-4.

Procedures for drilling, sampling, and reclaiming each borrow sampling location, and preparing and submitting samples for laboratory testing are:

1. A borehole will be drilled with hollow-stem auger drilling methods in accordance with SOP-01.
2. The borings will be drilled to the following depths, or to practical auger refusal:
 - Approximate depth of boreholes in East Borrow: 20 ft
 - Approximate depth of boreholes in West Borrow Area: 20 ft
 - Approximate depth of boreholes in Dilco Hill Borrow Area: 60 ft
 - Approximate depth of boreholes in the North Drainage Borrow Area: 30 ft
 - Approximate depth of boreholes in the South Drainage Borrow Area: 30 ft
3. Materials encountered during drilling will be logged in accordance with SOP-17. General field conditions will be logged and photographs will be taken in accordance with SOP-14.

4. Sampling will be performed with a continuous (dry-core) sampler or (as a secondary sampling method) with a 2.5-inch outside diameter California-type sampler, driven into the soil with blows of a 140-pound hammer falling 30 inches, in accordance with SOP-07.
5. Two bulk composite samples will be collected from each borehole, each representing a thoroughly mixed selection of all the materials encountered in the borehole. The samples will be labeled as described in MWH SOP-06.
6. After sampling is complete, the drill cuttings will be placed back into the borehole and compacted with drilling equipment. If additional backfill material is necessary, clean fill soils will be used to backfill the remainder of the borehole.
7. Borehole locations will be staked and surveyed in accordance with SOP-10.

3.1.3 Volume and Characteristics of On-site Erosion Protection Material

Sampling of the gravel admixture layer of the existing cover is described in the geotechnical evaluation of the tailings impoundment and underlying units in Section 3.1.1. Additionally, a bulk sample will be taken of each type of bedding material as well as the 1.5-inch and 3-inch rock stockpiled at the Mill Site. One composite bulk sample is expected to be collected from three to five stockpiles. The samples will be labeled in accordance with SOP-07, and submitted to the laboratory for particle size analysis and durability testing, as shown in Table 3-5. Estimates of stockpiled material volume will be made during sampling by measuring stockpile dimensions or surveying (in conjunction with Section 3.1.9).

3.1.4 Natural Analog for Long-Term Moisture Conditions

The following procedure will be used to measure hydraulic conditions of the proposed borrow soil material(s).

1. The surface of the area to be tested will be prepared by clearing the site (no surface vegetation, protruding rock, or debris) in an approximate 2-ft diameter area. The site will be prepared to be smooth and flat without disturbing the remaining soil.
2. Multiple tension infiltrometer measurements will be made of four adjacent areas, at and below the ground surface. This will prevent moisture from previous measurement(s) from affecting outcome of subsequent measurement(s). The tentative depths of measurement respectively are: (1) surface, (2) 1-ft below surface, (2) 2-ft below surface, and (3) 3-ft below surface. At each sampling depth, the surface will be prepared per step 1.
3. Soil disturbances will be repaired after the tension infiltrometer measurements are complete.
4. The areas tested will be staked and surveyed in accordance with SOP-10.
5. General field conditions will be logged and photographs will be taken as described in SOP-14.

3.1.5 Visual Inspection and Survey of Branch Swales

The following areas of the existing branch swales will be investigated:

- Western portion of Branch Swale A
- Western portion of Branch Swale B
- Western portion of Branch Swale C
- Western and northern portions of Branch Swale D
- Western portion of Branch Swale H
- Branch Swale E

The branch swales will be qualitatively evaluated, with specific attention to the physical condition of the drainage rock, and the amount of silt present in each swale. In addition to condition descriptions, general field conditions will be logged and photographed, in accordance with SOP-14. Cross sections will be surveyed across each branch swale in two to four locations, depending on the length of each swale to be evaluated. The cross sections will be surveyed in general accordance with SOP-10. Thicknesses of accumulated sediment in the swales (if present) will be measured along each cross section.

3.1.6 Repository and Borrow Area Revegetation Study

The procedures used to perform a baseline floral and faunal survey at the chosen analog site(s) are presented below.

3.1.6.1 Floral Study

Baseline floral surveys will be conducted to a minimum of 15 sample sites in each distinct evaluation area. Vegetation sampling protocols involve an emphasis upon ground cover to facilitate repeatable statistical comparisons among evaluation areas. In addition to ground cover evaluations, woody plant density and current annual vegetative production will be evaluated to facilitate a broader analysis. Pedestrian transects will also be implemented to detect occurrences of threatened, endangered, and rare plant species and/or listed noxious weeds. Methodologies for the sampling metrics are described below. In addition to the activities described below, general field conditions will be logged and photographs taken in accordance with SOP-14.

3.1.6.1.1 Determination of Ground Cover

Ground cover at each sampling site will be determined using the point-intercept methodology illustrated on Figure 3-9. Ground cover data will also be used to facilitate development of Leaf Area Index values for each suitable analog site which represent a potential ecological scenario for the repository cover. Implementation of ground cover monitoring will be performed as follows:

1. A transect of 10 meters length will be established from the starting point of each sample site and aligned toward the direction of the next site to be sampled.
2. At each one-meter interval along the transect, a "laser point bar" will be situated vertically above the ground surface, and a set of 10 readings will be recorded as registering counts of vegetation (by species), litter, rock (>2mm), or bare soil.

3. Counts are determined at each meter interval by activating a battery of 10 specialized lasers situated along the bar at 10 centimeter intervals and recording the variable intercepted by each of the narrow (0.02") focused beams (see Figure 3-9).
4. A total of 100 intercepts per transect are recorded resulting in 1 percent cover per intercept.

3.1.6.1.2 Determination of Woody Plant Density

Woody plant density at each sampling site will be determined using fixed length/width belt transects oriented parallel to, and co-located with, each ground cover transect. Each belt will be 2 meters in width and extended from the beginning of the sample point for a distance of 50 meters (see Figure 3-9). All shrubs, succulents, and trees rooted within the boundaries of these belts will be counted and classified according to species (sub-shrubs are not counted). Entire plants rather than stems are counted to provide a more accurate representation of actual woody plant density.

3.1.6.1.3 Determination of Current Annual Production

At each sample site, current annual production will be collected from a 1/2 m² quadrat frame flipped once (end to end, as shown on Figure 3-9) to facilitate less variable data, therefore sampling a total of 1 m² at each sampling location.

1. The quadrat will be initially placed one meter and 90 degrees to the right (clockwise) of the ground cover transect to avoid vegetation trampled by investigators during sample site location (see Figure 3-9).
2. From within each quadrat, all above-ground current annual vegetation within the vertical boundaries of the frame will be clipped and bagged separately by life form:

<i>Native Perennial Cool Season Grass</i>	<i>Native Perennial Forb</i>
<i>Native Perennial Warm Season Grass</i>	<i>Annual / Biennial Forb</i>
<i>Introduced Perennial Grass</i>	<i>Introduced Perennial Forb</i>
<i>Annual Grass</i>	<i>Noxious Weed</i>
<i>Sub-Shrub</i>	<i>Shrub</i>

3. All production samples will be returned to the lab for drying and weighing. Drying will occur at 105° C until a stable weight is achieved (24 hours). Sample weight will then be recorded to the nearest 0.1 gram.

3.1.6.1.4 Threatened, Endangered, and Rare Plant Surveys

A list of threatened, endangered, and rare plant species known to occur within McKinley County, and the ecotypes occupying the project area, will be developed from several sources (including New Mexico Natural Heritage Program and New Mexico Rare Plant Website) before baseline evaluation. Prior to field work, taxonomic descriptions and botanical drawings of these target species will be compiled into a field guide. Fieldwork will involve search patterns in all portions of appropriate habitat within the project area. Search procedures involve slow implementation of qualitative pedestrian transects and visual scanning of the ground surface for target plant species. The compiled field guide will be used to determine whether encountered plants are species of concern.

3.1.6.1.5 Noxious Weed Surveys

A noxious weed list from McKinley County will be obtained prior to baseline evaluations. Field work will involve search patterns in all portions the project area including potential sources of weed seed in the general vicinity. Search procedures involve slow implementation of qualitative pedestrian transects and visual scanning of the ground surface for any of the target plant species.

3.1.6.2 Faunal Study

Wildlife surveys in the baseline evaluation areas will be limited to the qualitative techniques of direct observation, observation of signs of wildlife, and/or evaluation of habitat owing to the modest size of disturbance footprints and the potential complication of livestock grazing. In this regard, these observations will be made while personnel are on site for vegetation investigations. All observations of wildlife, either directly or by sign, will be recorded in a manner to facilitate an indication of abundance and/or use of project area habitats.

In addition to site-specific "incidental" observations during vegetation evaluations, several pedestrian observation transects will be extended radially from the project area approximately one-quarter to one-half mile to provide a better indication of each of the following: 1) wildlife use of the overall vicinity and habitats, 2) any remaining mine-related impacts, and 3) any continuing hazards to wildlife. These transects (minimum of 4) will only be implemented during the early morning (preferred) or late evening hours to maximize opportunity for observing indigenous wildlife. A GPS will be used for spatial orientation and to facilitate documentation. Furthermore, project area habitats will be evaluated with regard to their capability to provide life requisites for anticipated indigenous wildlife, including sensitive or special status species.

3.1.7 Cultural Resources Survey

The cultural resource inventory of the areas that will potentially be disturbed by sampling and construction activities will begin with a records search of the Archeological Records Management Section (ARMS) database, the Navajo Nation Historic Preservation Division (NNHPD) (depending on property ownership), the National Register of Historic Places, and the State Register of Cultural Properties prior to any fieldwork. Cultural resources surveys will be performed in coordination with the Navajo Nation Historic Preservation Division and/or the New Mexico State Historic Preservation Division (NMHPD). Fieldwork will consist of a pedestrian survey by a crew made up of a supervisory archeologist permitted by NMHPD and/or NNHPD, and at least one other archeological technician, walking 15-meter wide non-overlapping, parallel transects across the area of potential effect, constituting 100 percent coverage of the areas. The areas that will be surveyed include all borrow areas identified in Figure 3-6, as well as the general area between the borrow areas and the tailings impoundment. All cultural sites (prehistoric or historic and newly discovered or previously-recorded) will be recorded in their entirety, using conventional survey methods described in SOP-10. A scaled site map will be created showing features, artifact concentrations, diagnostic artifacts, and topographic features. In-field artifact analysis will be conducted and photographs will be taken. Depending on site ownership, a Laboratory of Anthropology Site Form will be completed for the sites if necessary. The appropriate technical report will meet the standards of the given land managing agency.

3.1.8 Biointrusion Evaluation

3.1.8.1 Animal Intrusion

The procedure used to evaluate the presence or potential future presence of burrowing animals and their burrowing predators is:

1. A literature review of normal ranges of burrowing animals identified from the area will be conducted. The literature review will also provide information on the type of habitat where these animals are typically found.
2. Trapping (using Sherman live traps) of all unique habitats within a 200-meter perimeter analog site near the tailings impoundment will be conducted. Trapping will involve at least 200 trap-nights of effort (50 traps for 4 nights or 100 traps for 2 nights, or similar). Several pedestrian observational transects of animals, signs of animal presence, and presence of burrowing animals' habitats will also be conducted within the analog site. General field conditions will be logged and photographs will be taken in accordance with SOP-14.
3. The literature review, in combination with the results of the trapping program and observational survey, will provide information on the presence or potential future presence of burrowing animal populations and their burrowing predators in the vicinity of the Mill Site.

3.1.8.2 Plant Intrusion

Several soil excavations will be performed at the analog site(s) to define root density and depth for a variety of potential ecological scenarios. Root density and depth will be determined using the profile wall method, whereby the roots are counted on a freshly excavated soil profile. The profile wall method consists of the following steps:

1. At least two trenches will be excavated in each suitable analog site (measuring approximately 10 acres), representing a potential ecological scenario for the proposed repository cover. Test trenches will be excavated in accordance with SOP-08.
2. The vertical pit wall will be gently cleaned with a soft brush to expose the roots to a depth of approximately 1 to 1.5 m.
3. A 1 m² wire frame, divided into a 10 cm² grid will be attached to the pit face and the roots within each grid cell will be counted and mapped on field sheets.
4. Roots will also be described and classified by size and plant type (grass versus shrub, etc.).
5. General field conditions will be logged and photographs will be taken in accordance with MWH SOP-14.

3.1.9 Topographic Survey of North and Central Cells and Surrounding Areas

A topographic survey will be performed for the surface and peripheral features of the north and central cells, pipeline arroyo, diversion channels, and the berm adjacent to the north upstream diversion channel. Surveying will be performed by a Professional Licensed Surveyor using aerial or conventional surveying methods. The topographic survey will require a defined accuracy consistent with drafted standards of the American Society for Photogrammetry and Remote

Sensing (1990). The topographic survey will provide site topography sufficient to generate 1-ft contours of the proposed repository area.

3.2 DECONTAMINATION PROCEDURES

All sampling equipment will be cleaned and decontaminated prior to use at each location and prior to leaving the site. The decontamination procedures are described in SOP-31. Rinse water will be handled as Investigation Derived Waste (IDW).

3.3 DISPOSAL OF INVESTIGATION DERIVED WASTE

Generation of IDW such as equipment decontamination wastewater, rinsate, soil cuttings, sample containers, and personal protective equipment (PPE) will be minimal. Cuttings shall be placed back into the boreholes, as described in the Field Sampling Plans in Sections 3.1.1 and 3.1.2. Decontamination wastewater, rinsate, sample containers, and PPE will be characterized, as necessary, and disposed of in accordance with State and Federal Regulations, as applicable.

Liquid IDW will be discharged into the evaporation ponds located in the South Cell where it will be allowed to evaporate.

3.4 FIELD DOCUMENTATION

On-site field personnel will document field and sampling activities in accordance with SOP-14 and other applicable SOPs.

The sampling and site observation locations described above will be surveyed with a hand-held GPS accurate to within three feet (horizontal). After drilling and/or sampling, the precise locations will be surveyed using conventional survey methods in accordance with SOP-10.

3.5 SAMPLE LABELING AND DESIGNATION

The samples will be labeled for proper identification in the field and for tracking in the laboratory in accordance with SOP-06 and SOP-14. The samples will have identifiable and unique numbers. Samples IDs will consist of two parts. Part 1 will be designated as the sampling area (East Borrow (EB), West Borrow (WB), Tailings Impoundment (TI), etc.) and part 2 will be the sample location identification and the depth of sample (bulk, core, etc.).

As an example, sample designation East Borrow BH-1 9' will be a sample obtained from 9 feet below ground surface at borehole 1 in the East Borrow.

3.6 SAMPLE HANDLING, SHIPMENT AND ANALYSIS

The samples collected will be stored in accordance with SOP-06, SOP-07 and other applicable SOPs. Samples designated for off-site laboratory analysis will be packaged and shipped in accordance with applicable U.S. Department of Transportation regulations. (Title 49 Code of Federal Regulations, Subchapter C - Hazardous Material Characterization).

Due to the radiological nature of some site materials, samples will undergo a preliminary screening in the field before they are shipped off-site for analysis, in accordance with the

procedures described in SOP-06. The samples will be screened for exposure rates and then packaged and labeled in accordance with 49 CFR Part 172. The tailings samples will be classified as a "limited quantity" and can be shipped or transported in "excepted packaging" per 49 CFR Part 172. The samples will either be: 1) shipped by a commercial freight carrier, 2) driven from the site to the laboratory in a rented vehicle, or 3) will remain on site to be tested in a mobile laboratory established at the Mill Site office. The testing laboratory will have a license to test radioactive materials.

The samples will be tested for the properties presented in the Field Sampling Plans in Section 3.1. Testing will be in accordance with industry standards, such as ASTM or other applicable industry standards.

4.0 QUALITY ASSURANCE

Geotechnical and hydraulic laboratory testing will be conducted in general accordance with ASTM or other applicable laboratory testing standards. ASTM standards specify how to mix and split samples to obtain representative samples of the material, the methods and frequency for calibration of testing equipment, and the significant figures to be used when recording test results. Applicable SOPs for the sampling and handling activities are provided in Appendix C.

5.0 REFERENCES

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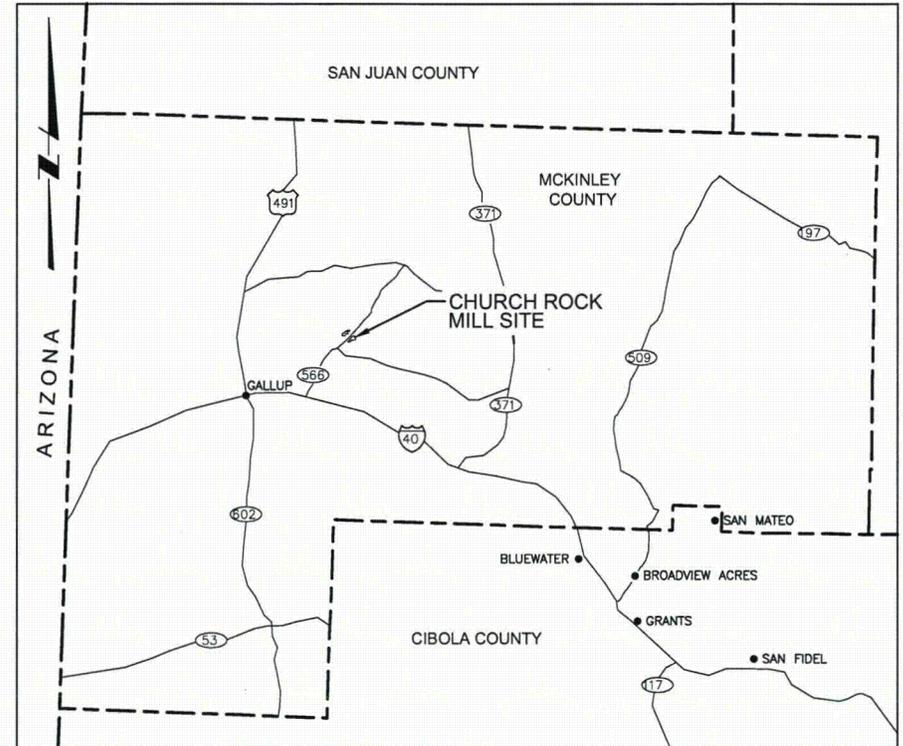


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FIGURES



LOCATION MAP
NOT TO SCALE



VICINITY MAP
NOT TO SCALE



PROJECT LOCATION
McKINLEY COUNTY, NEW MEXICO

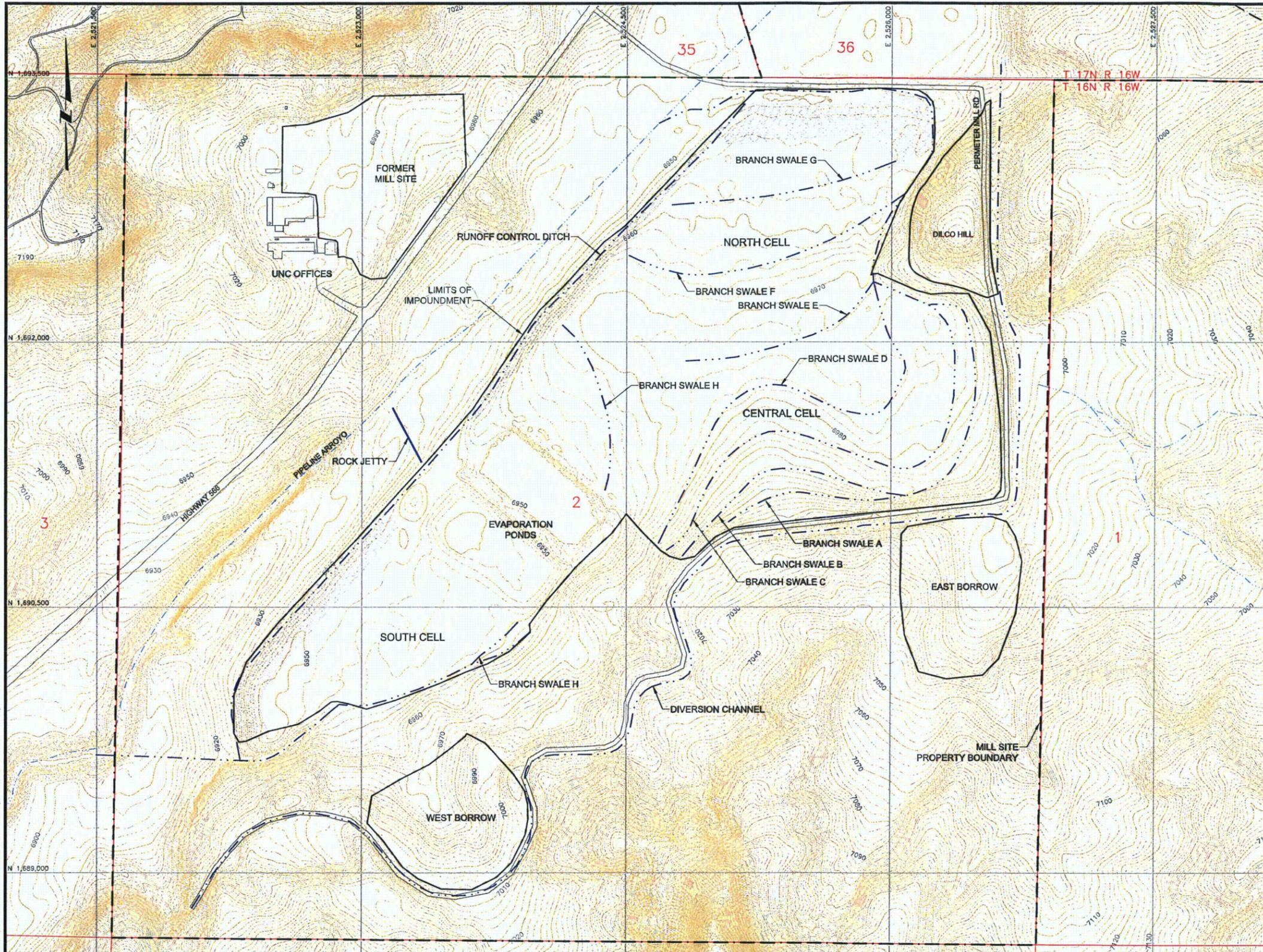
PROJECT
CHURCH ROCK MILL SITE PDS WORK PLAN

TITLE
SITE LOCATION MAP

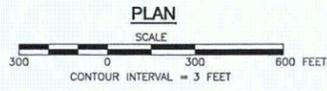


FIGURE 1-1 REVISION
0

FILE NAME 1011273 SLM



- LEGEND:**
- 7040 EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
 - APPROXIMATE IMPOUNDMENT AREA
 - ROADS
 - NATURAL DRAINAGE
 - MILL SITE PROPERTY BOUNDARY
 - CHANNEL
 - BRANCH SWALE
 - RIPRAP AREA
 - SECTION LINE
 - SECTION NUMBER
 - PHYSICAL STRUCTURE

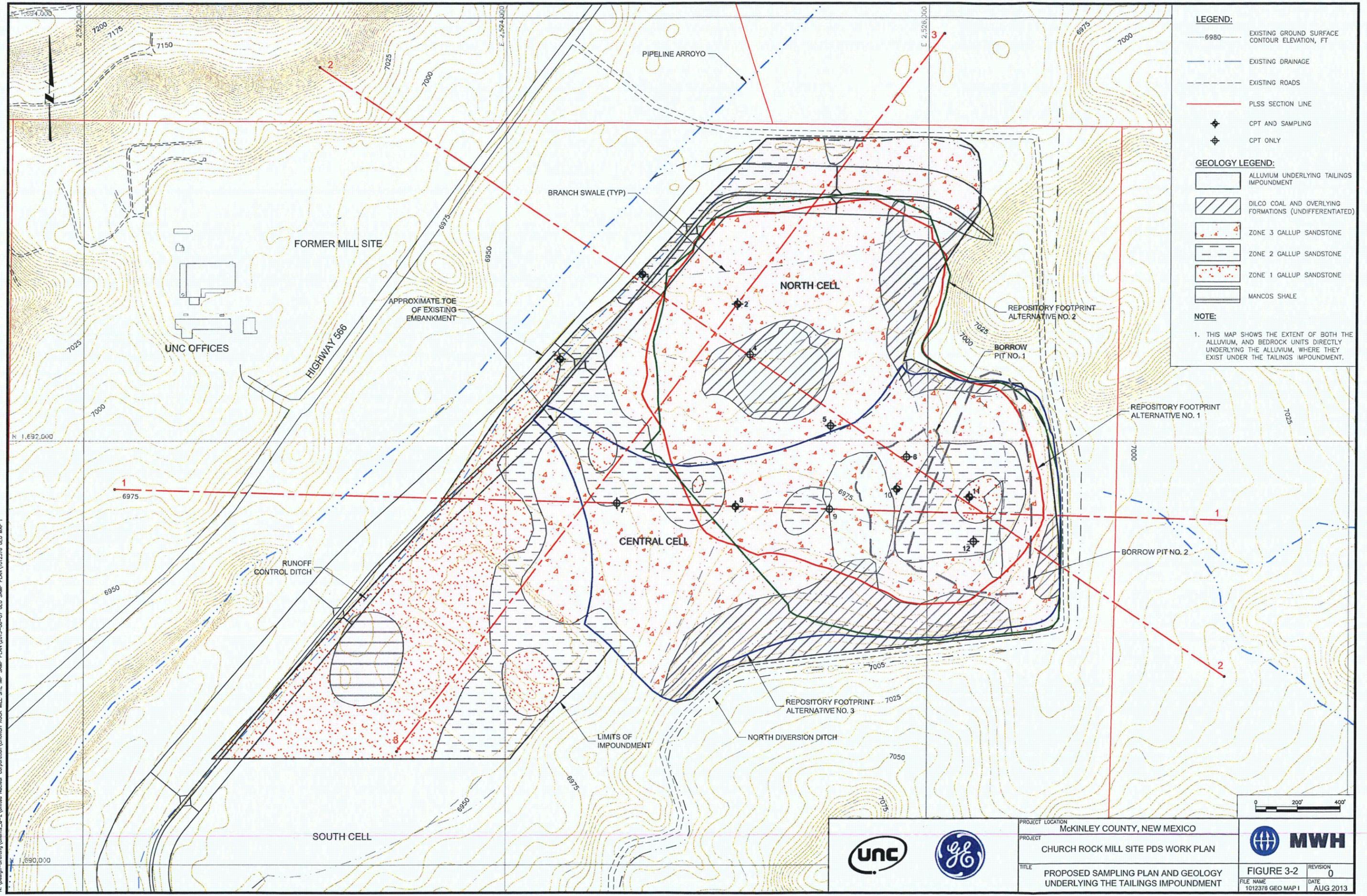


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PROJECT LOCATION McKINLEY COUNTY, NEW MEXICO		
PROJECT CHURCH ROCK MILL SITE PDS WORK PLAN		
TITLE CHURCH ROCK MILL SITE LAYOUT	FIGURE 1-2	REVISION 0
FILE NAME 1012217 CRMSL	DATE AUG 2013	

N:\Design-Drafting\Clients_Q-Z\United Nuclear Corporation\CHURCH ROCK MILL SITE IMP SAMPLING PLAN\1012376 GEO MAP 1



LEGEND:

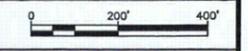
- 6980 — EXISTING GROUND SURFACE CONTOUR ELEVATION, FT
- - - - EXISTING DRAINAGE
- - - - EXISTING ROADS
- - - - PLSS SECTION LINE
- ⊕ CPT AND SAMPLING
- ⊕ CPT ONLY

GEOLOGY LEGEND:

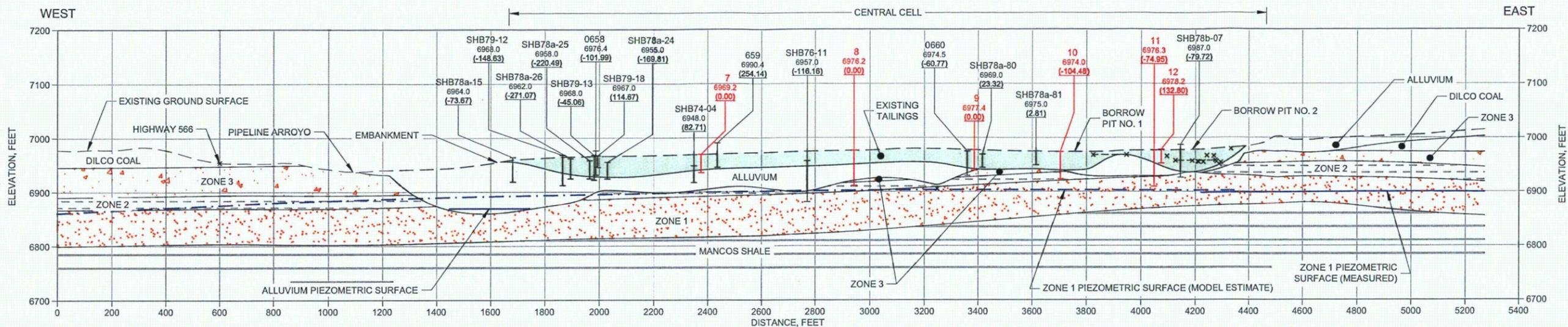
- [Blank box] ALLUVIUM UNDERLYING TAILINGS IMPOUNDMENT
- [Hatched box] DILCO COAL AND OVERLYING FORMATIONS (UNDIFFERENTIATED)
- [Red triangles] ZONE 3 GALLUP SANDSTONE
- [Dashed lines] ZONE 2 GALLUP SANDSTONE
- [Red dots] ZONE 1 GALLUP SANDSTONE
- [Horizontal lines] MANCOS SHALE

NOTE:

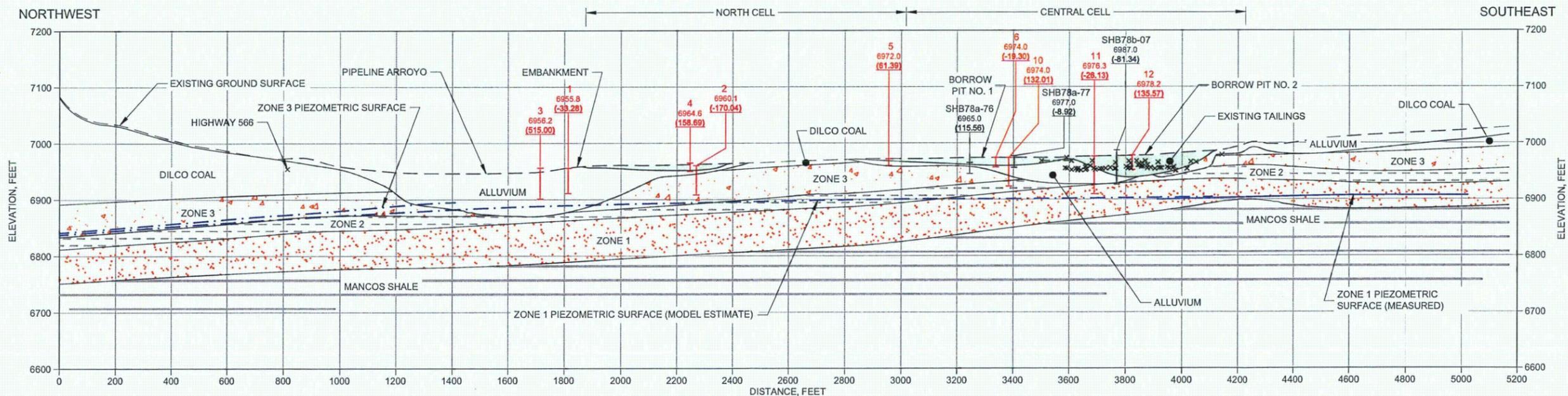
1. THIS MAP SHOWS THE EXTENT OF BOTH THE ALLUVIUM, AND BEDROCK UNITS DIRECTLY UNDERLYING THE ALLUVIUM, WHERE THEY EXIST UNDER THE TAILINGS IMPOUNDMENT.



	PROJECT LOCATION McKINLEY COUNTY, NEW MEXICO	
	PROJECT CHURCH ROCK MILL SITE PDS WORK PLAN	
	TITLE PROPOSED SAMPLING PLAN AND GEOLOGY UNDERLYING THE TAILINGS IMPOUNDMENT	
FIGURE 3-2 REVISION 0 FILE NAME 1012376 GEO MAP 1 DATE AUG 2013		



CROSS SECTION 1
 VERTICAL SCALE 100' 200'
 HORIZONTAL SCALE 200' 400'
 VERTICAL EXAGGERATION = 2X



CROSS SECTION 2
 VERTICAL SCALE 100' 200'
 HORIZONTAL SCALE 200' 400'
 VERTICAL EXAGGERATION = 2X

TABLE 1 - ESTIMATED PROFILE BY PROPOSED SAMPLING LOCATION, THICKNESS (FEET)

LOCATION	1	2	3	4	5	6	7	8	9	10	11	12
EMBANKMENT	25	-	35	-	-	-	-	-	-	-	-	-
TAILINGS / COVER	-	5	-	10	7	12	29	25	35	28	25	21
ALLUVIUM	20	27	20	5	5	5	5	30	3	3	22	5
ZONE 3 SANDSTONE	-	20	-	-	-	-	-	10	-	20	-	-
ZONE 1 SANDSTONE	-	-	-	-	-	-	-	-	-	-	20	-
TOTAL DEPTH (EST)	45	52	55	15	12	17	34	65	38	51	67	26

NOTE: ESTIMATED PROFILES BASED ON PROPOSED SAMPLING DEPTHS.

○ = PROPOSED CPT (ONLY) LOCATIONS

LEGEND:

- SHB79-14 6967.9 (467.34) — DESIGNATION
- ELEVATION
- OFFSET
- BORING
- PROPOSED BORING AND/OR CPT LOCATIONS (SHOWN IN RED)
- HISTORIC BORINGS (SHOWN IN BLACK) (LOCATIONS IN PLAN VIEW SHOWN ON FIGURE 3-1)
- x — BURIED MILL DEMOLITION DEBRIS
- x — — — DEBRIS AREAS (CONCRETE, STEEL, EXCAVATED MILL MATERIAL)

NOTES:

1. GEOLOGIC CROSS SECTION INFORMATION PROVIDED BY CHESTER ENGINEERS.
2. WATER LEVEL INFORMATION BASED ON OCTOBER, 2011 MEASUREMENTS. PORTIONS OF THE PIEZOMETRIC SURFACES ARE INTERPRETED BY CHESTER ENGINEERS USING THE SITE GROUNDWATER FLOW MODEL (CHESTER ENGINEERS, 2012).
3. DEBRIS SURVEY LOCATIONS IN BORROW PIT NO. 2 FROM UNC CHURCH ROCK MILL DECOMMISSIONING REPORT (UNC, 1993)
4. SELECT HISTORIC BORINGS SHOWN ARE BORINGS THAT INCLUDE TAILINGS DATA, EMBANKMENT DATA AND/OR ALLUVIUM DATA BENEATH THE TAILINGS.
5. BOREHOLE, DEBRIS AND CONTACT ELEVATIONS ARE BASED ON THE BEST AVAILABLE INFORMATION. DUE TO SURVEY ERROR AND DATUM CORRECTIONS, THE ELEVATIONS MAY NOT BE EXACT.



PROJECT LOCATION
 MCKINLEY COUNTY, NEW MEXICO
 PROJECT
 CHURCH ROCK MILL SITE PDS WORK PLAN
 TITLE
 GEOLOGIC CROSS SECTIONS 1 AND 2



FIGURE 3-3 REVISION 0
 FILE NAME DATE
 1012376 GEO XSEC AUG 2013

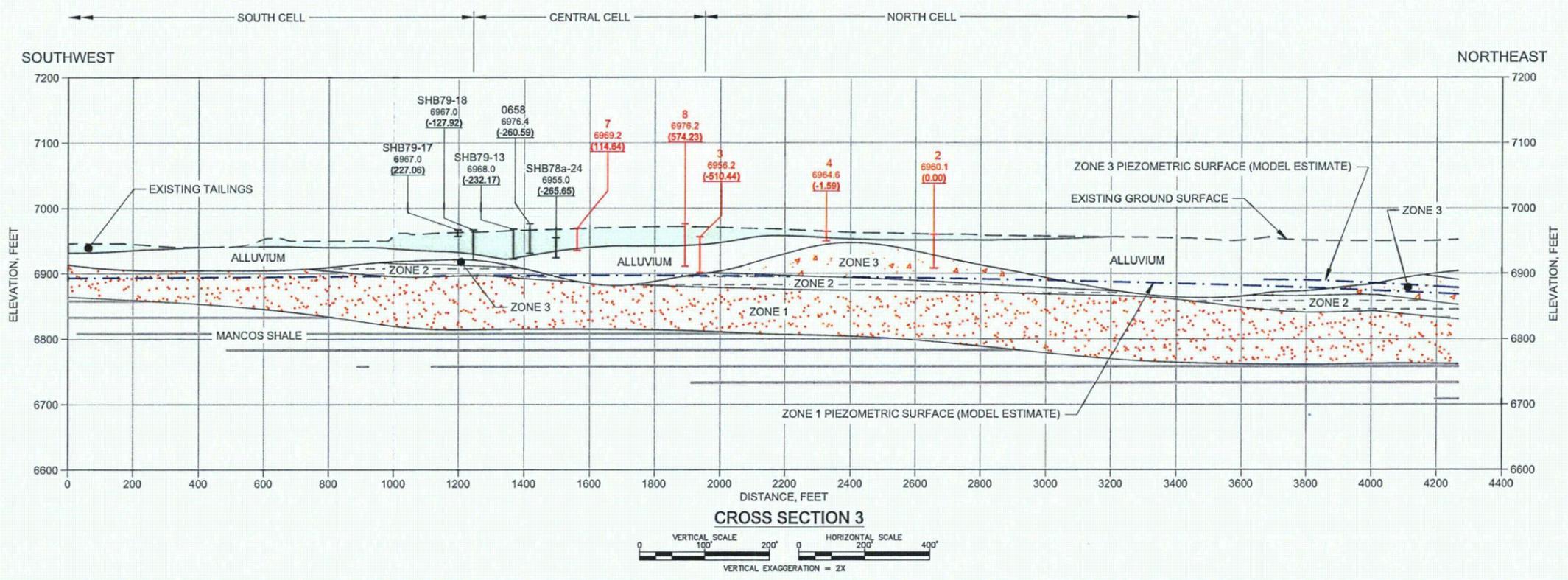


TABLE 1 - ESTIMATED PROFILE BY PROPOSED SAMPLING LOCATION, THICKNESS (FEET)

LOCATION	1	2	3	4	5	6	7	8	9	10	11	12
EMBANKMENT	25	-	35	-	-	-	-	-	-	-	-	-
TAILINGS / COVER	-	5	-	10	7	12	29	25	35	28	25	21
ALLUVIUM	20	27	20	5	5	5	5	30	3	3	22	5
ZONE 3 SANDSTONE	-	20	-	-	-	-	-	10	-	20	-	-
ZONE 1 SANDSTONE	-	-	-	-	-	-	-	-	-	-	20	-
TOTAL DEPTH (EST)	45	52	55	15	12	17	34	65	38	51	67	26

NOTE: ESTIMATED PROFILES BASED ON PROPOSED SAMPLING DEPTHS. ○ = PROPOSED CPT (ONLY) LOCATIONS

LEGEND:

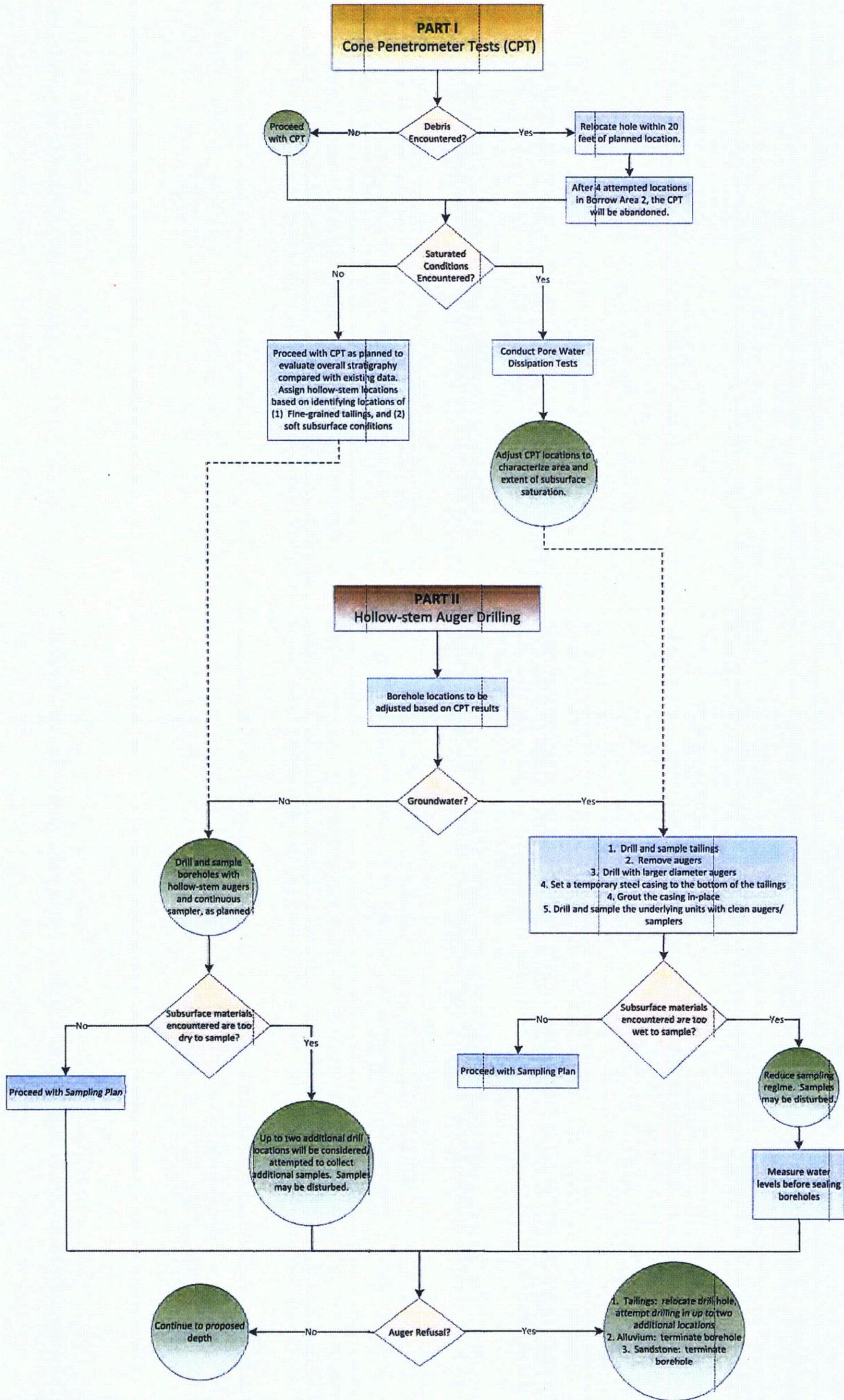
- SHB79-14 6967.9 (467.34) — DESIGNATION
- ELEVATION
- OFFSET
- BORING
- x — BURIED MILL DEMOLITION DEBRIS
- x--x — DEBRIS AREAS (CONCRETE, STEEL, EXCAVATED MILL MATERIAL)

PROPOSED BORING AND/OR CPT LOCATIONS (SHOWN IN RED)

HISTORIC BORINGS (SHOWN IN BLACK) (LOCATIONS IN PLAN VIEW SHOWN ON FIGURE 3-1)

- NOTES:**
1. GEOLOGIC CROSS SECTION INFORMATION PROVIDED BY CHESTER ENGINEERS.
 2. WATER LEVEL INFORMATION BASED ON OCTOBER, 2011 MEASUREMENTS. PORTIONS OF THE PIEZOMETRIC SURFACES ARE INTERPRETED BY CHESTER ENGINEERS USING THE SITE GROUNDWATER FLOW MODEL (CHESTER ENGINEERS, 2012).
 3. DEBRIS SURVEY LOCATIONS IN BORROW PIT NO. 2 FROM UNC CHURCH ROCK MILL DECOMMISSIONING REPORT (UNC, 1993)
 4. SELECT HISTORIC BORINGS SHOWN ARE BORINGS THAT INCLUDE TAILINGS DATA, EMBANKMENT DATA AND/OR ALLUVIUM DATA BENEATH THE TAILINGS.
 5. BOREHOLE, DEBRIS AND CONTACT ELEVATIONS ARE BASED ON THE BEST AVAILABLE INFORMATION. DUE TO SURVEY ERROR AND DATUM CORRECTIONS, THE ELEVATIONS MAY NOT BE EXACT.

	PROJECT LOCATION MCKINLEY COUNTY, NEW MEXICO	
	PROJECT CHURCH ROCK MILL SITE PDS WORK PLAN	
TITLE GEOLOGIC CROSS SECTION 3		FIGURE 3-4 REVISION 0
FILE NAME 1012378 GEO XSEC		DATE AUG 2013



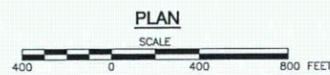


LEGEND:

- APPROXIMATE IMPOUNDMENT AREA
- MILL SITE PROPERTY BOUNDARY
- BORROW AREAS
- SECTION LINE
- 2** SECTION NUMBER
- PRELIMINARY BORROW DRILLING LOCATIONS (NORTH AND SOUTH DRAINAGE BORROW AREAS ONLY)

NOTES:

1. SAMPLING LOCATIONS FOR BORROW AREAS 1 AND 2 ARE SHOWN ON FIGURE 5-4.
2. SAMPLING LOCATIONS FOR DILCO HILL ARE SHOWN ON FIGURE 3-8.



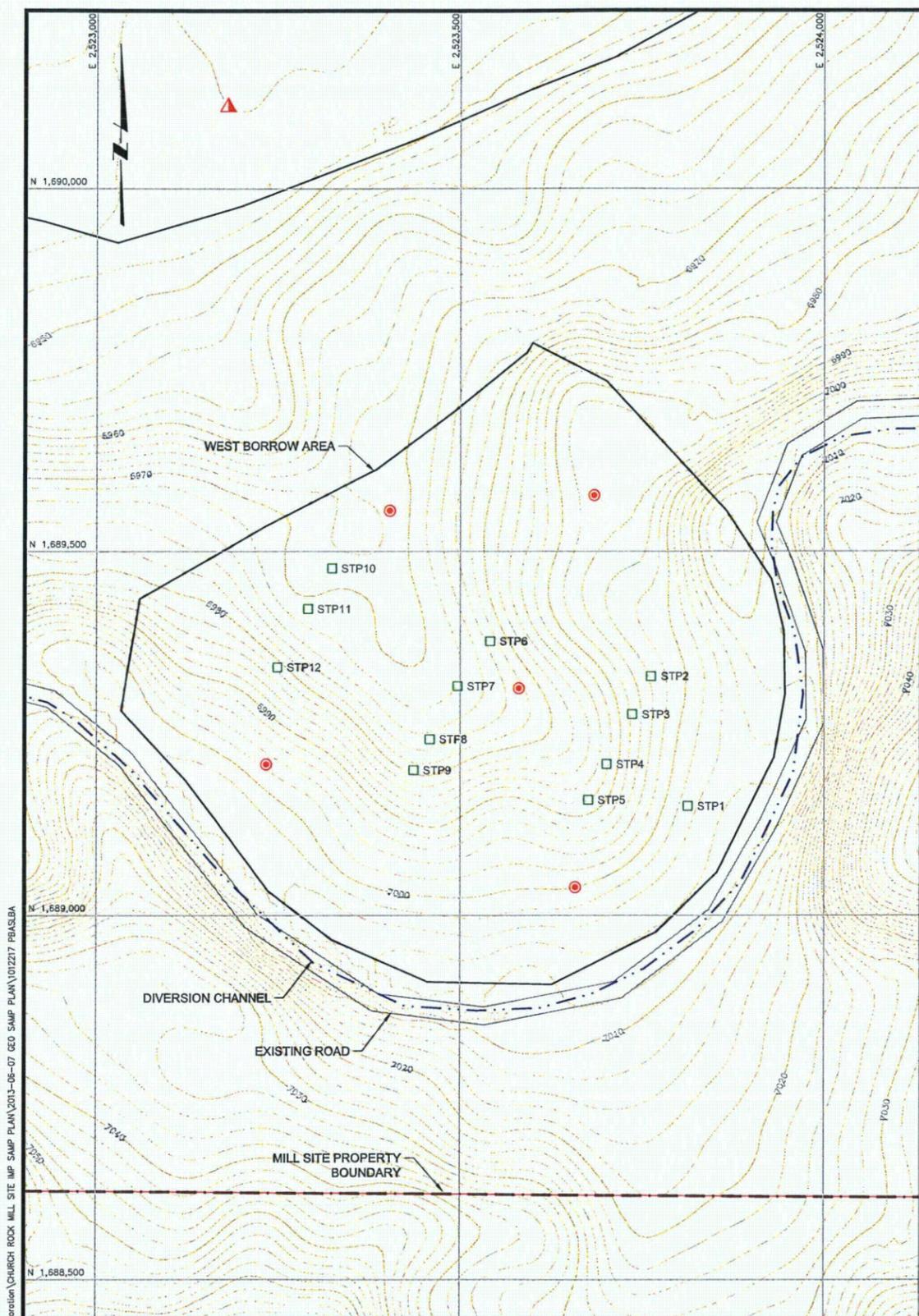
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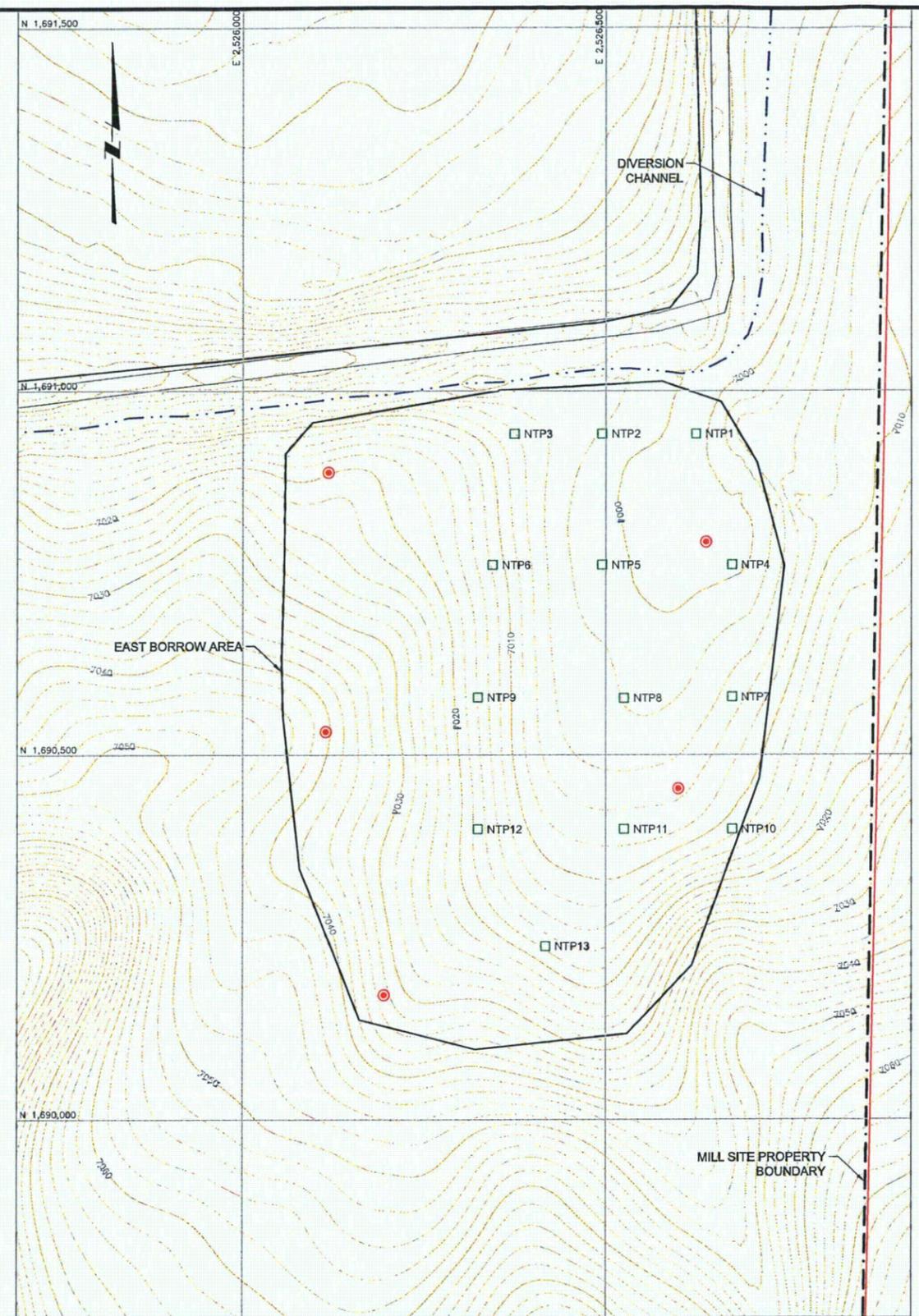
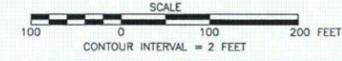
PROJECT LOCATION	McKINLEY COUNTY, NEW MEXICO
PROJECT	CHURCH ROCK MILL SITE PDS WORK PLAN
TITLE	POTENTIAL BORROW AREA LOCATIONS



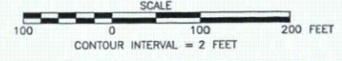
FIGURE 3-6	REVISION 0
FILE NAME 1012217 PBAL	DATE AUG 2013



WEST BORROW AREA SAMPLING LOCATIONS



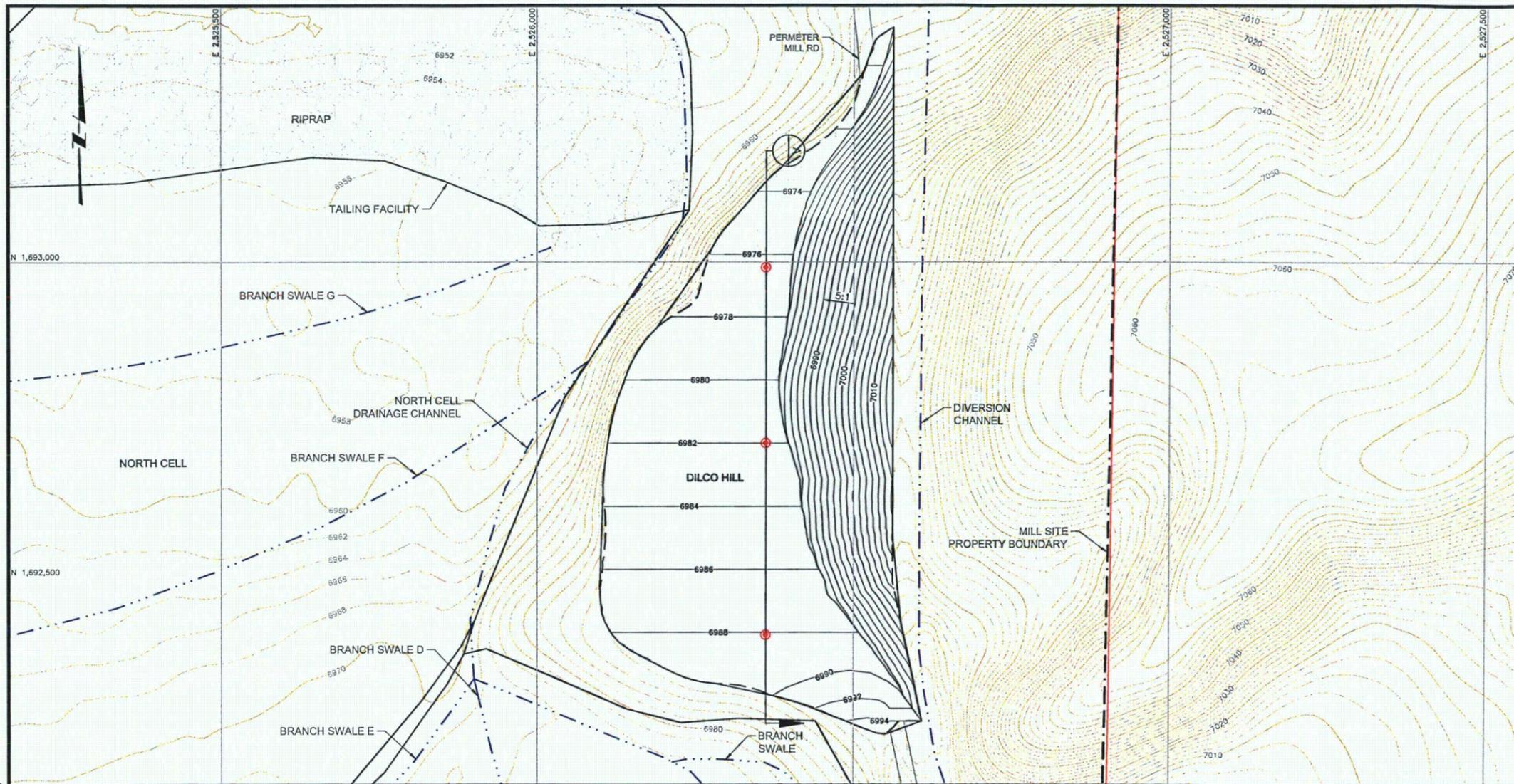
EAST BORROW AREA SAMPLING LOCATIONS



- LEGEND:**
- EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
 - APPROXIMATE IMPOUNDMENT AREA
 - ROADS
 - NATURAL DRAINAGE
 - MILL SITE PROPERTY BOUNDARY
 - CHANNEL
 - SECTION LINE
 - APPROXIMATE LOCATION OF 2008 PRELIMINARY BORROW INVESTIGATION TEST PIT, SEE MWH (2012)
 - PROPOSED DRILLING LOCATION

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	PROJECT LOCATION MCKINLEY COUNTY, NEW MEXICO		
	PROJECT CHURCH ROCK MILL SITE PDS WORK PLAN		TITLE PROPOSED BORROW AREA SAMPLE LOCATIONS, EAST AND WEST BORROW
	FILE NAME 1012217 PBASLBA		REVISION 0 DATE AUG 2013

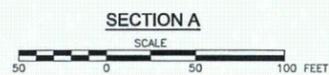
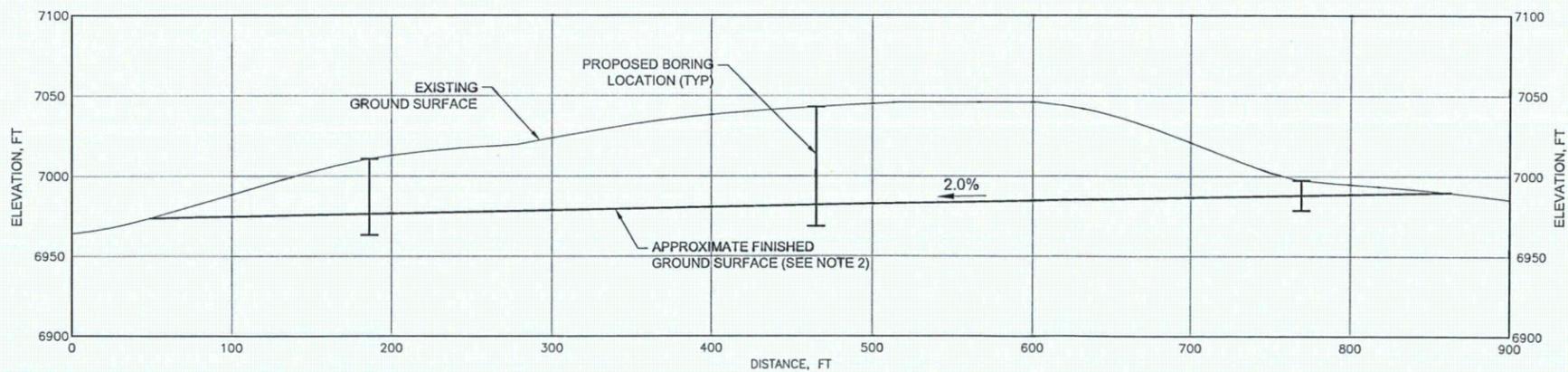
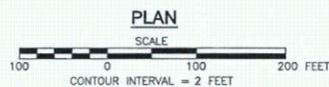


LEGEND:

- 7040 EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- 7040 POTENTIAL FINISHED GROUND SURFACE CONTOUR & ELEVATION, FEET (SEE NOTE 2)
- APPROXIMATE IMPOUNDMENT AREA
- ROADS
- NATURAL DRAINAGE
- MILL SITE PROPERTY BOUNDARY
- CHANNEL
- SWALE
- SECTION LINE
- PROPOSED DRILLING LOCATION

NOTE:

1. NO PRIOR BORROW INVESTIGATION HAS BEEN CONDUCTED AT THE DILCO HILL.
2. FINISHED GROUND SURFACE SHOWN IF DILCO HILL MATERIAL IS BORROWED FOR REPOSITORY CONSTRUCTION.



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PROJECT LOCATION
MCKINLEY COUNTY, NEW MEXICO
PROJECT
CHURCH ROCK MILL SITE PDS WORK PLAN
TITLE
PROPOSED BORROW AREA SAMPLING
LOCATIONS, DILCO HILL



FIGURE 3-8 REVISION
0
FILE NAME
1012217 PBASLDH DATE
AUG 2013

Ground Cover Transect
(Set-up points at 1-meter intervals)

Woody Plant Density Belt
2m X 50m

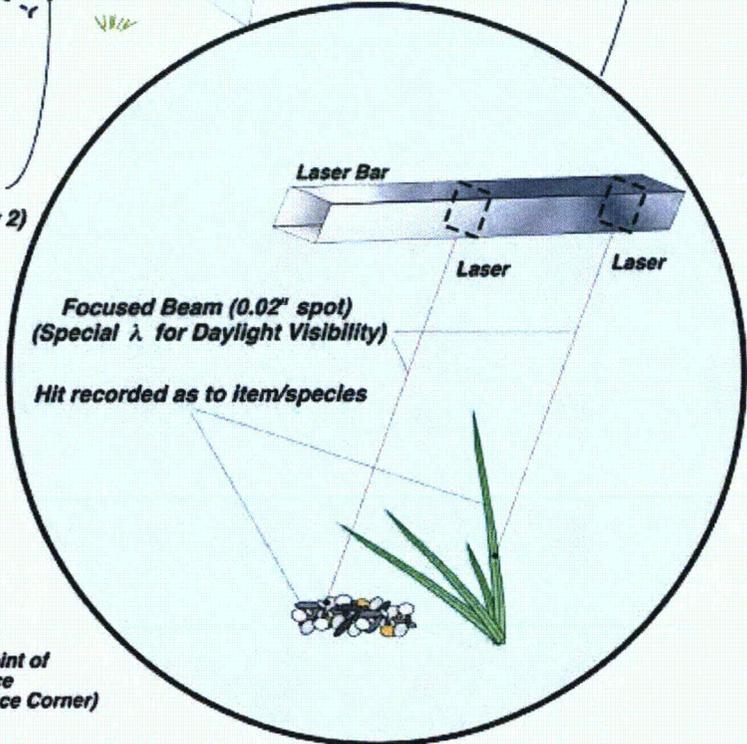
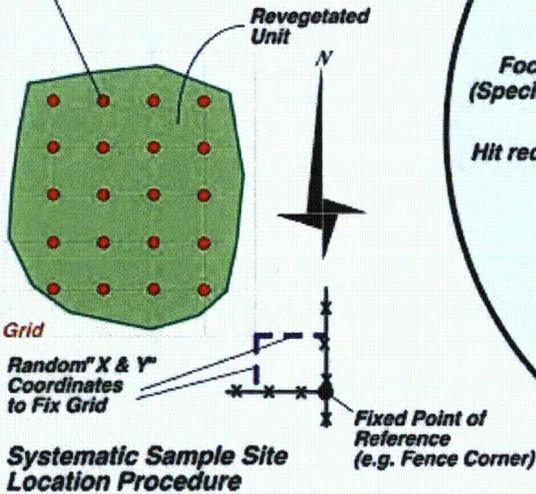
Laser / Point-Intercept Bar
(Intercepts at 10 cm intervals -
note path of "beams" for "hits"
on ground cover)

**Note: 10 set-up points per
transect with 10 intercepts
per set-up point results in
100 intercepts per transect**

0.5 m² Production Quadrat
(Situated to the side to
avoid trampling of vegetation).
Quadrat is also used for species
Frequency Evaluation.

Sample Site
(Starting Point)

Potential 2nd flip of quadrat
for highly variable types
(results would be divided by 2)



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PROJECT LOCATION	McKINLEY COUNTY, NEW MEXICO
PROJECT	CHURCH ROCK MILL SITE PDS WORK PLAN
TITLE	VEGETATION SAMPLING PROCEDURE



FIGURE 3-9	REVISION 0
FILE NAME 1011273 VEG	DATE AUG 2013

TABLES

Table 1-1. Basis of Design Summary

Design Element	Performance Criterion	Performance Criterion Reference or Guidance ¹	Data Reference ¹	Available Data	Potential Data Gaps
Repository and Cover Design					
Site restoration	Attainment of erosional stability and preclusion of off-site transport of generated sediments from the mine permit area. Establish self-sustaining ecosystem consistent with pre-mining conditions.	RG023, RG001	RSE and SRSE reports 623	Baseline vegetation information for adjacent community	Vegetation evaluation to be performed as described in Section 3.
Maintenance of cover over tailings and construction of new cover over mine spoils	Narrative performance standard, including isolation of tailings and associated mine materials, design of cover to limit flux into the underlying materials and minimize soil loss due to erosion, construct features for acceptable performance from runoff from design storm, and design to minimize future maintenance of the existing impoundment and new repository.	10CFR40 Appx A criterion 1, 6(1) (RG017); RG018; 40CFR192 (RG019) RG020 RG006 RG007			No field data required.
Consolidation of mine spoils onto tailings impoundment	Minimize footprint No proliferation of disposal sites Upstream catchment minimized	10CFR40 Appx A criterion 2, 3, 4a (RG017); NUREG 1620 (RG006)		As-Built reports document tailings reclamation procedure and consistency with closure plans. Closure plans document compliance with performance criteria.	No field data required.
Existing Tailings Cover/Low Permeability Layer at Base of Repository	Becomes low permeability layer at base of repository.	RG028	400, 402, 421, 422, 450, 460, and 470	As-Built reports include geotechnical information for existing tailings cover, including compaction, gradation, Atterberg limits.	Characterization of hydraulic conductivity of existing tailings cover under proposed repository footprint, compacted to anticipated construction specification. See Figure 3-1 for sampling locations, and Tables 3-1 and 3-2 for laboratory tests and methods.
Placement of Mine Spoils	Narrative performance standard including minimizing waste footprint and optimizing footprint with allowable slopes and erosion protection. Compaction to minimize settlement. Place higher activity material deeper in the repository, as possible.	RG019	Results of geotechnical testing of Mine Site soils presented in 620 and 613.	Geotechnical testing results for seven samples, including moisture content, saturated hydraulic conductivity, standard Proctor compaction, moisture retention characteristics, particle size, and specific gravity.	In place density and compaction information for Mine Site soils to be placed in repository and compacted. See Volume II (MWH, 2013).
Placement of comingled TPH and Ra-226 soils	Narrative performance standard, including minimization of waste footprint	RG019		Comingled TPH and Ra-226 soils were left in place during the IRA and/or stockpiled at the site.	No field data required
Placement of Mine Debris/Filling of Void Spaces	Minimize potential for future settlement	RG019 RG029 RG030		Consistent with 1993 UNC Mill Decommissioning Report	No field data required. Plan for mine debris placement will be developed during design.
Cover Material		RG018 RG020 RG007	510	Borrow soil required for repository cover construction approximately 200,000 to 320,000 cy. Volume of cover borrow material available, based on preliminary estimates: East Borrow Area: 204,000 cy West Borrow Area: 143,000 cy Dilco Hill: 337,000 cy	Characterization of variability and suitability of potential borrow areas. See Figures 3-6 through 3-8 for borrow sampling locations and Table 3-4 for laboratory tests and methods.

Table 1-1. Basis of Design Summary (continued)

Design Element	Performance Criterion	Performance Criterion Reference or Guidance ¹	Data Reference ¹	Available Data	Potential Data Gaps
Repository and Cover Design (Continued)					
Cover slopes	Surface features shall direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future	10CFR40 Appx A criterion 4c, 4f (RG017); RG018; RG007	410a-c, 461 (Appendices F and G)	Results of durability testing on existing stockpiled erosion protection rock. Cover slopes are anticipated to be 1-2% on top surface and 5:1 on side slopes.	No field data required.
Erosional stability	Erosion protection of self-sustaining vegetation and / or rock	10CFR40 Appx criterion 4a, 6(1)4 (RG017); RG007; RG013; Dwyer, Rager and Hopkins, 2006 Dwyer, 2012	510 410a-c, 461 (Appendices F and G)	Volume of stockpiled erosion protection (basalt) and bedding material on site: <ul style="list-style-type: none"> 0.02-inch (D₅₀) - 822 cy 0.35-inch (D₅₀) - 325 cy 1.5-inch (D₅₀) - 4,469 cy 3.0-inch (D₅₀) - 600 cy 6.0-inch (D₅₀) - 143 cy 10.0-inch (D₅₀) - 314 cy PMP will be determined during design - derived from Hydrometeorological Report No. 49, 410, or most current NOAA information.	Verify gradation and durability of stockpiled 1.5-in and 3-in rock. See Table 3-4 for laboratory tests and methods. PMP determination procedure has not changed since 1991. No additional PMP estimate is necessary.
Tie into existing site features	Performance narrative. Repository will tie into existing erosion protection features if possible, and will aesthetically match existing site features.		450, 460, 470	Site topography and drainage features As-built details and construction QC data on existing drainage swales	Topographic survey of repository and surrounding areas to be performed, as described in Section 3. Tie-ins to existing slopes and use of existing drainage swales will be developed during design. Qualitative evaluation of swale integrity and survey of cross section of drainage swales that may be used after repository construction.
Control of radon emanation	Attenuation of radon-222 to 20 pCi/m ² -sec average emanation rate	10CFR40 Appx A6(1) (RG017); RG019; RG009; RG008	Existing spoil results in 571, 580, and 610 601	Static gamma points: 2,350 Surface and subsurface sampling and testing for Ra-226: 750	Determination of long-term moisture content and density characteristics of soils.
Cover permeability	Cover permeability less than or equal to natural subsoils present	RG020 RG025 RG018	Geotechnical laboratory testing during preliminary borrow investigation presented in 622, 510	Results of hydraulic soil property testing and particle size analysis from sample from East and West Borrow Areas.	Hydraulic properties of borrow materials for cover construction. See Figures 3-6 through 3-8 for borrow sampling locations and Table 3-4 for laboratory tests and methods. Design will include review of historic weather data. Design will include unsaturated flow modeling.

Table 1-1. Basis of Design Summary (continued)

Design Element	Performance Criterion	Performance Criterion Reference or Guidance ¹	Data Reference ¹	Available Data	Potential Data Gaps
Repository and Cover Design (continued)					
Cover infiltration	Covers shall be designed to minimize to the extent practicable flux through the cover, to direct percolating or surface water away from the waste, and to resist degradation by surface geologic processes and biotic activity.	RG018 RG020	Geotechnical laboratory testing during preliminary borrow investigation presented in 622 510	Results of hydraulic soil property testing and particle size analysis from sample from East and West Borrow Areas.	Hydraulic properties of borrow materials for cover construction. See Figures 3-6 through 3-8 for borrow sampling locations and Table 3-4 for laboratory tests and methods. Design will include review of historic weather data. Design will include unsaturated flow modeling of flux through cover, including incorporation of gravel mulch and use of existing gravel mulch if appropriate Revegetation of cover will be developed during design, and incorporated in cover water balance model during design.
Surface Water Control		RG006			No field data required. Surface water control features (run-on and run-off control) to be designed.
Freeze/Thaw		RG006	Geotechnical laboratory testing during preliminary borrow investigation presented in 622	Results of hydraulic soil property testing and particle size analysis from sample from East and West Borrow Areas.	Geotechnical properties of borrow materials for cover construction. See Figures 3-6 through 3-8 for borrow sampling locations and Table 3-4 for laboratory tests and methods. Freeze/thaw evaluation to be performed during design.
Slope stability	<u>Loading Condition:</u> End of Construction – Min. factor of Safety = 1.3 (UU and CD) Static, Long-term – Min. factor of Safety = 1.5 (CU and CD) Earthquake – Min. factor of Safety = 1.0* *pseudostatic, in addition to liquefaction and deformation analyses	RG006, RG035	Geotechnical laboratory testing during preliminary borrow investigation presented in 622. Results of geotechnical testing of Mine Site soils presented in 620 and 613. 280, 281, 291a, 360, 362, 372, 431, 626, 990, 991, 992	Particle-size analysis, standard Proctor compaction. Original embankment design information (280, 281). Geotechnical properties of existing materials, groundwater information from Chester reports and summaries.	Sampling and geotechnical characterization of western embankment and foundation materials Figures 3-1 through 3-5 and Tables 3-1 and 3-2. Tailings sampling and geotechnical characterization per Figures 3-1 through 3-5 and Tables 3-1 and 3-2. Static and pseudostatic slope stability analyses to be performed during design.
Biointrusion				None	Characterize analog sites for depths of roots and borrows.

Table 1-1. Basis of Design Summary (continued)

Design Element	Performance Criterion	Performance Criterion Reference or Guidance ¹	Data Reference ¹	Available Data	Potential Data Gaps
Repository and Cover Design (continued)					
Liquefaction		10CFR40 Appx A criterion 4e (RG017); RG006, RG035	400, 402, 421, 422, 450, 460 and 470 300 ER001a-b, ER002a-c	As-built data on the existing impoundment Previous seismic information	Tailings sampling and geotechnical/hydraulic characterization per Figures 3-1 through 3-5 and Tables 3-1 and 3-2. Liquefaction evaluation to be performed during design.
Seismic Hazard Evaluation	Seismic stability	RG006; 10CFR40 Appx A criterion 4e (RG017), RG006	400, 402, 421, 422, 450, 460 and 470 300 ER001a-b, ER002a-c	As-built data on the existing impoundment Previous seismic information	Update with USGS 2008 Probabilistic Seismic Hazard Analysis data and capable fault information as part of design.
Cover Cracking		RG006	Geotechnical laboratory testing during preliminary borrow investigation presented in 622	Particle-size analysis, standard Proctor compaction for borrow soils.	Geotechnical properties of borrow materials for cover construction. See Figures 3-6 through 3-8 for borrow sampling locations and Table 3-4 for laboratory tests and methods. Tailings sampling and geotechnical/hydraulic characterization per Figures 3-1 through 3-5 and Tables 3-1 and 3-2. Cover cracking evaluation to be performed during design.
Differential Settlement	Place mine spoils and debris in manner to minimize settlement. Design repository to accommodate settlement/ subsidence and promote drainage. Potential differential settlement based on final cross section, soil properties and construction tolerances.	RG006	Historical settlement monitoring results as reported in 400, 422, 450, 440, Western Technologies (1991) 612, 570, 611, 620 360, 362, (tailings thickness data and consolidation test results) 372 (hydrogeologic data and geologic cross sections of the impoundment) 990, 991, 992 (Updated geologic cross sections and thickness contours).	<u>North Cell (400)</u> 3 settlement monitoring pts. (max. settlements 0.9 feet, at PSM-9) Plots indicate 90% consolidation reached, monitoring stopped (T100 = 72, 86 and 130 days). <u>Central Cell (421)</u> 1 settlement monitoring pt. (total settlement 0.42 feet, 10/91 to 3/92). 90% consolidation reached, monitoring stopped. <u>South Cell (422)</u> 3 settlement monitoring pts. (max. settlements 0.18 feet, 0.9 feet and 1.1 feet). Plots indicate 90% consolidation in about 100 days, monitoring stopped. (T100 = 101, 100 and 102 days).	Tailings sampling and geotechnical/hydraulic characterization per Figures 3-1 through 3-5 and Tables 3-1 and 3-2. Consolidation settlement to be evaluated during design.
Drainage		RG006, RG020	240, 280, 291a, 360, 362, 372, 431, 626, 990, 991, 992,	Geotechnical index, strength and consolidation properties of the tailings in the central cell; Hydraulic properties of the underlying units; groundwater data for the site;	Tailings sampling and geotechnical characterization of tailings and underlying strata per Figures 3-1 through 3-5 and Tables 3-1 and 3-2.

Table 1-1. Basis of Design Summary (continued)

Design Element	Performance Criterion	Performance Criterion Reference or Guidance ¹	Data Reference ¹	Available Data	Potential Data Gaps
Repository and Cover Design (continued)					
Design life for evaluation of facility components	Narrative performance standard including a design effective for 1,000 years or at least 200 years, and minimizes need for future maintenance	10CFR40 Appx A6(1) (RG017); RG019; RG004; RG005; RG007; RG034			Investigation of natural analog - Measurement of unsaturated hydraulic conductivity properties via 3 tension infiltrometer tests in soils at a nearby site.
Revegetation	To be established based on vegetation analog	10CFR40 Appx A criterion 4d (RG017)			Establishment and baseline characterization of vegetation analog sites.
Characterization of Underlying Units		RG006	190, 240, 250, 260, 261, 280, 281,291a, 300, 340, 341, 360, 362, 372, 431, 626, 990, 991, 992,	Pre-construction geotechnical data on the alluvium beneath the impoundment. Hydraulic conductivities of the alluvium and Zone 3 Gallup sandstone Geologic Cross Sections (372) Index properties and hydraulic conductivities of the alluvium (pre-construction), properties of the tailings	Includes fine and coarse tailings, alluvium and Zone 3 sandstone underlying the proposed repository. Sampling and characterization units underlying the tailings impoundment, per Figures 3-1 through 3-5 and Tables 3-1 and 3-2.
Construction sequencing	Narrative performance standard including design repository to minimize contact of water with waste during storage, contact of standing water with waste during disposal and contact of percolating or standing water with wastes after disposal.	RG018			No additional data required for design.
Environmental Elements Design					
Dust control	Nuisance dust – PM2.5 and PM10	RG022	None	None	No field data required for design. Develop air monitoring program, including baseline monitoring prior to the start of construction.
Radiological protection	Annual Occupational Dose Limits Annual dose limits to individual members of the public: Internal radiation	RG014, RG015, RG016; RG024	None	None	No field data required for design. Develop radiation protection program, including baseline monitoring prior to the start of construction.
Cultural Resources Protection	SHPO	SHPO	None	None	Cultural resources inventory of Mine Site and potential borrow areas.
Storm water management / E&S controls	Attainment of erosional stability and preclusion of off-site transport of generated sediments from work areas.	Substantive requirements of RG001		RSE report.	No additional data required for design.

Notes:

- (1) Project document references are provided in Table 1-2. Performance criteria references and guidance documents are listed in Table 1-3.
- (2) "Placement" refers to the general order and methods used to physically place the materials in lifts and compact them.

Table 1-2. Index of Project Documents for the Church Rock Mill Site

Record No.	Document/Dataset	Author	Date Issued	Description
Historic Documents - Church Rock Mill Site				
190	Report of Soils and Foundation Investigation, Church Rock Uranium Mill – United Nuclear Corporation, Gallup New Mexico	Hemphill Corporation	30 Jun 1969	Geotech data for the mill buildings, and preliminary info under the dam
240	Preliminary Geotechnical Investigation Report	Sergent, Hauskins & Beckwith	Oct 1974	Preliminary Geotechnical investigation for the construction of the tailings dam, this report includes borings prior to dam construction, laboratory and field testing of the alluvium (ref. is included as part of 1975 Env. Report)
250	Preliminary Geotechnical Investigation Report	Sergent, Hauskins & Beckwith	Jan 1975	Completed for Kaiser Engineers, borings along the dam alignment
260	Geotechnical Investigation Report UNC Tailings Dam and Pond	Sergent, Hauskins & Beckwith	May 1976	Geotechnical investigation for the construction of the tailings dam
261	Seismic Refraction Investigations Report	Sergent, Hauskins & Beckwith	Jul 1976	Seismic velocity profile and configuration of the near surface materials
280	Geotechnical and Design Development Investigation Report (Vol.2)	Sergent, Hauskins & Beckwith	Jul 1978	Borings and lab data (no report text), borings along the dam and in the Borrow No.1 and 2 area
281	Engineering Analysis Report	Sergent, Hauskins & Beckwith	Oct 1978	Embankment Volumes – Borrow Quantities, Tailings Disposal System Analysis
290	Discharge Plan for Northeast Church Rock Mine Backfill	United Nuclear Corp.	Feb 1979	A discharge plan for using coarse Church Rock Mill tailings for backfilling the Church Rock mine site.
291a	Geotechnical Investigation Report, Volume 1	Sergent, Hauskins & Beckwith	Jul 1979	Stability and integrity assessment, post breach investigation, borings through the dam in the south cell and north cell, borings through the cross dikes include tailings data
292	Letter to UNC from A.E. Saucier (consulting geologist)	Sedi-Met, Inc.	12 Dec 1979	Mapping of Sandstone ledge encountered in Borrow Pit 2
300	Final Design Report, Southeast Evaporation Ponds	Civil Systems Inc.	Aug 1980	Borings and geotechnical data, southeast of the Central Cell, for proposed evaporation ponds
301	Unsaturated Flow Parameters of Uranium Mill Tailings	Veyera	Fall 1980	<i>(reference only, not on Sharepoint)</i>
302	The Failure of the Church Rock Tailings Dam	J.D. Nelson and J.D. Kane	1980	Summary paper describing the 1979 breach of the south cell written for NRC
310	Geology of the Church Rock Area	Science Applications Inc.	Nov 1981	Geology of the area around the tailings facility
320	Evaluation of Proposed Tailings Deposition South Cell	Raney Geotechnical	15 Mar 1982	
321	Estimation of Soil Water Properties	Rawls, Brakensiek & Saxton	1982	<i>(reference only, not on Sharepoint)</i>
340	Tailings Ponds Seepage Treatment Study	Bechtel	Dec 1984	
341	Tailings Ponds Conceptual Seepage Abatement Plans	Bechtel	Dec 1984	
350	Reference Crop Evapotranspiration from Ambient Air Temperature	Hargreaves and Samani	Dec 1985	<i>(reference only, not on Sharepoint)</i>
360	Draft memorandum regarding estimated tailings cover thickness required to satisfy the USEPA radon flux standard – revision 1	UNC	12 Mar 1986	
361	Southwest Alluvial: Resistivity Study	Michael Penick	19 May 1986	
362	Letter to Canonie RE: Previous Geotechnical Data	UNC	14 Oct 1986	Includes data from borings through the Central Cell tailings and Borrow Pit No.1 Synopsis of Test Results on Auger Samples and Soil Pit samples taken in October 1985 and an SH&B report on auger holes drilled near NECR IX downslope from the last retention pond
370	Abandonment and Reclamation Plan, Church Rock I, IE and II Mines	Quivira Mining Co.	Jan 1987	
371a	Reclamation Plan, Engineering Concepts	Canonie Environmental	Apr 1987	Engineering concepts for proposed interim stabilization and final reclamation of tailings.
372	GeoHydrologic Report, Church Rock Site, UNC Mining and Milling, Gallup, New Mexico.	Canonie Environmental	May 1987	Geology and hydrogeology of the Mill Site tailings impoundment
371b	Reclamation Plan, Appendices A1, A2 & A3	Canonie Environmental	Jun 1987	Moisture-density; particle size; rock, boring & test pit logs
371c	Reclamation Plan, Appendix A4	Canonie Environmental	Jun 1987	Boring logs
371d	Reclamation Plan, Appendix A5	Canonie Environmental	Jun 1987	Test pit logs

Table 1-2. Index of Project Documents for the Church Rock Mill Site (continued)

Record No.	Document/Dataset	Author	Date Issued	Description
380	Reclamation Plan, Amendment 1	Canonie Environmental	Jul 1988	Reclamation Plan Amendment to License No. SUA-147.
381	NRC Reclamation Cost Estimate	Canonie Environmental	Aug 1988	
382	Mill Decommissioning Plan	UNC	Dec 1988	
390	Tailings Sand Backfill Cleanup Verification Report	United Nuclear Corp.	Apr 1989	Provides data that verify that the byproduct material from the tailings sand backfill areas and associated mine ponds were removed.
391	Cleanup of Tailings at the Northeast Church Rock Mine	United Nuclear Cop.	Oct 1989	Letter documenting the submittal and objectives of Docs. Ab017 and AB018.
400	As-Built Report, North Cell Interim Stabilization	Canonie Environmental	Jan 1990	North Cell interim stabilization as-built report.
401	Letter from BLM to Quivera Mining regarding Reclamation Plan	U.S. BLM	Oct 1990	Notification of approval for Abandonment and Reclamation Plan
402	Response to Comments and Proposed Reclamation Plan Modifications	Canonie Environmental	Dec 1990	Response to Comments and Proposed Reclamation Plan Modifications.
410a	Tailings Reclamation Plan, Vol. 1	Canonie Environmental	Aug 1991	Tailings Reclamation Plan as approved by NRC March 1, 1991 for License No. SUA - 1475, Vol. 1.
410b	Tailings Reclamation Plan, Vol. 2	Canonie Environmental	Aug 1991	Tailings Reclamation Plan as approved by NRC March 1, 1991 for License No. SUA - 1475, Vol. 2.
410c	Tailings Reclamation Plan, Vol. 3	Canonie Environmental	Aug 1991	Tailings Reclamation Plan as approved by NRC March 1, 1991 for License No. SUA - 1475, Vol. 3.
420	Engineer's Report: NRC Reclamation Cost Estimate Revised Reclamation Plan, Response to Comments	Canonie Environmental	Jan 1992	
421	As-Built Report, Central Cell Interim Stabilization	Canonie Environmental	Apr 1992	Central Cell interim stabilization as-built report.
422	As-Built Report, South Cell Interim Stabilization	Canonie Environmental	Apr 1992	South Cell interim stabilization as-built report.
423	Memorandum regarding Proposed Action Plan for Verification of Radon Flux over Central Cell	UNC	7 Oct 1992	
424	Comments on Proposed Tailings Investigation Program	Canonie Environmental	14 Oct 1992	
430	Mill Decommissioning Report	United Nuclear Corp	Apr 1993	Mill decommissioning report
431	Central Cell Soil Sampling results	Canonie	28 Sep 1993	
432	Final Radiological Report	United Nuclear Corp	Nov 1993	Request for License Amendment/Final Radiological Report for Mill Decommissioning.
440	As-Built Report, North Cell Final Reclamation	Canonie Environmental	Nov 1994	
450	As-Built Report, Central Cell Final Reclamation	Canonie Environmental	Jun 1995	Central Cell final reclamation as-built report.
460	As-Built Report, South Cell Final Reclamation	Smith Environmental	Apr 1996	South Cell final reclamation as-built report.
461	As-Built Report, Final Reclamation Borrow Pit No. 2	Environmental Technologies	Aug 1996	Final Reclamation Borrow Pit No. 2 as-built report
470	As-Built Report, 1996 Final Reclamation Construction	Smith Environmental	Mar 1997	1996 Final Reclamation Construction as-built report.
480	Tailings Pile Seepage Model, The Atlas Corporation Moab Mill, Moab, Utah	ORNL	Jan 9 1998	Prepared for US NRC
481	Evaluation of Church 1996 Rock Radon Flux Tests	U.S. NRC	Apr 1998	
500	UNSAT-H Version 3.0: Unsaturated Soil water and Heat Flow Model – Theory, User Manual and Examples	Fayer	Jun 2000	(reference only, not on Sharepoint)
510	Cover System Design Guidance and Requirements Document	Dwyer, Rager & Hopkins	Apr 2001	
530	Water Balance Measurements and Computer Simulations of Landfill Covers	Dwyer	May 2003	
531	Moab Site, Site Observational Work Plan for the Moab, Utah, Site	SM Stoller	Dec 2003	Work performed for DOE

Table 1-2. Index of Project Documents for the Church Rock Mill Site (continued)

Record No.	Document/Dataset	Author	Date Issued	Description
540	Rationale and Field Investigation Work Plan to Evaluate Recharge and Potential Cell Sourcing to the Zone 3 Plume, Church Rock Site	US Filter	Jan 2004	Includes geologic contour mapping and summary of existing data
541	Draft Technical Guidance for RCRA/CERCLA Final Covers	EPA	Apr 2004	Dwyer, Co-author
550	Cultural Resources Inventory Permit B05230	Navajo Nation	23 Mar 2005	
551	A Cultural Resources Survey of 125 Acres for the Proposed Closeout of the Northeast Church Rock Mine, McKinley County, New Mexico	Lone Mountain Archeological Services	11 Jul 2005	
570	Geophysical Survey Report	Document	Jun 2007	Results of magnetics (mag) and electromagnetic induction (EM) surveys that were conducted to identify subsurface geophysical anomalies within the Mine Site.
571	Removal Site Evaluation Report	Document	Oct 2007	Results of the Removal Site Evaluation (RSE) conducted between August and December 2006, including a baseline human health risk assessment.
581	Recommendations and Summary of Hydrogeologic Analysis Evaluation of Groundwater Flow in Zone 3 for the Design of a Pumping System to Intercept and Recover Impacted Groundwater	N.A. Water Systems	25 Apr 2008	
600	License Number SUA-1475, Amendment No. 43	NRC	2010	
612	Evaluation of Consolidation and Water Storage Capacity Related to Placement of Mine Material on the Existing UNC Mill Site Tailings Impoundment	Dwyer Engineering	May 2011	Evaluation of consolidation and water storage capacity related to placement of mine material on the existing Church Rock Mill Site tailings impoundment
613	Laboratory Report for Dwyer Engineering, LLC	Daniel B. Stephens & Assoc., Inc.	Aug 2011	Laboratory Testing Results for Mine Site soils, to accompany 612.
614	Technical Memorandum Summarizing Two Reports on Zone 3 Tailings Seepage Sourcing and Groundwater Recharge, with Information Update	Chester Engineers	Aug 2011	
620	Summary of Geotechnical Data	Dwyer Engineering	Jan 2012	
621	Approximation of Gravel/soil Admixture for NECR Cover	Dwyer	9 Jan 2012	
622	Potential Borrow Areas and Borrow Characterization Plan, Church Rock Millsite	MWH	Feb 2012	Evaluation of the locations and potential volumes of borrow material for use at the Church Rock Mill Site.
623	Vegetation and Wildlife Evaluations / Revegetation Recommendations, 2009 Evaluations and Planning	Cedar Creek	Feb 2010	Evaluation of vegetative conditions and revegetation potential for the 2009 IRA area; includes revegetation plan for the 2009 IRA
624	Preliminary Review of the Consolidation and Water Storage Capacity Related to Placement of Mine Material on the Existing UNC Mill Site Tailings Impoundments Report, Prepared for the Northeast Church Rock Mine Site, Gallup, New Mexico	Division of Waste Management and Protection	20 Aug 2012	
625	DOE-LM Comments on the Report Titled, "Evaluation of Consolidation and Water Storage Capacity Related to Placement of Mine Material on the Existing United Nuclear Corporation (UNC) Mill Site Tailings Impoundment, Northeast Church Rock Mine, Gallup, New Mexico, by Stephen F. Dwyer, Ph.D., PE, May 2011	DOE	7 Sep 2012	
626	Groundwater Flow Model of the Church Rock Site and Local Area, Church Rock, New Mexico	Chester Engineers	Oct 2012	
627	Proposed Additional Sensitivity Analysis: Evaluation of Consolidated and Water Storage Capacity Related to Placement of Mine Material on the Existing UNC Mill Site Tailings Impoundment – DRAFT	Dwyer	14 Dec 2012	
628	Reply to DOE Comments on the report: "Evaluation of Consolidation and Water Storage Capacity Related to Placement of Mine Material on the Existing UNC Mill Site Tailings Impoundment	Dwyer	14 Dec 2012	
629	Reply to NRC Comments on the report: "Evaluation of Consolidation and Water Storage Capacity Related to Placement of Mine Material on the Existing UNC Mill Site Tailings Impoundment	Dwyer	14 Dec 2012	

Table 1-2. Index of Project Documents for the Church Rock Mill Site (continued)

Record No.	Document/Dataset	Author	Date Issued	Description
630	Review of United Nuclear Corporation/General Electric Documents Submitted in November and December 2012 related to the UNC Church Rock – Northeast Church Rock Non-time Critical Removal Action	NRC	16 May 2013	
631	DOE Comments on MWH's Supplemental Data Needs Evaluation and Work Plans for Removal Design, Northeast Church Rock Mine Site Removal Action (November 9, 2012)	DOE	17 May 2013	
990	Aquifer Testing and Material Properties (compilation of information)	Chester Engineers	19 July 2013	Memo summary of available aquifer data
991	Geochemical Properties of Alluvium and Sandstone Units	Chester Engineers	19 July 2013	Memo summary of site geochemical properties
992	Geologic Setting, Structure and Piezometric Surfaces (compilation of information)	Chester Engineers	19 July 2013	Memo summary of site geology and piezometric surfaces.
993	Appendix A. Construction/Technical Specifications Seepage Remediation System	UNC?	Undated	
994	Transient Drainage from UMTRA Tailings	Larson & Goering	Undated	<i>(reference only, not on Sharepoint)</i>
995	Unsaturated Hydraulic Parameters of Grand Junction Uranium Tailings	Veyera and Nelson	Undated	<i>(reference only, not on Sharepoint)</i>
996	Geotechnical Properties of Hydraulically Placed Uranium Mill Tailings	Keshian & Rager	Undated	<i>(reference only, not on Sharepoint)</i>
999	Video Surveys of Mine Shafts and Vents	UNC	2008	Video and memorandum documenting location and condition of mine shafts and vents
Environmental Review Documents - Church Rock Mill Site				
ER001a	Applicant's Environmental Report on the Church Rock, New Mexico Uranium Mill and Mine, Volume 1	UNC	1975	Text, tables and figures
ER001b	Applicant's Environmental Report on the Church Rock, New Mexico Uranium Mill and Mine, Volume 2	UNC	1975	Appendices include Geology, Seismology and Stability Analyses Church Rock Uranium Tailings Dam (Kaiser Engineers, 10/2/74), Hydrologic Conditions Near the UNC Millsite (Shomaker, 11/74), Ecology of the UNC NE Church Rock, NM, Property (Gould, 9/13/74), the preliminary geotechnical investigation by Sergent, Hauskins & Beckwith, and correspondence regarding site archeology, demography, landmarks; the USEPA discharge permit; Design of Tailings Disposal System (Kaiser Engineers, 9/74)
ER002a	State of New Mexico Environmental Improvement Division Uranium Mill License Renewal Application – Environmental Report License No. NM-UNC-ML, Volume I	D'Appolonia	Dec 1981	Text and tables
ER002c	State of New Mexico Environmental Improvement Division Uranium Mill License Renewal Application – Environmental Report License No. NM-UNC-ML, Volume II	D'Appolonia	Dec 1981	Figures
ER002c	State of New Mexico Environmental Improvement Division Uranium Mill License Renewal Application – Environmental Report License No. NM-UNC-ML, Volume I	D'Appolonia	Dec 1981	Appendices

Table 1-3. Index of Regulatory and Guidance Documents for the Removal Action

Record No.	Document	Author	Date Issued
RG001	National Pollutant Discharge Elimination System Final General Construction Permit	US Environmental Protection Agency	February 2012
RG002	Action Memorandum: Request for a Non Time Critical Removal Action at the Northeast Church Rock Mine Site	US Environmental Protection Agency, Region 9	September 29, 2011
RG003	Manual on Uniform Traffic Control Devices	US Department of Transportation. Federal Highway Administration	2007
RG004	NUREG/CR-4620 Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments	US Nuclear Regulatory Commission	1986
RG005	NUREG/CR-3397 Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Impoundments	US Nuclear Regulatory Commission	1983
RG006	NUREG-1620 Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978	US Nuclear Regulatory Commission	June 2003
RG007	NUREG-1623 Design of Erosion Protection for Long-Term Stabilization	US Nuclear Regulatory Commission	September 2002
RG008	NRC Regulatory Guide 3.64 Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers	US Nuclear Regulatory Commission	June 1989
RG009	NUREG/CR-3533 Radon Attenuation Handbook for Uranium Mill Tailings Cover Design	US Nuclear Regulatory Commission	1984
RG010	NUREG/CR-5849 Manual for Conducting Radiological Surveys in Support of License Termination	US Nuclear Regulatory Commission	1992
RG011	Comprehensive Transportation Safety Plan	New Mexico Department of Transportation	April 2009
RG012	Probable Maximum Precipitation Estimates, Colorado River and great Basin Drainages Hydrometeorological Report No. 49	National Oceanic and Atmospheric Administration	1977
RG013	Final Staff Technical Position, Design of Erosion Protective Covers for Stabilization of Uranium Mill Tailings Sites	U.S. Nuclear Regulatory Commission	August 1990
RG014	10 CFR 20.1101 (Subpart B) Radiation Protection Programs	US Nuclear Regulatory Commission	
RG015	10 CFR 20.1301 (Subpart D) Dose Limits for Individual Members of the Public	US Nuclear Regulatory Commission	
RG016	10 CFR 20.1302 (Subpart D) Compliance with Dose Limits for Individual Members of the Public	US Nuclear Regulatory Commission	
RG017	10 CFR 40 Domestic Licensing of Source Material	US Nuclear Regulatory Commission	
RG018	10 CFR 61.51 Disposal Site Design for Land Disposal	US Nuclear Regulatory Commission	
RG019	40 CFR 192 Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings	US Environmental Protection Agency	
RG020	40 CFR 264.310 Closure and Post-Closure Care	US Environmental Protection Agency	
RG021	49 CFR 105-177	Occupational Safety and Health Administration	
RG022	Federal Register (FR) 71 National Ambient Air Quality Standards for Particulate Matter		
RG023	NMAC 19.10.5 Natural Resources and Wildlife Non-Coal Mining Existing Mining Operations	New Mexico Administrative Code	
RG024	NMAC 20.3.4 Environmental Protection Radiation Protection Standards for Protection Against Radiation	New Mexico Administrative Code	
RG025	ASTM Section C and D Test Standards		
RG026	MARSSIM		
RG027	NMAC 20.3.13.1313 Post-Closure Observation and Maintenance	New Mexico Administrative Code	
RG028	United Nuclear Corporation Superfund Site Surface Soil Operable Unit Proposed Plan Gallup, New Mexico	US Environmental Protection Agency Region 9	July 2012
RG029	Technical Approach Document, Revision II. UMTRA-DOE/AL 050425.0002.	Department of Energy	1989
RG030	WSSRAP Disposal Facility Technical Specifications, Section 2300: Waste removal, Handling, and Placement. WP-437, Disposal Cell Construction.	Department of Energy	May 2000
RG031	40 CFR 61 Subpart M. National Emission Standard for Asbestos. National Emissions Standards for Hazardous Air Pollutants	US Environmental Protection Agency	
RG032	OSHA Construction Asbestos Standard 29 CFR 1926.1101	Occupational Safety and Health Administration	
RG033	Surface Mining Control and Reclamation Act		December 2006
RG034	NUREG-1757 Volume 2, Revision 1, Appendix P		
RG035	NUREG-3.11 Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills (rev.2)	US Nuclear Regulatory Commission	December 1977

Table 3-1. Estimated Profile at Proposed Sampling Locations

Impoundment Profile ¹	Proposed Sampling Locations											
	1	2	3	4 ²	5 ²	6 ²	7 ²	8	9 ²	10	11	12 ²
	(thickness in feet ¹)											
Embankment	25	-	35	-	-	-	-	-	-	-	-	-
Tailings/Cover	-	5	-	10	7	12	29	25	35	28	25	21
Alluvium	20	27	20	5	5	5	5	30	3	3	22	5
Zone 3 Sandstone	-	20	-	-	-	-	-	10	-	20	-	-
Zone 1 Sandstone	-	-	-	-	-	-	-	-	-	-	20	-
Total Depth (est.)	45	52	55	15	12	17	34	65	38	51	67	26

Notes:

1. Estimated profiles and thicknesses are based on proposed sampling depths
2. CPT location only, no paired borehole
3. Sampling locations are shown in Figures 3-1 and 3-2.

Table 3-2. Geotechnical Characterization Objectives and Sampling Methods for the Tailings Impoundment and Underlying Units

Material	In-situ (Sample Type)	Ex-situ (Sample Type)
Existing cover – soil/rock layer	<ul style="list-style-type: none"> • Thickness/stratigraphy (visual) 	<ul style="list-style-type: none"> • Particle-size (bulk)
Existing cover – radon barrier	<ul style="list-style-type: none"> • Thickness/stratigraphy (visual) 	<ul style="list-style-type: none"> • Water content (bulk) • Particle-size (bulk) • Atterberg Limits (bulk) • Standard Proctor (bulk) • Saturated Hydraulic Conductivity (remolded) • Moisture retention SWCC (remolded)
Coarse tailings	<ul style="list-style-type: none"> • Thickness/stratigraphy (CC) • Density (CPT-SPT) 	<ul style="list-style-type: none"> • Water content (CA, Shelby) • Density (CA, Shelby) • Particle-size (Shelby, CC) • Specific gravity (CA, Shelby) • Atterberg Limits (bulk) • Saturated Hydraulic Conductivity (CA, Shelby) • Consolidation (CA, Shelby) • Shear strength (CA, Shelby) • Moisture retention SWCC (CA, Shelby)
Fine tailings	<ul style="list-style-type: none"> • Thickness/stratigraphy (CC) • Density (CPT-SPT) 	<ul style="list-style-type: none"> • Water content (CA, Shelby) • Density (CA, Shelby) • Particle-size (Shelby, CC) • Specific gravity (CA, Shelby) • Atterberg Limits (bulk) • Saturated Hydraulic Conductivity (CA, Shelby) • Consolidation (CA, Shelby) • Shear strength (CA, Shelby) • Moisture retention SWCC (CA, Shelby)
Embankment	<ul style="list-style-type: none"> • Thickness/stratigraphy (CC) • Density (CPT-SPT) 	<ul style="list-style-type: none"> • Water content (CA, Shelby) • Density (CA, Shelby) • Particle-size (Shelby, CC) • Specific gravity (CA, Shelby) • Atterberg Limits (bulk) • Swell/collapse (CA, Shelby) • Shear strength (CA, Shelby)
Alluvium	<ul style="list-style-type: none"> • Thickness/stratigraphy (CC) • Density (CPT-SPT) 	<ul style="list-style-type: none"> • Water content (CA, Shelby) • Density (CA, Shelby) • Particle-size (Shelby, CC) • Specific gravity (CA, Shelby) • Atterberg Limits (bulk) • Saturated Hydraulic Conductivity (CA, Shelby) • Consolidation (CA, Shelby) • Moisture retention SWCC (CA, Shelby)
Unit 3 Sandstone	<ul style="list-style-type: none"> • Thickness/stratigraphy (CC) • Competency (SPT) 	<ul style="list-style-type: none"> • Water content (CC, SS) • Density (CC) • Saturated Hydraulic Conductivity (CC)

Notes: CPT = cone penetration test
 SPT = standard penetration test
 CA = California samples
 Shelby = Shelby tube samples
 Bulk = bulk samples
 CC = continuous core sampling
 SS = split-spoon samples
 SWCC = soil water characteristic curve

Table 3-3. Tailings Impoundment Geotechnical Laboratory Testing Schedule

Geotechnical Laboratory Test	Gravel Admixture Cover Layer	Radon Barrier Cover Layer	Coarse Tailings	Fine Tailings	Embankment	Alluvium	Unit 3 Sandstone	ASTM Standard
	Estimated Number of Laboratory Tests							
Moisture content	-	12	20	8	16	20	3	ASTM D2216
Dry density	-	-	20	8	16	20	3	ASTM D2937
Particle-size (sieve and hydrometer ⁽¹⁾)	12	2	20	8	8	20	-	ASTM D422
Specific gravity	-	-	10	4	4	10	-	ASTM D854
Atterberg limits	-	12	10	8	8	10	-	ASTM D4318
Standard Proctor	-	4	-	-	-	-	-	ASTM D698
Saturated hydraulic conductivity ³	-	4 ⁽²⁾	5	2	-	5	2	ASTM D5084
Consolidation	-	-	5	4	-	5	-	ASTM D2435
Swell/collapse potential	-	-	-	-	4	-	-	ASTM D4546, D5333
Triaxial shear strength (CU)	-	-	3	1	4	-	-	ASTM D4767
Moisture retention - soil water characteristic curves (SWCC)	-	1	1	1	-	1	-	ASTM D6836

Note:

1. Hydrometer to be used, as applicable, based on material types.
2. Saturated hydraulic conductivity will be conducted on samples remolded to 90%, 95% and 100% of maximum dry density, as determined by the standard Proctor compaction method.
3. Rigid or flexible wall, depending on particle sizes.
4. Sample volumes will be determined in accordance with ASTM.
5. Testing schedule subject to change based on quantities of samples obtained.

Table 3-4. Soil Tests and Methods for Borrow Material Characterization

Test	Test Method	Estimated Number of Tests in Primary Borrow Areas ¹	Estimated Number of Tests in Alternative Borrow Areas ²
Dry bulk density	ASTM D7263	6	10
Moisture content	ASTM D2216	6	10
Calculated total porosity	ASTM D7263	6	10
Specific gravity	ASTM D854	6	10
Particle size analysis with hydrometer	ASTM D422	6	10
Soil classification	ASTM D422, USDA Soil Textural Triangle	6	10
Atterberg Limits	ASTM D4318	4	2
Standard Proctor compaction	ASTM D698	6	6
Saturated hydraulic conductivity	(Rigid Wall - ASTM D2434M) or flexible wall (ASTM D5084) ³	6	5
Dispersivity Classification – Pinhole Test	ASTM D4647	4	2
Moisture retention characteristics & calculated unsaturated hydraulic conductivity	ASTM D6836 Soil Water Characteristic Curve (5-7pts. Minimum) ⁴	6	5
Ra-226 activity	EPA Method 901.1	2	1
pH	Saturated Paste pH (USDA Staff, 1954)	2	1
Electrical conductivity	Solution conductivity (USDA Staff, 1954)	2	1
Exchangeable sodium percentage	SAR Estimation (USDA Staff, 1954)	2	1
Calcium carbonate equivalent	Rapid titration (Agronomy Society of America, 1965)	2	1
Cation exchange capacity	Na saturated then NH ₄ OAc extracted (Agronomy Society of America, 1965)	2	1
Percent organic matter	Walkley – Black (Agronomy Society of America, 1982)	2	1
Nitrogen	Kjeldahl (Agronomy Society of America, 1965)	2	1
Phosphorous	Olsen (Ludwick and Reuss, 1974; Olsen, et al., 1954)	2	1
Potassium (K)	1:5 NH ₄ OAc Extract (Ludwick and Reuss, 1974)	2	1

Notes:

1. For Borrow Area 1, Borrow Area 2, and the Dilco Hill Borrow Area.
2. For the North Drainage Borrow area and the South Drainage Borrow Area.
3. Hydraulic conductivity test method will be selected according to the sample material texture. Test specimen will be remolded to the determined undisturbed in situ density of borrow material and/or 90% of standard Proctor maximum dry density and dry of optimum water content (conditions consistent with density and moisture content of placed cover material) for the ET cover layer.
4. Testing could include hanging column, pressure plate, water potential, and/or relative humidity box methods, depending on desired range of suction values.
5. Sample volume will be determined in accordance with ASTM.
6. Sieve analyses will be performed initially, which may lead to a decision to perform additional analyses not specified above.

Table 3-5. Geotechnical Testing of On-Site Bedding and Erosion Protection Materials

Material	Test	Test Method	Estimated Number of Samples Per Sampling Location ¹	Estimated Volume of Samples Required
Gravel admixture layer of existing tailings cover	Particle-size analysis	ASTM D422 or D5519	1	Bulk ¹
Bedding sand	Particle-size analysis	ASTM D422 or D5519		
1-inch diameter rock 3-inch diameter rock	Particle-size analysis	ASTM D422 or D5519		
	L.A. Abrasion ²	ASTM Method C 535		
	Sodium sulfate soundness ²	ASTM Method C 88		
	Specific gravity ²	ASTM C 127		
	Absorption ²	ASTM C 127		
	Schmidt Hammer ²	ASTM D 5873		
	Splitting Tensile Strength ²	ASTM D 3967		

Notes:

1. Sample volumes will be determined in accordance with ASTM.
2. Some durability tests listed may be substituted or eliminated in accordance with NRC, 2002.