Prepared for

UNITED NUCLEAR CORPORATION
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SAINT ANTHONY MINE
MATERIALS CHARACTERIZATION WORK PLAN

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1.0 INTRODUCTION

1.1 BACKGROUND

The St. Anthony Mine was an open pit and underground shaft uranium mine located on the Cebolleta Land Grant approximately 40 miles West of Albuquerque, New Mexico located in Cibola County approximately 4.6 miles southeast of Seboyeta, New Mexico. The mine site is located in a very remote, sparsely populated area with difficult access. A location map is included as Figure 1, *General Location Map*. UNC operated the St. Anthony Mine from 1975 to 1981, pursuant to a mineral lease with the Cebolleta Land Grant, the current owner of the surface and mineral rights. The original lease covered approximately 2,560 acres. This lease was obtained on February 10th, 1964 and was surrendered by a Release of Mineral Lease dated October 24, 1988. UNC has access to the site through access agreements with the Cebolleta Land Grant and an adjacent landowner.

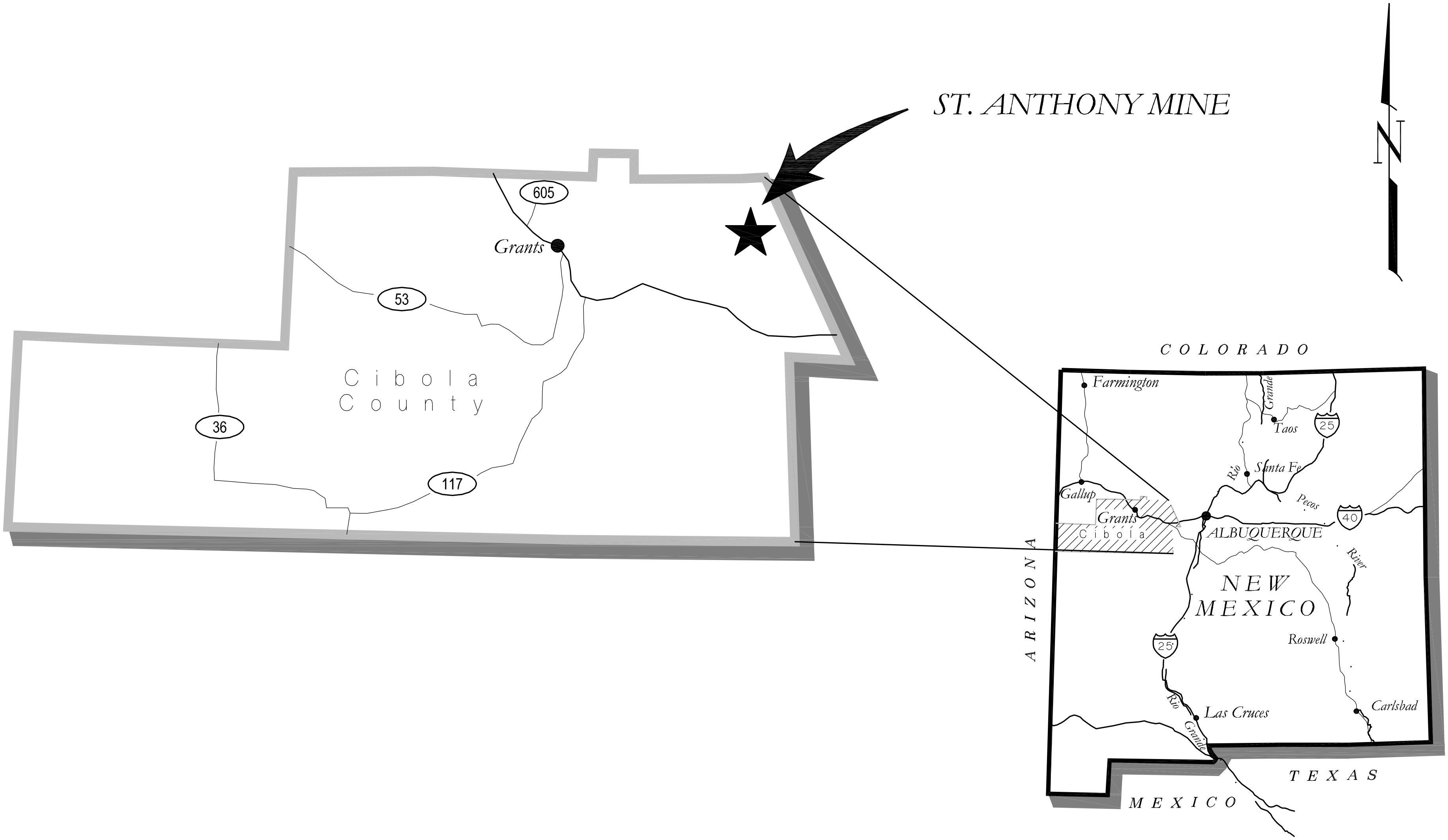
The site includes underground workings consisting of one shaft, approximately eight vent shafts that are sealed at the surface, two open pits (one containing a pond), seven large piles of non-economical mine materials with some revegetation, numerous smaller piles of non-economical mine materials, and three topsoil piles. No perennial streams occur within the St. Anthony site, but an arroyo (Meyer Gulch) passes through the site. The site layout of the St. Anthony Mine is included as Figure 2, *Site Layout*. The two open pits at the mine site are located in Sections 19 and 30, Township 11 North, Range 4 West, and the entrance to the underground mine is located in Section 24, Township 11 North, Range 5 West. The actively mined area encompasses approximately 430 acres and includes roads and other disturbed areas along with the open pits and non-economical mine materials piles.

1.2 PURPOSE

This Materials Characterization Work Plan (Work Plan) has been prepared in conjunction with the St. Anthony Mine Closeout Plan submitted to the New Mexico Mining and Minerals Division (MMD) January 6, 2006 to address environmental concerns. This work plan describes procedures that will be used to characterize materials at the site. Data collected will be used to determine soil suitability as growth media and radiological risk. Modifications to the Closeout Plan may be made based on the actions required to mitigate any risks identified from data developed from this Work Plan.

Potential impacts to surface and groundwater will be determined separately using the materials characterization results obtained from the September 30, 2005 New Mexico Environment Department (NMED) approved work plan.

Material characterization will include a radiological survey of non-economic materials at the site, drilling and sampling of non-economic materials and sampling of potential cover material borrow sources.



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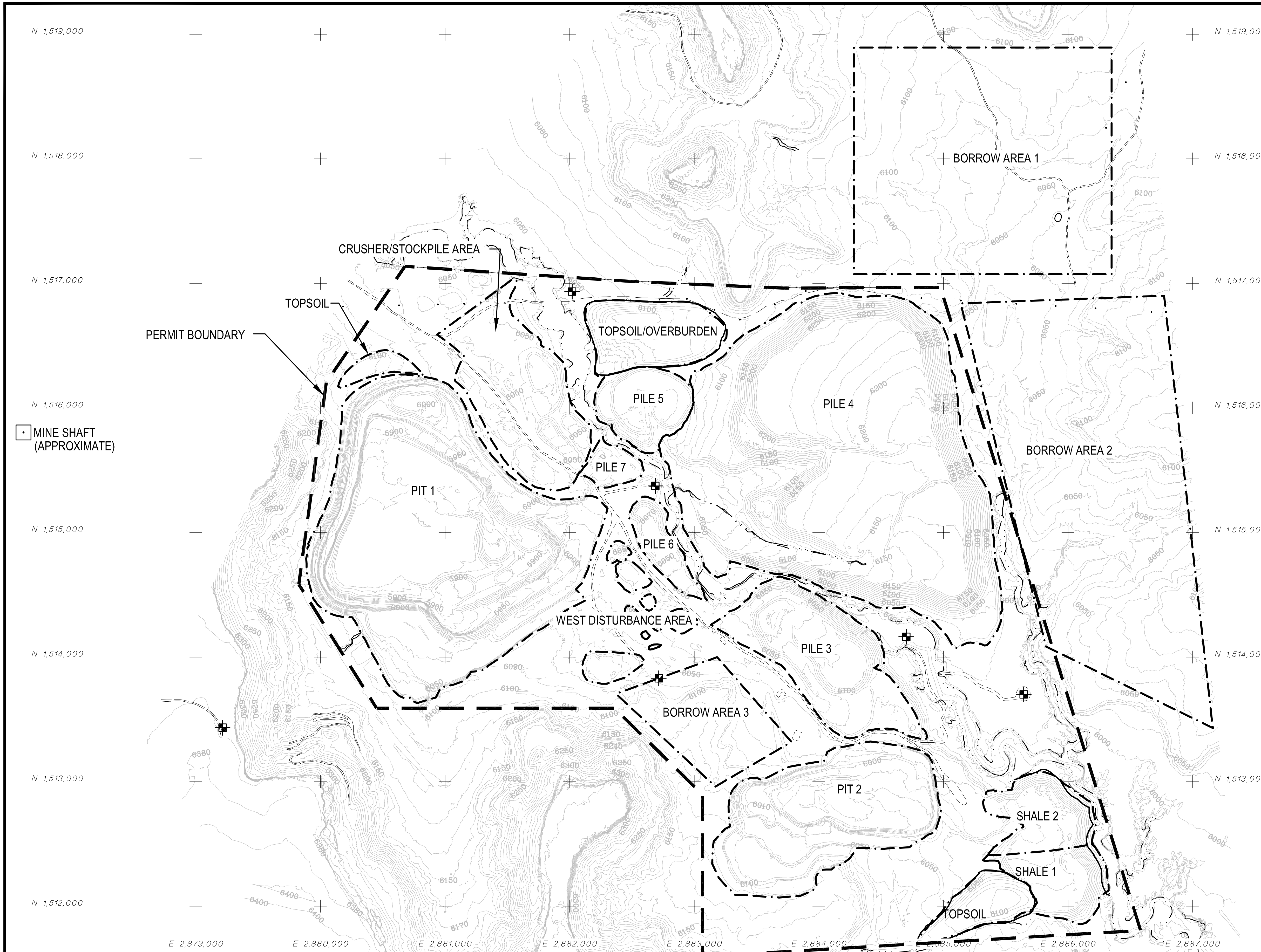
AutoCAD FILE: UNC Gen Location.dwg

SCALE: Not to Scale

FIGURE No: 1

UNITED NUCLEAR CORPORATION
St. Anthony Mine

GENERAL LOCATION MAP



LEGEND

- FACILITY BOUNDARY
- PERMANENT WASH
- DIRT ROAD
- PERMIT BOUNDARY
- MINE SHAFT
- MONITORING WELL

SCALE

400' 0 400' 800'

CONTOUR INTERVAL 10FT.

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PROJECT: ST ANTHONY MINE

DRAWING TITLE: SITE LAYOUT

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Sheet 1 Of 1 Sheets

SCALE: As Shown

DRAWING No. 2

AutoCAD FILE: UNC Site Layout.dwg PROJECT NUMBER: 1004490.018701

2.0 SOIL SAMPLING

2.1 SAMPLE COLLECTION

Samples will be collected from test borings and test pits to determine material homogeneity and identify material horizons. All samples will be visually classified in the field, while selected samples will be submitted for analytical analysis as discussed in Section 2.2 below. Sample locations are co-located with radiological survey points and distributed to best represent materials present at the Site.

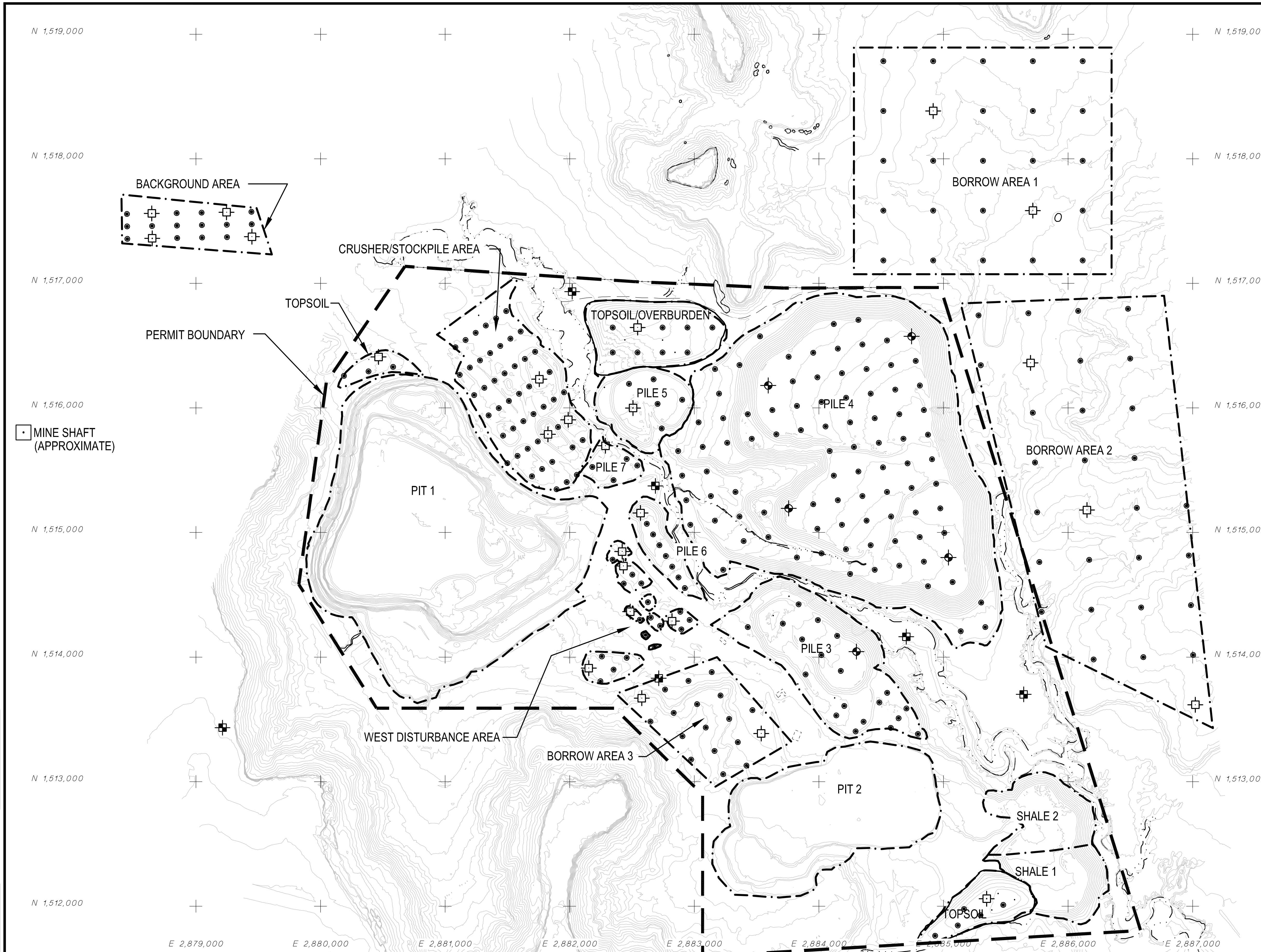
Material samples will be collected from 32 locations, including four background sample locations, 17 sample locations on the non-economic material piles, three sample locations on the topsoil stockpiles, three sample locations from the ore stockpiles and eight sample locations from proposed borrow areas. Sampling locations are shown on Figures 3, *Sample Locations.* All material sampling locations will be collocated with radiological survey points. The radiological survey will be performed as described in Section 3.0 prior to collection of the material samples. Sampling procedures are summarized below and detailed in Appendix B. The shale located in Piles 1 and 2, shown on Figure 2, has been identified by Cedar Creek Associates during the vegetation and wildlife survey be a poor growth medium. The Closeout Plan calls for Piles 1 and 2 to be covered with six feet of cover material, therefore this area will not be sampled under this Work Plan.

Soil samples will be collected by two methods: test borings and test pits. Deep samples on Non-economic Material Piles 3 and 4, as required by MMD, will be collected using a reverse-circulation drill rig. The northwest sample location on Pile 4 will be drilled to a depth of 145 feet. This depth extends past the depth of material to be exposed during excavation and down to the elevation of the shale fan located to the west of the sample location. The northeast sample location on Pile 4 will be drilled to a depth of 100 feet. This depth extends 50-feet past the maximum depth of material to be exposed during regrade. The remaining sample locations on Pile 4 will be drilled the full depth of the pile down to native ground, approximately 165 feet each. The sample location on Pile 3 will also be drilled the full depth of the pile to native ground, approximately 125 feet. Material excavation in these locations will extend the full depth of the piles. Drill samples will be collected over five foot intervals each sample will be visually classified in the field in accordance with U.S. Department of Agriculture (USDA) methods.

Test pit samples will be collected from the remaining sampling locations using a backhoe or excavator. Samples collected from the non-economic material piles, crusher/stockpile area and topsoil stockpiles will be collected to a depth of 15-feet or native ground, whichever is shallower. Composite samples will be collected from materials from the top two feet, two to four feet and one sample for every six feet to the bottom of the excavation. Test pits in the background area will be excavated to a depth of four feet with representative samples collected of the material in the top two feet and the bottom two feet. Test pits in the borrow areas will be excavated to a depth of six-feet with a representative composite sample collected of each soil strata encountered. All samples will be visually classified in the field in accordance with USDA methods.

2.2 SAMPLE ANALYSIS

Selected samples will be submitted to an American Association for Laboratory Accreditation (A2LA) or a National Environmental Laboratory Accreditation Conference (NELAC) certified laboratory for analysis to determine agronomic and radiological properties of the materials. The minimum number of samples to be submitted to the laboratory is presented in Table 2.1, *Sample Collection and Analysis Summary*.



LEGEND

- FACILITY BOUNDARY
- PERMANENT WASH
- DIRT ROAD
- PERMIT BOUNDARY
- MINE SHAFT
- MONITORING WELL
- RADIOLOGICAL SURVEY POINT AND BOREHOLE LOCATION
- RADIOLOGICAL SURVEY POINT
- RADIOLOGICAL SURVEY POINT AND TEST PIT LOCATION

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PROJECT: ST ANTHONY MINE

DRAWING TITLE: SAMPLE LOCATIONS

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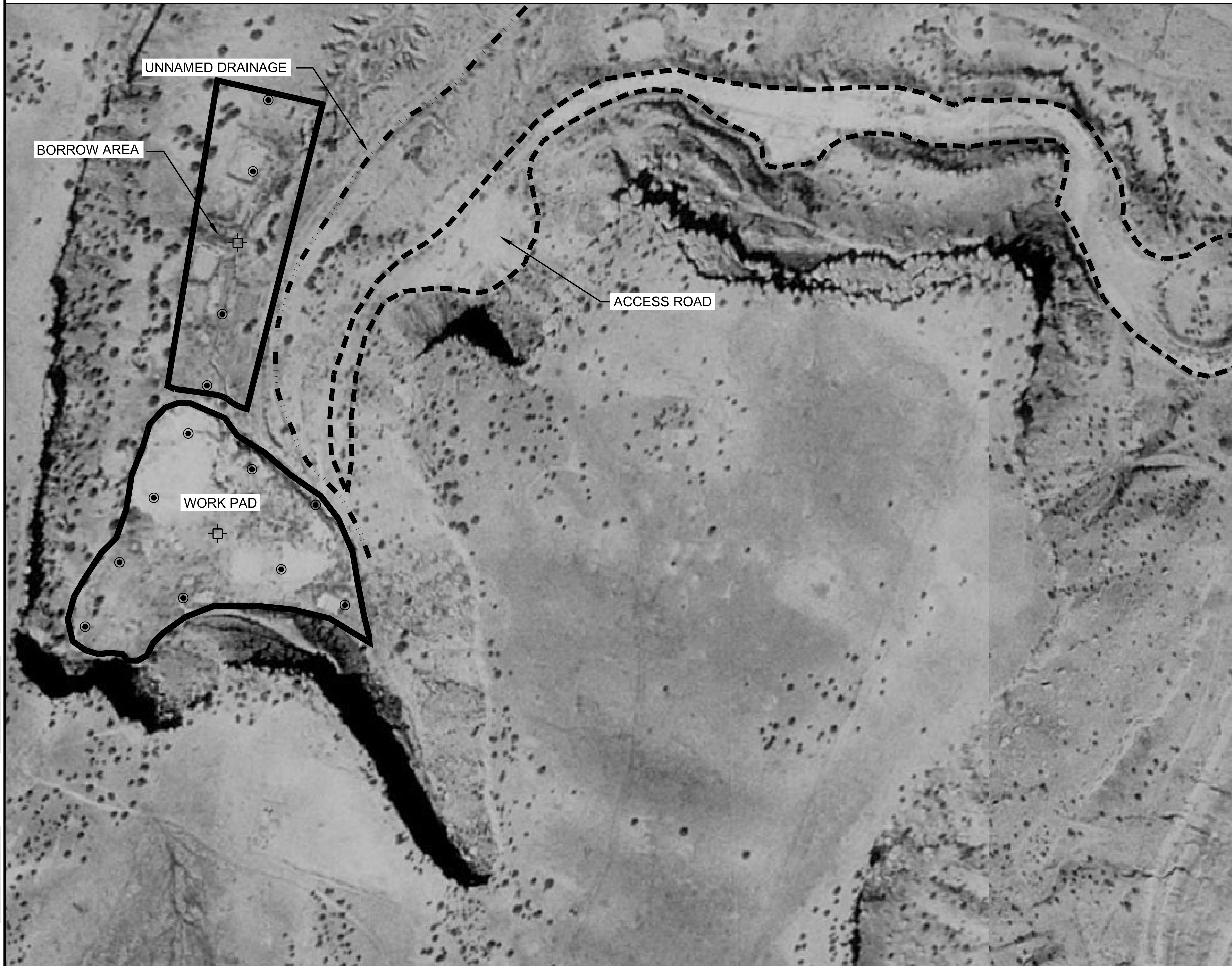
Sheet 1 Of 2 Sheets

SCALE: As Shown

DRAWING No. 3

AutoCAD FILE: UNC Sample Locations1.dwg PROJECT NUMBER: 1004490.018701



LEGEND

- WORK PAD
- DRAINAGE
- ACCESS ROAD
- RADIOLOGICAL SURVEY POINT
- RADIOLOGICAL SURVEY POINT AND TEST PIT LOCATION

N

0' 150' 300'
Approximate Scale in Ft.

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PROJECT: ***ST. ANTHONY MINE***

DRAWING TITLE: ***SAMPLE LOCATIONS***

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Sheet 2 Of 2 Sheets

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DRAWING No. **3**

AutoCAD FILE: UNC Site Adit1.dwg PROJECT NUMBER: 1004490.018701

A minimum of two samples will be submitted from each drill location. A representative sample of each material type encountered, or if only one material type is present, the sample of the first five feet and a representative sample from the bottom half of the hole will be submitted.

Samples from the non-economic material pile test pits will be submitted to the analytical laboratory based on radiological survey. Gamma ray exposure measurements will be made on all test pit samples from the non-economic material following the procedures presented in Section 3.0. The two samples from each location with the highest gamma ray exposure values will be submitted to the analytical laboratory.

TABLE 2.1
SAMPLE COLLECTION AND ANALYSIS SUMMARY

Source	Sample Locations	Samples Collected	Samples Analyzed
Non-economic Material Drilling	5	140	10
Non-economic Material Test Pits	12	48	24
Topsoil/Overburden Stockpiles	3	11	11
Borrow Areas	8	8	8
Background	4	8	4
Total	32	215	57

All samples from the topsoil and overburden piles and borrow areas will be submitted to the laboratory for analysis. Additionally, samples collected from the two background locations with the median ground contact radiation readings from the gamma radiation exposure survey will be submitted for analysis.

Samples will be processed for three groups of analytes. Agronomic properties to be evaluated are listed in Table 2.2, *Agronomic Analyses*. Results of these data will be used to determine suitability of the soils as growth media including availability of nutrients and any potential toxicities. Radiological parameters listed in Table 2.3, *Radiochemical Analytes*, will be collected to supplement and correlate with data collected in the radiological survey discussed in Section 3.0.

TABLE 2.2
AGRONOMIC ANALYSES

Analyte	Detection Limit	Extraction Method
pH	0.01 s.u.	ASA No. 9, Method 10-3.2
Electrical Conductivity	0.01 mmhos/cm	ASA No. 9, Method 10-3.3
Saturation Percentage	0.1 %	USDA Handbook 60, Method 27A
Texture	1 %	ASA No. 9, Method 15-2.2
Rock Fragment Percentage	–	ASA No. 9, Method 15-2.2
Sodium Adsorption Ratio (SAR)	0.01	ASA No. 9, Method 10-3.4
Nitrate as N	1 mg/kg	ASA No. 9, Method 38-8.1
Phosphorous	1 mg/kg	ASA No. 9, Method 24-5.1
Potassium	1 mg/kg	ASA No. 9, Method 13-3.5
Chloride	5 mg/kg	ASA No. 9, Method 10-2.3.2
Sulfate	0.1 mg/kg	ASA No. 9, Method 28-5.1
Organic Carbon	0.002 %	ASA No. 9, Method 29-3.5.2

TABLE 2.3 RADIOCHEMICAL ANALYTES		
Analyte	**Detection Limit**	**Method**
Uranium	0.001 mg/g	EPA M6020, ICP/MS
Gross Alpha	2 pCi/g	ESM 4103
Radium 226	1.0 pCi/g	EPA M9315
Thorium 230	0.2 pCi/g	ESM 4506

3.0 RADIOLOGICAL SURVEY

3.1 BACKGROUND LEVEL VERIFICATION

The radiological survey is designed to identify any areas that may have elevated gamma ray exposure rates. The survey will consist of verification of background gamma ray exposure rate determined during previous radiological surveys in the area and gamma ray exposure rate survey of selected materials at the site.

All gamma ray exposure rate measurements will be collected by a certified Radiation Safety Officer (RSO) using a Ludlum Model 19 Micro R Meter. The meter will have a calibration within the past year to a Cesium-137 source. A visual inspection of the instrument and a function check using a Cesium-137 source will be conducted daily prior to usage. An equivalent meter may be substituted for all or portions of the radiological survey. Any meters used will have a current calibration and will be appropriate to the radiation levels being measured. Any instrument used will have been calibrated within the past year. Function checks will be performed daily or more frequently if recommended by the manufacturer.

Background gamma ray exposure rate will be measured in an area where past mining activity was not conducted. The proposed area for the background rate measurement is located to the north of the access road to the mine shaft as shown in Figure 2. Shielded contact, shielded one meter and unshielded one meter exposure rates will be measured at identified locations in the background area.

Background gamma ray exposure rate measurements will be compared to background radiation rate for the site used for the Preliminary Assessment Report (NMED, 1995). If the monitored background exposure rate is not consistent with the historic rate, additional background locations will be added and a new background exposure rate will be developed.

3.2 GAMMA RAY EXPOSURE SURVEY

A grid will be established at each facility where a gamma ray exposure survey will be performed. The grid interval will vary depending on the side of the facility. A 400-foot grid will be used on Borrow Areas 1 and 2. A 200-foot grid will be used on Pile 4, Borrow Area 3 and the Background area. The remaining facilities will use a 100-foot grid. Approximate locations for the survey points are shown on Figure 3.

Three measurements will be made at each location: shielded contact with the ground, shielded one-meter above ground and unshielded one-meter above ground.

3.3 SOIL SAMPLE GAMMA RAY EXPOSURE RATE

Soil samples will be collected as described in Section 2 for laboratory analyses. A split from each sample will be collected in a plastic self-sealing (zip lock) bag for measurement of gamma ray exposure rate. All measurements will be shielded measurements with the meter in contact with the sample being tested.

The gamma ray exposure rate will be measured on native material with a shielded contact reading at or below the background level. Prior to measurement of the exposure rate for the sample a background reading will be made of the exposure rate of the testing location. Following measurement of the background exposure rate, the sample, in the plastic bag, will be placed under the shield and the exposure rate will be measured.

The exposure rate for the sample will be the greater of the background exposure rate at the measurement location or the measured exposure rate for the sample.

4.0 DATA EVALUATION

4.1 PLANT GROWTH MEDIUM SUITABILITY

Agronomic data will be analyzed to determine suitability of the soils as plant growth medium. The analysis will include general suitability of the soils, sufficiency of nutrients and any potential chemical toxicities. The majority of this information will be utilized in the development of the revegetation plan. The results could impact the borrow areas used as cover material, plant species to be seeded at the site and what soil amendments will be added to the soil.

The completion report for this work plan will provide summary data and its anticipated effect on the revegetation plan. Recommendations will be made for any adjustments required to the Closeout Plan to mitigate any chemical toxicities indicated by the analyses. A detailed revegetation plan will be developed using this data and data collected during implementation of the Vegetation and Wildlife Work Plan.

4.2 RADIOLOGICAL DATA

Radiological data will be compared against background data and appropriate barriers will be designed for areas emitting greater than 100 mrem/hr by a qualified radiological expert.

4.3 REPORT

A completion report will be issued following the implementation of this work plan. The report will provide the survey and sample methods, location of all sample and survey points and all data collected. An evaluation of the data and any recommendations for adjustments to the Closeout Plan will also be included in the report.

5.0 QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) documents project management and organization, identifies the procedures used to assure the accuracy, precision and representativeness of the data collected and assures the procedures provided in the Sampling Plan are implemented so that the project objectives are achieved. The QAPP presents an overall description of the methods, responsibilities and procedures associated with the field characterization activities at the St. Anthony Mine. Accordingly, this QAPP reflects MWH's current corporate standards and procedures for the implementation of these investigations, appropriate regulatory requirements and methods that have developed through experience on similar environmental programs. It is the responsibility of all project personnel either performing or overseeing sampling and analysis activities to adhere to the requirements of this QAPP and supporting project-specific documents.

5.1 PROGRAM MANAGEMENT

5.1.1 Project Organization

Effective project management is key to implementation of the sampling and analysis program. It provides all parties involved with a clear understanding of their role in the investigation and provides the lines of authority and reporting for the project. Key positions and associated responsibilities are outlined below.

United Nuclear Corporation – Larry Bush & Roy Blickwedel

- Review and approve work plan and deliverables
- Review project technical and data reports
- Provide project oversight

MWH Technical Manager – John Redmond

- Provide oversight of all technical deliverables
- Implement necessary actions and adjustments to accomplish project objectives

MWH Project Quality Assurance Manager / Field Coordinator – James Thompson

- Work closely with the Technical Manager to assure that data are available on time
- Assure that the appropriate field QA samples are collected per project SOPs
- Receive laboratory deliverables and pertinent field data
- Coordinate and oversee electronic data management system
- Assure sampling events are completed and all necessary data are collected
- Verify QA procedures are followed during sample collection
- Report difficulties/complications in sample collection to Technical Manager
- Assure chain-of-custody forms and field books are filled out properly

Radiation Safety Officer (RSO) – Max Chischilly

- Provide oversight of field radiological surveys
- Assure representativeness of survey data
- Assure data are collected by trained qualified personnel

Analytical Laboratory(s)

- Responsible for off-site analysis of samples
- Deliver analytical results in a timely manner
- Calibrate and maintain laboratory equipment
- Conduct internal QA/QC procedures
- Notify QA Manager when problems occur
- Assure data and QA information are properly recorded
- Assure all custody records are properly completed and handled

5.1.2 Special Training Requirements/Certification

All personnel who enter an abandoned mine site must recognize and understand the potential hazards to health and safety associated with the site. Employees working on sites exposed to hazardous substances, health hazards, or safety hazards; their supervisors; and management responsible for the site will, at all time of assignment to the field, meet at a minimum the Occupational Safety and Health Administration (OSHA) hazardous waste site workers 40-hour training requirement. Additional training requirements specified in the Site Specific Health and Safety Plan will be completed as necessary. In addition, personnel responsible for operating mechanical equipment, including pumps, generators, and mixing equipment, will receive the necessary operating instruction on that equipment. Sampling personnel will be trained in the of use industry-standard practices. A qualified geologist or engineer will provide sampling oversight.

Radiological survey data will be collected by personnel trained in the use of the radiological detection equipment used. Personnel conduction the radiological survey will be supervised by a certified RSO.

5.1.3 Problem Definition and Background

Background information for the St. Anthony Mine project is provided in Section 1.0 of the St. Anthony Mine closeout Plan. A description of the work to be performed under this plan is provided in Section 1.0 of this Work Plan.

5.1.4 Project Description

Sampling of surface and near surface soils and a radiological survey will be conducted to evaluate the suitability as plant growth material and radiological risk. Descriptions of the project and investigative activities to be performed are provided in Sections 2.0 and 3.0 of this document.

5.1.5 Criteria for Measurement Data

MWH will utilize an American Association for Laboratory Accreditation (A2LA) or a National Environmental Laboratory Accreditation Conference (NELAC) certified laboratory to analyze samples collected at the St. Anthony Mine site. The laboratory and its staff have the responsibility to process all samples submitted according to the specific protocols for sample custody, holding times, analysis and associated laboratory quality assurance. Designated laboratory personnel will maintain contact with the Project QA Manager to assure that internal laboratory Data Quality Objectives (DQOs) are achieved. Laboratory DQOs are defined in terms of accuracy and precision. Accuracy and precision will be assessed through the use of field quality assurance samples and consistent laboratory practices.

Table 5.1, *Summary of Analytical Schedule St. Anthony Materials Characterization Plan*,, presents sampling location, test matrix, test parameters, and number of samples including Quality Assurance/Quality Control (QA/QC) samples.

TABLE 5.1
SUMMARY OF ANALYTICAL SCHEDULE
ST. ANTHONY MATERIALS CHARACTERIZATION PLAN

Location	Matrix	Test Parameters	Total Estimated Number of Samples Analyzed	Field Duplicates
Non-Economic Material Piles	Soil	Tables 2.2, 2.3 & 2.4	34	4
Topsoil Stockpiles		Tables 2.2, 2.3 & 2.4	11	1
Borrow Areas		Tables 2.2, 2.3 & 2.4	8	1
Background Area		Tables 2.2, 2.3 & 2.4	4	1

5.2 MEASUREMENT/DATA ACQUISITION

5.2.1 Sample Handling and Custody Requirements

Sample handling and chain-of-custody procedures will be strictly adhered to during sample collection, transportation and laboratory handling to assure the identity of the samples. Improper sample and data handling and inadequate chain-of-custody procedures affect the credibility and acceptability of analytical results, regardless of their accuracy or precision.

All samples will be appropriately labeled with pre-prepared labels. Each label will include the job number and project name, time and date of collection, sample depth, sample identification number, preservative (if applicable), analyses to be performed, and the initials of the sampler. The chain-of-custody record (COCR) will be initiated by the field sampling personnel upon collection of a sample and will accompany each shipping container. The sampling personnel will retain a copy of the COCR and send the original with the sample shipment.

Samples will be properly packaged in shipping containers to ensure the integrity of the samples. Samples will be transported as soon as possible to the laboratory after sample collection. Shipping containers will be transported via courier or by priority next day delivery to the laboratory. Each shipment will be adequately tracked and documented and will arrive at the laboratory ready for analysis.

Each person who has the samples in his/her possession, including couriers (except Federal Express), will sign the COCR. Upon sample receipt at the laboratory, the cooler temperature will be recorded and the sample container integrity will be checked. Any deficiencies at the time of sample receipt at the laboratory will be documented on the cooler receipt form and the MWH QA Manager will be notified for necessary resolution.

5.2.2 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Instrument calibration is necessary to ensure that the analytical systems are operating correctly and functioning at the proper sensitivity to meet quantification limits. Calibration establishes the dynamic range of an instrument, establishes response factors to be used for quantification, and demonstrates instrument sensitivity. All laboratory instruments will be calibrated in accordance with each laboratory's SOPs. Criteria for calibration are specific to the instrument and the analytical method. Field instruments will be calibrated daily or immediately before use per manufacturer's instructions.

5.2.3 Inspection Requirements for Supplies and Consumables

All purchased supplies and consumables that support field monitoring and sampling activities or that have a direct relationship to sample quality (e.g. sample containers, decontamination supplies, distilled/de-ionized water) will be inspected upon receipt. At a minimum this inspection will check:

- Part number/physical description matches requisition
- Supplies are intact and undamaged
- All required components/documentation is included

Any non-conforming items will be documented and returned to the supplier for replacement or other action as necessary.

5.3 DATA VALIDATION AND USABILITY

5.3.1 Data Review and Verification Requirements

The contracted laboratories will be responsible for reviewing all analytical data generated under this contract to ensure that it meets the requirements of this QAPP. Each analyst reviews the quality of their work based on established protocols specified in laboratory SOPs, analytical method protocol, project-specific requirements and DQOs. The laboratory will provide analytical results in electronic and paper formats. At a minimum, data verification will include evaluation of sampling documentation, technical holding time, instrument calibration and tuning, field and lab blank sample analyses, method QC sample results, field duplicates and the presence of any elevated detection limits.

5.3.1.2 Laboratory Quality Control

Laboratory overall method performance shall be monitored by the inclusion of various internal Quality Control (QC) checks that allow an evaluation of method control (batch QC), and the effect of the sample matrix on the data being generated (matrix-specific QC). Batch QC is based on the analysis of a LCS to generate accuracy (precision and bias) data and method blank data to assess the potential for cross-contamination. Laboratory QC will be based on the labs internal QA/QC plan and SOPs. Some QC procedures discussed in this section are not included in the current scope, but are provided to cover future sampling scenarios. Current field QC requirements for the project were presented in Table 5.1. The overall quality objectives are to implement procedures for laboratory analysis and reporting of data that are indicative of the degree of quality consistent with their intended use. Laboratory QC methods typically used to meet this objective are discussed below. Only the methods appropriate for the current scope of work will be utilized.

Method Blank Samples

Method blanks are analyzed to assess background interference or contamination that exists in the analytical system that might lead to the reporting of elevated concentration levels or false positive data. The method blank is defined as an interference-free blank matrix similar to the sample matrix to which all reagents are added in the same volumes or proportions as used in sample preparation and carried through the complete sample preparation, cleanup, and determinative procedures. For aqueous analyses, analyte-free reagent water would typically be used. The results of the method blank analysis are evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples. Sample results shall not be corrected for blank contamination.

In general, one method blank sample shall be analyzed for each analytical batch (one every 12 hours for GC/MS analyses). Contamination in method blanks (as well as reagent blanks, instrument blanks, extraction blanks for elutriations, initial calibration blanks, and continuing calibration blanks) above the MDL is not allowed. Data found to be associated with blanks containing target analytes at or above the MDL may be rejected with re-sampling and/or re-extraction and reanalysis at the expense of the laboratory. The USACE will evaluate the data based on the level detected in the associated samples. Chronic systematic method blank contamination will not be accepted.

Laboratory Control Samples

The LCS is analyzed to assess general method performance by the ability of the laboratory to successfully recover the target analytes from a control matrix. The LCS is similar in composition to the method blank. For aqueous analyses use analyte-free reagent water. For soil analyses, a purified solid matrix (e.g., Ottawa sand, sodium sulfate, or other purified solid) would typically be used. However, due to the difficulty in obtaining a solid matrix that is metals-free, analyte-free reagent water is taken through the appropriate digestion procedures for metals analyses. The LCS is spiked with all single-component target analytes (the complete target compound or analyte list) before it is carried through the preparation, cleanup, and determinative procedures. The laboratory will perform corrective action based on failure of any analyte in the spiking list. When samples are not subjected to a separate preparatory procedure (i.e., purge and trap VOC analyses), the continuing calibration verification (CCV) may be used as the LCS, provided the CCV acceptance limits are used for evaluation. The spiking levels for the LCS would normally be set at the project-specific action limits assuming that the low standard used for the initial calibration was below this limit. If the low standard used was at this limit or if the site action levels were unknown, then the spiking levels would be set between the low and mid-level standards. The results of the LCS are evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples. The laboratory shall also maintain control charts, or tables for these samples to monitor the precision. The precision may be evaluated by comparing the results of the LCS from batch to batch, or by duplicate LCSs.

Matrix Spike

The MS is used to assess the performance of the method as applied to a particular project matrix. A MS is an environmental sample to which known concentrations of certain target analytes have been added before sample manipulation from the preparation, cleanup, and determinative procedures have been implemented. The entire target analyte list will be spiked within the MS. The laboratory will perform corrective action based on failure of any analyte in the spiking list. The spike concentrations of the target analytes would normally be set at the same level as the LCS. From the laboratory perspective, preparation batches require MS frequency at one per preparation batch. The merging of these MS frequencies is often difficult for the laboratory to implement. For instance, batches consisting of samples from multiple sites may require additional MSs to meet project requirements of evaluating the samples within the batch. For a MS from one site cannot be used to evaluate the matrix effects on samples from other sites. The results of the MS are evaluated, in conjunction with other QC information, to determine the effect of the matrix on the bias of the analysis. Sample results shall not be corrected for MS QC excursions.

Matrix Spike Duplicate

The MD or MSD is used to assess the performance of the method as applied to a particular matrix and to provide information on the homogeneity of the matrix. A MSD is a duplicate of the MS as previously described. A MD is an environmental sample that is either divided into two separate aliquots by the laboratory, or requires the submittal of an additional sample. When applicable, care should be taken to ensure that the sample is properly divided into homogeneous fractions. Both the MD and MSD are carried through the complete sample preparation, cleanup, and determinative procedures. The normal use of these QC samples would follow the same requirements as described for the MS. The MD is included with each preparation batch of samples processed where target analytes were expected to be present (e.g., inorganic methods). An MSD is included with each preparation batch of samples processed where target analytes were not expected to be present (e.g., organic methods). The results of the MD or MSD are evaluated, in conjunction with other QC information, to determine the effect of the matrix on the precision of the analysis.

Surrogate Standards

Surrogates are analyzed to assess the ability of the method to successfully recover these specific non-target compounds from an actual matrix. Surrogates are organic compounds that are similar to the compounds of interest in chemical behavior, but are not normally found in environmental samples. Surrogates to use are identified within the determinative methods. Other compounds may be chosen and used as surrogates, depending on the analysis requirements, whether they are representative of the compounds being analyzed, and whether they cover the chromatographic range of interest. These compounds should be spiked into all samples and accompanying QC samples requiring GC or GC/MS analysis prior to any sample manipulation. As a result, the surrogates are used in much the same way that MSs are used, but cannot replace the function of the MS. The results of the surrogates are evaluated, in conjunction with other QC information, to determine the effect of the matrix on the bias of the individual sample determinations. Control charts, or tables, shall be maintained for surrogates contained within the LCS or MB to monitor the accuracy of the method for each particular matrix. Sample results shall not be corrected for surrogate excursions.

5.3.1.3 Documentation and Records

MWH will store all-important project-related records in a centralized and easily accessible project file. The project manager or designee will maintain the project file. The project file will include the following types of field records:

- Field data measurements
- Sample collection records
- COCRs
- QC sample records
- Field notes, which will include descriptions of any deviations from the QAPP and any difficulties encountered in maintenance or sample collection
- Data results from the analytical laboratories
- Laboratory data deliverables (hard copy and electronic)

All laboratory-related documentation and records will be controlled, distributed, stored and maintained by the contracted laboratories. The information and records to be included in project-specific data reporting packages, and the reporting format, are specified in the following sections.

5.3.1.4 Analytical/Statistical/Control Parameters

Analytical parameters that can be used for statistical analysis and control are presented in this section. Only those parameters appropriate for the scope of work will be utilized.

Precision

Precision refers to the distribution of a set of reported values about the mean, or the closeness of agreement between individual test results obtained under prescribed conditions. Precision reflects the random error and may be affected by systematic error. Precision also characterized the natural variation of the matrix and how the contamination exists or varies within that matrix. In order to assess matrix heterogeneity or sample handling procedures, field precision is commonly determined from field duplicates samples. In general, field duplicates (QC samples) will be collected at a frequency of one duplicate for each ten samples of a given matrix. The current field duplicate schedule was presented in Table 5.1. The identity of QC samples shall be held blind to the Contract Laboratory until after analyses have been completed.

The relative percent difference for field and laboratory duplicates shall be calculated and used as a measure of precision, however only laboratory duplicates will be included in the quantitative assessment of completeness. Results of field duplicates will be described in qualitative assessment of completeness.

For environmental samples, laboratory precision is commonly determined from laboratory duplicate samples. Laboratory duplicates are defined as two aliquots obtained from the same sample which are extracted and analyzed for the purpose of determining matrix specific precision. In general, laboratory duplicates will be performed for all metals analyses at a rate of one in twenty (one for each batch up to a maximum of twenty). Precision for organic analyses may be determined by the analysis of Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples.

Laboratory duplicate samples not meeting QC criteria shall be re-extracted/reanalyzed once. (For organic analyses failure of different matrix spike compounds to meet QC criteria on successive runs shall constitute failure and satisfy the requirement for reanalysis.) Statistical measures of precision included RPD, standard deviation, or RSD.

Accuracy

Accuracy is the measure of the closeness of an observed value to the "true" value (e.g., theoretical or reference value). Accuracy includes a combination of random error and systematic error (bias) components that result from sampling and analytical operations.

Representativeness

Representativeness refers to the degree to which sample data accurately and precisely describe the characteristics of a population of samples, parameter variations at a sampling point, or environmental condition. Samples that are not properly collected or preserved (e.g., contaminant loss or addition) or are analyzed beyond acceptable holding times should not be considered to provide representative data. An assessment of represenativeness would include an evaluation of precision. The representativeness criterion is best satisfied in the laboratory by making certain that all subsamples taken from a given sample are representative of the sample as a whole. This would include sample pre-mixing/homogenizing prior to and during aliquotting procedures. Samples requiring volatiles analysis should not undergo any premixing or homogenization. Therefore, noting sampling characteristics in a case narrative may assist in the evaluation of data. Representativeness can be assessed by a review of the precision obtained form the field and laboratory duplicate samples. In this way, they provide both precision and representativeness information.

Comparability

Comparability is a qualitative objective of the data, expressing the confidence with which one data set can be compared with another. Sample data should be comparable for similar samples and sample conditions. Comparability is unknown unless precision and bias are provided. When this information is available, the data sets can be compared with confidence.

The laboratory shall make the necessary provisions to ensure the comparability of all data. These procedures include, but are not limited to, the use of standard approved methodologies, the use of standard units and report format, the use of calculations as referenced in the methodology for quantitation, and the use of standard measures of accuracy and precision for QC samples. All provisions to ensure data comparability shall be detailed in the QAPP.

Completeness

Completeness shall be evaluated qualitatively and quantitatively. The qualitative evaluation of completeness shall be determined as a function of all events contributing to the sampling event including items such as correct handling of chain of custody forms, etc. The quantitative description of completeness shall be defined as the percentage of measurements that are judged to be usable (i.e., which meet project-specific requirements) compared to the total number of measurements planned.

Sensitivity

The term sensitivity is used broadly here to describe the contract method detection, quantitation, and reporting limits established to meet the DQOs; and not limited to the definition which describes the capability of a method or instrument to discriminate between measurement responses. Several limits may be established to describe sensitivity requirements (i.e., instrument detection limits [IDL], method detection limits [MDL], sample quantitation limit [SQL], practical quantitation limits [PQL], contractor-required detection limits [CRDL], contract-required quantitation limits [CRQL], etc.). Current sensitivity requirements (MDLs) for this project are presented in the FSP.

5.3.2 Quality Control Responsibilities

All of the selected staff for this project have the qualifications and experience required for conducting their specific assignments. All MWH project personnel are responsible for identifying, reporting, and documenting any activities that could adversely affect the quality requirements set forth by the contract.

Each laboratory has a designated project manager for this project and shall provide direct interface with MWH personnel.

5.3.3 Reconciliation with Data Quality Objectives

An assessment of data quality will be performed by MWH to determine whether data generated are consistent with the investigation objectives. If data are found to deviate significantly (several orders of magnitude) from previous analyses or surrounding conditions upon which the sampling program was based, the data may be qualified based on the validator's assessment of the usability of the data for the intended end uses.

5.4 CORRECTIVE ACTION

Corrective action is required when potential or existing conditions are identified that may have an adverse impact on data quality. Corrective action applies to both the field and laboratory procedures. In general, any member of the project team who identifies a condition adversely affecting quality can initiate corrective action. Written evidence (e.g. field or laboratory logbook) will document and identify the condition and explain the way it may affect data quality.

A well-defined and effective policy for correcting quality problems is critical to the success of a quality assurance program. While this QA program is designed to minimize problems, it must also identify and correct any problems that do exist. The corrective action system for this project will include:

- Identify the problem
- Identify cause of the problem
- Identify corrective actions to correct the problem
- Implement corrective actions
- Verify effectiveness of corrective actions in correcting the problem
- Document corrective action including:
  - Problem identified and cause
  - Corrective actions implemented
  - Effectiveness of corrective actions
  - Samples impacted by problem

Documentation of corrective actions will be included in the project file.

6.0 HEALTH AND SAFETY PLAN

All sampling and survey activities will be performed under the Site Specific Health and Safety Plan included in Appendix A.

7.0 REFERENCES

MWH, 2002, St. Anthony Mine Site Stage 1 Abatement Plan, Steamboat Springs, Colorado.

NMED, 1995, Preliminary Assessment Report St. Anthony Mine, Cibola County, New Mexico, Santa Fe, New Mexico.

APPENDIX A

SITE SPECIFIC HEALTH AND SAFETY PLAN

ST. ANTHONY MINE

STANDARD OPERATING PROCEDURE
HEALTH AND SAFETY PLAN

Approvals: **Date**:

______________________________ ________________________

MWH Health and Safety Officer

______________________________ ________________________

MWH Project Manager

SITE SPECIFIC HEALTH AND SAFETY PLAN

for the
St. Anthony Mine Materials Characterization Plan
New Mexico

1.0 ITEMS 1.0 – 9.0 TO BE COMPLETED BY PROJECT MANAGER OR SITE SAFETY COORDINATOR:

PROJECT NAME: St. Anthony Materials Characterization Plan

REQUESTED BY: John V. Redmond

PROPOSED START-UP DATE: March 2006

Prepared by/Reviewed by Site Health and Safety Coordinator

Printed Name: James Thompson

Signature___________________________________ Date__________________

Reviewed by Corporate Health and Safety Officer

Printed Name: Beth Darnell

Signature___________________________________ Date__________________

Approved by Project Manager

Printed Name: James Thompson

Signature___________________________________ Date__________________

2.0 PROJECT DESCRIPTION: Work at the St. Anthony Mine may consist of data collection activities associated with characterization soils, surface water and groundwater. The role of MWH at the site during site investigation activities will include project management and sample collection.

3.0 LOCATION: The St. Anthony Mine was an open pit and underground shaft uranium mine located on the Cebolleta Land Grant approximately 40 miles West of Albuquerque, New Mexico located in Cibola County approximately 4.6 miles southeast of Seboyeta, New Mexico

4.0 FACILITY/WORK SITE DESCRIPTION: The St. Anthony Mine site includes underground workings consisting of one shaft, approximately eight vent shafts that are sealed at the surface, two open pits (one containing a pond), seven large piles of non-economical mine materials with some revegetation, and numerous smaller piles of non-economical mine materials.

5.0 PERSONNEL AND TASKS:

Project Manager: James Thompson

Field Personnel: Andy Rossi, Field Coordinator

On-site Safety Coordinator: James Thompson

All personnel will be required to have a site briefing prior to first entry onto site. This briefing will be conducted by the MWH Field Coordinator or Project Manager. Additionally, "tailgate" safety meetings will be conducted daily prior to any activities.

All contractors to MWH, and their subcontractors, are required to have their own individual Site-Specific Health and Safety Plans, which will be reviewed and approved by the MWH Site Safety Coordinator prior to mobilization on site.

6.0 EMERGENCY RESPONSE

The on-site safety coordinator will have final authority for first response to on-site emergency situations. In the event that the on-site safety coordinator is not on site, an alternate coordinator will be designated with all applicable authority.

Upon arrival of the appropriate emergency response personnel, the site emergency coordinator shall defer all authority to emergency response personnel but will remain on the scene to provide any and all possible assistance. At the earliest opportunity, the site safety officer or the site emergency coordinator shall contact the MWH Project Manager or MWH Health and Safety Officer.

Project Manager:
John Redmond **Phone (W) :** (970) 879-6260 **Phone (H) :** (970) 638-0918
Mobile Phone: (303) 324-2914

Health & Safety Officer:
Leah Wolf Martin **Phone (W) :** (970) 879-6260 **Phone (H) :** (303) 475-1135

Nearest Emergency Facility: Cibola General Hospital
Location: 1016 E. Roosevelt, Grants, NM (25 miles West of Cebolleta, NM)
Telephone: (505) 287-4446

7.0 DETAILED WORK DESCRIPTION

The St. Anthony Materials Characterization Plan investigation includes sampling of surface and near surface soils and a radiological survey will be conducted to evaluate the suitability as plant growth material and the potential impact of these materials to surface and ground waters. The work could be conducted at various locations on the site.

Site activities may include the following tasks:

- Excavation and trenching
- Drilling or boring

More detailed description of all sampling and characterization activities can be found in the work plan for the activities being performed.

8.0 CHEMICAL/RADIOLOGICAL HAZARD EVALUATION

Are chemicals or radiological hazards known or suspected at this site.

X Yes - describe below ___ No

Waste Media

X Airborne Contamination
X Surface Contamination
___ Contaminated Soil (hydrocarbons)
X Contaminated Groundwater
___ Contaminated Surface Water
X Solid Waste (waste rock materials)
___ Liquid Waste

Hazardous Characteristics

___ Ignitable
X Corrosive
___ Reactive
___ Explosive
___ Toxic (non-radiological)
X Radioactive

Description:

PRIMARY HAZARDS (Rate: low, medium, high, extreme)								
Substance	**Inhalation of Gases/ Vapors**	**Inhalation of Dusts/Mists**	**Ingestion**	**Dermal Absorption of Solids/Liquids and or Skin Contamination**	**Dermal Absorption of Gases/Vapors**	**Corrosive/ Irritant**	**Ignitability**	**Toxicity**
Waste Rock	N/A	MEDIUM	LOW	LOW	N/A	LOW	N/A	LOW

SUBSTANCE	Level D	Level C (APR) (1)	OSHA PEL (2)	ACGIH TLV (3)
Dust-(with metals or silica)	0-.05 mg/m^3	0.05-0.5 mg/m^3	0.05 mg/m^3	0.05 mg/m^3

(1) APR—Air Purifying Respirator
(2) PEL—Permissible Exposure Limit
(3) ACGIH TLV—American Conference on Government Industrial Hygienists, Threshold Limit Value

9.0 PERSONAL PROTECTIVE EQUIPMENT

Location	Job Function/Task	Initial Level of Protection			
		A	B	C	D
St. Anthony Site	Excavation, drilling and boring				X

List the specific protective equipment and material (where applicable) for each of the Levels of Protection identified above.

Level C (same as Level B with lower level respiratory protection)

__ Coveralls
__ Disposable nitrile
__ Chemical resistant clothing, gloves and boots
__ Long underwear
__ Ear Protection
__ Half or full face air purifying respirator with canister
Canister type: __ HEPA, __ (Other):
__ Hard hat, steel toed rubber boots, safety glasses
__ Inner latex gloves
__ Outer NBR (Nitrile Butyl Rubber) gloves
__ Tyvex if waste is dry. Polytyvek if wet. Saranex if PCB wastes.
__ Two-way radio communication

Level D

X Coveralls (as required)
X Standard work clothes
X Hard hat
X Safety boots
X Safety glasses
X Goggles (as needed during water sampling)
X Acid resistant gloves (when sampling water)
X Safety vest (as required when around heavy equipment)
X Ear protection
X Dust mask (required during dusty conditions)

Note: Dust masks will be made available to all personnel for use as site conditions warrant.

NO CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL BE MADE WITHOUT THE KNOWLEDGE AND APPROVAL OF THE HEALTH AND SAFETY OFFICER AND THE PROJECT MANAGER.

10.0 ACTION LEVELS

Task personnel shall observe the following Action Levels:

Substance	Action Level	Specific Action
Air Quality – Total Suspended Particulate	High Level Dust and Visibility <20[1] ft. Some Dusty Conditions	Stop Work; Disposable dust mask

11.0 CONFINED ENTRY PROCEDURES X Not Applicable __ Applicable

Will this project require entry into any confined or partially confined space?

__ Yes - describe below X No

It is not anticipated that any reclamation tasks will involve working in a confined space. If confined spaces are encountered work will be done in accordance with the subcontractor's HASP, as applicable.

12.0 CUTTING/WELDING PROCEDURES __ Not Applicable X Applicable

Will any task involve use of a cutting torch or welding?

X Yes - describe below __ No

Requirements

X Relocate or Protect Combustibles
__ Wet Down or Cover Combustible Floor
__ Check Flammable Gas Concentrations (% LEL) in air
__ Cover Wall, Floor, Duct and Tank Openings
X Provide Fire Extinguisher

13.0 OTHER POTENTIAL HAZARDS

__ Fire/Explosion
X Temperature Stress
__ Electrical
X Gas (Sulfur, O_2 deficiencies)
X Unstable/Uneven Terrain
X Torch Cutting or Welding
X Trips, Slips, Falls
__ Trenching/Shoring
X Heavy Equipment/Vehicular Traffic
X Overhead Hazards
X Machinery/Mechanical Equipment
X Other - Describe below

Description:

- Site location is subject to hot and cold weather extremes. Cold exposure may increase with wind velocity. Weather conditions have the potential become extreme rather quickly (rain or snow). Cold weather and rain gear should be available at the site at all times. Site personnel should be aware of heat stroke potential, and monitor as appropriate during warm weather activities.

- Personnel need to be aware of unmarked hazards which may potentially cause slips, trips, and falls. These unmarked hazards may include unstable or uneven terrain, steep terrain, pit highwalls, undercuts along natural drainages, miscellaneous site debris, piping, cables, etc.

- A drill rig will be used during the boring and drilling operations. Caution and an alert attitude should be used when near heavy equipment. Keep a safe distance at all times. Equipment should be approached only after it has stopped and after eye contact has been established with the operator. All drilling operations shall comply with the MWH ES&H Procedure No. 811: *Drilling Safety*, attachment 1. Personnel should also be aware of regular vehicular traffic. Site trucks and other equipment should always be parked outside of heavy equipment work areas.

- Overhead power lines are present at the St. Anthony Mine site. Caution and an alert attitude should be used when operating heavy equipment and vehicles near power lines. Keep heavy equipment and vehicles a safe distance from power lines at all times.

- The St. Anthony Mine site is an unimproved area. There are no fresh water, washing/shower, or toilet facilities at the site.

14.0 PERSONAL MONITORING   X Not Applicable   ___ Applicable

___ Passive Dosimeter ___ Biological Monitoring ___ Personal Air Sampling ___ Other

Does this project require medical surveillance or biological monitoring procedures beyond the provisions of the routine medical surveillance program? ___ Yes X No

If yes, describe below.

Description: N/A

15.0 PERSONAL DECONTAMINATION   X Not Applicable   ___ Applicable

ON-SITE CONTROL   X Not Applicable   ___ Applicable

At this time, contamination is not expected in any of the areas where monitoring is planned. Therefore, a Controlled Zone has not been established. If a Controlled Zone is established, personnel and equipment leaving the Controlled Zone shall proceed through the following decontamination stations and procedures from the decontamination zone (Decontamination area(s) designated for all decontamination activities, will be selected by MWH field supervisors):

A: Personnel Decontamination

(Procedure not required unless action level utilizes Level C PPE or higher.)

Station Procedure

1. Boot wash	Wash (scrub) and rinse steel toed rubber boots
2. Outer glove wash/drop	Wash and rinse outer rubber gloves
3. Respirator	Remove respirator - wash nightly

Emergency Decontamination Procedures:

If decontamination can be done: Wash, rinse and/or cut off protective clothing and equipment.

If decontamination cannot be done: Wrap victim in blankets, plastic or rubber to reduce contamination of other personnel. Alert emergency and off-site personnel to potential contamination; instruct them about specific decontamination procedures if necessary. Send along site personnel familiar with the incident.

The following decontamination equipment is required:

NONE

SANITATION REQUIREMENTS (May be clarified during future site visit.)

Potable water supply (portable water cooler) available on work site? __ Yes X No

Portable toilets required on work site? X Yes __ No

Temporary washing/shower facilities required at work site?

__ Yes If yes, describe below.
X No If no, state location of existing facilities. Cebolleta, New Mexico

16.0 EMERGENCY PROCEDURES

This section is to be posted in a prominent location on-site.

EMERGENCY RESPONSE

The on-site safety coordinator, James Thompson, has final authority for first response to on-site emergency situations. In the event that the on-site safety coordinator is not available, an alternate coordinator will be designated with all applicable authority.

Nearest Emergency Facility: Cibola General Hospital

Location: 1016 E. Roosevelt, Grants, NM (25 miles West of Cebolleta, NM)

Telephone: (505) 287-4446

Upon arrival of the appropriate emergency response personnel, the site emergency coordinator shall defer all authority but shall remain on the scene to provide any and all possible assistance. At the earliest opportunity, the site safety officer or the site emergency coordinator shall contact the MWH Project Manager or Health and Safety Officer.

Project Manager:
John V. Redmond **Phone (W) :** (970) 879-6260 **Phone (H) :** (970) 638-0918
Mobile Phone : (303) 324-2914

Health & Safety Officer:
Leah Wolf Martin **Phone (W) :** (970) 879-6260 **Phone (H) :** (303) 475-1135

On-site Communication Required? ___ Yes _X_ No

On-site Emergency Phone Number: N/A

Emergency Channel: N/A

Nearest Telephone: Mobile phone or public phone in Cebolleta, New Mexico.

Mobile Telephone (site): Limited cellular service in area.

FIRE AND EXPLOSION

In the event of a fire or explosion, if the situation can be readily controlled with available resources without jeopardizing the health and safety of yourself, the public, or other site personnel, take immediate action to do so, otherwise:

1. Notify emergency personnel by calling 911
2. If possible, isolate the fire to prevent spreading.
3. Evacuate the area.

EXPOSURE

Site workers must notify the site Health and Safety Officer immediately in the event of any injury or any of the signs or symptoms of overexposure to heat or cold.

Designated Personnel Current in First Aid/CPR: James Thompson

REQUIRED EMERGENCY BACK-UP EQUIPMENT/NOTIFICATIONS:
(Located in back of field vehicle.)

X Fire extinguisher
X First aid kit, including eye wash
X Portable phone
X Radio
X Flares
X Water in field vehicles, including ample volume for possible rinsing
X Hearing protection
X Dust masks
X Rain and cold weather gear
X Buddy System – make sure someone else knows where you are and your schedule

17.0 FIELD PROCEDURES CHANGE AUTHORIZATION

Instruction Number to be changed:
Duration of Authorization Requested:

Date:

Description of Procedure Modification:

Justification:

Person Requesting Change:	**Verbal Authorization Received From:**
Name	Name
Title	Title
Signature Date	Approved By Date

(Signature of person named above to be obtained within 48 hours of verbal authorization)

18.0 SAFETY BRIEFING

The following safety briefing will be completed each day prior to commencement of site activities:

The following personnel were present at pre-job safety briefing conducted at ___________(time), on _ ___________(date) at______________________________ (location) and have read the above plan and are familiar with its provisions:

The personnel whose signatures appear below were in attendance at said briefing and are familiar with the provisions of this Health and Safety Plan:

Name	Signature
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

Fully charged ABC Class fire extinguisher available at work site? Yes ___
Fully stocked first aid kit available on site? Yes ___
All project personnel advised of location of nearest phone? Yes ___
All project personnel advised of location of designated medical facility or facilities? Yes ___

____
Printed Name of Project Manager or Site Safety Officer

____
Signature and Date

ATTACHMENT 1

ES&H PROCEDURE 811
DRILLING SAFETY

811 DRILLING SAFETY

I. PURPOSE

This procedure provides information on the hazards, regulatory requirements, and safe work practices for using drilling equipment and performing drilling operations. This procedure address all forms of drilling, including cable tool, rotary, geo-probe, rotosonic, and hollow-stem auger drilling used for most geotechnical, investigation, groundwater, and subsurface exploration drilling projects.

II. REGULATORY REVIEW

There are no specific Occupational Safety and Health Administration (OSHA) regulations for drilling activities; however, general guidelines may be found in 29 CFR 1926.800, *Underground Construction,* section (q). In addition, some of the OSHA standards that are applicable to drilling operations include:

29 CFR 1926, Subpart E, *Personal Protective and Lifesaving Equipment*
29 CFR 1926.65, *Hazardous Waste Operations and Emergency Response*
29 CFR 1926.251, *Rigging Equipment for Material Handling*
29 CFR 1926.307, *Mechanical Power-transmission Apparatus.*
29 CFR 1926.550, *Cranes and Derricks*
29 CFR 1926, Subpart Z, *Toxic and Hazardous Substances*

Some state OSHA plans may have additional requirements for drilling. Also, the client may have specific permits or operation practices that will be applicable to MWH drilling operations. Contact the Regional ES&H Manager for additional information.

Additional information may be obtained from the following non-regulatory references:

- ATEC Associates, Inc. 1991. *Drilling Safety: Working in the Danger Zone.*
- Diamond Core Drill Manufacturers Association (DCDMA) and the National Drilling Contractors Association (NDCA). *Drilling Safety Guide.* National Drilling Federation.
- Driscoll, Fletcher. 1989. *Groundwater and Wells.*
- West Hazmat Drilling. 1991. *Workplace Injury & Illness Prevention Program.*
- U S Army Corps of Engineers, EM385-1-1, *Safety and Health Requirements* Chapter 16.

III. ROLES AND RESPONSIBILITIES

A. ES&H Director

The ES&H Director is responsible for establishing a program that provides for the protection of MWH employees and subcontractors and that meets the applicable regulatory requirements for the use of, and work adjacent to, drilling equipment.

B. Regional ES&H Manager

The Regional ES&H Manager is responsible for:

- Ensuring that this procedure is implemented within his or her region.
- Ensuring assessments are completed to verify compliance with regulatory and procedure requirements.

C. ES&H Representative

The ES&H Representative is responsible for the following:

- Evaluating work sites and activities to ensure drilling operations are conducted in compliance with the requirements of this procedure and regulatory standards.
- Verifying that equipment inspections are completed and that equipment used is in serviceable condition.
- Verifying that employees are following safe work practices for work with, and adjacent to, drilling operations.

D. Employee

Each employee is responsible for the following:

- Understanding the hazards and following the required safe work practices for drilling operations.
- Using the personal protective equipment (PPE) specified for the task being performed.

IV. DEFINITIONS

Annulus: The space between the drill string (length of connected drill pipe) or casing and the wall of the borehole or outer casing.

Auger Drilling: A general type of drilling in which the borehole is drilled by rotating augers (either hollow-stem or solid-stem), and cuttings are removed by being pushed up the "flights" (corkscrew-like flanges) of the augers. (Note: the term "flight" is often used to indicate the lengths of hollow-stem or solid-stem augers, as well as the flanges on the augers.) Hollow-stem augers allow drillers to send split-spoon samplers down through the center of the augers, thereby eliminating the need to pull out the augers first. Solid-stem augers are used for smaller-diameter holes and for drilling through formations where more concentrated downward force is necessary.

Bit: The cutting tool attached to the bottom of the drill string. Used in rotary drilling.

Blowout: An uncontrolled escape of drilling fluid, gas, oil, or water from the well caused by the formation pressure being greater than the hydrostatic head of the fluid in the borehole. Also, an uncontrolled escape of grout from the borehole or well caused by malfunctioning pressure grouting apparatus.

Cone Penetrometer Testing (CPT): This was originally a method of performing geotechnical evaluations of subsurface soils, now additionally used to obtain rough estimates of aquifer properties. The CPT rig uses a direct-push method to advance a cone equipped with electronic sensors. As the cone is pushed downward, measurements are collected by the sensor and are recorded on the CPT aboveground equipment. Some CPT rigs are also capable of collecting soil gas, soil and groundwater samples at shallow depths (usually less than 50 feet).

Cuttings: Formation particles obtained from a borehole during the drilling process.

Direct-Push Soil Gas/Soil/Groundwater Sampling: A method of sampling either soil gas, soil, or groundwater by advancing a small sampling probe. The probe is hydraulically pushed downward, generating virtually no cuttings and eliminating waste disposal concerns. Direct-push sampling is applicable where no permanent wells are desired, and/or where sampling is required at relatively shallow depths (usually less than 50 feet). Direct-push equipment may be truck-mounted (on a vehicle), or mounted on a modified hand truck.

Drill Collar: A length of extremely heavy steel tube. It is placed in the drill string immediately above the bit to minimize bending caused by the weight of the drill pipe.

Drill Pipe: A special pipe used to transmit rotation from the rotating mechanism to the bit. The pipe also transmits weight to the bit and conveys air or fluid, which removes cuttings from the borehole and cools the bit.

Drilling Fluid or Mud: A water-based or air-based fluid used in the well drilling operation to remove cuttings from the borehole, to clean and cool the bit, to reduce friction between the drill string and the sides of the borehole, and to seal the borehole.

Grouting: The operation by which grout is placed between the casing and the sides of the borehole to a predetermined height above the bottom of the well. This secures the casing in place and excludes water and other fluids from the borehole. A pressure grouting operation injects grout from the surface under high pressure, in order to move grout laterally in the subsurface and ensure an adequate seal.

Kelly: A hollow steel bar or pipe that is the main section of drill string to which the power is directly transmitted from the rotary table to rotate the drill pipe and bit. The cross section of the kelly is either square, hexagonal, or grooved. The kelly works up and down through drive bushings in the rotary table.

Limited Access Drill Rig: A type of drill rig, usually equipped with solid-stem augers, which allows drilling in tight spaces or in areas with low overhead clearance (less than 12 feet). Limited access drill rigs may be mounted on a small lawnmower-like vehicle, or on a modified hand truck.

Rotary Drilling: A general type of drilling in which the borehole is drilled by rotating a bit, and cuttings are removed by continuous circulation of a drilling fluid (e.g., mud, water, air, foam) as the bit penetrates the formation. The bit is attached to the lower end of a string of drill pipe, which transmits the rotating action from the rig to the bit.

Rotary Table: A mechanical or hydraulic assembly that transmits rotational torque to the kelly, which is connected to the drill pipe and the bit. The rotary table has a hole in the center through which the kelly passes.

Split-Spoon Sampler: A thick-walled steel tube split lengthwise used to collect soil samples. The sampler is commonly lined with metal sample sleeves and is pounded or pushed downhole by the drill rig to collect samples.

V. PLANNING

A. Training

Only trained and experienced personnel who are familiar with the use, limitations, and maintenance requirements of the equipment are permitted to operate the drill rig. The drill rig must be operated in accordance with the manufacturer's instructions and recommendations.

The drill crew shall be familiar with the hazards associated with the drilling operations, personal protective equipment requirements, location of emergency stops, site-specific safety requirements, and the content of this procedure.

Additional training requirements may be required based on the location of the drilling activities. This training may include:

- Hazardous Waste Operations training if work is conducted at a hazardous waste site.
- Waste management training, where waste streams (e.g., drill cuttings, purge water, decontamination water, contaminated personal protective equipment) will be generated.

Site-specific training requirements will be outlined in the project-specific HASP.

B. Medical Surveillance

There are no medical surveillance requirements specific to drilling activities. However, drilling at hazardous waste sites that involve toxicological hazards may require medical surveillance.

Medical surveillance requirements will be addressed in the Project HASP.

MWH drilling subcontractors are responsible for ensuring that their employees receive medical surveillance as required.

C. Safety Equipment

MWH will provide required PPE and safety equipment for its employees and operations. Subcontractors are responsible for providing all PPE and safety equipment necessary for safe operation. Safety equipment will be provided by the subcontractor as delineated in the subcontract and referenced documents. The minimum safety equipment for drilling activities includes safety-toed boots, hard hats, and safety glasses with side shields. Other safety equipment that may be required for drilling operations includes:

- Hearing protection when working in proximity to drilling machinery.
- Body protection (e.g., gloves and protective coveralls) when chemical hazards exist.

- Detection equipment shall be provided if the exact location of underground utilities cannot be determined.
- Air monitoring instruments shall be provided if the potential for a hazardous atmosphere exists in the drilling location.
- High-visibility warning vests are to be worn by all workers exposed to vehicle traffic.
- Fall protection equipment is required if working from unprotected platforms or surfaces greater that 6 feet above the lower level.

D. Subcontractor Selection and Oversight

The *Subcontractor Safety Program Review Criteria—Drilling Operations*, Attachment A, provides the minimum criteria for subcontractor drilling safety procedures. These criteria will be used by the ES&H Representative or ES&H Staff to review subcontractor programs and procedures

Responsibilities for environment, safety and health are expressly defined in the subcontract terms and conditions, and MWH's ES&H practices in the field are determined based on these defined responsibilities. MWH employees shall not direct the means and methods of the subcontractor's operations or direct the details of corrective actions except when MWH employees are responsible for the work activity by contract.

E. Planning Activities

Depending on the contract with the client, the subcontract with a drilling subcontractor, and the physical location of the drilling operation, MWH, may be responsible for some of the following functions to support drilling operations. The responsible party for these items should be clearly defined in the contract and subcontract requirements and included in the Project ES&H Plan.

1. Utility Location

The location of underground utilities, such as electric, fuel, water, cable, telephone, and sewer (either in service or abandoned), and underground installations such as foundations, underground storage tanks, piping, and any other structures need to be identified before drilling is permitted. Utility companies and/or installation owners shall be contacted to provide exact locations of their equipment or structures. Some states have a one-call phone number for locating underground utilities. Most utilities and call centers require a minimum 48-hour-notice (excluding Saturdays, Sundays, and holidays) to identify utilities before drilling work can begin.

If underground utilities cannot be positively located, or where drilling is performed in areas known or suspected to contain buried objects (e.g. drums, tanks, or cylinders), the area will be surveyed with the aid of audio and radio frequency transmitters and receivers, ground penetrating radar, ultrasonic testing, metal detectors, or other means necessary to ensure safe drilling operations.

Overhead electrical transmission and communication lines also need to be identified. If any portion of the drill rig will be within: 10 feet of electrical lines up to 50kV or 10 feet plus 4 inches for every 10 kV over 50 kV, the utility or other facility operating the system will be contacted to have the lines de-energized.

Access to the work location will also be evaluated. Where rigs must travel under energized electrical lines, clearance will be 4 feet for voltages up to 50kV; 10 feet for voltages over 50kV and up to 345kV; and 16 feet for voltages from 345kV up to 750kV.

2. Permits

The following permits and notifications may be required, depending on state, local, and client requirements. The Regional ES&H Manager should be contracted for assistance in determining applicability.

- Well driller license/certification or Professional Geologist requirements: MWH subcontractors will be required to submit licenses or certifications before subcontract award, where applicable.
- Well installation or abandonment notification: Submittal of a well log or inventory may be required after installation or abandonment.
- A groundwater withdrawal permit may be required for large water withdrawals in some states.
- A "drilling permit" may be required at certain client facilities.

3. Waste Management

Drill cuttings and purge water from uncontaminated soil or ground water shall be appropriately.

When drilling is conducted at hazardous waste sites, the Regional ES&H Manager or designee may be consulted on the proper evaluation, disposal, and decontamination procedures involving potential hazardous waste.

- All waste generated shall be evaluated for appropriate disposal and handled in accordance with the appropriate waste management procedure.
- If drilling involves hazardous waste, MWH decontamination procedures shall be followed. No potentially contaminated equipment shall be permitted to leave the work site.

4. Drilling at Ordnance Explosives (OE) or Unexploded Ordnance (UXO) Sites

If the project site is suspected of OE contamination, the requirements of the ES&H procedure for *Unexploded Ordnance, Open Firing Ranges, and Chemical Warfare Agents,* shall be followed. The following procedures will be implemented, at a minimum:

- Drilling operations on OE sites will not be conducted until a complete plan for the site is prepared and approved by MWH ES&H, and the UXO Safety Officer. OE/UXO avoidance must be conducted during drilling operations on known or suspect OE sites.
- The UXO team will identify and clearly mark the boundaries of a clear approach path for the drilling crews, vehicles, and equipment to enter the site. This path will be, at a minimum, twice the width of the widest vehicle. No personnel will be allowed outside any marked boundary.
- If OE is encountered on the ground surface, the UXO team will clearly mark the area where it is found, report it to the proper authorities, and divert the approach path around it.
- The UXO team will conduct an access survey using the appropriate geophysical instrument over the approach path for avoidance of OE that may be in the subsurface. If a magnetic anomaly is encountered, it will be assumed to be OE and the

approach path will be diverted around the anomaly. Only UXO personnel will operate the appropriate geophysical instrument and identify OE.

- An incremental geophysical survey of the drill hole location(s) will be initially accomplished by the UXO team using a hand auger to install a pilot hole. If OE is encountered or an anomaly cannot be positively identified as inert material, Hazardous Toxic Radiological Waste sampling personnel will select a new drill hole location.

- Once a drilling site has been surface cleared and a pilot hole established as described above, the drilling crew or subcontractor will be notified that the site is available for subsurface drilling.

VI. PROCEDURE

A. Safe Work Practices

Only authorized or licensed personnel, based on applicable state or local requirements, shall be permitted to operate drill rigs.

When moving large equipment in a confined area, spotters shall be used. The spotter and equipment operator must use standard hand signals for communication. Spotters shall never place themselves between equipment and fixed structures or equipment.

Drill site work areas shall be demarcated to deter unauthorized individuals from entering the work area.

Personnel not involved in equipment operation shall remain clear of drill rigs.

Personnel shall stay clear of the rotating augers and other rotating components of drill rigs at all times. Stand to the side while tripping and tailing rods and augers. Never stand under the rod/auger or between the rig and service truck while tripping rods or augers.

Stay as clear as possible of all hoisting operations. Loads shall not be hoisted over personnel. Never work around or under drilling rods or augers being hoisted.

Keep footwear and work area free of mud and drilling fluids. Maintain 3 points of contact when mounting and dismounting a drill rig. Do not climb the drill rig mast without the use of fall protection.

Augers shall not be stored standing up and shall be secured from rolling.

Hand tools shall be inspected before use. Wrench jaws must be periodically inspected and replaced when necessary.

Understand and be aware of all pinch points including breakout wrenches, pull down cables, and pulling jacks. These points should be color-coded. Experienced employees must show new employees these pinch points on the first day of work.

Good housekeeping shall be maintained at all times. Litter will be properly stored, and hand tools and other hardware will be properly secured on the drill rig. Before moving a drill rig, a check shall be made for loose tools and hardware.

All work areas, platforms, walkways, scaffolding, and other accessways should be maintained free of materials, debris, obstructions, and substances, such as ice, grease, or oil.

Drill rods and augers should be placed on dunage and secured to prevent movement. Always use a sling or strap while manually handling rods and augers.

Be aware of your footing to prevent slips, avoid stepping between rods and augers to prevent crushed ankles from their movement.

Do not wear loose-fitting clothing or other items, such as rings or watches, that could get caught in moving parts. Individuals with long hair should have it restrained.

Personnel shall not smoke around drilling operations.

Personnel shall wear the appropriate PPE. Minimum protection includes safety-toed boots, hard hats, safety glasses, and hearing protection.

A daily safety briefing shall be conducted with all work site personnel to discuss the work planned for the day and the ES&H requirements.

Unattended boreholes shall be covered or protected to avoid the possibility of animals or people accidentally falling into them.

Wellheads on roads and parking lots should be flush-mounted.

B. Site Preparation

Verify that underground utilities and structures have been located and marked, and overhead utilities de-energized as required.

As applicable, the drilling site shall be prepared, cleared, and leveled, particularly on steep slopes or areas that are covered with dry dead grass and weeds. Care should be taken in constructing pads if extensive cutting into existing slopes or surfaces is required to level the area. Areas where extensive fill is required should be avoided. Compaction is recommended if significant amounts of fill are needed; the ground must be capable of supporting the impact imposed by the drill rig and associated equipment. Clean fill or gravel can be brought in to cover areas with surface contamination.

Before drilling equipment is mobilized to the drilling pad, the travel route shall be surveyed for overhead and terrain hazards. Access roads shall be designed, constructed, and maintained to safely accommodate the movement of the drill rig and other equipment.

Material Safety Data Sheets (MSDSs) shall be available for all drilling fluids, grout, bentonite, or other substances used in the drilling process.

C. Drill Rig Requirements

All self-propelled drill rigs shall be equipped with the following safety features:

- Seatbelts,
- Multipurpose dry chemical fire extinguisher rated at not less that 2A:10B:C
- Multidirectional alarm
- Operator's Manual
- Horn
- Lights
- Other warning devices specified by the manufacturer

Self-propelled off-road drill rigs will be equipped with roll-over protective structures (ROPS) meeting Society of Automotive Engineers requirements.

The drilling equipment shall be equipped with two easily accessible emergency shutdown devices.

Control levers on the drill rig shall be clearly labeled indicating the function and direction of the movement.

All machine guards shall be in place while the rig is in operation.

Where drill rigs are equipped with a platform, the platform shall be constructed from material strong enough to support the weight of the load that will be placed on the platform. The platforms shall be accessed using a ladder or steps. Platforms over 6 feet above ground surface shall be equipped with a guardrail system that includes a toeboard.

The drill rig and associated equipment shall be inspected each day before use by a qualified mechanic or an operator knowledgeable of the specific equipment. Inspections and tests will be conducted in accordance with the manufacturer's recommendations. A written record of the inspections shall be kept on the equipment or in a project file. Consideration shall be given to the following items in the performance of equipment inspections.

- Missing nuts, bolts, pins, loose fittings and couplings.
- Cracked paint, frayed cables and hoses, evidence of fluid leakage on equipment or ground, and loose tracks and pads.
- Fluid levels in the battery, hydraulic system, brake system, and cooling systems; engine lubrication; and fuel supply. CAUTION: Never use your hands to check for hydraulic leaks. An open flame shall not be used to check fluid levels or look for leaks.
- Condition of glass in cab clean and not broken, gauges checked for proper function and readings; test of brake lights, horn, backup alarm, steering, and other controls.
- All emergency shutdown and warning systems to ensure that they are working correctly.

When deficiencies that affect the safe operation of equipment are identified, the equipment will be immediately taken out of service until unsafe conditions are corrected. A "DO NOT OPERATE" tag indicating that the equipment is not to be operated will be placed on the operator controls. When required or necessary, lockout procedures will be used. When corrections are made, the equipment will be re-tested for safe use before being returned to service.

D. Equipment Travel and Set-up

Safe clearances from overhead electrical transmission lines shall be maintained.

The operator shall ensure ground is stable and that grades, especially side traverses, are within the operating limits of the vehicle.

The mast shall be lowered and rig placed in appropriate configuration for travel. Drilling equipment shall not be transported for even a short distance with the mast up.

The drill rig must be leveled and stabilized with leveling jacks. Cribbing shall be used as necessary. Outriggers shall be extended per the manufacturer's specifications. Cribbing materials should be made from materials that are capable of supporting the weight of the rig. Care should be taken in muddy, soggy soils, or partially frozen areas. In addition to cribbing, guy wires should be used as required by the manufacturer to improve stability if the rig is located on wet, partially frozen ground, or in areas with loose, caving soil, or in an area subject to frequent gusty winds.

Prior to raising the mast (derrick) the operator shall look up for overhead obstructions. The drill rig operator shall verify that all personnel are cleared from the area immediately to the rear and the side of the mast.

Unsecured equipment shall be removed from the mast and cables; mud lines and cat line rope must be secured before raising the mast.

Before starting drill operations, the mast shall be secured and locked in accordance with the manufacturer's recommendations.

E. Equipment Operation

The drill rig shall be provided with a "kill" switch that, when activated, will shut down the rig. The switch should be clearly identified and tested daily to confirm operational status. All drilling crew members should be made aware of the location and purpose of this switch.

The rope, wire rope, or cable on the drill rig should never be wrapped around any part of the body.

The drill rig should not be operated during severe inclement weather, such as lightning storms, high winds, or severe rain. The mast should be lowered during these conditions.

Before starting, the operator shall verify that all gear boxes are in neutral; all hoist levers are disengaged; hydraulic levers are in the correct non-actuating positions; and the cathead rope is not on the cathead.

The operator shall verbally alert workers and visually verify that workers are clear from the dangerous parts of equipment before starting the equipment.

Drill crew members shall not wear loose clothing or clothing with loose ends, straps, drawstrings, belts, or otherwise unfastened parts that might catch on rotating or translating components of the drill rig. Rings and jewelry shall not be worn during a work shift.

The drill rig shall always be operated from the control panel. The operator must never leave the control panel while the drill is in operation. Only one person should operate the machine. If the operator must leave the area of the controls, the operator must shift the transmission controlling the rotary drive into neutral and place the feed control level in neutral. The drill rig shall be shut down before he operator leaves the vicinity of the drill.

Pressurized lines, such as airlines, mud hose, etc. shall be equipped with safety-type couplings and secured with wire or chain at each coupling to prevent whipping in the event of failure. Lines and safety connection shall be inspected daily. Pressurized lines shall not be disconnected until shut off and bled to reduce the pressure.

Drilling fluid discharges shall be channeled away from the work area to prevent the accumulation of water. Mud pits and drainage channels should be safely sloped and located to provide minimum interference with the work. Where necessary, suitable barricades or temporary fencing should be provided to protect the work area and reduce the possibility of injury to persons.

Where compressed air drilling is conducted, the exhaust shall be directed into an approved dust collection system. The cuttings shall be directed to the side away from employees. Workers shall be required to use protective clothing and respiratory protection, when required.

1. Tool Handling – Hoist Line

All wire ropes and rigging hardware shall be thoroughly inspected before use. Defective equipment shall not be used. Shop fabricated rigging or hooks without latches are not permitted. Where a chain sling is used, it shall be an alloy chain and shall be properly labeled.

Hoist and rigging hardware shall be used only for their designated intent and shall not be loaded beyond their rated capacity. Steps shall be taken to prevent two-blocking of hoist.

The tool handling hoist shall only be used for vertical lifting of tools. The tool hoist must not be used to pull on objects away from the drill rig, unless specifically designed for that purpose.

Drill rods shall be neither run nor rotated through rod slipping devices: no more than 1 foot of drill column shall be hoisted above the top of the drill mast. Drill rod joints shall not be made up, tightened, or loosened while a rod-slipping device supports the rod column.

Chuck jaws shall not be used to brake a string of drill rods while being lowered into the hole. A cat line or hoisting cable or plug should be used for braking before tightening the chuck.

- Drilling rods shall not be lowered into the hole with a pipe wrench.

- When stuck tools or similar loads cannot be raised with a hoist, disconnect the hoist line and connect the stuck tool directly to the feed mechanism of the drill. Do this only when the rope is secured with a wrench or dog collar. Do not use hydraulic leveling jacks for added pull to the hoist line or feed mechanism of the drill.

Loads shall not be hoisted over the head, body, or feet of any person. Loads shall not be left suspended when the hoist is unattended. Work is not permitted under a suspended load.

Hoist lines shall not be used to ride up the mast of a drill rig.

When wire rope hoist lines are used, the following precautions shall be followed:

- Wire rope must be properly matched with each sheave. (If too large, the rope will pinch; if too small, the sheave will groove. Once a sheave is grooved, it will pinch and damage the larger rope.)

- Most sheaves on rigs are stationary and designed for a single-part line. Never increase the number of sheaves, winch lines, or part lines unless approved by the drill manufacturer.

- Minimize the shock to wire rope. Pull loads smoothly and steadily, especially in cold weather. Never use frozen ropes.

- Protect wire rope from sharp corners and edges. Replace faulty guides and rollers.

- When handling wire rope, always wear gloves. Do not guide rope onto hoist drums with your hands. Replace the wire rope according to manufacturer's specifications. When new rope is installed, first lift a light load to allow the rope to adjust.

2. Auger Drilling

Use an auger guide to facilitate the starting of a straight hole through hard ground or pavement, as applicable. Apply an adequate amount of down pressure before rotation to seat the auger head below the ground surface.

The operator and tool handler shall establish a system of responsibility for the series of activities required for auger drilling, such as connecting and disconnecting auger sections, and inserting and removing auger fork.

The operator shall verify that the tool handler and others are clear from the auger column and that the auger fork is removed before starting rotation.

The manufacturer's recommendations must be followed for securing the auger to the power coupling. Workers shall not touch the coupling or the auger with their hands, a wrench, or any other tools during rotation.

Only tight-fitting pins designed for the auger shall be used to secure auger flights. The use of mismatched augers shall be avoided.

Augers shall be cleaned only when the rotating mechanism is in neutral and the auger stopped. Long-handled shovels may be used to move auger cuttings away from the auger.

Workers shall not place their hands or fingers under the bottom of auger section when hoisting the auger over the top auger section in the ground or over hard surfaces such as drill rig platform.

Workers shall, stay clear of the rotating auger and other rotating components of the drill rig. Never reach behind or around a rotating auger for any reason.

3. Cathead Operations

The cathead shall be inspected before use. Inspection shall be made with the engine off. The cathead shall be kept clean and free of rust, oil, and grease. When 1/8-inch or greater rope groves form, the cathead should be replaced. In wet or icy conditions, a cathead cannot be used.

Always use a clean, dry rope. An oily rope may grab on the cathead. Never use a rope that is longer than necessary.

If the rope grabs or tangles, alert personnel to back away and stay clear. If tools are suspended, carefully shutdown the drill and back away. Once you have resolved the situation, the drill may be restarted and the tools lowered to safety.

Hoist lines shall be positioned to prevent contact with the cathead rope.

The following precautions shall be used to prevent cathead incidents:

- The operator should be on a level surface with firm footing.
- Do not wear loose clothing or gloves with loose straps or cuffs.
- Never wrap the rope around your hand, wrist, arm or other body parts. Never stand on the end of the cathead rope.
- Maintain a distance of 18 inches clearance between operating hand and drum.
- Be aware, the rope advances with each hammer blow.
- Do not leave a cathead unattended with the rope wrapped on the drum.

4. Rotary and Core Drilling

Water swivels, hoist plugs, rod chuck jaws etc. shall be inspected before use. Defective equipment shall not be used.

Only the operator of the drill rig shall brake or set a manual chuck so that rotation of the chuck will not occur before removing the wrench from the chuck.

Chuck jaws shall not be used to brake drill rods while lowering rods into hole. Drill rods shall not be held or lowered into the hole with pipe wrenches. If a string of drill rods are accidentally or inadvertently released into the hole, no attempt shall be made to grab the falling rods with hands or a wrench.

When drill rods are hoisted from the hole, they shall be cleaned to facilitate safe handling. The hand should not be used to clean drilling fluids from drill rods.

Drill rods shall never be lifted and leaned unsecured against the mast. Drill rods shall be secured to the upper ends of the drill rod sections for safe vertical storage or shall be laid horizontally.

In the event of a plugged bit or other circulation blockage, the pressure in the piping and hose between the pump and the obstruction should be relieved or bled down before breaking the first tool joint.

The spinning chain is very powerful and must be treated with respect. Spinning chains must have a rope tail. Communication between the driller and tool handler is required for safe operation of the spinning chain.

If freezing weather is expected, all air and water lines should be drained when not in use.

F. Drill Rig Maintenance

Components found to be in defective condition, either during inspections or during rig operation, should be repaired immediately.

Rig maintenance shall only be performed after appropriate lockout/tagout procedures have been implemented.

The cathead should be kept clean and free of rust, oil, and grease. The cathead should be cleaned with a wire brush if it becomes rusty.

Drilling operations may require repair or disentanglement of wire rope on the mast while it is raised. Fall protection shall be used when personnel are exposed to a fall of 6 feet or greater.

Augers should be cleaned only when the drill rig is in neutral and the augers have stopped rotating. Hands or feet should not be used to move cuttings away from the auger.

G. Self-Assessment Checklist

The *ES&H Self-Assessment Checklist – Drilling* provides a method of verifying compliance with established regulations, safe work practices, and industry standards pertaining to drilling operations. The MWH ES&H Representative or ES&H staff may use this checklist when MWH employees and/or MWH Subcontractors are performing drilling operations or are exposed to the hazards of activities involving drilling.

VII. ATTACHMENTS

Attachment A: *Subcontractor Safety Program Criteria – Drilling Operations*
Attachment B: *ES&H Self-Assessment Checklist – Drilling Operations*

Drilling Operations
ES&H Procedure – 811
Attachment A

Subcontractor Safety Program Criteria – Drilling Operations

MWH

ATTACHMENT A

Subcontractor Safety Program Criteria – Drilling Operations

The following criteria are not intended to be all-inclusive, but are provided as a tool to facilitate review of subcontractor safety procedures. Subcontractors are expected to address the following items, at a minimum, in their safety procedures.

Minimum Acceptable Criteria for Subcontractor Drilling Safety Procedures:

1. Provide name and qualifications of the drilling "competent person" responsible for drilling (years and type of experience, training background, etc.).
2. Describe drill rig and equipment inspection criteria or procedures (frequency of inspections, visual vs. written inspections, items that are inspected).
3. Describe methods of identifying underground utilities (contacting utility companies, detection equipment).
4. Describe methods of avoiding contact with overhead power lines (de-energizing and grounding, insulating, safe clearance distances).
5. Describe methods to identify hazardous atmospheres and controls used to eliminate (detection equipment and controls).
6. Describe leveling and stabilizing methods for drill rig (drilling pad, jacks, cribbing, guy wires).
7. Verify that rig equipment is in good operational condition (including "kill" switch, cathead, ropes, pressurized hoses and lines, operator controls, machine guards, and drilling tools).
8. Describe procedures for operating in inclement weather, including lightning, high winds, and severe rain storms.
9. Describe other safe work practices for equipment operation (drill rig, equipment, tools, rig transportation, rig travel).
10. Describe on-the-job maintenance procedures, including lockout/tagout.
11. Describe safe work practices for other activities to be performed during this project (use of ladders, fall protection, electrical power tools, personal protective equipment, etc.).
12. Describe methods for disposal of non-hazardous drill cuttings and purge water (including accumulation, transport, and disposal).
13. If hazardous waste project, provide documentation of hazardous waste worker training and medical surveillance records for all project personnel (40-hour or 24-hour training, 8-hour refresher training) and describe methods of hazardous waste management (including accumulation, transport, and disposal).
14. Submit a copy of drilling license/certification and drill rig permit.
15. Describe methods and responsibilities for submittal of notifications and logs.
16. Complete the Waste Subcontractor Qualification form for each proposed transport and disposal facility.
17. Describe procedures for drilling site cleanup upon job completion.

<u>If drilling in areas with known or potential Ordance Explosives (OE)/Unexploded Ordnance (UXO) hazards:</u>

18. Provide documentation of UXO qualifications, hazardous waste worker training, and medical surveillance records for all project personnel (40-hour or 24-hour training, 8-hour refresher training).
19. Describe procedures for OE avoidance, identification and marking the boundaries of a clear approach path and work site for the sampling crews, vehicles, and equipment to enter the site.
20. Describe the procedures for drilling and monitoring and the process for encountered OE.

Drilling Operations
ES&H Procedure – 811
Attachment B

ES&H Self-Assessment Checklist – Drilling Operations

MWH

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

This checklist shall be used by MWH personnel only and may be completed at the frequency specified in the Project HASP or by the ES&H Representative.

This checklist is to be used at locations where (1) MWH employees and/or (2) MWH subcontractors are working on projects involving drilling operations.

During evaluation of MWH subcontractors, the ES&H Representative may consult with subcontractors when completing this checklist, but shall not direct the means and methods of operations nor direct the details of corrective actions unless provided for by contract requirements. Subcontractors shall determine how to correct deficiencies.

If deficiencies are identified that are considered imminent danger (possibility of serious injury or death) hazards, they shall be corrected immediately or all exposed MWH and MWH subcontract personnel shall be removed from the hazard until corrected.

Completed checklists shall be maintained in project ES&H Files.

Project Name: ______________________________ Project No.:______________

Location: ______________________________ PM: ______________________

Evaluator: ____________________ Title: ________________ Date: __________

This specific checklist has been completed to:

☐ Evaluate MWH employee compliance with requirements

☐ Evaluate an MWH subcontractor's compliance with requirements

Check "Yes" if an assessment item is complete/correct.

Check "No" if an item is incomplete/deficient, section 2 must be completed for all items checked "No."

Subcontractor deficiencies shall be brought to the immediate attention of the subcontractor.

Check "N/A" if an item is not applicable
Check "N/O" if an item is applicable, but was not observed during the assessment

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

	Yes	No	N/A	N/O
Section 1				
SAFE WORK PRACTICES				
1. Only authorized, licensed operators meeting local requirements.	☐	☐	☐	☐
2. Spotters used for equipment in constricted areas.	☐	☐	☐	☐
3. Drill site work area demarcation in place.	☐	☐	☐	☐
4. Personnel cleared during rig startup.	☐	☐	☐	☐
5. Personnel clear of rotating parts.	☐	☐	☐	☐
6. Personnel not positioned under hoisted loads.	☐	☐	☐	☐
7. Augers and drill strings stored properly.	☐	☐	☐	☐
8. Good Housekeeping maintained on rig and work site.	☐	☐	☐	☐
9. Loose clothing and jewelry removed.	☐	☐	☐	☐
10. Smoking is prohibited around drilling operation.	☐	☐	☐	☐
11. Personnel wearing appropriate personal protective equipment (PPE).	☐	☐	☐	☐
12. Daily safety meeting completed.	☐	☐	☐	☐
13. Traffic control in place, where required.	☐	☐	☐	☐
Site Preparation				
14. Underground utilities & structures identified.	☐	☐	☐	☐
15. Drill site prepared for rig.	☐	☐	☐	☐
16. Travel routes surveyed for obstruction.	☐	☐	☐	☐
17. Required MSDSs on site.	☐	☐	☐	☐
Drill Rig Requirements				
18. Drill rig equipped with emergency stop controls.	☐	☐	☐	☐
19. Drill rig inspected daily, deficiencies corrected.	☐	☐	☐	☐
20. All machine guards are in place.	☐	☐	☐	☐
21. Platforms are properly constructed and accessible.	☐	☐	☐	☐
Equipment Travel and Set-up				
22. Safe clearance from overhead electrical maintained.	☐	☐	☐	☐
23. Mast lowered and equipment secure during travel.	☐	☐	☐	☐
24. Drill rig level and stabilized, proper cribbing used.	☐	☐	☐	☐
25. Mast secured before drilling.	☐	☐	☐	☐
Equipment Operation				
26. Personnel remain clear of cables and ropes.	☐	☐	☐	☐
27. Drilling operations suspended in inclement weather.	☐	☐	☐	☐
28. All gearboxes in neutral before starting.	☐	☐	☐	☐
29. Drill rig is always operated from control panel. Operator never leaves control panel while drill is in operation.	☐	☐	☐	☐
30. Pressurized lines are equipped with safety cables.	☐	☐	☐	☐
31. Drilling discharges channeled away from work area.	☐	☐	☐	☐
32. Compressed-air exhaust is controlled.	☐	☐	☐	☐
33. Wire ropes are inspected before use.	☐	☐	☐	☐
34. Hoist and hardware used only for designed purpose.	☐	☐	☐	☐
35. No more than one foot of drill column hoisted above mast.	☐	☐	☐	☐
36. Chuck jaws are not used as drill rod brake.	☐	☐	☐	☐
37. Wire ropes are properly matched to sleeves and are protected from sharp edges.	☐	☐	☐	☐
38. Operators are not guiding wire ropes with hands.	☐	☐	☐	☐
39. Auger guides are used to start auger in hard surfaces.	☐	☐	☐	☐

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

	Yes	No	N/A	N/O
40. Operator and tool handler have established responsibilities.	☐	☐	☐	☐
41. Augers are attached to power coupling per Manufacturer's instructions.	☐	☐	☐	☐
42. Auger flights are connected only by pins designed for such use.	☐	☐	☐	☐
43. Workers remain clear of auger and other rotating parts.	☐	☐	☐	☐
44. Cathead inspected before use.	☐	☐	☐	☐
45. Clean dry rope is used on cathead.	☐	☐	☐	☐
46. Proper actions are followed for cathead operations.	☐	☐	☐	☐
47. Drill rods are not leaned unsecured against mast.	☐	☐	☐	☐
48. Prior to disconnection plugged core drill rods, pressure source is isolated and pressure is bled off.	☐	☐	☐	☐
Drill Rig Maintenance				
49. Defects identified during inspection or operation are corrected before continuing operation.	☐	☐	☐	☐
50. Fall protection is used while climbing mast and for other unprotected elevated work.	☐	☐	☐	☐
51. Augers are cleaned only when drill is in neutral and auger has stopped.	☐	☐	☐	☐

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

SECTION 2

Complete this section for all items checked "No" in Sections 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Evaluator:______________________ Project Manager:_________________________

APPENDIX B

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE 01

SOIL BORING AND DRILLING

STANDARD OPERATING PROCEDURE 01

SOIL BORING AND DRILLING

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11-1	Soil Boring Log Form

1.0 INTRODUCTION

This standard operating procedure (SOP) provides a description of the principles and applicability of standard soil boring drilling procedures used during field investigations. Soil borings are typically installed to collect soil samples for chemical or geotechnical purposes, to collect subsurface stratigraphic information, and to install vadose zone or groundwater monitoring wells. The purpose of this SOP is to aid in the selection of drilling methods appropriate for site-specific conditions. It is intended to be used by the Project Manager (PM) and the Field Team Leader (FTL) or site geologist/hydrogeologist to develop an understanding of each method sufficient to permit project planning, scheduling, subcontracting, and resource planning. Although monitoring wells may be installed in completed soil borings, details of monitoring well construction and installation are provided in SOP-13. For soil and groundwater sampling procedures refer to SOP 15, Sample Handling and Shipment, SOP 16, Surface and Subsurface Soil and Sediment Sampling Procedures for Volatile Organic Compounds, Sop 17, Subsurface Sampling, and SOP 20, Groundwater Sampling For Chemical Analysis.

This SOP focuses on methods and equipment that are readily available and typically applied in drilling activities. It is not intended to provide an all-inclusive discussion of soil boring drilling methods. Two general methods are discussed: 1) methods that do not use circulating fluids, and 2) methods requiring the circulation of drilling fluids to transport cuttings to the surface. Use of methods that do not require the addition of drilling fluids is preferred. A discussion of key considerations in the selection of a suitable soil boring method is also presented. Table 11-1 provides a summary of drilling methods that are applicable to various geologic settings.

2.0 DEFINITIONS

Auger: A hollow or solid tubular steel center shaft around which is welded a continuous steel strip in the form of a helix. A center bit is used inside the auger to prevent soil from entering the hollow-stem auger.

Bailer: A cylindrical tool designed to remove groundwater from a borehole. A valve at the bottom of the bailer retains the material in the bailer. The three types of bailers are a flat-valve bailer, a dart-valve bailer, and a sand pump with rod plunger.

Cone Penetrometer: An instrument used to identify the subsurface conditions by measuring the differences in the resistance and other physical parameters of the strata. The cone penetrometer consists of a conical point attached to a drive rod of smaller diameter. Penetration of the cone into the formation forces the soil aside, creating a complex shear failure.

Cuttings: Formation particles removed from a borehole during the drilling process.

Drilling Fluids or Muds: A water-based or air-based fluid used in the soil boring operation to remove cuttings from the borehole, to clean and cool the bit, to reduce friction between the drill string and the sides of the borehole, and to seal and stabilize the borehole.

Flight: A individual auger section, typically 5 feet in length.

Heaving Formation: Unconsolidated, saturated substrate encountered during drilling where the hydrostatic pressure of the formation is greater than the borehole pressure causing the substrate to move up into the borehole.

Kelly Bar: A solid steel bar or pipe that is the main section of drill string to which the power is directly transmitted from the rotary table to rotate the drill pipe and bit. The cross section of the kelly bar is either square, hexagonal, or grooved. The kelly bar works up and down through drive bushings in the rotary table.

Pitch: The distance along the axis of an auger flight that it takes for the helix to make one complete 360-degree turn.

Rotary Table: A mechanical or hydraulic assembly that transmits rotational torque to the kelly bar, which is connected to the drill pipe and the bit. The rotary table has a hole in the center through which the kelly bar passes.

Split-Spoon Sampler: A thick-walled, steel tube split lengthwise that is used to collect soil samples. The split-spoon sampler is commonly lined with brass or stainless steel sample sleeves and is driven or pushed down hole by the drill rig to collect samples.

Shelby Tube: A devise used to collect undisturbed soil samples for geotechnical analysis. This thin-walled sampler minimizes disturbance that results from displacement and friction of soil samples.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often, additional personnel may be involved. Project team member information will be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel will always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

Project Manager: Selects site-specific drilling methods with input from other key project staff. Prepares technical provisions for drilling subcontracts.

Quality Control Manager: Performs project audits. Ensures project-specific data quality objectives are fulfilled.

Field Team Leader (FTL) and/or Field Geologist, Hydrogeologist, or Engineer: Implements the field program and supervises other field staff. Prepares daily logs of field activities.

Field Technician (or other designated personnel): Assists the FTL and/or geologist, hydrogeologist, or engineer in the implementation of field tasks.

4.0 DRILLING METHODS

A field log will be maintained during all drilling activities. An example of a soil boring log form is included as Figure 11-1. Drilling methods can be separated into two general types; techniques that do not use circulating fluids and techniques that use circulating fluids. The following sections discuss the drilling methods that fall into each of these two general categories.

4.1 DRILLING METHODS WITHOUT CIRCULATING FLUIDS

Auger Drilling: Auger drilling is accomplished by rotating a pipe or rod that has a cutting bit. The common auger drilling methods discussed in this section are hand, continuous-flight, hollow-stem, and bucket.

Hand Auger: A hand auger typically cuts a 2-inch diameter and, depending on the geologic materials, up to 15-foot deep borehole, though typically the borehole is less than 10-feet. Generally, the borehole cannot be advanced below the water table because of collapse.

<u>Applications</u>

- Shallow (up to 15 feet deep) soil investigations
- Soil sampling for stratigraphic logging
- Water-bearing zone/water table identification.

<u>Limitations</u>

- Limited to very shallow depths
- Unable to penetrate dense or gravelly soil
- Borehole stability difficult to maintain

- Labor intensive.

Continuous-Flight Augers: Continuous-flight augers consist of a plugged tubular steel center shaft around which is welded a continuous steel strip in the form of a helix. An individual auger is known as a "flight" and is generally 5 feet long. Auger drill heads (bits) are generally designed to cut a hole 10 percent greater in diameter than the actual diameter of the auger. In addition to diameter, augers are specified by the pitch of the auger, and the shape and dimension of the connections.

The rotation of the augers causes the cuttings to move upward, which can be "smeared" along the borehole walls. This smearing may effectively seal off the upper zones, thereby reducing the possibility of cross contamination of the upper zones to the deeper zones but increases the possibility of deep to shallow contamination. Conversely, smearing of clays on the borehole walls may seal off aquifers to be monitored.

Applications

- Relatively shallow soil investigations (up to 150 feet, depending on site conditions and type of drill rig)
- Soil sampling for stratigraphic logging
- Installation of vadose zone monitoring wells
- Installation of groundwater monitoring wells in stable soils
- Identification of depth to bedrock.

Limitations

- Soil sampling difficult, labor intensive, and limited to areas of relatively stable soils
- Difficult to install monitoring wells in unstable soils
- Depth capability decreases as diameter of auger increases
- Monitoring well diameter limited by auger diameter.

Hollow-Stem Augers: Hollow-stem augers (HAS) are commonly used in unconsolidated materials up to 150 feet in depth. A key advantage of HAS drilling is that undisturbed soil samples can be collected through the augers, which act as a temporary outer casing during soil boring drilling. The augers also act as a temporary outer casing during monitoring well installation (discussed in SOP-13).

Hollow-stem augers consist of two parts: a tube with flights attached to the outside and connected to the lead auger, and a center rod and bit which prevents soil from entering the center of the auger. The removable inner plug is the primary advantage of this drilling method. Withdrawing the center bit while leaving the auger in place provides an open, cased hole into which soil samplers, down-hole drive hammers, instruments, casing, wire, pipe, or numerous other items can be inserted. Replacing the center bit allows for continuation of the borehole.

Hollow-stem augers are specified by the inside diameter of the hollow stem, not by the hole size it drills. Hollow-stem augers are available in a variety of inside-diameters, such as 2.5, 3.25, 3.375, 4.0, 4.25, 6.25, 6.625, 8.25, and 10.25 inches. The most commonly used sizes are 3.25 inches and 4.25 inches for soil borings.

The rotation of the augers causes the cuttings to move upward, which can be "smeared" along the borehole walls. This smearing may effectively seal off the upper zones, thereby reducing the possibility of cross contamination of the upper zones to the deeper zones but increases the possibility of deep to shallow contamination. Conversely, smearing of clays on the borehole walls may seal off aquifers to be monitored.

Applications

- Suitable for soil investigations with soils ranging in consistency from clays to fine gravels
- Allows good soil sampling with split-spoon samplers or Shelby tubes
- Monitoring well installation in all unconsolidated formations
- Can serve as temporary casing
- Can be used in stable formations to set surface casing.

Limitations

- Difficulty in preserving sample integrity in heaving formations
- Formation invasion by water or drilling mud if used to control heaving
- Possible cross contamination of aquifers where the annular space is not positively controlled by water, drilling mud or surface casing
- Limited diameter of augers limits casing size
- Smearing of clays may seal off aquifer to be monitored.

Bucket Auger: Bucket augers have a depth capacity of 30 to 75 feet, and are used for large diameter soil borings of about 16 to 48 inches. They are not normally used to drill monitoring wells or for soil sampling, but may be used to drill production and recovery wells. In addition, they may also be used to set large diameter conductor or surface casings for production and monitoring wells.

Applications

- Drilling of large diameter boreholes to a maximum depth of 75 feet
- Drilling in unconsolidated formations.

Limitations

- Difficult to advance the borehole below the water table
- Consolidated formations and cobbles are difficult to drill
- Loose sand formations may slough during drilling.

Percussion Drilling: Percussion drilling is a form of drilling where the basic method of advance is hammering, striking, or "beating" the drilling rods into the formation. Common percussion methods that do not use circulating fluids are cable-tool, driven boreholes, and rotosonic drilling.

Cable-Tool Drilling: Cable-tool drilling operates by alternately raising and dropping a bit, hammer, or other heavy tool. In consolidated formations, the drill bit breaks or crushes the formation. In unconsolidated formations, the drill bit primarily loosens the formation when drilling. In both instances, the reciprocating action of the tools mixes the crushed or loosened particles with water to form a slurry or sludge at the bottom of the borehole. If little or no water exists in the penetrated formation, water is added to form the slurry. Slurry accumulation increases as drilling proceeds and eventually it reduces the impact of the tools. When the thickened slurry hinders the drop of the string of tools, a bailer is used to remove the slurry. Water is then added, if needed, and drilling resumes.

Most boreholes drilled in competent formations are drilled "open hole", that is, no casing is used during part or all of the drilling operation. Drilling in competent formations differs from drilling in unconsolidated formations as pipe or well casing (ODEX well casing) must follow the drill bit closely as the hole is advanced to prevent caving and to keep the borehole open.

Use of the cable-tool drilling technique in environmental subsurface investigations is limited because the method is slow. Drilling rates of 20 to 50 feet per day are typical with the average being approximately 30-40 feet per day. Holes much smaller than 6-inches are impractical because of the need for a relatively large, heavy bit. The method does not use drilling muds and allows sampling of groundwater with a drive and bail technique as the hole is advanced in high-yielding formations.

Applications

- Suitable for drilling in all types of geologic formations
- Capable of drilling to almost any depth and diameter range
- Allows for relatively easy installation of monitoring wells and more practicable well development
- Allows collection of excellent samples of geologic materials.

Limitations

- Drilling is relatively slow
- Heaving of unconsolidated materials must be controlled.

Driven Borehole: A borehole can be constructed by driving a solid probe or plugged pipe into the ground. The information obtained by this technique can be either minimal or extensive. Driving through dense materials is often extremely difficult or impossible. Soil samples cannot be collected during this process; however, crude stratigraphic information may be obtained by recording the number of blows per foot of penetration.

Considerably more information can be obtained by driving a penetrometer or a Dutch Cone. Penetration of the soil with a cone forces the soil aside, creating a complex shear failure. The degree of resistance at the cone tip and friction along the side walls yields the geologic logs of the borehole. The borehole created by the penetrometer is usually abandoned; however, occasionally a small-diameter piezometer may be constructed within the borehole.

<u>Applications</u>

- Drilling of boreholes when soil samples are not needed
- Installation of shallow well points at sites with access and work place limitations.

<u>Limitations</u>

- Geologic formations must be conducive to driving method
- Driven boreholes are generally shallow.

Direct-Push Drilling : Direct-push drilling is a method that uses a hydraulic hammer to advance a steel drill stem. Typically, the drill stem consists of threaded lengths of 2-inch to 3-inch OD steel pipe with a center rod attached to a pointed steel end-plug to keep soils from entering the drill pipe as it is advanced. Sections of drill pipe and center rod are threaded onto the stem as the hole is advanced. The Geoprobe® system is an example of this type of method. Soil samples are collected by removing the center rod and replacing the end-plug with a polyethylene sample tube such as a Macro-Core Sampling Tube System®. The center rod and polyethylene tube are then re-inserted inside the drill casing and the entire assembly is advanced to the desired sampling depth. Once the sampling interval is reached, the sampler is opened and driven an additional two feet into the subsurface allowing soil to enter the tube.

Direct-push drilling is most suitable at sites where physical access restrictions may prevent mobilization of a truck-mounted auger drill rig, or where relatively shallow (<25 feet) soil borings are desired. Under optimal conditions, drilling depths of up to 50 feet may be achieved. Direct-push drilling equipment is typically mounted on the bed of a pick-up truck, a small tractor, or ATV. This set-up enables drilling in limited-access environments, (e.g., inside buildings). Because it is fast and relatively inexpensive, direct-push drilling is often used in screening investigations in relatively fine-grained unconsolidated materials.

<u>Applications & Advantages</u>

- Relatively inexpensive, fast
- No soil cuttings generated
- Usable in limited-access environments
- May be used to install small-diameter monitoring wells or piezometers in unconsolidated formations.

<u>Limitations</u>

- Limited diameter of drill stem limits casing size in monitoring well installations
- Possible cross-contamination of aquifers may occur where annular space is not positively controlled by water, drilling mud, or surface casing
- Smearing of clays may seal off aquifer to be monitored
- Sample integrity in heaving formations may be compromised
- Depending on the size of the drive-rod, coarse grain and stiff grained deposits may be impenetrable
- Not suitable for cobbles, boulders or bedrock.

4.2 DRILLING METHODS WITH CIRCULATING FLUIDS

Many drilling techniques use a circulating fluid, such as water, drilling mud, air, a combination of air and water, or even a surfactant to create foam, to aid in the removal of cuttings. Circulation fluids flow from the surface either through the drill pipe, out through the bit, and up the annulus between the borehole wall and the drill pipe (direct rotary) or down the borehole annulus, into the bit, and up the drill pipe (reverse rotary). Generally, the up-hole velocity needed to transport cuttings to the surface is between 100 to 150 feet per minute for plain water with no additives, 80 to 120 feet per minute for high-grade bentonite drill muds, 50 to 1,000 feet per minute for foam drilling, and up to 3,000 feet per minute for air with no additives. Additives decrease the required minimum velocity. Excessive velocities can cause erosion of the borehole wall.

The use of circulating fluids may involve the addition of chemicals to the borehole. Drilling mud utilizes bentonite clay or polymers. Additives to air drilling may include surfactants (detergents) and water mist to generate foam. Compressed air may also contain various amounts of hydrocarbon lubricants. Therefore, attention should be given to the circulating fluids and any possible additives that are used when using drilling methods that require circulation fluids.

Rotary Drilling Methods: Rotary drilling methods involve rotation of the drill pipe and the drill bit to advance the borehole. Penetration rates for rotary rigs depend on such mechanical factors as the weight, type, diameter, and condition of the bit, and its speed of rotation; the circulation rate of the drilling fluid and its properties; and the physical characteristics of the geological formation. In rock formations, drillability (defined as depth of penetration per revolution) is directly related to the compressive strength of the rock. The common rotary drilling methods that use circulating fluids to remove the drill cuttings from the borehole are air rotary and mud rotary. The conventional mud-rotary drilling method is not discussed because the addition of mud in environmental drilling is generally considered unacceptable. If geologic conditions require mud-rotary drilling to be conducted, the Contractor will then develop a project-specific workplan.

Air Rotary Drilling: In air rotary drilling, the circulation fluid is compressed air or a mixture of compressed air, a surfactant, and water mist, which creates a foam. As in conventional mud rotary, the drilling fluid is forced through the rotating drill pipe and bit to flush cuttings to the surface. The drilling fluid flows back to the surface by way of the annulus formed between the outside of the drill pipe and the borehole wall. At the surface, the fluid is directed into a pit or storage container. The up-hole velocity of the air and cuttings should be approximately 3,000 feet per minute. This drilling method is primarily used in consolidated formations due to the fact that the rapidly rising cuttings would cause considerable erosion of the borehole wall in unconsolidated formations. With the air rotary drilling method, the circulating fluid is not reused. The functions of the drilling fluid are to:

1. Lift the cuttings from the bottom of the borehole and carry them to the surface.
2. Cool and clean the drill bit.
3. Lubricate the bit, cone bearings, and drill pipe.

Air Rotary Applications & Advantages

- Rapid drilling of semi-consolidated and consolidated rock
- Good quality/reliable formation samples
- Equipment is generally available
- Allows easy and quick identification of lithologic changes
- Allows identification of most water bearing zones
- Allows estimation of yields in strong water-producing zones with short "down time."

Air Rotary Limitations

- Surface casing frequently required to protect top of hole
- Drilling restricted to semi-consolidated and consolidated formations
- Samples are reliable, but occur as small particles that are difficult to interpret
- Drying effect of air may mask lower yield water producing zones or identification of the water table
- Air stream requires contaminant filtration
- Air may modify chemical or biological conditions; recovery time uncertain.

Air Rotary Casing Hammer (Drill and Drive): This method combines percussion and air rotary drilling methods to drill in unconsolidated formations. The borehole is drilled using the air rotary drilling method. Casing or ODEX follows closely behind the rotary bit to prevent the erosion of the borehole wall. The drill bit is usually extended approximately 1-foot below the bottom of the casing that acts as temporary casing.

Applications & Advantages

- Rapid drilling of unconsolidated sands, silts, and clays
- Drilling in alluvial materials (including boulder formations)
- Casing supports borehole thereby maintaining borehole integrity and minimizing inter-aquifer cross contamination
- Eliminates circulation problems common with direct mud rotary method
- Good formation samples for stratigraphic evaluation
- Minimal formation damage as casing is pulled back.

Limitations

- Thin, low pressure water bearing zones easily overlooked if drilling not stopped at appropriate places to observe whether or not water levels are recovering
- Samples pulverized as in all rotary drilling
- Air may modify chemical or biological conditions
- Difficult to obtain soil samples for chemical analysis.

Center Stem Recovery Rotary Drilling (Reverse Circulation): In reverse circulation drilling, the circulating fluid (water) flows from the surface down the borehole annulus outside the drill pipe, into the drill bit, and up the inside of the drill pipe to the ground surface. The fluid carries the cuttings to the surface and discharges them into a settling pit or tank. Reverse circulation is particularly well suited to drilling large diameter boreholes in soft, unconsolidated formations, and in situations where the erosive velocity of conventional rotary circulation would be detrimental to the borehole wall. Drilling is accomplished typically with water, without the use of additives.

A dependable water supply is required to maintain sufficient drilling fluid in the borehole, thereby maintaining sufficient hydrostatic head on the borehole walls to prevent sloughing. Reverse circulation has limited application in environmental subsurface investigations. Typical borehole diameters range from 8 to 36 inches; however, 60-inch-diameter boreholes are not uncommon.

Applications & Advantages

- Large capacity production wells
- Nested wells
- Normally does not use drilling muds (little if any mud cake is formed on the wall of the borehole
- Drills best in unconsolidated sands, silts, and clays.

Limitations

- Requires large and dependable source of water during drilling and well installation
- Cobbles and bedrock are difficult to drill.

Dual-Tube Rotary: Dual-tube rotary is an exploratory drilling technique utilizing two concentric drill pipes which consist of an inner and an outer pipe. Both drill pipes are rotated during drilling.

The outside diameter of the outer drill pipe is typically 4.5 inches. The diameter of the borehole is approximately 5 inches. Compressed air is forced between the two drill pipes and is directed to the inner pipe at the bit. The air then flows up the inner pipe and cuttings are carried to the surface at a velocity of approximately 3,000 feet per minute. This drilling method provides for identification of the subsurface lithology and the locations of aquifers in deep boreholes.

It is very difficult to obtain undisturbed soil samples for chemical or geotechnical analyses using this method; however, groundwater samples can be obtained as aquifers are encountered. Geophysical logs can be obtained if the borehole is filled with drilling mud as the drill pipe is removed. Depths of 1,000 feet are not uncommon for this drilling method and typically, the more consolidated the formation, the more suitable the method. Unconsolidated formations may cause more drag or friction on the outside of the rotating drill pipe.

Applications & Advantages

- Used mostly for exploratory boreholes
- Allows rapid extraction of drill cuttings from the borehole
- Drill cuttings are representative of formation
- Very rapid penetration rate in all formations
- Able to collect groundwater samples as aquifers are encountered.

Limitations

- Equipment usually not readily available
- Inability to obtain undisturbed soil samples for chemical analysis
- Borehole typically small in diameter (5 inches).

Dual-Tube Percussion Drilling: Dual-tube percussion drilling is very similar to dual-tube rotary, with the exception that the two drive pipes do not rotate during drilling. The two concentric drive pipes are driven into the ground with a percussion hammer. The hammer is similar to the mechanisms mounted on pile drivers. The typical outside diameter of the outer drive pipe is 7 to 12 inches. The typical inside diameter of the inner pipe, where well materials are normally inserted, is 4.25 to 8 inches. This drilling system is also a center stem recovery system and is used primarily in hazardous waste investigations. It is rapid and effective to depths of about 250 feet.

The outer pipe effectively seals off the formation while drilling, reducing the chance of cross contamination. Air is pumped between the annulus of the two pipes to the bit where it is deflected upward into the inner pipe. Cuttings are transported to the surface through the inner pipe.

In general, three systems are available: 7-inch OD/4.25-inch ID, 9-inch OD/6-inch ID, and 12-inch OD/8-inch ID. A 2-inch-diameter monitoring well can be constructed in the 7-inch system, a 4-inch-diameter monitoring well can be constructed in the 9-inch system, and a 5- or 6-inch-diameter monitoring well can be constructed in the 12-inch system.

Applications

- Very rapid drilling through both unconsolidated and consolidated formations
- Allows continuous sampling for lithologic logging in all types of formations
- Representative samples can be obtained with minimal risk of contamination of sample and/or water bearing zone
- In stable formations, wells with diameters as large as 6 inches can be installed in open hole completions
- Soil samples can be easily obtained for chemical analysis.

Limitations

- In unstable formations wells are limited to approximately 4 inches
- Air may modify chemical or biological conditions; recovery time is uncertain.
- Not suitable for cobbles, boulders, or bedrock

Rock Coring: Rock coring is a valuable method of obtaining undisturbed samples of bedrock. Rock coring utilizes a diamond or carbide hollow drill bit driven by solid rods. Unlike rotary or cable-tool methods, which grind or pulverize solid rock into small particles, rock cores allow bedding, structures, fossils, and fractures or other types of secondary porosity to be examined directly. Cores can also be submitted for laboratory testing of engineering qualities, and for analysis of porosity and permeability.

The most conventional method of coring is by attaching a core barrel and coring bit to a rotary drill string. Core barrels generally come in 5- or 20-foot lengths, and can be joined together to allow continuous cores up to 60 feet long to be collected during a single run. A split inner barrel is wrapped with strapping tape at intervals to prevent the inner barrel from opening during coring. The inner barrel is inserted in the core barrel and the bit is attached. The ring-shaped face of the coring bit is typically a diamond-impregnated steel alloy. Many different bit styles and configurations are available; the most effective bit for coring a particular lithology is dependent on the rock's physical characteristics. Bit suppliers usually have knowledge of the type of bit most appropriate for the lithologies in their region, and are a good resource in planning a coring program.

Once the core barrel has been assembled, it is lowered downhole on the drill string and rotated. Drilling fluid is injected in the annular space between the inner split barrel and the core barrel, and exits through holes in the face of the coring bit. As with conventional rotary drilling, the drilling fluid cools and lubricates the bit, and carries cuttings to the surface from the annular space cut by the bit between the drillhole wall and the core.

When the desired interval has been cored, the core barrel is tripped out of the hole. Steel core retainers and friction between the core and the inside of the inner barrel keep the rock core from dropping out of the core barrel as it is tripped out. In conventional drilling and coring, the drill string is removed in 10 to 20-foot joints at a time, placed vertically on the rig floor, and attached at the crown of the mast in "fingerboards". This reduces the amount of time to break and make connections.

When the core barrel is out of the hole, the drill crew removes the split inner barrel and places it on the catwalk or on racks. The site geologist usually cuts the strapping tape and opens the split barrel to examine the core. Depending on the type of rock and the drilling fluid used, the rock core may need to be cleaned with a brush and clean water before it can be logged. A measuring tape is placed along the length of the core, to facilitate the logging process. Once logging is complete, the core is broken into 3-foot lengths and placed in plastic or waxed cardboard core boxes. The boxes are marked as to hole location, depth interval, date, and other pertinent information. Cores are placed in the box from left to right and top to bottom, such as one reads a book. Thus, the top of the core is in the upper left corner of the core box, and the bottom end of the core is in the lower right corner of the box.

Wireline coring is the preferred method wherever rock coring is necessary. Wireline coring uses similar methods to cut the rock core, but has the added advantage of retrieving the core through the drill string by wire. This eliminates the time-consuming round-trip of the drill string to retrieve the core and resume coring the next interval. The core barrel length will be determined in the field based on the actual drilling conditions.

Applications & Advantages

- Cores provide undisturbed samples of bedrock
- Cores can be used for testing engineering characteristics
- Cores can be used to analyze porosity and permeability.

Limitations

- Coring is very expensive and time-consuming compared to rotary drilling
- Extensively fractured or soft formations can result in incomplete core recovery
- To avoid missing an important formational contact, many geologists will core excessive lengths, incurring additional cost. Knowledge of local stratigraphy and structural conditions can reduce the core interval and minimize costs.

4.3 DRILLING IN ARTESIAN CONDITIONS

When drilling in artesian conditions or in an area where artesian conditions are suspected (e.g., a nearby monitoring well exhibits artesian pressure), special precautions must be taken to prevent the upward movement of artesian waters within the borehole. The driller will not move the drilling rig from the site until leakage is completely stopped. The following sections provide procedures for drilling and monitoring well installation in areas where known artesian conditions exist.

Drilling Procedures/Techniques: When drilling in areas where artesian conditions are known to exist, only drilling methods using a casing advancement technology will be permitted (e.g., reverse circulation air rotary system with percussion hammer, casing advanced air rotary drilling systems, cable-tool drilling, or ODEX drilling methods). Air rotary systems will be capable of drilling with supplementary water, or water with approved additives as a circulation medium. Compressed air will be filtered by an in-line filter system to prevent compressor-oil contamination of the circulation system and borehole. The filter will be capable of ensuring 99.999 percent removal of any oil in the compressed air. Filter samples ("knock-outs") will be collected and retained for potential analysis. Drilling rod joint lubricant will be vegetable-based and the use of the lubricant will be minimized. Documentation of drill rig compliance and the proposed lubricant will be provided to the Project Manager for approval prior to drilling. During air rotary drilling, cuttings will be collected in a cyclone. Dispersion of particulates will be minimized. All cuttings and fluids will be handled and contained appropriately to prevent their release to the environment. Source water used for circulation will be analyzed for contaminants of potential concern.

Soil Sampling and Sediment Logging: Soil samples for logging, geotechnical, and analytical purposes will be collected from boreholes in accordance with project-specific field sampling plans. During soil sample collection, care and diligence should be given so that the sample can be collected in a manner that causes minimal disturbance to the aquifer materials. A maximum water head (approved source water only) will be maintained inside the casing at all times to stabilize formation material during soil sampling. However, if flowing sands are encountered, no soil samples will be collected. The Contractor will maintain a detailed log of the volume of source water that has been added to the borehole. Well development must evacuate a minimum of five times the volume of water added to the borehole.

Dense drilling mud, used to stabilize the formation during drilling and sampling, may be permitted, but only when flowing sands present a significant problem, and stabilization with water has failed. If flowing sands are anticipated prior to drilling or encountered during drilling operations, the Project Manager must be contacted for approval of mud use. In addition, manufacturer certificates documenting the composition of all drilling additives will be provided to the Project Manager prior to approval. If flowing sands are unexpectedly encountered during drilling and further drilling or well completion is impossible without the use of drilling mud and the Project Manager cannot be reached, then use of drilling mud is assumed to be authorized. The Contractor will maintain detailed records of communication with the Project Manager. Provisions must also be made by the Contractor to contain drilling mud and cuttings (drilling mud cannot be separated from cuttings).

It is very important to recognize site-specific conditions and potential problems when drilling and installing wells in artesian conditions. Sound judgement from the site geologist is expected. Therefore, the site geologist must be, at a minimum, a mid-level geologist/hydrogeologist and have at a minimum of five years of well installation experience, and must have experience in installing wells in confined/artesian conditions. In addition, the drilling subcontractor will also provide a drill rig operator with more than five years operating experience, and the operator also must have experience in installing wells in confined/artesian conditions.

Borehole Diameter: Borehole diameter will be no less than 8-inches in diameter for 2.5-inch wells and smaller; no less than 10-inches in diameter for wells 3 to 4 inches in diameter; and no less than 12-inches in diameter for 6-inch diameter wells.

Well Completions in Artesian Conditions:

Filter Pack: The sand pack will extend from the base of the well screen to a minimum of 5 feet above the well screen, provided that the filter pack does not extend upward into the confining sedimentary unit. The sand pack will consist of 10-20 sieve size silica sand. A minimum of 5-feet of sand will be maintained inside the drill casing at all times during sand pack installation. Adding approved source water to the borehole during sand pack installation is permitted and recommended to stabilize the borehole. If necessary, sand may be flushed through a tremmie pipe using approved source water as the carrier fluid.

Well Screen: The well screens will be sized based on intended use of the well and 10-20 sieve size silica sand will be used for the filter pack.

Well Seal: The well seal will be a minimum of 5-feet thick and will consist of coated bentonite pellets. The well seal will extend from the top of the filter pack upward through the entire thickness of the confining sedimentary unit. Coated bentonite pellets will be maintained inside the drill casing during seal installation. Adding approved source water to the borehole during seal installation is permitted and recommended to stabilize the borehole.

Grout: Grout will consist of a mixture of Aqua-guard® Gel and Bar Bariod®. The grout mixture will contain 1-½ sacks Aqua-guard® Gel and 100 lbs. Bar Bariod® added to 10 gallons of water. The borehole will be grouted from the bottom up using a pump and tremmie pipe. A grout pump capable of pumping this thick, heavy mixture will be required. Grout will not be added from the surface and allowed to fall though the drill casing. The grout will extend from the top of the bentonite seal to 10 feet below the ground surface. Dense concrete will be used from 10 feet below the ground surface, to the ground surface, to hold the grout in place and to prevent the grout from heaving.

Surface Completion: In the event that the well is completed under artesian conditions and is a flowing well, the well top will be completed in one of two ways:

1. The top of casing may be fitted with a gate valve that will allow the flow to be controlled as necessary. The well head assembly will also include a pressure gauge capable of measuring the hydraulic head in the well to assist with static head measurements, and a sampling port for ground-water sample collection. The monitoring well vault will be designed to allow sufficient room inside the vault to accommodate the well head assembly.

2. The well may be completed above ground allowing sufficient stick-up to accommodate static heads above ground surface. This completion method may, however, not be practicable in cases where static groundwater levels are likely to exceed 3 - 4 feet above ground surface, or where lease agreements stipulate that the well be completed as flush mount.

4.4 BOREHOLE ABANDONMENT PROCEDURES

Soil borings will be abandoned according to the procedures outlined in SOP-14.

4.5 BOREHOLE REFUSAL CRITERIA

Certain types of subsurface conditions, (e.g., debris, boulders, and gravel layers), may halt the advancement of soil borings depending on the drilling method in use. In such cases, the borehole will be abandoned in accordance with the methods described in SOP 14, and a new boring will be performed if needed at a location that will fulfill the project-specific goals. The drilling subcontractor has the final authority in determining when refusal has been encountered

5.0 CONSIDERATIONS FOR SELECTION OF DRILLING METHODS

Each project or drilling site has its own characteristics that pose unique challenges in the selection of drilling methods. Prior to selecting a drilling method, several factors will be considered. The major factors addressed in this section include the objectives of the drilling program, site conditions, wastes generated, and client preferences. Other factors include drilling costs, availability of trained crews and appropriate equipment, and project schedule requirements. It is important to recognize that it may be very difficult to fulfill all of the drilling (and sampling) objectives with a single drilling method. The drilling method selected may compromise some of the objectives of the drilling program.

5.1 DRILLING OBJECTIVES

The primary consideration in the process of selecting any drilling method is the objective(s) of the drilling/sampling program. It is common to have more than one objective for the drilling/sampling program and it may be difficult to satisfy all of the objectives.

If sample collection (soil or groundwater) is the objective, the selected method will be capable of collecting, in an appropriate and approved manner, the necessary samples. Additionally, the contaminants of concern may have an influence on the selection of the drilling and sampling method.

If the objective of the drilling program is to install vapor or groundwater extraction wells, the selected method will be suitable for the installation of the designed well. It is important to not only consider the physical limitations of a particular drilling technique (i.e., depth and diameter), but to also examine the consequences of the drilling method with respect to the drilling objective (e.g., smearing of the borehole walls may render wells ineffective or inefficient).

Similarly, if one of the objectives of the drilling program is to identify the different water-bearing zones, the drilling method will be able to accomplish this task.

5.2 SITE CONDITIONS

Site conditions can limit the drilling methods available for a particular program. Site conditions to be considered include ease of access and applicable requirements, as well as surface and subsurface conditions. Issues relating to site access, clearance, and permit requirements are discussed in more detail in SOP-1.

Surface Conditions: Surface conditions can affect access to the site and the amount of available workspace (horizontal, vertical or overhead space). These in turn can affect the selection of a particular method or type of drill rig. Limited access and work space may require smaller or remotely powered drill rigs. The site terrain is also an important factor in choosing the drilling method as it may prove to be expensive and difficult to mobilize large and/or heavy equipment over rugged terrain. For such sites, drill rigs (typically hollow-stem auger) are usually mounted on all-terrain equipment.

In addition to access and workspace, the work environment will also be considered. This includes both weather conditions and other site activities. Extremely hot or cold climates may require use of special drilling equipment or methods. Sites where explosive atmospheres are likely to exist may require special consideration. All site activities will be considered as they may impact the selection of the drilling method.

Subsurface Conditions: The subsurface stratigraphy of a site is a fundamental consideration when selecting a particular drilling method. The drilling equipment selected will be capable of effectively and economically penetrating the strata at the site to meet the project data quality objectives. Particular stratigraphy which may pose problems for certain drilling methods include tight clayey soils, swelling clays, flowing sands, caliche, gravels, cobbles, lost circulation zones, and bedrock.

In addition to stratigraphy, the site hydrology will also be considered. If multiple water-bearing zones are expected, a conductor casing may be needed to seal off shallow water-bearing zones to prevent potential cross contamination. The need for conductor casings may influence the selection of a particular drilling method. Drilling of wells that penetrate deep aquifers may also influence the selection of a suitable drilling method.

5.3 WASTE GENERATION

Drilling operations typically generate significant volumes of waste that must be handled, stored, and eventually disposed. This is of particular concern when drilling into contaminated or hazardous subsurface environments. The type and volume of wastes generated during drilling differs for different drilling methods. The different handling and disposal requirements of generated wastes can greatly affect project costs. The different drilling methods may also require removal of vastly different volumes of groundwater to fully develop the well. For details on investigation-derived waste (IDW) refer to SOP 8, Investigation Derived Waste Management.

6.0 REFERENCES

Aller, L., T.W. Bennett, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, and D.M. Nielsen, 1989. Handbook of suggested practices for the design and installation of ground-water monitoring wells; National Water Well Association, Dublin, Ohio, 397 pp.

Driscoll, F.G., 1987, Groundwater and Wells: Second Edition , Johnson Division, St. Paul, Minnesota,.

Environmental Protection Agency (EPA). RCRA Ground-Water Monitoring: Draft Technical Guidance, November 1992.

MWHA
STANDARD OPERATING PROCEDURES

SOP-02
BOREHOLE ABANDONMENT

MWH

STANDARD OPERATING PROCEDURES

SOP-02
BOREHOLE ABANDONMENT

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THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES A GENERAL GUIDANCE ON INTERNAL PROCEDURES OF MWH AMERICAS, INC. ("MWH") RELATING TO TECHNICAL ISSUES TO BE ADDRESSED INVOLVING BORHOLE ABANDONMENT. IT IS NOTED, HOWEVER, THAT EACH PROJECT AND SITE IS UNIQUE AND THAT THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THESE STANDARD OPERATING PROCEDURES. MANAGEMENT RESERVES THE UNRESTRICTED RIGHT TO CHANGE, MODIFY OR NOT APPLY THESE GUIDELINES IN ITS SOLE, COMPLETE AND UNRESTRICTED DISCRETION TO MEET CERTAIN CIRCUMSTANCES, CONTRACTUAL REQUIREMENTS, SITE CONDITIONS OR JOB REQUIREMENTS.

1.0 INTRODUCTION

Drilling is a common activity associated with all phases of environmental investigations. Drilling methods are most commonly used to collect site data during site investigations (SIs) and remedial investigations (RIs), but are also used to install vapor extraction or water wells associated with remedial actions (RAs) and, to a lesser extent, feasibility studies (FSs).

Field investigations usually require invasive types of activities to gather information to evaluate the site. The investigation may require the analysis of soil and/or groundwater samples which would be accomplished by drilling a borehole. Many times the borehole is converted into a well for the evaluation of vapor or groundwater conditions over time. In addition to the collection of samples for analyses, other data such as physical parameters of soils can be obtained from boreholes.

For determining the most appropriate drilling method for an SI or an RI, primary consideration must be given to obtaining information that is representative of existing conditions and the collection of samples that are valid for chemical analysis. The samples must not be contaminated or adversely affected by the drilling method.

Drilling associated with RAs and FSs may include the installation of vapor or water extraction and/or injection wells. In selecting the most appropriate drilling method for RAs and FSs, primary consideration must be given to completion of a well which will perform as designed.

This SOP provides a description of the decontamination procedures used during field investigations for typical drilling equipment. This SOP is intended to be used by the Project Manager (PM), Project Engineer (PE), Field Team Leader (FTL), and site hydrogeologist to develop as general guidance for decontamination procedures for USACE work. The project specific SAPs may have site-specific concerns which would require additional or adjustment to these procedures.

This document focuses on methods and equipment that are readily available and typically applied. It is not intended to provide an all inclusive discussion of borehole abandonment methods.

2.0 DEFINITIONS

Cone Penetrometer

An instrument used to identify the underground conditions by measuring the differences in the resistance and other physical parameters of the strata. The cone penetrometer consists of a conical point attached to a drive rod of smaller diameter. Penetration of the cone into the formation forces the soil aside, creating a complex shear failure. The cone penetrometer is very sensitive to small differences in soil consistency.

Cuttings

Formation particles obtained from a borehole during the drilling process.

Drilling Fluids or Muds

A water-based or air-based fluid used in the well drilling operation to remove cuttings from the borehole, to clean and cool the bit, to reduce friction between the drill string and the sides of the borehole, and to seal the borehole.

Dual-Purpose Well

A well that can be used as both a monitoring and extraction or injection well.

Flight

A individual auger section, usually 5 feet in length.

Heaving Formation

Unconsolidated saturated substrate encountered during drilling where the hydrostatic pressure of the formation is greater than the borehole pressure causing the sands to move up into the borehole.

Kelly Bar

A hollow steel bar or pipe that is the main section of drill string to which the power is directly transmitted from the rotary table to rotate the drill pipe and bit. The cross section of the kelly is either square, hexagonal, or grooved. The kelly works up and down through drive bushings in the rotary table.

Pitch

The distance along the axis of an auger flight that it takes for the helix to make one complete 360 degree turn.

Rotary Table

A mechanical or hydraulic assembly that transmits rotational torque to the kelly, which is connected to the drill pipe and the bit. The rotary table has a hole in the center through which the kelly passes.

Split-Spoon Sampler

A thick-walled steel tube split lengthwise used to collect soil samples. The sampler is commonly lined with metal sample sleeves and is driven or pushed downhole by the drill rig to collect samples.

Thin-Walled Sampler

A sampling devise used to obtain undisturbed soil samples made from thin-wall tubing. The sampler is also known as a Shelby tube. The thin-wall sampler minimizes the most serious sources of disturbance: displacement and friction.

3.0 RESPONSIBILITIES

Project Manager

Selects site-specific borehole abandonment methods with input from the Field Team Leader and Site Hydrogeologist, and oversees and/or prepares drilling subcontracts.

Site Hydrogeologist

Selects site-specific drilling options. Helps prepare technical provisions of drilling subcontracts.

Field Team Leader

Implements selected drilling program. Aids in the selection of borehole abandonment methods and preparation of subcontracts.

4.0 BOREHOLE ABANDONMENT

A borehole that will not be converted into a well (for example, soil borings, test holes, and/or pilot holes) will be properly plugged and abandoned by methods approved by the USACE.

The boring will be abandoned by thoroughly mixing a sand-cement or cement-bentonite grout and pumping the grout to the bottom of the borehole through a tremie pipe until the borehole is filled to ground surface. Dry holes less than 10 feet deep can be filled with grout poured from the surface. The grout mixture may be either cement and water or some combination of cement, bentonite, sand, and water. Local or state agency criteria may require the grout plug to be completed several feet below the surface.

The grout will consist of clean water mixed with Type I or II Portland cement (or equivalent). It is also recommended that the grout include bentonite (3 to 5 percent by weight) to help reduce shrinkage. After the grout has been allowed to set at least 12 hours, the grout will be topped off if settlement has occurred.

Close attention will be paid to the mixture of the grout that is placed into the borehole. The recommended mixture will consist of one sack (94 pounds) of cement mixed with 7.2 to 8.5 gallons of clean water and 3 to 4 percent of bentonite. The optimum mix results in a volume of 1.5 to 1.6 cubic feet of slurry per sack of cement. The grout will be mixed to a smooth, uniform consistency with no lumps or balls present. It is best if the bentonite is mixed first, before adding the cement, to ensure that the bentonite is fully hydrated.

Under no circumstances, unless previously approved by the USACE, will the borings be backfilled with the soil removed during drilling and sampling operations.

Proper abandonment techniques for monitoring and other types of wells are dependent on site-specific circumstances and state and USACE requirements. Abandonment techniques may include, but not be limited to, removal of the well casing (for example, by pulling or by drilling out) followed by backfilling with cement/bentonite grout. The USACE and regulatory agencies will be contacted for specific requirements, and the abandonment methods will be described in site-specific planning documents.

5.0 REFERENCES

USACE EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans.

USEPA SW846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods Third Edition, 1986.

USEPA EPQ/540/G-89/004, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, 1988

6.0 ATTACHMENTS

None.

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TRENCHING AND TEST PITTING

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1.0 INTRODUCTION

This standard operating procedure establishes guidelines for conducting test pit and trench excavations at hazardous waste sites.

Shallow test pits accomplish the following:

- Permit the in-situ condition of the ground to be examined in detail both laterally and vertically
- Provide access for taking samples and for performing in-situ tests
- Provide a means of determining the orientation of discontinuities in the ground

Periodically, a portion of a site investigation will focus on abandoned subsurface structures or an area that may contain, or was at one time a dumping ground for, various types of hazardous and nonhazardous waste. Before drilling soil borings in these areas, excavation of a trench or test pit may be necessary to clear drilling areas of debris and identify sources or geophysical anomalies. Excavations can be readily extended to locate the boundaries of abandoned foundations, landfills, or trenches. At appropriate locations, trenches or test pits may be used to uncover unexploded ordnance by qualified explosive ordnance detection teams prior to commencing any intrusive activities. In suitable ground, shallow excavations may provide an efficient and economic method to evaluate the shallow subsurface environment of a site.

2.0 DEFINITIONS

Trench or Test Pit	Linear excavation, of varying width, usually used as an exploratory method to locate landfill boundaries or buried structures, or to characterize the soil/fill sequence at a site.
Ground Crew	Composed of excavating support crew and sampling crew.

3.0 RESPONSIBILITIES

The **Project Manager** selects site-specific soil sampling methods with input from the Site Geologist/Field Team Leader and oversees preparation of heavy equipment/explosive ordnance detection subcontract.

The **Site Geologist/Field Team Leader** selects excavation options, implements the trenching/test pit program, assists in the preparation of technical provisions, and prepares subcontracts.

The **Sampling Crew** performs sampling procedures.

4.0 TRENCH AND TEST PIT CONSTRUCTION

4.1 GENERAL

Trench and test pit excavation is carried out either manually or by using standard equipment such as backhoes, trenching machines, track dozers, track loaders, excavators, and scrapers. Operators of excavating equipment must be skilled and experienced in its safe use for digging test pits and trenches. A typical excavator with an extending backhoe arm can excavate to a depth of approximately 15 feet. If investigations are required to penetrate beyond 15 feet, soil borings may be a more feasible method.

A tailgate safety meeting is conducted by a designated on-site safety officer before commencing excavation.

Prior to all excavations, the Field Team Leader must confirm that underground utilities (electric, gas, telephone, water, etc.) within the proposed areas of excavation have been cleared or marked off. Certain underground services may not be picked up by detectors. Careful excavation, use of probing rods, and the ground crew watching for early signs can help prevent damaging or puncturing underground services.

Prior to commencing excavation, standard signals shall be developed and reviewed for rapid and efficient communication between the backhoe operator and the ground crew. Before approaching areas with operating equipment, the sampling and support crew must verify that the operator has noted their presence.

Upon locating the area for excavation, the backhoe operator determines wind direction and positions the machine upwind of the area of excavation. The backhoe operator outlines the area of investigation by extending the bucket arm to its maximum length and traces a 180-degree outline around the area to be excavated. The support crew cordons off the exclusion zone with a wooden lath and brightly colored "caution" tape, or other appropriate temporary fencing.

Once the excavation equipment has been positioned and stabilized, excavation can commence. If the area of investigation is beneath vegetative cover or surface debris, the backhoe operator removes the surface material to allow a clear and safe working area. Excavated soil is stockpiled away from the immediate edge to one side of the trench to prevent excavated soil from re-entering the trench or test pit and to reduce pressure on the sidewalls. When possible, the soil is deposited downwind of the ground crew and the machine operator. Shifting winds may cause the machine and its operator and the ground crew to periodically move in order to remain upwind. Under some conditions where remaining upwind is not possible, it may be necessary to curtail further activities. The support crew should regularly check the machine operator who, if in a partially enclosed cabin, may be susceptible to fumes/gases.

4.1.1 Safety Procedures

Material brought to the surface should be treated as hazardous and contained in an appropriate manner. If the material is wet, the liquid seeping from the stockpile should be collected, sampled, and disposed of in accordance with applicable regulations.

Entry of personnel into pits or trenches is strictly prohibited unless specifically approved and strict adherence to state and federal Occupational Safety and Health Administration guidelines is observed.

Unless full lateral support of the side walls is provided, personnel should never trench deeper than 4 feet (chest height) when personnel will be working in the trench. Any personnel entering the trench may be exposed to toxic or explosive gases and an oxygen-deficient environment. Air monitoring is required before and during entry and appropriate respiratory gear, protective clothing, and egress/rescue equipment is mandatory. Caution should be exercised at all times. For example, in combustible fills, temperature measurements may be necessary. On waste tips, burning material below ground may give rise to toxic or flammable fumes from the hole; tip fires may also create voids that may collapse under the weight of an investigation rig or backhoe machine. Lagoons within waste tips may be areas of very soft ground.

At least two people must be present at the immediate site. Ladder access/egress out of the pit must be installed before entry. Two ladders for worker access/egress must be provided for every 25 feet of lateral distance of a trench and, at a minimum, ladders shall be positioned at opposite ends of trenches less than 25 feet in length.

Care should be taken to ensure that personnel do not stand too close to the edge of the trench especially during sampling or depth measurements; the combination of depositing soil adjacent to the pit and the risk of caving or toppling of the side walls in unstable soils can lead to unsafe conditions.

4.1.2 Stability

Depending on the desired depth of excavation, the trench may require shoring to prevent the sides from collapsing. Lateral support may be provided by a support frame system, or by benching or sloping the sides of the excavation or trench to an appropriate angle. Any timbering or support systems must be installed by qualified personnel.

Groundwater may be pumped out of the pit to stabilize the sidewalls and to keep the excavation dry, allowing a greater depth to be reached especially in granular materials that are below the water table.

Near-vertical slopes can stand for seconds or months, depending on the types of material involved and various other factors affecting the stability. Although personnel should not be entering the excavation, it is prudent to know the possible behavior of the various soil types and conditions that may be encountered. Excavations into fill are generally much more unstable than those in natural soil.

Excavations in very soft, normally consolidated clay may stand vertically without support for short periods. Long-term stability is dependent on a combination of factors: the type of soils, pore pressures, and other forces acting within the soil, and adverse weather effects. Fissured clays can fail along well-defined shear planes; therefore, their long-term stability is not dependent on their shear strength and is difficult to predict.

Dry sands and gravels can stand at slopes equal to their natural angle of repose no matter what the depth of the excavation (angles can range from approximately 28 to 46 degrees depending on the angularity of grains and relative density).

Damp sands and gravels possess some cohesion and can stand vertically for short periods. Water-bearing sands, however, are very difficult in open excavations. If they are cut steeply, as in trench excavation, seepage of water from the face will result in erosion at the toe followed by collapse of the upper part of the face until a stable angle of approximately 15 to 20 degrees is obtained.

Dry silts may stand unsupported vertically, especially if slightly cemented. Wet silt is the most troublesome material to excavate. Seepage leads to slumping and undermining with subsequent collapse, eventually reaching a very shallow angle of repose.

It should not be taken for granted that excavations in rock will stand with vertical slopes unsupported. Their stability depends on the soundness, angle of bedding planes, and the degree of shattering. Unstable conditions can occur if bedding planes slope steeply towards the excavation, especially if groundwater is present to act as lubrication.

4.2 FIELD RECORDING AND SAMPLING TECHNIQUES

The field record should include a plan giving the location, dimensions, and orientation of the pit, together with dimensioned sections of the sidewalls, description of the strata encountered, and details of any sampling or testing carried out. A photographic record of the test pit, with an appropriate scale, would be ideal.

Any groundwater encountered should be noted with regard to its depth and approximate rate of seepage. If possible, the groundwater level within the test pit should be monitored for 20 minutes, with readings taken at 5-minute intervals.

Working from the ground surface the technician can prepare a visual log of the strata/soil profile and decide the interval of sampling. Samples from excavations can be either disturbed or undisturbed.

Disturbed samples are taken from the excavator bucket or from the spoil. To obtain a representative sample of the material at a certain depth, care must be taken not to include scrapings from the sidewalls.

Undisturbed samples may be block samples, cut from in situ material; tube samplers may be driven into the floor of the pit using a jarring link and drill rods and extracted using the backhoe of the excavator.

Samples of groundwater or leachate may be taken using telescoping poles or a small bailer.

The required size of the samples will vary according to the intended analysis/testing to be carried out.

4.3 BACKFILLING

The test pits or trenches should be backfilled immediately upon completion of the hole. Prior to backfilling, pits and test trenches should be inspected to make sure it is safe to approach the excavation with the backfill and equipment. Poorly compacted backfill will cause settlement at the ground surface and hence the spoil should be recompacted in several thin layers using the excavator bucket and any surplus material placed over the top of the pit.

In certain areas where soil borings are not required, the pit may be used to install gas monitoring standpipes or piezometers. The granular filter is kept in place using sacking while the backfill material is carefully emplaced around the instrument.

If a sealing layer has been penetrated during excavation, resulting in a groundwater connection between contaminated and previously uncontaminated zones, the backfill material must represent the original conditions or be impermeable. Backfill material could comprise a soil-bentonite mix or a cement-bentonite grout.

4.4 DECONTAMINATION

The purpose of decontamination and cleaning procedures during sampling tasks is to prevent foreign contamination of the samples and cross contamination between sites. All sampling and excavation equipment must be decontaminated before use. All fluids generated by decontamination must be contained in Department of Transportation (DOT)-approved 55-gallon drums or other appropriate containers as specified in the site work plan.

5.0 REFERENCES

Scientific and Technical Standards for Hazardous Waste Sites, Book 1, Volume 1, Site Characterization, August 1990.

Tomlinson, M.J., 1986. *Foundation Design and Construction*, 5th Edition.

STANDARD OPERATING PROCEDURE

SOP-04
SOIL GRAB SAMPLING

MONTGOMERY WATSON HARZA

STANDARD OPERATING PROCEDURE

SOP-04
SOIL GRAB SAMPLING

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1.0 INTRODUCTION

For remedial investigations, primary consideration must be given to obtaining samples that are representative of existing conditions and valid for chemical analysis. SOP 1, "Shallow Hand Auger Sampling," contains specific procedures regarding drilling and sampling. The samples must not be contaminated by drilling fluids or by the sampling procedures.

This guideline provides a description of the principles of operation, applicability, and implementability of grab soil sampling methods used during remedial investigations. The purpose of this document is to aid in the selection of soil sampling methods that are appropriate for site specific conditions. It is intended to be used by the project manager (PM), project engineer (PE), field team leader (FTL) or Superintendent, and site geologist to develop an understanding of each method sufficient to permit work planning, scheduling, subcontracting, and resource planning.

This guideline focuses on methods and equipment that are readily available and typically applied. It is not intended to provide an all-inclusive discussion of soil sampling methods. Sample types, samplers, and sampling methods are discussed.

2.0 DEFINITIONS

Blow Counts	Number of hammer blows needed to advance a split spoon sampler. Blow counts are usually counted in 6-inch increments.
VOCs	Volatile organic compounds

3.0 RESPONSIBILITIES

The **Project Manager** selects site-specific soil sampling methods with input from the FTL and site geologist, and oversees and/or prepares drilling subcontracts.

The **Site Geologist** selects site-specific drilling and sampling options and helps prepare technical provisions of drilling subcontracts.

The **Field Team Leader** implements the selected drilling program and assists in the selection of drilling methods and preparation of subcontracts.

The **Rig Geologist** supervises and/or performs actual sampling procedures.

4.0 SOIL SAMPLING

4.1 TYPES OF SAMPLES

Four basic types of samples are collected in site investigation work: bulk, representative, "undisturbed", and composite. Each of these basic types of sampling approaches is discussed in the following sections.

4.1.1 Bulk Samples

Bulk samples are generally a shovelful or trowelful of material taken from drill cuttings. There is usually significant uncertainty regarding which interval the drill cuttings represent. This type of sampling is rarely used and is the least accurate of the four basic sample types.

4.1.2 Representative Samples

Representative samples are collected with a drive or push tube. They do not represent undisturbed conditions but do represent all the constituents that exist at a certain interval. This type of sampling is often used to discern an average representation of a certain interval and is moderately accurate.

4.1.3 Undisturbed Samples

"Undisturbed" samples are high quality samples collected under strictly controlled conditions to minimize the structural disturbance of the sample. Undisturbed samples should be collected when all the presampling relationships need to be preserved. Every effort is made to avoid altering the sample during the sampling process. Undisturbed samples are generally required for geotechnical work and are rarely necessary to assess environmental quality. This type of sampling is highly accurate.

4.1.4 Composite Samples

Composite samples are a blend or mix of sample material, usually combined from two or more stratigraphic intervals mixed in such a way as to represent the total borehole. Homogenized samples are samples that are composited over a discreet interval. For example, if a sample represented the 10- to 11.5-foot interval, the material from that interval would be mechanically blended before being put into the appropriate sample container. VOC samples are never composited or homogenized. Metals samples are often dried and sieved after homogenization before placement into the sample container. (See USEPA Soil Sampling Guidance EPA/540/R-96/018 for composite sampling procedures for specific metals.)

4.2 GRAB SAMPLING METHODS

An element in the design of an effective sampling strategy is the selection of appropriate sample types. Based on the desired analytical objectives of the sampling, analytical considerations, and available resources (for sampling and analysis), two basic types of samples—grab and composite—are commonly collected.

- **Grab—**a sample taken from a particular location. Most common type of sample collected. Useful in determining discrete spatial variability when multiple samples are collected.
- **Composite—** a number of samples that are individually collected and combined into a single sample for subsequent analysis. Used where average or normalized concentration estimates of a waste stream's or area's constituent are desired.

Chapter 9 of SW846 has detailed procedures for determining the type technique for sampling waste streams. The sampling procedures are determined based on the physical characteristics of the site and matrix.

4.2.1 Sampling Equipment Selection

There are many different types of equipment used for sample collection. Seven of the most common types are composite liquid waste sampler (Coliwasa), weighted bottle, dipper, thief, trier, auger, scoops and shovels. In order to reduce the possibility of cross contamination of samples, the appropriate decontamination procedure for each type of equipment must be followed. Listed below are the uses for these types of equipment:

- Coliwasa is used to sample free-flowing liquids and slurries contained in drums, shallow tanks, pits or similar containers. It is especially useful for wastes with several immiscible liquid phases. Coliwasa is used for composite sampling.
- Weighted bottles are used to sample liquids and free-flowing slurries.
- Dippers are used to sample liquids and free-flowing slurries.
- Thiefs are used to sample dry granules or powdered wastes whose particle diameter is less than one-third the width of the slots.
- Triers are used to sample moist or sticky solids with a particle size less than one-half the diameter of the trier.
- Augers are used to sample hard or packed solid wastes.
- Scoops and shovels are used to sample granular or powdered materials in bins and shallow containers.

Selection of the type of equipment used will be based on 1) limiting the possibility of cross contamination, 2) assuring comparability, 3) obtaining adequate sample volume, 4) ease of use, 5) limiting the degree of hazard during sample collection, and 6) limiting the cost of sample collection. A more detailed description of each type of equipment is presented in USEPA SW846, Chapter 9.

5.0 REFERENCES

Aller, L., Bennett, T.W., Hackett, G., Petty, R.J., Lehr, J.H., Sedoris, H., and Nielsen, D.M., 1989. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*, National Water Well Association, Dublin, Ohio, 397 pp.

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STANDARD OPERATING PROCEDURE 05

SAMPLE HANDLING AND SHIPPING

STANDARD OPERATING PROCEDURE 05

SAMPLE HANDLING AND SHIPPING

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1.0 INTRODUCTION

This standard operating procedure (SOP) describes the requirements for sample identification; chain-of-custody (COC) documentation; and sample handling, storage and shipping. The purpose of this SOP is to define sample management activities as performed from the time of sample collection to the time they are received by the laboratory.

2.0 DEFINITIONS

Chain-of-Custody: An accurate written record of the possession of each sample from the time of collection in the field to the time the sample is received by the designated analytical laboratory.

Sample: Physical evidence collected for environmental measuring and monitoring. For the purposes of this SOP, sample is restricted to solid, aqueous, air, or waste matrices. This SOP does not cover samples collected for lithologic description nor does it include remote sensing imagery or photographs (refer to SOP-4 for field documentation procedures).

Sampler: The individual who collects environmental samples during fieldwork.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often additional personnel may be involved. Project team member information will be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance project plan, and etc.), and field personnel will always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

Project Manager: The Project Manager is responsible for ensuring that the requirements for sample management are included in the appropriate project plans. The Project Manager is responsible for coordinating sample management efforts with input from other key project staff.

Quality Control Manager: Performs project audits. Ensures project-specific data quality objectives are fulfilled.

Field Team Leader and/or Field Hydrogeologist, Geologist or Engineer: Conducts the procedures described herein and, if applicable, the requirements of the project plan. Responsible for reviewing documentation developed from sample management to determine compliance with this SOP and project quality control (QC) requirements. Prepares daily logs of field activities.

Field Technician: Responsible for sample collection, documentation, packaging, and shipping. Assists the FTL and/or geologist, hydrogeologist, or engineer in the implementation of tasks.

4.0 PROCEDURES

4.1 APPLICABILITY

The sample handling and shipping procedures described in this SOP apply to all work conducted at the Site. Deviations or modifications to procedures addressed herein must be brought to the attention of, and approved by, the Project Manager.

4.2 SAMPLE MANAGEMENT

Sample Containers: The sample containers to be used will be dependent on the sample matrix and analyses desired. Unless specified otherwise by the project-specific work plan, the containers to be used for various analyses are described in the Quality Assurance Project Plan (QAPP). Sample containers will be filled with adequate headspace (approximately 10 percent) for safe handling upon opening, except containers for volatile organic compound (VOC) analyses, which will be filled completely with no headspace. This no-headspace requirement applies to both soil and groundwater samples.

Once opened, the containers will be used immediately. If the container is used for any reason in the field (e.g., screening) and not sent to the laboratory for analysis, it will be discarded. Prior to discarding the contents of the used container and the container, disposal requirements will be evaluated. When storing before and after sampling, the containers will remain separate from solvents and other volatile organic materials. Sample containers with preservatives added by the laboratory will not be used if held for an extended period on the job site or exposed to extreme heat conditions. Containers will be kept in a cool, dry place.

Numbering and Labeling:

Sample Label. A sample label will be affixed to all sample containers. Labels provided by the laboratory or another supplier may be used, and at a minimum will include the following information:

- Client name, project title, or project location (sufficiently specific for data management)
- Sample location
- Sample identification number
- Date and time of sample collection
- Type of sample (grab or composite)
- Initials of sampler
- Preservative used

- Analyte(s) of interest.

If a sample is split with another party, identical labels will be attached to each sample container. After labeling, each sample will be refrigerated or placed in a cooler containing wet ice to reduce sample temperature to approximately 4 degrees Celsius (°C).

Custody Seals. Custody seals will be used on each shipping container to ensure custody. Custody seals used during the course of the project will consist of security tape with the date and initials of the sampler. The custody seal will be placed on the outside of the cooler across the seam of the lid and the cooler body. Alternatively, if the sample containers are all placed inside a liner bag within the cooler, the custody seal may be placed across the seal of the liner bag inside of the cooler.

Chain-of-Custody: Chain-of-custody (COC) procedures require a written record of the possession of individual samples from the time of collection through laboratory analyses. A sample is considered to be in custody if it is:

- In a person's possession
- In view after being in physical possession
- In a secured condition after having been in physical custody
- In a designated secure area, restricted to authorized personnel

The COC record will be used to document the samples taken and the analyses requested. Information recorded by field personnel on the COC record will include the following:

- Client name
- Project name
- Project location
- Sampling location
- Signature of sampler(s)
- Sample identification number
- Date and time of collection
- Sample designation (grab or composite)

- Sample matrix
- Signature of individuals involved in custody transfer (including date and time of transfer)
- Airbill number (if appropriate)
- Type of analysis and laboratory method number
- Any comments regarding individual samples (e.g., organic vapor meter readings, special instructions).

COC records will be placed in a waterproof plastic bag (e.g., Ziploc®), taped to the inside lid of the cooler or placed at the top of the cooler, and transported with the samples. When the sample(s) are transferred, both the receiving and relinquishing individuals will sign the record. Signed airbills will serve as evidence of custody transfer between the field sampler and courier, as well as courier and laboratory. If a carrier service is used to ship the samples (e.g., Federal Express, etc.), custody will remain with the sampler until it is relinquished to the laboratory. The sampler will retain copies of the COC record and airbill.

Sample Register/Sample Tracking: The sample register is a logbook with sequentially numbered pages used to document which samples were collected on a particular day. The sample register is also used as the key to correlate field samples with duplicate samples. Information recorded in the sample register will include the following:

- Client name
- Project name and location
- Job number
- Date and time of collection
- Sample identification number
- Sample designation (e.g., grab or composite, etc.)
- Sample matrix (e.g., soil, groundwater, etc.)
- Number and type of bottles
- Type of analysis
- Sample destination
- Sampler's initials.

A sample tracking database, which includes the above information, may be substituted for a handwritten sample register. However, a hard copy of each day's sampling activities will be maintained in the field files or field logbook as discussed in SOP-4 (Field Documentation).

Sample Preservation/Storage: The requirements for sample preservation are dependent on the desired analyses and the sample matrix. Unless otherwise specified by the project plan, sample preservation requirements outlined in the QAPP will be observed.

4.3 SAMPLE SHIPPING

Procedures for packaging and transporting samples to the laboratory are based on the actual chemical, physical, and hazard properties of the material. The procedures may also be based on an estimation of contaminant concentrations/properties in the samples to be shipped. Samples will be identified as either environmental samples, excepted quantities samples, limited quantities samples, or standard hazardous materials. Environmental samples are defined as solid or liquid samples collected for chemical or geotechnical analysis. These samples are used to support remedial investigation, feasibility studies, treatability studies, remediation design and performance assessment, waste characterization, etc. Excepted quantities involve the shipment of a few milliliters of either an acid or base preservative in an otherwise empty sample container. Limited quantities are restricted amounts of hazardous materials that may be shipped in generic, sturdy containers. Standard hazardous material shipments require the use of stamped/certified containers. All samples will be packaged and shipped or hand delivered to the laboratories the same day of sample collection, unless otherwise specified in the project-specific work plans.

The following paragraphs describe standard shipping procedures for different types of samples. Any exceptions to these procedures will be defined in the project-specific work plan. It is the responsibility of the sampler to understand U.S. Department of Transportation (DOT) requirements and limitations associated with the shipment of all types of samples.

Sample Shipping via Commercial Carrier:

Aqueous or Solid Samples: Samples will be packaged and shipped to the laboratories the same day of sample collection, unless otherwise specified in the project work plans and depending on holding time requirements for individual samples. For aqueous or solid samples that are shipped to the Contract Laboratory via a commercial carrier the following procedures apply:

- Sample labels will be completed and attached to sample containers as described in Section 4.2.
- The samples will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler.
- Ice in double Ziploc® bags (to prevent leakage) will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled and maintained at 4°C ± 2°C during transport to the laboratory. Dry ice will not be used. In addition, experience has shown that blue ice is inadequate.
- To prevent the sample containers from shifting inside the cooler, the remaining space in the cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC form will be placed in a waterproof plastic bag and taped to the inside of the cooler lid or placed at the top of the cooler.
- The lid will be secured by wrapping strapping tape completely around the cooler in two locations.
- Custody seals will be used on each shipping container to ensure custody. Custody seals used during the course of the project will consist of security tape with the date and initials of the sampler.

- A copy of the COC record and the signed air bill will be retained for the project files.

Air Samples: If transported by a commercial carrier, air, soil vapor, or treatment system off-gas samples will be packaged and shipped to the Contract Laboratory using the following procedures:

- A completed sample tag will be attached with a wire to the PUF/XAD-2 Cartridge, Summa® canister or Tedlar™ bag for each investigative or quality control sample. All entries will be made using indelible ink, or pre-printed individual labels. Any errors will be corrected by drawing a single line through the incorrect entry, entering the correct information, and then initialing and dating the change. The tag will include the field sample number, location (if not encoded in the sample ID), date and time of sample collection, and type of analysis. There will also be a space available for entry of the lab sample ID number.
- The samples in PUF/XAD-2 Cartridge or Tedlar™ bags will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler. The Summa® canisters will be placed in their original shipping container.
- To prevent the PUF/XAD-2 Cartridge or Tedlar™ bags from shifting inside the cooler, the cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- Ice in double Ziploc® bags (to prevent leakage) will be placed around, among, and on top of the PUF/XAD-2 Cartridges. There are no temperature criteria for samples in Tedlar™ bags. Enough ice will be used so that the samples will be chilled and maintained at $4 \pm 2°C$ during transport to the laboratory.
- The original copy of the completed COC form will be placed in a waterproof plastic bag and either taped to the inside of the cooler lid or placed at the top of the cooler or in the Summa® canister packaging box.
- The coolers or Summa® canister packaging box will be secured by wrapping strapping tape completely around the containers in two locations.
- Custody seals will be used on each shipping container to ensure custody. Custody seals used during the course of the project will consist of security tape with the date and initials of the sampler. The custody seal will be placed on the outside of the container used for shipping.
- A copy of the COC record and the signed air bill will be retained for the

project files.

Hand-Delivered Samples:

Aqueous or Solid Samples: For aqueous or solid samples that will be hand carried to the Contract Laboratory, the following procedures apply:

- Sample labels will be completed and attached to sample containers as described in Section 4.2.
- The samples will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler.
- Ice in double Ziploc® bags (to prevent leakage) will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled during transport to the laboratory.
- To prevent the sample containers from shifting inside the cooler, the remaining space in cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC form will accompany the samples to the laboratory.
- A copy of the COC record will be retained for the project files.

Air Samples: The following procedures will apply for air, soil gas, or treatment system off-gas samples that are hand delivered to the laboratory:

- A completed sample tag will be attached with a wire to each PUF/XAD-2 Cartridge, Summa® canister or Tedlar™ bag for each investigative or quality control sample. All entries will be made using indelible ink. Any errors will be corrected by drawing a single line through the incorrect entry, entering the correct information, and then initialing and dating the change. The tag will include the field sample number, location (if not encoded in the sample ID), date and time of sample collection, and type of analysis. There will also be a space available for entry of the lab sample ID number.

- The samples in PUF/XAD-2 Cartridge or Tedlar™ bags will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler. The Summa® canisters will be placed in their original shipping container.
- To prevent the PUF/XAD-2 Cartridge or Tedlar™ bags from shifting inside the cooler, the cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- Wet ice in double Ziploc® bags (to prevent leakage) will be placed around, among, and on top of the PUF/XAD-2 Cartridges. There are no temperature criteria for samples in Tedlar™ bags. Enough ice will be used so that the samples will be chilled during transport to the laboratory.
- The original copy of the completed COC form will accompany the samples to the laboratory.
- A copy of the COC record will be retained for the project files.

Excepted Quantities: Usually, corrosive preservatives (e.g., hydrochloric acid, sulfuric acid, nitric acid, or sodium hydroxide) are added to otherwise empty sample bottles by the analytical laboratory prior to shipment to field sites. However, if there is an occasion whereby personnel are required to ship bottles with these undiluted acids or bases, the containers will be shipped in the following manner:

1. Each individual sample container will have not more than 30 milliliters of preservative.
2. Collectively, the preservative in these individual containers will not exceed a volume of 500 milliliters in the same outer box or package.
3. Despite the small quantities, only chemically compatible material may be placed in the same outer box, (e.g., sodium hydroxide, a base, must be packaged separately from the acids).
4. Federal Express will transport nitric acid only in concentrations of 40 percent or less.
5. A "Dangerous Goods in Excepted Quantities" label will be affixed to the outside of the outer box or container. Information required on the label includes:

- Signature of Shipper
- Title of Shipper
- Date
- Name and Address of Shipper
- Check of Applicable Hazard Class
- Listing of UN Numbers for Materials in Hazard Classes

Limited Quantities: Occasionally, it may become necessary to ship known hazardous materials, such as pure or floating product. DOT regulations permit the shipment of many hazardous materials in "sturdy" packages, such as an ice chest or cardboard box (not a specially constructed and certified container), provided the following conditions are met:

1. Each sample bottle is placed in a plastic bag, and the bag is sealed. Each VOC vial is wrapped in a paper towel, and the vials are placed in a sealable bag. As much air as possible is squeezed from the bag before sealing. Bags may be sealed with evidence tape for additional security.
2. Or each bottle is placed in a separate paint can, the paint can is filled with vermiculite, and the lid is affixed to the can. The lid must be sealed with metal clips, filament, or evidence tape. If clips are used, the manufacturer typically recommends six clips.
3. The cans are placed upright in a cooler that has had the drain plug taped shut inside and outside, and the cooler is lined with a large plastic bag. Approximately 1 inch of packing material, such as vermiculite or other type adsorbent sufficient to retain any liquid that may be spilled, is placed in the bottom of the liner. Three sizes of paint cans are used: pint, half-gallon, and gallon. The pint or half-gallon paint cans may be stored on top of each other; however, the gallon cans are too high to stack. The cooler will be filled with additional packing material, and the liner will be taped shut. Only containers having chemically compatible material may be packaged in each cooler or other outer container.
4. The COC record is sealed inside a plastic bag and placed inside the cooler. The sampler retains one copy of the COC record. The laboratory will be

notified if the sample is suspected of containing any substance for which the laboratory personnel should take safety precautions.

5. The cooler is shut and sealed with strapping tape (filament type) around both ends. Two signed custody seals will be placed on the cooler, one on the front and one on the back. Additional seals may be used if the sampler and/or shipper consider more seals to be necessary. Wide, clear tape will be placed over the seals to ensure against accidental breakage.
6. The following markings are placed on the side of the cooler:

   - Proper Shipping Name (Column B, List of Dangerous Goods, Section 4, IATA Dangerous Goods Regulations [DGR])
   - UN Number (Column A, List of Dangerous Goods, Section 4, IATA DGR)
   - Shipper's name and address
   - Consignee's name and address
   - The words "LIMITED QUANTITY"
   - Hazard Labels (Column E, List of Dangerous Goods, Section 4, IATA DGR)
   - Two Orientation (Arrow) labels placed on opposite sides.

7. The Airbill/Declaration of Dangerous Goods form is completed as follows:

   - Shipper's name and address
   - Consignee's name and address
   - Services, Delivery & Special Handling Instructions
   - Cross out "Cargo Aircraft Only" in the Transport Details Box
   - Cross out "Radioactive" under Shipment Type
   - Nature and Quantity of Dangerous Goods

     - Proper Shipping Name (Column B, List of Dangerous Goods, Section 4, IATA DGR)
     - Class or Division (Column C, List of Dangerous Goods, Section 4, IATA DGR)

- UN Number (Column A, List of Dangerous Goods, Section 4, IATA DGR)
- Packing Group (Column F, List of Dangerous Goods, Section 4, IATA DGR)
- Subsidiary Risk, if any (Column D, List of Dangerous Goods, Section 4, IATA DGR)
- Quantity and type of packing (number and type of containers: for example, "3 plastic boxes", and the quantity per container, "2 L", is noted as "3 Plastic boxes X 2 L" This refers to 3 plastic boxes (coolers are referred to as plastic boxes) with 2 liters in each box.
- Packing Instructions (Column G, List of Dangerous Goods, Section 4, IATA DGR).
- Note: Only those Packing Instructions in Column G that begin with the letter "Y" may be used. These refer specifically to the Limited Quantity provisions.
- Authorization (Write in the words Limited Quantity)
- Emergency Telephone Number (List 800-535-5053. This is the number for INFOTRAC.)
- Printed Name and Title, Place and Date, Signature.

Standard Hazardous Materials: Shipment of standard hazardous materials presents the most difficulty and expense. However, there may be occasion whereby a hazardous material cannot be shipped under the Limited Quantity provisions, (e.g., where there is no Packing Instruction in Column G, List of Dangerous Goods, IATA Dangerous Goods Regulations, that is preceded by the letter "Y").

In such cases, the general instructions noted above but for non-Limited Quantity materials will apply, with one important difference: standard hazardous materials shipment requires the use of certified outer shipping containers. These containers have undergone rigid testing and are, therefore, designated by a "UN" stamp on the outside, usually along the bottom of a container's side. The UN stamp is also accompanied by codes specifying container type, packing group rating, gross mass, density, test pressure, year of manufacturer, state of manufacturer, and manufacturer code name. The transport of lithium batteries in Hermit Data Loggers is an example of a standard hazardous material where only a designated outer shipping container may be used.

4.4 HOLDING TIMES

The holding times for samples will depend on the analysis and the sample matrix. Unless otherwise specified, holding times listed in the QAPP will be followed.

4.5 TRAINING

The U.S. DOT requires that all employees involved in any aspect of hazardous materials transport (e.g. shipping, transport, receipt, preparing documents, and etc.) receive training at least bi-annually.

4.6 ADDITIONAL INFORMATION

General questions regarding this SOP or inquiries on the safe transport of other specific chemicals or by other carriers should be referred to the Project Manager.

5.0 REFERENCES

Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Disposal Sites by Contractors, Draft, Appendix D, April 1980.