Standard Operating Procedure No. 6

Drilling, Logging, and Sampling of Subsurface Materials

REVISION LOG		
Revision Number	Description	Date
6.0	Original SOP	12/03/03
6.1	Revisions by McLemore	1/19/04
6.2	Revisions by PJP	5/20/2004
6v3	LMK added forms, minor formatting edits, no content edits	8/15/05
6v3	LMK finalized for posting on Utah site and to send George Robinson for lab audit	3/20/07
6v4	Editorial by SKA	10/22/08

1.0 PURPOSE AND SCOPE

This Standard Operating Procedure (SOP) provides technical guidance and methods that will be used to describe subsurface soil and rock samples during field activities performed at the Molycorp Mine Site.

2.0 RESPONSIBILITIES AND QUALIFICATIONS

The Principal Investigator (PI) or Bureau Field Geologist have the overall responsibility for implementing this SOP. They will be responsible for assigning appropriate technical staff to implement this SOP and for ensuring that the procedures are followed by all personnel. A "site geologist" (geologist, hydrogeologist or geotechnical engineer, provided by Molycorp) experienced in borehole drilling and soil sampling will be present at each operating drill rig.

All personnel performing these procedures are required to have the appropriate health and safety training. In addition, all personnel are required to have a complete understanding of the procedures described within this SOP and receive specific training regarding these procedures, if necessary.

All project staff are responsible for reporting deviations from this SOP to the PI or Bureau Field Geologist.

3.0 RELATED STANDARD OPERATING PROCEDURES

The procedure for borehole logging set forth in this SOP is intended for use with the following SOPs:

- SOP 2 Sample Management
- SOP 3 Surveying (GPS)
- SOP 4 Taking Photographs
- SOP 5 Sampling Outcrops, Rock Piles, and Drill Core
- SOP 7 Decontamination of Sampling Equipment
- SOP 8 Sample Preparation (solids)
- SOP 35 In Situ Volumetric Moisture Content
- SOP 36 Sample Preservation, storage, and shipment
- Any future SOPs dealing with subsurface sampling

4.0 EQUIPMENT LIST

The following materials and equipment listed will be needed for borehole logging:

- Molycorp Access 97 Data Base Forms
- Waterproof pens
- Hand lens (10X magnification or stronger)
- Metal or wooden tape measure
- Stainless steel knife, screwdriver, rock hammer
- Decontamination equipment and supplies (see SOP 7.0 Decontamination of Sampling Equipment)
- Reference tables listing ASTM and/or Unified Soil Classification System (USCS) codes and descriptions

The following is a list of equipment that will be necessary to perform drilling and sampling of subsurface materials:

- Monitoring equipment and personal protective equipment (PPE) as outlined in the site-specific HSP
- Dual wall percussion or air rotary drill rig with appropriate sized drill rods and downhole bits/casing systems for drilling in unconsolidated materials. Sonic drill rig with appropriately sized drill tubes and drill rods for drilling in unconsolidated materials. Air rotary drill rig for drilling in unconsolidated materials underlying the unconsolidated rock piles with associated bits and drill rod

- High pressure, hot water washer for decontamination
- Decontamination equipment and supplies (e.g., wash/rinse tubs, brushes, alconox, plastic sheeting, paper towels, sponges, baby wipes, garden-type sprayers, large plastic bags, potable water, distilled water and/or deionized water)
- Sampling equipment for HSA rig (e.g., stainless steel 2.0, 2.5, and 3.0 inch outer diameter split spoon sampler (dual tube) and 4.0 inch core split barrel (sonic)
- Reclosable plastic bags for archiving samples
- 55-gallon drums or other approved containers for containing soil cuttings

Other materials and equipment may be needed based on field conditions.

5.0 PROCEDURES

5.1 DRILL LOGS

The Bureau Field Geologist will be responsible for logging samples, monitoring drilling operations, recording water losses or gains, and preparing field boring logs. Procedures for completing boring logs are described below:

- Boring log information will be recorded on the Molycorp database forms (eg. Appendix 1):
    a. Chain_of_Custody_Form
    b. Chain_of_Custody_Trans_Subform
    c. Drillhole Form
    d. Drill_Core_Photos_Subform
    e. Drill_Hole_Mineralogy_Subform
    f. Drill_Log
    g. Drill_Log_Subform
    h. Fieldphotos_Subform
    i. Field_Activity_Form
    j. Grav_m_c_Form
    k. Grav_m_c_Subform
    l. Relect_Spect_Subform
    m. Sample_Anal_Request_Subform
    n. Sample_Field_Form
    o. Sample_Preparation_Form
    p. Screening_Subform
    q. Tailgate_Safety_Mtg_Form

r. Test_Pit_Form
s. Test_Pit_Fractures_Subform
t. Test_Pit_Header
u. Test_Pit_Lab_Measurements
v. Test_Pit_Log
w. Test_Pit_Log_Subform
x. Test_Pit_Photos
y. Waterlevel_Subform

- Forms will be prepared in the field by the site geologist as borings are drilled. The preparer will enter the data into the electronic database as soon as possible.
- All log entries will be legibly printed such that reproductions will be clear and legible.
- Borehole depth information will be recorded to the nearest 0.1 foot.
- All relevant information in the Database forms will be completed. If surveyed horizontal control is not available at the time of drilling, location sketches referenced by measuring distances or prominent surface features shall be shown on, or attached to, the forms.
- Each and every material type encountered will be described in the Database forms. Material types will be logged directly from samples and indirectly interpolated using professional judgment, drill cuttings, drill action, etc., between sampling intervals.
- Geotechnical materials will be classified in accordance with the USCS (equivalent to ASTM D 2488-93, "Description and Identification of Soil [Visual Manual Procedure]"; (Tables 1, 2). Soil classifications will be made in the field at the time of sampling by the site geologist and are subject to change based on laboratory tests and subsequent review.
- Consolidated material (e.g., igneous and metamorphic rocks) will be described by parameters listed in the Database forms.
- For consolidated material, fracture information will be recorded on the Drill_Log_Fracture form. Breaks believed to be machine induced, or purposely made so that the core could fit in the core box, will be so annotated. The intervals by depth of all lost core and hydrologically significant details will also be noted. This information will be recorded at the time of core logging.
- The drilling equipment used will be described on the Drillhole form. Information such as drill rod size, bit size and type, and rig manufacturer and model will be recorded.
- All special problems encountered during drilling and their resolution will be recorded on the Field Activity form. This would include loss of circulation, sudden tool drops, unrecovered tools in the borehole, and lost casing.
- The dates for the start and completion of borings will be recorded on the Drill_Log form. Changes in shift, day, driller, and site geologist will also be noted at the depth they occur.

- Stratigraphic/lithologic changes will be identified on the Drill_Log form. Gradational transitions and changes identified from cuttings or methods other than direct observation and measurement will be identified on the Drill_Log form.
- Borehole and sample diameters and depths at which drilling or sampling methods or equipment changes will be recorded on the Drillhole form.
- The total depth of penetration and sampling will be recorded on the Drillhole form.
- The depth at which water is first encountered, the depth of water at the completion of drilling, and the stabilized depth to water will be recorded on the Waterlevel form. If the interval is damp, the interval and moisture content will be noted on the Moisture_Content form. The absence of water in borings will also be indicated. Stabilized water-level data will include time allowed for levels to stabilize.
- Blow counts will be recorded on the Drill_Log Form in half-foot increments when a standard penetration test is performed. For penetration less than a half-foot, the count will be annotated with the distance over which the count was taken. Refusal, if reached, will be noted.
- Other information to be noted on the Drill_Log form include, but not limited to:

- Odors
- Field screening or test results (e.g., organic vapors and/or radiological)
- Any observed evidence of contamination in samples, cuttings or drilling fluid

5.2 DRILLING PROCEDURES

Prior to drilling, drill holes will be numbered and the site cleared for utilities with the assistance of Molycorp personnel. Boring locations may be adjusted in the field due to the presence of underground utilities, overhead power lines, or other structures, or if access problems are encountered. Drilling locations will be approved by PI and a designated Molycorp representative prior to initiating drilling activities.

Health and safety equipment specified in the site-specific Health and Safety Plan (HSP) will be done before proceeding with subsurface drilling activities. The HSP will specify action levels for various contaminants and the field monitoring required to measure ambient conditions.

All drill cuttings will be placed in labeled drums and moved to a central secured location for storage. Any water generated during drilling will be contained in labeled drums or tanks. Handling of investigation derived wastes (IDW) will be handled and disposed of by Molycorp.

Downhole equipment will be steam-cleaned prior to proceeding to the drill site and between subsequent boreholes using the procedures presented in SOP No. 7.0 Decontamination of Sampling Equipment. Split-spoon samplers and core barrels will be decontaminated at the drill site between each sample interval.

All work areas around borings will be restored to a physical condition equivalent to that of pre-drilling, as near as practical. This will include drill cuttings removal and rut repair.

At the direction of the Bureau Field Geologist, only potable water may be introduced into boreholes. No bentonite, barite, polymers, or other additives or viscosifying agents will be introduced into the

borehole or used during drilling. It is expected that it will not be necessary to introduce foaming agents into boreholes to lift cuttings during bedrock drilling. However, if the drilling subcontractor suggests that foaming agents are needed, the subcontractor must provide Material Safety Data Sheets (MSDS) for any product that they suggest. The MSDS will then be reviewed by the Bureau Field Geologist to determine if any unacceptable substances are present in the foaming agent before approving its use.

The rig shall be free of leaks that could contaminate the boreholes (i.e., hydraulic fluid, oil, fuel, etc.). Pipe lubricants that are used should not introduce contaminants into the borehole. Lubricants that are environmentally acceptable include Green Stuff®, King Stuff®, vegetable oil, Crisco™, and some Teflon™-based lubricants. Lubricants that are not acceptable include petroleum-based and most metal-based lubricants. The Bureau Field Geologist will pre-approve lubricants that will be used.

5.3 DUAL WALL PERCUSSION, SONIC, AND AIR-ROTARY DRILLING

The procedures below address drilling of boreholes using a dual wall percussion, sonic, or air-rotary drill rig. Dual wall percussion or sonic drill rigs will be used to drill and install monitoring wells and tensiometers. Air rotary drilling will be reserved for drilling in consolidated rock. Samples of drill cuttings will be collected for visual logging purposes will be continuously cored. At locations specified in the SAP, samples will also be collected and archived for possible future testing. Drilling and sampling procedures using a dual wall percussion, sonic, or air-rotary drill rig are as follows:

- Remove stones, vegetation, etc., from the sampling location surface.
- Install 10-inch steel surface casing to an appropriate depth to stabilize the borehole.
- Convert to down-hole hammer or tricone bit and continue drilling through the surface casing to the desired depth. Use an appropriate drill bit to provide for a minimum 4-inch annulus around the groundwater monitoring well casing.
- Sampling of drill cuttings will be performed at five-foot intervals to the total depth of the borehole. Samples will be collected directly from the cyclone and placed in quart-sized baggies and labeled with the boring number and depth.
- Screen the sampled material using the instruments specified in the HSP.
- Log the sample in accordance with Section 5.1 of this SOP.

- Follow sample handling procedures for collecting samples as described in SOP No. 2.0 Sample Management.

5.4 DRILL HOLE ABANDONMENT

Drill hole abandonment may be necessary in some cases. The following procedures will be used to abandon boreholes:

- All downhole equipment will be removed from the borehole. Cuttings scraped from the drill rods and bits will be drummed in accordance with the procedures provided by Molycorp.

Equipment will be decontaminated in accordance with SOP No. 7.0 Decontamination of Sampling Equipment.

- Boreholes will be grouted using cement-bentonite grout. The grout mix will be in the proportions of one sack of Portland cement (94 pounds), 2 to 5 pounds of powdered bentonite, and approximately 7 to 9 gallons of water. The bentonite will be well mixed with the water prior to adding the cement.
- Grouting will be performed by placing a tremie pipe to the bottom of the drill hole and pumping grout through the tremie pipe until undiluted grout flows from the ground surface.
- Twenty-four hours after grouting, the drill hole will be checked for settlement and topped off to the ground surface with grout.
- Details concerning the abandonment process will be recorded on the Drill_Log and Field_Activity forms.

6.0 DOCUMENTATION

Documentation of observations and data acquired in the field will provide information on the activities concluded and also provide a permanent record of field activities. The observations and data will be transferred from the hardcopy database forms to electronic format daily.

7.0 REFERENCES

ASTM D2488-93 Standard Practice for Description and Identification of Soils (Visual Manual Procedure)

TABLE 1
DESCRIPTION OF UNCONSOLIDATED SOIL

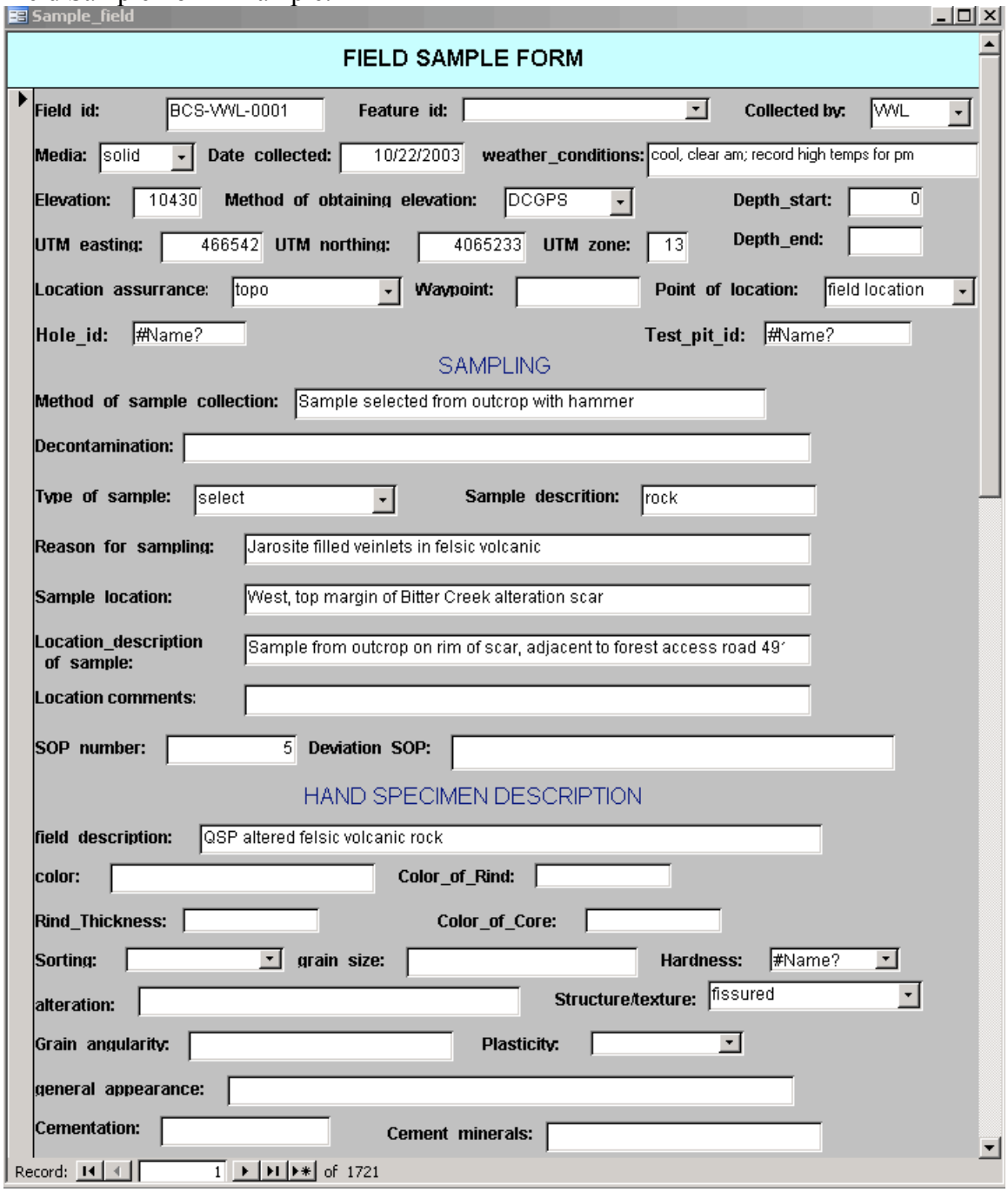
Parameter	Example
Depositional Environment and Formation, (if named and if known)	Sugar Shack South Waste Rock Pile
Unified Soil Classification System	Sandy Clay
Secondary Components and Estimated Quantities by percentages or by descriptive percentage ranges (Note: terms used to indicate ranges should be described on the log or in a general legend)	30% fine sand, 5% medium sand
Color	Munsell Color Chart Descriptor
Consistency (cohesive soil). Use relative term	very soft, soft, medium, stiff, very stiff, hard
Density (non-cohesive soil). Use relative term	loose, medium, dense, very dense
Moisture Content. (Use relative term. Do not express as a percentage unless a value has been measured)	dry, damp, wet
Structure	Stratified
Grain Angularity	Subangular to angular sand grains
Sorting (sands)	poorly sorted
Grain or fragment size	Clay to medium sand
Note "Fill", "Top of Natural Ground", and "Top of Bedrock" where appropriate	No fill

TABLE 2
DESCRIPTION OF CONSOLIDATED ROCK

Parameter	Example
Formation Name (if known)	Togo Formation of the Belt Supergroup
Rock Type	Quartz monzonite, granite
Modifier denoting variety	Shaley, calcareous, siliceous, argillaceous, sandy, micaceous
Grain Size	Very coarse-grained, coarse-grained, medium-grained, fine-grained, very fine-grained
Grain Shape	Angular, subangular, subrounded, rounded, well-rounded
Color	Munsell Color Chart Descriptor
Stratification/Foliation	Parting band, thinly bedded, thickly bedded, very thickly bedded, laminated, (Note: provide thickness range of each in legend)
Texture	Crystalline, porphyritic, glassy, poorly cemented, well cemented
Weathering/Alteration	Residual soil, completely weathered/altered, highly weathered/altered, moderately weathered/altered, slightly weathered/altered, fresh
Rock Strength	Extremely weak, very weak, weak, medium strong, strong, very strong, extremely strong
Structure and Orientation	Horizontal bedding, dipping beds at 30□, highly fractured, open near vertical joints, healed 30 degree fractures, slickensides at 45 degree, fissile
Core loss interval and reason for loss if known or "Unaccountable"	50-51', noncemented sandstone likely

APPENDIX 1. Forms

Field Sample Form Example:



See Molycorp Database for examples of other forms.