Lithologic Logging

SSFL SOP 9
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Signature/Date

1.0 Objective

This technical standard operating procedure (SOP) governs basic lithologic logging of surface and subsurface soil samples collected during field operations at the Santa Susana Field Laboratory (SSFL) site. The purpose of this SOP is to present a protocol and standardized documentation format for lithologic observations. Protocols for recording basic lithologic data including, but not limited to, soil types (per the Unified Soil Classification System [USCS] classification), presence of fill (and associated deleterious materials), lithologic names, color, moisture, density, contacts, and secondary features such as organic material and fractures.

The goal of this SOP is to have consistent descriptions of the subsurface materials.

2.0 Background

Thousands of boreholes and associated descriptions of the surface and subsurface soil and rock have been completed at the SSFL site. Lithologic information about soil, rock, and fill assists in the understanding of subsurface conditions, moisture infiltration, groundwater flow, and potential contaminant migration pathways.

2.1 Definitions

The following list corresponds to the description sequences outlined in Section 5.2.1. An example lithologic log is included in Attachment A.

Name of Sediment or Rock – In naming unconsolidated sediments, the logger shall describe the grain size, distribution, color, and moisture content, and determine the presence of fill materials. In naming sedimentary rocks (only type of bedrock anticipated at SSFL), the logger shall examine the specimen for mineralogy and use the appropriate rock description.

Color - Color may be determined using the appropriate Munsell color chart (soil or rock) and listing the Munsell number that corresponds to the color. If an unconsolidated material is mottled in color, the ranges in color shall be described. When describing core samples with several individual colors, individual color names shall be listed and an overall best color name shall be given.

Degree of Consolidation – The degree of consolidation refers to how well the material has been indurated. Unconsolidated sediments may be compacted somewhat and should be described as loose, moderately compacted, or strongly compacted. In some cases they may be slightly cemented by caliche and should be described as slightly cemented, moderately cemented, or strongly cemented. Sedimentary rocks are typically indurated, but may vary in the degree of cementation. These rocks should be described as friable, moderately friable, or well indurated. If the logger believes he/she can identify the cementing material, then it shall be included in the description.

Moisture Content – Moisture content refers to the amount of water within the sediment or the matrix. Sedimentary rocks and unconsolidated sediments may have associated moisture within and should be described as dry, slightly moist, medium moist, moist, wet (not flowing), or saturated (flowing water).

Evidence of Contamination – The logger should examine the sample/core and note any obvious signs of contamination such as streaking, free product, odor, or discoloration. These observations will be noted in the field book and on the lithologic log, as well as screening measurements from the photoionization detector (PID) and radiation (alpha, beta) probes.

Description of Contacts – The logger will note changes in lithology. These changes may be gradational contacts within sediments or may be sharp contacts such as sediments over rocks. The logger should describe whether the contacts are

gradational or sharp, and note the depth below the surface.

Composition – The composition of the rock refers to the mineralogy of the material encountered. The logger should describe the mineralogy, if it can be determined.

2.2 Associated Procedures

- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 8, *Field Data Collection Documents, Content, and Control*

2.3 Discussion

The subsurface sampling techniques used at SSFL (i.e., slide hammer, hand auger, DPT rigs, and trenching) all result in soil/rock being brought to the surface for description and logging. The soil boring, core retrieval, and lithologic logging will be conducted under the guidance of a California professional geologist, or other earth scientist under a geologist's supervision. An important aspect of soil sampling is the identification and differentiation of native soil/rock from fill material. To help in this task, it is important to use the USCS classification scheme, and uniform and consistent descriptions. Soil and rock descriptions will be consistent with ASTM 2488-06 (Standard Practice for Description and Identification of Soils – Visual Manual Procedure). This SOP also provides a sequence for recording information on a standardized log form to make descriptions as uniform and consistent as possible.

The local geology of SSFL is well characterized; thousands of shallow boreholes and excavations have been completed. Local soil and rock are well documented. As such, detailed lithologic logs are not necessary. The primary goal of lithologic logging is to document the stratigraphic sequence, the presence of fill or native soil, occurrence and type of debris and/or staining, associated PID and radiological screening values, and deviations from the normal or anticipated stratigraphic section.

In addition, all SOPS will be on hand with the field sampling crew.

3.0 General Responsibilities

Field Team Leader (FTL) – The FTL is responsible for maintaining logbooks and qualified field staff.

Site Geologist – Individual responsible for describing and logging of all soil cuttings/samples and all rock per this SOP. A California professional geologist is required to lead this project work.

4.0 Required Equipment

The description of subsurface lithologies requires a minor amount of field equipment for the geologist. This section provides a list of equipment to be used by the lithologic logger but does not include equipment such as drill rigs, PID, sampling equipment, and personal protection equipment. The following is a general list of equipment that may be used:

- Field logbook and lithologic log form
- Clipboard
- Munsell color chart for soil
- Munsell color chart for rock
- Dilute (10 percent) hydrochloric acid, as desired
- Waterproof pens
- 10x magnifying hand lens
- Knife or cutting tool
- Zip-top baggies
- Reference field charts, as desired

5.0 Procedures

5.1 Office

- Obtain field logbook and lithologic log forms
- Coordinate schedules/actions with FTL
- Obtain necessary field equipment (see above)

- Review field support documents (i.e., Field Sampling Plan [FSP] Addendum, health and safety plan)
- Review applicable geologic references such as historic lithologic logs from the site and/or geologic maps, as needed

5.1.1 Documentation

Record observations in a bound field logbook (SSFL SOP 8) and/or on individual lithologic log forms. Site geologists (i.e., lithologic loggers) will follow the general procedures for keeping a field logbook. If using a bound field logbook, record the same data required on the lithologic log form. Data from the field logbook must be transcribed to the lithologic log form if filling in the form in the field is not feasible. In this case, the data must be the identical to those recorded in the field logbook. Post-logging editing of field logbook data is not allowed. In addition, if data are transcribed to the lithologic log form, it must be completed within 24 hours of the original data recording. All blanks in the lithologic log form must be filled out; if an item is not applicable, an "NA" shall be entered.

The Lithologic Log Form shall be filled out according to the following instructions. The front page of the form contains general information:

- The project name, sample location, subarea, and sample type
- Date that the drilling activity was started and completed
- Name of the person logging along with the beginning depth-end depth (in feet)
- Borehole diameter(s) and drilling methods
- Name and company of the driller and the type of sampling tool used

A map showing the soil sampling location may be attached.

The continuation page(s) of the log form should be completed according to the instructions provided within this section and according to the sequence provided in Section 5.2.1. The depth column refers to the depth below ground surface (bgs) in feet. The tick marks can be arbitrarily set to any depth interval depending on the scale needed except where client requirements dictate the spacing. The lithology column shall contain the USCS soil type/rock type; schematic symbols are not required. Use a single X to mark the area where no core was recovered, and notes shall be recorded as to why the section was not recovered. Sharp or abrupt contacts between lithologies will be indicated by a solid horizontal line. Gradational changes in lithologic composition should be noted. PID and radiation measurements will be recorded within the PID column at the appropriate depth. The description column, where the lithology is described, is the most important part of the lithologic log. In completing this section, use the applicable reference charts and complete according to the sequence in Section 5.2.1. The sample interval column is reserved for noting any samples taken and processed for the laboratory. The sample number shall be filled in at the appropriate depth. The last column refers to the percent core recovery. The geologist will estimate the amount recovered and record the percentage at the appropriate depth.

In addition to the information on the log form, the geologist will record the appropriate information into the logbook when there is a rig shutdown, rig problems, failures to recover cores, or other issues.

5.2 General Guidelines for Using and Supplementing Lithologic Descriptive Protocols

This SOP is intended to serve as a guide for recording basic lithologic information. The descriptive protocol presented here must be followed in making basic observations. Selected information charts may be used for classification and naming of rock, sediment, and soil. Some observations will be common to all rock and soil descriptions. All descriptions shall include as appropriate: name of sediment or rock, color (using the Munsell color charts), moisture content, composition, significant inclusions, and degree of consolidation or induration, and the presence and type of fill materials, if identified. The description of each category shall be separated by a semicolon. Any interpretive comments will be segregated from lithologic descriptions and recorded in the remarks column.

Describe all unconsolidated sediment and soil according to the USCS. It is often more practical to use abbreviations for often-repeated terminology when recording lithologic descriptions. Abbreviations are allowed; however, the abbreviation and its meaning must be recorded on the lithologic log the first time it is used, or listed at the bottom the log. Loggers are cautioned to limit the use of abbreviations to avoid a lithologic log that is cryptic.

5.2.1 Protocols for Lithologic Description of Discrete Soil or Rock Cores

This section describes the protocols for completing a lithologic description based on discrete soil or rock core samples. For instance, in a 5-foot soil core, the dominant lithology may be siltstone that is interrupted by several thin beds of another lithology such as gravel. This section description can be simplified by writing: 5-10 bgs = siltstone (with other descriptors) except as noted; 7-8 foot gravel zone (with descriptors); 8-9 foot pebble zone (with descriptors); etc. This also aids in "seeing" the thickest unit designations possible for use in modeling.

Description of Unconsolidated Material

Unconsolidated material comprises the majority of the subsurface interval for the Phase 3 investigation. The shallow subsurface is very important to the chemical characterization because of infiltration and migration. Soils are to be described as unconsolidated material and will include:

- Name of sediment (sand, silt, clay, etc.)
- Grain size and distribution
- Composition of larger-grained sediments
- Color (per Munsell color chart)
- Degree of consolidation and cementation
- Moisture content
- Density
- Description of contacts

In accordance with the USCS on naming unconsolidated sediment, the particle size with the highest percentage is the root name. When additional grains are present in excess of 15 percent, the root name is modified by adding a term in front of the root name. For instance, if a material is 80 percent sand and 20 percent gravel, then it is gravelly sand. If the subordinate grains comprise less than 15 percent but greater than 5 percent, the name is written: _____(dominant grain) with _____(subordinate grain). For example, a soil with 90 percent sand and 10 percent silt would be named a sand with silt. If a soil contains greater than 15 percent of four particle sizes, then the name is comprised of the dominant grain size as the root name and modifiers as added before. For example, if a material is 60 percent sand, 20 percent silt, and 20 percent clay the name would be a silty clayey sand. If a material is 70 percent sand, 20 percent silt, and 10 percent clay, it would be a silty sand with clay. When large cobbles or boulders are present, their percentage shall be estimated and their mineralogy recorded.

6.0 Restrictions/Limitations

Only geologists, or similarly qualified persons trained in lithologic description, are qualified to perform the duties described in this SOP. The FTL for a project will have the authority to decide whether or not an individual is qualified.

7.0 References

ASTM 2488-06 Standard Practice for Description and Identification of Soils – Visual Manual Procedure

8.0 Attachments

Note: These Attachments are for informational purposes. Other equivalent charts such as USCS or logs may be used.

Attachment A - Lithologic Logs
Attachment B - Common Abbreviations for Lithologic Logging
Attachment C - Naming of Unconsolidated Materials
Attachment D - Example of Unified Soil Classification System (USCS)

Attachment A
Lithologic Log

DRILLING LOG			Client		Boring Number
Company Name CDM Smith			Drilling Subcontractor		Sheet 1 of Sheets
Project			Location		
Name of Driller			Drill Rig(s)		
Sizes and Types of Drilling and Sampling Equipment			Northing	Easting	ORNL Grid
			Surface Elevation		
			Date Started	Date Completed	
Overburden Thickness			Depth Groundwater Encountered		
Depth Drilled into Rock			Depth to Water and Elapsed Time After Drilling Completed		
Total Depth of Hole			Other Water Level Measurements (Specify)		
Drilling Method	Borehole Diameter(s)	Depth of Surface Casing	Signature of Geologist		
Location Map					
Project					Boring Number

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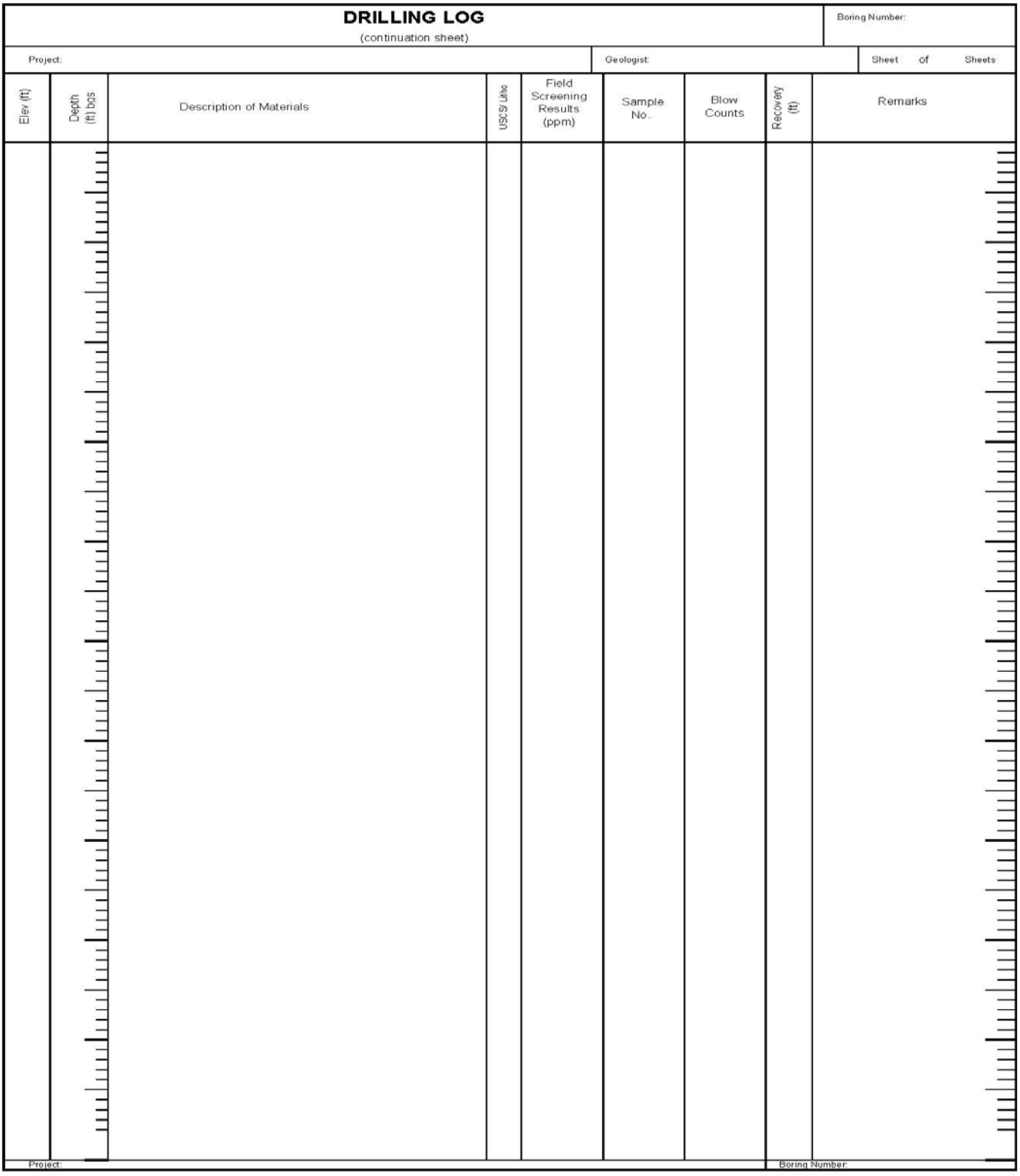

DRILLING LOG
(continuation sheet)

Boring Number:

Project:

Geologist:

Sheet of Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS/ Lithe	Field Screening Results (ppm)	Sample No.	Blow Counts	Recovery (ft)	Remarks

Project:

Boring Number:

Attachment B
Common Abbreviations

Common Abbreviations		
Abundant – abnt	Diameter – dia	Laminated – lam
Amount – amt	Different – diff	Maximum – max
Approximate – approx	Disseminated – dissem	Pebble – pbl
Arenaceous – aren	Elevation – elev	Phenocryst – phen
Argillaceous – arg	Equivalent – equiv	Porphyritic – proph
Average – ave	Foliated – fol	Probable – prob
Bedded – bdd	Formation – frm	Quartz – qrz
Bedding – bdg	Fracture – frac	Regular – reg
Calcareous – calc	Fragmental – frag	Rocks – rx
Cemented – cmt	Granular – gran	Rounded – rnd
Cobble – cbl	Gypsiferous – gyp	Saturated – sat
Contact – ctc	Horizontal – hriz	Secondary – sec
Cross-bedded – xbdd	Igneous – ign	Siliceous – sil
Cross-bedding – xbdg	Inclusion – incl	Structure – struc
Cross-laminated – xlam	Interbedded – intbdd	Unconformity – uncnf
Crystal – xl	Irregular – ireg	Variegated – vrgt
Crystalline – xln	Joint – jnt	Vein – vn
Grain Size	**Contacts**	**Sorting**
grain – gn	gradational – grad	poor – pr
fine – f	erosional – er	moderate – mod
very fine – vf	abrupt – ab	well – well
medium – med		
coarse – crs	**Fabric**	
large – lg	grain supported – gs	
very large – vlg	matrix supported – ms	
small – sm	imbricate – im	

Adapted from, Compton, R.R., *Manual of Field Geology*, 1962.

Attachment C
Naming of Unconsolidated Materials

Main Particle	Gravel	Sand	Silt	Clay
> 15 % gravel	Gravel	Gravelly sand	Gravelly silt	Gravelly clay
> 15 % sand	Sandy gravel	Sand	Sandy silt	Sandy clay
> 15 % silt	Silty gravel	Silty sand	Silt	Silty clay
> 15 % clay	Clayey gravel	Clayey sand	Clayey silt	Clay
5-15 % gravel	Not applicable	Sand with gravel	Silt with gravel	Clay with gravel
5-15 % sand	Gravel with sand	Not applicable	Silt with sand	Clay with sand
5-15 % silt	Gravel with silt	Sand with silt	Not applicable	Clay with silt
5-15 % clay	Gravel with clay	Sand with clay	Silt with clay	Not applicable
> 15% gravel plus 15% sand	Sandy gravel	Gravelly sand	Gravelly sandy silt	Gravelly sandy clay
> 15% gravel plus 15% silt	Silty gravel	Gravelly silty sand	Gravelly silt	Gravelly silty clay
> 15% gravel plus 15% clay	Clayey gravel	Gravelly clayey sand	Gravelly sandy silt	Gravelly clay
> 15% sand plus 15% silt	Silty sandy ravel	Silty sand	Sandy silt	Sandy silty clay
> 15% sand plus 15% clay	Sandy clayey gravel	Clayey sand	Sandy clayey silt	Sandy clay
> 15% silt plus 15% clay	Silty clayey gravel	Silty clayey sand	Clayey silt	Silty clay
Note: Other combinations are possible when all particle sizes are present in greater than 15%. For example, a silty clayey gravelly sand. Other possible combinations exist such as a gravelly sand with silt.				

Compton, R.R., *Manual of Field Geology*, 1962.

Attachment D
Example of Unified Soil Classification System (USCS)

Summary of USCS Field Identification Tests							
Coarse-Grained Soils **More than half the material (by weight) is individual grains visible to the naked eye.**	**Gravelly Soils** More than half of coarse fraction is larger than 4.75 mm.		**Clean Gravels** Will not leave a stain on a wet palm	Substantial amounts of all grain particle sizes			GW
				Predominantly one size or range of sizes with some intermediate sizes missing			GP
			Dirty Gravels Will leave a stain on a wet palm	Non-plastic fines (to identify, see ML below)			GM
				Plastic fines (to identify, see CL below)			GC
	Sandy Soils More than half of coarse fraction is smaller than 4.75 mm.		**Clean Sands** Will not leave a stain on a wet palm	Wide range in grain size and substantial amounts of all grain particle sizes			SW
				Predominantly one size or a range of sizes with some intermediate sizes missing			SP
			Dirty Sands Will leave a stain on a wet palm	Non-plastic fines (to identify, see ML below)			SM
				Plastic fines (to identify, see CL below)			SC
Fine-Grained Soils **More than half the material (by weight) is individual grains not visible to the naked eye.** **(<0.074 mm)**	**Ribbon**	**Liquid Limit**	**Dry Crushing Strength**	**Dilatancy Reaction**	**Toughness**	**Stickiness**	
	None	<50	None to Slight	Rapid	Low	None	ML
	Weak	<50	Medium to High	None to Very Slow	Medium to High	Medium	CL
	Strong	>50	Slight to Medium	Slow to None	Medium	Low	MH
	Very Strong	>50	High to Very High	None	High	Very High	CH
Highly Organic Soils	Readily identified by color, odor, spongy feel, and frequently by fibrous texture						OL OH Pt