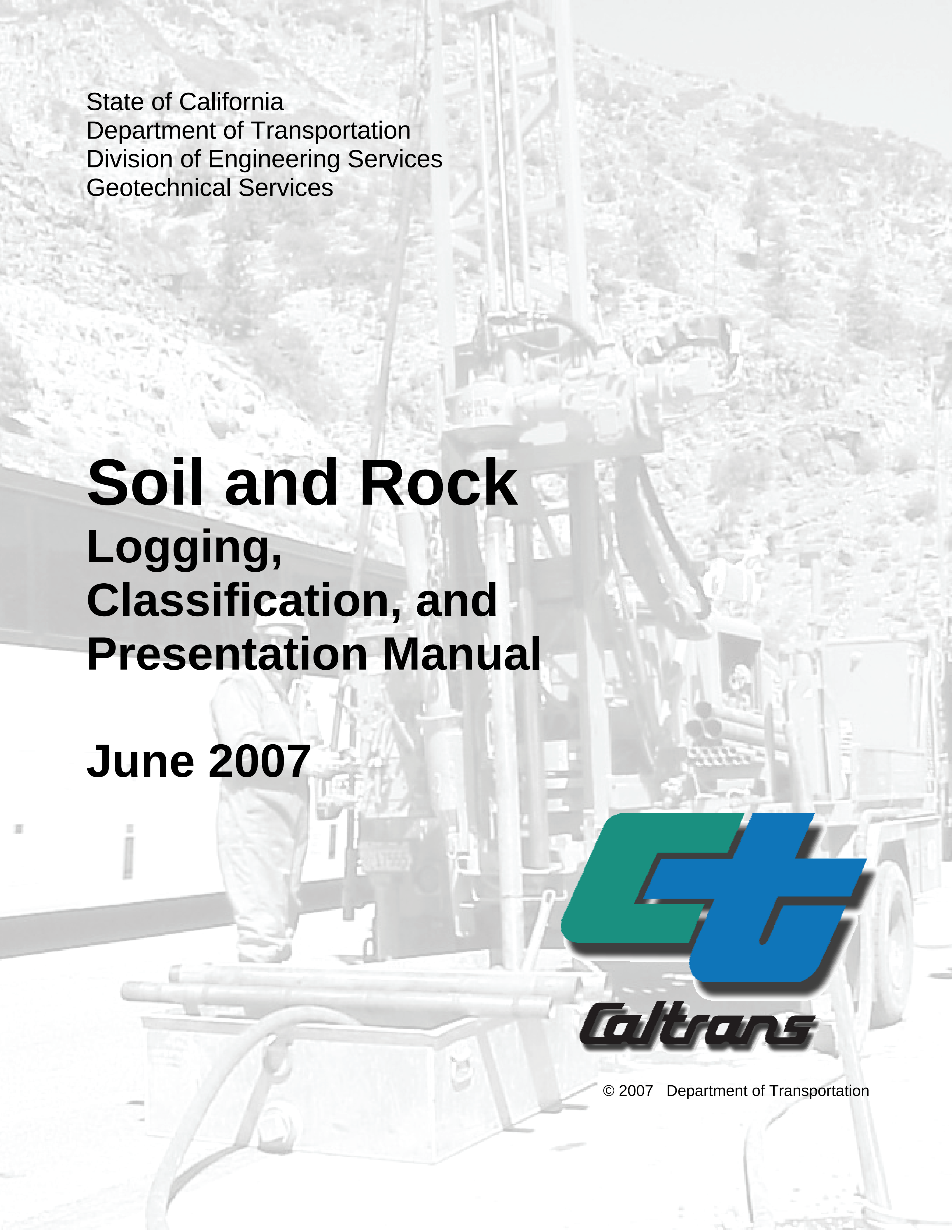

State of California
Department of Transportation
Division of Engineering Services
Geotechnical Services

Soil and Rock
Logging, Classification, and Presentation Manual

June 2007

Caltrans

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Preface

Detailed soil and rock descriptions and classifications are an essential part of the information developed to support Caltrans' design and construction processes. Subsurface information for any given area is, and can be, generated and accumulated over a prolonged period of time by various geotechnical practitioners for different projects and purposes. It is imperative that geotechnical practitioners working on Caltrans projects use standardized terminology and procedures to maintain consistency in borehole logging and reporting practices. Geotechnical Services in the Division of Engineering Services, has published this Manual to ensure the Department's investment in maintaining consistent logging practices.

This Manual, "*Soil and Rock Logging, Classification, and Presentation Manual*", improves upon the original version of the manual, "*Soil and Rock Logging Classification Manual (Field Guide)*", published in 1996, by addressing the following:

- Serves as a comprehensive reference for Departmental staff, consultants, and contractors
- Provides standardized soil *description* and *identification* procedures utilizing field data
- Provides standardized soil *classification* procedures utilizing laboratory data
- Provides standardized rock *description* and *identification* procedures utilizing field and laboratory data
- Serves as a basis for Departmental products and tools, such as:
  - Boring Log presentation formats,
  - Log of Test Boring (LOTB) legend sheets,
  - Descriptive terminology presented in geotechnical reports, and
  - Geotechnical Data Management System

The information presented in this Manual is based predominantly on American Standards for Testing Materials (ASTM) and other publications. These references provide standardized methods for identifying, describing, or classifying soil and rock; however, they do not provide adequate descriptive terminology and criteria for identifying soil and rock for engineering purposes. Consequently, this manual extends, and in some cases modifies these standards to include additional descriptive terms and criteria.

In addition to soil and rock identification, description, or classification, this Manual contains instructions that present Departmental standards for borehole and sample identification, minimum material requirements for various laboratory tests, and boring log presentation formats.

Geotechnical Services staff and any other organization providing geotechnical reports or records of geotechnical investigations for the Department shall use the procedures presented in this Manual.

James E. Davis
Deputy Division Chief, Geotechnical Services

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Table of Contents

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Section 1: Introduction

1.1 Intent of this Manual

The intent of this Manual is to define the Department's practices and procedures for soil and rock description, identification, classification, and preparation of boring logs.

Standardized terminology and consistent presentation procedures for projects statewide benefit the Department's staff, engineering consultants, bidders, and contractors. Geotechnical Services staff as well as any other organization providing geotechnical reports or records of geotechnical investigations to the Department shall follow the procedures presented in this Manual.

The following terms, as defined below, are used throughout this Manual to convey the Department's policy:

Term	Definition
Shall, Required	*Mandatory Standard*. The associated provisions **must** be used. There is no acceptable alternative.
Should	*Advisory Standard*. The associated provisions are preferred practices.
May, Optional	*Permissive Standard.* Use or application of the associated provisions is left to the discretion of the Geoprofessional.

1.2 Limitations

Although this manual may be used to train new employees, this is not its primary intent.

This manual does not replace education or experience and shall be used in conjunction with professional judgment. Not all aspects of this manual may be applicable in all circumstances and should be applied with consideration of a project's many unique aspects.

This manual does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish, or adhere to, appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. The reader shall follow at a minimum, the *Caltrans Code of Safe Drilling Practices*.

1.3 Exceptions to Policy

Exceptions to the policy and procedures set forth in this Manual require prior approval by the Geotechnical Services Deputy Division Chief. Staff shall use the procedure for obtaining approval for an exception, as documented in a memorandum to all staff dated June 15, 2007, included in Appendix C.

1.4 Revisions to the Manual

Staff who wish to propose changes to the Manual shall do so in accordance with the *Soil and Rock Logging, Classification, and Presentation Manual Committee Charter and Standard Procedures,* included in Appendix C.

1.5 Organization of this Manual

The Manual is divided into five sections, as described below:

Section 1

– Explains the intent and organization of this Manual and the process for requesting exceptions and proposing changes to the Manual

– Presents an overview of the logging process and acceptable presentation formats

Section 2

– Presents the Department's field description and indentification procedures for soil and rock, without the benefit of laboratory testing

– Explains procedures for handling and labeling of samples

– Explains how to perform a quality check of borehole logs and soil and rock samples

Section 3

– Describes the Department's classification procedures for soil and rock samples for which the data was refined by appropriate laboratory tests

Section 4

– Presents the process for developing and presenting geotechnical information on a *Log of Test Boring (LOTB)* or a *Boring Record (BR)*.

Section 5

– Specifies presentation content and formats for *Log of Test Boring (LOTB)* and *Boring Record (BR)*.

1.6 Overview of the Logging Process and Presentation Formats

The Department uses the following formats to present subsurface information:

- Log of Test Boring (LOTB), and/or
- Boring Record (BR).

An LOTB is typically associated with a structure facility and is attached to Project Plans. A BR is typically associated with an earthwork facility and is attached to a Geotechnical Report.

The process of creating boring logs, i.e., Log of Test Boring (LOTB) and Boring Record (BR) can be summarized in four steps:

- Field sampling and descriptions *(Section 2)*
- Quality check of field descriptions *(Section 2)*
- Refinement of descriptions, and classification of soil, based on laboratory test results, if performed *(Section 3)*
- Preparation of the boring logs *(Sections 4 and 5)*

(See Figure 1-1.)

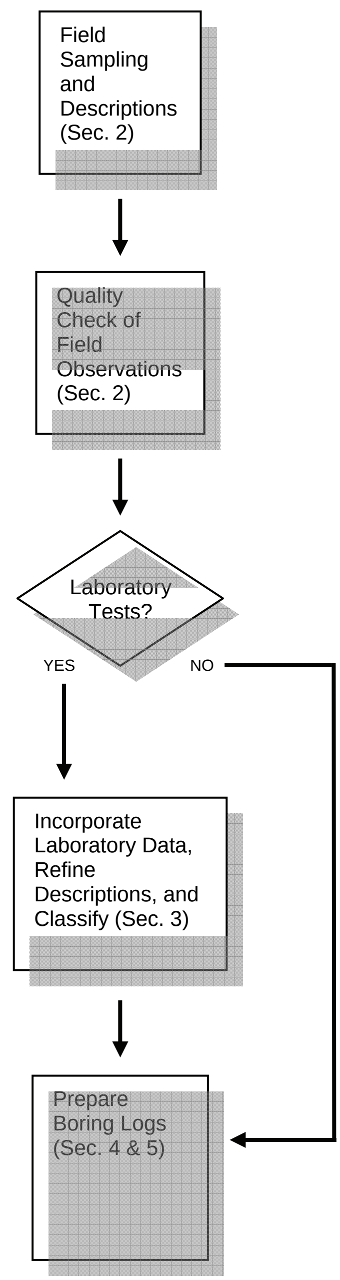
Prior to the field investigation, the geoprofessional should have general understanding of the local soils and geologic information, and know the parameters and the basic descriptors required for the planned analyses. Specific laboratory tests, such as strength, consolidation, or permeability may govern the type of drilling and sampling used.

Recovering and labeling, and accurately describing and classifying samples is a detailed process that typically necessitates a thorough check of field notes and samples in the office before requesting laboratory tests. In some cases, the geoprofessional may use only field observations. *(See Section 2.)*

In other cases, it may be the judgment of the geoprofessional that a combination of field observations and laboratory test results are needed to describe or classify the soil or rock samples, and generate appropriate layer descriptions for LOTB or BR. *(See Sections 2 and 3.)*

If the results of laboratory tests change the description of the sample generated by field observation, the classification and/or description resulting from the laboratory tests shall be used on the LOTB and/or the BR, and in the geotechnical report. Disclosure of the tests on the LOTB and/or the BR makes it clear whether the sample or layer descriptor was based on visual observation or on laboratory test results. *(See Sections 4 and 5.)*

Figure 1-1
Logging and Presentation Process



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Section 2:
Field Procedures for Soil and Rock Logging, Description, and Identification

2.1 Introduction

This section presents the procedures for logging, describing, and identifying soil and rock samples in the field based on visual and manual procedures.

The information presented in this section is predominantly based on:

- American Society for Testing and Materials (ASTM) D 2488-06, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, and
- The *Engineering Geology Field Manual* published by the Bureau of Reclamation.

Although ASTM D 2488-06 provides a standardized method for indentification of soils, it does not provide adequate descriptive terminology and criteria for identifying soils for engineering purposes. Section 17 of ASTM D 2488-06 states, "*this practice provides qualitative information only*," and Note 4 adds, "*The ability to describe and identify soils correctly … may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics*."

This Manual extends, and in some cases modifies, the ASTM standard to include additional descriptive terms and criteria. It is not our intent to replace the ASTM standards but to build on them, and make them better understood.

The identifications and descriptions in the field logs may be corrected, calibrated, or verified later based on laboratory test results of selected soil samples to develop the final boring logs, as described in Section 3.

The process of correction, calibration, and verification in developing the updated logs based on laboratory test results can effectively serve the purpose of self-training and self-calibration for future field identification and description of soil samples.

In addition to soil and rock identification and description, this section contains instructions that describe proper hole and sample identification practices, and minimum material requirements for various laboratory tests.

2.2 General Project and Hole Information

One of the most important aspects of field work is properly identifying the location of the project site, drilling tools and methods used, and the personnel involved in the field work. Figure 2-1 presents the information that is required to be recorded for every hole.

Figure 2-1
Information Required for Borehole

Item	Description
1	**Date(s) of work**
2	**Hole Identification**
3	**Project and Site Information:** • Project Name • Structure/Bridge Name and Number (if available) • Project Number (Charge District - Expenditure Authorization, 8-digits) • District • County • Route • Postmile, range and prefix
4	**Borehole Location and Elevation:** • Location (at least one of the following): o Station and offset o Latitude and longitude, horizontal datum o Northing and Easting, local coordinate reference system *Note:* In the absence of accurate coordinate data, a suitable and verifiable field description may be temporarily used. (e.g., postmile and centerline offset, distance to fixed object or benchmark, etc.) • Elevation, vertical datum, benchmark description • Survey method(s) used, approximate accuracy
5	**Personnel:** • Logger/Geoprofessional • Drillers
6	**Drilling and Sampling Equipment (verify with Driller):** • Drill rig (manufacturer and model, and Caltrans Equipment Identification number) • Drilling method (mud rotary, air rotary, solid auger, hollow stem auger. etc.) • Drill rod description (type, diameter) • Drill bit description • Casing (type, diameter) and installation depth • SPT Hammer Type: Safety/Automatic Hammer, etc. o Lifting mechanism (for safety hammer) o Manufacturer & model o Caltrans Equipment Identification number o Measured SPT energy efficiency ratio (if available) • Type of sampler(s) and size(s) o Undisturbed Shelby tube o Undisturbed Piston o Split spoon (e.g. SPT, Cal Mod, etc.) o Core (both rock and soil) o Disturbed (include auger cuttings) o Other
7	**Groundwater** • Method (observed while drilling, measured in hole, etc.) • Date, time, and depth of each reading
8	**Hole Completion** • Cause of termination (e.g., drilled to depth, refusal, early termination of traffic control, etc.) • Abandonment (e.g., grout, soil cuttings, dry bentonite chips, piezometers installed, slope inclinometer installed, TDR, instrumentation, etc.)

2.3 Assignment of Hole Identification

Holes shall be identified using the following convention:

HHH – YY – NNN

Where:

HHH: The Hole Type or Sounding Codes defined in Figure 2-2, which generally follow ASTM D 6453-99

YY: 2-digit year

NNN: 3-digit number (001-199)

The numbers 001–099 are reserved for holes used to produce a foundation report; numbers 101–199 are reserved for holes used to produce a geotechnical design report.

The *YY-NNN* component of the hole identification is unique and matched to a Caltrans project expenditure authorization number (EA), not to a site, structure, or bridge number. If two drilling methods are used, such as auger boring followed by rotary drilled boring, the prominent tool governs the selection of Hole Type Code (HHH).

Figure 2-2
Hole Type Code and Description

Hole Type Code	Description
A	Auger boring (hollow or solid stem, bucket)
R	Rotary drilled boring (both conventional and wire-line)
P	Rotary percussion boring (Air)
HD	Hand driven (1-inch soil tube)
HA	Hand auger
D	Driven (dynamic cone penetrometer)
CPT	Cone Penetration Test
O	Other

2.4 Soil Description and Identification Procedures

This section presents the method for identification and description of soil based on ASTM D 2488-06 and USBR (2001). The detail of description provided for a particular soil should be dictated by the complexity and objectives of the project. Optional descriptors should be considered by the geoprofessional on a project by project basis.

2.4.1 Soil Description and Identification

When describing and identifying soil in the field, the geoprofessional shall record the field data following the sequence presented in Figure 2-3 below. Items marked "required" shall be used, when applicable, to describe the soil sample to ensure complete descriptive coverage. For example, percent cobbles and/or boulders is only required if cobbles and/or boulders are encountered.

Figure 2-3

Identification and Description Sequence

Sequence	Identification Components	Refer to Section	Required	Optional
1	Group Name	2.4.2	●	
2	Group Symbol	2.4.2	●	
	Description Components			
3	Consistency (for cohesive soils)	2.4.3	●	
4	Apparent Density (for cohesionless soils)	2.4.4	●	
5	Color (in moist condition)	2.4.5	●	
6	Moisture	2.4.6	●	
7	Percent of cobbles or boulders	2.4.7	●	
8	Percent or proportion of soils	2.4.8	●	
9	Particle Size Range	2.4.9	●	
10	Particle Angularity	2.4.10		○
11	Particle Shape	2.4.11		○
12	Plasticity (for fine-grained soils)	2.4.12	●	
13	Dry Strength (for fine-grained soils)	2.4.13		○
14	Dilatency (for fine-grained soils)	2.4.14		○
15	Toughness (for fine-grained soils)	2.4.15		○
16	Structure	2.4.16		○
17	Cementation	2.4.17	●	
18	Description of Cobbles and Boulders	2.4.18	●	
19	Additional Comments	2.4.19		○

Below are some examples that illustrate the application of the descriptive sequence based on field procedures.

Example of a complete descriptive sequence for a sample using required <u>and</u> optional components:

> *Well-graded SAND with GRAVEL (SW), medium dense, brown to light gray, wet, about 20% coarse subrounded to rounded flat and elongated GRAVEL, about 75% coarse to fine rounded SAND, about 5% fines, weak cementation.*

Example of a complete descriptive sequence for a soil sample using <u>only</u> required components:

> *Well-graded SAND with GRAVEL (SW), medium dense, brown to light gray, wet, little coarse GRAVEL, mostly coarse to fine SAND, few fines, weak cementation.*

Example of a complete descriptive sequence that omits the percent or proportion of the primary soil constituent, which may be used when the percentage or proportion of the primary soil constituent can be clearly inferred:

> *Well-graded SAND with GRAVEL (SW), medium dense, brown to light gray, wet, little coarse GRAVEL, few fines, weak cementation.*

2.4.1.1 Soil Description for Intensely Weathered or Decomposed Rock

Intensely weathered or decomposed rock that is friable and that can be reduced to gravel size or smaller by normal hand pressure shall be identified and described as rock followed by the soil identification or classification, and description in parenthesis (per Section 2.5).

2.4.2 Group Name and Group Symbol

Using visual examination and simple manual tests, this section provides standardized criteria and procedures for describing and identifying soil in the field per ASTM D 2488-06. The soil is to be identified by assigning a group name and symbol. The Figures in this section are to be used for the identification of both fine and coarse-grained soil and to determine the appropriate group symbol(s) and name(s) to be used.

The ASTM procedure for identifying and describing fine-grained and coarse-grained soils is only applicable to material passing the 3-inch sieve. If the presence of cobbles or boulders or both is identified during the site exploration, the percentage of cobbles and boulders shall be estimated and reported per Section 2.4.7.

Borderline Symbol **–** Because ASTM D 2488-06 is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol shall be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

A borderline symbol shall be used when:

- The percentage of fines is estimated to be between 45 and 55%. One symbol shall be for a coarse-grained soil with fines; the other for a fine-grained soil, e.g., GM/ML or CL/SC.
- The percentage of sand and the percentage of gravel are estimated to be about the same, e.g., GP/SP, SC/GC, GM/SM.
- The soil could be well graded or poorly graded, e.g., GW/GP, SW/SP.
- The soil could either be a silt or a clay, e.g., CL/ML, CH/MH, SC/SM.
- A fine-grained soil has properties that indicate that it is at the boundary between a soil of low plasticity and a soil of high plasticity, e.g., CL/CH, MH/ML.

The order of the borderline symbols shall reflect similarity to surrounding or adjacent soils. For example, soils in a borrow area have been identified as CH, and one sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol shall be CH/CL.

The group name for a soil with a borderline symbol shall be the group name for the first symbol, except for:

- CL/CH lean to fat clay,
- ML/CL clayey silt, and
- CL/ML silty clay

Borderline symbols should not be used indiscriminately. Use of a single group symbol is preferable.

Dual Symbol **–** A dual symbol is two symbols separated by a hyphen, e.g., GP-GM, SW-SC, CL-ML. They are used to indicate that the soil has been identified as having the properties of a classification in accordance with ASTM Test Method D 2487-06 requiring dual symbols, i.e., when the soil has between 5 and 12% fines, or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

2.4.2.1 Fine Grained Soils

A soil is considered to be fine-grained if it contains 50% or more fines. Particles that pass through a Number 200 sieve are defined as fine-grained. Fine-grained soils shall be assigned the Group Name and Symbol according to Figure 2-4, below.

Figure 2-4

Flow chart for fine-grained soils *(from ASTM D 2488-06)*

Group Symbol	Fines	Coarseness	Sand or Gravel	Group Name
CL	<30% plus No.200	<15% plus No.200		Lean CLAY
		15-25% plus No.200	% sand ≥ % gravel	Lean CLAY with SAND
			% sand < % gravel	Lean CLAY with GRAVEL
	≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	SANDY lean CLAY
			≥ 15% gravel	SANDY lean CLAY with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY lean CLAY
			≥ 15% sand	GRAVELLY lean CLAY with SAND
ML	<30% plus No.200	<15% plus No.200		SILT
		15-25% plus No.200	% sand ≥ % gravel	SILT with SAND
			% sand < % gravel	SILT with GRAVEL
	≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	SANDY SILT
			≥ 15% gravel	SANDY SILT with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY SILT
			≥ 15% sand	GRAVELLY SILT with SAND
CH	<30% plus No.200	<15% plus No.200		Fat CLAY
		15-25% plus No.200	% sand ≥ % gravel	Fat CLAY with SAND
			% sand < % gravel	Fat CLAY with GRAVEL
	≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	SANDY fat CLAY
			≥ 15% gravel	SANDY fat CLAY with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY fat CLAY
			≥ 15% sand	GRAVELLY fat CLAY with SAND
MH	<30% plus No.200	<15% plus No.200		Elastic SILT
		15-25% plus No.200	% sand ≥ % gravel	Elastic SILT with SAND
			% sand < % gravel	Elastic SILT with GRAVEL
	≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	SANDY elastic SILT
			≥ 15% gravel	SANDY elastic SILT with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY elastic SILT
			≥ 15% sand	GRAVELLY elastic SILT with SAND
OL/ OH	<30% plus No.200	<15% plus No.200		ORGANIC SOIL
		15-25% plus No.200	% sand ≥ % gravel	ORGANIC SOIL with SAND
			% sand < % gravel	ORGANIC SOIL with GRAVEL
	≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	SANDY ORGANIC SOIL
			≥ 15% gravel	SANDY ORGANIC SOIL with GRAVEL
		% sand < % gravel	< 15% sand	GRAVELLY ORGANIC SOIL
			≥ 15% sand	GRAVELLY ORGANIC SOIL with SAND

***Clay and Silt* –** Identify the soil as a Lean CLAY (CL), a Fat CLAY (CH), a SILT (ML), or an Elastic SILT (MH), using the criteria in Figure 2-5:

Figure 2-5

Identification of clayey and silty soils

Group Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

***Organic Soil* –** Identify the soil as organic, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

Identification of Peat – A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified with the Group Name and Symbol, PEAT (PT), and not subjected to the identification procedures described hereafter.

2.4.2.2 Coarse-Grained Soil

A soil is considered coarse-grained if it contains fewer than 50% fines. (Coarse-grain particles will not pass through a Number 200 sieve.) Soil is identified as gravel if the percentage of gravel is estimated to be greater than the percentage of sand. Soil is identified as sand if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

Figure 2-7
Flow chart for coarse-grained soils *(from ASTM D-2488-06)*

	Fines	Grade	Type of Fines	Group Symbol	Sand/Gravel	Group Name
Gravel	≤ 5%	Well		GW	< 15% sand	Well-graded GRAVEL
					≥ 15% sand	Well-graded GRAVEL with SAND
		Poorly		GP	< 15% sand	Poorly graded GRAVEL
					≥ 15% sand	Poorly graded GRAVEL with SAND
	10%	Well	ML or MH	GW-GM	< 15% sand	Well-graded GRAVEL with SILT
					≥ 15% sand	Well-graded GRAVEL with SILT and SAND
			CL or CH	GW-GC	< 15% sand	Well-graded GRAVEL with CLAY
					≥ 15% sand	Well-graded GRAVEL with CLAY and SAND
		Poorly	ML or MH	GP-GM	< 15% sand	Poorly graded GRAVEL with SILT
					≥ 15% sand	Poorly graded GRAVEL with SILT and SAND
			CL or CH	GP-GC	< 15% sand	Poorly graded GRAVEL with CLAY
					≥ 15% sand	Poorly graded GRAVEL with CLAY and SAND
	≥ 15%		ML or MH	GM	< 15% sand	SILTY GRAVEL
					≥ 15% sand	SILTY GRAVEL with SAND
			CL or CH	GC	< 15% sand	CLAYEY GRAVEL
					≥ 15% sand	CLAYEY GRAVEL with SAND
Sand	≤ 5%	Well		SW	< 15% gravel	Well-graded SAND
					≥ 15% gravel	Well-graded SAND with GRAVEL
		Poorly		SP	< 15% gravel	Poorly graded SAND
					≥ 15% gravel	Poorly graded SAND with GRAVEL
	10%	Well	ML or MH	SW-SM	< 15% gravel	Well-graded SAND with SILT
					≥ 15% gravel	Well-graded SAND with SILT and GRAVEL
			CL or CH	SW-SC	< 15% gravel	Well-graded SAND with CLAY
					≥ 15% gravel	Well-graded SAND with CLAY and GRAVEL
		Poorly	ML or MH	SP-SM	< 15% gravel	Poorly graded SAND with SILT
					≥ 15% gravel	Poorly graded SAND with SILT and GRAVEL
			CL or CH	SP-SC	< 15% gravel	Poorly graded SAND with CLAY
					≥ 15% gravel	Poorly graded SAND with CLAY and GRAVEL
	≥ 15%		ML or MH	SM	< 15% gravel	SILTY SAND
					≥ 15% gravel	SILTY SAND with GRAVEL
			CL or CH	SC	< 15% gravel	CLAYEY SAND
					≥ 15% gravel	CLAYEY SAND with GRAVEL

2.4.3 Consistency (Cohesive Soils)

The preferred procedure for the determination of consistency of cohesive soils is to obtain relatively undisturbed samples and perform field tests with a pocket penetrometer or torvane. *(See Appendix A for details on the test procedures.)*

Use the terms and criteria indicated in Figure 2-8 below to describe the consistency of cohesive soils. These terms generally follow, with some modifications, AASHTO (1988) and Bureau of Reclamation (2001) standards.

Figure 2-8

Descriptors for Consistency of Cohesive Soils

Description	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.25 to 0.50	Can be penetrated several inches by thumb with moderate effort
Stiff	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 2.0	Indented by thumbnail with difficulty

2.4.4 Apparent Density (Cohesionless Soils)

Use the AASHTO (1988) standards to describe the apparent density of cohesionless soils, as indicated in Figure 2-9 below.

Figure 2-9
Descriptors for Apparent Density of Cohesionless Soils

Description	SPT N_{60} (blows/ft)
Very loose	0 – 4
Loose	5 – 10
Medium dense	11 – 30
Dense	31 – 50
Very dense	>50

Apparent density of a coarse-grained (cohesionless) soil is based on a corrected Standard Penetration Test (SPT) N_{60} value as described in Appendix A and provided here:

$$N_{60} = N_{measured}\ X\ (ER_i\ /60)$$

where,

$$ER_i = \text{Hammer energy ratio}$$

N values are highly dependent on the energy efficiency of the SPT method. Inconsistency in the N values across a site may be attributed to variations in energy efficiency between different drill rigs and crews.

2.4.5 Color

Color is an important property in identifying organic soils, and it may also be useful in identifying materials of similar geologic origin within a given locality. Use the color name from the *Munsell Color System* to describe the color of a moist soil sample at the time of drilling and sampling. If the sample contains layers or patches of varying colors, record this information and describe all observed colors. For example:

Brown to light yellowish brown

For additional information, see ASTM D 1535-06, *Standard Practice for Specifying Color by the Munsell System.*

2.4.6 Moisture

Use the ASTM D 2488-06 standard to describe the moisture condition, as indicated in Figure 2-10 below.

Figure 2-10
Descriptors for Moisture

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

2.4.7 Percent of Cobbles or Boulders

When particles greater than 3 inches in diameter are encountered, they shall be identified and described as “COBBLES,” or “BOULDERS,” or “COBBLES and BOULDERS” as defined in Section 2.4.9. Cobbles and boulders reported as present within a matrix shall be estimated, by volume, and reported by percentage of total volume.

Estimation of volume of cobbles and/or boulders is based upon recovered intersected lengths, drilling chatter, and observations and experience of the driller and/or geoprofessional.

A subset of rock descriptors shall be used to describe cobbles and boulders as explained in Section 2.4.18. Isolated boulders may be treated as individual units and described as such.

For example, if it is estimated that 40% by volume of the material is cobbles, describe the sample in this way:

> *Well-graded SAND with GRAVEL and COBBLES (SW), medium dense, brown to light gray, wet, about 40% COBBLES, about 20% coarse subrounded to rounded flat and elongated GRAVEL, about 75% coarse to fine rounded SAND, about 5% fines, weak cementation; COBBLES consist of sandstone, fresh, hard, intersecting lengths from 8 to 10 inches.*

Note, the percentages of constituents in the example do not add up to 100%., as cobbles are estimated by total volume, whereas gravel, sand,

and fines, are estimated by weight of the total sample excluding the cobbles and boulders, per Section 2.4.8

If the sample or layer is estimated to be more than 50% cobbles and/or boulders by volume, the layer shall be described as “COBBLES” or “BOULDERS” or “COBBLES and BOULDERS” with the soil matrix description following. Note, this is a departure from the descriptive sequence in Section 2.4.1. For example, if it is estimated that 60% by volume of the material was cobbles, describe the layer as:

> *COBBLES with some well-graded SAND with GRAVEL, about 60% COBBLES (sandstone, fresh, hard, intersecting lengths from 8 to 10 inches), matrix consists of medium dense, brown to light gray, wet, about 20% coarse subrounded to rounded flat and elongated GRAVEL, about 75% coarse to fine rounded SAND, about 5% fines, weak cementation.*

Note that the Group Symbol is not used in the last example, because the cobbles and boulders were the predominant material.

2.4.8 Percent or Proportion of Soils

Use the ASTM D 2488-06 standard to describe the estimated percentage (to the nearest 5%) or proportion of gravel, sand, and fines, by weight of the total sample excluding the cobbles and boulders, as shown in Figure 2-11, below.

Figure 2-11
Descriptors for percent or proportion of soils

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

The percentages of gravel, sand, and fines must add up to 100 %. The term “about” shall be used if the percentage or proportion of constituents is estimated in the field. (The word “about” shall be removed if the percentage was revised based on laboratory particle size analysis results.)

2.4.9 Particle Size

Use the ASTM D 2488-06 standard to describe the size of particles, as shown in Figure 2-12, below.

Figure 2-12
Descriptors for Particle Size

Description	Size	Familiar Example
Boulder	>12 in.	Larger than a basketball
Cobble	3 to 12 in.	Larger than a grapefruit or orange
Coarse Gravel	3/4 to 3 in.	Larger than a walnut or grape
Fine Gravel	No. 4 to 3/4 in.	Larger than a pea
Coarse Sand	No. 10 to No. 4	Larger than rock salt grain
Medium Sand	No. 40 to No. 10	Larger than openings of a window screen
Fine Sand	No. 200 to No. 40	Larger than a sugar grain

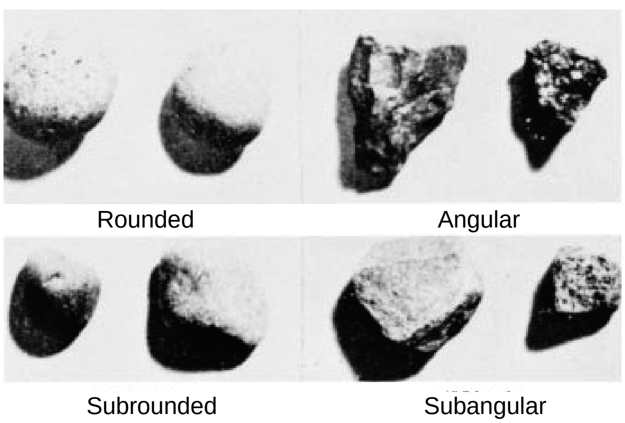
2.4.10 Particle Angularity

Use the ASTM D 2488-06 standard to describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as indicated in Figure 2-13 below.

Figure 2-13

Descriptors for particle angularity

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description, but have rounded edges
Subrounded	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges



2.4.11 Particle Shape

Use the ASTM D 2488-06 standard to describe the shape of the gravel, cobbles, and boulders *if* they meet any of the criteria in Figure 2-14.

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Figure 2-14
Descriptors for Particle Shape

Description	Criteria
Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

2.4.12 Plasticity (for Fine-Grained Soils)

Use the ASTM D 2488-06 standard to describe the plasticity of the material based on observations made during the toughness test, as indicated in Figure 2-15 below.

Figure 2-15

Descriptors for Plasticity

Description	Criteria
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

2.4.13 Dry Strength (for Fine-Grained Soils)

Use the ASTM D 2488-06 standard to determine dry strength, as indicated in Figure 2-16 below. *(See Appendix A for details on field test procedures.)*

Figure 2-16
Descriptors for Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

2.4.14 Dilatancy (for Fine-Grained Soils)

Use the ASTM D 2488-06 standard to determine dilatancy, as indicated in Figure 2-17 below. *(See Appendix A for details on field test procedures.)*

Figure 2-17
Descriptors for dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

2.4.15 Toughness (for Fine-Grained Soils)

Use the ASTM D 2488-06 standard to determine toughness, as indicated in Figure 2-18 below. *(See Appendix A for details on field test procedures.)*

Figure 2-18
Descriptors for toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

2.4.16 Structure

Use the ASTM D 2488-06 standard to describe the structure of intact soils, as indicated in Figure 2-19 below.

Figure 2-19
Descriptors for structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least ¼ in. thick; note thickness.
Laminated	Alternating layers of varying material or color with the layers less than ¼ in. thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

2.4.17 Cementation

Use the ASTM D 2488-06 standard to describe the cementation of intact coarse-grained soils, as indicated in Figure 2-20 below.

Figure 2-20
Descriptors for cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

2.4.18 Description of Cobbles and Boulders

Use the descriptive sequence for rock in Section 2.5. of this Manual to describe cobbles and boulders. The description shall include, at minimum, the following information:

- Rock identification
- Weathering
- Rock hardness
- Range of intersected lengths of core (An "intersected length" is the length of the intact core. This is not necessarily the size of the cobble or boulder.)

2.4.19 Additional Comments

Additional constituents and soil characteristics not included in the previous categories may be noted. Observations may include:

- Presence of roots or root holes
- Presence of mica, gypsum, etc.
- Presence of voids
- Surface coatings on coarse-grained particles
- Oxide staining
- Cementing agents (e.g. calcium carbonate – see Appendix A.7)
- Odor
- Depositional history (i.e. Alluvium, Colluvium, Aeolian, Lacustrine, Fill)
- Geologic formation name or soil survey unit name

All soils shall be examined to see if they contain materials indicative of man-made fills. Man-made fill items shall be listed in each of the soil descriptions. Common fill indicators include glass, brick, clay pipe, dimensioned lumber, concrete debris, in-place pavement sections, asphalt debris, metal, plastics, plaster, etc. Other items that may suggest fill include buried vegetation mats, tree limbs, stumps, etc.

The size and distribution of fill indicators shall be noted. The limits (depth range) of fill material shall be determined and identified at each exploration location.

2.4.20 Other Drilling Observations

Other observations, not included in the descriptive sequence, may include:

- Caving or sloughing of borehole or trench sides
- Difficulty in drilling or excavating, etc.
- Generic name (e.g., hard pan, fault gouge, etc.)
- Ground water inflow, elevation(s), and estimated rate(s)
- Loss of drill fluid circulation

2.5 Rock Identification Procedures for Borehole Cores

Rock identification procedures presented in this section are based on a hybrid of the International Society of Rock Mechanics (ISRM) (1981) standards and the Bureau of Reclamation (2001) standards. The detail of description provided for a particular material shall be dictated by the complexity and objectives of the project. Optional descriptors should be considered by the geoprofessional on a project by project basis.

Intensely weathered or decomposed rock that is friable and that can be reduced to gravel size or smaller by normal hand pressure shall also be classified as a soil. The material shall be identified and described as rock followed by the soil identification or classification, and description in parenthesis.

For example:

> *IGNEOUS ROCK (GRANITE), massive, light gray to light yellowish brown, intensely weathered, soft, unfractured, (Lean CLAY with SAND (CL), medium stiff, moist, mostly clay, little coarse SAND, medium plasticity).*

Note, color is not repeated in the descriptive sequence for soil.

Although not included in the descriptive sequence, Core Recovery (REC) and Rock Quality Designation (RQD) shall be recorded and presented on the boring logs. Core Recovery shall be reported for all rock coring operations as described in Appendix A.9. RQD shall be recorded and presented on the boring logs in accordance with Appendix A.10.

2.5.1 Rock Identification and Descriptive Sequence for Borehole Cores

Use the descriptors and the descriptive sequence, shown in Figure 2-21, when identifying rock specimens collected from exploratory boreholes.

Figure 2-21

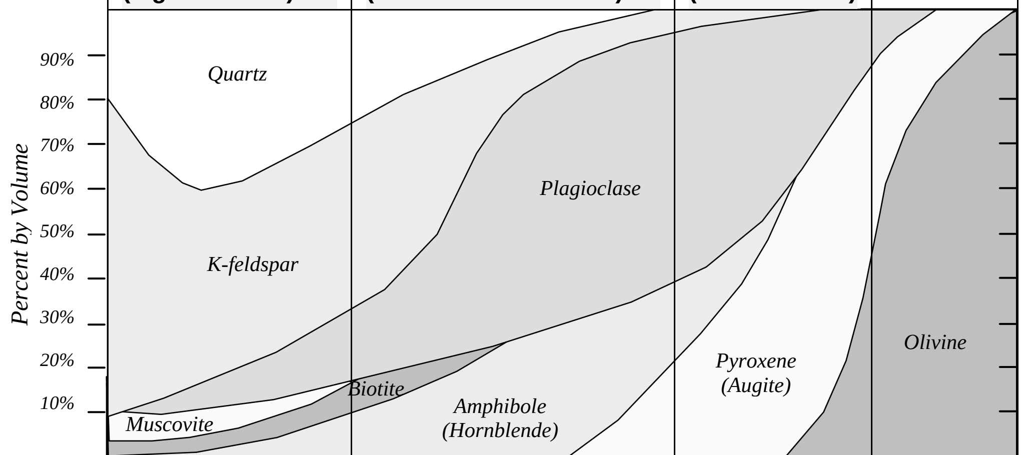
Rock Identification and Descriptive Sequence

Sequence	Identification Components	Refer to Section	Required	Optional
1	Rock Name	2.5.2	●	
	Description Components			
2	Rock Grain-size	2.5.3		O
3	Bedding Spacing	2.5.4	●	
4	Color	2.5.5	●	
5	Texture	2.5.6		O
6	Weathering Descriptors for Intact Rock	2.5.7	●	
7	Rock Hardness	2.5.8	●	
8	Fracture Density	2.5.9	●	
9	Discontinuity Type	2.5.10		O
10	Discontinuity Condition (Weathering, Infilling and Healing)	2.5.11		O
11	Discontinuity Dip Magnitude	2.5.12		O
12	Rate of Slaking (Jar Slake Test)	2.5.13		O
13	Odor	2.5.14		O
14	Additional Comments	2.5.15		O

2.5.2 Rock Name

Rock name based on field identification in this section is taken from those presented by Zumberge et al. (2003). As a general practice, a staff geologist should be consulted if there are questions of the correct lithology. Rock name shall be reported using a combination of the *family name* (e.g. sedimentary, igneous, metamorphic), followed by the *rock identification*. The identification can be approximated using Figures 2-22, 2-23, or 2-24, or specifically identified by a qualified geologist.

Figure 2-22
Field identification of Igneous rock



Texture	Felsic (Light Colored)	Intermediate (Intermediate-Colored)	Mafic (Dark-Colored)	Ultramafic
	Rock Identification			
Phaneritic	Granite	Diorite	Gabbro	Peridotite
Phaneritic with Phenocrysts	Granite Porphyry	Diorite Porphyry	Gabbro Porphyry	Peridotite Porphyry
Aphanitic	Rhyolite	Andesite	Basalt	
Aphanitic with Phenocrysts	Rhyolite Porphyry	Andesite Porphyry	Basalt Porphyry	
Vesicular	Pumice, Scoria			
Glassy	Obsidian			
Non-vesicular	Agglomerate, Breccia, Tuff			

Figure 2-23
Field identification of Sedimentary rock

Origin	Textural Features and Particle Size	Composition	Diagnostic Features	Color	Rock Identification
Inorganic Detrital Materials	Clastic (Boulders, Gravels, Pebbles and granules embedded in a matrix of cemented sand grains	Angular rock or mineral fragments			Sedimentary Breccia
		Rounded rock or mineral fragments			Conglomerate
	Clastic (Coarse sand and granules)	angular fragments of feldspar mixed with quartz and other mineral grains	K-feldspar common		Arkose
	Clastic (Sand size particles)	Rounded to subrounded quartz grains		white, buff, pink, brown, tan	Quartz Sandstone
		Calcite and/or dolomite grains	effervesces freely with cold dilute HCl	light-colored	Calcarenite
	Clastic (Sand size particles mixed with clay size particles)	Quartz and other mineral grains mixed with clay		dark gray to gray-green	Wacke (Lithic Arenite)
	Clastic (Silt and clay size particles)	Mineral constituents may be identifiable with a hand lens	usually well stratified	varies	Siltstone
		Mineral constituents not identifiable	fissile, may be scratched with fingernail, usually well stratified	varies	Shale
		Mineral constituents not identifiable	massive (earthy), may be scratched with a fingernail	varies	Claystone
Inorganic Chemical Precipitates	Dense (Crystalline or Oolitic)	Calcium Carbonate	effervesces freely with cold dilute HCl, may contain fossils, generally lacks stratification	white, gray, black	Limestone
	Dense or Crystalline	Calcium Magnesium Carbonate	powder effervesces weakly with cold dilute HCl, may contain fossils, generally lacks stratification	varies, but similar to Limestone	Dolomite
	Dense (Porous)	Silica	conchoidal fracture, scratches glass	black, white, gray, red	Chert
	Dense (Amorphous)	Hydrous Calcium Sulfate	commonly can be scratched with a fingernail	varies, commonly pink, buff, white	Rock Gypsum
	Crystalline	Sodium Chloride	crystalline, salty taste	white to gray	Rock Salt
Organic Detrital Materials	Earthy (Bioclastic)	Calcium Carbonate	effervesces freely with cold dilute HCl, easily scratched with a fingernail	white	Chalk
		Silica	does not react with HCl, soft, commonly stratified	gray to white	Diatomite
	Bioclastic	Calcium Carbonate	effervesces freely with cold dilute HCl, shell fragments in a massive or crystallne matrix		Fossiliferous Limestone
		Calcium Carbonate	effervesces freely with cold dilute HCl, shell fragments cemented with little or no matrix material		Coquina
	Fibrous (Bioclastic)	Plant fibers	soft, porous, low specific gravity	brown	Peat
	Dense (Bioclastic)	Mineral free carbonaceous plant matter	harder than peat, moist	brownish to black	Lignite
		Mineral free carbonaceous plant matter	harder than lignite, dull luster, smudges fingers when handled	black	Bituminous Coal

The names of rocks derived from inorganic detrital materials may be appended to indicate the cementing agent, e.g., arkose with calcite cement.

Figure 2-24
Field identification of Metamorphic rock

Texture	Diagnostic Features	Composition	Color	Rock Identification
Foliated	slaty texture with slaty cleavage, dense, microscopic grains		variable, black and dark gray common	Slate
	phyllitic texture, fine grained to dense, "shiny" appearance	micaceous minerals are dominant		Phyllite
	schistose texture, medium to fine grained, "sparkling" appearance, porphyroblasts common	chlorite, biotite, muscovite, garnet and dark elongate silicate minerals, talc, feldspar commonly absent		Schist
	gneissic texture, coarse grained, foliation present as macroscopic grains arranged in light and dark bands	abundant quartz and feldspar in light bands and hornblende, augite, garnet or biotite in dark bands		Gneiss
	granulitic texture, medium to coarse grained, even grained, foliation present in quartzo-feldspathic rocks			Granulite
Foliated or Nonfoliated	medium to coarse-grained	mostly crystals of amphibole, sometimes feldspar, mica and talc		Amphibolite
Nonfoliated	crystalline, scratches glass, breaks across grains as easily as around them	quartz	color variable, white, pink, buff, brown, red, purple	Quartzite
	dense, dark colored		various shades of gray, gray-green, to nearly black	Hornfels
	texture of conglomerate but breaks across coarse grains as easily as around them	granules, pebbles or cobbles are commonly granitic or jasper, chert, quartz or quartzite		Metaconglomerate
	crystalline, scratches glass, breaks across grains as easily as around them, fossils in some	calcite or dolomite	white, pink, gray	Marble
	microcrystalline texture, usually with smooth wavy surfaces	serpentine, sometimes with crysotile	shades of green	Serpentinite
	granulitic texture, medium to coarse grained, even grained, foliation lacking in pyroxene-plagioclase bearing rocks			Granulite
	shiny luster, conchoidal fracture		black	Anthracite Coal

2.5.3 Rock Grain-size descriptors

The rock grain-size descriptors that follow are based on USBR (2001) standards.

Figure 2-25
Rock grain-size descriptors for Crystalline Igneous rock and Metamorphic rock

Description	Average Crystal Diameter
Very coarse grained or pegmatitic	> 3/8 in
Coarse-grained	3/16 – 3/8 in
Medium-grained	1/32 – 3/16 in
Fine-grained	0.04 – 1/32 in
Aphanitic	<0.04 in

Figure 2-26
Rock grain-size descriptors for Sedimentary and Pyroclastic Igneous rock

USCS (soils only) Particle Size	Size (inches)	Sedimentary (epiclastic) Rounded, subrounded, subangular		Volcanic (pyroclastic)	
		Particle or Fragment	Lithified Product	Fragment	Lithified Product
Boulder		Boulder	Boulder Conglomerate	Block (Angular)	Volcanic Breccia
	12				
	10				
Cobble		Cobble	Cobble Conglomerate	Bomb (Rounded)	Agglomerate
	3				
	2.5				
Coarse Gravel		Pebble	Pebble Conglomerate		
	0.8			Lapilli	Lapilli Tuff
Fine Gravel					
	0.19				
	0.16				
Coarse Sand		Granule	Granule Conglomerate	Coarse Ash	Coarse Tuff
	0.08				
Medium Sand		Very Coarse Sand	Sandstone (Very Coarse, Coarse, Medium, Fine, or Very Fine)		
	0.04				
		Coarse Sand			
	0.02				
		Medium Sand			
	0.0165				
Fine Sand					
	0.0098				
		Fine Sand			
	0.0049				
		Very Fine Sand			
	0.0029				
Fines Non-plastic Silt / Plastic Clay					
	0.0025				
		Silt	Siltstone, Shale	Fine Ash	Fine Tuff
	0.0002				
		Clay	Claystone, Shale		

2.5.4 Bedding Spacing Descriptors

Bedding planes are discontinuities along which rock mass failure may occur. They also influence the hydraulic conductivity and shear strength of the rock mass.

The bedding thickness or spacing, modified from USBR (2001), shall be used as indicated in Figure 2-27 below.

Figure 2-27
Bedding Spacing Descriptors

Description	Thickness/Spacing
Massive	Greater than 10 ft.
Very thickly bedded	3 to 10 ft.
Thickly bedded	1 to 3 ft.
Moderately bedded	3-5/8 in. to 1 ft.
Thinly bedded	1-1/4 to 3-5/8 in.
Very thinly bedded	3/8 to 1-1/4 in.
Laminated	Less than 3/8 in.

2.5.5 Rock Colors

Use the color name from the *Munsell Rock Color Chart*, which is based on the National Bureau of Standards/Inter Society Color Council system, to describe the rock at the time of sampling. If the sample contains layers or patches of varying colors, record that information and describe and all colors observed.

For additional information, see ASTM D 1535-06, *Standard Practice for Specifying Color by the Munsell System*.

2.5.6 Textural Descriptors

Textural adjectives are employed to describe the size and shape of voids within the rock mass that are visible to the unaided eye. These voids are relevant to the estimation of the hydraulic conductivity, unconfined compressive strength, and the weathering susceptibility of the intact rock.

Use the USBR (2001) standard to describe the size and shape of voids, as indicated in Figure 2-28 below.

Figure 2-28
Textural Descriptors

Description	Criteria
Pitted	Pinhole to 3/8 in. openings.
Vuggy	Small opening (usually lined with crystals) ranging in diameter from 3/8 in. to 4 in.
Cavity	An opening larger than 4 in., size descriptions are required, and adjectives such as small, or large, may be used, if defined.
Honeycombed	If numerous enough that only thin walls separate individual pits or vugs, this term further describes the preceding nomenclature to indicate cell-like form.
Vesicular	Small openings in volcanic rocks of variable shape formed by entrapped gas bubbles during solidification.

2.5.7 Weathering Descriptors for Intact Rock

Weathering increases the clay content of the intact rock and the amount of separation at grain boundaries. Weathered rock masses have lower unconfined compressive strength, lower intact rock shear strength, lower shear strength along discontinuities, higher hydraulic conductivity, and are more likely to fail through the intact rock. Use USBR (2001) weathering descriptors, as indicated in Figure 2-29 below.

Figure 2-29

Weathering Descriptors for Intact Rock

	Diagnostic Features					
	Chemical weathering-discoloration and/or oxidation		Mechanical weathering-grain boundary conditions (disaggregation) primarily for granitics and some coarse-grained sediments	Texture and solutioning		
Description	**Body of rock**	**Fracture surfaces**		**Texture**	**Solutioning**	**General characteristics**
Fresh	No discoloration, not oxidized	No discoloration or oxidation	No separation, intact (tight)	No change	No solutioning	Hammer rings when crystalline rocks are struck.
Slightly Weathered to Fresh						
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact (tight)	Preserved	Minor leaching of some soluble minerals may be noted	Hammer rings when crystalline rocks are stuck. Body of rock not weakened.
Moderately to Slightly Weathered						
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty," feldspar crystals are "cloudy"	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally preserved	Soluble minerals may be mostly leached	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely to Moderately Weathered						
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation, see grain boundary conditions	All fracture surfaces are discolored or oxidized, surfaces friable	Partial separation, rock is friable; in semiarid conditions granitics are disaggregated	Texture altered by chemical disintegration (hydration, argillation)	Leaching of soluble minerals may be complete	Dull sound when struck with hammer, usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures, or veinlets. Rock is significantly weakened.
Very Intensely Weathered						
Decomposed	Discolored or oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil, partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete		Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes."
NOTE: Combination descriptors (such as "slightly weathered to fresh") are permissible where equal distribution of both weathering characteristics is present over significant intervals or where characteristics present are "in between" the diagnostic feature. However, combination descriptors shall not be used where significant identifiable zones can be delineated. Only two adjacent descriptors shall be combined.						

2.5.8 Rock Hardness

Use the modified USBR (2001) descriptors to describe the hardness of intact rock, as indicated in Figure 2-30 below.

Figure 2-30

Descriptors for Rock Hardness

Description	Criteria
Extremely Hard	Specimen cannot be scratched with a pocket knife or sharp pick; can only be chipped with repeated heavy hammer blows
Very Hard	Specimen cannot be scratched with a pocket knife or sharp pick. Breaks with repeated heavy hammer blows.
Hard	Specimen can be scratched with a pocket knife or sharp pick with difficulty (heavy pressure). Heavy Hammer blows required to break specimen
Moderately Hard	Specimen can be scratched with a pocket knife or sharp pick with light or moderate pressure. Core breaks with moderate hammer blows
Moderately Soft	Specimen can be grooved 1/6 in. deep with a pocket knife or sharp pick with moderate or heavy pressure. Breaks with light hammer blow or heavy manual pressure.
Soft	Specimen can be grooved or gouged easily with a pocket knife or sharp pick with light pressure, can be scratched with fingernail. Breaks with light to moderate manual pressure.
Very Soft	Specimen can be readily indented, grooved or gouged with fingernail, or carved with a pocket knife. Breaks with light manual pressure.

2.5.9 Fracture Density

Fractures are defined in Section 2.5.10. The fracture density is based on the spacing of all of the fractures observed in recovered core lengths from boreholes. This measurement excludes mechanical breaks and incipient joints/fractures. It also excludes features not identified as fractures, such as shears, faults, foliations, and bedding plane separations, etc.

Descriptive criteria presented below are based on borehole cores where lengths are measured along the core axis. Use the USBR (2001) fracture density standard, as indicated in Figure 2-31 below.

Figure 2-31

Descriptors for Fracture Density

Description	Observed Fracture Density
Unfractured	No fractures.
Very slightly fractured	Lengths greater than 3 ft.
Slightly to very slightly fractured	
Slightly fractured	Lengths from 1 to 3 ft. with few lengths less than 1 ft. or greater than 3 ft.
Moderately to slightly fractured	
Moderately fractured	Lengths mostly in 4 in. to 1 ft. range with most lengths about 8 in.
Intensely to moderately fractured	
Intensely fractured	Lengths average from 1 to 4 in. with scattered fragmented intervals with lengths less than 4 in.
Very intensely to intensely fractured	
Very intensely fractured	Mostly chips and fragments with a few scattered short core lengths.
NOTE: Combination descriptors (such as “very intensely to intensely fractured”) are used where equal distribution of both fracture density characteristics is present over a significant interval or exposure, or where characteristics are “in between” the descriptor definitions. Only two adjacent descriptors may be combined.	

2.5.10 Discontinuity Type

A single description, or range of descriptors, shall be used to describe the discontinuities observed over the length of the reported fracture density.

Discontinuity: A collective term used for all planes including fractures, joints, faults, shears, bedding planes and foliations. Contacts between rock bodies of different lithologies may also be considered discontinuities.

Fracture: A term used to describe any break in geologic material, excluding shears and shear zones. Additional fracture terminology is provided in Figure 2-32, below.

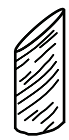
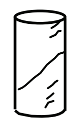
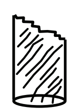
Shear: A structural break where differential movement has taken place along a surface, or zone of failure by a shear couplet, is termed a shear. Shears are sometimes characterized by striations, slickensides, gouge, breccia, mylonite, or any combination of these. Often direction, amount of displacement, and continuity may not be known because of limited exposures or observations.

Fault: A shear with significant continuity that can be correlated between observations is a fault. Faults demonstrate high spatial continuity, and therefore occur over significant portions of given sites, foundation areas, or regions. The observed fault feature may be a segment of a fault or fault zone, as defined in the literature. The designation of a shear as a fault or fault zone is a site-specific determination.

Shear/Fault Zone: A shear or fault that exhibits significant width when measured perpendicular to the plane of the shear or fault. The zone may consist of gouge, breccia, or many related faults or shears together with fractured and crushed rock between the shears or faults, or any combination of these. In the literature, many fault zones are referred to as faults.

Shear/Fault Disturbed Zone: An associated zone of fractures and/or folds adjacent to a shear or a shear zone where the country rock has been subjected to only minor cataclastic action and may be mineralized. If adjacent to a fault or fault zone, the term *fault-disturbed zone* is used. Occurrence, orientation, and aerial extent of these phenomena depend on the depth of burial (pressure and temperature) during shearing, brittleness of the geo-materials, and the stress conditions.

Figure 2-32
Descriptors for Discontinuity Type

Description		Criteria
Joint (JT)		A relatively planar fracture along which there has been little or no shearing displacement.
Foliation Joint (FJ) or Bedding Joint (BJ)		A relatively planar fracture that is parallel to foliation or bedding along which there has been little or no shearing displacement.
Bedding Plane Separation		A separation along bedding after extraction or exposure due to stress relief or slaking.
Incipient Joint (IJ) or Incipient Fracture (IF)		A joint or fracture that does not continue through the specimen or is not seen with the naked eye. However when the specimen is wetted and then allowed to dry, the joint or fracture trace is evident. When core is broken, it breaks along an existing plane.
Random Fracture (RF)		A natural break (fracture) with a generally rough, very irregular, non-planar surface which does not belong to a joint set.
Mechanical Break (MB)		A break due to drilling, blasting, or handling. Mechanical breaks parallel to bedding or foliation are called *Bedding Breaks* (BB) or *Foliation Breaks* (FB), respectively. Recognizing mechanical breaks may be difficult. The absence of oxidation, staining, or mineral fillings, and often a hackly or irregular surface are clues for recognition.
Fracture Zone (FZ)		Numerous, very closely intersecting fractures. Often fragmented core cannot be fitted together.

2.5.11 Discontinuity Condition (Weathering, Infilling and Healing)

Weathering: Descriptors for discontinuity weathering or alteration of fracture surfaces and fracture fillings (excluding soil materials) are the same as those used for weathering and alteration of intact rock (per Section 2.5.7, Figure 2-29, third column).

Discontinuity Infilling: Descriptors for hardness of fillings, gouges and/or fracture surfaces are the same as those presented for intact rock or consistency of soils.

Discontinuity Healing: Discontinuities may be filled with air, water, soil, or a crystalline mineral material that provides a significant tensile and shear strength to the discontinuity. Discontinuity healing can be observed when there is a color contrast with the bordering intact rock. Features often referred to as veins are healed discontinuities.

In addition to an observation of the amount of the discontinuity that has been healed, the healing material should be observed and recorded. The amount and material of the healing discontinuity is relevant to the estimation of discontinuity shear strength, discontinuity hydraulic conductivity, and to the ease with which the rock can be excavated (e.g., open excavation, tunnel, or borehole).

Use the USBR (2001) standard, as indicated below in Figure 2-33 below, to describe the discontinuity condition.

Figure 2-33
Descriptors for Discontinuity Healing

Descriptor	Criteria
Totally Healed	All fragments bonded, discontinuity is completely healed or recemented to a degree at least as hard as surrounding rock.
Moderately Healed	Greater than 50 percent of fractured or sheared material, discontinuity surface or filling is healed or recemented, and/or strength of healing agent is less hard than surrounding rock.
Partially Healed	Less than 50 percent of fractured or sheared material, discontinuity surface or filling is healed or recemented.
Not Healed	Discontinuity surface, fracture zone, sheared material, or filling is not healed or recemented. Rock fragments or filling (if present) held in place by their own angularity and/or cohesiveness.

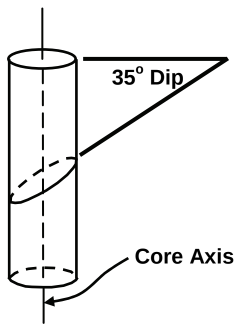
2.5.12 Discontinuity Dip Magnitude

Observation of the magnitude of discontinuity dip made with non-oriented core is useful for anticipating difficulties that may arise from boring piles or shafts in rock masses that contain discontinuities that are oriented close to vertical.

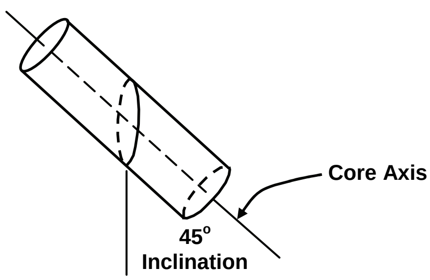
Use the USBR (2001) standard, as indicated below in Figure 2-34 below, to describe the magnitude of discontinuity dip.

Figure 2-34
Discontinuity Dip Magnitude

Vertical Hole: Apparent dip is measured and reported.



Angle Hole: True dip is usually not known, angle is measured from core axis and is called inclination.



2.5.13 Rate of Slaking

Some rock types are subject to degradation when exposed to weathering processes, particularly repeated wetting and drying cycles. Rocks that exhibit slaking may disintegrate into gravel size particles, or they may disaggregate completely to the individual constituent particles: clay, silt, and sand.

Rocks that are prone to slaking include: shale, siltstone, claystone, weakly welded tuff, and highly weathered crystalline igneous and metamorphic rocks. Slaking behavior is relevant to the performance of cut slopes and the stability of bored piles/drilled shafts. See Appendix A for test procedures.

Figure 2-35
Rate of Slaking

Jar Slake Index, I_J	Observed Behavior
1	Degrades to a pile of flakes or mud
2	Breaks rapidly and forms many chips
3	Breaks slowly and forms few chips
4	Breaks rapidly and develops several fractures
5	Breaks slowly and develops few fractures
6	No change to condition of the rock fragment

2.5.14 Odor

Rocks containing significant amounts of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor often may be revived by heating a moistened sample. Petroleum products or other chemicals may also influence the odor of the sample. Describe the odor, if organic, and identify anything unusual, such as odor of a petroleum product or other chemical.

2.5.15 Additional Comments

Additional rock characteristics not included in the previous categories may be noted.

2.5.16 Other Drilling Observations

Other observations (not included in the descriptive sequence) that may be presented on the LOTB or BR as notes or remarks include:

- Time for core run
- Difficulty in drilling or excavating, etc.
- Generic name (e.g., hard pan, fault gouge, etc.)
- Ground water inflow, elevation(s), and estimated rate(s)
- Loss of drill fluid circulation

2.6 Sample Preparation and Identification for Laboratory Testing and Storage

Geoprofessionals who drill, sample, preserve, and transport soil samples play an important role in ensuring the quality of the laboratory test results. When performing field investigations, the geoprofessional shall be familiar with the procedures contained within the following ASTM standards:

- ASTM D 1586-99, "Test Method for Penetration Test and Split-Barrel Sampling of Soils"
- ASTM D 1587-00, "Practice for Thin-Walled Tube Sampling of Soils"
- ASTM D 3550-01, "Practice for Ring-Lined Barrel Sampling of Soils"
- ASTM D 4220-00, "Standard Practices for Preserving and Transporting Soil Samples"

The information that follows explains the procedures and information required to submit soil samples and request testing services from the Caltrans Geotechnical Laboratory, an AASHTO Materials Reference Laboratory (AMRL) accredited facility located in Sacramento.

2.6.1 Sample Preparation and Identification for Laboratory Testing and Storage

All samples shall be named according to the following convention:

Hole ID – SNN – T

Where,

Hole ID: Refer to Section 2.3

S: The Sample Type Code, as defined in Figure 2-36, which generally follow ASTM D 6453

NN: 2-digit sample number (01–99), sequenced consecutively from the top down.

T: 1-digit tube number, starting with the bottom tube numbered as 1.

For example:

A – 06 – 105 – U02 – 3

Figure 2-36
Sample Type Codes

Code	Description
U	Undisturbed Shelby tube
P	Undisturbed Piston
S	Split spoon (includes SPT and Cal Mod Samplers)
B	Block
C	Core (both rock and soil)
D	Disturbed (include auger cuttings)
R	Reconstituted
O	Other

Label Brass and Shelby Tubes as explained below and shown in Figure 2-37, below:

- Use electrical tape to completely seal the end caps onto the sample tubes.
- Clearly label samples with permanent marker
- Place the top of the label at the top end of the tube to identify the proper orientation of the sample as shown above.
- If the sample tube is only partially filled, use a filler, such as newspaper, cloth rags, or sawdust

to prevent movement of the sample in the tube during shipping and handling.

- Whenever possible use a wax seal on the end of the sample to prevent moisture exchange with or contamination by the filler material.

Label bagged samples as explained below and shown in Figure 2-38:

- Identify the sample by writing directly on the plastic bag or attaching an adhesive label.
- Seal or tie the plastic bag properly to prevent loss of moisture.

Figure 2-37
Brass and Shelby Tube Label

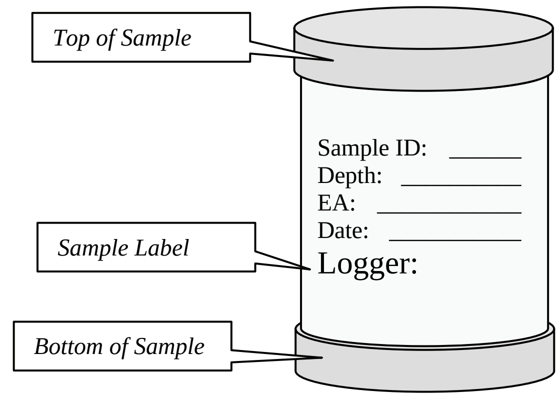
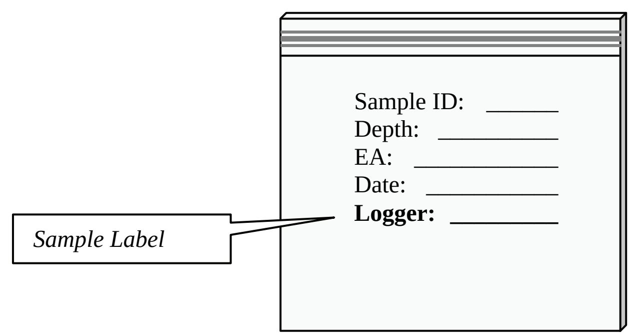


Figure 2-38
Bagged Sample Label



2.6.2 Identification of Large Soil Samples

In addition to the labeling requirements explained above, some soil samples must also be labeled with a Sample Identification Card (Caltrans Form TL-101), including:

- Samples weighing more than 5 lbs.
- Samples to be tested by the Materials Engineering and Testing Services (METS), test names are followed by "**" in Figure 2-39 below.

Place Form TL-101 inside a sealed plastic bag, then place it inside the large plastic or canvas bag that contains the sample.

Figure 2-39
Minimum Material Requirements for Various Test Methods

Test Method(s)	Test Name	Material Required	Typical Sample Size/Type	TL-101 Required
AASHTO T 265-93 (2004) ASTM D 2216-05	Moisture Content	0.5 lb	1/2 Tube	No
ASTM D 4767-04	Unit Weight	1 lb	1 Tube	No
AASHTO T 100-06	Specific Gravity	0.5 lb	1/2 Tube	No
ASTM D 422-63 (2002)	Particle-Size Analysis	1 lb	1 Tube	No
AASHTO T 89-02 AASHTO T 90-00 (2004)	Liquid Limit Plastic Limit, Plasticity Index	1 lb	1 Tube	No
ASTM D 2435-04	Consolidation Undisturbed (2.0" Diameter) (2.5" Diameter) Remolded (2.0" Diameter)	 - - 80 lb	 1 Tube 1 Tube 2 Full Canvas Bags	 No No **Yes**
ASTM D 4546-03	Swell Potential Undisturbed (2.0" Diameter) (2.5" Diameter) Remolded (2.0" Diameter)	 - - 80 lb	 1 Tube 1 Tube 2 Full Canvas Bags	 No No **Yes**
ASTM D 5333-03	Collapse Potential Undisturbed (2.0" Diameter) (2.5" Diameter) Remolded (2.0" Diameter)	 - - 80 lb	 1 Tube 1 Tube 2 Full Canvas Bags	 No No **Yes**
ASTM D 3080-04	Direct Shear Undisturbed Remolded	 - 80 lb	 1 Tube 2 Full Canvas Bags	 No **Yes**
CTM 216 (Oct 2006)	Relative Compaction (Compaction Curve Only)	80 lb	2 Full Canvas Bags	**Yes**

Test Method(s)	Test Name	Material Required	Typical Sample Size/Type	TL-101 Required
CTM 220 (Nov 2005)	Permeability Undisturbed Falling Head Remolded Falling Head Constant Head	- 80 lb 80 lb	1 Tube 2 Full Canvas Bags 2 Full Canvas Bags	No **Yes** **Yes**
ASTM D 2166-06 ASTM D 2938-95 (2002)	Unconfined Compression	-	1 Tube or Core	No
ASTM D 4767-02	Triaxial CU (3 points) Undisturbed (2.0" Diameter) (2.5" Diameter) Remolded (2.8" Diameter)	- - 80 lb	3 Tubes - in series 3 Tubes - in series 2 Full Canvas Bags	No No **Yes**
ASTM D 2850-03	Triaxial UU (1 point) Undisturbed (2.0" Diameter) (2.5" Diameter) Remolded (2.8" Diameter)	- - 80 lb	1 Tube 1 Tube 2 Full Canvas Bags	No No **Yes**
ASTM D 427-04	Shrinkage Limit	1 lb	1 Tube	No
ASTM D 5731-05	Point Load	-	Rock Core	No
ASTM D 4829-03	Expansion Index	40 lb	1 Full Canvas Bag	**Yes**
CTM 217 (Nov 1999) AASHTO T 176-02	Sand Equivalent**	10 lb	1/4 Full Canvas Bag	**Yes**
CTM 301 (Mar 2000) AASHTO T 190-02	R-Value**	80 lb	2 Full Canvas Bags	**Yes**
CTM 643 (Nov 1999) CTM 417 (Nov 2006) CTM 422 (Nov 2006)	Corrosion** Sulfates** Chlorides**	10 lb	1/4 Full Canvas Bag	**Yes**
EPA 9081	Organic Content** PH** Cation Exchange**	10 lb	1/4 Full Canvas Bag	**Yes**

Notes:

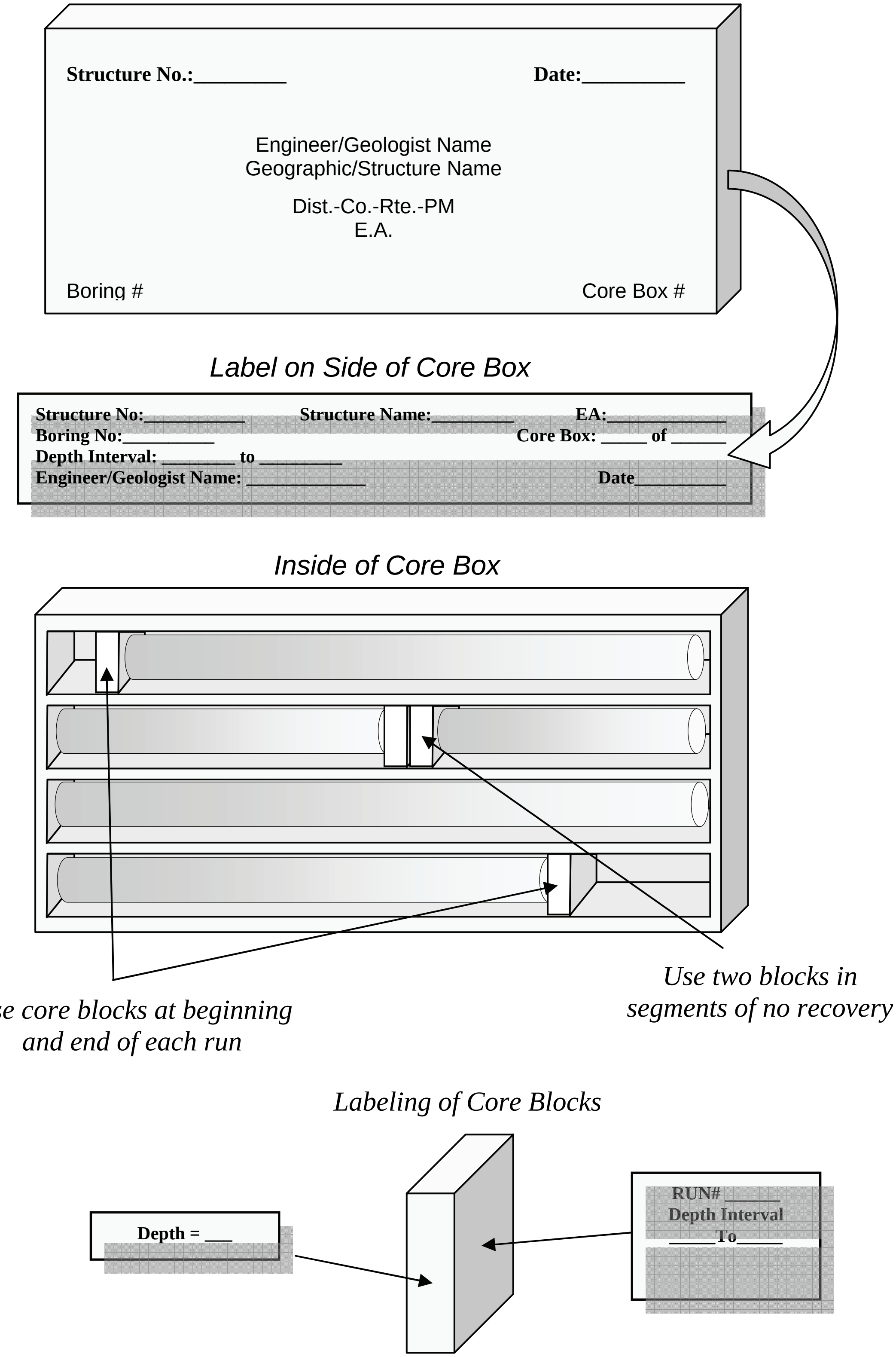
1. ** Tests performed by Materials Engineering and Testing Services (METS)
2. A 12" by 24" canvas bag completely filled contains approximately 40 lb of material.
3. A 2" by 4" tube contains approximately 1 lb. of material.
4. Minimum material weights shown for remolded samples include sufficient material for the development of a moisture density curve.

5. When calculating the number of triaxial samples that can be obtained from a Shelby tube, use a minimum sample length equal to three times the sample diameter.

2.6.3 Core Box Layout

Core boxes shall be labeled as shown in Figure 2-40.

Figure 2-40
Core Box Layout and Label



2.7 Quality Check of Field Observations and Samples

The geoprofessional shall conduct a quality check of his/her field notes and observations once back in the office. Sample descriptions and identifications shall be reviewed and revised as necessary to ensure that they are in compliance with the procedures presented in this section.

Descriptors of sample properties that are subject to change due to time or environment, such as moisture or RQD, shall not be revised. Samples that are to be stored for laboratory testing or other purposes shall be inventoried to ensure correct labeling and accounting.

Section 3: Procedures for Soil and Rock Description and/or Classification Using Laboratory Test Results

3.1 Introduction

Section 2 describes the procedures for describing and identifying soil and rock samples in the field using visual and manual methods and basic field testing tools. Most of these field procedures are sufficient to generally identify and describe the soil and rock in qualitative terms, and are appropriate for reporting in final boring records, as described later in Sections 4 and 5. In many cases these descriptors can be correlated, to some degree, to engineering parameters for use in geotechnical designs. However, the geoprofessional may want to more quantitatively and definitively characterize a particular sample using laboratory test results.

This Section addresses how to apply the results of specific laboratory tests to revise and supplement the original field observations, identifications, and descriptions. The information presented in this Section is based largely on the American Society for Testing and Materials (ASTM) D 2487-06, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).*

Laboratory test results can be used to systematically refine field observations. The process of correction, calibration, and verification in developing an updated Log of Test Boring (LOTB) or Boring Record (BR) based on laboratory test results can effectively serve the purpose of self-training and self-calibration. This process is described in more detail in Section 4 of this Manual.

3.2 Revising Soil Descriptions and Assigning Soil Classification Using Laboratory Test Results

Six of the 21 attributes in the identification and descriptive sequence for soils, listed previously in section 2.4.1, may be revised with laboratory test results. They are:

- Group Name
- Group Symbol
- Consistency
- Percent or Proportion of Soils
- Particle Size Range
- Plasticity

The *Group Name* and *Group Symbol* are estimated in the field using visual and manual procedures based on ASTM D 2488-06, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).* The field method requires the user to make judgments on a number of observations (e.g., percent of constituents by weight, whether a soil is well or poorly graded, and whether the soil is a clay or silt or some combination thereof).

Laboratory particle-size analysis, liquid limit, and plasticity index provide a quantitative basis for *classification* of the soil. Furthermore, the laboratory procedure employs a much more comprehensive listing of possible Group Names, as compared to field methods.

Consistency is estimated in the field using one or more of three methods (thumb test, Torvane, or Pocket Penetrometer), with varying levels of accuracy and repeatability. Laboratory triaxial, direct shear, and unconfined compression tests provide less subjective undrained shear strength values that can be correlated to specific consistency descriptors.

Percent gravel, sand, and fines, and range of particle sizes are estimated in the field using visual methods (e.g. jar test, visual approximation, etc.). The laboratory particle-size analysis test provides a quantitative distribution of particle sizes in proportion to the total sample weight. It is important to recognize that the sample size is significant when dealing with gravel or larger sized soils.

Plasticity is estimated in the field in order to determine Group Name and Group Symbol for fine-grained soils and to provide a plasticity descriptor. The liquid limit and plasticity index used in conjunction with ASTM D 2487-06 provide a Group Name and Group Symbol. The field-based plasticity descriptor is eliminated, as the plasticity is inherent in the Group Name and Group Symbol.

3.2.1 Soil Classification and Description Descriptive Sequence

The descriptive sequence presented in the Figure 3-1 below shall be used when classifying and describing soils. Items indicated by a check mark in the "Required" column shall be repeated to describe all the components of the subject soil to provide complete descriptive coverage. To incorporate laboratory test data in the classification and descriptive sequence, where applicable, refer to the sections in this Manual as noted in Figure 3-1. *(See "Lab" column below.)*

Figure 3-1
Classification and Description Sequence

Sequence	Classification Components	Refer to Section: Field	Refer to Section: Lab	Required	Optional
1	Group Name	2.4.2	3.2.2	●	
2	Group Symbol	2.4.2	3.2.2	●	
	Description Components				
3	Consistency (for cohesive soils)	2.4.3	3.2.3	●	
4	Apparent Density (for cohesionless soils)	2.4.4		●	
5	Color (in moist condition)	2.4.5		●	
6	Moisture	2.4.6		●	
7	Percent of cobbles or boulders	2.4.7		●	
8	Percent or proportion of soils	2.4.8	3.2.4	●	
9	Particle Size Range	2.4.9	3.2.5	●	
10	Particle Angularity	2.4.10			o
11	Particle Shape	2.4.11			o
12	Hardness (for coarse sand and larger particles)	2.4.12			o
13	Plasticity (for fine-grained soils)*	2.4.13	3.2.6	●	
14	Dry Strength (for fine-grained soils)	2.4.14			o
15	Dilatency (for fine-grained soils)	2.4.15			o
16	Toughness (for fine-grained soils)	2.4.16			o
17	Calcium Carbonate (Reaction with HCl)	2.4.17			o
18	Structure	2.4.18			o
19	Cementation	2.4.19		●	
20	Description of Cobbles and Boulders	2.4.20		●	
21	Additional Comments	2.4.21			o

* *This descriptive component is not reported for the primary soil type if the liquid limit and plasticity index are available. (See Section 3.2.7)*

3.2.2 Group Name and Group Symbol

This section presents a procedure for classifying soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index. It shall be used when precise classification is required. This method is based on the ASTM version of the Unified Soil Classification System (USCS).

The ASTM procedure for classifying and describing fine-grained and coarse-grained soils is only applicable to material passing the 3-inch sieve. If the presence of cobbles or boulders or both is identified during the site exploration, the percentage of cobbles and boulders shall be reported per Section 2.4.7.

3.2.2.1 Procedure for Classification of Fine-Grained Soils

If 50% or more by dry weight of the test specimen passes the No. 200 sieve, the soil is fine-grained. Fine-grained soils are classified using the liquid limit and plasticity index in Figures 3-2 and 3-3, below.

Classify the soil as fine-grained:

- In cases where the liquid limit exceeds 110, or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scale on both axes and extending the "A" line at the indicated slope.
- The soil is organic if organic matter is present in sufficient amounts to influence the liquid limit. Typically, organic soils have a dark color and an organic odor when moist and warm, and may contain visible organic matter. If the geoprofessional suspects there is sufficient organic matter to influence the soil's classification, consult with the Caltrans Geotechnical Laboratory about additional laboratory testing.

Figure 3-2
Classification of Fine-Grained Soils

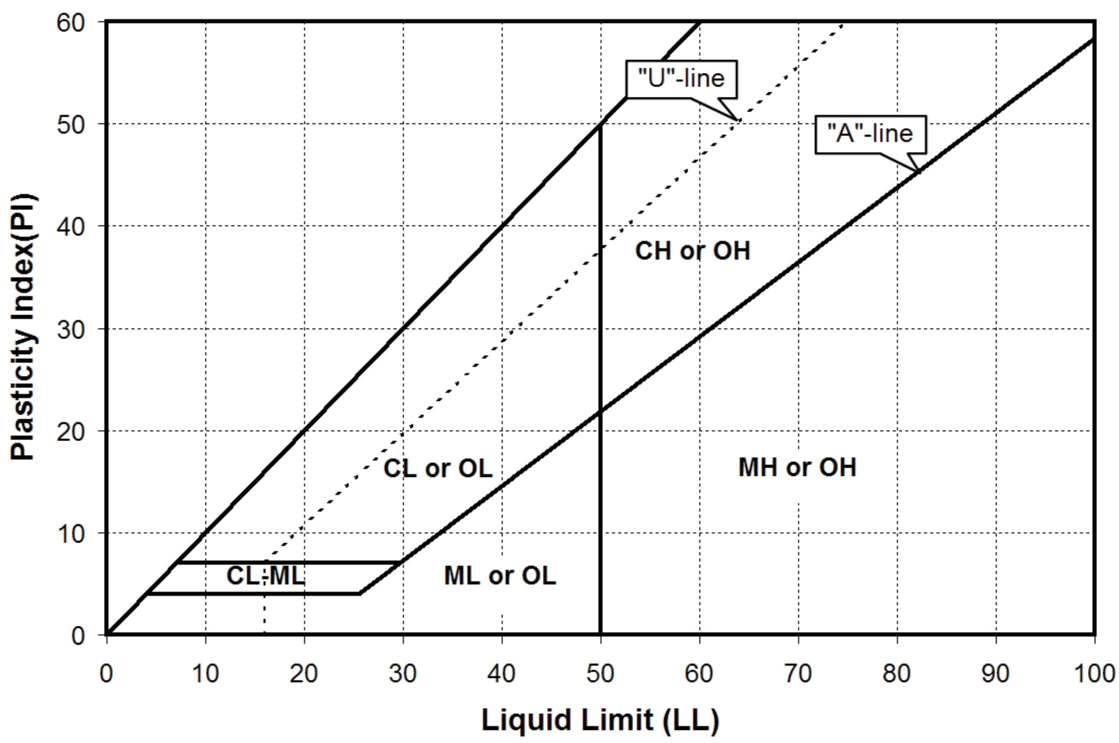


Figure 3-3
Flow chart for fine-grained soils

Liquid Limit	Organic	Plasticity Index	Group Symbol	Fines	Coarseness		Group Name
LL<50	Inorganic	PI>7 and plots on or above "A"-line	CL	<30% plus No. 200	<15% plus No. 200		Lean CLAY
					15-29% plus No. 200	% sand ≥ % gravel	Lean CLAY with SAND
						% sand < % gravel	Lean CLAY with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY lean CLAY
						≥ 15% gravel	SANDY lean CLAY with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY lean CLAY
						≥ 15% sand	GRAVELLY lean CLAY with SAND
		4≤PI≤7 and plots on or above "A"-line	CL-ML	<30% plus No. 200	<15% plus No. 200		SILTY CLAY
					15-29% plus No. 200	% sand ≥ % gravel	SILTY CLAY with SAND
						% sand < % gravel	SILTY CLAY with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY SILTY CLAY
						≥ 15% gravel	SANDY SILTY CLAY with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY SILTY CLAY
						≥ 15% sand	GRAVELLY SILTY CLAY with SAND
		PI<4 or plots below "A"-line	ML	<30% plus No. 200	<15% plus No. 200		SILT
					15-29% plus No. 200	% sand ≥ % gravel	SILT with SAND
						% sand < % gravel	SILT with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY SILT
						≥ 15% gravel	SANDY SILT with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY SILT
						≥ 15% sand	GRAVELLY SILT with SAND
	Organic	PI≥4 and plots on or above "A"-line	OL	<30% plus No. 200	<15% plus No. 200		ORGANIC CLAY
					15-29% plus No. 200	% sand ≥ % gravel	ORGANIC CLAY with SAND
						% sand < % gravel	ORGANIC CLAY with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY ORGANIC CLAY
						≥ 15% gravel	SANDY ORGANIC CLAY with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY ORGANIC CLAY
						≥ 15% sand	GRAVELLY ORGANIC CLAY with SAND
		PI<4 or plots below "A"-line		<30% plus No. 200	<15% plus No. 200		ORGANIC SILT
					15-29% plus No. 200	% sand ≥ % gravel	ORGANIC SILT with SAND
						% sand < % gravel	ORGANIC SILT with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY ORGANIC SILT
						≥ 15% gravel	SANDY ORGANIC SILT with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY ORGANIC SILT
						≥ 15% sand	GRAVELLY ORGANIC SILT with SAND

Figure 3-3, continued

Liquid Limit	Organic	Plasticity Index	Group Symbol	Fines	Coarseness		Group Name
LL≥50	Inorganic	Plots on or above "A"-line	CH	<30% plus No. 200	<15% plus No. 200		Fat CLAY
					15-29% plus No. 200	% sand ≥ % gravel	Fat CLAY with SAND
						% sand < % gravel	Fat CLAY with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY fat CLAY
						≥ 15% gravel	SANDY fat CLAY with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY fat CLAY
						≥ 15% sand	GRAVELLY fat CLAY with SAND
		Plots below "A"-line	MH	<30% plus No. 200	<15% plus No. 200		Elastic SILT
					15-29% plus No. 200	% sand ≥ % gravel	Elastic SILT with SAND
						% sand < % gravel	Elastic SILT with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY elastic SILT
						≥ 15% gravel	SANDY elastic SILT with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY elastic SILT
						≥ 15% sand	GRAVELLY elastic SILT with SAND
	Organic	Plots on or above "A"-line	OH	<30% plus No. 200	<15% plus No. 200		ORGANIC CLAY
					15-29% plus No. 200	% sand ≥ % gravel	ORGANIC CLAY with SAND
						% sand < % gravel	ORGANIC CLAY with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY ORGANIC CLAY
						≥ 15% gravel	SANDY ORGANIC CLAY with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY ORGANIC CLAY
						≥ 15% sand	GRAVELLY ORGANIC CLAY with SAND
		Plots below "A"-line		<30% plus No. 200	<15% plus No. 200		ORGANIC SILT
					15-29% plus No. 200	% sand ≥ % gravel	ORGANIC SILT with SAND
						% sand < % gravel	ORGANIC SILT with GRAVEL
				≥30% plus No. 200	% sand ≥ % gravel	< 15% gravel	SANDY ORGANIC SILT
						≥ 15% gravel	SANDY ORGANIC SILT with GRAVEL
					% sand < % gravel	< 15% sand	GRAVELLY ORGANIC SILT
						≥ 15% sand	GRAVELLY ORGANIC SILT with SAND

3.2.2.2 Procedure for Classification of Coarse-Grained Soils

If 50% or more by dry weight of the test specimen is retained on the No. 200 sieve the soil is coarse-grained. Coarse-grained soils are classified using the following procedure:

- Classify the soil as gravel if more than 50% of the coarse fraction (plus No. 200 sieve) is retained on the No. 4 sieve.
- Classify the soil as sand if 50% or more of the coarse fraction (plus No. 200 sieve) passes through the No. 4 sieve.
- If 12% or less of the test specimen passes through the No. 200 sieve, plot the cumulative particle-size distribution and compute the coefficient of uniformity, Cu, and coefficient of curvature, Cc, as given in Equations 1 and 2.

Equation 1

$$Cu = \frac{D_{60}}{D_{10}}$$

Equation 2

$$Cc = \frac{(D_{30})^2}{(D_{10} \times D_{60})}$$

Where D_{10}, D_{30}, and D_{60} are the particle-size diameters corresponding to 10, 30, and 60 percentiles passing on the cumulative particle-size distribution curve. It may be necessary to extrapolate the curve to obtain the D_{10} diameter.

Use the above results to determine the classification according to Figure 3-4 on the following page.

Figure 3-4
Flow chart for coarse-grained soils

	Fines	Grade	Type of Fines	Group Symbol	Sand/ Gravel	Group Name
Gravel	≤ 5%	Cu≥4 1≤Cc≤3		GW	< 15% sand	Well-graded GRAVEL
					≥ 15% sand	Well-graded GRAVEL with SAND
		Cu<4 1>Cc>3		GP	< 15% sand	Poorly graded GRAVEL
					≥ 15% sand	Poorly graded GRAVEL with SAND
	5-12%	Cu≥4 1≤Cc≤3	ML or MH	GW-GM	< 15% sand	Well-graded GRAVEL with SILT
					≥ 15% sand	Well-graded GRAVEL with SILT and SAND
			CL, CH or CL-ML	GW-GC	< 15% sand	Well-graded GRAVEL with CLAY (or SILTY CLAY)
					≥ 15% sand	Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
		Cu<4 1>Cc>3	ML or MH	GP-GM	< 15% sand	Poorly graded GRAVEL with SILT
					≥ 15% sand	Poorly graded GRAVEL with SILT and SAND
			CL, CH or CL-ML	GP-GC	< 15% sand	Poorly graded GRAVEL with CLAY (or SILTY CLAY)
					≥ 15% sand	Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
	> 12%		ML or MH	GM	< 15% sand	SILTY GRAVEL
					≥ 15% sand	SILTY GRAVEL with SAND
			CL or CH	GC	< 15% sand	CLAYEY GRAVEL
					≥ 15% sand	CLAYEY GRAVEL with SAND
			CL-ML	GC-GM	< 15% sand	SILTY, CLAYEY GRAVEL
					≥ 15% sand	SILTY, CLAYEY GRAVEL with SAND
Sand	≤ 5%	Cu≥6 1≤Cc≤3		SW	< 15% gravel	Well-graded SAND
					≥ 15% gravel	Well-graded SAND with GRAVEL
		Cu<6 1>Cc>3		SP	< 15% gravel	Poorly graded SAND
					≥ 15% gravel	Poorly graded SAND with GRAVEL
	5-12%	Cu≥6 1≤Cc≤3	ML or MH	SW-SM	< 15% gravel	Well-graded SAND with SILT
					≥ 15% gravel	Well-graded SAND with SILT and GRAVEL
			CL, CH or CL-ML	SW-SC	< 15% gravel	Well-graded SAND with CLAY
					≥ 15% gravel	Well-graded SAND with CLAY and GRAVEL
		Cu<6 1>Cc>3	ML or MH	SP-SM	< 15% gravel	Poorly graded SAND with SILT
					≥ 15% gravel	Poorly graded SAND with SILT and GRAVEL
			CL, CH or CL-ML	SP-SC	< 15% gravel	Poorly graded SAND with CLAY
					≥ 15% gravel	Poorly graded SAND with CLAY and GRAVEL
	> 12%		ML or MH	SM	< 15% gravel	SILTY SAND
					≥ 15% gravel	SILTY SAND with GRAVEL
			CL or CH	SC	< 15% gravel	CLAYEY SAND
					≥ 15% gravel	CLAYEY SAND with GRAVEL
			CL-ML	SC-SM	< 15% gravel	SILTY, CLAYEY SAND
					≥ 15% gravel	SILTY, CLAYEY SAND with GRAVEL

3.2.3 Consistency (Cohesive Soils)

Cohesive soil consistency descriptors shall conform to terminology and criteria established in Figure 3-5 below, generally after Das (1983) and Bureau of Reclamation standards (2001). Note that the terms to be used have been modified from those contained in both references.

The preferred procedure for the determination of consistency of cohesive soils is to obtain relatively undisturbed samples and perform laboratory triaxial, direct shear, or unconfined compression tests. The results from these tests can be correlated to specific consistency descriptors as presented in Figure 3-5 below.

A triaxial unconsolidated-undrained (UU) test is recommended for strength determination. This can be converted to an equivalent unconfined compressive strength by multiplying the Undrained Shear Strength value by 2.

Figure 3-5

Consistency

Description	Unconfined Compressive Strength (tsf)
Very Soft	< 0.25
Soft	0.25 to 0.50
Medium Stiff	0.50 to 1.0
Stiff	1 to 2
Very Stiff	2 to 4
Hard	> 4.0

3.2.4 Percent or Proportion of Soils

Percentages of gravel, sand, and fines shall be reported as percentages based on gradation and particle-size analysis (ASTM D 422-63 (2002)). Qualitative proportional descriptors (e.g. trace, some, etc.) shall not be used when gradation data is available.

Figure 3-6

Percent or proportion of soils

Descriptive Term	Size
Gravel	3 inch to No.4 Sieve
Sand	No.4 to No. 200 Sieve
Fines	Passing No. 200 Sieve

3.2.5 Particle Size

When laboratory particle size analyses are performed, the USCS soil descriptions shall be further refined using the results and the Figure 3-8 below.

Figure 3-8

Particle size

Description	Size
Boulder	>12 in
Cobble	3 to 12 in
Coarse Gravel	¾ to 3 in
Fine Gravel	No.4 to ¾ in
Coarse Sand	No.10 to No.4
Medium Sand	No.40 to No.10
Fine Sand	No. 200 to No.40
Clay and Silt	Passing No. 200

3.2.6 Plasticity (for Fine-Grained Soils)

Field estimates of plasticity shall not be included in the descriptive sequence when USCS classifications are based on liquid limit and plasticity index, since the plasticity is inherent in the group name and group symbol.

3.3 Revising Rock Identification and Description for Borehole Cores Using Laboratory Test Results

One additional component, relative strength of intact rock, can be added to the descriptive sequence for rock.

Figure 3-9

Rock Identification and Descriptive Sequence

Sequence	Identification Components	Refer to Section		Required	Optional
		Field	Lab		
1	Rock Name	2.5.2		●	
	Description Components				
2	Rock Grain-size	2.5.3			O
3	Bedding Spacing	2.5.4		●	
4	Color	2.5.5		●	
5	Texture	2.5.6			O
6	Weathering Descriptors for Intact Rock	2.5.7		●	
7	Relative Strength of Intact Rock		3.3.1	●	
8	Rock Hardness	2.5.8		●	
9	Fracture Density	2.5.9		●	
10	Discontinuity Type	2.5.10			O
11	Discontinuity Condition (Weathering, Infilling and Healing)	2.5.11			O
12	Discontinuity Dip Magnitude	2.5.12			O
13	Rate of Slaking (Jar Slake Test)	2.5.13			O
14	Odor	2.5.14			O
15	Additional Comments	2.5.15			O

3.3.1 Strength of Intact Rock

Absent discontinuities, the strength of intact rock is best determined using unconfined compression laboratory testing.

Figure 3-10

Descriptors for Relative Strength of Intact Rock

Description	Uniaxial Compressive Strength (psi)
Extremely Strong	> 30,000
Very Strong	14,500 – 30,000
Strong	7,000 – 14,500
Medium Strong	3,500 – 7,000
Weak	700 – 3,500
Very Weak	150 – 700
Extremely Weak	< 150

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Section 4:
Methods of Presentation of Subsurface Information

4.1 Introduction

The process of creating boring logs, i.e., Log of Test Borings (LOTB) and Boring Records (BR) can be summarized in four steps:

- Field sampling and descriptions *(Section 2)*
- Quality check of field descriptions *(Section 2)*
- Refinement of descriptions, and classification of soil, based on laboratory test results, if performed *(Section 3)*
- Preparation of the boring logs *(Sections 4 and 5)*

This section provides details and guidance for incorporating laboratory test data and preparing boring logs. Figure 4-1 is a schematic representation of the process from obtaining subsurface information to the creation of boring logs.

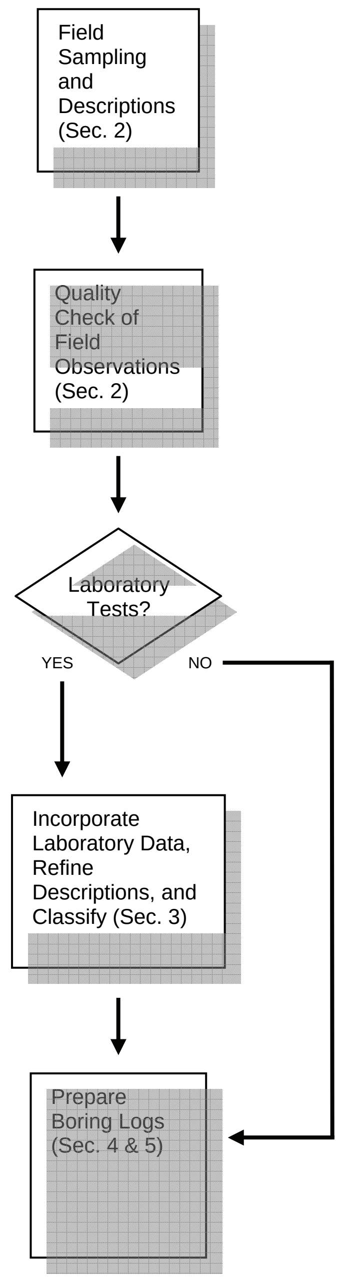
4.2 Factual vs. Interpretive Subsurface Data

FHWA guidelines state: "factual subsurface data which is pertinent to the project subsurface conditions should be presented in an easily understood fashion on the contract documents." However, there is an inherent level of professional interpretation in describing subsurface conditions that cannot be avoided.

Some examples:

- Field description and identification procedures, according to ASTM D 2488-06, require estimation and interpretation.
- Sampling may occur at discrete intervals, yet layer boundaries may fall between sampling locations. The boundaries may be identified based on visual observations of cuttings during boring advancement. There may be uncertainty as to the depth at which a material change occurs.
- Continuity of material types between discrete sampling locations is sometimes difficult to confirm.

Figure 4-1



4.3 Incorporating Laboratory Data, Refining Descriptions, and Classifying Soil

When describing soil or rock, the geoprofessional shall use the most reliable data available. Such data could be field-generated, or a combination of field- and laboratory-generated data. If laboratory tests are performed, and in the opinion of the geoprofessional, those test results represent the actual conditions of the soil or rock, those test results shall control the identification, description, or classification.

Laboratory tests are usually not performed on every sample, especially on contiguous samples within a layer of similar material. Professional judgment should be used to apply test results from one sample to the descriptor of contiguous samples within a boring when the field observations were such that the geoprofessional considers that particular attribute of the material to be consistent across the contiguous samples.

For example, three contiguous samples were determined to be "medium stiff" using the thumb method. However, a triaxial test on one of those samples indicated that the material was in fact "stiff." In this example, the consistency descriptor for the entire layer should be "stiff."

4.3.1 Subsurface Data Presentation Method

A "layer presentation" method shall be used to present soil and rock descriptions on boring logs. *(See Figure 4-3.)* This method presents a single primary description for a layer spanning one or more contiguous sample locations. However, the layer description may vary with depth as observations and/or laboratory testing at sample locations warrant. This method is used to simplify the boring log presentation format and provide clarity, especially to prospective bidders.

4.3.2 General Rules and Considerations

The following general rules apply to the layer presentation method:

- A change in a soil's Group Symbol or a rock type shall result in a new layer within the boring log.
- Reliable laboratory test results shall be used when performed to determine the applicable descriptors within the descriptive sequence (i.e. Group Name and Symbol, consistency, gradation properties, plasticity, and rock strength).
- Individual descriptors for contiguous samples with the same descriptions and classifications should be adjusted based on the test results of one or more representative samples. Use of more than one test sample is encouraged.
- When specifying a descriptive range, the range shall not span more than one step on the range of descriptors. For example, "stiff to very stiff" would be acceptable; but "soft to hard" would not be acceptable because the range is too broad to be useful.
  Exception: Any range of colors is acceptable.
- The descriptive sequence used to describe a layer of soil or rock shall describe that layer in its entirety. Where changes are noted at depths within the layer, those changes shall replace the preceding descriptor and shall apply from that depth to the bottom of the layer.
- The layer presentation of the boring log shall enable the reader to derive individual sample descriptions based on the layer description and sample information provided.

4.3.3 Example

The process for developing boring logs has been presented in detail throughout this Manual In general, field sample descriptions are corrected and calibrated based on laboratory results, layer boundaries are determined by grouping samples within the same group symbol, sample descriptions are consolidated into a single layer description, and, finally, description changes are noted with depth within layers.

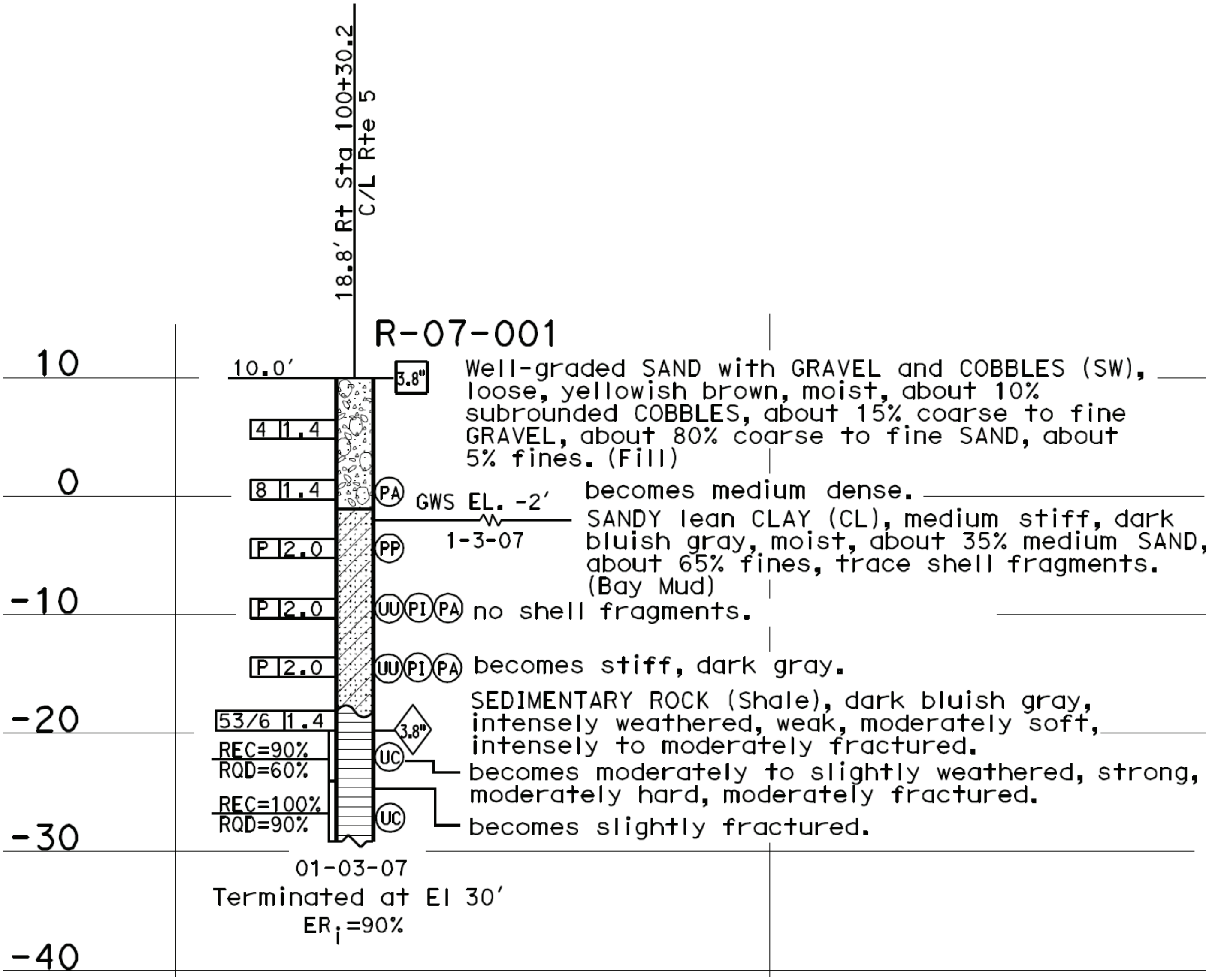
The following example demonstrates how a geoprofessional develops a layer presentation, based on field descriptions and laboratory test results.

Figure 4-2

Depth (ft.)	Sample	Field Testing	Field Description and Identification	Lab Testing	Lab Corrected Description and Identification or Classification	Final Layer Presentation
3.5-5	R-07-001-S01	SPT	Well-graded SAND with GRAVEL and COBBLES (SW), loose, yellowish brown, moist, about 10% subrounded COBBLES, about 15% coarse to fine GRAVEL, about 80% coarse to fine SAND, about 5% fines, (fill)		Well-graded SAND with GRAVEL and COBBLES (SW), loose, yellowish brown, moist, about 10% subrounded COBBLES, about 15% coarse to fine GRAVEL, about 80% coarse to fine SAND, about 5% fines, (fill)	Well-graded SAND with GRAVEL and COBBLES (SW), loose, yellowish brown, moist, about 10% subrounded COBBLES, about 15% coarse to fine GRAVEL, about 80% coarse to fine SAND, about 5% fines, (fill)
8.5-10	R-07-001-S02	SPT	Well-graded SAND with GRAVEL and COBBLES (SW), medium dense, yellowish brown, moist, about 10% subrounded COBBLES, about 95% coarse to fine SAND, about 5% fines, (fill)	PA	Well-graded SAND with GRAVEL and COBBLES (SW), medium dense, yellowish brown, moist, about 10% subrounded COBBLES, about 95% coarse to fine SAND, about 5% fines, (fill)	becomes medium dense
13.5-15	R-07-001-U03	PP	SANDY lean CLAY (CL), medium stiff, dark bluish gray, moist, about 35% medium SAND, about 65% fines, trace shell fragments, (bay mud)		SANDY lean CLAY (CL), medium stiff, dark bluish gray, moist, about 35% medium SAND, about 65% fines, trace shell fragments, (bay mud)	SANDY lean CLAY (CL), medium stiff, dark bluish gray, moist, about 35% medium SAND, about 65% fines, trace shell fragments, (bay mud)
18.5-20	R-07-001-U04	PP	SANDY lean CLAY (CL), soft, dark bluish gray, moist, about 35% medium SAND, about 65% fines, (bay mud)	UU, PA, PI	SANDY lean CLAY (CL), medium stiff, dark bluish gray, moist, about 35% medium SAND, about 65% fines, (bay mud)	as above except no shell fragments
23.5-25	R-07-001-U05	PP	SANDY lean CLAY (CL), medium stiff, dark gray, moist, about 35% medium SAND, about 65% fines, trace shell fragments, (bay mud)	UU, PA, PI	SANDY lean CLAY (CL), stiff, dark gray, moist, about 35% medium SAND, about 65% fines, trace shell fragments, (bay mud)	becomes stiff, dark gray
28-29	R-07-001-S06	SPT	SEDIMENTARY ROCK (SHALE), dark bluish gray, intensely weathered, moderately soft, intensely to moderately fractured		SEDIMENTARY ROCK (SHALE), dark bluish gray, intensely weathered, moderately soft, intensely to moderately fractured	SEDIMENTARY ROCK (SHALE), dark bluish gray, intensely weathered, moderately soft, intensely to moderately fractured
29-34	R-07-001-C07		SEDIMENTARY ROCK (SHALE), dark bluish gray, moderately to slightly weathered, moderately hard, moderately fractured	UC	SEDIMENTARY ROCK (SHALE), dark bluish gray, moderately to slightly weathered, strong, moderately hard, moderately fractured	becomes moderately to slightly weathered, strong, moderately hard, moderately fractured
34-39	R-07-001-C08		SEDIMENTARY ROCK (SHALE), dark bluish gray, moderately to slightly weathered, moderately hard, slightly fractured	UC	SEDIMENTARY ROCK (SHALE), dark bluish gray, moderately to slightly weathered, strong, moderately hard, slightly fractured	becomes slightly fractured

The LOTB for the preceding example would appear as follows:

Figure 4-3



Section 5:
Boring Log and Legend Presentation Formats

5.1 Introduction

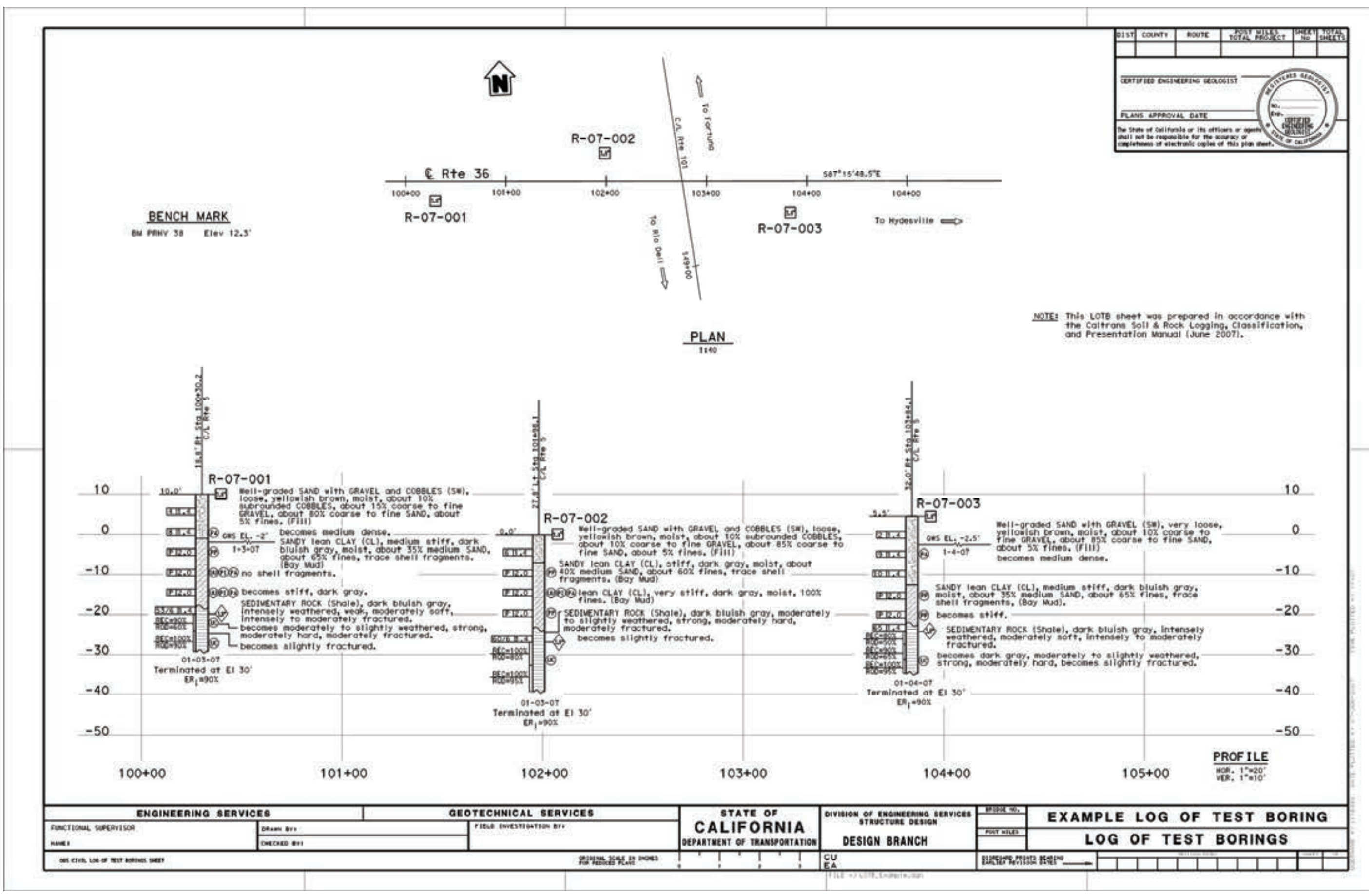
The Department uses the following formats to present subsurface information:

- Log of Test Boring (LOTB), and/or
- Boring Record (BR).

An LOTB is typically associated with a structure facility and is attached to Project Plans. A BR is typically associated with an earthwork facility and is attached to a Geotechnical Report. If a subsurface exploration was performed, there shall be at least one type of log presentation.

5.2 Log of Test Boring

Figure 5-1
Example of LOTB



5.2.1 Contents and Characteristics of the LOTB

The Log of Test Boring (LOTB) document is presented as an attachment to project plans and characterized by the following attributes:

- Presents the boring logs on an elevation scale.
- Presents a plan view showing the location of each boring relative to an alignment and/or existing or planned facility.
- Presents the type of drilling methods used to perform the investigation, the type of sampling performed, and how the sampler was advanced.
- Presents the location and description, both graphical and written, of the types of soil and rock encountered within the borehole.
- Presents the types of field and laboratory testing performed.
- Field and Laboratory test data, if presented, appear at the end of the descriptive sequence.
- Optimized for printing on full-size plan sheets (24" x 36") and typically reproduced on 11" x 17" sized paper.
- Allows presentation of more than one boring log per plan sheet.
- Is accompanied by LOTB legend sheets.

5.2.2 Notes on the LOTB

Each LOTB sheet shall contain a note section for the geoprofessional to present notes deemed to be of interest to the reader. Content of notes is left to the discretion of the geoprofessional except that the one of the following two notes shall be placed on each LOTB sheet:
If the procedures of this manual were followed without exception, then the note shall read:

"This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date)"

If an exception to the procedures of this manual has been approved and implemented, then the note shall be modified to read:

"This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date) except as noted in (Section) of (Report Title) dated (Date)"

Optional notes may include:

- Changes in drilling equipment
- Site observations
- Other drilling observations from Sections 2.4.20 or 2.5.16.

5.2.3 LOTB Sheet Formatting

LOTB sheets shall be prepared in accordance with this manual and the Caltrans *Plans Preparation Manual*. The LOTB sheet border shall present the following:

5.2.3.1 Signature Block (Upper Right Corner)

a) The State of California Registered Civil Engineer, Certified Engineering Geologist, or Registered Geologist seal with the signature, date, license number, and registration certificate expiration date of the engineer or geologist in responsible charge of the LOTB sheet;
b) Caltrans District, County, and Route;
c) Name and address of consultant firm in responsible charge of the LOTB sheet (if applicable);
d) Name and address of the lead local agency (if applicable); and
e) A disclaimer stating "The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet."

(The Office Engineer will provide the Post Miles Total Project, Sheet Number, Total Sheets, and Plans Approval Date.)

5.2.3.2 Title Block (Bottom, from left to right)

a) Notes stating "DIVISION OF ENGINEERING SERVICES" and "GEOTECHNICAL SERVICES." For consultant-prepared LOTB sheets, instead of those notes, show the name of the Design

Oversight (i.e., OSFP/OSCM Senior Liaison) Engineer and sign-off date.

b) "FUNCTIONAL SUPERVISOR": The name of the person in charge of the functional unit responsible for providing oversight of the registered engineer or geologist who developed the LOTB sheet.
c) "DRAWN BY": The name of the person who prepared (drafted) the LOTB sheet
d) "CHECKED BY": The name of the person who performed the quality control check of the LOTB sheet
e) "FIELD INVESTIGATION BY": The name(s) of the field investigator(s);
f) A note stating "STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION" with a scale below the sub-block and a label on the left side stating "ORIGINAL SCALE IN INCHES FOR REDUCED PLANS." For consultant-prepared LOTB sheets, the note shall state "PREPARED FOR THE STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION."
g) A note stating "DIVISION OF ENGINEERING SERVICES STRUCTURE DESIGN." For consultant-prepared LOTB sheets, instead of this note, show the name of the Project Engineer;
h) The Caltrans Contract Expenditure Authorization (CU and EA) numbers;
i) The State-assigned Bridge (or Structure) Number, Kilometer Post, and the State-assigned Bridge (or Structure) Name;
j) The initial drawn by and subsequent revision dates; and
k) A label stating "LOG OF TEST BORINGS _ OF _" (if applicable).

(The Office Engineer will provide the Sheet Number and Total Sheets Number.)

5.2.3.3 Plan View

a) Plan View shall be shown at the top of the first LOTB sheet. When the site is sufficiently large or complex, the first LOTB sheet should be used entirely for the Plan View.
b) When multiple LOTB sheets are drafted, they shall be numbered with reference to the stationing of the control line (i.e., showing sheet No. 1 with the lowest stationing and the last sheet with the highest stationing).
c) A distinct Plan View of the project site that is independent of the Profile View shall be shown on the LOTB.
d) Show the location, description, and elevation of the benchmark used for determining the top of boring elevations at the top left side of the Plan View under the heading "BENCHMARK". Identify the vertical datum (National Geodetic Vertical Datum, U.S. Geological Survey, U.S. Coast & Geodetic Survey, District, etc.) used to determine the benchmark elevations.
e) Show the scale directly below the Plan View label.
f) Show a North arrow.
g) Lines or control lines shown in the Plan View shall be consistent with those shown on the General Plan sheet.
h) Show stationing and names for control lines. Stationing shall increase from left to right. Show a minimum of two stations on all lines.
i) Show control line intersection stationing and bearings.
j) Show names and directions of nearest cities.
k) Show names and directions of stream flows when applicable.
l) Plot boring locations with symbols as shown in the legend to identify drilling methods (e.g., auger hole, rotary hole, cone penetration). The Hole Identification shall be presented with each symbol.
m) Boring locations are to be identified by reference line, station, and offset. Coordinates, such as Northing and Easting, may also be shown on the LOTB sheets.

5.2.3.4 Profile View

a) Show the control line, increasing from left to right, horizontally across the bottom of the Profile View.
b) Show the elevations and grid lines on both the left and right margins. Numerical values shall be in multiples of 10 (i.e. 20, 10, 0, -10, -20).

c) Show the Hole Identification, top of hole elevation, stationing, and offset at the top of each boring log.
d) Show types and diameters of each boring as shown in the legend.
e) Show the completion date of boring (m/d/y) at the bottom of each boring log.
f) Show "Terminated at EL. XX'" to indicate the bottom of boring elevation.
g) Show the SPT hammer energy ratio, "Hammer Energy Ratio (ER_i) = XX%," at the bottom of each boring.
h) Show date and elevation of groundwater measurement.
i) Show results from field penetration tests at relevant elevations along the boring log.
j) Show types of field and laboratory tests with symbols as indicated in the legend, at relevant elevations along the right side of the boring log.
k) Show the Profile scales (horizontal and vertical) under the heading "PROFILE".

5.2.3.5 Additional information to be included

a) Show standard note identifying the logging practice as follows:

   "This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual"

   When a LOTB presents information that deviates from the Caltrans Soil & Rock Logging, Classification, and Presentation Manual standards, the standard note shall be modified to read as follows:

   "This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual except as noted in (section) of (Report Title) dated (Date)"

b) Descriptions of types of samplers used for the field exploration.

5.2.4 As-Built LOTB Sheet Formatting

As-Built LOTB sheet(s) shall be prepared according to the following standards.

5.2.4.1 Obtaining and Reproducing the As-Built LOTB Sheet

a) Reproducible copies of As-Built LOTB sheets may be obtained from the Microfilm Services Units in the Caltrans District Offices. If the As-Built LOTB sheets provided to Local Agencies or consultants by the Caltrans District Offices are not legible, a full sized copy should be requested from Geotechnical Services.
b) As-Built LOTB sheets shall be size "D" (24" by 36"). The As-Built LOTB title block shall be sized to fit and placed over any open space (preferably toward the top) on the As-Built LOTB sheet.
c) Information on the As-Built LOTB sheet shall be clear and legible. In order to improve the legibility of the information, it may be necessary to darken the line work and the notations.

5.2.4.2 Typical Modifications to As-Built LOTB Sheets

a) If As-Built LOTB sheets are shown in metric units, the offset and stationing location of each boring must be converted to imperial units. A table shall be added showing the dual dimensions (Metric and English) of each boring. The table shall show the station and offset in relation to the new English line. The General Plan will show the current English control line.

5.2.4.3 The As-Built LOTB Title Block shall include the following information for the current project

a) A note stating "GEOTECHNICAL SERVICES -- DIVISION OF ENGINEERING SERVICES" (if applicable).
b) Caltrans District, County, Route, Post Miles - Total Project, State-assigned Bridge (or Structure) Number and Name, and Expenditure Authorization (CU and EA)

numbers. The Office Engineer will provide the Sheet Number and Total Sheets Number.

c) The State of California Registered Civil Engineer or Registered Geologist seal with the signature, date, license number, and registration certificate expiration date of the engineer or geologist in responsible charge of the LOTB sheet.

d) A note stating, "As-Built Log of Test Borings sheet is considered an informational document only. As such, the State of California registration seal with signature, license number and registration certificate expiration date confirm that this is a true and accurate copy of the original document. It does not attest to the accuracy or validity of the information contained in the original document. This drawing is available and presented only for the convenience of any bidder, contractor or other interested party."

e) A sub-box stating "LOG OF TEST BORINGS _ OF _" (if applicable).

e) A note stating "A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA" (if applicable).

5.2.5 The LOTB Legend Sheets

The soil and rock legend sheets are standard forms that provide convenient references for the *required* soil and rock description, identification, and/or classification components presented in this Manual. References for *optional* descriptors do not appear on the legend sheets; however, they are explained in this Manual. To correctly interpret the LOTB, the reader shall be familiar with this Manual.

There are two legend sheets, one predominantly for soil and the other for rock, as shown in the Figures 5-2 and 5-3.

The legend sheets define the format for the graphical presentation of a boring log and differentiate among the various borehole and sounding types. The legend sheets also present the symbols used to identify laboratory tests.

<table>
<tr><td colspan="6">GEOTECHNICAL SERVICES – DIVISION OF ENGINEERING SERVICES</td></tr>
<tr><td colspan="6">As-Built Log of Test Borings sheet is considered an informational document only. As such, the State of California registration seal with signature, license number and registration certificate expiration date confirm that is this a true and accurate copy of the original document. It does not attest to the accuracy or validity of the information contained in the original document. This drawing is available and presented only for the convenience of any bidder, contractor or other interested party.</td></tr>
<tr><td>DIST.</td><td>COUNTY</td><td>ROUTE</td><td>POST MILES – TOTAL PROJECT</td><td>SHEET NO.</td><td>TOTAL SHEETS</td></tr>
<tr><td>08</td><td>SBD</td><td>210</td><td>10.00-15.00</td><td>24</td><td>25</td></tr>
<tr><td colspan="6">REGISTERED ENGINEER – CIVIL DATE</td></tr>
<tr><td colspan="6">MAIN STREET OVERCROSSING</td></tr>
<tr><td colspan="6">LOG OF TEST BORINGS 5 OF 6</td></tr>
<tr><td colspan="4">NOTE: A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA</td><td>CU: 12
EA: 432563</td><td>BRIDGE NO.
12-3456</td></tr>
</table>

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Figure 5-2

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE, 2007)

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

REGISTERED PROFESSIONAL ENGINEER No. Exp. CIVIL STATE OF CALIFORNIA

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly graded SAND Poorly graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic/Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

FIELD AND LABORATORY TESTING

C	Consolidation (ASTM D 2435-04)
CL	Collapse Potential (ASTM D 5333-03)
CP	Compaction Curve (CTM 216-06)
CR	Corrosivity Testing (CTM 643, CTM 422, CTM 417)
CU	Consolidated Undrained Triaxial (ASTM D 4767-02)
DS	Direct Shear (ASTM D 3080-04)
EI	Expansion Index (ASTM D 4829-03)
M	Moisture Content (ASTM D 2216-05)
OC	Organic Content-% (ASTM D 2974-07)
P	Permeability (CTM 220-05)
PA	Particle Size Analysis (ASTM D 422-63) (2002)
PI	Plasticity Index (AASHTO T 90-00) Liquid Limit (AASHTO T 89-02)
PL	Point Load Index (ASTM D 5731-05)
PM	Pressure Meter
PP	Pocket Penetrometer
R	R-Value (CTM 301-00)
SE	Sand Equivalent (CTM 217-99)
SG	Specific Gravity (AASHTO T 100-06)
SL	Shrinkage Limit (ASTM D 427-04)
SW	Swell Potential (ASTM D 4546-03)
TV	Pocket Torvane
UC	Unconfined Compression-Soil (ASTM D 2166-06) Unconfined Compression-Rock (ASTM D 2938-95) (2002)
UU	Unconsolidated Undrained Triaxial (ASTM D 2850-03)
UW	Unit Weight (ASTM D 4767-04)
VS	Vane Shear (AASHTO T 223-96) (2004)

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60}-Value (Blows / 12 in.)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12 in.
Cobble		3 to 12 in.
Gravel	Coarse	3/4 to 3 in.
	Fine	No. 4 to 3/4 in.
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

CONSISTENCY OF COHESIVE SOILS

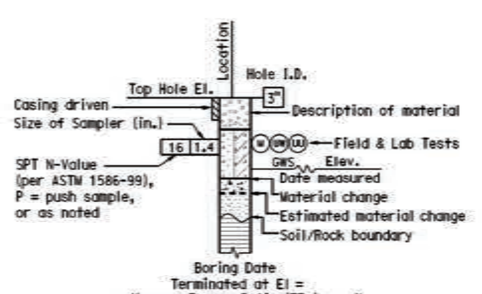
Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

PLASTICITY OF FINE-GRAINED SOILS

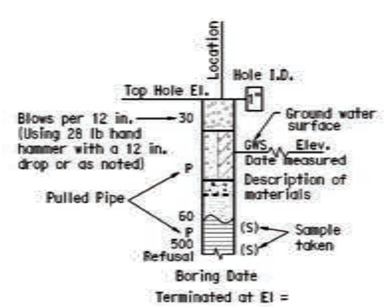
Description	Criteria
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

BOREHOLE IDENTIFICATION

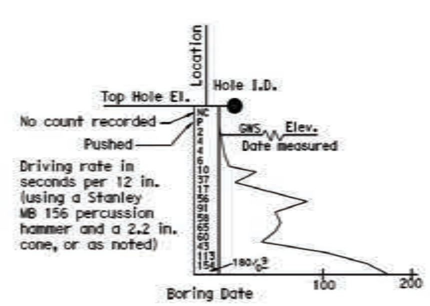
Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
	O	Other



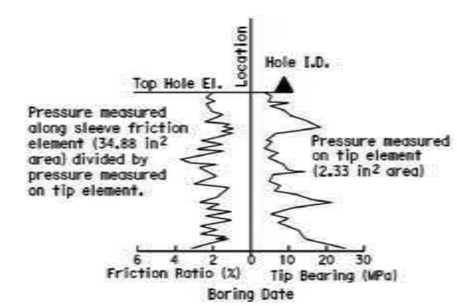
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

ENGINEERING SERVICES	GEOTECHNICAL SERVICES	STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	DIVISION OF ENGINEERING SERVICES STRUCTURE DESIGN DESIGN BRANCH	BRIDGE NO. POST MILE	SOIL LEGEND LOG OF TEST BORINGS
PREPARED BY CHECKED BY		CU EA			

GS LOTB SOIL LEGEND

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES SHEET OF

Figure 5-3

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

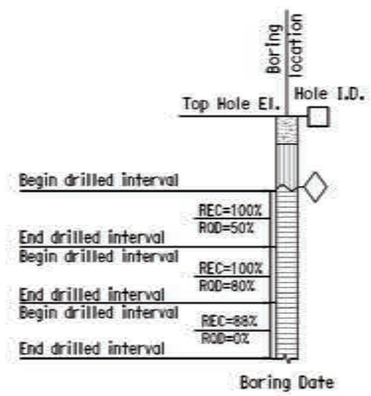
REGISTERED PROFESSIONAL ENGINEER — No. — Exp. — CIVIL — STATE OF CALIFORNIA

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE, 2007)

PERCENT CORE RECOVERY (REC) & ROCK QUALITY DESIGNATION (RQD)

$$REC = \frac{\sum \text{Length of the recovered core pieces (in.)}}{\text{Total length of core run (in.)}} \times 100\%$$

$$RQD = \frac{\sum \text{Length of intact core pieces} \geq 4 \text{ in.}}{\text{Total length of core run (in.)}} \times 100\%$$



RELATIVE STRENGTH OF INTACT ROCK

Term	Uniaxial Compressive Strength (PSI)
Extremely Strong	> 30,000
Very Strong	14,500 - 30,000
Strong	7,000 - 14,500
Medium Strong	3,500 - 7,000
Weak	700 - 3,500
Very Weak	150 - 700
Extremely Weak	< 150

BEDDING SPACING

Description	Thickness / Spacing
Massive	Greater than 10 ft
Very thickly bedded	3 to 10 ft
Thickly bedded	1 to 3 ft
Moderately bedded	4 in. to 1 ft
Thinly bedded	1 in. to 4 in.
Very thinly bedded	3/8 in. to 1 in.
Laminated	Less than 3/8 in.

LEGEND OF ROCK MATERIALS

- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

ROCK HARDNESS

Description	Criteria
Extremely Hard	Specimen cannot be scratched with a pocket knife; no steel marks left on surface.
Very Hard	Specimen cannot be scratched with a pocket knife; steel marks left on surface.
Hard	Specimen can be scratched with a pocket knife with difficulty (heavy pressure).
Moderately Hard	Specimen can be scratched with pocket knife with light or moderate pressure.
Moderately Soft	Specimen can be grooved 1/6 in. deep with a pocket knife with moderate or heavy pressure.
Soft	Specimen can be grooved or gouged easily by a pocket knife with light pressure, can be scratched with fingernail.
Very Soft	Specimen can be readily indented, grooved or gouged with fingernail, or carved with a pocket knife.

FRACTURE DENSITY

Description	Observed Fracture Density
Unfractured	No fractures.
Very slightly fractured	Lengths greater than 3 feet.
Slightly fractured	Lengths from 1 to 3 feet with few lengths less than 1 foot or greater than 3 feet.
Moderately fractured	Lengths mostly in 4 in. to 1 foot range with most lengths about 8 in.
Intensely fractured	Lengths average from 1 to 4 in. with scattered fragmented intervals with lengths less than 4 in.
Very intensely fractured	Mostly chips and fragments with a few scattered short core lengths.

Combination descriptors (such as "Very intensely to intensely fractured") are used where equal distribution of both fracture density characteristics is present over a significant interval or exposure, or where characteristics are "in between" the descriptor definitions. Only two adjacent descriptors may be combined.

WEATHERING DESCRIPTORS FOR INTACT ROCK

Description	Diagnostic features					General Characteristics
	Chemical Weathering-Discoloration and/or oxidation		Mechanical Weathering-Grain boundary conditions (disaggregation) primarily for granitics and some coarse-grained sediments	Texture and Solutioning		
	Body of Rock	Fracture Surfaces		Texture	Solutioning	
Fresh	No discoloration, not oxidized.	No discoloration or oxidation.	No separation, intact (tight).	No change.	No solutioning.	Hammer rings when crystalline rocks are struck.
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull.	Minor to complete discoloration or oxidation of most surfaces.	No visible separation, intact (tight).	Preserved.	Minor leaching of some soluble minerals may be noted.	Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty," feldspar crystals are "cloudy."	All fracture surfaces are discolored or oxidized.	Partial separation of boundaries visible.	Generally preserved.	Soluble minerals may be mostly leached.	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in-situ disaggregation, see grain boundary conditions.	All fracture surfaces are discolored or oxidized, surfaces friable.	Partial separation, rock is friable; in semiarid conditions granitics are disaggregated.	Texture altered by chemical disintegration (hydration, argillation).	Leaching of soluble minerals may be complete.	Dull sound when struck with hammer, usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures, or veinlets. Rock is significantly weakened.
Decomposed	Discolored or oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay.		Complete separation of grain boundaries (disaggregated).	Resembles a soil, partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete.		Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes."

Combination descriptors (such as "slightly weathered to fresh") are used where equal distribution of both weathering characteristics is present over significant intervals or where characteristics present are "in between" the diagnostic feature. However, combination descriptors should not be used where significant, identifiable zones can be delineated. Only two adjacent descriptors may be combined. "Very intensely weathered" is the combination descriptor for "intensely weathered to decomposed."

ENGINEERING SERVICES	GEOTECHNICAL SERVICES	STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	DIVISION OF ENGINEERING SERVICES STRUCTURE DESIGN — DESIGN BRANCH	BRIDGE NO. / POST MILE	ROCK LEGEND — LOG OF TEST BORINGS
PREPARED BY / CHECKED BY					

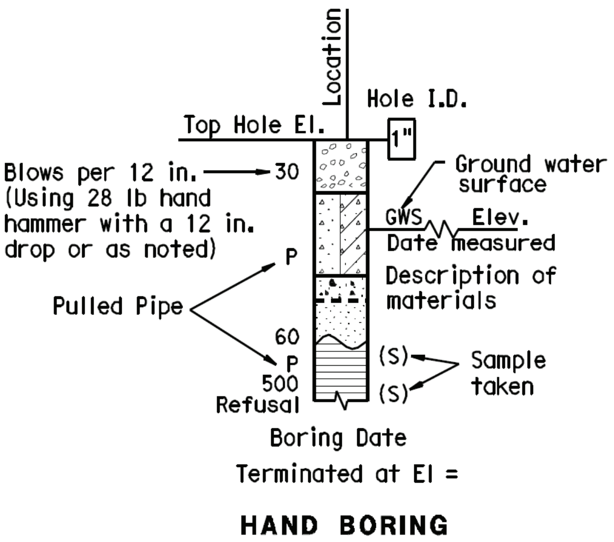
GS LOTB ROCK LEGEND — ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3 — CU EA — DISREGARD PRINTS BEARING EARLIER REVISION DATES — REVISION DATES — SHEET OF

Four general hole-type formats are graphically presented as follows:

5.2.5.1 Hand Boring

Hand Driven (HD) (1-inch soil tube) and Hand Auger (HA) borings shall be presented using the following format:

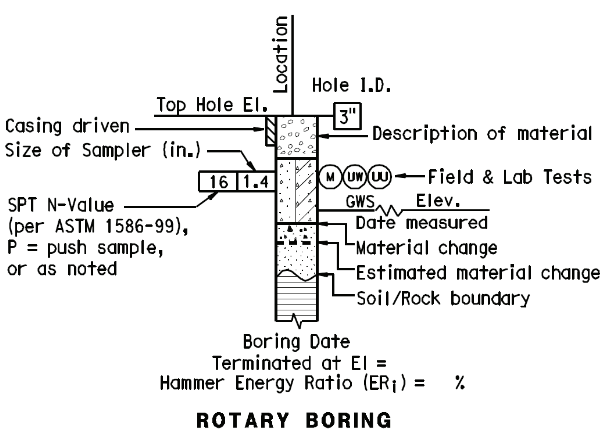
Figure 5-4



5.2.5.2 Rotary Boring

Rotary Drilled Boring or Diamond Core (R), Rotary Percussion Boring (Air) (P), Auger Boring (A), shall be presented using the following format:

Figure 5-5



Notes:

If laboratory tests are not shown as being performed, the soil descriptions presented in the LOTB are based solely on the visual practices described in this Manual.

Changes in material with depth shall be noted using the following terms:

Figure 5-6

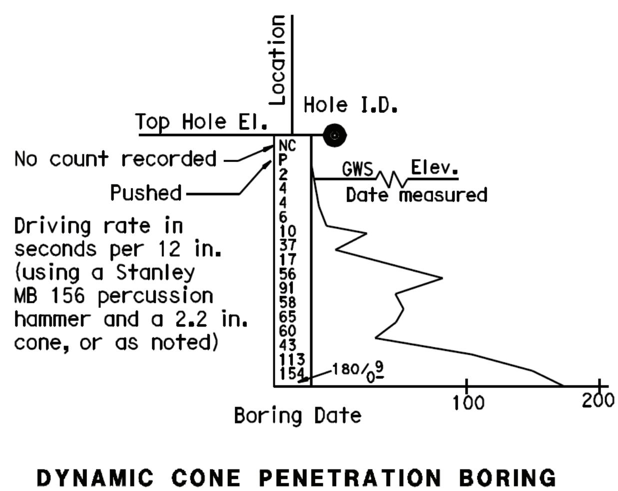
Definitions for changes in material

Term	Definition
Material Change	Change in material is observed in the sample or core, and the location of change can be accurately measured.
Estimated Material Change	Change in material cannot be accurately located because either the change is gradational or because of limitations in the drilling/sampling methods used.
Soil/Rock Boundary	Material changes from soil characteristics to rock characteristics and that change can be measured or estimated.

5.2.5.3 Dynamic Cone Penetration Sounding

The Dynamic Cone Penetration Sounding (D) shall be presented using the following format:

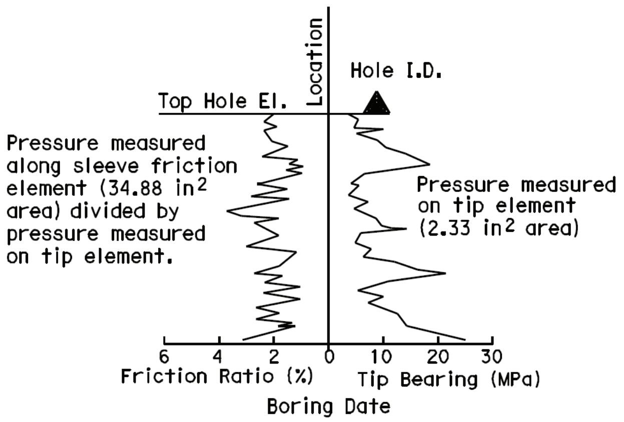
Figure 5-7



5.2.5.4 Cone Penetration Test (CPT) Sounding

A Cone Penetration Test (CPT) sounding shall be presented using the following format:

Figure 5-8

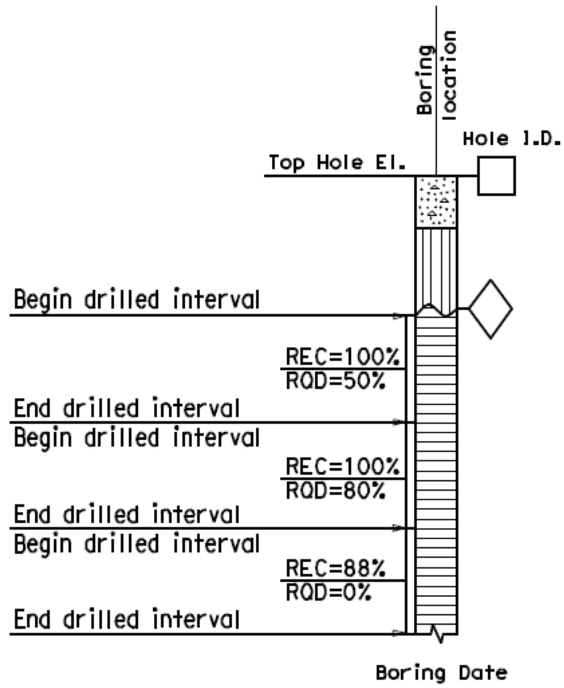


CONE PENETRATION TEST (CPT) SOUNDING

5.2.5.5 Rock Coring

Rock coring logs shall be presented using the following format:

Figure 5-9



5.2.5.6 Hole Type Symbols

Hole type is identified within the hole identification numbering convention (see Section 2.3) and symbolized on the LOTB as follows:

Figure 5-10

BOREHOLE IDENTIFICATION		
Symbol	Hole Type	Description
Size (double box)	A	Auger Boring
Size (box)	R P	Rotary drilled boring Rotary percussion boring (air)
Size (diamond)	R	Rotary drilled diamond core
Size (vertical box)	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
[ ]	O	Other

5.2.5.7 Graphical Representation of Material Types

Soil Group Name and Group Symbol and Rock Type are symbolized on the LOTB as follows:

Figure 5-11

GROUP SYMBOLS AND NAMES

Graphic / Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly graded SAND Poorly graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic / Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY elastic ELASTIC SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

ROCK GRAPHIC SYMBOLS
IGNEOUS ROCK
SEDIMENTARY ROCK
METAMORPHIC ROCK

5.3 Boring Records

Figure 5-12

LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
Sue Pervisor	**1-1-07**	**1-2-07**	**34° 0' 24.62" / -117° 7' 62.55" WGS 84**	**R-07-001**
DRILLING CONTRACTOR			BOREHOLE LOCATION (Station, Offset, Line)	SURFACE ELEVATION
Gregg Drilling & Testing, Inc.			**Offset 24R C/L Rte 36**	**20.7 ft NAVD 88**
DRILLING METHOD			DRILL RIG	BOREHOLE DIAMETER
Rotary Wash			**CS 2000 (track)**	**8.5 in. (soil); 4 in. (rock)**
SAMPLER TYPE(S) AND SIZE(S) (ID)			SPT HAMMER TYPE	HAMMER EFFICIENCY, ERi
SPT (1.4"), Shelby (2.87"), HQ core			**Safety semi-automatic, 140 lb, 30-inch drop**	**90%**
BOREHOLE BACKFILL AND COMPLETION			GROUNDWATER READINGS — DURING DRILLING **12 ft** — AFTER DRILLING (DATE) **21 ft on 1-4-07**	TOTAL DEPTH OF BORING
Neat cement grout backfill				**39.0 ft**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per Foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0		Well-graded SAND with GRAVEL and COBBLES (SW); loose; yellowish brown; moist; about 10% subrounded COBBLES; about 15% fine to coarse GRAVEL; about 80% fine to coarse SAND; about 5% fines [FILL].												
	1														
18.72	2														
	3														
					S01	2 2 2	4	94							
16.72	4														
	5														
14.72	6														
	7														
12.72	8														
			At 8.5 ft, becomes medium dense.		S02	4 6 6	12	100		5	105				PA
	9														
10.72	10														
	11		SANDY lean CLAY (CL); medium stiff; dark bluish gray; moist; about 35% medium SAND; about 65% fines; trace shell fragments [BAY MUD].												
8.72	12														
	13														
					U03		0.25	100		22	100	PP = 0.55 TV = 0.25			
6.72	14														
	15														
4.72	16														
	17														
2.72	18														
			At 18.5 ft, with no shell fragments.		U04			100		20	100	PP = 0.45 UU = 0.50			PA, PI
	19														
0.72	20														
	21														
-1.28	22														
	23														
			At 23.5 ft, becomes stiff; dark gray.		U05			100		20	101	PP = 0.45 UU = 0.60			PA, PI
-3.28	24														
	25														

(continued)

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Office of Geotechnical Design - North

REPORT TITLE				HOLE ID
BORING RECORD				**R-07-001**
DIST. **12**	COUNTY **Orange**	ROUTE **I-405**	POSTMILE **R34.1/R39.2**	EA **12-047643**
PROJECT OR BRIDGE NAME **I-880 Realignment, Whitman Dr., O. C.**				
BRIDGE NUMBER **53-0045**	PREPARED BY **Sue Pervisor**		DATE **5-25-07**	SHEET **1 of 2**

Figure 5-12 (continued)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per Foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	25	SANDY lean CLAY (CL) *(continued)*.												
-5.28	26													
	27													
-7.28	28	SEDIMENTARY ROCK (Shale), grayish blue, intensely weathered, weak, moderately soft, intensely to moderately fractured, [BEDROCK].		S06	10 53/6"		100							SPT refusal at 6"; switch to coring.
	29	At 29 ft, becomes moderately to slightly weathered, strong, moderately hard, moderately fractured.		C07			90	60						
-9.28	30													PL
	31													
-11.28	32													
	33													
-13.28	34	At 34 ft, becomes slightly fractured.		C08			100	90						
	35													
-15.28	36													
	37													
-17.28	38													
	39	Bottom of Borehole at 39.0 ft. Boring terminated at planned depth.												
-19.28	40													
	41													
-21.28	42													
	43													
-23.28	44													
	45													
-25.28	46													
	47													
-27.28	48													
	49													
-29.28	50													
	51													
-31.28	52													
	53													
-33.28	54													
	55													

Department of Transportation
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Geotechnical Services
Office of Geotechnical Design - North

REPORT TITLE				HOLE ID
BORING RECORD				R-07-001
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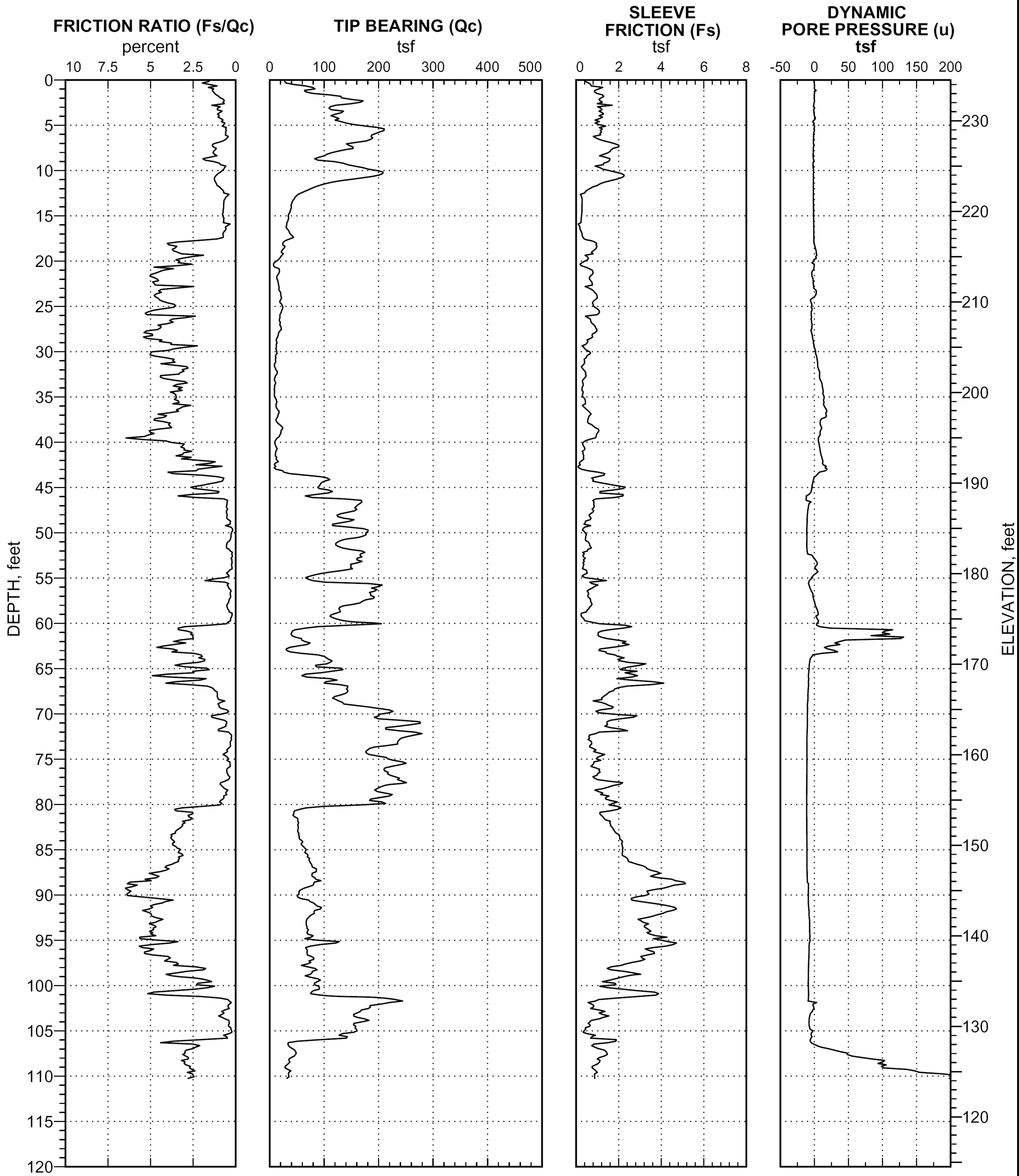
PROJECT OR BRIDGE NAME I-880 Realignment, Whitman Dr., O. C.				
BRIDGE NUMBER 53-0045	PREPARED BY Sue Pervisor		DATE 5-25-07	SHEET 2 of 2

Figure 5-13



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REPORT TITLE				HOLE ID
BORING RECORD				**CPT-07-001**
DIST. **04**	COUNTY **Alameda**	ROUTE **Rte 36**	POSTMILE **R34.1/R39.2**	EA **04-047643**
PROJECT OR BRIDGE NAME **Rte 36 Realignment Project**				
BRIDGE NUMBER **53-0045**	PREPARED BY **Sue Pervisor**		DATE **5-20-07**	SHEET **1 of 1**

5.3.1 Content and Characteristics of the BR

A Boring Record (BR) document is presented as an attachment to a geotechnical report and is characterized by the following attributes:

- Presents a single borehole record or CPT sounding.
- Presents the borings to an elevation scale.
- Presents the type of drilling method used to perform the investigation, the type of sampling performed, and how the sampler was advanced.
- Presents the location and description, both graphical and written, of the types of soil and rock encountered within the borehole.
- Accommodates the presentation of select field and laboratory test results.
- Optimized for printing on 8.5" x 11" sheets
- Is accompanied by BR Legend Sheets.

5.3.2 Notes on the BR

If the procedures of this manual were followed without exception, then the following note shall appear on the first page of the BR:

"This Boring Record was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date)"

If an exception to the procedures of this manual has been approved and implemented, then the note shall be modified to read:

"This Boring Record was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (Date) except as noted in (Section) of (Report Title) dated (Date)"

Optional notes are left to the discretion of the geoprofessional and, if are specific to an elevation or depth, should be presented at the appropriate location in the "Remarks" column. These notes may include:

- Changes in drilling equipment
- Other drilling observations from Sections 2.4.22 or 2.5.17.

Notes that are more general in content, such as a site observation, should be placed within the body of the geotechnical report.

5.3.3 The Boring Record Legend Sheets

The soil and rock legend sheets are standard forms that provide convenient references for the *required* soil and rock description, identification, and/or classification components presented in this Manual. References for *optional* descriptors do not appear on the legend sheets; however, they are explained in this Manual. To correctly interpret the BR, the reader shall be familiar with this Manual.

There are three legend sheets: one predominantly for soil and the other for rock, as shown in the following figures.

The legend sheets define the format for the graphical presentation of a boring log and differentiate among the various borehole and sounding types. The legend sheets also present the symbols used to identify laboratory tests.

Figure 5-14

GROUP SYMBOLS AND NAMES

Graphic / Symbol	Group Names	Graphic / Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY elastic ELASTIC SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTS

C	Consolidation (ASTM D 2435-04)
CL	Collapse Potential (ASTM D 5333-03)
CP	Compaction Curve (CTM 216 - 06)
CR	Corrosion, Sulfates, Chlorides (CTM 643 - 99; CTM 417 - 06; CTM 422 - 06)
CU	Consolidated Undrained Triaxial (ASTM D 4767-02)
DS	Direct Shear (ASTM D 3080-04)
EI	Expansion Index (ASTM D 4829-03)
M	Moisture Content (ASTM D 2216-05)
OC	Organic Content (ASTM D 2974-07)
P	Permeability (CTM 220 - 05)
PA	Particle Size Analysis (ASTM D 422-63 [2002])
PI	Liquid Limit, Plastic Limit, Plasticity Index (AASHTO T 89-02, AASHTO T 90-00)
PL	Point Load Index (ASTM D 5731-05)
PM	Pressure Meter
PP	Pocket Penetrometer
R	R-Value (CTM 301 - 00)
SE	Sand Equivalent (CTM 217 - 99)
SG	Specific Gravity (AASHTO T 100-06)
SL	Shrinkage Limit (ASTM D 427-04)
SW	Swell Potential (ASTM D 4546-03)
TV	Pocket Torvane
UC	Unconfined Compression - Soil (ASTM D 2166-06) Unconfined Compression - Rock (ASTM D 2938-95)
UU	Unconsolidated Undrained Triaxial (ASTM D 2850-03)
UW	Unit Weight (ASTM D 4767-04)
VS	Vane Shear (AASHTO T 223-96 [2004])

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (SPT)
- Standard California Sampler
- Modified California Sampler
- Shelby Tube
- Piston Sampler
- NX Rock Core
- HQ Rock Core
- Bulk Sample
- Other (see remarks)

DRILLING METHOD SYMBOLS

- Auger Drilling
- Rotary Drilling
- Dynamic Cone or Hand Driven
- Diamond Core

WATER LEVEL SYMBOLS

- First Water Level Reading (during drilling)
- Static Water Level Reading (short-term)
- Static Water Level Reading (long-term)

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DIST. 12	COUNTY Orange	ROUTE I-405	POSTMILE R34.1/R39.2	EA 12-047643
PROJECT OR BRIDGE NAME: I-880 Realignment, Whitman Dr., O. C.				
BRIDGE NUMBER 53-0045	PREPARED BY		DATE	SHEET 1 of 3

Figure 5-15

CONSISTENCY OF COHESIVE SOILS				
Descriptor	**Unconfined Compressive Strength (tsf)**	**Pocket Penetrometer (tsf)**	**Torvane (tsf)**	**Field Approximation**
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 - 0.50	0.25 - 0.50	0.12 - 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 - 1.0	0.50 - 1.0	0.25 - 0.50	Can be penetrated several inches by thumb with moderate effort
Stiff	1.0 - 2.0	1.0 - 2.0	0.50 - 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2.0 - 4.0	2.0 - 4.0	1.0 - 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

APPARENT DENSITY OF COHESIONLESS SOILS	
Descriptor	**SPT N_{60} - Value (blows / foot)**
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE	
Descriptor	**Criteria**
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS	
Descriptor	**Criteria**
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

SOIL PARTICLE SIZE		
Descriptor		**Size**
Boulder		> 12 inches
Cobble		3 to 12 inches
Gravel	Coarse	3/4 inch to 3 inches
	Fine	No. 4 Sieve to 3/4 inch
Sand	Coarse	No. 10 Sieve to No. 4 Sieve
	Medium	No. 40 Sieve to No. 10 Sieve
	Fine	No. 200 Sieve to No. 40 Sieve
Silt and Clay		Passing No. 200 Sieve

PLASTICITY OF FINE-GRAINED SOILS	
Descriptor	**Criteria**
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll, and not much time is required to reach the plastic limit; it cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

CEMENTATION	
Descriptor	**Criteria**
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

NOTE: This legend sheet provides descriptors and associated criteria for required soil description components only. Refer to Caltrans Soil and Rock Logging, Classification, and Presentation Manual (July 2007), Section 2, for tables of additional soil description components and discussion of soil description and identification.

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Geotechnical Services
Office of Geotechnical Design - North

REPORT TITLE				
BORING RECORD LEGEND				
DIST. **12**	COUNTY **Orange**	ROUTE **I-405**	POSTMILE **R34.1/R39.2**	EA **12-047643**
PROJECT OR BRIDGE NAME **I-880 Realignment, Whitman Dr., O. C.**				
BRIDGE NUMBER **53-0045**	PREPARED BY		DATE	SHEET **2 of 3**

Figure 5-16

ROCK GRAPHIC SYMBOLS

- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

BEDDING SPACING

Descriptor	Thickness or Spacing
Massive	> 10 ft
Very thickly bedded	3 to 10 ft
Thickly bedded	1 to 3 ft
Moderately bedded	3-5/8 inches to 1 ft
Thinly bedded	1-1/4 to 3-5/8 inches
Very thinly bedded	3/8 inch to 1-1/4 inches
Laminated	< 3/8 inch

WEATHERING DESCRIPTORS FOR INTACT ROCK

	Diagnostic Features					
	Chemical Weathering-Discoloration-Oxidation		Mechanical Weathering and Grain Boundary Conditions	Texture and Solutioning		
Descriptor	Body of Rock	Fracture Surfaces		Texture	Solutioning	General Characteristics
Fresh	No discoloration, not oxidized	No discoloration or oxidation	No separation, intact (tight)	No change	No solutioning	Hammer rings when crystalline rocks are struck.
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact (tight)	Preserved	Minor leaching of some soluble minerals may be noted	Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty"; feldspar crystals are "cloudy"	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally preserved	Soluble minerals may be mostly leached	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation (refer to grain boundary conditions)	All fracture surfaces are discolored or oxidized; surfaces are friable	Partial separation, rock is friable; in semi-arid conditions, granitics are disaggregated	Altered by chemical disintegration such as via hydration or argillation	Leaching of soluble minerals may be complete	Dull sound when struck with hammer; usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures or veinlets. Rock is significantly weakened.
Decomposed	Discolored of oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil; partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete		Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes".

Note: Combination descriptors (such as "slightly weathered to fresh") are used where equal distribution of both weathering characteristics is present over significant intervals or where characteristics present are "in between" the diagnostic feature. However, combination descriptors should not be used where significant identifiable zones can be delineated. Only two adjacent descriptors shall be combined. "Very intensely weathered" is the combination descriptor for "decomposed to intensely weathered".

RELATIVE STRENGTH OF INTACT ROCK

Descriptor	Uniaxial Compressive Strength (psi)
Extremely Strong	> 30,000
Very Strong	14,500 - 30,000
Strong	7,000 - 14,500
Medium Strong	3,500 - 7,000
Weak	700 - 3,500
Very Weak	150 - 700
Extremely Weak	< 150

ROCK HARDNESS

Descriptor	Criteria
Extremely Hard	Specimen cannot be scratched with pocket knife or sharp pick; can only be chipped with repeated heavy hammer blows
Very hard	Specimen cannot be scratched with pocket knife or sharp pick; breaks with repeated heavy hammer blows
Hard	Specimen can be scratched with pocket knife or sharp pick with heavy pressure; heavy hammer blows required to break specimen
Moderately Hard	Specimen can be scratched with pocket knife or sharp pick with light or moderate pressure; breaks with moderate hammer blows
Moderately Soft	Specimen can be grooved 1/6 in. with pocket knife or sharp pick with moderate or heavy pressure; breaks with light hammer blow or heavy hand pressure
Soft	Specimen can be grooved or gouged with pocket knife or sharp pick with light pressure, breaks with light to moderate hand pressure
Very Soft	Specimen can be readily indented, grooved, or gouged with fingernail, or carved with pocket knife; breaks with light hand pressure

CORE RECOVERY CALCULATION (%)

$$\frac{\Sigma \text{ Length of the recovered core pieces (in.)}}{\text{Total length of core run (in.)}} \times 100$$

RQD CALCULATION (%)

$$\frac{\Sigma \text{ Length of intact core pieces > 4 in.}}{\text{Total length of core run (in.)}} \times 100$$

FRACTURE DENSITY

Descriptor	Criteria
Unfractured	No fractures
Very Slightly Fractured	Lengths greater 3 ft
Slightly Fractured	Lengths from 1 to 3 ft, few lengths outside that range
Moderately Fractured	Lengths mostly in range of 4 in. to 1 ft, with most lengths about 8 in.
Intensely Fractured	Lengths average from 1 in. to 4 in. with scattered fragmented intervals with lengths less than 4 in.
Very Intensely Fractured	Mostly chips and fragments with few scattered short core lengths

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Geotechnical Services
Office of Geotechnical Design - North

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DIST. 12	COUNTY Orange	ROUTE I-405	POSTMILE R34.1/R39.2	EA 12-047643
PROJECT OR BRIDGE NAME: I-880 Realignment, Whitman Dr., O. C.				
BRIDGE NUMBER 53-0045	PREPARED BY	DATE	SHEET 3 of 3	

References

Association of State Highway and Transportation Officials (AASHTO) (1988), *Manual on Subsurface Investigations*. Washington, D.C.

American Society for Testing and Materials (ASTM), *Annual Book of ASTM Standards, 2007 Edition*, ASTM International, West Conshohocken, PA

Das, Braja M. (1997), *Advanced Soil Mechanics,2nd Edition*, Taylor & Francis Group

Departments of the Army And The Air Force (1983), *Backfill For Subsurface Structures*, 5-8184/AFM 85, Chap. 5, Technical Manual Headquarters, No. 5-818-4, Air Force Manual No. 88-5, Chapter 5 Washington, Dc, 1 June 1983

International Society of Rock Mechanics (ISRM) (1981), *Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses*, ed. E. T. Brown

U.S. Department of the Interior, Bureau of Reclamation (2001), *Engineering Geology Field Manual, 2nd Edition*

U.S. Department of Transportation, Federal Highway Administration, *Geotechnical Guideline No.15, Differing Site Conditions, Geotechnical Engineering Notebook* (1996)

Wyllie, D.C., Mah, C. M. (2004), *Rock Slope Engineering: Civil and Mining*, 4th Edition, Taylor & Francis

Zumberge, J. H., Rutford, R. H., Carter, J. L. (2003), *Laboratory Manual For Physical Geology, 11th Edition*

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Appendix A: Field Test Procedures

A.1 Pocket Penetrometer

The Pocket Penetrometer test is conducted using the following general instructions:

- To begin test, remove protective cap, push ring against body so that low side reads 0.
- Slowly insert piston until engraved mark is level with soil.
- Observe the reading in TSF (KG/SQ CM) using low side of ring, (side closest to the piston end): record reading and repeat.
- For weak soils, use 1” adapter foot, multiply reading by 0.0625.

A.2 Torvane

The Torvane test is conducted using the following general instructions:

- To start test, push indicator counter clockwise to zero stop.
- Select reasonably flat surface at least 1 inch in diameter.
- Using midsize vane, one revolution equals 1 TSF (1KG/SQ CM).
- One revolution using small and large vane equals respectively 2.5 and 0.2 TSF (KG/SQ CM).
- Press pocket vane shear tester into soil to depth of blade; maintain constant vertical pressure while turning knob clockwise at rate to develop failure within 5 to 10 seconds.
- After failure develops, release remaining spring tension slowly. Pointer will indicate maximum shear value until manually reset.

A.3 Dry Strength

From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary. From the molded material, make at least three test specimens. A test specimen shall be a ball of material about 1⁄2 in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C. If the test specimen contains natural dry lumps, those that are about 1⁄2 in. (12 mm) in diameter may be used in place of the molded balls. Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in the table in Section 2.4.14. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand. The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid.

A.4 Dilatancy

From the specimen, select enough material to mold into a ball about 1⁄2 in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in the table in Section 2.4.15. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

A.5 Toughness

Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1⁄8 in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1⁄8 in. The thread will crumble at a diameter of 1⁄8 in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in the table in Section 2.4.16.

A.6 Jar Slake Index Test

Slaking behavior of intact rock specimens is quantified as an index. A laboratory index test called the Slake Durability Test (ASTM D 4644-04) is the most rigorous method of measuring this behavior. A simple, but less sensitive method can be employed in the field or in the office to screen specimens of the Slake Durability test. The “Jar Slake Test” method is presented here. A water filled jar and a watch are all that are required to perform this simple test. The steps are as follows:

- A fragment of rock is immersed in enough water to cover it by 15 mm. It is best if the rock is oven dried. It has been reported that damp material is relatively insensitive to degradation in this test when compared with dry material.
- After immersion, the fragment is observed continuously for the first 10 minutes and carefully during the first 30 minutes. When a reaction occurs, it is often during the first 30 minutes. A final observation is made after 24 hours.
- The condition of the piece is categorized (complete breakdown, partial breakdown, no change), as shown in the table in Section 2.5.14 (Air Force Manual 1983).

A.7 Calcium Carbonate

Because calcium carbonate is a common cementing agent, it is important to report its presence, which is done on the basis of the reaction with dilute hydrochloric acid (HCl). Use the ASTM D 2488-06 standard to describe the reaction with HCl, as indicated in Figure 2-19 below.

Figure 2-19
Descriptors for calcium carbonate reaction

Description	Criteria
None	No visible reaction.
Weak	Some reaction, with bubbles forming slowly.
Strong	Violent reaction, with bubbles forming immediately.

A.8 Standard Penetration Test

Standard Penetration Tests (SPT) shall be conducted according to the following test methods:

- ASTM D 1586-99, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils
- ASTM D 6066-96, Standard Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

The following guidance is provided:

- Blow counts shall be reported on the LOTB and BR as observed in the field, N, with no corrections.

  Where,

  N The sum of the hammer blows required to drive the sampler over the test interval from 0.5 to 1.5 ft below the cleanout depth.

- Hammer efficiency shall be noted on the LOTB and BR to allow the reader to determine N_{60} or $(N_1)_{60}$.

  Where,

  ER_i Hammer energy ratio

N_{60} Penetration resistance adjusted to a 60 % drill rod energy ratio per ASTM D 6066-96: $N_{60} = N_{measured} \times (ER_i / 60)$

$(N_1)_{60}$ Penetration resistance adjusted for energy and normalized to a 1 ton/ft^2 stress level.

- Blow counts for each of the 6 inch increments shall be recorded in the field, but not necessarily reported on the LOTB and BR. The 2nd and 3rd driving intervals shall be summed and reported.

  For example:

  1st 6 in. interval: 10 blows
  2nd 6 in. interval: 15 blows
  3rd 6 in. interval: 18 blows
  N reported as "33"

- For partial increments, the depth of penetration shall be reported to the nearest 1 inch, in addition to the number of blows.

  For example:

  1st 6 in. interval: 20 blows
  2nd 6 in. interval: 40 blows
  3rd 6 in. interval: 60 blows for 2 inches, then refusal
  N reported as "100/8"

- If the seating interval (1st 6 in. interval) is not achieved, note refusal.

  For example:

  1st 6 in. interval: 50 blows for 2 inches, then refusal
  N reported as "REF"

- If a substantial change in material is encountered over the course of driving the sampler, the 2nd and 3rd driving intervals can be reported separately.

  For example:

  1st 6 in. interval: 10 blows
  2nd 6 in. interval: 20 blows
  3rd 6 in. interval: 60 blows for 3 inches, then refusal
  N reported as "20/6, 60/3"

A.9 Core Recovery (REC)

The core recovery value (REC), with few exceptions, provides an indication of the success of the coring operation in recovering the cored rock. Portions of the cored rock mass may not be recovered because the fluid used in the drilling operations transports portions of the rock mass during the coring operation or the rotation of the core barrel traps and grinds away portions of the rock mass. Diminished core recovery can also be attributed to voids within the rock mass. Core recovery is expressed as a percentage.

$$\text{REC} = \frac{\Sigma\,(\text{Length of the recovered core pieces, inches})(100\%)}{\text{Total length of the core run, inches}}$$

A.10 Rock Quality Designation (RQD)

Rock Quality Designation is an index that relates to the degree of fracturing in a rock mass as observed in a core specimen. A high value of RQD is indicative of a less fractured rock mass or a rock mass having widely spaced fractures. RQD is valid for core diameters from 1.4 to 3.35 inches. This RQD criteria is generally based on ASTM D 6032-02.

$$\text{RQD} = \frac{\Sigma\,(\text{Length of intact core pieces} \geq 4 \text{ inches})(100\%)}{\text{Total length of the core run, inches}}$$

Used alone, RQD is not sufficient to provide an adequate description of rock mass quality. The RQD does not account for joint orientation, tightness, continuity, and gouge material. The RQD shall be used in combination with other geological and geotechnical input.

The RQD denotes the percentage of intact rock retrieved from a borehole of any orientation. All pieces of intact rock core equal to or greater than 4 inches long are summed and divided by the total length of the core run. An intact core is any segment of core between two open, natural discontinuities.

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Appendix B: Field Logging Aids

B.1 Field Sample Logging Forms

Forms are provided to assist the sample logging process in the field. One form is used specifically for soil samples, while the other used for rock samples.

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Soil Sample Field Description & Identification

Instructions:

- Field Description and Identification based upon *Soil and Rock Logging, Classification, and Presentation Manual*, dated July 1, 2007.
- Shaded fields are *required*, non-shaded fields are *optional*.
- Intensely weathered or decomposed rock that is friable and that can be reduced to gravel size or smaller by normal hand pressure shall be identified and described as rock followed by the soil identification or classification, and description in parenthesis.

Project				**Logged by**	**Date**	**Hole ID**
District	**County**	**Route**	**Postmile**	**EA**	**Sample Depth**	**Sample ID**
Drilling Method				**Sampler Type and Size**		

SPT Blow Counts	**Hammer energy ratio (ER_i)**	**Pocket Penetrometer Measurement**
1st 6 in. interval		
2nd 6 in. interval	$N_{60} = N_{measured} \times (ER_i/60)$	**Torvane Measurement**
3rd 6 in. interval		
$N_{measured}$ =		

Group Name	**Group Symbol**	**Color**

Consistency	Apparent Density	Moisture	Structure	Cementation	Additional Description
☐Very Soft ☐Soft ☐Medium Stiff ☐Stiff ☐Very Stiff ☐Hard	☐Very loose ☐Loose ☐Medium dense ☐Dense ☐Very dense	☐Dry ☐Moist ☐Wet	☐Stratified ☐Laminated ☐Fissured ☐Slickensided ☐Blocky ☐Lensed ☐Homogeneous	☐Weak ☐Moderate ☐Strong	

Percent (est.) 100% Total by Volume of entire sample

			Weathering	Rock Hardness	Angularity	Shape
Boulders	%	**Rock Identification** **Intersected Lengths of Core**	☐Fresh ☐Slightly Weathered to Fresh ☐Slightly Weathered ☐Moderately to Slightly Weathered ☐Moderately Weathered ☐Intensely to Moderately Weathered ☐Intensely Weathered ☐Very Intensely Weathered ☐Decomposed	☐Extremely Hard ☐Very Hard ☐Hard ☐Moderately Hard ☐Moderately Soft ☐Soft ☐Very Soft	☐Angular ☐Subangular ☐Subrounded ☐Rounded	☐Flat ☐Elongated ☐Flat and Elongated
Cobbles	%	**Rock Identification** **Intersected Lengths of Core**	☐Fresh ☐Slightly Weathered to Fresh ☐Slightly Weathered ☐Moderately to Slightly Weathered ☐Moderately Weathered ☐Intensely to Moderately Weathered ☐Intensely Weathered ☐Very Intensely Weathered ☐Decomposed	☐Extremely Hard ☐Very Hard ☐Hard ☐Moderately Hard ☐Moderately Soft ☐Soft ☐Very Soft	☐Angular ☐Subangular ☐Subrounded ☐Rounded	☐Flat ☐Elongated ☐Flat and Elongated

Percent (est.) 100% Total by Weight of soils portion

Gravel	%	(or) **Proportion** ☐Trace ☐Few ☐Little ☐Some ☐Mostly	**Size** ☐Coarse ☐Fine	**Angularity** ☐Angular ☐Subangular ☐Subrounded ☐Rounded	**Shape** ☐Flat ☐Elongated ☐Flat and Elongated	
Sand	%	(or) **Proportion** ☐Trace ☐Few ☐Little ☐Some ☐Mostly	**Size** ☐Coarse ☐Medium ☐Fine	**Angularity** (for coarse only) ☐Angular ☐Subangular ☐Subrounded ☐Rounded		
Fines	%	(or) **Proportion** ☐Trace ☐Few ☐Little ☐Some ☐Mostly	**Plasticity** ☐Nonplastic ☐Low ☐Medium ☐High	**Dry Strength** ☐None ☐Low ☐Medium ☐High ☐Very High	**Dilatency** ☐None ☐Slow ☐Rapid	**Toughness** ☐Low ☐Medium ☐High

Rock Sample Field Description & Identification

Instructions:

- Field Description and Identification based upon *Soil and Rock Logging, Classification, and Presentation Manual*, dated July 1, 2007.
- Shaded fields are *required*, non-shaded fields are *optional*.
- Intensely weathered or decomposed rock that is friable and that can be reduced to gravel size or smaller by normal hand pressure shall be identified and described as rock followed by the soil identification or classification, and description in parenthesis.

Project				**Logged by**	**Date**	**Hole ID**
District	**County**	**Route**	**Postmile**	**EA**	**Sample Depth**	**Sample ID**

Drilling or Coring Method	**Sampler Type and Size**

Length of Core Run	**Length of the recovered core pieces**	**Length of intact core pieces > 4 inches**

Recovery (REC)	**Rock Quality Designation (RQD)**

Rock Identification

Color | **Odor**

Additional Description

Family Name
☐Sedimentary
☐Igneous
☐Metamorphic

Bedding Spacing
☐Massive
☐Very thickly bedded
☐Thickly bedded
☐Moderately bedded
☐Thinly bedded
☐Very thinly bedded
☐Laminated

Texture
☐Pitted
☐Vuggy
☐Cavity
☐Honeycombed
☐Vesicular

Rock Grain-Size

(Crystalline Igneous and Metamorphic Rock)
☐Very coarse grained or pegmatitic
☐Coarse-grained
☐Medium-grained
☐Fine-grained
☐Aphanitic

(Sedimentary Rock)
☐Boulder, Boulder Conglomerate
☐Cobble, Cobble Conglomerate
☐Pebble, Pebble Conglomerate
☐Granule, Granule Conglomerate
☐Very Coarse Sand
☐Coarse Sand
☐Medium Sand
☐Fine Sand
☐Very Fine Sand
☐Silt, Siltstone, Shale
☐Clay, Claystone, Shale

(Pyroclastic Igneous Rock)
☐Block (Angular), Volcanic Breccia
☐Bomb (Rounded), Agglomerate
☐Lapilli, Lapilli Tuff
☐Coarse Ash, Coarse Tuff
☐Fine Ash, Fine Tuff

Weathering
☐Fresh
☐Slightly Weathered to Fresh
☐Slightly Weathered
☐Moderately to Slightly Weathered
☐Moderately Weathered
☐Intensely to Moderately Weathered

(Requires completion of *Soil Sample Field Description and Identification* form)
☐Intensely Weathered
☐Very Intensely Weathered
☐Decomposed

Rock Hardness
☐Extremely Hard
☐Very Hard
☐Hard
☐Moderately Hard
☐Moderately Soft
☐Soft
☐Very Soft

Fracture Density
☐Unfractured
☐Very slightly fractured
☐Slightly to very slightly fractured
☐Slightly fractured
☐Moderately to slightly fractured
☐Moderately fractured
☐Intensely to moderately fractured
☐Intensely fractured
☐Very intensely to intensely fractured
☐Very intensely fractured

Discontinuity Type
☐Joint (JT)
☐Foliation Joint (FJ) or Bedding Joint (BJ)
☐Bedding Plane Separation
☐Incipient Joint (IJ) or Incipient Fracture (IF)
☐Random Fracture (RF)
☐Mechanical Break (MB)
☐Fracture Zone (FZ)

Discontinuity Dip Magnitude

Jar Slake Index, I_j
☐1
☐2
☐3
☐4
☐5
☐6

Discontinuity Weathering
☐Fresh
☐Slightly Weathered to Fresh
☐Slightly Weathered
☐Moderately to Slightly Weathered
☐Moderately Weathered
☐Intensely to Moderately Weathered
☐Intensely Weathered
☐Very Intensely Weathered
☐Decomposed

Discontinuity Healing
☐Totally Healed
☐Moderately Healed
☐Partially Healed
☐Not Healed

Healing Material:

Discontinuity Infilling

Rock:
☐Extremely Hard
☐Very Hard
☐Hard
☐Moderately Hard
☐Moderately Soft
☐Soft
☐Very Soft

Soils:
☐Very Soft
☐Soft
☐Medium Stiff
☐Stiff
☐Very Stiff
☐Hard

Appendix C:
Procedural Documents

State of California
DEPARTMENT OF TRANSPORTATION

Business, Transportation and Housing Agency

Memorandum

Flex your power!
Be energy efficient!

To: ALL STAFF
GEOTECHNICAL SERVICES
DIVISION OF ENGINEERING SERVICES

Date: June 15, 2007

From: JAMES E. DAVIS
Deputy Division Chief
Geotechnical Services

Subject: Exception Process for the Soil & Rock Logging, Classification, and Presentation Manual

All Geotechnical Services staff, including consultants performing work on behalf of the Department, shall follow the procedures in the Soil & Rock Logging, Classification, and Presentation Manual (ref: memo to all staff dated June 15, 2007). Although the manual attempts to provide for most geotechnical conditions, there may be reason to deviate from its procedures or terminology. This memorandum provides the procedure that staff shall follow in order to gain approval for such deviations.

The policy terminology used in the manual is defined as follows:

Term	Standard Type	Definition
Shall, Required	Mandatory	*Mandatory Standard*. The associated provisions **must** be used. There is no acceptable alternative.
Should	Advisory	*Advisory Standard*. The associated provisions are preferred practices.
May, Optional	Permissive	*Permissive Standard*. Use or application of the associated provisions is left to the discretion of the Geoprofessional.

In cases where exceptions to mandatory or advisory standards are proposed by the geotechnical professional, a *Request for Exception* form shall be completed and signatures retained prior to finalizing or issuing any related document, such as a Log of Test Boring or Geotechnical Report. The completed *Request for Exception* form shall be placed in the project file and any related geotechnical report shall discuss the exception. When a LOTB or Boring Record presents information that deviates from mandatory or advisory standards, the standard note:

"This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (date)"

Shall be modified to read as follows:

"This LOTB sheet (Boring Record) was prepared in accordance with the Caltrans Soil & Rock Logging, Classification, and Presentation Manual (date) except as noted in (section) of (Report Title) dated (Date)"

Attachments

"Caltrans improves mobility across California"

Soil & Rock Logging, Classification, and Presentation Manual
Request for Exception

Name:
Office:
District-EA: -
Project Name:
Manual Section No.:

Description of Exception Being Requested:

Discussion of Why the Exception to Policy is Necessary:

Should the Manual be revised to allow for the exception? Please discuss.

Branch Chief	Office Chief (Advisory & Mandatory Standards)
Deputy Division Chief (Mandatory Standards)	Date Approved

cc: Project File, GS Corporate

Caltrans Soil & Rock Logging, Classification, and Presentation Manual

Committee Charter and Standard Procedures (June 2007)

Committee Members:	Tom Whitman, Chairperson David Jang Bob Price Hector Valencia Mark Hagy Craig Hannenian Loren Turner (DRI)
Committee Sponsor:	Tim Pokrywka

Purpose of Committee

The Soil & Rock Logging, Classification, and Presentation Manual Committee, formed by the Geotechnical Services Management Team (GSMT), shall maintain the manual as follows.

- The manual shall be kept current with respect to the state of practice of all standards and procedures presented in the manual.

- The committee shall consider all requests for modifications to the manual and respond to those requests in a timely manner.

Annual Review

The committee shall perform an annual review of the manual due to the GSMT in June of each year. The review shall consist of the following:

- Review of the manual's references and considerations of changes to reflect updated references, if any.
- Review of approved *"Request for Exception"* forms and consideration for revision to the manual to accommodate approved exceptions.
- Solicitation of comments by our partners such as the Association of Drilled Shaft Contractors (ADSC), Consultants and Construction and consideration of their issues.

Page 1 of 3

Standard Procedure for Modifying the Manual

1. Staff shall post requests for modifications on the *Caltrans Geotechnical Services Discussion Board, Soil & Rock Logging, Classification and Presentation Manual* Category located at:

   http://cap1.dot.ca.gov/forum/GeotechnicalServices/index.php

   The request for modification shall include at least the following information:
   - Name of requestor
   - Office
   - Manual Section Number
   - Description of Proposed Change
   - Discussion of Reason or Need for the Proposed Change
   - If applicable, reference to an approved *Request for Exception* relating to the Proposed Change

2. The committee chairperson will monitor the discussion board, review the proposal and assign any additional research to an appropriate person. The person will typically be the Committee Member representing the requesting office, but may be others depending on the proposal topic.
3. If the proposal is minor, the chairperson may implement the revision without input from the committee. Otherwise, depending on the proposal's complexity, the chairperson will either schedule a committee meeting, solicit comments on the discussion board, or ask for each member's recommendation on whether to implement the proposed change or not.
4. Acceptability of proposed changes will be by majority vote of the committee members present at the meeting, or by those who respond to the chairperson by the stated deadline.
5. Unless deemed urgent by the committee chairperson, revisions will be made annually and coincide with the annual report to the GSMT. An exception to this shall be during the first 12 months after initial release where the committee will be expected to address comments on an ongoing basis.

Committee Member Roles and Responsibilities

Committee members pledge to actively participate in maintenance of the manual according to this committee charter. It is expected that each committee member respond to correspondence in a timely manner so not to delay progress of related business.

Member Signatures

Thomas Whitman

David Jang

Robert Price

Hector Valencia

Mark Hagy

Craig Hannenian

Loren Turner

Page 3 of 3