SOIL AND ROCK CLASSIFICATION

1.0 PURPOSE

This section sets forth standard operating procedures (SOPs) for soil and rock classification to be used by AMEC personnel.

2.0 SCOPE

This document applies to all AMEC personnel involved with managing or participating in drilling and sampling activities who are responsible for soil and rock description.

This procedure shall serve as professional guidance for the AMEC personnel. It is not intended to obviate the need for professional judgment in unforeseen circumstances. Deviations from this procedure in the planning, or execution of activities, must be approved by the Project Manager.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

The Project Manager is responsible for ensuring that these standard soil and rock classification procedures are followed during projects conducted or supervised by a qualified individual. A qualified individual is defined as a person with a degree in geology, hydrogeology, soil science, or geotechnical/civil engineering with at least 1 year of experience in the classification of soils. Supervision is defined as onsite and continuous monitoring of the individual conducting soil classification.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

5.0 PROCEDURES

5.1 SOIL CLASSIFICATION

The basic purpose of the classification of soils is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serves as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but a complete word description.

Describing soils on a common basis is essential so that soils described by different site qualified personnel are comparable. Site individuals describing soils as part of U.S. Navy site activities must use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities at sites.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes and maximum particle size
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions such as consistency, density, structure, etc.
- USCS classification symbol

The USCS serves as a "shorthand" for classifying soil into 15 basic groups:

GW[1] Well graded (poorly sorted) gravel (>50% gravel, <5% fines)

GP[1] Poorly graded (well sorted) gravel (>50% gravel, <5% fines)

GM[1]	Silty gravel (>50% gravel, >15% silt)
GC[1]	Clayey gravel (>50% gravel, >15% clay)
SW[1]	Well graded (poorly sorted) sand (>50% sand, <5% fines)
SP[1]	Poorly graded (well sorted) sand (>50% sand, <5% fines)
SM1	Silty sand (>50% sand, >15% silt)
SC1	Clayey sand (>50% sand, >15% clay)
ML2	Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness and plasticity)
CL2	Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)
MH2	Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)
CH2	Inorganic, high plasticity (fat) clay (no dilatancy, high toughness and plasticity)
OL	Organic low plasticity silt or organic silty clay
OH	Organic high plasticity clay or silt
PT	Peat and other highly organic soils

[1] If percentage of fines is 5% to 15%, a dual identification shall be given (e.g., a soil with more than 50% poorly sorted gravel and 10% clay is designated GW-GC.

[2] If the soil is estimated to have 15% to 25% sand or gravel, or both, the words "with sand" or "with gravel" (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30% or more sand or gravel, or both, the words "sandy" or "gravely" (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use "sandy."

Figure I defines the terminology of the USCS. Flow charts presented in Figures 2 and 3 indicate the process for describing soils. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification, e.g., SC/CL, if the soil has been identified as having properties that do not distinctly place the soil into one group.

5.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. To become proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below.

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5 inch diameter sample liner.)

2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.

3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch.

4. Considering the rest of the sample, estimate and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).

5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).

6. Estimate percentages to the nearest 5%. If one of the components is present in a quantity considered less than 5%, indicate its presence by the term "trace".

7. The percentages of gravel, sand, and fines must add up to 100%. "Trace" is not included in the 100% total.

DEFINITION OF TERMS					
MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	GRAVELS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN GRAVELS (Less than 6% Fines)		GW	Well graded gravels, gravel-sand mixtures, little or no fines
				GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines		GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
				GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN SANDS (Less than 6% Fines)		SW	Well graded sands, gravelly sands, little or no fines
				SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines		SM	Silty sands, sand-silt mixtures, non-plastic fines
				SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	SILTS AND CLAYS Liquid Limit is Less Than 50%			ML	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
				CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
				OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
				CH	Inorganic clays of high plasticity, fat clays
				OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS				PT	Peat and other highly organic soils

GRAIN SIZES								
SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS	
	FINE	MEDIUM	COARSE	FINE	COARSE			
200	40	10	4	3/4"	3"	12"		
U.S. STANDARD SERIES SIEVE				CLEAR SQUARE SIEVE OPENINGS				

Figure 1

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

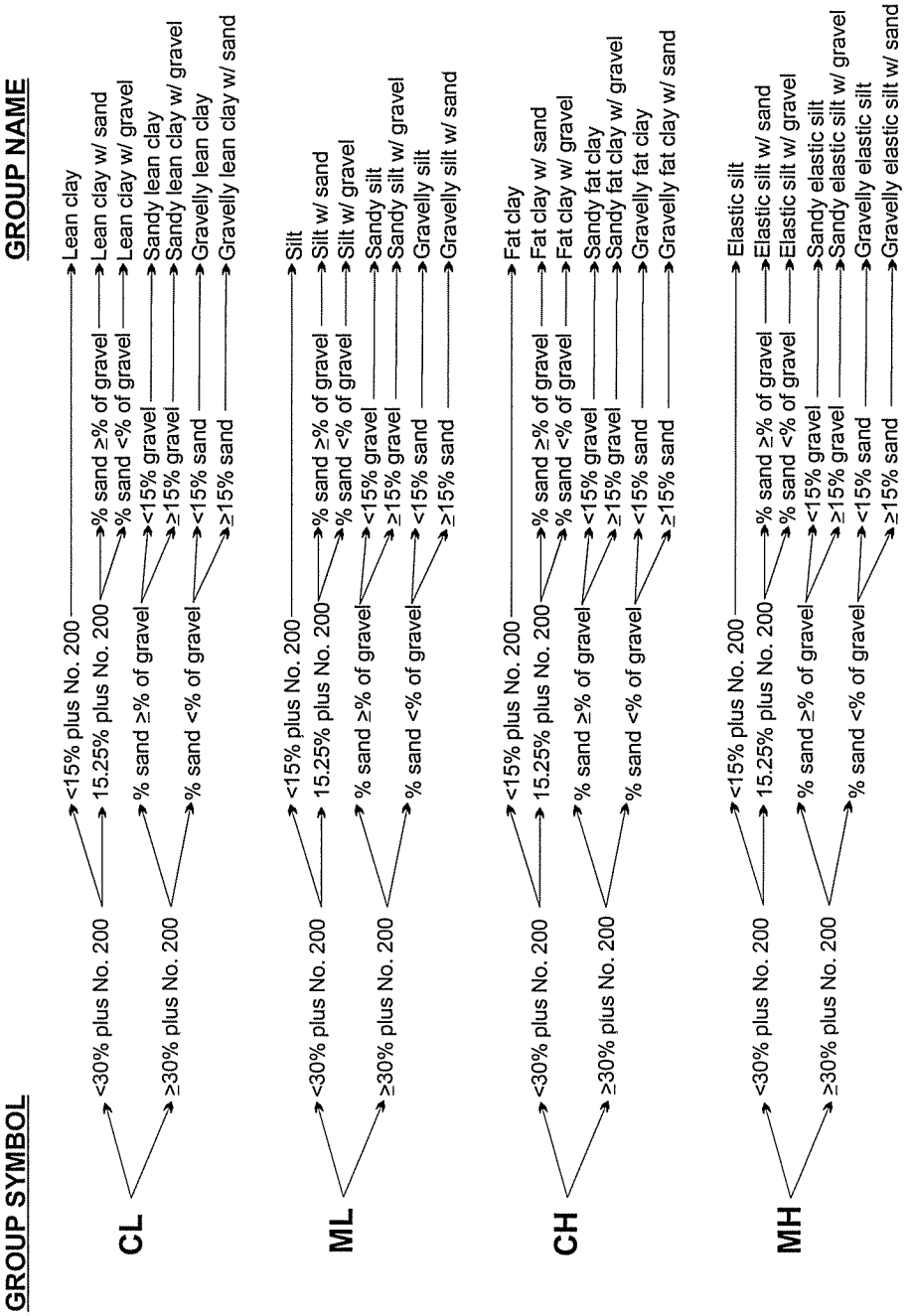


Figure 2

FLOW CHART FOR FINE GRAIN SOILS CLASSIFICATION

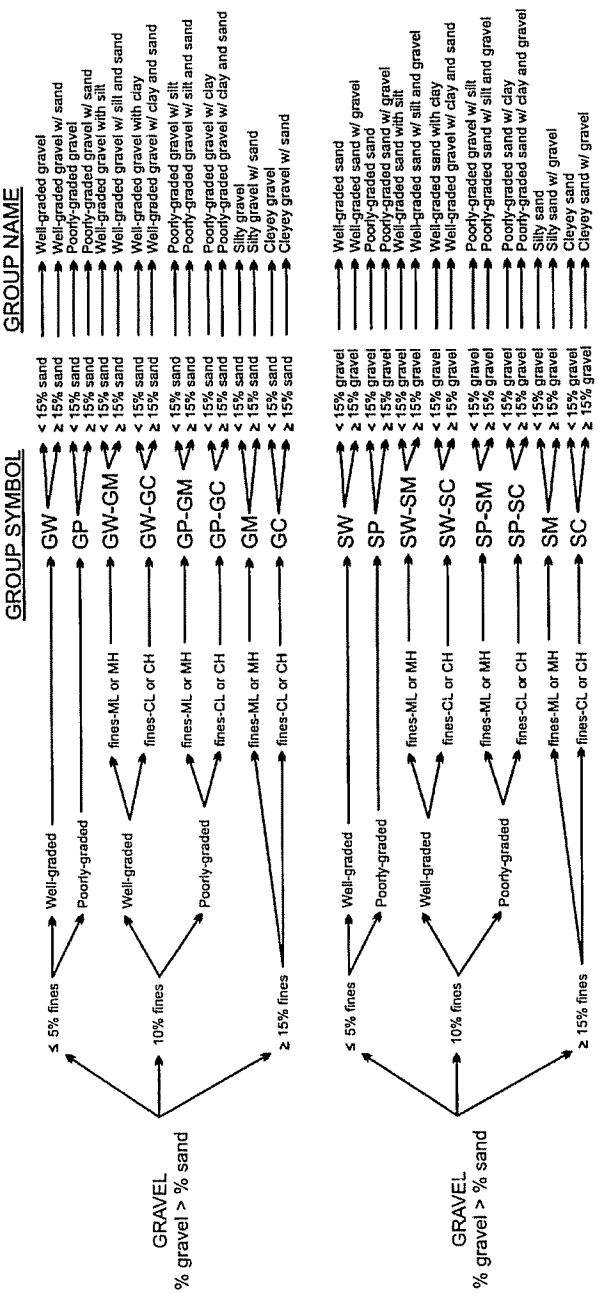


Figure 3

FLOW CHART FOR SOILS WITH GRAVEL

5.1.2 Soil Dilatancy, Toughness, and Plasticity

5.1.2.1 Dilatancy

To evaluate dilatancy, the following procedures shall be followed:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

2. 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 Table 1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table 1

CRITERIA FOR DESCRIBING DILATANCY

Description	Criteria
None	No visible change in 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.

5.1.2.2 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 inch (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 re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch 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 Table 2.

Table 2

CRITERIA FOR DESCRIBING 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.

5.1.2.3 Plasticity

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials are defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, water should be added prior to performing classification. If a soil sample is too sticky, the sample should be spread thin and allowed to lose some soil moisture.

The criteria for describing plasticity in the field using the rolled thread method is presented in Table 3.

Table 3

CRITERIA FOR DESCRIBING PLASTICITY

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low plasticity	The thread can barely be rolled.
Medium plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High plasticity	It takes considerable time rolling the thread to reach the plastic limit

5.1.3 Angularity

The angularity of the coarse sand and gravel particles is described according to the following criteria:

- Rounded—particles have smoothly-curved sides and no edges;
- Subrounded-particles have nearly plane sides, but have well-rounded corners and edges;
- Subangular—particles are similar to angular, but have somewhat rounded or smooth edges; and
- Angular—particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

5.1.4 Color, Moisture, and Odor

The natural moisture content of soils is very important information. The terms for describing the moisture condition and the criteria for each are shown in Table 4.

Table 4

SOIL MOISTURE CONTENT QUALIFIERS

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

Color is described by hue and chroma using the Munsell Soil Color Chart. For the sake of uniformity, all site geologists shall utilize this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists The Munsell color chart is a small booklet of numbered color chips with names like "5YR 5/6, yellowish-red". Mottling or banding of colors should be noted. It is particularly important to note and describe staining because it may indicate contamination.

In general, respirators should be worn if strong organic odors are present. If odors are noted, they should be described if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer (OVA) may be used to detect the presence of volatile organic contaminants.

5.1.5 In-place Conditions

The conditions of undisturbed soil samples shall be described in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

5.1.5.1 Density/Consistency

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term "density" is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term "consistency" is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 lbs (63.5 kg) dropped over a distance of 30 inches (0.76 m). The number of blows required to penetrate each 6 inches of soil is recorded in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the "standard penetration resistance," or the "N-value." The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch I.D. Modified California Sampler equipped with brass or stainless steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

The sampler should be driven and blow counts recorded for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed "refusal" and noted as such on the boring log.
- A total of 150 blows have been applied.

- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, the number of blows per partial increment shall be recorded on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Representative descriptions of soil density/consistency vs. N-values are presented in Table 5.

Table 5

MEASURING SOIL DENSITY WITH A CALIFORNIA SAMPLER RELATIVE DENSITY (SANDS, GRAVELS)

	Field Criteria (N-Value)	
Description	**1 3/8" I.D. Sampler**	**2" I.D. Sampler using 1.43 factor**
Very loose	0-4	0-6
Loose	4-10	6-14
Medium dense	10-30	14-43
Dense	30-50	43-71
Very Dense	>50	>71

Table I-E-5a

MEASURING SOIL DENSITY WITH A CALIFORNIA SAMPLER CONSISTENCY: FINE-GRAINED COHESIVE SOILS

	Field Criteria (N-Value)	
Description	**1 3/8" I.D. Sampler**	**2" I.D. Sampler using 1.13 factor**
Very soft	0-2	0-2
Soft	2-4	2-4
Medium Stiff	4-8	4-9

Stiff	8-16	9-18
Very Stiff	16-32	18-36
Hard	>32	>36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot (PSF). The values are as follows:

Table 6

MEASURING SOIL CONSISTENCY WITH A HAND-HELD PENETROMETER

Description	Pocket Penetrometer Reading (PSF)
Very Soft	0 to 250
Soft	250 to 500
Medium Stiff	500 to 1000
Stiff	1000 to 2000
Very Stiff	2000 to 4000
Hard	>4000

Consistency can also be estimated using thumb pressure using the following Table:

Table 7

MEASURING SOIL CONSISTENCY USING THUMB PRESSURE

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

5.1.5.2 Cementation

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

Quartz - siliceous;

Chert - chert-cemented or chalcedonic;

Opal - opaline;

Carbonate - calcitic, dolomitic, sideritic (if in doubt, calcareous should be used);

Iron oxides - hematitic, limonitic (if in doubt, ferruginous should be used);

Clay minerals - if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as "kaolin-cemented," "chlorite-cemented," etc.

Miscellaneous minerals - pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

Weak - friable, crumbles or breaks with handling or slight finger pressure;

Moderate - friable, crumbles or breaks with considerable finger pressure;

Strong - not friable, will not crumble or break with finger pressure.

5.1.5.3 Structure

This variable is used to qualitatively describe physical characteristics of soils that are important to incorporate into hydrogeological and/or geotechnical descriptions of soils at a site. Appropriate soil structure descriptors are as follows:

Granular - spherically shaped aggregates with faces that do not accommodate adjoining faces.

Stratified - alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness.

Laminated - alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness.

Blocky - cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown.

Lensed - inclusion of a small pocket of different soils, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soils are present, the soil being described can be termed homogeneous if the description of the lenses is included.

Prismatic or Columnar - particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top.

Platy - particles are arranged about a horizontal plane.

5.1.5.4 Other Features

Mottled - soil that appears to consist of material of two or more colors in blotchy distribution.

Fissured - breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)

Slickensided - fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

5.1.6 Development of Soil Description

Standard soil descriptions will be developed according to the following examples. There are three principal categories under which all soils can be classified. They are described below.

5.1.6.1 Coarse-grained Soils

Coarse-grained soils are divided into sands and gravels. A soil is classified as a sand if over 50% of the coarse fraction is "sand-sized." It is classified as a gravel if over 50% of the coarse fraction is composed of "gravel-sized" particles. The written description of a coarse-grained soil shall contain, in order of appearance:

Typical name including the second highest percentage constituent as an adjective, if applicable (underlined), grain size of coarse fraction, Munsell color and color number, moisture content, relative density, sorting, angularity, other features such

as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts, etc.) in parentheses.

Example: POORLY-SORTED SAND WITH SILT, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20% coarse-grained sand-sized shell fragments, and 80% medium-grained quartz sand, and 5% to 15% ML).

5.1.6.2 Fine-grained Soils

Fine-grained soils are further subdivided into clays and silts according to their plasticity. Clays are rather plastic, while silts have little or no plasticity. The written description of a fine-grained soil should contain, in order of appearance:

Typical name including the second highest percentage constituent as an adjective, if applicable (underlined), Munsell color, moisture content, consistency, plasticity, other features such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: SANDY LEAN CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70% fines, 30% sand, with minor amounts of disarticulated bivalves (about 5%)).

5.1.6.3 Organic Soils

For highly organic soils, the types of organic materials present will be described as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, 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, from black to brown, when exposed to 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.

Example: ORGANIC CLAY, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100% fines), weak reaction to HCl.

5.2 ROCK CLASSIFICATION

The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed for AMEC because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site WP and FSP. Any modifications to this classification system, or the use of another classification system, must be approved by both the Project Manager and the Technical Director/QA Program Manager.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities at Project sites.

In order to provide a more consistent rock classification between geologists, a rock classification template has been designated as shown in Figure 4. The template includes classification of rocks by origin and mineralogical composition. This template shall be used by all site geologists when classifying rocks.

- The site geologist shall describe the rock specimen and record the description in a borehole log or logbook. The items essential in any written rock description are as Classification group (i.e., metamorphic foliated)

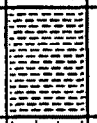
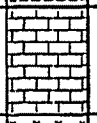
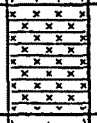
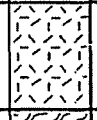
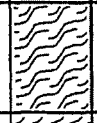
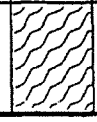
DEFINITION OF TERMS					
PRIMARY DIVISIONS				SYMBOLS	SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE		CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
		SANDSTONE		SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
		SHALE		SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
	Chemical Precipitates	CARBONATES		LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
		EVAPORITES		EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS		EXTRUSIVE (Volcanic)		IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
		INTRUSIVE (Plutonic)		II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS		FOLIATED		MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
		NON-FOLIATED		MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

Figure 4

ROCK CLASSIFICATION SYSTEM

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphlitic, glassy, etc.)
- Structure (i.e., foliated, fractured, lenticular, etc.)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage) and
- Classification symbol (i.e., MF).

Example: Metamorphic foliated schist: Olive gray, 5Y, 3/2, Garnet 25%, Quartz 45%, Chlorite 15%, Tourmaline 15%, Fine-grained with Pegmatite garnet, highly foliated, slightly wavy, MF

6.0 RECORDS

Soil classification information collected during soil sampling should be documented onto the field boring logs, field trench logs, and into the field notebook. Copies of the field boring log form are presented in SOP, *Soil Sampling*. Copies of this information shall be placed in the project files and reviewed by the Project Manager on a monthly basis at a minimum.

7.0 HEALTH AND SAFETY

Standard Health and Safety (H&S) practices should be observed according to the -specific Health and Safety Plan (HSP). Monitoring during excavation activities should determine contaminant concentrations and any required personal protective equipment (PPE) that may be necessary.

Suggested minimum protection during soil and rock classification activities in conjunction with field excavations shall include inner disposable vinyl or nitrile gloves, outer chemical protective nitrile gloves, Tyvek® coveralls, steel-toed boots , and

overboots, safety glasses, hearing protection, and an ANSI-Standard hard hat. Half-face respirators and cartridges may be necessary depending on the contaminant concentrations and shall always be available onsite. At no time during classification activities are personnel to reach for debris near machinery that is in operation, place any samples in their mouth, or come in contact with the soils/rocks without the use of gloves.

In addition to the aforementioned precautions, the following safe work practices will be employed:

Physical Hazards Associated With Soil and Rock Classification:

1. To avoid lifting injuries associated with large specimens, use large muscles of the legs, not the back.

2. Be wary of uneven terrain to avoid slip/trip/fall conditions.

3. To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1-2 cups/hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.

4. Be aware of restricted mobility due to the wearing of PPE.

8.0 REFERENCES

ASTM, 1990. Standard Practice for Description and Identification of Soils (Visual, Manual Procedure) Designation D 2488-90.

Birkeland, Peter W. 1984. Soils and Geomorphology. Oxford University Press.

Compton, Robert R. 1985. Geology in the Field. John Wiley & Sons, Inc.

Folk, Robert L. 1980. Petrology of Sedimentary Rocks.

Huang, Walter T. 1962. Petrology. McGraw-Hill Book Company.

McCarthy, David F. 1988. Essentials of Soil Mechanics and Foundations: Basic Geotechnics. Prentice Hall.

Munsell Soil Color Chart, 1990 Edition (Revised).

Pettijohn, F.J. 1957. Sedimentary Rocks. Harper, New York.

Rahn, Perry H. 1986. Engineering Geology. Elsevier Science Publishing Company, Inc.

SOP, *Soil Sampling*

U.S. EPA Environmental Response Team. 1988. Response Engineering and Analytical Contract Standard Operating Procedures. U.S. EPA, Research Triangle Park, NC.

9.0 ATTACHMENTS

None.

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