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May 7, 1999

GEOTECHNICAL EVALUATION OF BORROW SOURCE FOR LANDFILL COVERS MARINE CORPS AIR STATION EL TORO EL TORO, CALIFORNIA

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LIST OF ACRONYMS

amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
CIH	Certified Industrial Hygienist
CEG	Certified Engineering Geologist
CL	sandy clays
cm/sec	centimeters per second
COC	Chain-of-Custody
CSS	coastal sage scrub
CTO	Contract Task Order
cy	cubic yards
EPA	U.S. Environmental Protection Agency
FML	flexible membrane liner
Foster Wheeler Environmental	Foster Wheeler Environmental Corporation
GE	Geotechnical Engineer
Helix	Helix Environmental Planning
HSA	hollow stem auger
IRP	Installation Restoration Program
MCAS	Marine Corps Air Station
ML	sandy silts
MSCS	Monolithic Soil Cover System
OFBS	Off-Site Borrow Source
OHM	OHM Remediation Services Corp.
ONBS	On-Station Borrow Source
OVA	Organic Vapor Analyzer
QC	Quality Control
QAO	Quality Assurance Officer
ROICC	Resident Officer In Charge of Construction
RPM	Remedial Project Manager
SC	clayey sands
SM	silty sand
SMARA	Surface Mining and Reclamation Act of 1975
SWDIV	Southwest Division Naval Facilities Engineering Command
USCS	Unified Soil Classification System
USFWS	U.S. Fish and Wildlife Service

1.0 INTRODUCTION

Foster Wheeler Environmental Corporation (Foster Wheeler Environmental) has been contracted by the U.S. Navy to conduct remedial actions for the cleanup of hazardous waste sites in California, New Mexico, southern Nevada, and Arizona under Basic Contract N68711-98-D-5713. The objective of this project [Contract Task Order (CTO) No. 0005] is to provide a geotechnical evaluation of the quality of borrow material from a potential on-station borrow source (ONBS) located in the vicinity of IRP Site 17. This potential source has been proposed for use in the construction of the final remedy for the inactive landfills at IRP Sites 2, 3, 5, and 17 at Marine Corps Air Station (MCAS) El Toro, El Toro, California. In addition, a cost comparison between utilizing the ONSB versus utilizing an off-site borrow source(s) (OFBS) will be evaluated.

This Work Plan describes the steps that will be taken to conduct the geotechnical evaluation. The evaluation will include exploratory borings for geotechnical sampling, laboratory analyses, and evaluation of the quality, quantity and cost of utilizing borrow material from the on-Station borrow source. In addition, potential OFBSs will be evaluated. Specifications of the borrow source soil requires a hydraulic conductivity of 2×10^{-5} centimeters per second (cm/sec) or less. Typically, soils with this hydraulic conductivity are silty sand (SM), sandy silts (ML), clayey sands (SC), and sandy clays (CL). The approximate quantity of soil needed for the landfill cover systems is up to 300,000 cubic yards (cy). Results of the geotechnical investigation and evaluation activities of the ONBS and OFBS will be summarized in a Technical Memorandum.

The Technical Memorandum will focus on addressing the following questions in regards to the ONBS:

1. Is the proposed borrow source capable of generating up to 300,000 cy of suitable soil that meets the required specifications (hydraulic conductivity, etc.)?
2. Can up to 300,000 cy be excavated or mined economically from the proposed ONBS?
3. How do costs compare between mining material from the ONBS and importing material from a commercial OFBS?
4. What impact will excavating or mining the proposed borrow source have on protected plant and animal species?
5. Will a mining claim under the Surface Mining and Reclamation Act of 1975 (SMARA) be required?

1.1 SCOPE OF WORK AND APPROACH

This Work Plan presents the proposed scope of work and approaches to conduct a geotechnical investigation for potential borrow sources. Subsurface materials encountered during the field exploration are anticipated to be clean, uncontaminated soils. If contamination were to be encountered, the ONBS will be re-evaluated as a potential borrow source. The scope of work for the project consists of the following:

- Perform a biological clearance survey of the proposed exploration locations prior to fieldwork.
- Conduct drilling and trenching exploration activities at approximately 25 locations within the ONBS area for collecting soil samples for geotechnical testing.
- Perform geotechnical laboratory testing on collected soil samples. Testing consists of Moisture/Density, Particle-Size Analysis (with Hydrometer), Atterberg Limits, Modified Proctor Compaction, Pinhole Erosion (dispersion), and Triaxial Permeability.
- Evaluate the availability and cost to import soil from up to 4 OFBS.
- Prepare a Technical Memorandum summarizing the field exploration, laboratory testing, evaluation activities, and cost comparison of obtaining soil from the ONBS vs the OFBS.

1.2 SCHEDULE

The current proposed schedule for the entire project is presented in Attachment 1, Project Schedule and Project Decision Flow Diagram. Fieldwork is anticipated to start on May 10, 1999. Field activities for this project will begin upon approval of the Work Plan from Southwest Division Naval Facilities Engineering Command (SWDIV).

1.3 PROJECT ORGANIZATION

Foster Wheeler Environmental will have overall responsibility for the geotechnical investigation under the direction of the SWDIV staff. Figure 1, Project Organization Chart, illustrates the organization of the project team. Table 1, Project Points of Contact, provides a list of names and phone numbers for SWDIV, Foster Wheeler Environmental, and other personnel involved with the project.

Foster Wheeler Environmental will be responsible for project management, quality assurance/ quality control, health and safety, field investigations, and final reports. Foster Wheeler Environmental will also directly coordinate and supervise the activities of the subcontractors.

1.4 STRATEGY AND RATIONALE

1.4.1 Introduction

This section describes the strategy and rationale to evaluate the suitability of the ONBS to produce up to 300,000 cubic yards of material that meets the permeability requirement of 2×10^{-5} cm/sec (or less). The methodology is described to select:

- Location of adequate number of exploration boreholes;
- Appropriate depth of exploration boreholes; and
- Methods of exploration.

and the guidelines used by the exploration staff to:

- Select samples for laboratory classification based on field observations; and
- Select samples for additional laboratory testing including hydraulic conductivity testing based on laboratory classification.

1.4.2 Subsurface Exploration

Boreholes and test pits will be utilized:

- To assess the uniformity and homogeneity of the material;
- To assess the presence of physical features, which may render the site impractical or uneconomical to mine (for example, hard-rock layers; extensive coarse granular layers; or cavities, seeps, etc.); and
- To obtain material for laboratory testing.

The ONBS area is about 9 acres, and 25 exploration locations (i.e., about 2.5 to 3 per acre) are considered adequate to satisfactorily characterize the site based on our experience and the standard practices in geotechnical site investigations. In general, the proposed spacing for the exploration locations ranges from 100 to 200 feet, which is consistent with exploration spacing in larger earthwork projects. The average depth of the proposed explorations is 40 feet below ground surface (bgs).

The sampling locations were selected to meet the following criteria:

- Provide adequate coverage;
- Align to facilitate the development of cross-sections;
- Utilize existing access roads and tracks; and thus
- Minimize the disturbance to sensitive habitat.

Three methods of exploration are proposed: (1) hollow stem auger (HSA) drilling; (2) bucket auger drilling; and (3) test pit trenching. The order of the methods may be rearranged in the field to facilitate and accommodate the effectiveness of the exploration program.

A Project Decision Flow Diagram, presented in Attachment 1, depicts the general process of the exploration program. This process has been used to select the planned exploration locations as shown in Figure 3. The flow diagram also indicates the sequence of the drilling and the decision points.

The HSA drilling will be performed to obtain drive samples down to the proposed target exploration depth to develop an understanding of the overall homogeneity of the soil. If the HSA cannot reach the target depth (for example, refusal within 10 feet below grade is encountered), the drilling location will be relocated within the vicinity of the original borehole. If refusal is again encountered, the drilling location will be abandoned and noted in the final report.

After a number of the HSA boreholes are completed, and the uniformity and homogeneity of the site, or a portion thereof, is established, the bucket auger drilling will proceed. This method of exploration will be used to collect bulk samples at specific depths, to evaluate formation rippability at intermediate depths (i.e., 10 to 40 feet bgs), and to identify over-sized material. Test pit trenching was also selected to collect bulk samples, evaluate over-sized material, and to evaluate formation rippability. Test pits are utilized for shallower depths (i.e., above 10 feet bgs). Both the bucket auger borings (5) and test pit locations (5) were selected to fill in potential vertical and horizontal exploration data gaps and to complement the HSA borings. If the bucket-auger and test pit exploration encounter refusal, the exploration locations will be re-located within the vicinity of the original exploration location. If refusal is again encountered, the drilling location will be abandoned and noted in the final report.

1.4.3 Logging and Selection of Samples for Laboratory Analysis

During the HSA drilling, drive samples will be recovered at every 5 feet. Each sample will be logged and classified in accordance with the Unified Soil Classification System (USCS). This information will be used to establish the uniformity and homogeneity of the soil, the sequence and thickness of layers, as well as to provide the first information on the suitability of the material as monolithic cover soil. Experience shows that low plasticity clay (classification symbol CL) and silt (ML), silty sand (SM), and clayey sand (SC) are most likely to meet the permeability requirements.

A selected number of the drive samples will be sent to the geotechnical laboratory for laboratory classification, which serves essentially as a Quality Assurance measure. The Project Decision Flow Diagram depicts the overall flow of field logging, classification, and sample selection.

The samples that are not logged and classified as CL, ML, SM or SC, will be regarded as unsuitable, and will not be used in the laboratory program. Furthermore, if a relatively thick (greater than 30 feet) uniform and homogeneous material is encountered, there is no need to send to the laboratory all 5 or 6 samples taken from this layer. Two or three samples will suffice. Conversely, a sample taken from a thin layer (2 to 3 feet) of suitable soil embedded in between unsuitable materials, will also not be sent for further analysis. Such a thin layer cannot be excavated in a practical manner, so during mining this layer would be ignored. Similarly, thick suitable layers may not be practical or economical to be mined if overlain by large quantities of unsuitable overburden. Thus, samples from such a suitable layer may not be further analyzed.

The Foster Wheeler Environmental Field Geologist, under the oversight of the Certified Engineering Geologist and the Project Manager will make these types of decisions in the field. These decisions will be made considering the topography, the layers and materials encountered, economic and practicality considerations.

Bulk samples will be collected from the bucket auger boreholes and the backhoe test pits. The bulk samples will also be logged and classified in the field, and based on the general guidelines described earlier and depicted on the Project Decision Flow Diagram, the promising bulk samples will be forwarded to the laboratory for further testing. Since the sampling locations and depth already reflect the findings of the HAS exploration, the bulk samples will have been taken from soils logged and classified as suitable material.

1.4.4 Laboratory Testing Program

Together with the drive samples, approximately 50 bulk samples will also be sent to the laboratory. The drive samples will be used for laboratory classification, as described earlier. The bulk samples will be reviewed and most of them will undergo Particle Size Analysis and Atterberg Limits tests to further support the laboratory classification program.

Then, some of the bulk samples will be selected for Compaction and Hydraulic Permeability Tests. In this selection, the following main factors will be considered:

- Bulk samples representing large, thick layers of suitable soils, whose suitability is indicated by field and laboratory logging, verified by Particle Size Analysis and Atterberg Limits tests, will be tested.
- Bulk samples representing adjacent thin layers of potentially suitable soils, which will likely get mixed during mining, will be combined and composite samples will be selected for testing.
- Bulk samples representing thin and relatively isolated layers of suitable soils will not be selected for testing.

Saturated hydraulic conductivity tests will be performed at 90 percent relative compaction. The samples that meet the permeability requirement will undergo further testing. The samples that do not meet the permeability requirement, but have hydraulic conductivity within the same order of magnitude (i.e., $k < 5 \times 10^{-5}$ cm/sec), will be considered marginal, and will be selected for an additional round of saturated hydraulic conductivity testing, this time at 95 percent relative compaction. Other soil improvement techniques may also be considered.

The samples that meet the saturated permeability requirement will be sent for pinhole erosion tests and unsaturated hydraulic conductivity tests. The Project Decision Flow Diagram depicts the overall flow chart of the laboratory sampling procedure.

1.4.5 Overall Site Acceptance

Throughout the field and laboratory exploration program Foster Wheeler Environmental staff will be carefully assessing two factors:

1. Suitability of the materials encountered with respect to the 2×10^{-5} cm/sec permeability requirements; and
2. Available volume of suitable material with respect to the material volume requirement of up to 300,000 cubic yards, taking into account practicality and economy of any future mining operation.

The findings and overall assessment of the site will be summarized in a Technical Memorandum.

2.0 BACKGROUND

2.1 SITE LOCATION AND SETTING

MCAS El Toro is located in the south-central portion of Orange County, California, encompassing approximately 4,700 acres. The facility is bordered on the northwest, south, and west by the City of Irvine, and on the east by the City of Lake Forest. The ONBS consists of an 8- to 9-acre area located between Magazine Road Landfill (IRP Site 2) and Communication Station Landfill (IRP Site 17) (Figure 2, Vicinity Map). The general area has been identified as Operable Unit 2B, located to the northeast of the main station. The average annual precipitation for this area is approximately 12 inches; precipitation occurs mostly during the winter.

MCAS El Toro, which contains the ONBS area, is situated on the southeastern edge of the Tustin Plain, a gently sloping surface of alluvial fan deposits derived mainly from the Santa Ana Mountains (Yerkes et al., 1965). The Tustin Plain, bounded on the north and east by the Santa Ana Mountains and on the south by the San Joaquin Hills, is at the southeast end of the Los Angeles Basin (the Basin), a large sedimentary basin in the Peninsular Ranges Geologic Province (Yerkes et al., 1965). The plain also lies in the "Central Block" of the Basin, which is bound on the north by the Whittier Fault zone and on the south by the Newport-Inglewood Fault zone (CDMG, 1978).

2.2 GEOLOGY

The ONBS is a rounded hill with an aerial extent of 9 acres and ranges in elevation from approximately 550 feet above mean sea level (amsl) at the base to 620 feet amsl at its crest. The ONBS is situated on the extreme west flank of the Santa Ana Mountains in the Peninsular Ranges geomorphic province and is composed of sedimentary bedrock. Tertiary bedrock is exposed throughout the site and has been identified on geologic maps as the Vaqueros and Topanga Formations (CDMG, 1974), which primarily consist of sandstone and siltstone units.

The proposed borrow site may be underlain and characterized by predominantly very fine-grained sandstone and silty sandstone and siltstone, with an occasional coarse-grained sandstone layer. The units dip gently to the southwest and are characterized as moderately-to-well consolidated and gray-brown to light yellowish brown in color. The California Division of Mines and Geology geologic map (CDMG, 1974) indicates the area is underlain by an undifferentiated Vaqueros and Topanga Formations. The mapped gradational contact between the two formations is at approximately 575 feet amsl on the eastern portion of the borrow site and 530 feet on the western portion of the site. The Vaqueros and Topanga Formations are middle and early Miocene in age, respectively, and are primarily distinguished by fossil content.

2.3 HYDROGEOLOGY

Considering the depths of the proposed explorations, groundwater is not expected to be encountered at the ONBS. However, some perched conditions may exist and will be identified during drilling if encountered. Encountered perched water could affect the sampling program. Foster Wheeler Environmental will contact SWDIV to discuss any variances in the sampling program resulting from perched groundwater or other encountered subsurface anomalies. At IRP Site 2, an intermittent seep has been observed, so there may be a potential for seeps within the ONBS general area.

MCAS El Toro is situated over the Irvine Subbasin in the Main Orange County Basin. Although the aquifers beneath the Tustin Plain are in hydraulic contact with the Main Orange County Groundwater Basin, the forebay area lies along the margin of the basin where relatively shallow and coarse-grained sediments overlie semiconsolidated rock. Groundwater is thought to occur under unconfined conditions in this area.

Occurrences of groundwater within the foothills are reported to be within 50 feet of the ground surface (JMM, 1988). Groundwater is most shallow in the foothills, where it lies about 45 to 60 feet beneath the washes.

2.4 ENVIRONMENTAL RESOURCES

The following paragraphs summarize the historical environmental or biological resources within the vicinity of the MCAS El Toro and general area of the ONBS.

2.4.1 Vegetation

The predominant vegetation on the uplands of the study area consists of Venturan/Diegan transitional coastal sage scrub (CSS) and ruderal vegetation, while mule fat scrub and freshwater marsh (Gray and Bramlett, 1992) dominate the drainage areas.

The CSS is scattered in many locations and dominated by California sagebrush *(Artemisia californica)*. A variety of other shrub species also occurs within the sage scrub community. The number and cover of annual species is limited, however, because of the relatively dense and tall cover of the shrub component. CSS is considered a sensitive habitat by several resource agencies (Holland, 1986) because it supports a number of state and federally listed endangered, threatened, and rare vascular plants as well as several bird and reptile species that are federally listed or are candidate species for federal listing. Of particular importance is the coastal California gnatcatcher *(Polioptila californica californica)*, which is federally listed as threatened.

Ruderal vegetation, including black mustard *(Brassica* sp.), ripgut grass *(Bromus diandrus)*, brome species *(Bromus* spp.), wild oat *(Avena* sp.), and filaree *(Erodium* spp.) occurs over disturbed portions. Ruderal vegetation is not considered sensitive.

The mule fat plant community is dominated by its namesake, mule fat *(Baccharis salicifolia).* Minor plant associates include black willow *(Salix goodingii),* coyote brush *(Baccharis pilularis),* and tree tobacco *(Nicotiana glauca).* Mule fat scrub is considered a sensitive plant community by the resource agencies because it is a riparian habitat.

Freshwater marsh typically includes cat-tails *(Typha* sp.), spike sedge *(Eleocharis* sp.), rush *Uuncus* sp.), and umbrella sedge *(Cyperus* sp.). This community occurs in three small isolated pockets in a side tributary to Borrego Canyon Wash and is dominated by cat-tails. Like mule fat scrub, freshwater marsh is considered sensitive by the resource agencies because it is a riparian habitat.

2.4.2 Wildlife

MCAS El Toro supports a wide variety of wildlife species, including representatives from nearly all major vertebrate groups (reptiles, amphibians, birds, and mammals). Undoubtedly, the diversity of invertebrate species is at least commensurate.

Several sensitive species are known from MCAS El Toro, but only one that is federally listed is being affected by the project, the coastal California gnatcatcher. Distribution and habitat characteristics of the California gnatcatcher are provided below:

Distribution: Southern Los Angeles, Orange, western Riverside, and San Diego counties south into Baja California, Mexico.

Habitat: Coastal sage scrub vegetation composed of relatively low-growing drought deciduous plant species such as California sagebrush, black sage, purple sage (S. *leucophylla),* white sage (S. *apiana),* laurel sumac *(Malosma laurina),* coast encelia *(Encelia californica),* California buckwheat *(Erigonium fasciculatum),* and yellow-flowered bush penstemon *(Keckiella antirrhinoides).*

3.0 FIELD INVESTIGATIONS

3.1 INTRODUCTION

The proposed field investigation will focus on determining the suitability of the ONBS soil for use in the MSCS.

3.1.1 Environmental Resource Assessment (ONBS only)

To address the potential environmental resource concerns for this project, Helix Environmental Planning (Helix), a subcontractor, performed a biological clearance survey of the proposed exploration locations. The work consisted of reviewing previous environmental work performed for OHM Remediation Services, Corp. (OHM) [Helix Environmental Planning (Helix) Project Number: OHM-01] at MCAS El Toro, and conducting a field survey of proposed exploration locations at the ONBS for environmentally sensitive resources. The proposed boring locations were evaluated, optimized and cleared, based on the field survey conducted by Helix on April 21, 1999. Field observations will be documented in a letter report that will be submitted to the Navy under separate cover. Additionally, photographs taken of the exploration locations (to document "before and after" site conditions) will be included in the Technical Memorandum.

Based on the historical site-specific information, the biological clearance survey focused on the following:

- ***Coastal Sage Scrub and Coastal California Gnatcatcher Impact Assessment***: An assessment of potential impacts to coastal sage scrub and the coastal California gnatcatcher for each of the proposed exploration locations was performed based on a single site visit. Typically, the protocol surveys for the gnatcatcher require three site visits; however, based on results of previous fieldwork, anticipated site conditions and the scope of work for this project, a single site visit survey was justified. No gnatcatchers were observed within the ONBS, however, Helix recommended moving two exploration locations to reduce potential impacts to the gnatcatchers observed out side the study area.
- ***Quino Checkerspot Butterfly Habitat Assessment***: Helix also conducted a focused Quino Checkerspot Butterfly and habitat assessment based on U.S. Fish and Wildlife Service (USFWS) protocol. Protocol requires that the assessment be conducted at no more than 12.5 acres per hour between February 1 and May 31 prior to the end of the adult flight season. No Quino Checkerspot Butterfly were observed, however, potential host plant or habitat was identified in the vicinity of a few exploration locations.

3.1.2 Field Exploration

Field exploration activities will be conducted based on procedures provided by the American Society for Testing and Materials (ASTM). Applicable standards for field exploration activities are listed below and the complete procedures are provided in Appendix A. Standard sampling methods should conform to the applicable ASTM methods.

- ASTM D 1452 - Standard Practice for Soil Investigation and Sampling by Auger Boring
- ASTM D 1586 - Standard Method for Penetration Test and Split-Barrel Sampling of Soils
- ASTM D 1587 - Standard Method for Thin-Walled Tube Sampling of Soils
- ASTM D 2488 - Standard Practice for Description and Identification of Soils (Visual Manual Procedure)
- ASTM D 3550 - Standard Practice for Ring-Lined Barrel Sampling of Soils
- ASTM D 4220 - Standard Practice for Preserving and Transporting Soil Samples

A total of 20 soil borings will be drilled and 5 test pits are proposed to be performed at the ONBS. Figure 3, Proposed Exploration Locations, shows the locations of the various soil borings and test pits. Fifteen soil borings will be drilled using a HSA drill rig. Five soil borings will be drilled with a bucket auger and 5 test pits will be excavated with a backhoe. The order of the exploration methods may be rearranged in the field to facilitate and accommodate the effectiveness of the exploration program. An HSA rig will be used due to its higher drilling production rate and its ability to collect drive samples. The bucket auger rig will be used in order to collect bulk samples at specific depths, to evaluate formation rippability at greater depths, and to identify over-sized material at greater depth. Five test pits will be excavated to determine the rippability and evaluate over-sized material of the proposed borrow material, i.e., its relative resistance to excavation techniques. Target depth for the deeper HSA borings are shown on Figure 3, Proposed Exploration Locations, and the target depth is based on a potential mining depth (i.e., final excavation grade surface) plus 20 feet. Geologic cross sections will be constructed from field logs as the field work progresses. Soil borings and test pit locations were selected based on the following criteria:

- Accessibility
- Sensitivity of surrounding environment, i.e., locations with relatively low environmental receptors—vegetation and wildlife. For example, most borings and test pits were located in areas with scarce vegetation such as along established dirt roads
- Collection of representative soil samples

3.2 SITE ACCESS

Prior to mobilization, minor grading to existing dirt roads (i.e., fill in ruts) will be performed to establish safe access to exploration locations. Appropriate earth working equipment will be utilized to prepare and repair access routes.

3.3 UTILITY CLEARANCE

The ONBS is a previously cut area and no subsurface utilities are expected to be encountered during drilling or excavation activities. . Proposed boring and test pits have been located away from the known/documented locations of existing utilities. However, proper care will be exercised to avoid hitting abandoned or undocumented subsurface lines/structures. A Foster Wheeler Environmental representative will coordinate with the Resident Officer In Charge of Construction (ROICC) and Public Works to obtain utility clearance. In addition, Dig Alert, a public utility notification service, will be notified and a ticket number obtained prior to exploration activities. Excavation/drilling within the upper few feet will proceed slowly and cautiously.

3.4 FIELD EQUIPMENT

The field sampling equipment to be used on the project will consist of the following:

- Sampling Equipment
  - Drive sampler (California type), waste barrel, shoes, sand trap
  - Sampling kit—typically each sampling kit will include:

    Camera
    Film
    Screwdriver
    Spanner wrenches/pipe wrenches
    Metal tape measure
    100-foot surveyor's tape - with weight
    Shovel
    Hammer
    Non-shrink wax sheet squares for tube sealing
    Sample bags
    Electrical tape
    Sample labels
    Munsell color chart
    Wire brush
    Bristle brush
    Putty knife
    Brass rings (to be provided by driller)
    Sample containers and end caps (to be provided by driller)

Ziploc™ plastic bags
Paper towels
Marking pens
Field notebook
Soil boring log (Appendix B)
Test pit log (Appendix C)
Organic Vapor Analyzer (OVA)
OVA calibration form (Appendix D)
Chain-of-Custody (COC) form (Appendix E)

- Health and Safety Monitoring Equipment and Personal Protective Equipment (PPE)

3.5 SOIL BORING AND TEST PIT ACTIVITIES

3.5.1 Soil Boring

A total of 20 soil borings will be drilled at the site. Fifteen soil borings will be drilled, depending on its location, from 30 to 75 feet bgs or refusal using the HSA drill rig. The remaining 5 soil borings will be drilled, depending on its location, from 20 to 40 feet bgs or refusal using the bucket auger drill rig. Bulk and drive sampling will be performed at various intervals. The sampling interval is anticipated to be every 5 feet in the HSA boring and will vary in the bucket auger borings based on materials (soil types) and changes in lithology encountered. Sampling efforts in the bucket auger boring will focus on collection of discrete bulk samples of various soil types. The proposed locations and depths of the various explorations are shown on Figure 3.

General procedures to be followed for soil borings are as follows:

- Check location, elevation, and boring number on topographic map.
- Take pre-activity photographs of the exploration location to document environmental conditions.
- Establish safety zone around drill site.
- Set up health and safety monitoring equipment.
- Continuously check the drill cuttings or augered soil cuttings to note changes in strata.
- Refer to ASTM D 2488 (Appendix A) for standard practice for identification and description of soils.
- Backfill soil borings with soil cuttings generated from drilling activities and tamp for compaction every 5 feet with exploration equipment to grade.
- Take post-activity photographs of the exploration location to document any changes in environmental conditions as a result of drilling/excavation activities.

3.5.2 Soil Boring Logs

A Foster Wheeler Environmental Certified Engineering Geologist (CEG) will oversee the logging of the borings. No downhole logging will be performed. Each soil boring will be logged using a field boring log form presented in Appendix B. Soil descriptions will follow USCS guidelines.

Soil boring logs will contain the following general site-specific information requested in the "header" on the log form:

- Physical characteristics of soil according to USCS
- Grain size distribution
- Stratigraphic boundaries
- Soil color, soil moisture
- Odors (if any)
- OVA readings
- Depth of samples taken

3.5.3 Test Pits

Five test pits are to be excavated at the ONBS to a depth between 8 and 10 feet bgs or refusal with a backhoe using an 18- to 24-inch-wide bucket. Bulk sampling will be performed at various intervals based on conditions encountered. Approximately 3 sample intervals are anticipated per test pit. Materials that have sloughed down into the pit will be avoided when collecting a test pit sample.

General work procedures to be followed for test pits are as follows:

- Check location, elevation, and test pit number on topographic map.
- Take pre-activity photographs of the exploration location to document environmental conditions.
- Establish safety zone.
- Excavate test pits perpendicular to slope contours.
- Excavate test pits to a depth of 8 to 10 feet bgs and no more than 10 feet in length.
- Collect bulk soil samples at 3-foot vertical intervals and note changes in soil type.
- Log excavated soils in accordance with ASTM D 2488 (Appendix A).
- Map walls of test pits noting subsurface features including voids, oversized rock, rooting depth, root channels, depth of saturation, and cracks. Mapping will be done from the surface. Field personnel will not enter test pits.

- Backfill test pits with excavated material, place in thin layers, and tamp with the backhoe bucket.
- Take post-activity photographs of the exploration location to document any changes in environmental conditions as a result of drilling/excavation activities.

At this time no exploration activities will be performed at OFBS locations. However, if at a later date additional investigation is justified, test pits may be performed at the OFBS.

3.5.4 Test Pit Logs

A Foster Wheeler Environmental CEG will oversee the logging of the test pits. No downhole logging will be performed. Test pits will be logged using a trench log as presented in Appendix C. Soil descriptions will follow USCS guidelines. The procedures for completing the field test pit log forms are described below:

- Fill in information in heading.
- Provide physical characteristics of soil according to USCS.
- Provide grain size distribution.
- Provide stratigraphic boundaries.
- Describe soil color, soil moisture.
- Identify odors.
- Provide OVA readings.
- Provide depth of samples taken.
- Test pit logs should contain a sketch of the test pit wall showing depth of root penetration, root channels, voids, moisture front, and cracks. The sketch should also identify soil types, horizons, and cross-reference symbol to soil descriptions.

3.5.5 Exploration Termination Before Reaching Planned Depth

In the event that an obstruction or other cause prevents exploration advancement, the borehole/test pit will be terminated and backfilled with soil cuttings to grade. The exploration equipment will be moved a few feet to drill/excavate a replacement boring/test pit (after making sure the new location is cleared of underground utilities and is biologically cleared, if needed). The decision to perform a replacement boring/test pit will be based on previous exploration efforts and will be made by the CEG or Project Manager. If the replacement boring/test pit fails to reach the required depth due to obstruction or refusal, the replacement exploration will be backfilled and the field geologist will inform the Project Manager.

3.6 SAMPLING PROCEDURES

Soil samples will be obtained at the intervals specified in Section 3.5. Sampling intervals may be changed under the direction of the Geotechnical Engineer (GE), CEG, or Project Manager. If a sample is not recovered, another attempt will be made directly below the unsuccessful sample interval. Soil samples that represent soil that has the proper characteristics and is available in sufficient volume will be submitted for laboratory testing.

3.6.1 Drive Samples

Sampling procedures using drive samplers will be conducted in general accordance with ASTM D 3550-84 (Appendix A). A California Modified Sampler will be used for the collection of soil samples. Sampling procedures are as follows:

- After the boring has been advanced to the desirable sampling depth, excessive cuttings will be removed from the bottom of the borehole. The depth of the borehole will be confirmed by using a weighted measuring tape to tag the bottom and record on the boring log. The sampling assembly will be lowered to total depth. Using a downhole hammer a drive sample will be collected, which is indicated when the sampler has been advanced approximately 12 inches or more. The number of blows, hammer weight, and drop height will be recorded on the soil boring log. The soil sample will be retrieved, soil description recorded, and processed as outlined in Section 3.7. An OVA headspace reading will be collected from a portion of the sample contained in either the sampling "shoe" or sleeve. If refusal is encountered while sampling, the boring will be advanced a few feet to collect a sample. The following two criteria can be used to define refusal:
  - A total of 50 blows has been applied.
  - There is no observed advancement of the sampler during 10 successive blows.

3.6.2 Bulk Samples

Bulk samples will be collected from soil cuttings in a plastic geotechnical sampling bag. A minimum of 35 pounds of soil will be collected per sample. The bag will be twisted and taped closed and a twist tie identification label will be fixed to the bag. An OVA headspace reading will be collected from a portion of the sample.

3.7 SAMPLE HANDLING

3.7.1 Sample Documentation

Collected soil samples will be documented on a sample-tracking log [see Appendix E, Chain-of-Custody form]. Entries will include the following information, as applicable:

- Name of Sampler
- Sample Identification Number(s)
- Date and Time of Collection
- Field Observations

3.7.2 Sample Labeling

Soil samples are required to be affixed with a proper label. Sample labels will be securely placed on or affixed to sample containers by the field geologist. Information to be entered on each label in indelible ink includes the following:

- Sample Identification Number
- Description of Sample
- Depth of Sample
- Date and Time of Sample Collection
- Name of Sampler
- Project Identifier (CTO Number)

3.7.3 Sample Identification

Soil samples will be assigned an alphanumeric identifier to differentiate them from other collected soil samples. Each collected soil sample identification will contain three components.

1. The first component of the identifier corresponds to the sample location. The MCAS El Toro borrow source will be identified as "ETONBS," and an OFBS will be identified as XXOFBS, where the "XX" represents site-specific alpha-characters that will be used to identify the location of the borrow source. It should be noted that no OFBS sampling will be performed at this time.
2. The second component corresponds to a sampling method; "B" for soil borings and "TP" for test pits followed by a location number.
3. The third component will distinguish between sample types; "BS" for bulk samples and "DS" for drive samples followed by a sample number.

The sample collection depths will be recorded in the field logbook in addition to being entered on the COC form. The COC form contains an entry specifically for recording sample depths. A copy of the COC form is provided in Appendix E.

Below are examples of various sample identifications to be used for the ONBS and OFBS(s):

ETONBS-B1-BS1 = MCAS El Toro borrow source, Soil Boring location #1, the first bag sample.

ETONBS-B2-DS1 = MCAS El Toro borrow source, Soil Boring location #2, the first drive sample.

ETONBS-TP1-BS1 = MCAS El Toro borrow source, Test Pit location #1, the first bag sample.

Example OFBS - Pacific Clay in Corona, CA

PCOFBS-TP1-BS1 = Pacific Clay off-site borrow source, Test Pit location #1, the first bag sample.

3.7.4 Sample Containers

Drive samples taken with the California Modified Drive Sampler will be retained in six 1-inch-high brass storage sleeves and placed in a containment canister that will be sealed with plastic end-caps. Bulk samples (i.e., those collected from cuttings by shovel) will be placed in soil sampling bags and twisted closed and taped shut. A minimum of 35 lbs of soil will be collected for each bulk sample.

3.8 FIELD DOCUMENTATION

At a minimum, sampling information will be recorded in a COC form and field logbook. Both documents will be completed in the field at the time of sample collection. In addition, field activity reports and/or appropriate monitoring datasheets will be completed at the time of the activity or immediately thereafter. All entries will be legibly recorded in indelible ink.

3.8.1 Chain-of-Custody

Soil samples are required to be handled and transported using a COC form (Appendix E). The COC provides the means to identify and track the chain-of-custody of each individual soil sample from the point of collection through data analysis. The following procedures will be carried out:

- A COC record is required for each shipment of samples. Daily shipments are anticipated. The record is to be completed in indelible ink. Changes or corrections to the record consist of line-out deletions (e.g., no "white-out" correction fluid) which are initialed and dated by the author of the change or correction.
- The COC record completed by a field geologist who performed and/or witnessed the sample collection activity. After completion of the record down through the initial "Relinquished by:" row, a copy is made of the record for retention by the originating field geologist or designee.

- The person relinquishing the samples to the courier retains a copy of the shipping paper.
- The laboratory representative who accepts the incoming sample shipment at the receiving laboratory will complete the first incomplete "Received by:" row on the COC record to acknowledge receipt of the samples. This signed original (or a copy) will then be returned with the analytical reports.
- The laboratory representative who accepts the incoming sample shipment at the receiving laboratory will inspect the samples. If there is any apparent discrepancy or potential anomaly, the samples will not be logged in for testing until the issue is resolved through contact with the originating field geologist or his/her Project Manager. The laboratory will provide such notification by the most expedient method (e.g., telephone and/or facsimile) followed by a written notification. A complete copy of the issue and its resolution will be documented and provided by the laboratory with the test reports.

3.8.2 Field Logbooks

A bound field logbook with consecutively numbered pages will be assigned to this project. All entries will be executed in indelible ink. Corrections will be made by crossing out erroneous data with a single line and dating and initializing the entry. At the end of each workday, the logbook pages will be signed by the responsible sampler and any unused portions of logbook pages will be crossed out, signed, and dated.

If it is necessary to transfer the logbook to another person, the person relinquishing the logbook will sign and date the last page used and the person receiving the logbook will sign and date the next page to be used.

At a minimum, the logbook will contain the following information:

Project name and location
Date and time
Personnel in attendance
General weather information
Work performed
Field observations
Sampling performed, including specifics such as location, type of sample, sample depth, type of analysis, and sample identification
Field analyses performed, including results, instrument checks, problems, and calibration records for the field instrumentation
Problems encountered and corrective actions taken
QC activities
Verbal or written instructions
Any other events that may affect the samples

3.8.3 Document Correction

Changes and corrections on any project documentation and data will be made by crossing out the wrong information with a single line, and writing the new information immediately above the crossed-out information, using permanent (indelible) ink and legible handwriting. The original item, although erroneous, must remain legible beneath the cross-out. The person making the correction will initial and date the correction.

4.0 GEOTECHNICAL TESTING

Geotechnical laboratory testing will be performed on selected soil samples as described in the table below. Laboratory testing will consist of Moisture/Density, Particle-Size Analysis with Hydrometer, Atterberg Limits, Modified Proctor Compaction, Pinhole Erosion (dispersion), and Triaxial Permeability tests. The subcontracted laboratory facility will be inspected and audited by Foster Wheeler Environmental prior to procurement.

GEOTECHNICAL TESTING

Tests	Estimated Quantity
Moisture/Density – ASTM D 2937	50
Visual Classification – ASTM D 2488	270
Particle-Size Analysis with Hydrometer – ASTM D 422	50
Atterberg Limits – ASTM D 4318 (3 Pt.)	5
Modified Proctor Compaction – ASTM D 1557	30
Pinhole Erosion (dispersion) – ASTM D 4647	5
Triaxial Permeability (remolded at 90 to 95% RC[1]) (saturated) – ASTM D 5084	15
Triaxial Permeability (remolded at 90 to 95% RC[1]) (unsaturated [2])	7

[1] RC – Relative Compaction.

[2] There are no ASTM standards for the unsaturated permeability test. Therefore, the test will be performed in accordance with the Soil Science Society of America standards by Daniel B. Stephens and Associates, Albuquerque, New Mexico.

Samples (i.e., drive and bulk samples) sent to the laboratory will be logged in and stored for testing assignments. Drive samples will be visual classified (ASTM D 2488) and selected drive samples will be prepared for moisture-density determinations (ASTM D 2937) and particle size analysis ASTM D 422. Once a sufficient number of drive samples have been tested and correlations developed, hydraulic conductivity testing will be initiated. Assignments of saturated and unsaturated Triaxial Permeability tests will be done by the Project Manager with the assistance of the CEG and GE and will be based on achieving the objectives presented in Section 1.0.

Test results will be presented in a "report quality" format from the subcontracted laboratory with summary tables in an electronic format. The laboratory report will be signed and stamped by the laboratory's GE and reviewed by Foster Wheeler Environmental.

Samples will be picked up once a day for 10 days at MCAS El Toro, California, specific location pending. Pickup service will include both drive and bulk samples. (Note that up to 150 bulk samples may be generated during the field exploration activities.)

Sample retention period will be 60 days following the final reporting date for all drive and bulk samples. In addition, up to 20 selected bulk samples will be retained for a period of 1 year.

5.0 OFF-SITE BORROW SOURCES

Foster Wheeler Environmental will perform a survey of up to four OFBS by contacting various commercial vendors. Geotechnical data sheets, and other information, such as U.S. Army Corp of Engineers' material data submittals, will be evaluated (i.e., do the materials meet the hydraulic conductivity specifications?). The primary focus of evaluating the OFBS is to determine the availability, cost and feasibility of importing soil material.

6.0 REPORTING

Foster Wheeler Environmental will prepare a "Technical Memorandum: Report of Findings from Geotechnical Evaluation of Borrow Source for Landfill Covers." The primary focus of the Technical Memorandum will be to provide a determination of the feasibility and suitability of the borrow sources and a cost comparison between using the proposed ONBS versus an OFBS. The report will also address the following questions previously stated in Section 1.0.

1. Is the proposed borrow source capable of generating up to 300,000 cy of soil that meets the required specification (hydraulic conductivity)?
2. Can up to 300,000 cy be excavated economically from the proposed ONBS?
3. How do costs compare between mining material from the ONBS and importing material from a commercial OFBS?
4. What impact will excavating the proposed borrow source have on protected plant and animal species?
5. Will a mining claim under SMARA be required?

In addition, the report will also contain the following:

- The geology of the sites based upon soil boring and test pit activities.
- Detailed site reference and location maps including borehole and test pit locations.
- Evaluation of technical data generated during the investigations including laboratory results and borehole and test pit logs.
- Discussion of alternative treatment or enrichment methods that can be applied to potential borrow material.
- The cost for restoration of ONBS and possible mitigation for coastal habitat losses.

A draft of the proposed Table of Contents for the Technical Memorandum is presented in Attachment 2, Technical Memorandum – Proposed Table of Contents.

7.0 HEALTH AND SAFETY PROCEDURES

The health and safety procedures necessary to carry out the field sampling activities throughout the project will follow the Draft Site-Specific Health and Safety Plan (Foster Wheeler Environmental, 1999).

8.0 REFERENCES

Banks, H.O. 1984. Groundwater Management, Irvine Area, Orange County, California. Prepared for the Orange County Water District. September.

Bechtel National, Inc. 1996a. *Draft Phase II Remedial Investigation Report, Operable Unit 2B-IRP Site 2, Marine Corps Air Station, El Toro, California.* Prepared for Southwest Division Naval Facilities Engineering Command (Contract No. N68711-92-D-4670, CTO-0076-O119). March.

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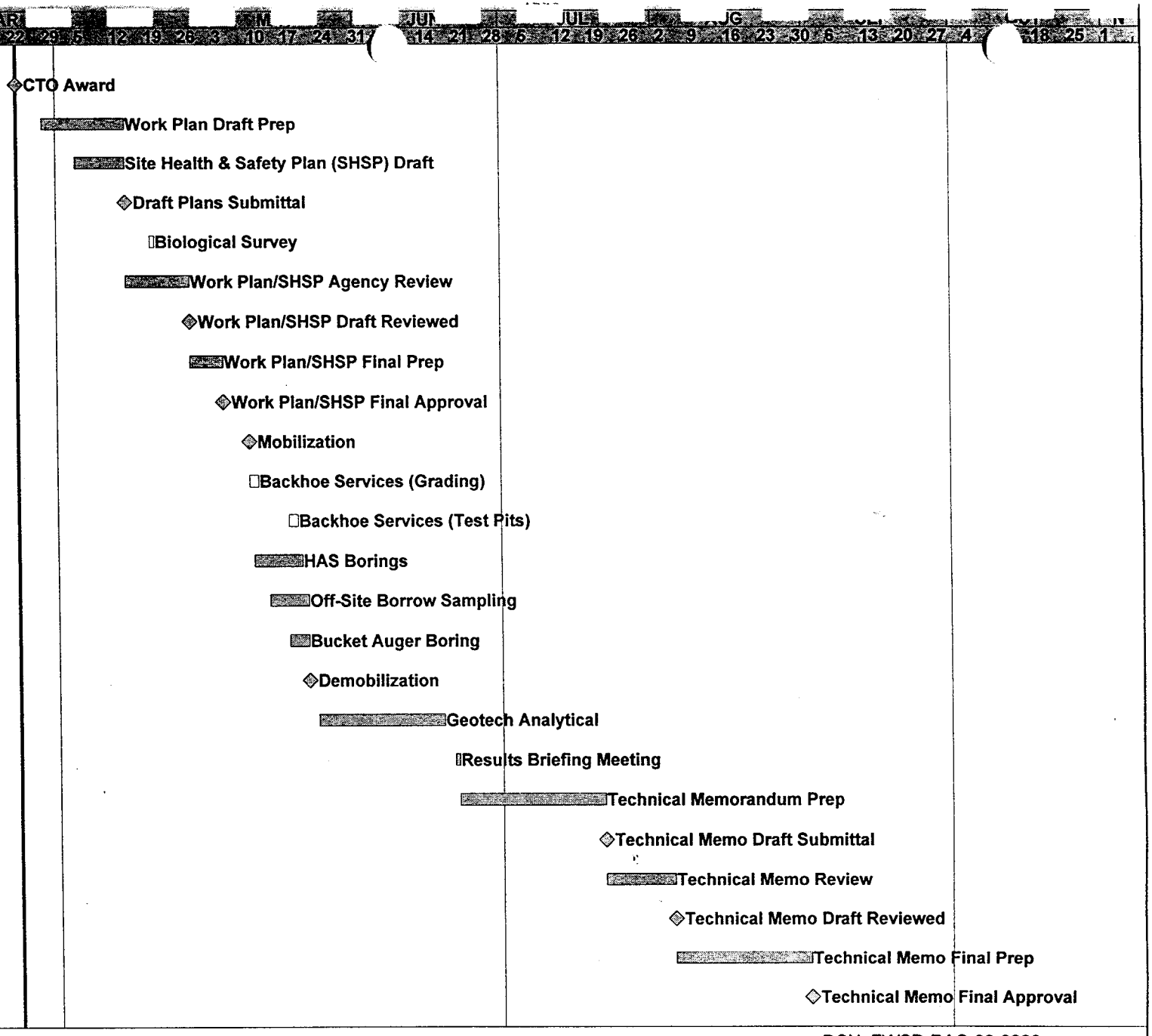
JMM (James M. Montgomery Engineers). 1988. Site Inspection Plan of Action, MCAS Tustin and MCAS El Toro. August.

ATTACHMENT 1

PROJECT SCHEDULE
AND
PROJECT DECISION FLOW DIAGRAM

Activity	Orig Dur	Early Start	Early Finish
A51AW	0	24MAR99	
A5110	13	29MAR99	14APR99
A5115	8	05APR99	14APR99
A51DS	0	15APR99	
A5180	1	20APR99	20APR99
A5120	9	15APR99	27APR99
A51DR	0	28APR99	
A5135	5	28APR99	04MAY99
A51FA	0		04MAY99
A55MB	0	10MAY99	
A5520	2	10MAY99	11MAY99
A5580	2	18MAY99	19MAY99
A5510	8	11MAY99	20MAY99
A5570	6	14MAY99	21MAY99
A5530	4	18MAY99	21MAY99
A55DB	0		21MAY99
A5800	19	24MAY99	18JUN99
A5870	1	21JUN99	21JUN99
A5810	21	22JUN99	21JUL99
A58DS	0	22JUL99	
A5820	10	22JUL99	04AUG99
A58DR	0	05AUG99	
A5850	20	05AUG99	01SEP99
A58FA	0		01SEP99



DCN: FWSD-RAC-99-0228

Project Start	24MAR99
Project Finish	09DEC99
Data Date	24MAR99
Run Date	27APR99

Early Bar
Progress Bar
Critical Activity

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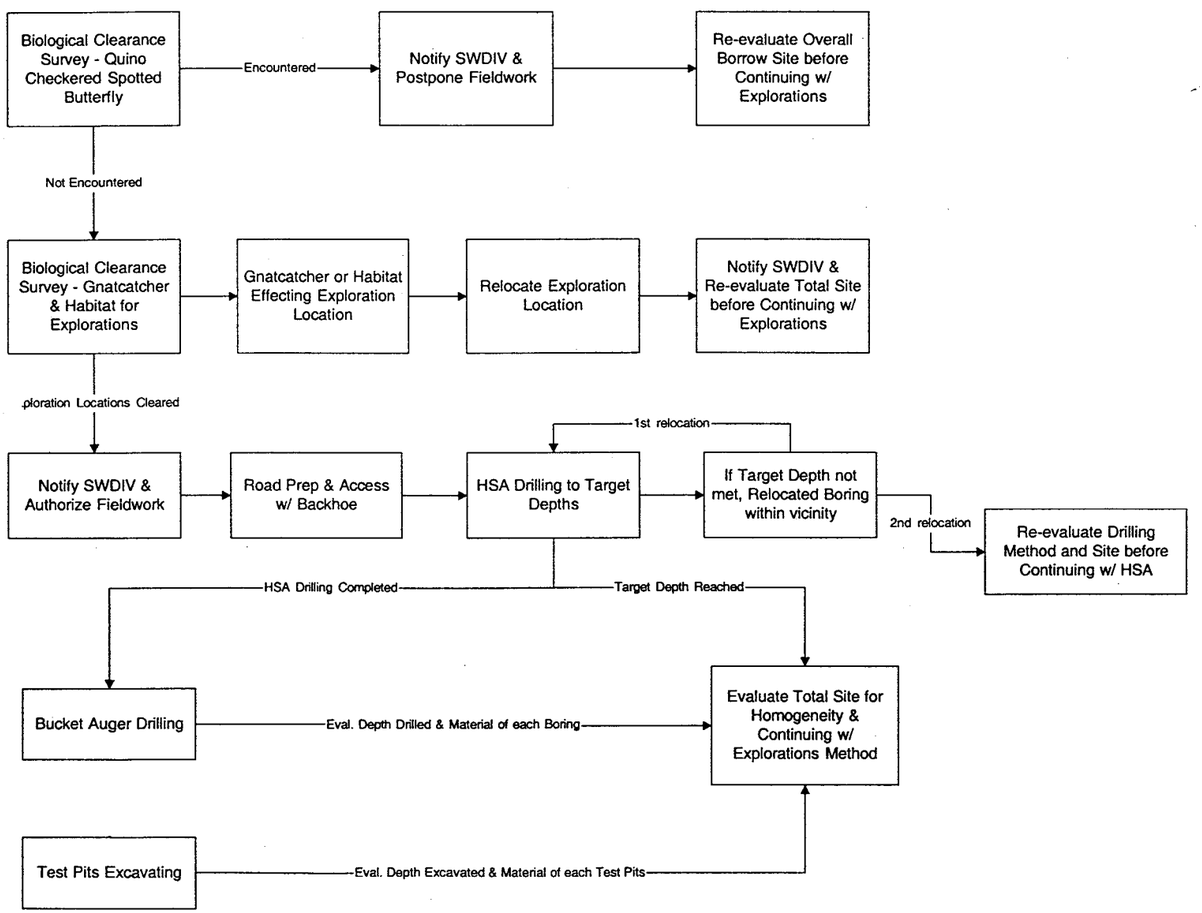
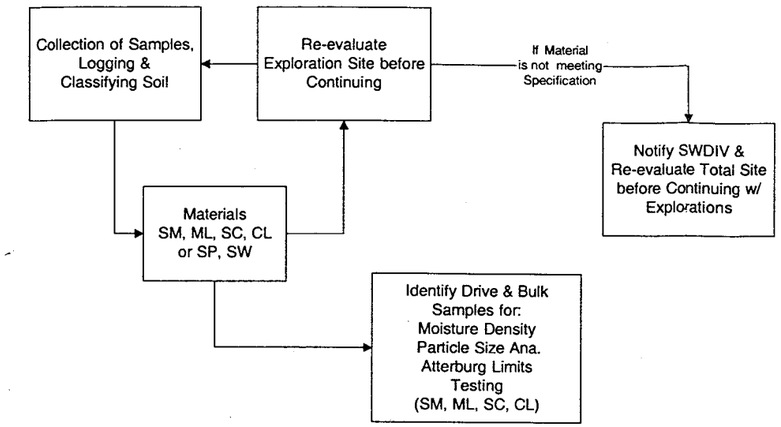
Sheet 1 of 1

Foster Wheeler Environmental Corp.
Southwest Division Environmental RAC
CTO 0005 - Geotech Eval at El Toro

Field Exploration



Field Sampling & Logging



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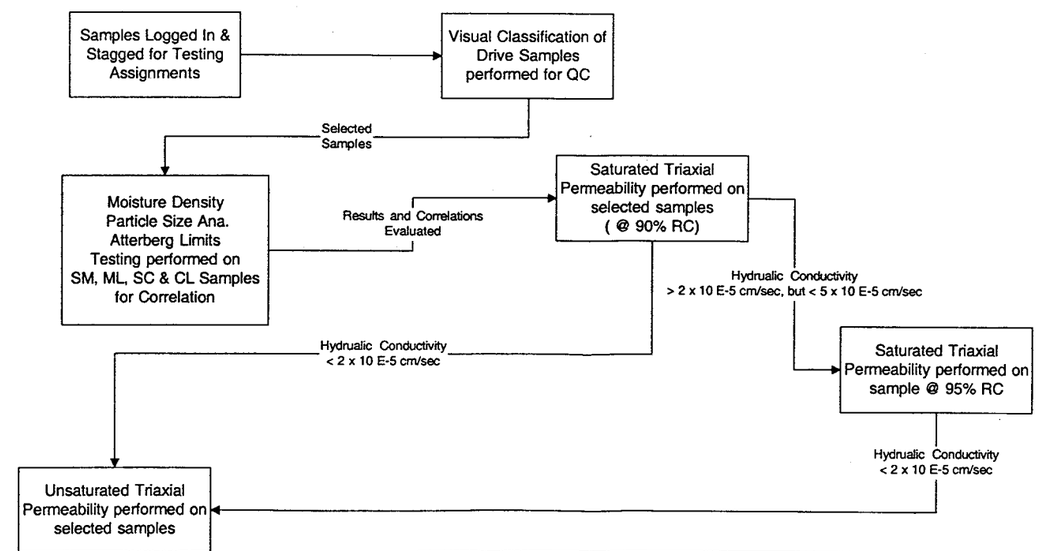

PROJECT DECISION FLOW DIAGRAM

CTO 0005 - GEOTECHNICAL EVALUATION, MCAS EL TORO, CA

ATTACHMENT 2

TECHNICAL MEMORANDUM – PROPOSED TABLE OF CONTENTS

TECHNICAL MEMORANDUM – PROPOSED TABLE OF CONTENTS

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7.0 RECOMMENDATIONS

Appendix A Summary of Drilling Methods, Soil Boring and Test Pit Logs

Appendix B Laboratory Test Methodology and Laboratory Results

Appendix C Photographic Log

TABLES

TABLE 1

PROJECT POINTS OF CONTACT

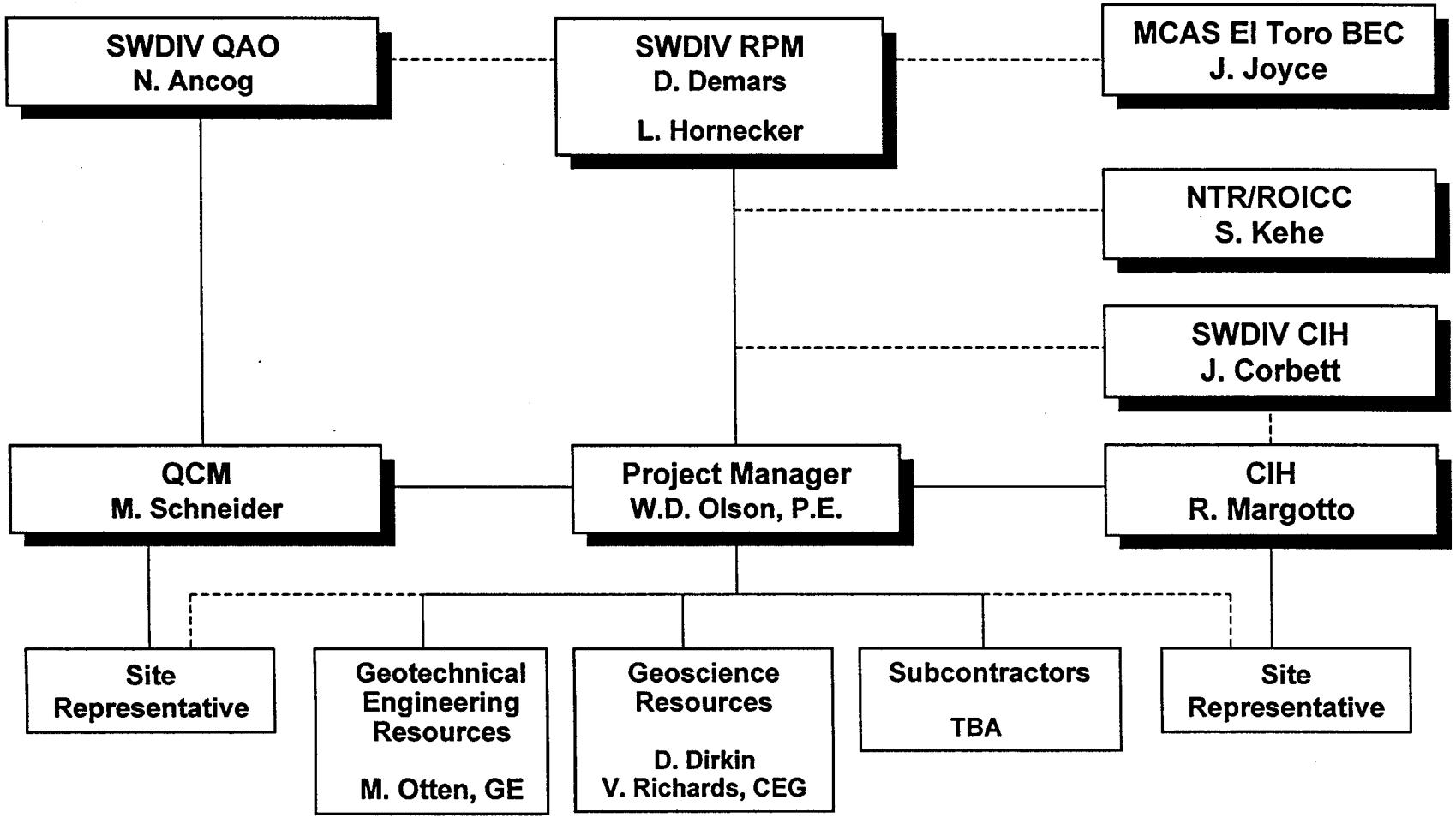
An organization chart for the cover characterization field activities is shown in Figure 1. Telephone numbers of project points of contact are listed below:

Name	Position	Telephone No.	Company
Ancog, Narciso	SWDIV QAO	(619) 532-2540	SWDIV
Corbett, Janet	SWDIV CIH	(619) 532-1378	SWDIV
Demars, Dave	Remedial Project Manager	(619) 532-4163	SWDIV
Hornecker, Lynn	Remedial Project Manager	(619) 532-4162	SWDIV
Kehe, Scott	ROICC	(949) 726-2501	SWDIV
Piszkin, Andy	Lead Remedial Project Manager	(619) 532-4159	SWDIV
Olson, William D.	Project Manager	(619) 234-8696 x209	Foster Wheeler Environmental
Dirkin, David	Field Geologist	(714) 444-5550	Foster Wheeler Environmental
Margotto, Roger	Health and Safety Manager	(619) 234-8696 x203	Foster Wheeler Environmental
O'Rourke, Craig	Regulatory Compliance	(714) 444-5511	Foster Wheeler Environmental
Otten, Mark	Geotechnical Engineer	(425) 688-3797	Foster Wheeler Environmental
Richards, Vince	CEG	(323) 278-4636	Foster Wheeler Environmental
Schneider, Mary	Program Chemist	(714) 444-5517	Foster Wheeler Environmental
Jones, Barry	Subcontract Biologist, PM	(619) 462-1515	Helix, Environmental Planning

FIGURES

Figure 1

Project Organization Chart



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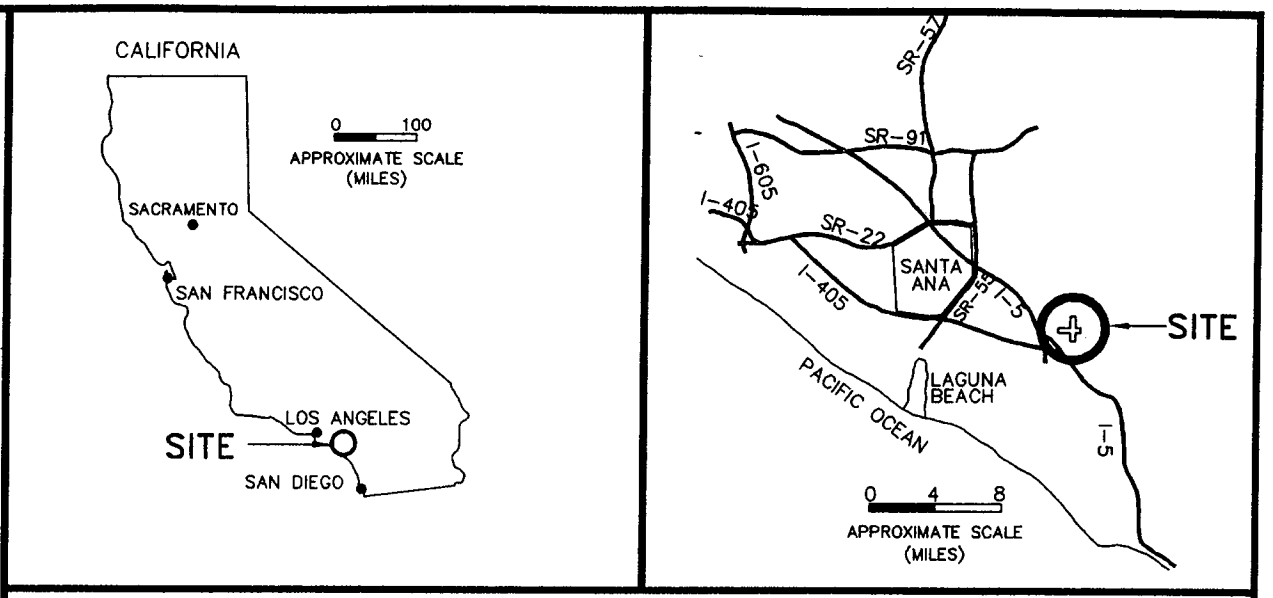

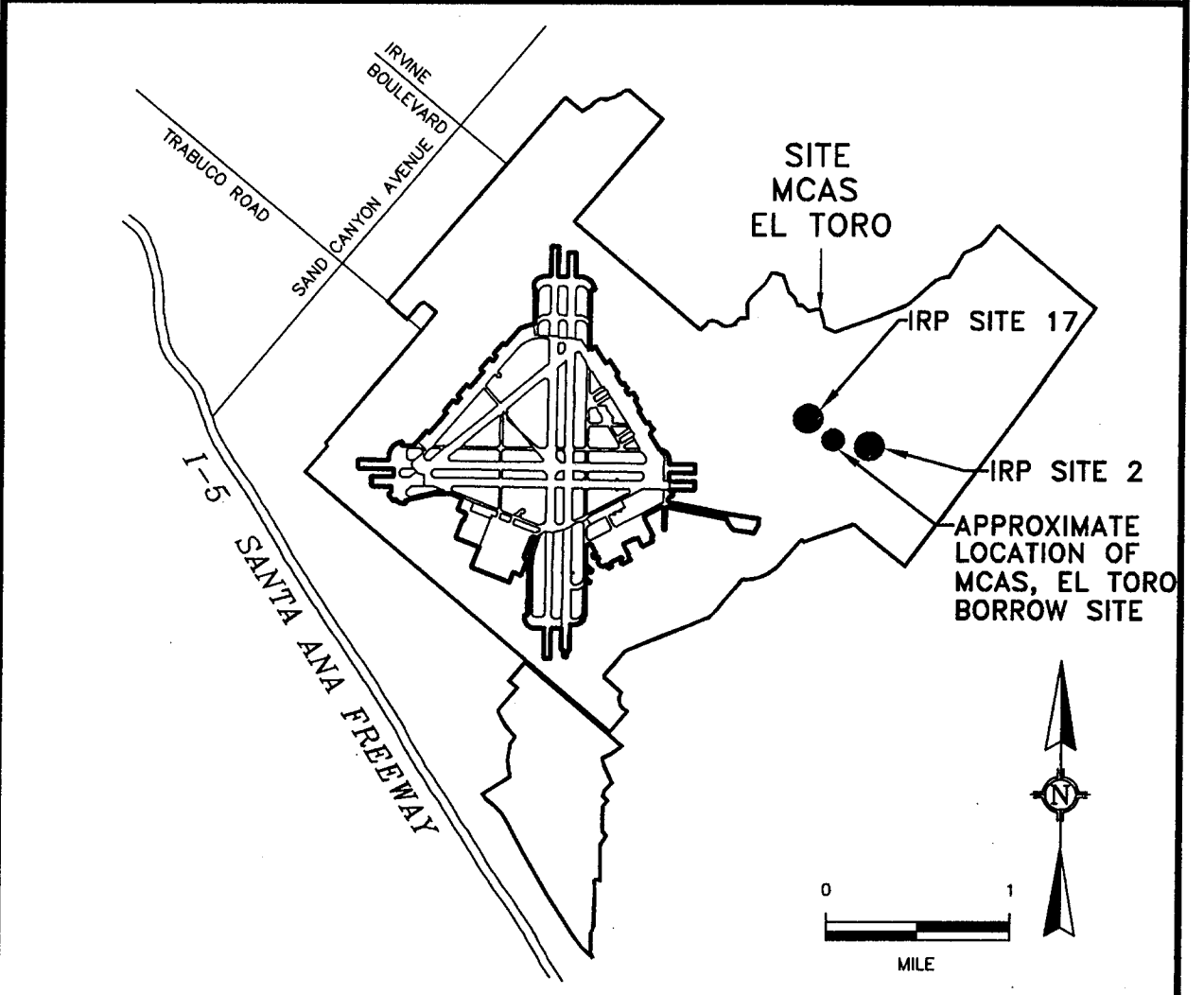

Figure 2
MCAS EL TORO VICINITY MAP
MCAS, EL TORO, CA

Southwest Division
Naval Facilities Engineering Command

FOSTER WHEELER
ENVIRONMENTAL CORPORATION

DRAWN BY: MD	CHECKED BY:	APPROVED BY:	DCN: FWSD-RAC-990193	DRAWING NO: 99019302
DATE: 04/06/99	REV: REVISION 0, April 6, 1999		CTO #005	

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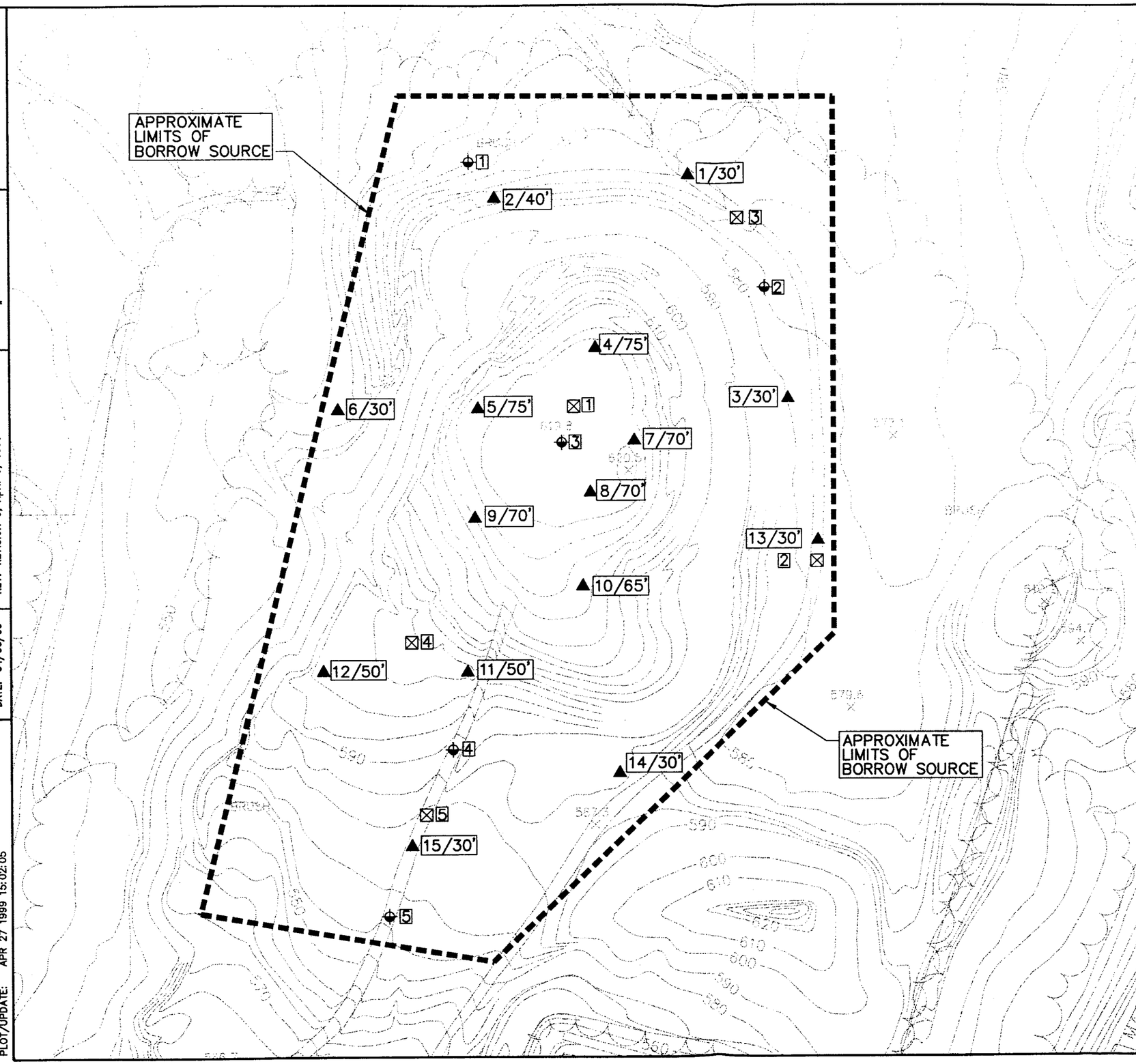

LEGEND

- ▲ PROPOSED HOLLOW STEM AUGER BORING
- ⊕ PROPOSED BUCKET AUGER BORING
- ⊠ PROPOSED TEST PIT
- 1/30' BORING NUMBER AND PROPOSED TARGET DEPTH

Figure 3
PROPOSED EXPLORATION LOCATIONS
MCAS, EL TORO, CA

Southwest Division
Naval Facilities Engineering Command

FOSTER WHEELER ENVIRONMENTAL CORPORATION

DRAWING NO: 99022803
DCN: FWSD-RAC-990228
CTO #005
APPROVED BY:
CHECKED BY:
REV: REVISION 0, April 6, 1999
DRAWN BY: MD
DATE: 04/06/99

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PLOT/UPDATE: APR 27 1999 15:02:05

APPENDIX A

ASTM STANDARDS

Designation: D 1452 – 80 (Reapproved 1990)[ε1]

Standard Practice for Soil Investigation and Sampling by Auger Borings[1]

This standard is issued under the fixed designation D 1452; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

[ε1] NOTE—Section 6 was added editorially in July 1990.

1. Scope

1.1 This practice covers equipment and procedures for the use of earth augers in shallow geotechnical exploration. This practice does not apply to sectional continuous flight augers.

1.2 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Significance and Use

2.1 Auger borings often provide the simplest method of soil investigation and sampling. They may be used for any purpose where disturbed samples can be used and are valuable in connection with ground water level determination and indication of changes in strata and advancement of hole for spoon and tube sampling. Equipment required is simple and readily available. Depths of auger investigations are, however, limited by ground water conditions, soil characteristics, and the equipment used.

3. Apparatus

3.1 *Hand-Operated Augers*:

3.1.1 *Helical Augers*—Small lightweight augers generally available in sizes from 1 through 3 in. (25.4 through 76.2 mm).

3.1.1.1 *Spiral-Type Auger*, consisting of a flat thin metal strip, machine twisted to a spiral configuration of uniform pitch; having at one end, a sharpened or hardened point, with a means of attaching a shaft or extension at the opposite end.

3.1.1.2 *Ship-Type Auger*—Similar to a carpenter's wood bit. It is generally forged from steel and machined to the desired size and configuration. It is normally provided with sharpened and hardened nibs at the point end and with an integral shaft extending through its length for attachment of a handle or extension at the opposite end.

3.1.2 *Open Tubular Augers*, ranging in size from 1.5 through 8 in. (38.1 through 203.2 mm) and having the common characteristic of appearing essentially tubular when viewed from the digging end.

3.1.2.1 *Orchard-Barrel Type*, consisting essentially of a tube having cutting lips or nibs hardened and sharpened to penetrate the formation on one end and an adaptor fitting for an extension or handle on the opposite end.

3.1.2.2 *Open-Spiral Type*, consisting of a flat thin metal strip that has been helically wound around a circular mandrel to form a spiral in which the flat faces of the strip are parallel to the axis of the augered hole. The lower helix edges are hard-faced to improve wear characteristics. The opposite end is fitted with an adaptor for extension.

3.1.2.3 *Closed-Spiral Type*—Nearly identical to the open-spiral type except, the pitch of the helically wound spiral is much less than that of the open-spiral type.

3.1.3 *Post-Hole Augers*, generally 2 through 8 in. (50.8 through 203.2 mm), and having in common a means of blocking the escape of soil from the auger.

3.1.3.1 *Clam-Shell Type*, consisting of two halves, hinged to allow opening and closing for alternately digging and retrieving. It is not usable deeper than about 3.5 ft (1.07 m).

3.1.3.2 *Iwan Type*, consisting of two tubular steel segments, connected at the top to a common member to form a nearly complete tube, but with diametrically opposed openings. It is connected at the bottom by two radial blades pitched to serve as cutters which also block the escape of contained soil. Attachment of handle or extension is at the top connector.

3.2 *Machine-Operated Augers*:

3.2.1 *Helical Augers*, generally 8 through 48 in. (203.2 through 1219 mm), consisting essentially of a center shaft fitted with a shank or socket for application of power, and having one to three complete 360° (6.28-rad) spirals for conveyance and storage of cut soil. Cutter bits and pilot bits are available in moderate and hard formation types and normally replaceable in the field. They are normally operated by heavy-duty, high-torque machines, designed for heavy construction work.

3.2.2 *Stinger Augers*, generally 6 through 30 in. (152.4 through 762 mm), are similar to the helical auger in 3.2.1, but lighter and generally smaller. They are commonly operated by light-duty machines for post and power pole holes.

3.2.3 *Disk Augers*, generally 10 through 30 in. (254 through 762 mm), consisting essentially of a flat, steel disk with diametrically opposed segments removed and having a

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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ak or socket located centrally for application of power. placeable cutter bits, located downward from the leading edges of the remaining disk, dig and load soil that is held on the disk by valves or shutters hinged at the disk in order to close the removed segments. The disk auger is specifically designed to be operated by machines having limited vertical clearance between spindle and ground surface.

3.2.4 *Bucket Auger*, generally 12 through 48 in. (304.8 through 1219 mm), consisting essentially of a disk auger, without shank or socket, but hinge-mounted to the bottom of a steel tube or bucket of approximately the same diameter as the disk auger. A socket or shank for power application is located in the top center of the bucket diametral cross piece provided for the purpose.

3.3 *Casing* (when needed), consisting of pipe of slightly larger diameter than the auger used.

3.4 *Accessory Equipment*—Labels, field log sheets, sample jars, sealing wax, sample bags, and other necessary tools and supplies.

4. Procedure

4.1 Make the auger boring by rotating and advancing the desired distance into the soil. Withdraw the auger from the hole and remove the soil for examination and test. Return the empty auger to the hole and repeat the procedure. Continue the sequence until the required depth is reached.

4.2 Casing is required in unstable soil in which the bore hole fails to stay open and especially when the boring is nded below the ground-water level. The inside diameter e casing must be slightly larger than the diameter of the auger used. The casing shall be driven to a depth not greater than the top of the next sample and shall be cleaned out by means of the auger. The auger can then be inserted into the bore hole and turned below the bottom of the casing to obtain a sample.

4.3 The soil auger can be used both for boring the hole and for bringing up disturbed samples of the soil encountered. The structure of a cohesive soil is completely destroyed and the moisture may be changed by the auger. Seal all samples in a jar or other airtight container and label appropriately. If more than one type of soil is picked up in the sample, prepare a separate container for each type of soil.

4.4 *Field Observations*—Record complete ground water information in the field logs. Where casing is used, measure ground water levels, both before and after the casing is pulled. In sands, determine the water level at least 30 min after the boring is completed; in silts, at least 24 h. In clays, no accurate water level determination is possible unless pervious seams are present. As a precaution, however, water levels in clays shall be taken after at least 24 h.

5. Report

5.1 The data obtained in boring shall be recorded in the field logs and shall include the following:

5.1.1 Date of start and completion of boring,

5.1.2 Identifying number of boring,

5.1.3 Reference datum including direction and distance of boring relative to reference line of project or other suitable reference points,

5.1.4 Type and size of auger used in boring,

5.1.5 Depth of changes in strata,

5.1.6 Description of soil in each major stratum,

5.1.7 Ground water elevation and location of seepage zones, when found, and

5.1.8 Condition of augered hole upon removal of auger, that is, whether the hole remains open or the sides cave, when such can be observed.

6. Keywords

Auger borings; sampling; soil investigations

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: D 3550 - 84 (Reapproved 1995)[ε1]

Standard Practice for Ring-Lined Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 3550; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

[ε1] NOTE—Editorial changes were made in March 1995.

1. Scope

1.1 This practice covers a procedure for using a ring-lined barrel sampler to obtain representative samples of soil for identification purposes and other laboratory tests. In cases where it has been established that the quality of the sample is adequate, this practice provides shear and consolidation specimens that can be used directly in the test apparatus without prior trimming. Some types of soils may gain or lose significant shear strength or compressibility, or both, as a result of sampling. In cases like these, suitable comparison tests should be made to evaluate the effect of sample disturbance on shear strength and compressibility.

1.2 This practice is not intended to be used as a penetration test; however, the force required to achieve penetration or a blow count, when driving is necessary, is recommended as supplemental information.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

3. Significance and Use

3.1 This practice is used where soil condition and resistance to advance of the sampler do not permit the use of a thin-wall tube (Practice D 1587) and where the formation does not require diamond coring (Practice D 2113).

4. Apparatus

4.1 *Drilling Equipment*—Any drilling equipment may b used that provides a reasonably clean hole before insertion of the sampler and that does not disturb the soil to be sampled However, in no case shall a bottom-discharge bit be pe mitted. Side-discharge bits are permissible.

4.2 *Drive Weight Assembly*—Any drive weight assembly that will provide penetration in the range from 1 to 20 blow per foot (0.30-m) may be used. Whenever possible, soils ar to be sampled by pushing instead of driving (see Section 5).

4.3 *Ring-Lined Barrel Sampling Assembly*—This shall consist of a shoe, sampler, and waste barrel, as shown in Fi 1.

4.4 *Ring-Lined Sampler*—Test specimens shall be obtained using a suitable one piece or split sampling b lined on the inside with removable rings. These rings s thin-walled and shall conform to the size requirements of th particular laboratory test determinations employed. They shall fit snugly inside the sampler with no discernible fre play in any direction. The sampler may be sectionalized t allow end-to-end make-up of sections as necessary. Eac section shall be designed so that addition or removal of sections will not loosen, permit movement, or otherwi adversely affect retention of the rings within the sample The sampler and rings shall be free of bumps, dents, scratches, rust, dirt, and corrosion.

NOTE 1—It is recommended that the sampler contain at least rings in order to provide samples for a variety of tests.

4.5 *Waste Barrel*—A waste barrel that can be remov from the sampler in the field shall be provided to conta space for disturbed soil originally at the bottom of the hole. The length of the waste barrel shall be at least three times its interior diameter, and the inside diameter shall be the sam or slightly larger than, the inside diameter of the rings.

4.5.1 An attachment, check valve, and one or more vents is required. The design of these items is optional.

4.6 *Shoe*—The shoe shall be machined as shown in Fig. The inside of the assembled shoe and ring-lined sampler sh be smooth, straight, and uniform. The thin-walled extension of the shoe shall be 2 to 4 in. (51 to 102 mm) in outsi diameter and made of any materials of adequate streng and resistance to corrosion. The length of the thin extension shall be equal to three times the diameter opening, but shall not exceed 8 in. (203 mm). The insi clearance ratio shall be between 0.5 and 3.0 %. (See Fig. 1

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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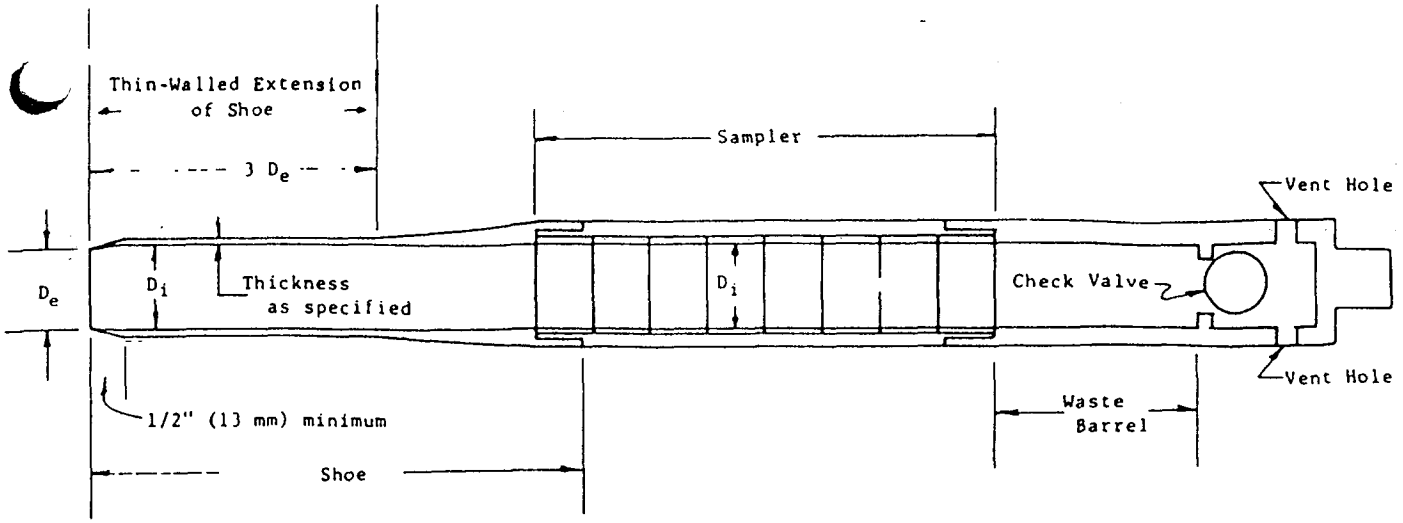
[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE 1—Inside clearance ratio = $(D_i - D_e)/D_e$
NOTE 2—Dimensional tolerance of D_i = ±0.003 in. (±0.08 mm)

FIG. 1 Ring-Lined Barrel Sampling Assembly

nside clearance ratio formula.) The wall thickness of the hin-walled extension shall conform to Table 1.

4.6.1 The thin-walled extension of the shoe shall be perfectly round. Shoes that have become out-of-round for ny reason shall not be used. If the thin-walled extension of ıe shoe deforms during sampling, the sample obtained shall not be used for tests, such as shear strength, where soil dist ance is a factor.

2—The thin-walled extension of the shoe is not suitable for ıiff or gravelly soils. In cases such as these, a shoe similar to the type specified in Method D 1586 is required for penetration. The use of this pe of shoe, however, may result in excessive disturbance of the soil so ıat it is no longer suitable for shear or consolidation determinations, or ɔth.

4.7 *Sample Extractor*—Specimen-filled rings shall be re-ıoved from the sampler by pressing them out or alterna-vely by the use of a split barrel. The extractor disk shall be ıt least 0.5 in. (13 mm) thick and shall bear solidly against the sample rings at all points. It shall slide easily inside the ımpler barrel without jamming and without free play.

4.8 *Containers for Specimen-Filled Rings*—These shall be ɜnug fitting, tightly sealed (watertight), rigid containers that ill not permit movement of the specimen-filled rings inside. hey shall be noncorrosive.

4.9 *Miscellaneous Equipment*—This includes a pipe vise, ɔipe wrenches, spatulas, cleaning brushes, buckets, rags, data eets, transporting boxes, etc. Water must be available for eaning the equipment.

5. Procedure

5.1 Clean the hole to sampling elevation using whatever ethod is preferred that will ensure that the material to be ampled is not disturbed. In saturated sands and silts, vithdraw the drill bit slowly to prevent loosening of the soil ound the hole. When casing is used, it shall not be driven low mpling elevation. Water or drilling liquid within the ɔor ust be maintained at all times at or above the ıtural ground water level; it is preferable to keep the hole led.

5.2 Keep a careful record of drill penetration and sampler depth to ensure that the soil being sampled is the original soil at the bottom of the hole and is not contaminated by soil falling down from the sides of the hole. If there is any significant tendency for soil to fall from the sides of the hole to the bottom, use water, drilling mud, or casing, as necessary, in order to prevent this from happening. The process of jetting through an open-tube sampler and then sampling when the desired depth is reached shall not be permitted. The use of bottom-discharge bits shall not be allowed.

5.3 Assemble the sampling assembly and lower it carefully into the hole. With the cutting edge of the shoe resting on the bottom of the hole and the water level in the boring at the ground water level or above, push the sampling assembly into the soil by a continuous and rapid motion without impact or twisting. Push the assembly in far enough so that all cuttings, sludge, and soil disturbed by drilling are in the waste barrel; however, in no case push the assembly farther than the total length of the shoe, sampler, and waste barrel. Take care that none of the sample is lost due to improper operation of the check valve.

5.4 When the soils are so hard that they cannot be penetrated by pushing, using generally acceptable field procedures, and where recovery by pushing in sands is poor, use a driving hammer to drive the sampling assembly. In such a case, record the hammer weight, height of drop, and number of blows.

5.5 Carefully disassemble the sampling assembly in such a manner as to minimize soil disturbance as much as possible. Trim the soil flush with the ends of the sampling barrel, and remove the specimen (consisting of soil plus rings). Slip the container over the specimen-filled rings and cap both ends. Be certain that there is no movement of the specimen-filled rings inside the container and that the specimen was not disturbed while being removed from the barrel and placed in the container. Label the container in a suitable manner. If the soil in the bottom end ring does not protrude from the ring after removing the shoe, do not use the soil in the

bottom ring for tests other than soil classification and moisture content. If the top ring or rings contain voids, depressions, or any material other than the soil which is being sampled, do not use the soil in this ring (or rings) for any purpose whatsoever. The filling of depressions in the end rings with additional soil shall not be permitted. Discard samples that appear to be disturbed or questionable.

5.6 Examine the soil remaining in the shoe for structure, consistency, color, and condition. Record these observations and include them in the report (see 6.1.8).

NOTE 3—The soil remaining in the shoe is relatively undisturbed and therefore may be suitable for a variety of laboratory tests.

6. Report

6.1 Data obtained in each boring shall be recorded in the field and shall contain the following:

6.1.1 Name and location of job,

6.1.2 Date of boring and times of start and finish,

6.1.3 Boring number and location,

6.1.4 Surface elevation, if available,

6.1.5 Sample number and depth,

6.1.6 Method of advancing sampler, penetration, and recovery lengths,

6.1.7 Description and size of sampler,

6.1.8 Description of soil (see Practice D 2488),

6.1.9 Thickness of layer,

6.1.10 Depth to water table or depth of overlying water and time of reading,

6.1.11 Size of casing, depth of cased hole,

6.1.12 Type of drilling equipment—description,

6.1.13 Names of personnel: crewman, field engineer, technician, etc.,

6.1.14 Weather conditions, and

6.1.15 General remarks.

7. Precision and Bias

7.1 This practice does not produce numerical or repeatable data and therefore a precision and bias statement is not applicable.

8. Keywords

8.1 consolidation; direct shear; identification; liner; representative; ring; sampling

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Designation: D 2488 – 93

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard 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 appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1.2 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.6 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.1.7 *sand*—particles of rock that will pass a No. 4

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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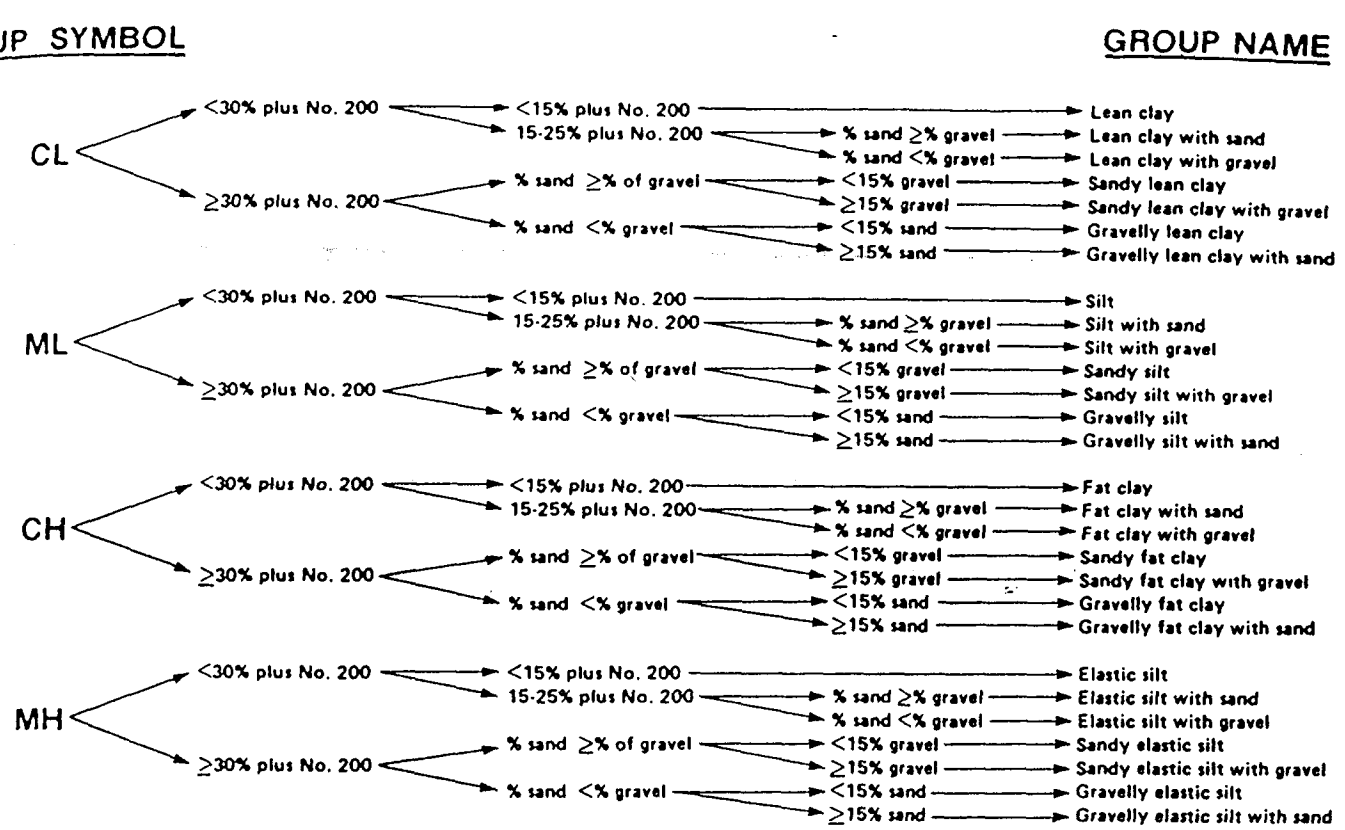
[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

(4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.1.8 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

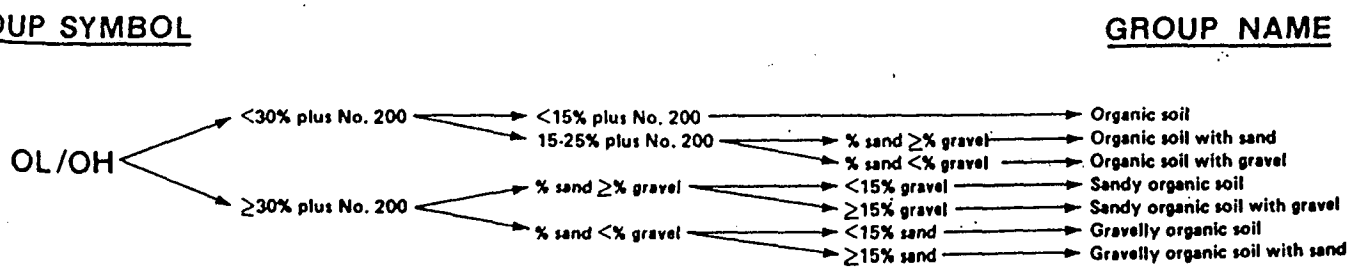
4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

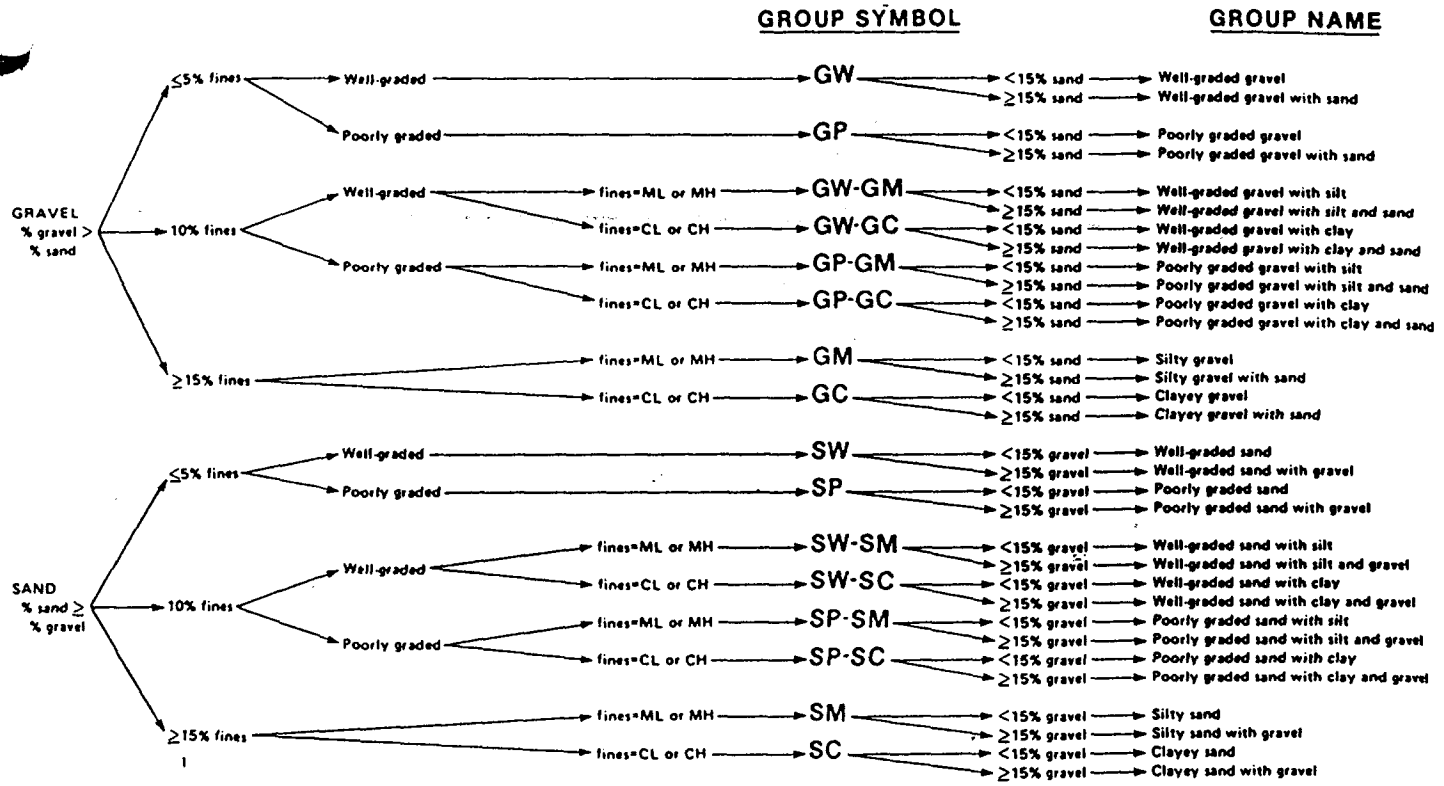
NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

FIG. 3 Typical Angularity of Bulky Grains

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly water.

..2 Caution—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3/8 in.)	200 g (0.5 lb)
19.0 mm (3/4 in.)	1.0 kg (2.2 lb)
38.1 mm (1 1/2 in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

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
brounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

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.

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

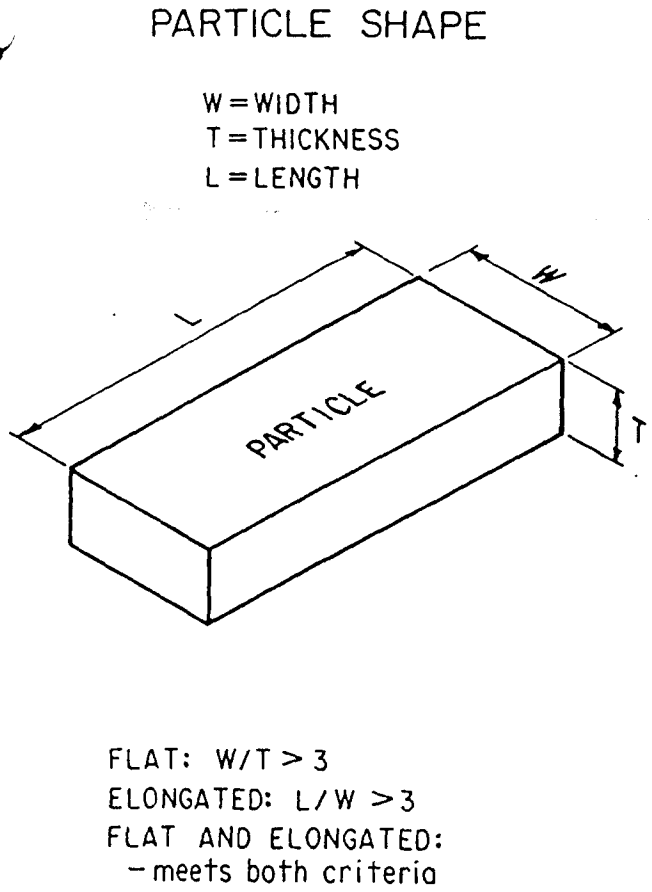


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

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

locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount 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 may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

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

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpre-

TABLE 6 Criteria for Describing 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

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm 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

tation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 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 as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 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.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ 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.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 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 accorance with the criteria in Table 8. 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.

14.2.5 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 (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 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

TABLE 8 Criteria for Describing 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

TABLE 9 Criteria for Describing 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

TABLE 10 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

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

14.4 *Toughness:*

14.4.1 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 ⅛ 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 ⅛ in. The thread will crumble at a diameter of ⅛ 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.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) 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

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 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, 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.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil 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

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

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 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice 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 may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the

percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

Standard Practices for Preserving and Transporting Soil Samples[1]

This standard is issued under the fixed designation D 4220; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 These practices cover procedures for preserving soil samples immediately after they are obtained in the field and accompanying procedures for transporting and handling the samples.

1.2 *Limitations*—These practices are not intended to address requirements applicable to transporting of soil samples known or suspected to contain hazardous materials.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

D 420 Guide to Site Characterization for Engineering, Design, and Construction Purposes[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 4564 Test Method for Density of Soil in Place by the Sleeve Method[2]

D 4700 Guide for Soil Sampling from the Vadose Zone[2]

3. Terminology

3.1 Terminology in these practices is in accordance with Terminology D 653.

4. Summary of Practices

4.1 The various procedures are given under four groupings as follows:

4.1.1 *Group A*—Samples for which only general visual identification is necessary.

4.1.2 *Group B*—Samples for which only water content and classification tests, proctor and relative density, or profile logging is required, and bulk samples that will be remolded or compacted into specimens for swell pressure, percent swell, consolidation, permeability, shear testing, CBR, stabilimeter, etc.

4.1.3 *Group C*—Intact, naturally formed or field fabricated, samples for density determinations; or for swell pressure, percent swell, consolidation, permeability testing and shear testing with or without stress-strain and volume change measurements, to include dynamic and cyclic testing.

4.1.4 *Group D*—Samples that are fragile or highly sensitive for which tests in Group C are required.

4.2 The procedure(s) to be used should be included in the project specifications or defined by the designated responsible person.

5. Significance and Use

5.1 Use of the various procedures recommended in these practices is dependent on the type of samples obtained (Practice D 420), the type of testing and engineering properties required, the fragility and sensitivity of the soil, and the climatic conditions. In all cases, the primary purpose is to preserve the desired inherent conditions.

5.2 The procedures presented in these practices were primarily developed for soil samples that are to be tested for engineering properties, however, they may be applicable for samples of soil and other materials obtained for other purposes.

6. Apparatus

6.1 The type of materials and containers needed depend upon the conditions and requirements listed under the four groupings A to D in Section 4, and also on the climate and transporting mode and distance.

6.1.1 *Sealing Wax*, includes microcrystalline wax, paraffin, beeswax, ceresine, carnaubawax, or combinations thereof.

6.1.2 *Metal Disks*, about 1/16 in. (about 2 mm) thick and having a diameter slightly less than the inside diameter of the tube, liner, or ring and to be used in union with wax or caps and tape, or both.

6.1.3 *Wood Disks*, prewaxed, 1 in. (25 mm) thick and having a diameter slightly less than the inside diameter of the liner or tube.

6.1.4 *Tape*, either waterproof plastic, adhesive friction, or duct tape.

6.1.5 *Cheesecloth*, to be used in union with wax in alternative layers.

6.1.6 *Caps*, either plastic, rubber or metal, to be placed

[1] These practices are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

* A Summary of Changes section appears at the end of these practices.

without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.

NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the markings or labels are adequate to survive transportation and storage.

8. Report

8.1 The appropriate information is required as follows:

8.1.1 Name and location of the project,

8.1.2 Boring number and precise location on project,

8.1.3 Surface elevation or reference to a datum,

8.1.4 Date and time of boring—start and finish,

8.1.5 Depth to top of sample and number of sample,

8.1.6 Description of sampler: size, type of metal, type of coating,

8.1.7 Method of sampler insertion: push or drive,

8.1.8 Method of drilling, size of hole, casing, and drilling fluid used,

8.1.9 Depth to groundwater level: date and time measured,

8.1.10 Any possible current or tidal effect on water level,

8.1.11 Soil description in accordance with Practice D 2488,

8.1.12 Length of sampler advance, and

8.1.13 Recovery: length of sample obtained.

9. Precision and Bias

9.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

10. Keywords

10.1 sampling; soil exploration; undisturbed

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

r the end of thin-walled tubes (Practice D 1587), liners (Practice D 3550), in union with tape or wax.

O'ring (Sealing End Caps), used to seal the ends of nples within thin-walled tubes, by mechanically exding an O'ring against the tube wall.

NOTE 1—Plastic expandable end caps are preferred. Metal expand- end caps seal equally well; however, long-term storage may cause osion problems.

1.8 *Jars*, wide mouthed, with rubber-ringed lids or lids ed with a coated paper seal and of a size to comfortably ive the sample, commonly ½ pt (250 mL), 1 pt (500 mL) quart-sized (1000 mL).

1.9 *Bag*, either plastic, burlap with liner, burlap or cloth e (Practice D 1452).

1.10 *Packing Material*, to protect against vibration and k.

1.11 *Insulation*, either granule (bead), sheet or foam e, to resist temperature change of soil or to prevent ing.

1.12 *Sample Cube Boxes*, for transporting cube (block) nples. Constructed with ½ to ¾ in. (13 to 19 mm) thick wood (marine type).

1.13 *Cylindrical Sample Containers*, somewhat larger in nsion than the thin-walled tube or liner samples, such as indrical frozen food cartons.

1.14 *Shipping Containers*, either box or cylindrical type of proper construction to protect against vibration, k, and the elements, to the degree required.

–The length, girth and weight restrictions for commercial n must be considered.

1.15 *Identification Material*—This includes the necesy writing pens, tags, and labels to properly identify the le(s).

Precautions

1 Special instructions, descriptions, and marking of iners must accompany any sample that may include active, chemical, toxic, or other contaminant material.

2 Interstate transportation containment, storage, and sal of soil samples obtained from certain areas within nited States and the transportation of foreign soils into unrough the United States are subject to regulations blished by the U.S. Department of Agriculture, Animal, Plant Health Service, Plant Protection and Quarantine ams, and possibly to regulations of other federal, state, ocal agencies.

2.1 Samples shipped by way of common carrier or U.S. l Service must comply with the Department of Transtion Hazardous Materials Regulation, 49CRF Part 172.

3 Sample traceability records (see Fig. 1) are encouraged hould be required for suspected contaminated samples.

1 The possession of all samples must be traceable, collection to shipment to laboratory to disposition, and ld be handled by as few persons as possible.

2 The sample collector(s) should be responsible for the sample traceability record; recording the mple identification and location, sample type, and the number and types of containers.

3 A separate traceability record shall accompany each ent.

7.3.4 When transferring the possession of samples the person(s) relinquishing and receiving the samples shall sign, date, record the time, and check for completeness of the traceability record.

8. Procedure

8.1 *All Samples*—Properly identify samples with tags, labels, and markings prior to transporting them as follows:

8.1.1 Job name or number, or both,

8.1.2 Sampling date,

8.1.3 Sample/boring number and location,

8.1.4 Depth or elevation, or both,

8.1.5 Sample orientation,

8.1.6 Special shipping or laboratory handling instructions, or both, including sampling orientation, and

8.1.7 Penetration test data, if applicable (Test Method D 1586).

8.1.8 Subdivided samples must be identified while maintaining association to the original sample.

8.1.9 If required, sample traceability record.

8.2 *Group A*—Transport samples in any type of container by way of available transportation. If transported commercially, the container need only meet the minimum requirements of the transporting agency and any other requirements necessary to assure against sample loss.

8.3 *Group B:*

8.3.1 Preserve and transport these samples in sealed, moistureproof containers. All containers shall be of sufficient thickness and strength to ensure against breakage and moisture loss. The container types include: plastic bags or pails, glass or plastic (provided they are waterproof) jars, thin walled tubes, liners, and rings. Wrap cylindrical and cube samples in suitable plastic film or aluminum foil, or both, (Note 3) and coat with several layers of wax, or seal in several layers of cheesecloth and wax.

8.3.2 Transport these samples by any available transportation. Ship these samples as prepared or placed in larger shipping containers, including bags, cardboard, or wooden boxes or barrels.

NOTE 3—Some soils may cause holes to develop in aluminum foil, due to corrosion. Avoid direct contact where adverse affects to sample composition are a concern.

8.3.3 *Plastic Bags*—Place the plastic bags as tightly as possible around the sample, squeezing out as much air as possible. They shall be 3 mil or thicker to prevent leakage.

8.3.4 *Glass-Plastic Jars*—If the jar lids are not rubber ringed or lined with new waxed paper seals, seal the lids with wax.

8.3.5 *Plastic Pails*—If the plastic pail lids are not air tight, seal them with wax or tape.

8.3.6 *Thin-Walled Tubes:*

8.3.6.1 *Expandable Packers*—The preferred method of sealing sample ends within tubes is with plastic, expandable packers.

8.3.6.2 *Wax With Disks*—For short-term sealing, paraffin wax is acceptable. For long term sealing (in excess of 3 days) use microcrystalline waxes or combine with up to 15 % beeswax or resin, for better adherence to the wall of the tube and to reduce shrinkage. Several thin layers of wax are preferred over one thick layer. The minimum final thickness shall be 0.4 in. (10 mm).

8.3.6.3 *End Caps*—Seal metal, rubber, or plastic end caps with tape. For long term storage (longer than 3 days), also dip them in wax, applying two or more layers of wax.

8.3.6.4 *Cheesecloth and Wax*—Use alternating layers (a minimum of two each) of cheesecloth and wax to seal each end of the tube and stabilize the sample.

NOTE 4—Where necessary, spacers or appropriate packing materials, or both, must be placed prior to sealing the tube ends to provide proper confinement. Packing material must be nonabsorbent and must maintain its properties to provide the same degree of continued sample support.

8.3.7 *Liners and Rings*—Refer to 8.3.6.3 or 8.3.6.4.

8.3.8 *Exposed Samples:*

8.3.8.1 *Cylindrical, Cubical or Other Samples Wrapped in Plastic*, such as polyethylene and polypropylene, or foil should be further protected with a minimum of three coats of wax.

8.3.8.2 *Cylindrical and Cube Samples Wrapped in Cheesecloth and Wax*, shall be sealed with a minimum of three layers of each, placed alternatively.

8.3.8.3 *Carton Samples (Frozen Food Cartons)*—Samples placed in these containers must be situated so that wax can be poured completely around the sample. The wax should fill the void between the sample and container wall. The wax should be sufficiently warm to flow, but not so hot that it penetrates the pores of the soil. Generally, the samples should be wrapped in plastic or foil before being surrounded with wax.

8.4 *Group C:*

8.4.1 Preserve and seal these samples in containers as covered in 8.3. In addition, they must be protected against vibration and shock, and protected from extreme heat or cold.

8.4.2 Samples transported by the sampling or testing agency personnel on seats of automobiles and trucks need only be placed in cardboard boxes, or similar containers into which the sealed samples fit snugly, preventing bumping, rolling, dropping, etc.

8.4.3 For all other methods of transporting samples, including automobile trunk, bus, parcel services, truck, boat, air, etc., place the sealed samples in wood, metal, or other type of suitable shipping containers that provide cushioning or insulation, or both, for each sample and container. Avoid transporting by any agency whose handling of containers is suspect.

8.4.4 The cushioning material (sawdust, rubber, polystyrene, urethane foam, or material with similar resiliency) should completely encase each sample. The cushioning between the samples and walls of the shipping containers should have a minimum thickness of 1 in. (25 mm). A minimum thickness of 2 in. (50 mm) shall be provided on the container floor.

8.4.5 When required, the samples should be shipped in the same orientation in which they were sampled. Otherwise, special conditions shall be provided such as freezing, controlled drainage, or sufficient confinement, or a combination thereof, to maintain sample integrity.

8.5 *Group D:*

8.5.1 The requirements of 8.4 must be met, in addition to the following:

8.5.1.1 Samples should be handled in the same orientation in which they were sampled, including during transportation or shipping, with appropriate markings on the shipping container.

8.5.1.2 For all modes of private or commercial transportation, the loading, transporting and unloading of the shipment containers should be supervised as much as possible by a qualified person.

NOTE 5—A qualified person may be an engineer, geologist, soil scientist, soils technician or responsible person designated by the project manager.

8.6 *Shipping Containers* (see Figs. 2 to 7 for typical containers):

8.6.1 The following features should be included in the design of the shipping container for Groups C and D.

8.6.1.1 It should be reuseable,

8.6.1.2 It should be constructed so that the samples can be maintained, at all times, in the same position as when sampled or packed, or both,

8.6.1.3 It should include sufficient packing material to cushion or isolate, or both, the tubes from the adverse effect of vibration and shock, and

8.6.1.4 It should include sufficient insulating material to prevent freezing, sublimation and thawing, or undesirable temperature changes.

8.6.2 *Wood Shipping Containers:*

8.6.2.1 Wood is preferred over metal. Outdoor (marine) plywood having a thickness of ½ and ¾ in. (13 to 19 mm) may be used. The top (cover) should be hinged and latched, or fastened with screws.

8.6.2.2 The cushioning requirements are given in 8.4.4.

8.6.2.3 For protection against freezing or extreme temperature variation, the entire shipping container should be lined with a minimum insulation thickness of 2 in. (50 mm).

8.6.3 *Metal Shipping Containers*—The metal shipping containers must incorporate cushioning and insulation material to minimum thicknesses in accordance with 8.6.2, although slightly greater thicknesses would be appropriate. Alternatively, the cushion effect could be achieved with a spring suspension system, or any other means that would provide similar protection.

8.6.4 *Styrene Shipping Containers*—Bulk styrene with slots cut to the dimensions of the sample tube or liner. A protective outer box of plywood or reinforced cardboard is recommended.

8.6.5 *Other Containers*—Containers constructed with laminated fiberboard, plastic or reinforced cardboard outer walls, and properly lined, may also be used.

9. Reporting

9.1 The data obtained in the field shall be recorded and should include the following:

9.1.1 Job name or number, or both,

9.1.2 Sampling date(s),

9.1.3 Sample/boring number(s) and location(s),

9.1.4 Depth(s) or elevation(s), or both,

9.1.5 Sample orientation,

Sample Identification/Traceability Record
(Controlled Document)

Project: _____ W.O. # _____
Shipped by: _____
Shipped to: _____ Attention of:
Comments: _____ Hazardous materials suspected? (yes/no)

Sampling Point	Location	Field ID #	Date	Sample Type	No. of Containers	Analysis/Test Required	(optional) Lab ID

Sampler(s) (signature) _____

Field ID	Relinquished by: (signature)	Date/Time		Received by: (signature)	Date/Time		Comments

Shipment prepared by: (signature) _____ Date/Time _____ Shipment method: _____
Received for Lab by: (signature) _____ Date/Time _____ Comments _____

Receiving Laboratory: Please return original form after signing for receipt of samples.

FIG. 1 Example Layout of Record Form

9.1.6 Groundwater observation, if any,
9.1.7 Method of sampling, and penetration test data, if applicable,
9.1.8 Sample dimensions,
9.1.9 Soil description (Practice D 2488),
9.1.10 Names of technician/crewman, engineer, project chief, etc.,
9.1.11 Comments regarding contaminated or possible contaminated samples,
9.1.12 If used, a copy of traceability records,
9.1.13 Weather conditions, and
9.1.14 General remarks.

10. Precision and Bias

10.1 This practice provides qualitative and general information only. Therefore, a precision and bias statement is not applicable.

11. Keywords

11.1 preservation; soil samples; transportation

SUMMARY OF CHANGES

This section identifies the location of changes to these practices that have been incorporated since the last issue. Committee D-18 has highlighted those changes that affect the technical interpretation or use of these practices.

(1) Section 11 was added since the last revision.
(2) Section 2 was expanded since the last revision.

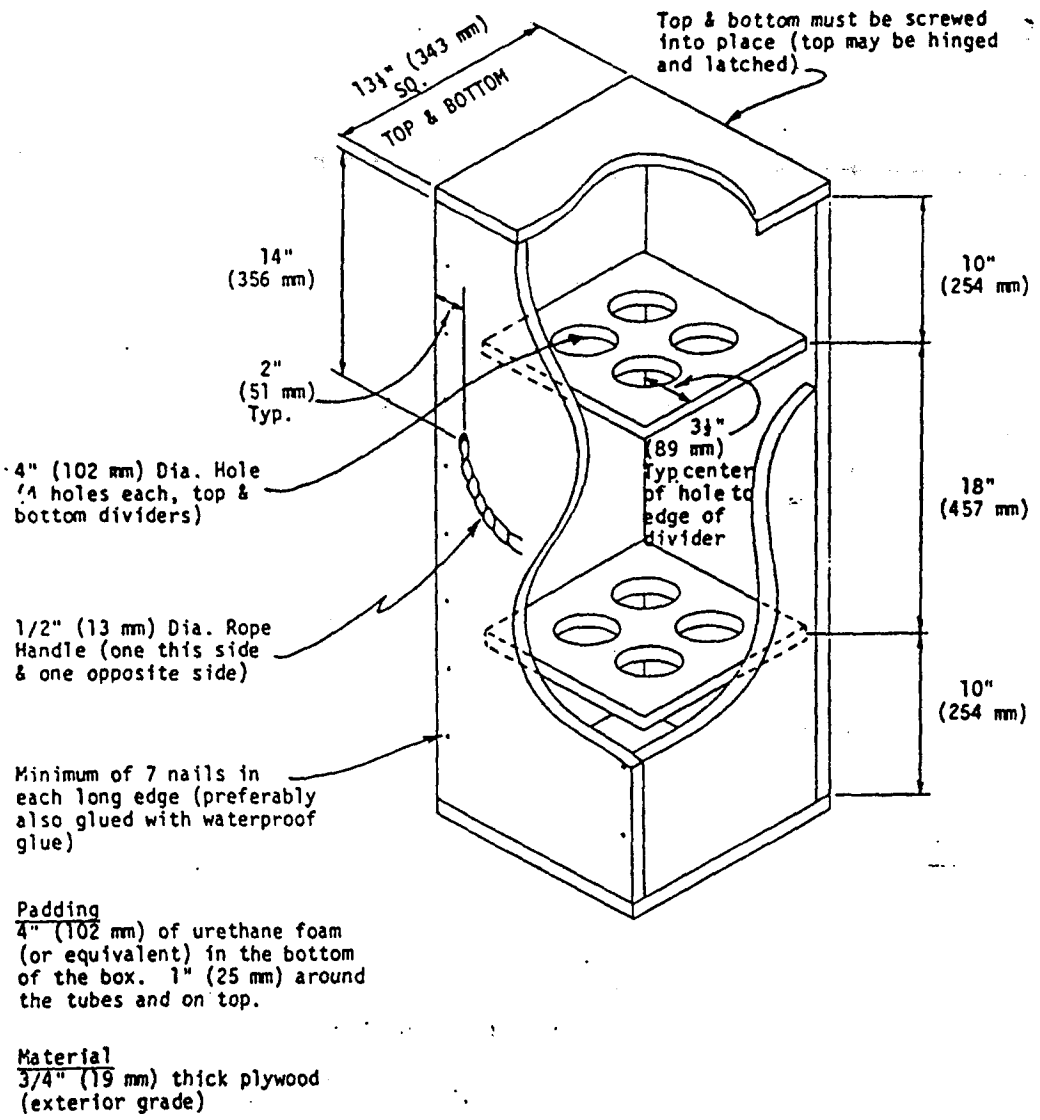
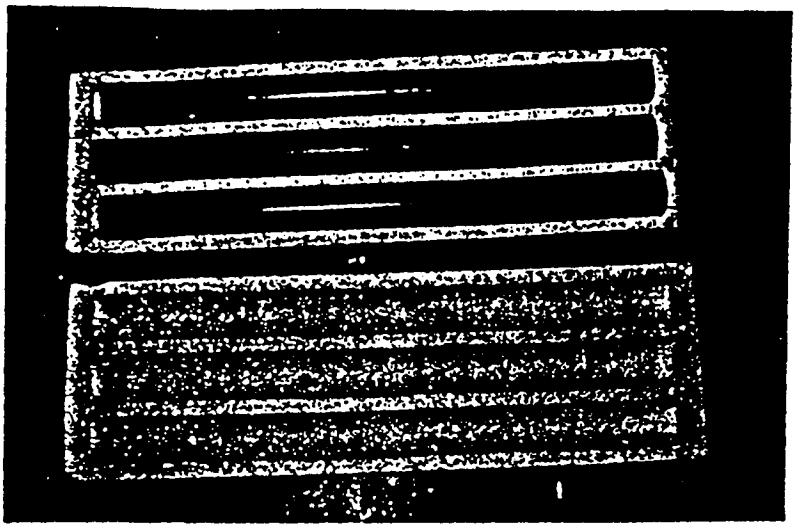
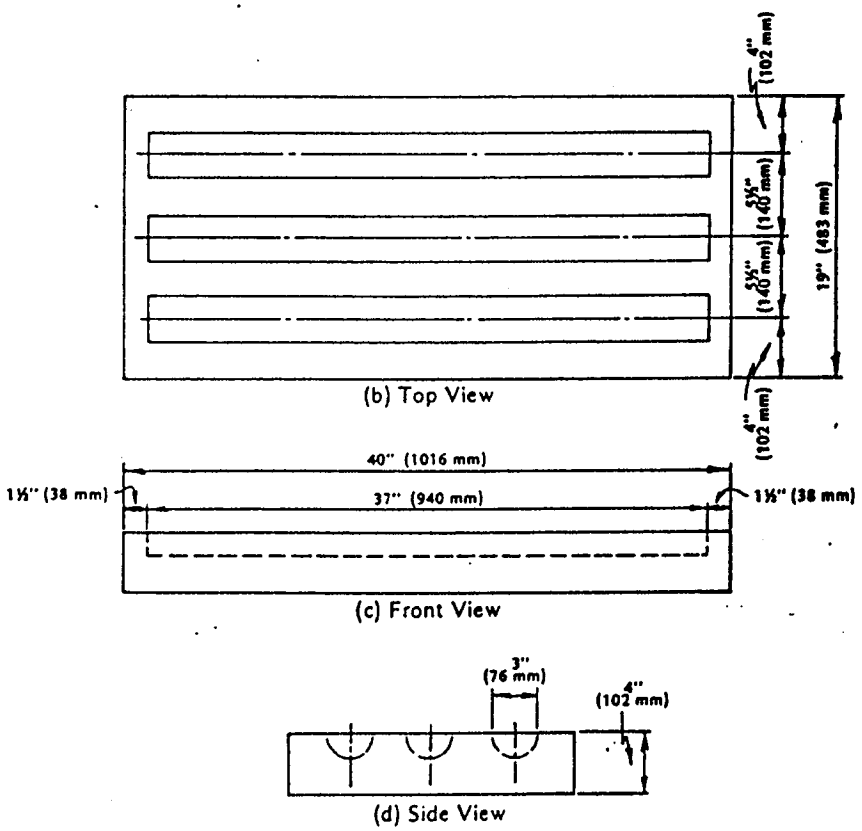


FIG. 2 Shipping Box for 3-in. (76-mm) Thin-Walled Tubes



(a) Photo of Open Box For 5" (127 mm) Tubes



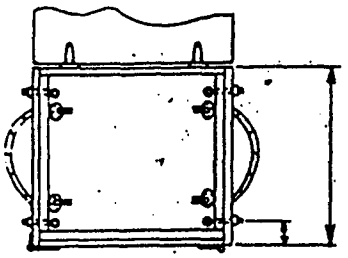
(b) Top View

(c) Front View

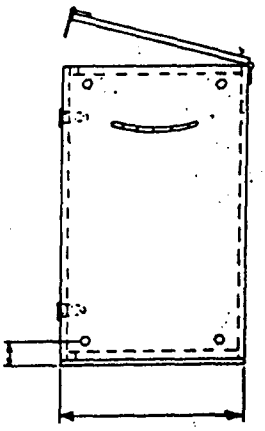
(d) Side View

E—Top and bottom halves are identical

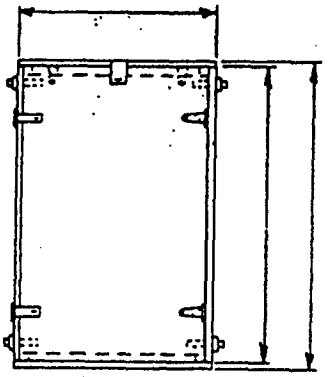
FIG. 3 Styrene Shipping Container for 3-in. (76-mm) Thin-Walled Tubes



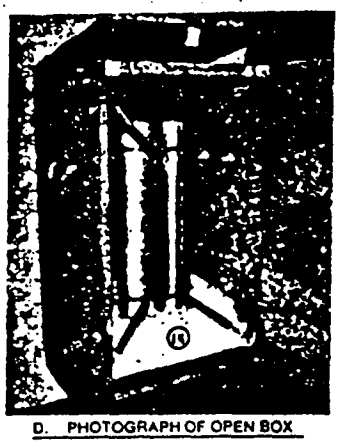
A. TOP VIEW
(lid open)



C. SIDE VIEW



B. FRONT VIEW



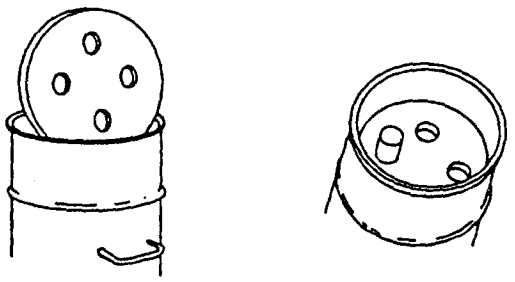
D. PHOTOGRAPH OF OPEN BOX

BILL OF MATERIALS

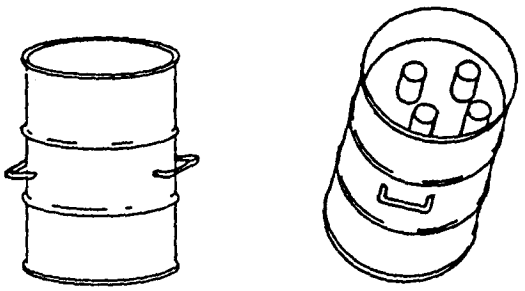
Item No.	Description of Item	Quantity
1	*Plywood*, 4 ft by 8 ft by ¾ in. (1220 mm by 2440 mm by 19.1 mm) exterior, Grade AC	1 Sheet
2	*Hinge*, strap, 4 in. (102 mm), heavy duty with screws	4 Each
3	*Hasp*, hinged, 4½ in. (114 mm), with screws	3 Each
4	*Screw, Wood, Steel, Flathead*, No. 10 by 1¾ in. (44.5 mm)	72 Each
5	*Bolt, Machine*, ⅜ in. (9.5 mm), with nut to secure hasps	3 Each
6	*Washer*, flat, ⅜ in. (9.5 mm)	3 Each
7	*Eye Bolt*, ½ by 2 in. (6.4 mm by 51 mm), zinc-plated, with nut	8 Each
8	*Washer*, flat, ¼ in. (6.4 mm), for hasp bolt	8 Each
9	*S Hooks*, 2 in. (51 mm), open, zinc-plated	8 Each
10	*Clamp*, adjustable, hose, steel, worm screw adjustment	2 Each
11	*Spring*, expansion	8 Each
12	*Adhesive*, woodworking	1 lb (454 g)
13	*Rope*, nylon, ½-in. (12.7-mm) diameter, solid braided	5 ft (1524 mm)
14	*Cushioning Material*, expanded polystyrene foam	10 ft^3 (0.28 m^3)

NOTES–(a) All wooden components can be sawed from one sheet of plywood.
(b) This shipping box will accommodate approximately three 3-in. (76-mm) diameter tubes or two 5-in (127-mm) diameter tubes up to 30 in. (762 mm) in length. For longer tubes the inside height of the box must be a minimum of 6-in. (152 mm) greater than the length of the tube.
(c) All joints to be glued and fastened with screws.
(d) Stencil all sides as follows (See Views B and C).
TO PROTECT FROM FREEZING
(e) After suspending samples as indicated above, all void space must be filled with a suitable resilient packing material.

FIG. 4 Suspension System Container for Thin-Walled Tubes



(a) 55-gallon (0.21 m^3) oil barrels with sections of styrofoam insulation; welded handles on each side.



(b) Same as (a) showing barrel ready for shipment. Steel lids bolted on to provide tight seal.

NOTE—Two in. (51 mm) of foam rubber covers 2 in. of styrofoam at the base. One in. (25 mm) of foam rubber overlays the top of the tubes, and the remaining space to the lid is filled with styrofoam.

FIG. 5 Shipping Barrel for Thin-Walled Tubes

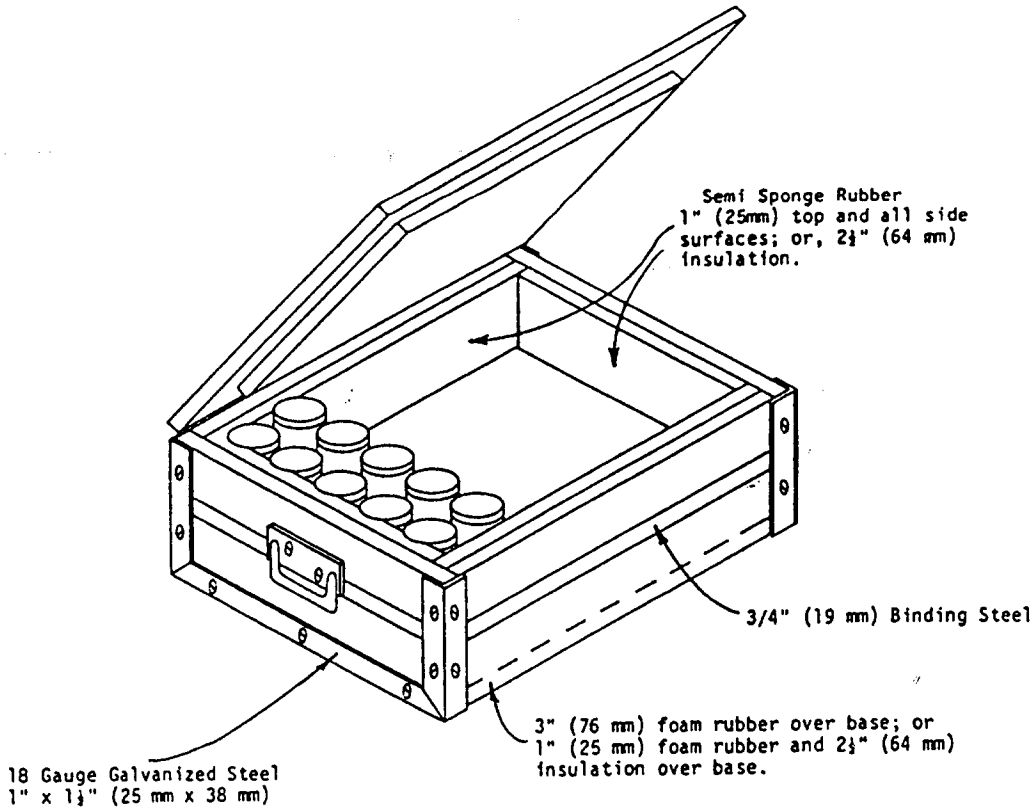
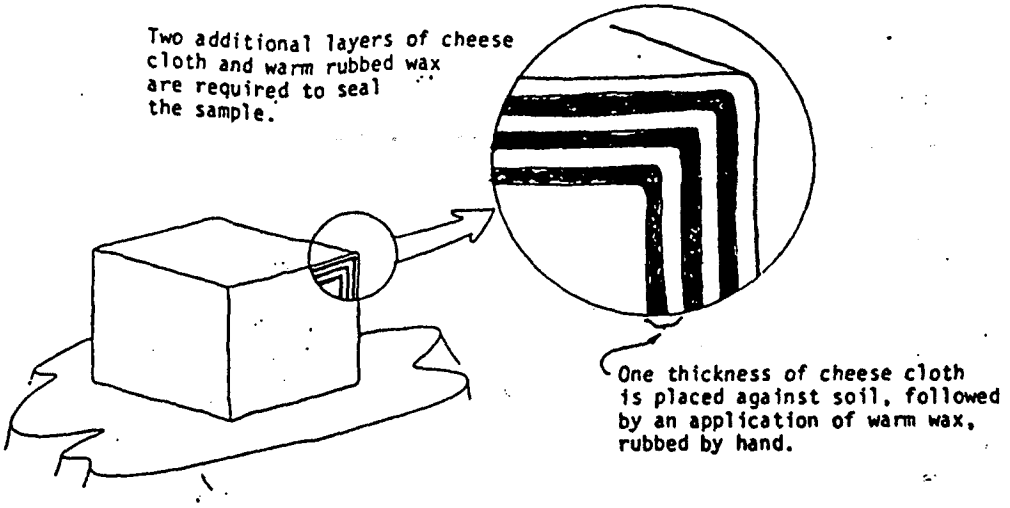
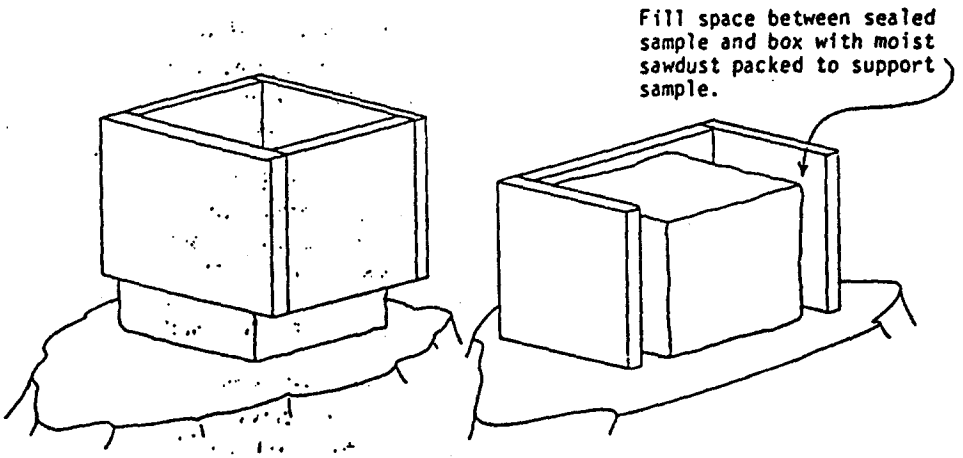


FIG. 6 Shipping Box for Liner (Short Tube) or Ring Samples



A. METHOD FOR SEALING HAND-CUT UNDISTURBED SAMPLES



B. ENCASE EASILY DISTURBED SAMPLES IN BOX PRIOR TO CUTTING

Box constructed with 1/2"-3/4" (13 - 19 mm) exterior plywood.

FIG. 7 Preparing and Packaging a Block Sample

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This practice has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of structural properties. Thin-walled tubes used in piston, plug, or rotary-type samplers, such as the Denison or Pitcher, must comply with the portions of this practice which describe the thin-walled tubes (5.3).

NOTE 1—This practice does not apply to liners used within the above samplers.

1.2 The values stated in both inch-pound and SI units are to be regarded as the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Summary of Practice

3.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil, removing the soil-filled tube, and sealing the ends to prevent the soil from being disturbed or losing moisture.

4. Significance and Use

4.1 This practice, or Practice D 3550, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil disturbance.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole; that does not disturb the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

5.2 *Sampler Insertion Equipment,* shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

5.3 *Thin-Walled Tubes,* should be manufactured as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. and be made of metal having adequate strength for use in the soil and formation intended. Tubes shall be clean and free of all surface irregularities including projecting weld seams.

5.3.1 *Length of Tubes*—See Table 1 and 6.4.

5.3.2 *Tolerances,* shall be within the limits shown in Table 2.

5.3.3 *Inside Clearance Ratio,* should be 1 % or as specified by the engineer or geologist for the soil and formation to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled. See Fig. 1 for definition of inside clearance ratio.

5.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating. Tubes which will contain samples for more than 72 h shall be coated. The type of coating to be used may vary depending upon the material to be sampled. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, and others. Type of coating must be specified by the engineer or geologist if storage will exceed 72 h. Plating of the tubes or alternate base metals may be specified by the engineer or geologist.

5.4 *Sampler Head,* serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a suitable check valve and a venting area to the outside equal to or greater than the area through the check valve. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

6. Procedure

6.1 Clean out the borehole to sampling elevation using whatever method is preferred that will ensure the material to

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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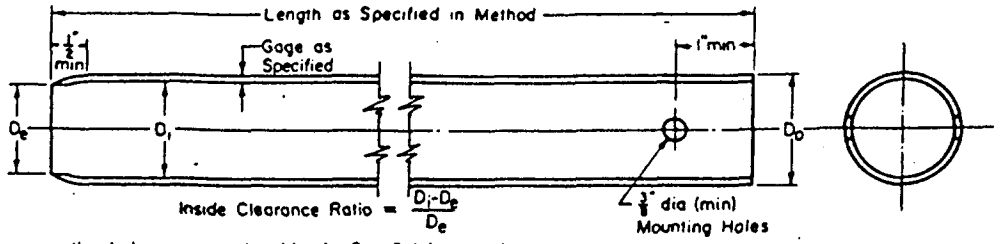
[2] *Annual Book of ASTM Standards,* Vol 04.08.



NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.
NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.
NOTE 3—Tube held with hardened screws.
NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

in.	mm
⅜	9.53
½	12.7
1	25.4
2	50.8
3½	88.9
4	101.6

FIG. 1 Thin-Walled Tube for Sampling

TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter:			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
	0.91	0.91	1.45
Clearance ratio, %	1	1	1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Size Outside Diameter	Nominal Tube Diameters from Table 1[A] Tolerances, in.		
	2	3	5
Outside diameter	+0.007 −0.000	+0.010 −0.000	+0.015 −0.000
Inside diameter	+0.000 −0.007	+0.000 −0.010	+0.000 −0.015
Wall thickness	±0.007	±0.010	±0.015
Ovality	0.015	0.020	0.030
Straightness	0.030/ft	0.030/ft	0.030/ft

[A] Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three tolerances; that is, O.D. and I.D., or O.D. and Wall, or I.D. and Wall.

be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the sampling operation.

6.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the auger of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler without rotation by a continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed

without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.

NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the markings or labels are adequate to survive transportation and storage.

8. Report

8.1 The appropriate information is required as follows:

8.1.1 Name and location of the project,

8.1.2 Boring number and precise location on project,

8.1.3 Surface elevation or reference to a datum,

8.1.4 Date and time of boring—start and finish,

8.1.5 Depth to top of sample and number of sample,

8.1.6 Description of sampler: size, type of metal, type coating,

8.1.7 Method of sampler insertion: push or drive,

8.1.8 Method of drilling, size of hole, casing, and drilling fluid used,

8.1.9 Depth to groundwater level: date and time measured,

8.1.10 Any possible current or tidal effect on water level

8.1.11 Soil description in accordance with Practice D 2488,

8.1.12 Length of sampler advance, and

8.1.13 Recovery: length of sample obtained.

9. Precision and Bias

9.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

10. Keywords

10.1 sampling; soil exploration; undisturbed

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APPENDIX B

SOIL BORING LOG

SUBSURFACE EXPLORATION LOG

BORING/WELL ID NUMBER:

CLIENT:
PROJECT NUMBER:
LOCATION:
SURFACE ELEVATION:

GEOLOGIST:
DATE DRILLED:
DRILLING COMPANY:
NORTHING:

TOTAL DEPTH:
DRILLING METHOD:
SAMPLE METHOD:
EASTING:

Page __ of __

Depth (ft)	Samples	Sample Number	Time (24 hr)	FID/PID (ppm) Sample	FID/PID (ppm) Breathing Zone	Blow Count	Recovery (ft)	GEOLOGIC DESCRIPTION % gravel	% sand	% non-plastic fines	% plastic fines	Grading	Lithologic Name	Color	Moisture	Density	Consistency	Plasticity	Angularity	Max. grain size	Additonal Modifiers	Soil Class. Symbol	Lithologic Contact (ft bgs)
Notes:								> 1/4 inch	visible -1/4 in.	visible with hand lens	not visible	poorly vs. well	See USCS flow Charts. Describe sand and gravel grading, ie, fine to coarse grained	Use Munsell color chart if available	Dry Moist Wet	Course: v. loose loose md. dense dense v. dense	Fines: v. soft soft md. Stiff v.stiff hard	high med low non	A Sa Sr R	in inches	odor, staining, minerology, stucture, cementation		

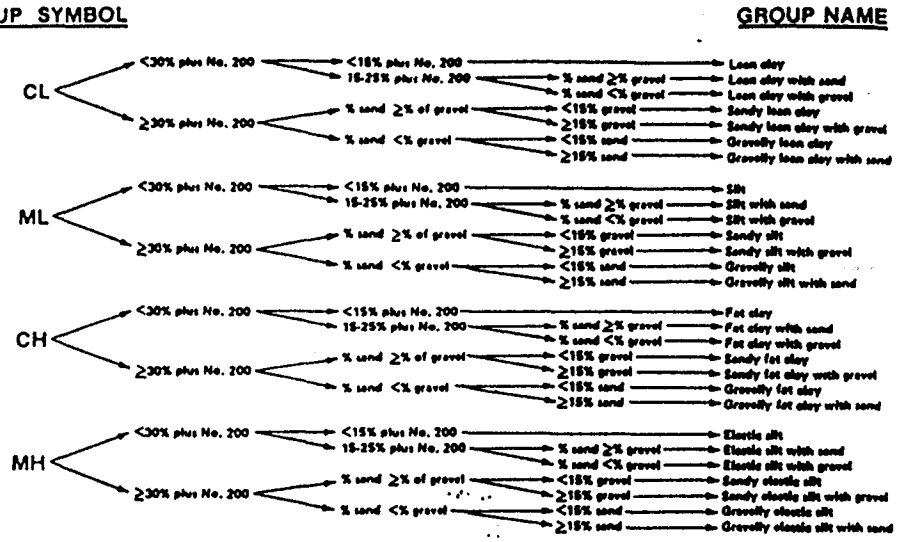

Figure 1a. – Flowchart for identifying inorganic fine-grained soil (50% or more fines) — visual-manual method.

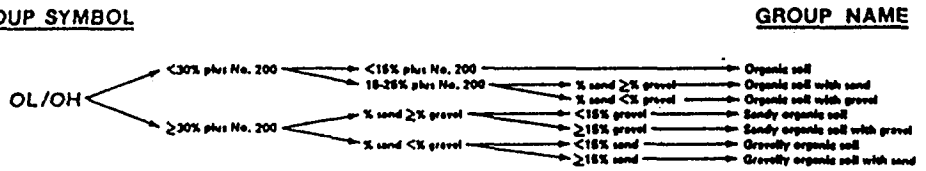

Figure 1b. – Flowchart for identifying organic fine-grained soil (50% or more fines) — visual-manual method.

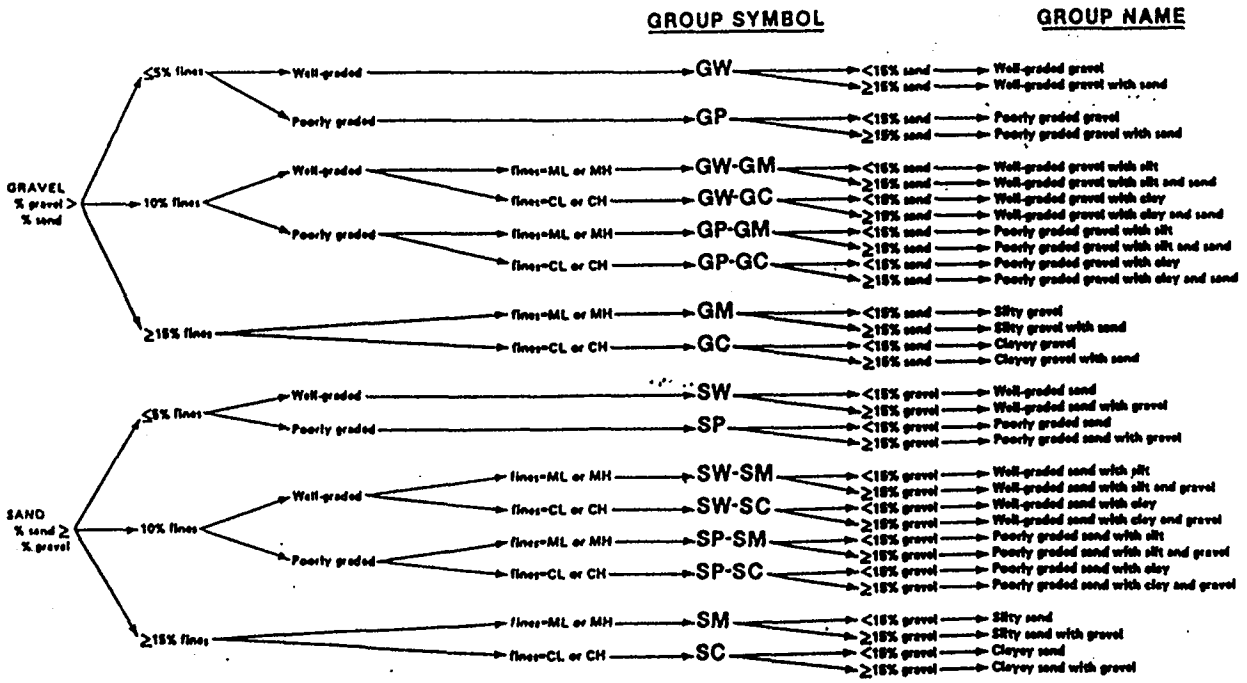

Figure 2. – Flowchart for identifying coarse-grained soils (less than 50% fines) — visual-manual method.

APPENDIX C

TEST PIT LOG

LENGTH _____	**TEST PIT NO.** _____	SHEET ____ OF ____
WIDTH _____		COORDINATES N _____
DEPTH _____	FIELD ENGINEER/ GEOLOGIST _____	E _____
_____	EDITED BY _____	DATE BEGAN _____
_____	CHECKED BY _____	DATE FINISHED _____
		GROUND SURFACE EL. _____

DESCRIPTION AND NOTES:

_____

_____

_____

_____

_____

_____

_____

_____

PROFILE OF PITWALL:

SCALE 1" = ----- BEARING = ----- TRENCH WALL: -----

CLIENT _____

PROJECT NO. _____

LOCATION _____

FOSTER WHEELER

FOSTER WHEELER ENVIRONMENTAL CORPORATION

APPENDIX D

OVA CALIBRATION FORM

ORGANIC VAPOR ANALYZER (OVA)
CALIBRATION RECORD FORM

Project Name: _____

Calibration By: _____

Date: _____ Time: _____

Instrument Serial No.: _____

Calibration Gas Supplier: _____

Lot Number, 100 ppm Methane: _____

INSTRUMENT TEST RESULTS

	PRE-FIELD WORK		POST-FIELD WORK	
Battery Test Indicator*:	P F		P F	
Hydrogen Tank Pressure:	_____	psi	_____	psi
Hydrogen Supply Pressure:	_____	psi	_____	psi
Sample Flow Rate:	_____	l/min	_____	l/min
Air Temperature	_____	°F	_____	°F
Instrument Response, 100 ppm Methane	_____		_____	

**With pump running*

NOTES (INCLUDING DESCRIPTION OF ANY FIELD MAINTENANCE):

_____

_____

_____

_____

_____

_____

_____

APPENDIX E

CHAIN-OF-CUSTODY FORM

NU R 1051

FOSTER WHEELER ENVIRONMENTAL CORPORATION

CHAIN OF CUSTODY FORM REQUEST FOR ANALYSIS

PAGE OF

PROJECT	OFS NO.
PROJECT ADDRESS	
SAMPLER (Name)	SAMPLER (Signature)
LABORATORY	
REPORTS TO BE SENT TO	

HAZARD IDENTIFICATION
Non Hazard ☐ Reactive ☐
Flammable ☐ Toxic ☐
Skin Irritant ☐ Infectious ☐

TIME REQUIRED
NORMAL ☐ _____ DAYS
RUSH ☐ _____ DAYS

ANALYSES REQUIRED

THE INFORMATION IN THIS SECTION WILL NOT BE AVAILABLE TO THE LABORATORY

SAMPLE NUMBER	TIME COLLECTED	DATE COLLECTED	NUMBER OF CONTAINERS	CONTAINER SIZE(S)	SAMPLE MATERIAL																LOCATION	DEPTH	QC CODE
					WATER	SOIL	OTHER (Describe)																

LABORATORY INSTRUCTIONS/COMMENTS

SAMPLING COMMENTS

RELINQUISHED BY (Signature)	DATE	RECEIVED BY (Signature)	RELINQUISHED BY (Signature)	DATE	RECEIVED BY (Signature)
COMPANY	TIME	COMPANY	COMPANY	TIME	COMPANY