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Environmental Corporation

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REMEDIAL INVESTIGATION/FEASIBILITY STUDY

PROJECT OPERATIONS PLAN

APPENDIX B - NUS ARCS III STANDARD OPERATING PROCEDURES
APPENDIX C - SAS REQUEST FORMS

AIW FRANK/MID-COUNTY MUSTANG SITE
CHESTER COUNTY, PENNSYLVANIA

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APPENDIX B

NUS ARCS III STANDARD OPERATING PROCEDURES

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		Prepared: Earth Sciences	
Subject: SOIL AND ROCK SAMPLING		Approved: A. K. Bomberger, P.E.	

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1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during remedial investigation activities.

2.0 SCOPE

The methods described within this procedure are applicable while conducting standard penetration tests and subsurface soil sampling; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

Hand Auger- A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches o.d. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively.

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

5.0 PROCEDURES

5.2 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize the three-dimensional subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants from waste disposal sites. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

5.1.1 **Equipment**

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long
- Thin walled tubes (Shelby), OD 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. weight, driving head and guide permitting free fall of 30 inches
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 **Split Barrel (Split Spoon) Sampling**

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.
- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.
- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.
- The 2-inch OD split barrel sampler shall be driven with blows from a 140-pound hammer falling 30 inches until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced

18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are far less inert, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape them into place, and then dip the ends in wax to seal them.

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use shall be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel or plastic scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 12 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.

- Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.

- Use a new or freshly-decontaminated sampler for each sample taken.

- Pack and ship accordingly.

- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis.

If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

5.3 WASTE PILE SAMPLES

The use of stainless steel or plastic scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers or triers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.

- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.

- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

5.4 ROCK SAMPLING (CORING)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It yields better quality data than air rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Downhole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross contamination of aquifers.

ATTACHMENT 1

Coring bit size	Nominal *		Set size *	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	.735
EWT	1 1/2	29/32	1.470	905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	.845
AWT	1 7/8	1 9/32	1.875	1 281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1 185
BWT	2 3/8	1 3/4	2.345	1 750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 3/16	2 965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2 690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7 655	5.970
AX Wire line 1/	1 7/8	1	1.875	1 000
BX Wire line 1/	2 3/8	1 7/16	2.345	1 437
NX Wire line 1/	3	1 15/16	2 965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 254.
1/ Wire line dimensions and designations may vary according to manufacturer.

ATTACHMENT 1(CONT'D)

Size Designations			Casing coupling					Approximate core diameter	
Casing; Casing coupling; Casing bits, Core barrel bits	Rod; Rod couplings	Casing O.D., inches	O.D., inches	I.D., inches	Casing bit, O.D., inches	Core barrel bit O.D., inches*	Drill rod O.D., inches	Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1 485	1.160	1.094	—	735
EX	E	1 812	1.812	1.500	1 875	1.470	1.313	845	905
AX	A	2 250	2.250	1 906	2.345	1.875	1 625	1.185	1 281
BX	B	2.875	2.875	2.375	2965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1 437	Flush joint	No coupling	1.485	1.160	1 094	—	735
EW	EW	1.812			1.875	1.470	1 375	845	905
AW	AW	2 250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7 800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX 1/	—	—	—	—	1.875	1.750	1.000	—
—	BX 1/	—	—	—	—	2.345	2.250	1.437	—
—	NX 1/	—	—	—	—	2 965	2.813	1.937	—

* For hole diameter approximation, assume $\frac{1}{32}$ inch larger than core barrel bit.

1/ Wire line size designation, drill rod only, serves as both casing and drill rod. Wire line core bit, and core diameters vary slightly according to manufacturer

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

5.4.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb hammer dropping 30 inches with a 2-inch split spoon sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used.

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross contamination of aquifers in the unconsolidated materials is unlikely, it may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole, and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) for Sampling of Soils (see Procedure GH-1.3). Resume diamond core drilling when refusal materials are again encountered.

- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as the conditions warrant.

- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.4.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in Procedure GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Field Engineer. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. Any core loss areas shall be spaced with wooden blocks or PVC pipe so that the entire core run is represented. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer,the top of the cored interval contained within the box is in the upper left corner of the box,and the bottom of the cored interval is in the lower right corner of the box (see Attachment 2). The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

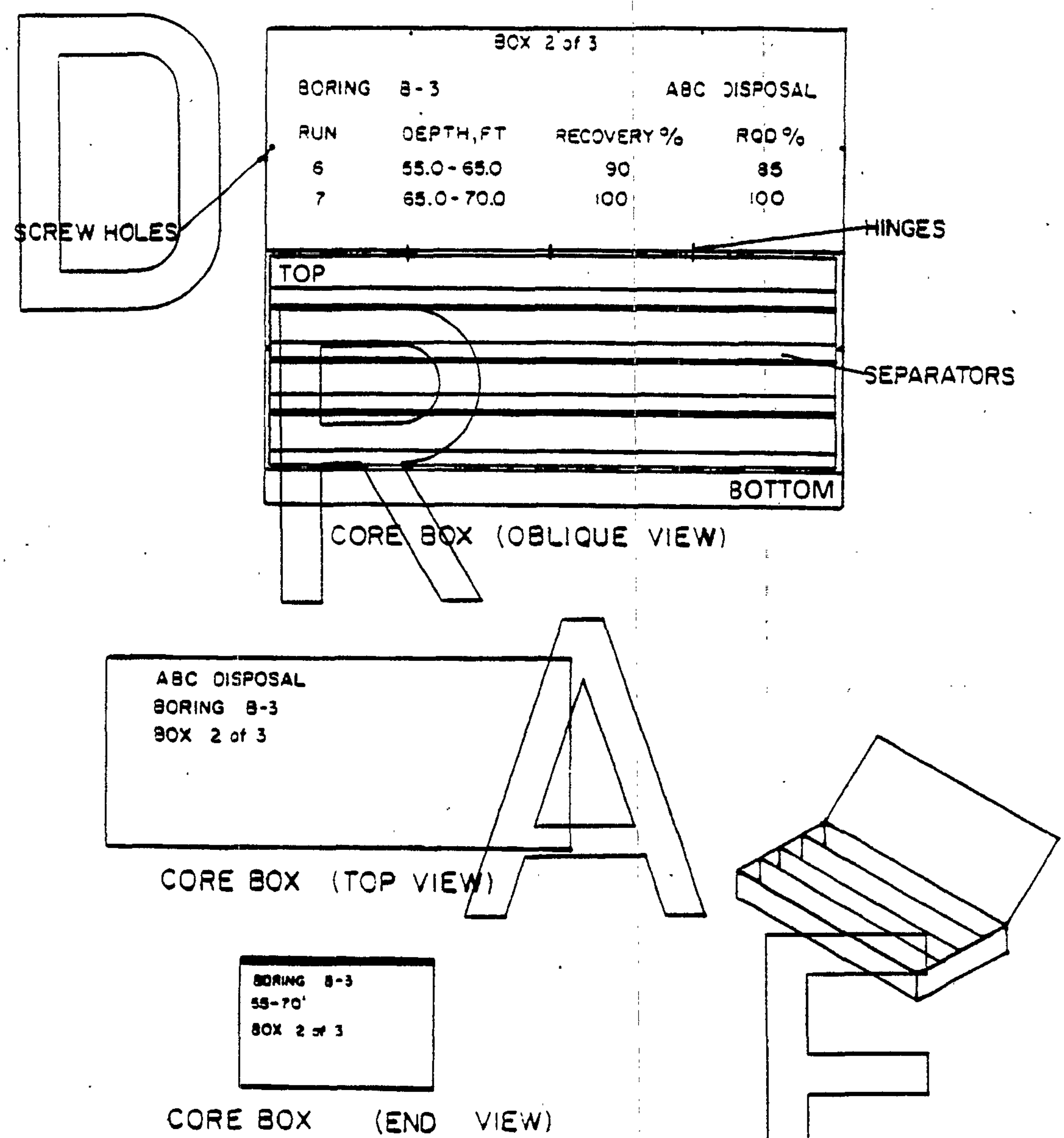
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

ATTACHMENT 2



TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

6.0 REFERENCES

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- American Society for Testing and Materials, 1985. Thin-Walled Tube Sampling of Soils. Method D-1587-83, Annual Book of Standards, ASTM, Philadelphia, PA.
- Acker Drill Co., 1958. Basic Procedures of Soil Sampling. Acker Drill Co., Scranton, PA.
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7.0 RECORDS

None.

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.5	Page 1 of 26
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject BOREHOLE AND SAMPLE LOGGING		Approved A. K. Bomberger	

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each rig geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer shall be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Brunton compass
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms and sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as (1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray". Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

5.3 CLASSIFICATION OF ROCKS

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 and 2 inch in diameter.

- Siltstone - Made up of granular materials less than 1/16 inch in diameter. Fractures irregularly. Medium thick to thick bedded.

- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

- Shale - A fissile very fine grained rock. Fractures along bedding planes.

- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.

- Coal - Rock consisting mainly of organic remains.

- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock Color Charts shall not be used unless specified by the project manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge". A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokeness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

RQD % = r/l x 100

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcoreous, siliceous, hematitic)

- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.

- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.

- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.

- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.

- Quartzite - A ~~fine-to-coarse~~-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer <u>as the boring is being drilled</u>. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

5.5.1 <u>Soil Classification</u>

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.

- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and HNu or OVA reading if applicable.

  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).

  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

  Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.
- As a final check the boring log shall include the following:
  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 REVIEW

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

EXHIBIT 4-1

BORING LOG — **NUS CORPORATION**

PROJECT: .... BORING NO.: ....
PROJECT NO.: .... DATE: .... DRILLER: ....
ELEVATION: .... FIELD GEOLOGIST: ....
WATER LEVEL DATA: ....
(Date, Time & Conditions) ....

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS

REMARKS ____________________

BORING ______

PAGE ____ OF ____

EXHIBIT 4-2

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

More than half of material is LARGER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+) > 1/4" Ø	CLEAN GRAVELS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel sand mixtures, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
	GRAVELS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand clay mixtures
SANDS 50%(+) < 1/4" Ø	CLEAN SANDS (Low % fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	SW	Well graded sand, gravelly sands, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines
	SANDS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand-silt mixtures
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand clay mixtures

FINE GRAINED SOILS

More than half of material is SMALLER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)				GROUP SYMBOL	TYPICAL NAMES
Identification procedures on fraction smaller than No. 40 sieve size	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

S 2" O.D. Split Barrel Sample
ST 3" O.D. Undisturbed Sample
O Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X NX (Conventional) Core (~2 1/8" O.D.)
Q NQ (Wireline) Core (~1 7/8" O.D.)
Z Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
12.6' Initial Level w/Date & Depth

12/18
12.6' Stabilized Level w/Date & Depth

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3′	Massive
30 cm - 1 meter	1.0′ - 3.3′	Thick Bedded
10 cm - 30 cm	4″ - 1.0′	Medium Bedded
3 cm - 10 cm	1″ - 4″	Thin Bedded
1 cm - 3 cm	2/5″ - 1″	Very Thin Bedded
3 mm - 1 cm	1/8″ - 2/5″	Laminated
1 mm - 3 mm	1/32″ - 1/8″	Thinly Laminated
<1 mm	<1/32″	Micro Laminated

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922

BORING LOG — NUS CORPORATION

PROJECT: HEBELKA SITE — BORING NO: MW 3A
PROJECT NO: 619Y — DATE: 9-21-87 — DRILLER: B. GOLLHUE
ELEVATION: 510.07 — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): WL 26.35 - TPVC 10-16-87

Sample No & Type/ RQD	Depth Ft / RUN NO.	Blows/6 in or RQD %	Sample Recovery/ Sample Length	Lithology Change (Depth ft) or SCREEN INT	Soil Density/Consistency or Rock Hardness	Color	Material Classification*	USCS or Rock Brokenness	Remarks
S-1	0.0	3 / 6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
	1.5	6					FRAG - TR ORG.		RESIDUAL SOIL.
	5.0								
S-2	6.0	11 / 100/.5	0.8/1.0	5.5 / 6.0	M. SOFT TO M. HARD	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM. REFUSAL @ 6' 5.5 TOP OF DEC ROCK. AUGERED TO 15' W/SOLID STEM AUG CUTTING MOIST @ ~8' WATER @ 11' ±. WL @ 12:10 PM WAS ≈ 9' FROM GS. SET 4" PVC CAS. @ 15.0'
9-21 / 9-22	15.0								
					M.HARD	BRN GRAY	SILTY SHALE - FEW QUARTZ PCS	VBR	SEVERAL Fe STAINED JOINTS ON CORE 0 PPM THRUOUT RUN. JOINTS AND BREAKS ARE HORIZ TO LO ∠. W/VUGS ON LOWER PORTION 23 TO 25 OF CORE
0.0/10.0	①	0%	7.9/10.0						
	25.0								

REMARKS: ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT & 30" DROP - TO TAKE 2" Φ SP SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

* See Legend on Back

BORING MW 3A
PAGE 1 OF 3

BORING LOG — NUS CORPORATION

PROJECT: HEBELKA SITE
PROJECT NO.: 619Y
ELEVATION:
WATER LEVEL DATA (Date, Time & Conditions):
DATE: 9-22-87
FIELD GEOLOGIST: SJ CONTI
BORING NO.: MW 3A
DRILLER: B. GOLLIHUE

	SAMPLE NO & TYPE (ROD)	DEPTH (FT) (RUN)	BLOWS/6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22	▼	25.0		▼		M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR w/ HORIZ TO LO ∠ JNTS
								(SILTSTONE)		≈26 TO 27 2-VERT
								- FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
								SEAMS		ROCK BECOMES AND BREAKS MORE LIKE
										A SILTSTONE WITH DEPTH.
	0/10.0	②	0%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES w/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX - 30X MAG.
										≈34 TO 35 - 2 VERT JOINTS
	◆	35.0		◆						
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
								- FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
										LAMINATIONS WATER STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	1.0/10.0	③	10%	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI ∠ JNT
									BR	~~40.4~~ → 42.7 VERT JNT
	◆	45.0		◆					VBR	
										~~45.2~~ → 45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS

* See Legend on Back

BORING MW 3A
PAGE 2 OF 3

BORING LOG — NUS CORPORATION

PROJECT: HEBELKA SITE
PROJECT NO.: GIDY
ELEVATION:
WATER LEVEL DATA (Date, Time & Conditions):
DATE: 9-22-87
FIELD GEOLOGIST: SJ CONTI
BORING NO: MW 3A
DRILLER: B. GOLLIHUE

Sample No. & Type	Depth (ft)	Blows / 6" or RQD	Sample Recovery / Sample Length	Lithology Change (Depth ft)	Soil Density Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks
1.9/10.0	(4)	19%	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY W/ SOFT ZONES.
0/10	(5)	0%	1.8/10.0						
	65.0			66					
									68.0 - DRILLER NOTED SOFT AREA - LOSS OF ~~1/3 OF~~ WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	(6)	0%	1.3/10.0						
									POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS: AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE. AT 1:50 PM CORED HOLE TO 75' REAMED TWICE DUE TO RUNNING SAND (FRACTURE) AT ≈ 68. REAMED 2ND TIME TO 81'. SET WELL 66'-76'.

* See Legend on Back

BORING MW 3A
PAGE 3 OF 3

AR300377

Subject	Number	Page
BOREHOLE AND SAMPLE LOGGING	GH-1.5	23 of 26
	Revision 1	Effective Date 08/10/88

EXHIBIT 4-6

BORING LOG — NUS CORPORATION

PROJECT: WESTLINE SITE — BORING NO: MW 013
PROJECT NO: 473Y — DATE: 7-7-87 — DRILLER: B ERICSON
ELEVATION: 1462.37 — FIELD GEOLOGIST: SJ CONTI — PENN - DRILL
WATER LEVEL DATA (Date, Time & Conditions): 5.54' @ 8:50 AM 7-23-87 T-PVC — ACKER AD-II

Sample No. & Type or RQD	Depth (ft) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth (ft) or Screen Int)	Soil Density Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks (HNU) (Head Sp)
	0.0	5 / 3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR. COAL FRAG		3/4 Φ FRAG - NEAR OLD RR. LINE.
							TR-CC FRAG		
							(FILL)		
	5.0								
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	RED BRN TO GRAY	SANDY SILT - TR FRAG TO	SM	MOIST TO WET (0PPM)
	6.5	3					SILTY SAND - TR GRAVEL		GRAY SAND @ 6' ± MICACEOUS LOOSE NATURAL
									DRILLER NOTE H2O 8-10'
	10.0								
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (0PPM)
	11.5	27					FRAGS (GRAVEL)		1" Φ SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	SM	WET (0PPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 / 50/.4	.6/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME GRAVEL AND S.S. FRAGS	GM	WET (0PPM) MOIST BECOMES MORE LIKE SANDY SILT AT BOTM OF SAMPLE

REMARKS: STARTED 1:15 PM 7-7-87 USING 4 1/4" ID HOLLOW STEMS
S-4 @ 3:30 PM — TO ADVANCE THE BORING USING
S-5 @ 4:30 PM — ACKER DRILL - MOUNTED ON
FORD 3000 TRUCK
SAMPLES TAKEN USING 140 lb WT AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

BORING LOG — NUS CORPORATION

PROJECT: WESTLINE SITE — BORING NO.: MW03
PROJECT NO.: 473Y — DATE: 7-7-87 — DRILLER: [illegible] ERICSON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions):

SAMPLE NO. & TYPE OR RQD	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/Ft.) OR SCREEN INT.	SOIL DENSITY/CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-6	25.0	6 / 14	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	GM	WET 0 PPM
	26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS FRIABLE FIRST CHANGE IN
							TR. SS. FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
									NOTE: MAY SET ZONE 2
7/7	30.0								CASING ≈ 28'
7/8 S-7		17 / 27	1.4/1.5		V. DENSE	BRN BLUE	SILTY SAND - SOME GRAVEL	GM	MOIST → WET (0 PPM)
	31.5	36				GRAY	TR. SS. FRAG	GM	[illegible] BLUE GRAY & FRIABLE. SUBROUNDED GR. FL
							TR CLAY		NOT [illegible] CLAY - BUT MAY BE SEMI-CONFINING.
	35.0								
S-8	35.3	30 / 50/.4	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND -	GM/SM	MOIST → WET (0 PPM)
							SOME GRAVEL	GM	V. SL. TR CLAY - LESS THAN S-7
							TR. SS. FRAG		SS FRAG - MORE COARSE SAND THAN ABOVE
	40.0					BLUE			POSSIBLE 35 TO 45 SCREEN LOC. SQUEEZED HOLDS TOGETHER WHEN
S-9		31 / 34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE [illegible])	SM/GM	MOIST → WET (0 PPM)
	41.5	24					SOME GRAVEL TR		LITTLE MORE CLAY THAN S-8 SUBROUNDED GRAVEL
							CLAY		VERY SLOW DRILLING 40-45 (RIG STALLS)
	45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
S-10		13 / 34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M)	SM/GM	MOIST → WET (0 PPM)
	46.5	50					SOME GRAVEL TR	SM	1" Ø SIZE - HOLDS TOGETHER WHEN SQUEEZED
							CLAY		BUT NOT COHESIVE CLASSIFICATION
									[illegible] DRILLING TO 50'

REMARKS: S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM [illegible]

BORING MW03
PAGE 2 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: NESTLÉ NE SITE
PROJECT NO: 473Y
DATE: 7-8-87
ELEVATION:
FIELD GEOLOGIST: S. COUNT
WATER LEVEL DATA:
(Date, Time & Conditions)
BORING NO: MW-013
DRILLER: B. ERICSON

	SAMPLE NO. & TYPE OR RQD	DEPTH (FT.) OR RUN NO.	BLOWS/6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREEN INT.	SOIL DENSITY/CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	S-11	50.0	15 / 41	1.0/1.3		V. DENSE	MOTTLED BUFF	SILTY SAND - SOME GR.	GM/	MOIST - (0PPM)
		51.3	50/.3				BRN		SM	MOTTLED W/ PCS OF BLACK COAL/LIGNITE
							GRAY	TR CLAY		MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLASSIF.
		55.0			55.0					
	S-12		11 / 15	1.1/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (0PPM)
		56.5	26					SOME GRAVEL		NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE SUB-ROUNDED GRAINS FIRST COHESIVE TYPE CLASSIF.
		60.0	40							
	S-13	60.9	50/.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY/ CLAYEY SAND - SOME GRAVEL	SC/ GW	MOIST → WET (0PPM) NOT AS MUCH CLAY AS S-12 BUT VERY COMPACT. SUBROUNDED GRAINS SET CAS. @ 62'.
		65.0								
7/13	S-14	65.8	37 / 50/.3	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR AND ROCK FRAG	SM/ GW	MOIST (0PPM) MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4" Φ SIZE
					68.0			TR. CLAY		
							YELLOW BRN			COLOR CHANGE AT ≈68' MORE SAND PER DRILLER - BOTM OF SEMI CONF LAYER ?
		70.0								
7/14	S-15		39 / 39	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO C.) SOME GRAVEL - TR ROCK FRAG.	SC/ GC	MOIST → WET (0PPM)
		71.5	41							1" MAX GRAVEL MORE GRAVEL @ 72' PER DRILLER

REMARKS: USING HOLLOW STEM TO ADVANCE BORING WASHING OUT THRU AUGERS, WHEN NEEDED TO OBTAIN SAMPLE
S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 3:47 PM
SET 6" Φ STEEL CASING TO 62' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:30 PM 7-13-87
S-15 - 7:57 AM 7-14-87

BORING MW-013
PAGE 3 OF 4

BORING LOG — NUS CORPORATION

PROJECT: WESTLINE SITE
PROJECT NO.: 437Y
ELEVATION:
WATER LEVEL DATA (Date, Time & Conditions):
DATE: 7-13-87 / 7-14-87
FIELD GEOLOGIST: SJ. CONTI
BORING NO: MW013
DRILLER: B. ERICSON

Sample No & Type or RQD	Depth (ft.) or Run No	Blows/6" or RQD	Sample Recovery / Sample Length	Lithology Change (Depth ft.) or Scr. Int.	Soil Density / Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks (HNU)
S-16	75.0	28 / 50/.3	0.9/1.0	75	V. DENSE	GRAY ORANG BRN	FINE TO C. CLAYEY SAND - SOME	GC	WET (OPPM)
	76.0						GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTM OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" Φ RC.
	80.0								NO SAMPLE @ 80' - DECIDED TO GO TO 85'
	85.0	50/.4	0.4/0.4		V. DENSE	GRAY ORANG. BRN	SILTY F. TO C. SAND - SOME	GW	WET (OPPM)
S-17	85.4			85			GRAVEL - TR		SUBROUNDED GRAINS
							S.S FRAG - TR		V. SL TR CLAY - WILL
							CLAY		SET SCREEN ≈ 75' TO 85' IN THIS BORING.
							BOTM OF HOLE @ 85.0		

REMARKS: S-17 @ 2:20 PM 7-14-87 - [illegible] 6" CASING SPUN 4" Φ - 5½" OD [illegible] TO BOTM. USING WATER AS DRILLING FLUID

BORING: MW 013
PAGE 4 OF 4

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.6	Page 1 of 3
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject	DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS	Approved A. K. Bomberger	

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1.0 PURPOSE

2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES

6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

5.0 PROCEDURE

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

Prior to the initiation of a drilling program, all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment involved in field investigations. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens. The steam cleaning area shall be designed to contain decontamination wastes and waste waters, and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites. Due to the types of contaminants or proximity to residences, concerns may exist about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing an enclosed steam cleaning area. For example, augers and drill rods can be steam cleaned in drums that have been modified. Tarpaulins can also be placed around the steam cleaning area to control emissions.

Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 REFERENCES

Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-6.03; October 27, 1987.

7.0 RECORDS

None.

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.8	Page 1 of 6
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject EXCAVATION OF EXPLORATORY TEST PITS AND TRENCHES		Approved A.K. Bomberger	

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2.0 **SCOPE**

3.0 **GLOSSARY**

4.0 **RESPONSIBILITIES**

5.0 **PROCEDURES**
- 5.1 APPLICABILITY
- 5.2 TEST PIT AND TRENCH CONSTRUCTION
- 5.3 BACKFILLING OF TRENCHES AND TEST PITS

6.0 **REFERENCES**

7.0 **RECORDS**

1.0 PURPOSE

This procedure describes methods for proper excavation of test pits and trenches.

2.0 SCOPE

These procedures give overall technical guidance and may be modified by site-specific requirements for field exploratory test pits and trenches. Conditions which would make trench excavation technically difficult (such as shallow water table), potentially dangerous (presence of explosive materials or underground utilities) or likely to cause even greater environmental problems (such as potential rupture of buried containerized wastes) would require modifications to the methods described herein and may prevent implementation of the exploratory excavation program. Furthermore, the costs and difficulties in disposing of potentially hazardous materials removed from test pits may constrain their use to areas where contamination potential is low. Consequently, the techniques described herein are most applicable in areas of low apparent contamination and where potentially explosive materials are not expected to be present.

3.0 GLOSSARY

Trenches or test pit. - Open shallow excavations, typically longitudinal (if a trench) or rectangular (if a pit), to determine the shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by a machine, such as a backhoe, clamshell, trencher excavator, or bulldozer.

4.0 RESPONSIBILITIES

Site Manager - is responsible for determining, in consultation with other project personnel (geologist, geochemist, engineer), the need for test pits or trenches, their approximate locations, depths and sampling objectives.

Field Operation Leader (FOL) - is responsible for finalizing the location and depth of test pits/trenches based on site conditions and the site geologist's advice. The FOL is ultimately responsible for the proper construction and backfilling of test pits and trenches, including adherence to OSHA regulations if applicable (see Section 5.0).

Health and Safety Officer - responsible for air quality monitoring during test pit construction and sampling, to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. He/She may also be required to advise the FOL on other safety-related matters and mitigative measures to address potential physical hazards from unstable trench walls, puncturing of drums, or other hazardous objects, etc.

Site Geologist/Sampler - responsible for recording all information and data pertaining to the test pit excavation. Engineers, field technicians, or other properly trained personnel may also serve in this capacity.

5.0 PROCEDURE

5.1 APPLICABILITY

This subsection presents routine test pit or trench excavation techniques. Specialized techniques that are applicable only under certain conditions are not presented.

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise and control the method of excavation. All excavations that are deeper than 4 feet must be stabilized (before entry into the excavation) by bracing the pit sides using wooden or steel support structures. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments. In these cases, substantial air monitoring is required before entry, and appropriate respiratory gear and protective clothing is mandatory. There must be at least two persons present at the immediate site before entry by one of the investigators. The reader shall refer to OSHA regulations 29 CFR 1926, 29 CFR 1910.120, and 29 CFR 1910.134.

Machine-dug excavations are generally not practical where a depth of more than about 15 feet is desired. These excavations are also usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pits, providing that pumped water can be adequately stored or disposed. If data on soils at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

5.2 TEST PIT AND TRENCH EXCAVATION

These procedures describe the methods for excavating and logging test pits and trenches to determine subsurface soil and rock conditions.

Test pits and trenches may be excavated by hand or by power equipment to permit detailed explanation and clear understanding of the nature and contamination of the in situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration
- The space required for efficient excavation
- The chemicals of concern
- The economics and efficiency of available equipment

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table, which is based on equipment efficiencies, can give a rough guide for design consideration:

Equipment	Typical Widths, in Feet
Trenching machine	2
Backhoe	2-6
Track dozer	10
Track loader	10
Excavator	10
Scraper	20

Fifteen feet is considered to be the economical vertical limit of excavation. However, larger and deeper excavations have been used when special problems justified the expense.

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous waste materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. It may be necessary to record several elevations for irregular or sloping surfaces. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying. For regional studies test pits and trenches may be located by survey or by using existing topographic maps and plans.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit, temporary staging area and spoils pile will be predicated on site conditions and wind direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

The test pits and trenches shall be excavated in compliance with applicable safety regulations as specified by the health and safety officer.

If the depth exceeds 4 feet and people will be entering the pit or trench, Occupational Safety and Health Administration (OSHA) requirements must be met: Walls must be braced with wooden or steel braces, ladders must be in the hole at all times, and a temporary guardrail must be placed along the surface of the hole before entry. It is advisable to stay out of test pits as much as possible; if possible the required data or samples shall be gathered without entering the pit. Samples of leachate, groundwater, or sidewall soils can be taken with telescoping poles, etc.

Stabilization of the sides of test pits and trenches, when required, generally is achieved by sloping the walls at a sufficiently flat angle or by using sheeting. Benching or terracing can be used for deeper holes. Shallow excavations are generally stabilized by sheeting. Test pits excavated into fill are generally much more unstable than pits dug into natural in-place soil.

Sufficient space shall be maintained between trenches or pits to place soil that will be stockpiled for cover, as well as to allow access and free movement by haul vehicles and operating equipment. Excavated soil shall be stockpiled to one side, in one location, preferably downwind, away from the edge of the pit to reduce pressure on the pit walls.

Dewatering may be required to assure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation dry. This is an important consideration for excavations in cohesionless material below the groundwater table. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials are discussed in the site-specific POP.

The overland flow of water from excavated saturated soils and the erosion or sedimentation of the stockpiled soil shall be controlled. A temporary detention basin and a drainage system shall be planned to prevent the contaminated wastes from spreading.

5.3 BACKFILLING OF TRENCHES AND TEST PITS

Before backfilling, the onsite crew shall photograph all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the logbook. All photographs shall be indexed and maintained for future reference.

After inspection, backfill material shall be returned to the pit under the direciton of the field supervisor.

If a low permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the field supervisor (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

6.0 REFERENCES

Ebasco Services Inc., EPA Rem III Program Guidelines, FT-6.04, March 25, 1986.; by

NUS and CH_2MHill, August, 1987. Compendium of Field Operation Methods. Prepared for the USEPA.

OSHA, 1979. Excavation, Trenching and Shoring 29 CFR 1926.650-653.

7.0 RECORDS

Test pits and trenches shall be logged by the field geologist in accordance with Procedure GH-1.5.

Test pit logs shall contain a sketch of pit conditions (see Attachment A, Test Pit Log Form). In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Test pit locations shall be documented by tying in the location of two or more nearby permanent landmarks (trees, house, fence, etc.) and shall be located on a site map. Surveying may also be required, depending on the requirements of each project. Other data to be recorded in the field logbook include the following:

- Name and location of job.
- Data of excavation.
- Approximate surface elevation.
- Total depth of excavation.
- Dimensions of pit.
- Method of sample acquisition.
- Type and size of samples.
- Soil and rock descriptions.
- Photographs.
- Groundwater levels.
- Organic gas or methane levels.
- Other pertinent information, such as waste material encountered.

ATTACHMENT A

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TEST PIT LOG — *NUS CORPORATION*

PROJECT: .... TEST PIT NO.: ....
PROJECT NO.: .... DATE: ....
LOCATION: ....
FIELD GEOLOGIST: ....

DEPTH (ft.)	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION (Soil Density / Consistency, Color)	USCS	REMARKS

Test Pit Cross Section and / or Plan View

REMARKS ....

PHOTO LOG ....

TEST PIT ....

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1.0 PURPOSE

The objective of this procedure is to provide general reference information and technical guidance on the performance and evaluation of pumping tests.

2.0 SCOPE

This procedure gives overall technical guidance for the performance and evaluation of pumping tests performed as a part of a field investigation. The methodologies presented should be modified to meet the requirements/constraints of specific projects.

Pumping test data analysis is subject to much interpretation, therefore, evaluation of the test results should be performed by an experienced hydrogeologist familiar with pumping test analytical techniques and interpretation. Due to the complexity of some of the evaluation methods and the wide variety of corrections which may be required to be factored into the data obtained, this guideline presents only a general overview of the pumping test evaluation process. The references provided in Section 6.0 should be consulted for detailed discussions regarding pumping test evaluation techniques.

3.0 GLOSSARY

Cone of Influence - The area around a discharging well where the hydraulic head in the aquifer has been resultingly lowered. Also called cone of depression.

Confined Aquifer - An aquifer that is overlain and underlain by strata of lower permeability. The potentiometric surface of a confined aquifer is higher than the base of the upper confining layer at any given point.

Discharge (Q) - Volume of water removed per unit time.

Drawdown (S) - Difference between the elevation of initial static water level and the water level position at a given time during pumping.

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid.

Pumping Test - A test made by pumping a well for a period of time and observing the resulting change in hydraulic head in the aquifer. A pumping test may be used to determine the hydraulic characteristics of the aquifer and the capacity of the pumped well.

Specific Capacity (SC) - Rate of yield per unit drawdown. Often expressed as gallons per minute per foot of drawdown.

Specific Storage - The amount of water released from or taken into storage per unit volume of aquifer per unit change in head.

Specific yield - The ratio of the volume of water a rock or soil will yield by gravity drainage to the total volume of the rock or soil.

Storage Coefficient (S) - Volume of water an aquifer releases from or takes into storage per unit volume of aquifer per unit change in head. The product of specific storage times saturated thickness. Also called storativity.

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity times saturated thickness.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist has the responsibility of determining the need to perform a pumping test or tests for a site investigation. Factors that should be taken into account when considering whether a pumping test should be performed or not include:

- Project objectives and the data required to meet these objectives.
- The amount and accuracy of hydrogeologic data currently available.
- Cost and schedule constraints.
- Physical site limitations (discharge of contaminated/uncontaminated water, aquifer water yielding capability, access, etc.)

Pumping tests (especially long-term tests) can be time consuming, labor intensive, and costly. On the other hand, pumping tests generally yield the most accurate data regarding aquifer characteristics that can be obtained, when designed, performed, and evaluated properly. Specific uses for pumping tests include:

- Determination of aquifer hydraulic characteristics.
- Determination of the extent of influence of a pumped well.
- Design of groundwater withdrawal systems (for groundwater treatment or water supply).
- Determination of the interconnection between water bearing formations.
- Identification of aquifer boundaries (recharge/discharge boundaries).

Once the need to perform a pumping test has been established, the project hydrogeologist is responsible for the design and oversight of the pumping test, including identifying the wells to be used, designing and locating the pumping and observation wells as needed, specifying methodologies to be used, and determining the length of time of the test. The project hydrogeologist should ensure that all field personnel involved are familiar with the planned test and the field operations related to the performance of the test. During the startup of the pumping test, the project hydrogeologist may need to be onsite to ensure that proper field procedures are used. Data generated during the performance of the pumping test should be concurrently reviewed by the project hydrogeologist to identify any modifications to the planned procedure that may be required during the performance of the test. Data reduction/evaluation should be performed under the supervision of the project hydrogeologist.

Field Personnel - All field personnel should be familiar with the overall methodology of performing pumping tests, as well as being familiar with the specific requirements of each individual test that they will participate in. The field personnel should be familiar with the types and uses of the various field equipment required for the performance of a pumping test (surface or submersible pumps, generators, water level measuring devices, data sheets, support equipment). It is the responsibility of the field personnel to alert the project hydrogeologist/project manager to any unexpected conditions that may be encountered that would require modifications to the planned procedure, and perform the test as described in the Field Operations Plan (with approved modifications as required). Once the pumping test has been completed, field personnel are to assist the project geologist in the process of data reduction/evaluation.

5.0 PROCEDURES

5.1 PLANNING FOR A PUMPING TEST

The need for and design of a pumping test is determined largely by the project goals and geologic/hydrogeologic conditions within the study area. The pumping test should be set up so that the results obtained will be representative of the area under study.

As much information as possible should be collected and evaluated before running a pumping test. This includes data regarding physical and hydraulic characteristics of the aquifer, groundwater flow direction, hydraulic gradients, velocity, regional water level trend, the existence of other pumping wells in the vicinity of the test area, and the expected quality/quantity of the discharge water.

The placement and design of the pumping well is critical to the success of the pumping test. Placement of the well is dependent on pumping test objectives and local geologic conditions. In general, the pumping well should fully penetrate the aquifer to be pumped, and be screened across the entire saturated interval of the aquifer. Due to project constraints, this is often not the case, and corrections must be factored into the data analysis.

If an existing well is to be used for a test, the well should closely conform to the requirements for aquifer testing. Boring logs, construction data, and performance characteristics of other wells in the area should be examined to develop a preliminary estimate of the aquifer characteristics. Transmissivities can be estimated from the boring logs and preliminary testing.

Any number of observation wells may be used. The number chosen depends on maintaining a balance between cost and need to obtain the maximum amount of accurate and reliable data. If three of four observation wells are to be installed in the pumped aquifer, all but one well should be installed along a radial line from the pumping well, with the remaining well placed along a line normal to the line of observation wells and passing through the pumping well, to detect any radial anisotropy within the aquifer. If two observation wells are to be installed, they should be placed in a straight line away from the pumping well. In a fracture controlled bedrock flow system, joint orientations should be considered when deciding where to place observation wells.

When a pumping well does not fully penetrate an unconfined aquifer (any well with an 85 percent or more open or screened hole in the saturated thickness may be considered as fully penetrating), the observation wells should be located at a minimum distance equal to 1-1/2 to 2 times the aquifer thickness from a partially penetrating pumping well, to minimize the effect of flow field distortions resulting from pumping a partially penetrating well.

If the confined aquifer is not thick, the pumping well should be screened for the entire thickness of the aquifer. The nearest observation well should be located at least 25 feet from the pumping well and should penetrate and be screened in the middle portion of the aquifer.

Observation wells screened within the aquifer that is being pumped will provide information regarding aquifer characteristics. Wells screened in an overlying or underlying aquifer will provide information regarding the degree of interconnection between aquifers. If an observation well is screened in an overlying aquifer, it should be placed close to the pumping well so that the response of the overlying aquifer is monitored at a point where the difference in head between aquifers is relatively large.

The pumping and observation well configurations and locations described above are not requirements, but are suggested setups to maximize the accuracy of the data generated. In many instances, less than ideal conditions regarding screened intervals/depths and observation well numbers/locations will be encountered due to project constraints. Valid pumping tests can still be performed if the wells used do not conform to the ideal setup.

Single well pumping tests can be performed when project constraints do not allow for the installation of observation wells. The data obtained from these tests is less accurate than for tests performed using observation wells, and specific yield/specific storage cannot be determined. Drawdown measurements in a pumped well may not reflect the actual drawdown in the adjacent aquifer due to well inefficiency, so this factor must be considered when interpreting results.

5.2 PREPARATION FOR A TEST

For a few days before starting a long term pumping test, water levels in the pumping well and observation wells should be measured at about the same time each day to determine whether there is a measurable trend in groundwater levels. If such a trend is apparent, a graph of the change in water level versus time should be prepared and used to correct the water levels obtained during the test.

Pumping wells should undergo a preliminary pumping prior to the actual test to ensure that the well will function at it's maximum efficiency. This will enable fines to be flushed from the formation and a steady flow rate to be established. The preliminary pumping should determine the maximum drawdown in the well at a given pumping rate and establish the pumping rate for the later test. The aquifer should then be given adequate time to fully recover before the pumping test is begun.

Step-drawdown tests can be performed prior to the actual pumping test, to determine the optimum pumping rate for the test. A step-drawdown test consists of pumping a well at several successively higher rates, for a given time period (1/2-2 hours) for each rate, and measuring the rate of drawdown for each pumping rate. If possible, the well should be allowed to recover between tests. The resulting data generated can be used to predict drawdown versus time over an extended period for various pumping rates.

Barometric changes may affect water levels in wells. An increase in barometric pressure may cause a decrease in the water level. The response of wells to changes in barometric pressure should be determined in order to correct the measurement of water levels during a long term pumping test.

A record should be maintained of the pumping times and discharge rates of other pumping wells in the vicinity if their radius of influence intersects the cone of depression of the pumping test well.

In areas of severe winter climate, where the frostline may extend to depths of several feet, pumping tests should be avoided during the winter where the water table is near ground surface. Under some circumstances, the frozen soil acts as a confining bed, combining with leaky aquifer and delayed yield characteristics to make the results of the test unreliable.

5.3 CONDUCTING A TEST

Immediately before the pump is started, the water levels should be measured in the pumping well and all observation wells to determine the static water levels upon which drawdowns will be based. These data and the time of measurement should be recorded on the pumping test data sheet (see Attachment 1).

It may be useful to collect water samples from the pumping well (at least) before and after pumping. This data can give an indication of changes in groundwater contamination due to pumpage.

Critical data that must be collected for each pumping test includes the time that pumping started and ended, water level measurements during the test, periodic measurements of the pumping rate, and the distances between the pumping well and the observation wells.

Pump selection depends on the expected pumping rate and the physical constraints of the test (depth to water, expected total drawdown, pumping well diameter). Pump size is related to the required discharge capacity and the well diameter. Submersible pumps or air-lift set-ups are required when the drawdown of the water level is expected to exceed 25 feet below ground surface. Suction pumps can be used if total drawdown is not expected to exceed 25 feet.

Once pumping is initiated, the flow rate should immediately be measured and adjusted as necessary to achieve a constant discharge at the desired rate. The discharge rate should be checked, adjusted, and recorded frequently during the performance of the test, especially during the early stages of the test. The initial pumping rate should not be the maximum rate that the pump is capable of, as progressive drawdown may decrease the pump's efficiency, thereby reducing the discharge rate. If the pump is initially operating at less than full capacity, the decrease in efficiency can be countered by increasing the pump speed or, if the discharge rate is controlled through a valve (as is more typical), opening the value further. Pumping rates can be monitored using a flowmeter or, for low volume pumping tests, a stopwatch and calibrated bucket can be used to measure discharge rates.

The tone or rhythm of an internal-combustion engine provides a check of performance. If there is sudden change in tone, the discharge should be checked immediately and proper adjustments made to the gate valve or to the engine speed if necessary.

At least 10 observations of drawdown within each log cycle of time should be measured in the pumping well and observation wells. Continuous water level recording for the nearest observation wells to the pumping well can be extremely useful. A suggested schedule for measurements is as follows:

- 0 to 10 minutes -- 0.0, 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6.5, 8, and 10 minutes. It is important in the early part of the test to record with maximum accuracy the time at which readings are taken.
- 10 to 100 minutes -- 10, 15, 20,25, 30, 40, 50, 60, 80, and 100 minutes.
- Then, at 1- to 2-hour intervals, to completion.

Initially, there should be enough manpower available to station a minimum of one person at each well used in the pumping test, unless continuous water level recorders are used. After the first two hours of the pumping test, two people are usually sufficient to continue the test.

The total pumping time for a test depends on the type of aquifer and degree of accuracy desired, and can range from less than 2 hours to several days. Economizing on the period of pumping is not recommended. More reliable results are obtained if pumping continues until the cone of depression reaches a stabilized condition, however, this is not always practical or necessary. The cone of depression will continue to expand at a progressively slower rate until recharge of the aquifer equals the pumping rate and a steady state condition is established. The time required to achieve steady state flow conditions may vary from less than an hour to beyond the practical limits of a pumping test. Under average conditions it is good practice to run a large scale pumping test in a confined aquifer for at least 24 hours and in an unconfined aquifer for a minimum of 72 hours. A longer period of pumping may reveal the presence of boundary conditions not previously known. Single well pumping tests or small scale tests may be run for shorter time periods. Preliminary field plotting of drawdown data should be conducted during the test to evaluate how the test is progressing and how much longer it should continue.

Water pumped from an unconfined aquifer during a pumping test should be disposed of in such a way so that the aquifer is not recharged by discharge water infiltration during the test, as recharge would influence the results obtained. Also, if contaminated water is pumped during the test, the water may have to be stored and treated or disposed of in an acceptable manner.

The method of disposal of discharge water from the pumping well should be planned. The discharge water could be routed to a storm sewer or surface water body if uncontaminated, or temporarily stored in tanks, drums or in a lined pit if collection is required. If necessary it should be transported and deposited to a designated secure area.

5.4 RECOVERY TEST

When pumping is stopped after completing the drawdown portion of the pumping test, the cumulative drawdown and time at which pumping was discontinued are recorded. The rate of recovery of the water levels in the wells should then be measured.

The same procedure and time pattern are followed as at the beginning of a pumping test, that is, the depth-to-water is periodically measured during the recovery test in the pumping well and observation wells. Recovery data should follow the same general trend as drawdown data, and is considered in many cases to be more accurate and useful for pumping test analysis than drawdown data.

The recovery data should be recorded until the aquifer fully recovers, or as long as possible within project constraints.

5.5 DATA ANALYSIS

A constant rate pumping test can be run to determine transmissivity and hydraulic conductivity. If the effects of pumping the well can be measured in one or more observation wells at known distances from the pumping well, the specific yield or storage coefficient can also be determined. A good check of the transmissivity value can be made using recovery data from the pumped well and of transmissivity and storage coefficient from recovery rate measurements in observation wells.

The data collection form for a sample pumping test is illustrated in Figure 4.11-1. The form can be used to record data for either the pumping well or an observation well. It should be noted that some different types of data are to be recorded for pumping versus observation wells.

The effects of all extraneous factors such as barometric pressure, tidal influence, injection interference, or other pumpage in the nearby area, can be adjusted and corrected from the measured data by applicable correlation techniques.

After correction of the raw data to eliminate or reduce the amount of extraneous interference, graphs are prepared showing resulting drawdowns versus time and/or distance; these are plotted on semi-log or log-log paper. The graphs are used to determine aquifer characteristics by matching type curves or by straight line slope analysis processes. Analytical methods not requiring the use of a graph have also been developed. Selection of the most appropriate evaluation technique is dependent on the test setup and results.

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7.0 RECORDS

Attachment A, the Pumping Test Data Sheet, should be used to record data from pumping and observation wells. A written log of the field setup and performance of the pumping test should also be kept, describing procedures used, daily activities, and any other pertinent observations made prior to, during, and following the test.

PUMPING TEST DATA SHEET — **NUS CORPORATION**

PROJECT NAME: ______ MEASURED WELL: ______
PROJECT NO.: ______ DATE: ______ PUMPING WELL: ______
GEOLOGIST: ______ CHECKED: ______ TEST NO ______
DISTANCE FROM PUMPING WELL(ft.)(r): ______ PUMP SETTING, FEET BELOW MONITORING POINT: ______
STATIC H_2O LEVEL (ft.)(s_o): ______ MONITORING POINT: ______
TIME PURGE START OR STOP (t_o): ______ ELEVATION OF MONITORING POINT (ft. above MSL): ______

TIME	(t) MIN. SINCE PUMP START OR STOP	WATER LEVEL MEASUREMENTS (ft.)			(s) DD Or RECOVERY (ft.)	PUMPING RATE (Q) GPM	REMARKS
		READING	CORRECTION	DTW			

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1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly described.

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are less accurate than pumping tests, as a much more localized area is involved, so a number of slug tests are performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests in regards to the quality of data obtained and time/cost considerations. A disadvantage to constant-head tests is that a significant volume of water may be added to the formation, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K): A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T): A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity x saturated thickness.

Slug-test: A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time.

4.0 RESPONSIBILITIES

The project geologist shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project geologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

The field geologist is responsible for performing the planned field tests as specified in the planning documents, or as directed by the project geologist shall the field program require modification, and generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies required and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 In-Situ Hydraulic Conductivity Testing in Wells

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The same type of slug can be placed below the static water level in the well, left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume to change the water level (slug test) is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water. A bailer or pump can be used to withdraw water from the well. (If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery.) Falling head slug tests can only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Chalked steel tape, although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water levels need to be taken during the performance of a slug test.

The following data shall be obtained when performing slug tests in wells or borings:

- Well/boring ID no.
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data

A variation of the slug test is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level, and is called a constant-head test. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements shall be recorded in place of time/recovery data for approximately 10 to 20 minutes, then the hydraulic conductivity calculated from this. This type of test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 In-Situ Hydraulic Conductivity Testing in Borings

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies with drilling, geologic, and general site conditions and shall be selected after a careful evaluation of the above factors.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level shall be measured and recorded. The water level shall then be raised (falling head test) or lowered (rising head test) and the change in water level measured at time intervals as determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water-level measurements will vary according to the formation's hydraulic conductivity. The faster the rate of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals shall be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test shall be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method consists of placing a temporary well with a short screen into the cleaned out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. this method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity calculated from this. This method is the most accurate method depicted in this section and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 Data Analysis

There are a number of data analysis methods available for use to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973), have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/ piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, factors in partial/full penetration, and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling-head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well is screened in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) shall be used as the screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by senior level personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, v. 3, No. 1, pp. 263-269.

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, v. 9, No. 4, pp. 1087-1089.

Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, CO.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A. Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the field logbook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the field logbook.

ATTACHMENT A

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET — *NUS CORPORATION*

PROJECT NAME: .... WELL/BORING NO.: ....

PROJECT NO.: .... GEOLOGIST: ....

WELL DIAMETER: .... SCREEN LENGTH/DEPTH: .... TEST NO.: ....

STATIC WATER LEVEL (Depth/Elevation): ..../................ DATE: ....

TEST TYPE (Rising/Falling/Constant Head): .... CHECKED: ....

METHOD OF INDUCING WATER LEVEL CHANGE: .... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

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7.0 RECORDS

1.0 PURPOSE

The objective of this procedure is to provide general reference information and technical guidance on the measurement of hydraulic head levels and the determination of the direction of groundwater flow, using contour maps of the water table or the potentiometric surface of an unconfined or confined aquifer.

2.0 SCOPE

This procedure gives overall technical guidance for obtaining hydraulic head measurements in wells (frequently conducted in conjunction with groundwater sampling) and preparation of groundwater contour maps. The specific methods could be modified by requirements of project-specific plans.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

Potentiometric Surface - A surface which is defined by the levels to which water will rise in wells which are screened or open in a specified zone of an unconfined or confined aquifer.

Unconfined (water table) aquifer - An aquifer in which the water table forms the upper boundary.

Confined aquifer - An aquifer confined between two low permeability layers (aquitards).

Artesian conditions - A common condition in a confined aquifer in which the water level in a well completed within the aquifer rises above the top of the aquifer.

Flow Net - A diagram of groundwater flow, showing flow lines and equipotential lines.

Flow Line - A line indicating the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Equipotential Line - A contour line on the potentiometric surface or water table showing uniform hydraulic head levels. Equipotential lines on the water table are also called water-table contour lines.

4.0 RESPONSIBILITIES

Project Hydrogeologist - has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

5.0 PROCEDURES

5.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater if required.

Water level readings shall be taken regularly, as required by the site hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due weather changes, and at least during the same day.

5.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the onsite hydrogeologist.

In most instances, preparation of accurate potentiometric surface requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, the Chalked Tape or Electrical Water Level Indicator methods have been found best, and thus are the most often utilized. Other, less precise methods, such as the Popper or Bell Sound or Bailer Line methods, may be appropriate for developing preliminary estimates of hydraulic conditions. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use the Float Recorder or Pressure Transducer methods. When conditions in the well limit readings (i.e., turbulence in the water surface or limited access through small diameter tubing), less precise, but appropriate, methods such as the Air Line or Capillary Tubing methods can be used.

5.2.1 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required.

2. Record all information specified below in the geologist's field notebook or on the Groundwater Level Measurement Sheet.

   a. Well number.
   b. Record water level to the nearest 0.01 foot (0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.
   c. Record the time ~~and day of~~ the measurement.

Water level measuring devices with permanently marked intervals shall be used when possible. If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in accurate reference points (see Section 5.2.3).

5.2.2 Water Level Measuring Devices

Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time consuming; difficult to use during periods of precipitation.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape and added to the band reading to obtain the depth to water. If band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.2.3.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (ft of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used, this method cannot be used to obtain water level readings to the nearest 0.01 ft).

Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves, indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel samples. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwater. Since the piezometer tubing and capillary tubing usually are somewhat coiled when installed, it is difficult to accurately measure absolute water level elevations using this method. However, the method is useful in accurately measuring differences or changes in water levels (i.e., during pumping tests).

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost-effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

Bailer Line Method

Water levels can be measured during a bailing test of a well by marking and measuring the bailer line from the bottom of the bailer (where water is first encountered) to the point even with the top of the well casing. This is a useful technique during bailing tests (particularly if recovery is rapid) if the bailer is heard hitting the water. However, it is not recommended for measuring static water levels because it is not usually as accurate as some of the other methods described above.

5.2.3 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.2.4 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells.

Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy periodically. A water level indicator calibration sheet shall be completed each time the measuring device is checked. A water level indicator calibration form is shown in Attachment A. The "actual reading" column on the sheet is the actual length of the interval from the end of the indicator to the appropriate marked depth interval. In many cases, these measurements are different because the water level measuring device is connected to the end of the measuring tape or line, and may extend beyond "0" feet on the measuring line.

5.3 Potentiometric Surface Mapping

5.3.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day.

Before mapping, review the recorded water levels and monitoring-well construction data, site geology and topographic setting to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounce correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this decision. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow, and many more wells will be needed to provide an accurate contour map. Generally, shallow systems require more wells than deep systems for accurate contour mapping.

5.3.2 Construction of Equipotential Lines

Plot the water elevations in the chosen wells on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is most commonly used, as it is the simplest technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful for large data sets. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted in accordance with these, utilizing the professional judgment of the hydrogeologist. Closed contours should be avoided unless a known sink exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must show in the contour plot.

5.3.3 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

5.4 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a Health/Safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID (HNU) or FID (OVA) and combustible gas meters shall be performed to determine required levels of protection.

6.0 REFERENCES

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, 604pp.

Cedergren, H. R., 1977. Seepage, Drainage and Flow Nets (2nd edition). John Wiley and Sons, New York.

Fetter, C. W., 1980. Applied Hydrogeology. Merrill, Columbus, Ohio, 488pp.

Ebasco Services Inc. REM III Field Technical Guideline No. FT-6.07, October 27, 1987.

7.0 RECORDS

Attachment A - Groundwater Level Measurement Sheet
Attachment B - Water Level Indicator Calibration Sheet.

ATTACHMENT A

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: ______________________
Project No.: ______________________
Personnel: ______________________
Date: ______________________

LOCATION

Municipality: ______________________
County: ______________________
State: ______________________
Street or Map Location (If Off-Site) ______________________

WEATHER CONDITIONS

Temperature Range: ______________________
Precipitation: ______________________
Barometric Pressure: ______________________

Equipment No.: ______________________
Equipment Name: ______________________
Latest Calibration Date: ______________________

Tidally-Influenced: [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* All elevations to nearest 0.01 foot.

ATTACHMENT B

WATER LEVEL INDICATOR CALIBRATION SHEET

Project Name ____________________ Date ____________________

Project No. ____________________

Equipment No. ____________________

Equipment Name ____________________

Water Level Indicator Marking (Feet)	Actual Reading* (Feet)
0.0	
5.0	
10.0	
15.0	
20.0	
25.0	
30.0	
35.0	
40.0	
45.0	
50.0	
55.0	
60.0	
65.0	
70.0	
75.0	
80.0	
85.0	
90.0	
95.0	
100.0	

* Record readings to the nearest 0.01 foot. The actual reading may be different than marking because the water level measuring device (electrode, popper, etc.) may extend beyond the "0" feet mark on the measuring line.

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		Effective Date 01/01/88	Revision 0
		Applicability WMSG	
		Prepared Earth Sciences	
Subject MEASUREMENT OF STREAM CHANNEL CROSS SECTION AND FLOW		Approved A. K. Bomberger	

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1.0 PURPOSE

The purpose of this guideline is to provide general guidance on field methods and equipment used to measure stream cross sections, flow rates, and flow volumes.

2.0 SCOPE

This guideline describes several methods for determining cross-sectional area and flow. Since the physical characteristics that a stream could exhibit vary widely, several methods and techniques are presented, so as to offer a variety of techniques which can be used in the field.

3.0 GLOSSARY

Flow (or volumetric flow rate) - the volume of water which passes through a cross-sectional plane in some unit of time. (Syn. - DISCHARGE)

Flume - an artificial channel used for constricting the flow of wastewater or water, in order to promote laminar flow and provide a flow channel of known configuration for the purpose of measuring flow volume.

Stage - the height of a water surface above an arbitrarily established datum plane.

Weir - a levee or dam-type structure containing a notch through which the flow of water can be measured.

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project hydrologist, responsible for determining the optimum location for performing flow determinations within an open channel, including the selection of the appropriate methodology, technique and field procedure for conducting the field test.

Field Operations Leader - Responsible for direct supervision of the installation and execution of the field tests used to determine flow in an open channel. This individual is responsible for inspection of the equipment, to ensure its adequacy for performance of the test.

5.0 PROCEDURES

5.1 GENERAL

The discussion below addresses the various methods and techniques used to measure cross-section and stream velocities with respect to the velocity-area open channel technique of stream flow measurement. These techniques should be applied whenever stream gaging information is not available. When possible, stream gaging station information shall be utilized since, not only can real time flow information be obtained, but historical flow information can be readily obtained from the authority responsible for the station.

The most common method of open channel flow determination is the velocity-area method. In this method, a flow or discharge measurement is computed as the summation of the products of partial areas of the flow cross-section and their respective average velocities. This is represented by the formula:

$$Q = \sum (av)$$

where:

Q = total discharge,
a = individual partial cross-sectional area,
v = corresponding mean velocity normal to the partial area.

5.2 CROSS SECTIONAL AREA DETERMINATION

5.2.1 Width Determination

Width determination for shallow streams and brooks can usually be accomplished by a simple tape measurement. However, when streams or rivers are wide (greater than 100 feet), deep (greater than five feet), or exhibit a high flow velocity, width determination can be a problem. As a general rule, width determinations under these conditions need only be accurate to the nearest foot for 100-foot streams. Tape measurement of streams or rivers is usually accurate enough for streams up to 500 feet in width; however, for large streams, alternatives may be required. Bridges are convenient avenues across which measurements can be made. An equally acceptable method of determining width is by transit and stadia survey techniques.

5.2.2 Depth Determinations

Most often depth measurements are taken directly with a measured rod or sounding weight. The mass of the weight suspended at the end of the tape must be sufficient to keep the tape essentially vertical. For high velocity streams or excessively deep channels, a sonic sounder may be appropriate, since some can be adapted to produce a continuous strip chart profile of the channel depth.

5.2.3 Stormwater Containment Capacity

In some cases it may be useful to measure the cross sectional area of a stream or drainage ditch channel up to the top of the channel (including both the submerged portion of the channel and the portion above the water surface). Knowledge of the volume capacity of the stream channel at various points can be used to determine the capability of the channel to contain increased water flows from storm events of various magnitudes, and predict when and where overflows may occur.

5.3 VELOCITY/FLOW DETERMINATIONS

As a general procedure, the actual measurement of depth, width and velocity would normally occur concurrently. In any case, in many parts of the country and along many sections of streams, the actual measurement of the above parameters are not required because this information has already been determined at gaging stations.

5.3.1 Stream Gaging Stations

A network of stream gaging stations has been in place for several decades. The authorities responsible for their placement are the U S Army COE, USGS, and other Federal or state agencies. In general, they have been placed in sensitive watersheds and along major tributaries and rivers throughout the United States.

These stations have established water stage-discharge relationships ("rating curves") which allow flow to be determined from water stage measurements. By measuring the water level directly from the staff gage and applying it to the rating curve for that station, flow can be easily determined. The rating curve is maintained by the operator of the gaging station. If a new gaging station is to be established, the techniques outlined in the USGS publication "Discharge Measurements at Gaging Stations," Hydraulic Measurement and Computation, Book I, Chapter II, United States Department of the Interior, Geological Survey, 1965 shall be used.

5.3.2 Alternative Velocity/Flow Determination Methods

In general, the methods specified below refer to open channel stream flow where continuous long-term measurements are not required. Zero flow or non-channel flow conditions (overland flow) are not discussed within this text and require special procedures for flow determination. The main parameters to be collected for open channel flow determinations are cross-sectional area and stream velocity.

5.3.2.1 Current Meters

Current meters provide a rather quick and relatively accurate method of determining flow under existing site conditions. They are generally not used for long-term determinations. There are many types of current meters. Some are mechanical, others are electrical; some have vertical shafts, and others have horizontal shafts. The type preferred for open channel stream measurement are those which have a vertical shaft. The basic concept behind a current meter is that a rotating element at the end of the vertical shaft (or, in some cases, stationary electrodes) is submerged beneath the stream's surface where the flow of water rotates the element (or passes between the electrodes). The speed of rotation of the element (or flow between the electrodes) is measured directly by the current meter, which is then correlated to stream flow velocity through the meter's own electronic circuitry or by graphs or charts which accompany the instrument. Speed is normally measured in meters/sec or feet/sec.

Current meters can generally measure flow down to 0.03 meters/sec (0.1 ft/sec). Current meters which use electrodes are good for measuring streams that have weedy growths emanating from the stream bottom which would affect the rotating element. The depth to which current meters can be used is only limited by the ability to hold the element rigid at depth. Once a current meter measurement is taken, the measurement is averaged with other measurements taken along a vertical transect of the stream at that point to determine the mean velocity along that vertical transect. In a wide stream, several vertical transects are constructed such that less than 10 percent of the volume of the stream is represented by each transect. The mean stream velocity is calculated as the average of the individual average vertical velocities of each transect, with each average velocity weighted by the cross-sectional area of the stream that it represents. Some of the methods by which a current meter can be used are as follows:

- Six-tenths method - This method is best utilized when flow information must be gained quickly and/or the depth of the stream is less than 0.8 meters (2.6 feet) but greater than 0.1 meters (0.3 feet). In general, current meters cannot be used when depth of streams are less than 0.1 meters (0.3 feet). In this method, one measurement is taken at a depth 0.6 of the total depth below the surface along each of the vertical transects mentioned above. To gain a little more accuracy, each measurement within each transect may be taken three times and the result averaged to determine the mean velocity along that transect. This method reduces the effects of aberrant measurements.

- Two-point Method - This method can only be used for streams exhibiting a depth greater than 0.8 meters (2.6 feet). This restriction is due to the effects that the surface of the stream and stream bed would have on the rotating element. In this method, measurements are taken at 0.2 and 0.8 of the total depth below the surface. The two measurements are then averaged to obtain the mean velocity along the vertical transect. Then all the transects are averaged to determine the stream flow.

- Three-point Method - This method is also restricted to those streams exhibit a depth greater than 0.8 meters (2.6 feet). In this method, velocities are determined with a current meter at 0.2, 0.6, and 0.8 of the total depth below the surface. The 0.2 and 0.8 readings are averaged. The result is then averaged with the 0.6 reading. This method is very effective in those streams in which the vertical velocities are not normally distributed.

- Vertical-velocity method - This method is primarily used for deep channels. In this method, readings are taken at 0.1 depth increments starting at 0.1 and ending at 0.9. These values are then averaged together to determine the mean velocity of the vertical. Due to the numerous readings required, this method is not often used.

5.3.2.2 Deflection or Drag-body Methods

This method utilizes the relationship that drag is proportional to the square of the velocity. This method tends to be insensitive to very low velocities and is also affected by aquatic growth or debris which can affect the drag coefficient of the body utilized. This method is, however, relatively inexpensive and, under certain conditions, will yield as accurate a result as any device.

5.3.2.3 Floats

Floats use the principle that velocity of the stream can be determined by measuring the velocity of a float carried on the surface of the stream. If the stream is wide enough to require several velocity measurements, several floats should be used, with the resulting velocity multiplied by the fraction of the cross-sectional area of each represented measurement. The sum of the products equates to the flow or total discharge of the stream. There are many types of floats and each has its own coefficient to obtain mean velocity from a surface velocity measurement.

5.3.2.4 Pressure Methods

Pressure methods use a device called an impact tube to measure stream velocity. The impact tube comes in several different varieties, e.g., the Pitot tube, Barcy tube, Prandtl tube, or Brabbe tube. Impact tubes work under the principle that velocity is proportional to the square root of the dynamic pressure head, which is either measured directly or as a difference between the total and static pressure head in these impact tubes.

5.3.2.5 Tracer Methods

Several types of tracers, including salt, dye, or radioisotopes, are used in this method. The major drawback to this type of velocity measurement is that pools and eddies tend to trap the tracer. Therefore, a uniform cross-sectional portion of the stream channel must be used. The tracer must be introduced as a slug into the stream channel. This may be at one point or simultaneously at many points across the stream. The tracer concentration is measured at one or more points at known distances downstream of the injection point. At each of the downstream points, concentration/time curves are created by continuous measurement. The most precise determination of average velocity is made by using the centroid of the concentration/time curve to measure the travel time; however, the measurement of time at the concentration peaks is nearly as accurate.

5.3.2.6 Weirs and Flumes

A considerably more sophisticated method of determining stream flow is through the installation of artificial pre-calibrated control structures such as weirs and flumes. A weir is a dam-like structure behind which the water is ponded. The top of the weir contains a calibrated notch through which the ponded water eventually flows. Stream flow is determined by measuring the height of flow through the weir, which is a function of potential energy behind the overfall. A flume is basically a constricted flow structure which provides a uniform cross-section for measurement of flow. Flow is determined within the supercritical section within the throat of the constriction. For a detailed discussion of weirs and flumes, see U S Geological Survey (1977), Volume 1, Chapter 1, p. 1-65 to 1-77.

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7.0 ATTACHMENTS

None.

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number SA-1.1	Page 1 of 13
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject GROUNDWATER SAMPLE ACQUISITION		Approved A. K. Bomberger, P.E.	

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

5.0 PROCEDURES

5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.

- Pumps

  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$),

  where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet, i.e., linear feet of static water.
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers - Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps - There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venture to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Working schedule.

- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.

6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.

7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.

8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.

9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer). Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning,

sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

12. Add preservative if required. Label, tag, and number the sample bottle(s).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.

15. Decontaminate all equipment.

5.5.3 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

5.5.6 Sample Holding Times

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.

- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.

- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).

- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.

- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

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7.0 RECORDS

Attachment A - Well Sampling Data Sheet
Attachment B - Purging Equipment Selection

NUS CORPORATION
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SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other ____________

Page _____ of _____
Case # ____________
By ____________

Project Site Name ____________ Project Site Number ____________
NUS Source No. ____________ Source Location ____________

	Purge Data				
Total Well Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Well Casing Size & Depth:					
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					

	Sample Data			
Sample Date & Time:	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				
Signature(s):	Observations / Notes:			

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT A

ATTACHMENT B

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch								
Water level <25 ft		x	x	x	x			
Water level >25 ft				x				
2-Inch								
Water level <25 ft	x	x	x	x	x	x		
Water level >25 ft	x			x		x		
4-Inch								
Water level <25 ft	x	x	x	x	x	x	x	x
Water level >25 ft	x			x		x	x	x
6-Inch								
Water level <25 ft				x	x		x	x
Water level >25 ft				x			x	x
8-Inch								
Water level <25 ft				x	x		x	x
Water level >25 ft				x			x	x

Manufacturer	Model name/number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc	BarCad Sampler	dedicated, gas drive (positive displacement)	1 5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas, custom sizes and materials available, acts as piezometer
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	500-600	AC/DC, variable speed control available, other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	400-700	AC, DC, or gasoline driven motors available; must be primed
Geltek Corp.	Bailer 219-4	portable; grab (positive displacement)	1.66/38	Teflon®	no limit	1075 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2800 mL/min	1500-3000	requires compressed gas, other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable, grab (positive displacement)	1.75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Delrin® acetal	0-150	0-7500 mL/min	990	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable; grab (positive displacement)	1.75/12	acrylic, Delrin®	no limit	app. 250 mL	125-160	other materials and models available, for measuring thickness of "floating" contaminants
Q E D Environmental ~~Systems, Inc.~~	Well Wizard® Monitoring System (P 100)	dedicated, bladder (positive displacement)	1.66/36	PVC	0-230	0-2000 mL/min	300-400	requires compressed gas, piezometric level indicator, other materials available

Source: Barcelona et al., 1983

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co.	Model 500 Vari Flow Pump	portable; peristaltic (suction)	<0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	200-1300	flow rate dependent on motor and tubing selected, AC operated, other models available
Robert Bennett Co.	Model 180	portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin®, PP, Viton® acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas, water level indicator and flow meter, custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flushing cycle	250-350	requires compressed gas, SS available, piezometer model available, dedicated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas, custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive displacement)	1.66/custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available, optional bottom-emptying device available, no solvents used
TIMCO	Air or Gas Lift Sampler	portable; gas drive (positive displacement)	1.66/30	PVC, Tygon® Teflon®	0-150	350 mL/flushing cycle	100-200	requires compressed gas, other sizes, materials, models available; no solvents used
Tole Devices Co.	Sampling Pump	portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas required; DC control module, custom built

Construction Materials Abbreviations

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
SS	Stainless Steel
PC	Polycarbonate
EPDM	Ethylene-Propylene Diene (synthetic rubber)

Other Abbreviations

NA	Not Applicable
AC	Alternating Current
DC	Direct Current

NOTE: Other manufacturers market pumping devices which could be used for ground-water sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high capacity pumps are included.

Source: Barcelona et al., 1983

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1.0 PURPOSE

This procedure describes methods and equipment commonly-used for collecting environmental samples of surface water and aquatic sediment for either on-site examination and chemical testing or for laboratory analysis.

2.0 SCOPE

The information presented in this guideline is generally applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.4), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions and equipment different from those described herein.

3.0 GLOSSARY

Environmental Sample - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling or CLP handling as a high concentration sample.

Hazardous Waste Sample - medium to high concentration sample (e.g., source material, sludge, leachate) requiring DOT labeling and CLP handling as a high concentration sample.

4.0 RESPONSIBILITIES

Field Operations Leader - has overall responsibility for the correct implementation of surface water and sediment sampling activities, including review of the sampling plan with, and any necessary training of, the sampling technician(s). The actual collection, packaging, documentation (sample label and log sheet, chain-of-custody record, CLP traffic reports, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

5.0 PROCEDURES

5.1 INTRODUCTION

Collecting a representative sample from surface water or sediments is difficult because of water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are not better than the confidence that can be placed in the representativeness of the samples.

5.2 DEFINING THE SAMPLING PROGRAM

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives; accessibility; site topography; flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which affect an adsorption/desorption). The hydrologist developing the sampling plan must therefore, know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

5.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or in a surface water body. Sources may include point sources (leaky tanks, outfalls, etc) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition are: (a) overland runoff; (b) leachate influx to the waterbody; (c) direct waste disposal (solid or liquid) into the water body; and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to be absorbed by particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates. Samples will be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

5.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrologist shall explore the possibility of obtaining streamflow data by direct or indirect methods.

5.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the work plan. For single-event site- or area-characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples shall be collected at a pre-established and constant interval as specified in the work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water-quality data shall be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

5.3 SURFACE WATER SAMPLE COLLECTION

5.3.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand sampling procedures to the more sophisticated multipoint sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the water course taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, discharge and on the suspended sediment the river's transports. The greater number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well-mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross-section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of DO, pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected.

5.3.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have as much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each aliquot of the vertical composite. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample. These verticals are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality since it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in-situ using sensors and automatic readout or recording devices. Single and multiparameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

5.3.3 Estuaries

Estuarine areas are by definition zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations:

- Mixed estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling location are not critical in this type of estuary.

- Salt wedge estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic estuary - characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e. when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1 to 5 foot increments coupled with vertical dissolved oxygen and temperature profiles.

5.3.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- Open tube
- Dip sampler
- Hand pump
- Kemmerer
- Depth-Integrating Sampler

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation
- Nonreactive/noncontaminating - Teflon-coating, glass, stainless steel or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) shall be measured for:

- Specific conductance
- Temperature
- pH (optional)
- Dissolved oxygen (optional)

as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

Dip Sampling

Water is often sampled by filling a container either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling is:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the sampler line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. "Messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

5.3.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following suggestions are made to help ensure that the samples obtained are representative of site conditions:

- The most representative samples are obtained from mid-channel at 0.6 stream depth in a well-mixed stream.
- Even though the containers used to obtain the samples are previously laboratory cleaned, it is suggested that the sample container be rinsed at least once with the water to be sampled before the sample is taken.
- For sampling running water, it is suggested that the farthest downstream sample be obtained first and that subsequent samples be taken as one works upstream. Work from zones suspected of low contamination to zones of high contamination.
- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one sample, or several grids are selected at random.
- Care should be taken to avoid excessive agitation of the water that results in the loss of volatile constituents.
- When obtaining samples in 40 ml septum vials for volatile organics, analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner faces in after the bottle is filled and capped. The bottle can be turned upside down to check for air bubbles.
- Do not sample at the surface, unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the month of the bottle facing upstream.

5.4 SEDIMENT SAMPLING

5.4.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the site shall be approximately at the center of water body. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathometry (depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (high-velocity, turbulent areas) and suspension of fine solid materials shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are below detection limits). It is therefore important to minimize the loss of low-density "fines" during any sampling process.

5.4.2 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using on-shore or off-shore techniques.

When boats are used for sampling, life preservers must be provided and two individuals must undertake the sampling. An additional person shall remain on-shore in visual contact at all times.

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permitting direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the change of metal contamination from the frame of the device.

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7.0 RECORDS

None

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1.0 PURPOSE

This procedure describes the method for logging and sampling of test pits and trenches to determine subsurface soil and rock conditions and recover small-volume or bulk samples. The methods apply only to data collection and do not apply to the construction of excavations.

2.0 SCOPE

The procedure is applicable to the collection of bulk and small-volume samples of subsurface soils for laboratory testing which are exposed through excavating at hazardous substance sites.

3.0 GLOSSARY

Test pit or trench - A pit or trench, either machine or manually excavated, from which large quantities of soil may be removed.

4.0 RESPONSIBILITIES

Site Manager - responsible for determining, in consultation with other project personnel (geologist, geochemist), the need for test pits or trenches, their approximate locations, depths and sampling objectives.

Field Operations Leader (FOL) - responsible for finalizing the location, orientation and depth of test pits/trenches based on on-site conditions and the site geologist's advice. The FOL is ultimately responsible for the proper construction, sampling and backfilling of test pits and trenches, including adherence to OSHA regulations.

Health and Safety Officer (HSO) - responsible for air quality monitoring during test pit construction and sampling, to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The HSO may also be required to advise the FOL on other safety-related matters regarding the test pit or trench excavation and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Site Geologist/Sampler - responsible for recording all information and data on test pit/trench construction and for the proper collection and logging of samples according to this procedure.

5.0 PROCEDURES

5.1 DATA COLLECTION AND SAMPLING

5.1.1 General

Test pits and trenches are usually logged as they are excavated. Records of each test pit/trench will be made on prepared forms or in a field notebook. If the log is made in a field notebook, it will be transcribed to the prepared forms. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records will also include safety and sample screening information.

Requirements for sampling shall be determined by the Site Manager, and shall be documented in the Project Operation Plan (POP). A copy of this plan shall be maintained by the Field Operations Leader. To expedite sampling, the crew shall have sufficient tools and equipment to sample each pit. The tools and equipment must be properly decontaminated prior to use.

Entry of test pits by personnel is extremely dangerous and shall be avoided unless absolutely necessary. Pits more than four feet deep must be shored prior to entry, the "buddy" system must be used, and all applicable H&S and OSHA requirements followed.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, such as to obtain geotechnical information. Such information would include soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples, which can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than borings.

5.1.2 Sampling Equipment

The following equipment is needed for taking samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks and hand augers, stainless steel trowels.
- Sample container - bucket with locking lid for large samples and glass bottles for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample; buckets.
- Remote sampler consisting of ten foot sections of steel conduit (one inch diameter), hose clamps and right angle adapter for conduit (See Attachment A).

5.1.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 5.1.4.

- Excavate trench or pit in several depth increments. After each increment the operator will wait while the sampler inspects the test pit from grade level to decide if conditions are appropriate for sampling. (Monitoring of volatiles by the HSO will also be used to evaluate the need for sampling.) Practical depth increments range from 2 to 4 feet.

The backhoe operator, who will have the best view of the test pit, will immediately cease digging if:

- Any fluid phase or groundwater seepage is encountered in the test pit.
- Any drums, other potential waste containers, obstructions or utility lines are encountered.
- Distinct changes of material are encountered.

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending upon the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

- Remove loose material to the greatest extent possible with backhoe.
- Secure walls of pit if necessary. (There is seldom any need to enter a pit or trench which would justify the expense of shoring the walls. All observations and samples can generally be taken from the ground surface.)
- Samples of the test pit material will be obtained either directly from the backhoe bucket or from the material once it has been deposited on the ground. The sampler or Field Operations Leader directs the backhoe operator to remove material from the selected depth or location within the test pit/trench. The bucket is brought to the surface and moved away from the pit. The sampler and/or HSO then approaches the bucket and monitors its contents with a photoionization (HNU) or OVA meter. The sample is collected from the center of the bucket or pile and placed in sample jars using a clean stainless steel trowel or spatula.
- If a composite sample is desired, several depths or locations within the pit/trench are selected and a bucket is filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample bottle shall be emptied into a mixing container (e.g., stainless steel bucket) and thoroughly stirred prior to being placed into the sample jars. Composite sampling is not appropriate for samples which will undergo analysis for volatile organic compounds.

- Using the remote sampler shown in Attachment A, samples can be taken at the desired depth from the side wall or bottom of the pit. The face of the pit/trench shall first be scraped (using a long-handled shovel or hoe) to remove the smeared zone that has contacted the backhoe bucket. The sample is then collected directly into the sample jar, by scraping with the jar edge, eliminating the need to utilize samplers and minimizing the likelihood of cross-contamination. The sample jar can be capped, removed from the assembly, and packaged for shipment.

- Prepare shipping papers, labels, and chain-of-custody records, as described in SA-6.2, Sample Packaging and Shipping.

5.1.4 In-Pit Sampling

Samples can also be obtained by personnel entering the test pit/trench. This is necessary when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soils or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- The project will benefit significantly from the improved quality of the logging and sampling data obtained if personnel enter a pit or trench rather than conduct such operations from the ground surface.

- There is no practical alternative means of obtaining such data.

- The Site Health & Safety Officer determines that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of volatile organics, explosive gases and available oxygen).

- An experienced geotechnical professional determines that the pit/trench is stable or is made stable prior to entrance of any personnel (by grading the sidewalls or using shoring). OSHA requirements (Reference 1) must be strictly implemented.

If these conditions are satisfied, one person will enter the pit/trench. On potentially hazardous waste sites, this individual will be dressed in safety gear as required by the conditions in the pit, usually Level B. He will be affixed to a safety rope and continuously monitored while in the pit.

A second individual will be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations. The individual entering the pit will remain therein for as brief a period as practical, commensurate with performance of his work. After removing the smeared zone, samples are obtained with a clean trowel or spoon. As an added precaution, it is advisable to keep the backhoe bucket in the test pit when personnel are working below grade. Such personnel can either stand in or near the bucket while performing sample operations. In the event of a cave-in they can either be lifted clear in the bucket, or at least climb up on the backhoe arm to reach safety.

5.1.5 Geotechnical Sampling

In addition to the equipment described in Section 5.1.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., open tube samplers) which can be pushed or driven into the floor of the test pit.
- Suitable driving (i.e., a sledge hammer) or pushing (i.e., the backhoe bucket) equipment which is used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soils in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties, to aid in soil identification and classification, while larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soils using open tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than a drill rig. Also, the sampler may be extracted from the test pit by excavation around the sampler when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit the requirements described in Section 5.1.4 must be followed. The open tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate, because the sample will not have the correct orientation.

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, to minimize disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand excavation to remove the soil from around the sides of the sampler and slice off the sample at its bottom may be required. If this requires entry of the test pit, the requirements in Section 5.1.4 must be followed. Prepare, label, pack and transport the sample in the required manner, as described in SA-6.2, Sample Packaging and Shipping.

Hand-carved block samples are extracted in a similar manner to open tube samples, except that the sampling container (usually a large tube or box with no top or bottom) is not used to cut the sample. Instead, the surrounding sections of the test pit floor are carved away by hand to leave a sample slightly smaller in plan dimensions than the container, with the sample remaining connected to the test pit floor at its bottom. The container is slipped over the sample, and the annular space and top of the sample is covered with melted wax. The bottom of the sample is then sliced away from the test pit floor, the container is inverted, about 1/2 inch of soil removed, and the space filled with melted wax. Caps are then installed, taped, and dipped in hot wax for each end of the container, and the block sample is labeled and shipped in the same manner as a tube sample.

5.2 RECORDS

The following information will be recorded on the test pit/trench log form and in the field notebook:

- Name, work assignment number, and location of job.
- Date of digging or trenching.
- Surface elevation.
- Depth, surface area and orientation of pit or trench.
- Sample numbers.
- Method of taking samples, type and size of samples.
- Approximate water levels after stabilization (if below the water table), and location and depth of any seeps.
- Description of soil.
- Other pertinent information, such as HNU or OVA readings, weather conditions, etc.
- List of photographs.
- Name of contractor, backhoe (or other equipment) operator and sampler.
- Date and type of backfill.

6.0 REFERENCES

OSHA, 1979. Excavation Trenching and Shoring, 29 CFR 1926.650-653.

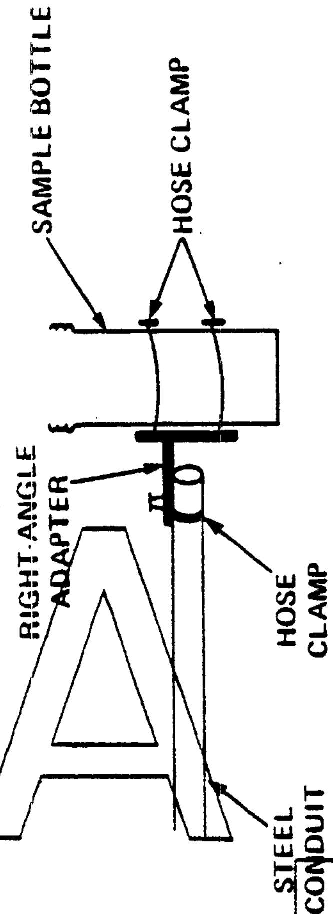
Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-7.09. March 25, 1986.

7.0 RECORDS

Attachment A - Remote Sampling/Sample Holder for Test Pit/Trench

ATTACHMENT A

REMOTE SAMPLE HOLDER FOR TEST PIT/ TRENCH SAMPLING



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		Effective Date 01/01/88	Revision 0
		Applicability WMSG	
		Prepared Earth Sciences	
Subject DRUM OPENING AND SAMPLING		Approved A. K. Bomberger, P.E.	

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information for use in planning for and implementing sampling programs involving the moving and/or opening of closed containers in uncontrolled hazardous substance sites. Procedures are provided for selecting containers to be opened and for moving and opening them. In addition, site organization, protective clothing, worker protection, and other safety procedures are discussed.

2.0 SCOPE

This procedure is applicable to opening and sampling of closed containers (120 gallons or less) on uncontrolled hazardous substance sites. Bulk tanks such as railroad tank cars, large above- and below-ground tanks (with a capacity of more than 120 gallons) and tank trailers are not considered in this guideline.

3.0 GLOSSARY

Air Reactive Wastes - Some chemicals, such as white phosphorus or barium oxide, react with oxygen in the air, while others, such as sodium, cesium or various metal hydrides, react with the moisture or water vapor in the air. Many of these compounds are explosive when they come in contact with air or water.

Container - is defined as any drum, bottle, can, bag, etc., with a capacity of 120 gallons (450 liters) or less.

Glass Thief - a glass tube 4 feet long and 3/4 inches in diameter, used for taking samples from drums. The tube is usually broken and disposed of in the drum following sampling.

4.0 RESPONSIBILITIES

Field Operations Leader (FOL) - responsible for the overall safe conduct of the container opening and sampling operations. These include informing and obtaining help from local authorities if necessary; selection of containers to open/sample; testing; moving, and staging of containers; container opening and sampling; resealing; and halting operations, including ordering site evacuation or requesting public evacuation (with help from local authorities) if necessary. The drum opening and sampling program will be planned in detail in the Site Operations Plan. If any unexpected results (e.g., explosions, atmospheric releases) occur, the FOL must inform the Site Manager immediately. Together with the Health and Safety Officer and outside assistance, if necessary, (e.g., EPA's Emergency Response Team), he must determine the most prudent course of action.

Health and Safety Officer (HSO) - responsible for safety of all on-site operations, alerting the FOL of any potentially unsafe conditions, and halting work if on-site personnel or off-site public health is threatened.

Site Manager - responsible for determining that opening and sampling of containers is necessary for the RI program, and the approximate numbers and types of containers to be opened.

5.0 PROCEDURES

5.1 GENERAL PRINCIPLES

In general, a container opening and sampling program will have one of the following objectives:

- To determine (usually for enforcement case support) the presence of hazardous materials on the site. Such a program involves a very limited number of containers, perhaps as few as one.
- To characterize the range of materials present at a site. Containers would be chosen for sampling by means of systematic selection criteria.
- To characterize container contents for such purposes as bulking for disposal. This program may involve opening and sampling every container on a site in support of a remedial-action program, and performing on-site compatibility testing.

The guidance presented is based on field experience in working with containers on uncontrolled hazardous substance sites. It will be evident that in many cases hard-and-fast rules cannot be given, and professional judgment is required because uncontrolled variables are involved. For example, no one can be absolutely certain of any assessment of the potential contents of a container. Labels cannot be absolutely trusted; only educated guesses can be made by a through review of all available background data, such as potential sources of the wastes.

Three basic risks are involved in moving and opening closed containers: (1) exposure of personnel to toxic materials, (2) fire, and (3) explosion. The first risk can be reasonably eliminated through the use of proper skin and respiratory protection equipment. The use of Level A protection acceptably reduces the risk of a worker being injured by toxic vapors, mists, or splashes. In the same way, standard fire prevention procedures can be used to reduce the fire hazard through the use of detector instruments and proper equipment. These include the use of non-sparking tools and intrinsically safe radios, pumps, and other equipment, as well as the staging of fire fighting equipment and the elimination of any other possible ignition sources.

The explosive risk, however, is not as easily handled, and thus is the primary consideration in any container-opening operation. Even if no solid evidence of the presence of explosives is found during the preliminary data collection, one can never be certain that explosives have not been disposed of at the site. In order to provide the same reasonable level of protection against this risk as against toxic exposure and fire, a very cautious approach, such as the one recommended in this procedure, should be used.

5.2 BACKGROUND REVIEW

This section details the elements of a site background review necessary to prepare a Site Operations Plan for drum opening. The decision of whether or not to conduct the operations depends on the assessment of the site history. Therefore, it is important that the following tasks are completed thoroughly.

5.2.1 Preliminary Assessment

The FIT preliminary assessment (if available) or the RI evaluation of existing data should be consulted in planning for a container-opening operation. Of special importance are items that can be used to characterize the types of hazardous materials present at the site (e.g., generator records, manifests.

inventories, personal interviews, monitoring data). The review of all such data should search for the possible presence of shock-sensitive explosives and/or reactive chemicals. The absence of waste inventory information could prevent drum opening on the site without prior review by the ZPMO.

5.2.2 Explosive Product Survey

If the site is a waste disposal or storage operations, a survey of commercial producers or users of explosives within the area served by the facility must be conducted. The determination of the area covered in this survey is a judgment that should be based on locations of known waste generators that used the facility and geographic locations of the site. Agencies that could assist in identifying explosive producers or users are local and state police units, state transportation departments, the U.S. Department of Transportation (DOT), and EPA state hazardous-waste permit offices. Standard Industrial Classification (SIC) codes can be used to locate producers of explosives from lists of manufacturers available from state commerce agencies, local chamber of commerce, planning agencies, etc.

5.2.3 Site Inspection

A site visit is required prior to planning a drum opening operation. This visit may be in addition to the Reconnaissance Survey. Information on the following should be gathered during the inspection:

- Site boundaries - fences, roads, natural boundaries, etc.
- Access points and travel routes on the site.
- Topographic features
- Adjacent land uses - residential, agricultural, public use areas, commercial establishments, schools, natural areas,etc.
- Power lines, railroad, and public roads close to the site.
- Container storage areas - provide observational details; describe if drums are jumbled, stacked, piled, arranged in rows, etc. General condition of drums indicates if containers can be grouped according to visual features, contents, or any other classification method.
- Buildings and other site structures, as well as any other disposal areas such as lagoons, surface piles, etc.
- Location of water sources.
- Location of potential staging areas.

In general, the FIT preliminary assessment and site inspection should have been completed prior to NUS involvement in opening and sampling drums. Field characterization resulting from the FIT work should help to establish ambient conditions and identify potential hot spots. This information is to be plotted on the site sketch required in the Site Operations Plan. Observations from maps and aerial photographs can also be used in compiling the site sketch.

During the site inspection phase, local officials should be contacted to arrange for fire protection and police support during the operation. Interviews should also be conducted with site workers, local officials, and any other people familiar with the site's history.

The central purpose of the background review is to evaluate the risk presented to personnel engaged in drum-opening operations. Assessment of drum contents is most important because it identifies specific risks. However, other site features also affect the hazard potential. Leaking and corroded drums, crowded and poorly organized conditions, and drums of unknown and apparently diverse origins are conditions that require careful planning.

There are no accurate quantitative methods available to evaluate the total danger. Assessment of the danger is subjective and should be done by personnel experienced in field operations at hazardous sites. Good professional judgment is required, and project management must feel that adequate information is available to support a decision to conduct the drum-opening operations. Any positive indication of shock-sensitive materials that might react or explode requires special consideration. Sites that are suspected or known to contain such materials are to be referred to the ZPMO for planning for drum opening. In addition, sites that are judged to be unduly hazardous for any other reason should be referred to the ZPMO. If the project team decides to proceed, an operations plan and Health and Safety Plan is required and needs to be approved by the ZPMO.

5.3 CONTAINER SELECTION CONSIDERATIONS

The containers selected for opening and sampling will depend on the purpose of the operations and on considerations of safety--that is, a container that may detonate is to be avoided. Even though many drums are found at uncontrolled disposal sites where the contents are unknown, it is worthwhile to consider drum markings and types, as well as drum groupings.

When considering sampling for enforcement, the first choice of drums would be those marked with known hazardous materials (trade name, chemical name, empirical formula), or hazardous labeling. Next would be those isolated by themselves or material contained in an exotic metal container (e.g., aluminum, nickel, monel, stainless steel). Then consideration should be given to the unmarked drum piles or stacks. These should be sampled randomly among the various distinguishable drum lots.

When sampling for site characterization purposes, a concerted effort should be made to distinguish drum lots and to get a good drum count among the lots. A drum that appears to be characteristic and in the center of all the major drum lots should be sampled first, followed by drums in as many of the smaller lots as practical. Also, if practical, duplicate samples should be taken on major drum lots at either end of a lot to see if the wastes appear to be characteristic all the way through.

On most abandoned waste sites, there is some organization or pattern to the way the material was placed on the site. The pattern is occasionally as detailed as finding the flammable solvents in one area, acids in another, cyanide in another, recoverable metals in a fourth, and so on. Some disposal facilities stencil control numbers on drums to indicate specific lots. Often, if the site was poorly run, the only indication that a group of drums is related will be their color, size, or type.

Typically, waste is shipped to sites in 55-gal drums on trucks. About 60 to 80 drums are delivered from a given load, depending on the weight of the load. During the initial site inspection, one should look for distinguishing features in an attempt to define the different lots of drums on the site. Often the trade name, chemical name, or empirical formula will be written on the drum. Another distinguishing feature would be drums of exotic metal such as aluminum, nickel, monel, stainless steel, etc. A manufacturing facility will use a specified DOT coded drum, a strange drum size, or a drum with an unusual configuration or adaptation for a particular process line (center of drum head fill bung, double-sided fill/vent bungs, etc.).

At almost every site that has been receiving waste, there is an isolated group of containers. Approach these with care but do try to determine why they were segregated. Occasionally a group of drums is found marked 'DFW' (roughly translates as "Don't Fool With") because of their extreme hazard or because the people handling them have had an accident or other unusual experience with them.

In any lot of drums there is sometimes encountered an unusual or out-of-place container. This oddball container will not fit the pattern, color, size, etc., of those around it (e.g., it may be the only distended drum among undistended drums or a lined drum among unlined drums).

An attempt should be made to avoid drums that are structurally damaged or if their movement or sampling would endanger a team member. Samples of drums in stacks or piles should not be taken if at all possible.

Before sampling any drums, an external radioactivity scan must be conducted with the results recorded in the field notebook. On a site where many different types of containers are present, they should be sampled in the following order, based on what they can be expected to contain and in increasing order of hazard:

- Paper, plastic, cloth, and burlap bags.
- Glass carboys and jugs (except chemical reagent or laboratory-packed bottles).
- Fiberboard drums.
- Plastic and polyethylene carboys and containers.
- Plastic-lined steel drums.
- Steel drums.
- Exotic metal drums.
- Odd containers (distended, isolated, marked "DFW", etc.).

Attachment A contains information on the types, sizes, DOT designation, openings, and recommended opening techniques for the various kinds of containers. Any drum without a DOT designation should be avoided, as it may have military origins. The DOT designation, which is usually found on the bottom of a drum, can be useful in determining the material of the drum.

5.4 CONTAINER HANDLING AND STAGING

Personnel involved in handling and transporting containerized waste shall work in teams containing no fewer than two people. Visual contact shall be maintained between members of the working team at all times. All team members shall be able to communicate between themselves and with the Site Health and Safety Officer by intrinsically safe two-way radio at all times on the work site.

Prior to physically handling a drum or other container, the following preliminary classifications checklist must be reviewed and each response noted in a field notebook:

- Is the drum radioactive?
- Does the drum exhibit leakage or deterioration, i.e., is it unsound?
- Does the drum exhibit apparent internal pressure?

- 's the drum empty?

- Does the drum contain markings which would indicate that the contents are potentially explosive?

The results of the preliminary classification checklist dictate which specific procedures shall be followed in handling, opening, and sampling the drum.

The handling, movement, and transport of drums and other containers should be by use of mechanical equipment only; equipment may consist of a grappler equipped backhoe or front-end loader. Drum transportation should be with front-end loaders or fork lifts with modified carrying platforms. Portions of equipment that contact drums or canisters should be constructed of non-ferrous metals or contact portions should be coated or lined to preclude spark generation. Handling and transport equipment must be equipped with full frontal and slide splash and explosion shields. Class ABC fire extinguishers shall be fitted to the body of each piece of equipment.

When possible, drums or other containers to be sampled should be opened and sampled in place to minimize handling. However, when drums are stacked or are close together, they may have to be moved to prevent sympathetic detonation of, or chemical reaction with, other drums around the one being opened. The main criterion is distance to other drums--a reasonable distance should be maintained to keep the drum to be opened segregated from others.

Drums or containers exhibiting the following characteristics require special treatment in handling and sampling:

- Leaking or deteriorated drums
- Bulging drums
- Drums containing explosive or shock-sensitive waste
- Drums containing radioactive waste
- Lab packs
- Gas cylinders

When drums are moved, they should be taken to a staging and sampling area that is diked or bermed to control any major spillage. Again, this area should be far enough away from other drums on the site to prevent a chain reaction. Only one container at a time should be placed in the staging area and opened. One crew can be moving and setting up the remote-opening equipment on the next container while another crew is sampling, labeling, and resealing the first container.

Containers that are inside warehouses, basements, or other buildings must be moved outside before they can be opened. If this is not possible, the ZPMO should be contacted for special assistance in developing the opening plan. Adequate ventilation is critical for container-opening operations.

Empty drums containing less than 1 in. of solid residual waste and those resulting from on-site bulking and repack operations shall be loaded by grappler into transport equipment and placed within the empty drum staging area. Residuals, where possible, shall be transferred to repack contianers prior to movement.

5.5 REMOTE OPENING

Because of the possibility of encountering a drum containing a shock-sensitive material, any drum to be moved and/or sampled should be remotely shaken. One way of doing this is to carefully tie a rope around the drum and shake it from behind a barrier at a safe distance.

The required method of opening drums is by remote means (except as noted in Attachment A). Three types of remote-opening equipment are available: the bung spinner, the remote-controlled drill, and the drum piercer.

The bung spinner consists of:

- Air impact wrench with nonsparking adapter.
- Drum-mounting bracket.
- Two-stage regulator.
- Compressed-air cylinder with 100 ft. of air hose and control valve.

The impact wrench is mounted over the bung on top of the drum by means of the steel-mounting bracket. The air tank, regulator, and control valve can be placed up to 100 ft. away from the drum in a well-protected location.

A remote-controlled, air-operated, self-feeding, and self-retracting drill can also be used. This tool consists of:

- Self-feeding and self-retracting drill.
- Drum-mounting bracket.
- 100 feet of air and control hoses.
- Two-stage high-pressure regulator.
- Compressed air cylinder.
- Filter/regulator/lubricator unit.

As with the bung spinner, the air tank, regulator, and control valves can be placed up to 100 feet away from the drum in a well-protected location. There are two controls on this piece of equipment--a start valve and an emergency retract valve.

The drum piercer consists of:

- Hydraulic ram with hand pump.
- 100 feet of hydraulic hose.
- Drum-mounting bracket (top or side).
- Piercing nail.

This unit uses the same bracket as the drum drill. The hydraulic ram slowly forces the steel piercer through the drum surface as the hand pump is operated. When the 1/2 in.-diameter hole is complete, opening a relief valve on the pump allows the spring to retract the piercer from the hole.

When any of these pieces of equipment is used, the control lines are to be extended to their maximum, and drum-opening personnel are to operate the controls from behind sandbags, a concrete or brick structure, or other solid barriers. Remember, the opening surfaces of the drill or bung spinner should be decontaminated after each use.

The following guidelines are offered for other types of containers:

- Ring-closed, open-top drums - Loosen the ring and then remove it remotely by means of a rope. If it is necessary to cut the ring, do so near the bolt or clamp/lever so that there will be a place to attach the rope.

- Glass carboys or jugs with lapped/ground-glass stopper or plastic cap - Slowly release any retaining wire and vent any pressure. Remove the stopper or cap by hand only.

- Fiberpacks or corrugated cardboard containers - Release the locking ring and remove the ring and lid by hand.

- Plastic or polyethylene carboys and plastic-lined drums (when necessary) - Use a nonsparking aluminum, brass, or beryllium bung wrench of the proper size. Do not use a bung wrench on any distended drums of this type; remote methods will be applied.

- Plastic Kraft paper, burlap, or cloth bags - Use a trowel or sampling trier. The bags should be resealed or placed in an overpack.

5.6 PROBLEM CONTAINERS

Special handling techniques are required for containers which may expose personnel to particularly hazardous conditions. These techniques are described in general below, although site-specific conditions may require the development of specialized methods in the Site Operations Plan.

5.6.1 Leaking or deteriorated Drums

- The contents of drums that exhibit leakage or apparent deterioration such that movement will cause repture (determined by the HSO) must immediately be transferred to a repack drum. Equipment, including transfer pumps used in the repack operation, must be of explosion proof construction.

- Leaking drums containing sludges or semi-solids, drums that are structurally sound but which are open and contain liquid or solid waste, and drums which are deteriorated but can be moved without rupture, must be immediately placed in overpack containers.

5.6.2 Bulging Drums

- Drums which potentially may be under internal pressure, as evidenced by bulging, must be sampled in place. Extreme care shall be exercised when working with and adjacent to potentially pressurized drums.

- Should movement of a pressurized drum be unavoidable, handle only with a grappler unit constructed for explosive containment. The bulging drum should be moved only as far as necessary to allow seating on firm ground or it should be carefully overpacked.

- Openings into pressurized drums shall be plugged and the bung holes fitted with pressure venting caps set at 5 psi release.

5.6.3 Drums Containing Explosive or Shock Sensitive Waste

- If drums containing wastes that have been identified by sampling, or are suspected by visual examination to be explosive in nature are found, the Site Manager and HSO must be notified immediately, before the drums are handled in any way.

- If the Site Manager and HSO approve handling of these drums, they shall be handled with extreme caution. Initial handling shall be by a grappler unit constructed for explosive containment. Drums shall be palletized prior to transport to a high hazard interim storage and disposal area.

- If at any time during remedial activities, an explosive, pursuant to provisions of Title 18, U.S. Code, Chapter 40 (Importation, Manufacture, Distribution, and Storage of Explosive Materials, 1975 Explosives List) is identified, it should be secured and the appropriate state and federal agencies notified.

- Identification of an explosive substance during the course of a remedial action is usually based on the experience of the on-site personnel. Potentially explosive materials usually may be identified by their physical characteristics -- texture, color, density, etc., as well as the way they are packaged or labeled. Most explosives are solids. In some cases they are packaged in water-tight containers to exclude water, while in other cases they are packaged wet to preclude explosion.

- Prior to handling or transporting drums containing explosive wastes, personnel working in the area shall be removed to a safe distance (as determined by the HSO). Continuous contact with the command post shall be maintained until handling or transporting operations are complete. An audible siren signal system, similar to that employed in conventional blasting operations, shall be used to signify the commencement and completion of explosive waste handling or transporting activities.

5.6.4 Drums Containing Radioactive Waste

- Drums containing radioactive wastes shall not be handled until radiation levels have been determined by an initial field survey which is recorded in a field notebook. The survey shall include background levels, direct gamma readings and laboratory analysis of drum surface wipe samples.

- Depending on the level of radiation encountered, handling and transport may require special shielding devices to protect personnel. Following handling and transport, equipment used shall be surveyed by the HSO and decontaminated to background levels prior to recommencing work. Surveys shall also be made of the ground surface in the vicinity of original drum storage to identify potential soil contamination by spilled or leaked radioactive waste. Prior to recommencing work in the area, radioactive soil areas shall be isolated to prevent tracking of radioactive contaminants about the site, and workers who entered the area should have their gloves and boots surveyed for radiation.

5.6.5 Packaged Laboratory Wastes (Lab Packs)

- If drums known or suspected of containing discarded laboratory chemicals, reagents or other potentially dangerous materials in small volume, or individual containers are found, the Site Manager is to be notified immediately, before the drums or containers are moved or opened.

- If the Site Manager and HSO approve the handling or these containers, they shall be handled with extreme caution. Until otherwise categorized, they shall be considered explosive or shock sensitive wastes. Initial handling shall be by a grappler unit constructed for explosive containment. Drums shall be palletized and overpacked if required prior to transport to the Lab pack staging area for sorting, identification, repacking and/or stabilization.

- Prior to handling or transportating Lab Packs from the existing drum area, personnel working in the immediate area shall be removed to a safe distance. Continuous contact with the command post shall be maintained until handling or transporting operations are complete. An audible siren signal system, similar to that employed in conventional blasting operations will be used to signify the commencement and cessation of Lab Pack handling or transporting activities.

5.6.6 <u>Air Reactive Wastes</u>

- If the presence of an air reactive substance is verified or even suspected, the material should be immediately segregated and transported to a separate high hazard interim storage and disposal area.

- Air reactive wastes may be discovered during opening or sampling operations. Air reactive substances normally require special packaging. They may be stored under water or some other liquid to minimize air contact. They may also be found in sealed ampoules, corrugated drums, stainless steel canisters, or specially lined drums.

5.6.7 <u>Gas Cylinders</u>

- Gas cylinders, when encountered, should be stored and disposed of on a special case basis depending on the integrity of the cylinders and type of substance they are expected to contain.

5.7 **CONTAINER SAMPLING**

5.7.1 <u>Equipment</u>

- Personal protection equipment.

- 500 ml, wide-mouth amber glass bottle with teflon cap liner.

- Uniquely numbered sample identification labels and tags filled out and affixed to sample containers before sampling commences.

- 4-ft. x 3/4-in. ID glass sampling thief.

- Remotely operated opening device.

- One gallon covered cans half-filled with absorbent material (for offsite shipment only).

5.7.2 Sampling Procedures

All drums and mechanical equipment should be grounded prior to the commencement of sampling. If the bung or container lid can be removed, sample contained liquids using a glass thief, which shall then be broken and discarded within the barrel. A barrel that has a badly rusted bung, or that cannot be sampled as above, shall be safely entered with a hydraulic penetrating device operated remotely. All openings shall be plugged except during sampling operation.

The steps to be followed in sampling are as follows:

- Record any markings, special drum conditions, and type of opening in the field notebook, ~~on the~~ sample log ~~sheet, and~~ later, on the Chain-of-Custody form Locate the general area on a sketch of the site.
- Stencil an identifying number on the drums and record in logbook. Consult the sampling plan for identification.
- Make certain that the drum/container is set on a firm base, preferably in a fully upright position.
- Open the drum/container as described in Section 5.5 and Attachment A.
- Insert glass tubing almost to the bottom of the drum or until a solid layer is encountered. About 1 foot of tubing should extend above the drum.
- Allow the waste in the drum to reach its natural level in the tube. Then cap the top of the sampling tube with a tapered stopper, ensuring liquid does not come into contact with stopper.
- Carefully remove the capped tube from the drum and insert the uncapped end in the sample container. Do not spill liquid on the outside of the sample container. Release the stopper and allow the glass thief to drain completely into the sample container.
- Deliver 100 to 250 ml of the sample (the sampling plan will specify the amount) to a clean, wide-mouth, 500-ml (1-pt) glass sample jar. If the sample is not free flowing and is taken through a bung opening, repeated sampling may be necessary.
- Place the used sampling tube, along with paper towels or ~~waste rags~~ used to wipe up any spills, into an empty metal barrel for subsequent disposal. If glass tubing has been used, it may be broken and left inside the drum being sampled.
- Cap the sample container tightly and place prelabeled and tagged sample container in a carrier.
- Replace the bung or lids or place plastic over the drum/container.
- Measure the sample for radioactivity and record results in a field notebook. If the meter readings exceed 10 mR/hr, notify the FOL immediately.

DRAFT

- Fill out Chain-of-Custody Record and carefully pack samples. The finished package will be padlocked or custody-sealed for shipment to the laboratory. The preferred procedure includes the use of a custody seal across filament tape that is wrapped around the package at least twice The custody seal (paper, plastic, or metal) is then folded over and stuck to itself so that the only access to the samples is by cutting the filament tape or breaking the seal to unwrap the tape. The seal is signed before the package is shipped.

- Complete the appropriate traffic report. Drum samples are always considered to be high-hazard samples.

5.7.3 <u>Sample Preservation and Packing Procedures for Drummed Waste Samples</u>

- No preservatives shall be used.

- Place sample container in a ziplock plastic bag.

- Place each bagged container in a 1-gallon covered can containing absorbent packing material. Place lid on can.

- Mark the sample identification number on the outside of the can.

- Arrange for the appropriate transportation mode consistent with the type of hazardous waste involved.

5.8 RESEALING AND SITING CONTAINERS

All containers opened for sampling need to be resealed to prevent the escape of vapors and possible reactions from rainwater, air and so on. The resealing methods will depend on the opening methods used and include the following.

- Replacing the bung, screw cap, etc.

- Replacing the lid and retaining ring.

- Placing the drum in an overpack (larger drum) when it cannot be resealed by any other method.

- If a hole is drilled, use of a special rubber or plastic plug. A drum bonnet should be used to ensure that rainwater does not seep around the plug.

It is important to note that these resealing methods are for the purpose of preventing leakage from the container while it is in storage on the site. If the container is to be moved off the site, DOT regulations regarding transportation of drums must be complied with. These will generally require more rigorous sealing procedures.

Once the drum is sampled and resealed, it should be left where it cannot react with other containers on the site. For a small number of drums, the storage areas may be the staging and opening area. In any event, the sampled drums should be placed in an area away from other groups of containers on the site. The reason is that slowly progressing chemical reactions can start when a container is opened and the contents exposed to air or the disturbance caused by handling the drum. Such a reaction could take hours or even days to occur. Another reason for the segregation and identification of drums for recovery is for use as evidence.

5.9 PUBLIC EVACUATION/ALERT CONSIDERATION

5.9.1 General

The potential need for evacuation of the site and surrounding area must be considered when the Site Operations Plan and Health and Safety Plan are developed. The HASP should describe the conditions requiring evacuations and the parties responsible for issuing and enforcing an evacuation order. Several site-specific factors influence the need for, and the extent of, the evacuation or alerting of the nearby off-site public. These factors include the following.

- Proximity of residences, shopping or other commercial or business areas, factories, highways, railroads, and airfields or other transportation routes that may have to be evacuated. This information will be available from the background review and preliminary site inspections.

- Proximity of other facilities that could be involved in, cause, or propagate a fire, explosion, or toxic release on the site. This information will also be known from the background review and site inspection.

- Presence of explosive, flammable, or volatile substances on the site. Some general indications of the types of hazards present may be provided by the background review and site inspection. The probability of encountering explosives (i.e., directly detonatable or shock-sensitive materials as opposed to explosive vapor-oxygen mixtures) will have been reduced by the screening procedures applied during earlier site evaluation. Preliminary assessment and site inspection may provide indications, or definite knowledge, that specific compounds presenting known flammability or toxicity hazards are in the containers. Of these known hazards, those having the greatest potential for atmospheric spread off the site should be used in estimating evacuation hazard distances as described below. For example, if several volatile toxic liquids, or toxic vapors, are present, those having the greatest toxic potential in air, as measured by a Threshold Limit Value (TLV) or classified as Immediately Dangerous to Life and Health (IDLH), should determine the hazard distance, since these have the potential for the greatest health impacts.

  Atmospheric drift of a toxic or flammable vapor cloud or plume can often extend to great distances from the site, and hence potentially threaten more people than even an explosive hazard. Similarly, thermal-radiation hazards generated by even a large fire on the site generally reach to distances which are small compared to possible atmospheric drift distances of a vapor cloud.

- Potential for an accident on the site which could result in an atmospheric release of flammable or toxic liquid or vapor. This possibility should be remote if only one drum is opened at a time and if that drum is segregated from other drums.

  The most important parameter that needs to be estimated for any accident is the rate of liberaiton of flammable or toxic vapor; unfortunately, this is often the most uncertain quantity.

- Prevailing wind speed and direction and atmospheric stability affect very strongly the pattern of atmospheric spread of a gas cloud. If these can be quantitatively estimated at the time an actual accidental release occurs, this information should be used in calculating an estimated evacuation corridor as detailed below.

However, because wind direction is subject to rapid and unpredictable variations, and because atmospneric drift of a concentrated cloud or plume is greatest under stable atmospheric conditions and low wind speeds, it is usually preferable to take a conservative approach. Thus, one should base a public hazard evacuation distance, in any direction from the site, on an assumed worst-case atmospheric condition, that is, a stable atmosphere and moninal low wind speed, say 5 mph.

5.9.2 Plausible Accident Scenario

A plausible but hypothetical scenario for an accident that may be expected to occur during closed-container opening operations would involve a release, from only the one 55-gal drum being opened, of a volatile toxic liquid that rapidly vaporizes and forms a nonburning but continuous source of a toxic vapor plume. The rate of vapor generation and release can be calculated from the assumption that the upright drum is completely open at the top and a knowledge of the vapor pressure and some other readily available chemical properties of the chemical involved. For simplicity, the fact that a complex mixture of chemicals may actually be involved is neglected and the most toxic liquid or vapor is treated as if it were a pure component.

5.9.3 Estimating Hazard Evacuation Radius

Once the rate of atmospheric release of vapor is estimated for the accident scenario, outside assistance from any of several sources may be sought to estimate an atmospheric dispersion distance appropriate for the degree of flammability or toxicity hazard of the chemical involved. This estimate would then be used as a recommendation of an evacuation radius to be made to the responsible official in charge at the site, who will actually determine the necessity and extent of public evacuation.

Outside assistance in estimating the hazard radius in an emergency situation may be obtained from EPA"s Emergency Response Team (ERT), the U.S. Coast Guard's Hazard Assessment Computer System (HACS), or from other hazard analysts.

Two different situations may require the evacuation of the off-site public:

- The emergency resulting from an actual occurrence of an accident involving atmospheric release during drum-opening operations.
- Precautionary planning before the start of drum-opening operations, in anticipation of an accident.

The above hypothetical scenario involving a single drum may be used in planning precautionary evacuations before the start of a dangerous drum-opening operation. On the other hand, in an actual accident, the rate may be estimated if the number of drums releasing and the size of the opening in each such drum can be estimated by observation.

The decision to evacuate or alert the public off the site as a precautionary measure depends on the degree of hazard presented by the materials known to be present at the site. For the scenario described above, a table of numerical hazard distances for several of the commonly encountered chemicals and those expected to be found at the site will be prepared before drum-opening commences as part of the Health and Safety Plan. These distances may then be used as numerical decision criteria for precautionary evacuation by comparing them to the known distances of populated areas from the site.

6.0 REFERENCES

Casis, J.A., et al., 1985. Guidance Document for cleanup of Surface Tank and Drum Sites. Prepared for Office of Emergency and Remedial Response, USEPA, Washington, D.C. under Contract No. 68-01-6930.

EBASCO Services Incorporated; REM III Field Technical Guideline No. 11.01, January 9, 1986.

7.0 RECORDS

Attachment A - Techniques for Opening Containers (2 Sheets)

ATTACHMENT A - Page 1

TECHNIQUES FOR OPENING CONTAINERS

Types	Size	DOT Designation	Type of Opening	Recommended Opening Technique
Steel drum, open head, unlined and lined	5-110G	DOT 5 - DOT 6 - DOT 17 - DOT 37 - DOT 42 -	Detachable steel lid with a clamp or lever-locking ring, or a ring with forged lugs and secured by a bolt.	Remove bolt. If possible, relieve pressure on clamp or lever-locking ring remotely (i.e., lanyard); Remove ring with lanyard. Remove lid by hand.
Steel drum, closed head, lined	5-110G	DOT 5 - DOT 6 - DOT 17 - DOT 37 - DOT 42 -	Plastic bung opening not larger than 2.3 in.	Preferred method is to remotely open bung. Manually open otherwise.
Steel drum, closed head, unlined (steel, monel, stainless, nickel, and aluminum)	5-110G	DOT 5 - DOT 6 - DOT 17 - DOT 37 - DOT 42 -	Steel or other metal bung not over 2.3 in.	Remote method.
Burlap bag, double Kraft paper bag, cloth bag, plastic bag	Various	DOT 36 - DOT 44 - DOT 45 -	Various.	Open with sharp implement; reseal bag or overpack in fiberpack.

ATTACHMENT A - Page 2

TECHNIQUES FOR OPENING CONTAINERS (Cont'd)

Types	Size	DOT Designation	Type of Opening	Recommended Opening Technique
Glass carboys and jugs	6-20G	Usually DOT 1- branded into the wooden outer sheathing; often sheathing is no longer present.	Lapped or ground glass stopper; occasionally a plastic screw cap will be encountered.	Manually.
Laboratory reagent bottles (amber bottles), small reagent cans	Various	None	Screw top or press lid.	Usually encountered in lab packs. Not to be handled or sampled. Replace drum lid carefully. Contact ZPMO for action.
Polyethylene and other plastic drums or barrels	5-110G	DOT 2 -	Usually bung opening not over 2.7 in. in diameter.	Manually.
Gas cylinders	Various	DOT 3 - DOT 4 - DOT 8 - DOT 39 -	Valve, threaded fitting, quick-connect or puncture-type fittings.	Not to be handled or sampled. Contact ZPMO for action.
Fiberpack or corrugated	5-110G	DOT 12 - DOT 21 - DOT 23 -	Usually a detachable plastic lid with a clamp or lever-locking ring.	Manually remove locking ring and lid.

NUS CORPORATION

WASTE MANAGEMENT SERVICES GROUP

STANDARD OPERATING PROCEDURES

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Prepared Earth Sciences

Approved A. K. Bomberger, P.E.

Subject TANK SAMPLING

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1.0 PURPOSE

The purpose of these procedures is to provide general reference information regarding sampling of liquid or solid materials from tanks by methods which do not require tank entry.

2.0 SCOPE

This procedure covers tank inspection and sampling techniques for use in assessing the condition and, contents of tanks. This guideline does not address actual entry for internal inspection or sampling which requires strict Health and Safety protocols during this potentially hazardous activity.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - responsible to assure that the need for tank sampling is well justified and that the sampling techniques chosen are adequate to obtain a representative sample and prevent significant spills and atmospheric releases.

Field Operations Leader - responsible for implementing the FSAP and for overseeing the sampling effort in the field.

Health and Safety Officer - responsible for developing the safety-related procedures for tank entry and sampling and for assuring their correct implementation in the field.

5.0 PROCEDURES

5.1 ACCESS FOR SAMPLING

If possible, tanks will be opened and sampled from the top. The physical size, shape, construction material and location of access will determine the best methods of opening and sampling. In some cases, (for example, if the tank is being sampled from a valve at the bottom of the tank) it may be necessary to have spill response personnel on-site in case of an accidental release.

When liquids are contained in sealed vessels, gas vapor pressures build up, sludges settle out, and density layering develops. The potential for explosive reactions or the release of noxious gases when containers are opened require considerable safeguards. The vessels should be opened with extreme caution. Preliminary sampling of any headspace gases may be warranted. As a minimum, a preliminary check with an explosimeter or an organic vapor analyzer will determine levels of personnel protection and may be of aid in selecting a sampling method.

5.2 TANK SAMPLING

At least two persons must always perform tank sampling: one should collect the actual samples and the other should stand back, usually at the head of the access stairway and observe, ready to assist or call for help. If the walls or roof of the tank are corroded, the samplers should not attempt to climb up the outside of a tank, but instead an aerial lift should be used to gain access to the sampling point.

The sampling of tanks is similar to the sampling of drums. The techniques for sampling are the same, except sampling equipment may need to be longer to give a representative sample of deep tanks. Steps to be followed in tanks sampling include the following:

1. Record the tank's condition, markings, openings or valve types, and approximate size in gallons in the site logbook and on the sample log sheet. Note the tank location on the site sketch.

2. Attach an identification number to the tank using a stencil or weatherproof tag. Number succeeding tanks consecutively. Record the numbers in the site logbook.

3. Determine whether the tank contents are stratified by inserting a long plastic or glass tube sampler, withdrawing it, and examining the tube contents. Samples of stratified contents can be taken using a bomb, weighted bottle, or a Kemmerer sampler. For a description of these methods, see Attachment A of this Guideline. If a composite sample is desired, take one sample each for the upper, middle, and lower sections of the tank or for each identified layer, and composite them in one container.

   NOTE: If a reaction is observed when the glass tube is inserted (violent agitation, fumes, light, etc.) the investigators should leave the area immediately. If the glass tube becomes cloudy or smokey after insertion into the tank, the presence of hydrofluoric acid is indicated and a comparable length of rigid plastic tubing should be used.

4. If contents of the tank are homogenous, a sample may be taken using glass tubes. See Attachment B for details of this procedure.

5. After collecting the sample in the appropriate container(s), add preservative required, screw the lid, and attach a label and identification tag. Tape the lid. Fill out the appropriate sample log sheet and traffic report and Chain-of-Custody Record.

5.3 SAMPLE PACKAGING AND SHIPPING

Many samples collected from storage tanks will be shipped as high-hazard samples.

6.0 REFERENCES

Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-11.04. March 3, 1986.

7.0 RECORDS

Attachment A - Methods of Sampling Stratified Contents of Tanks (7 sheets)
Attachment B - Collection of Liquid Containerized Wastes Using Glass Tubes

ATTACHMENT A
METHODS OF SAMPLING STRATIFIED CONTENTS OF TANKS

1. Sampling Using the Bacon Bomb Sampler

Discussion

The Bacon Bomb (Figure A-1) is designed for the withdrawal of samples by the "thief" method from various levels within a storage tank. It consists of a cylindrical body with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger is used to open and close the valve. A removable top cover provides a point of attachment for the sample in and has a locking mechanism to keep the plunger closed after sampling. The Bacon Bomb is usually constructed of chrome-plated brass and bronze with a rubber O-ring acting as the plunger sealing surface. Stainless steel versions are also available. The volumetric capacity is 8, 16, or 32 ounces (236, 473 or 946 milliliters).

Uses

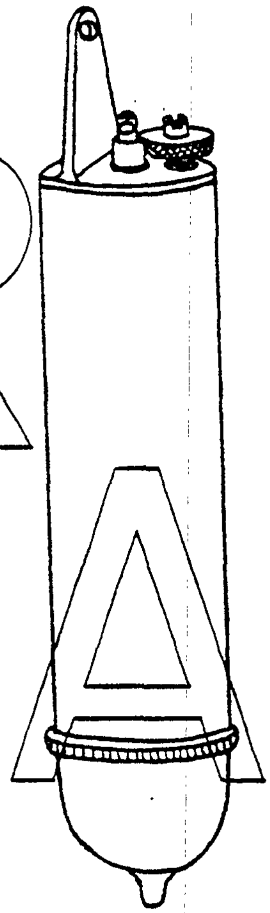
The Bacon Bomb is a heavy sampler suited best for viscous materials held in large storage tanks or in lagoons. If a more non-reactive sampler is needed, the stainless steel version should be used or any of the samplers could be coated with Teflon.

Sampling Method

1. Attach the sample line and the plunger line to the sampler.
2. Measure and then mark the sampling line at the desired depth for sampling.
3. Gradually lower the sampler by the sample line until the desired level is reached.
4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill before releasing the plunger line to seal off the sampler.
5. Retrieve the sampler by the sample line, being careful not to pull up on the plunger line and thereby prevent accidental opening of the bottom valve.
6. Rinse or wipe off the exterior of the sampler body.
7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.
8. Thoroughly decontaminate the sampler prior to next use.

FIGURE A-1

BACON BOMB SAMPLER



2. Discussion

The weighted bottle sampler consists of a glass bottle, a weight sinker, a bottle stopper, and a line for opening the bottle and lowering and raising the sampler during sampling (Figure A-2). There are variations of this sampler, as illustrated in the American Society of Testing and Materials (ASTM) Methods D-270 and E-300. This sampler can be either fabricated or purchased commercially.

Uses

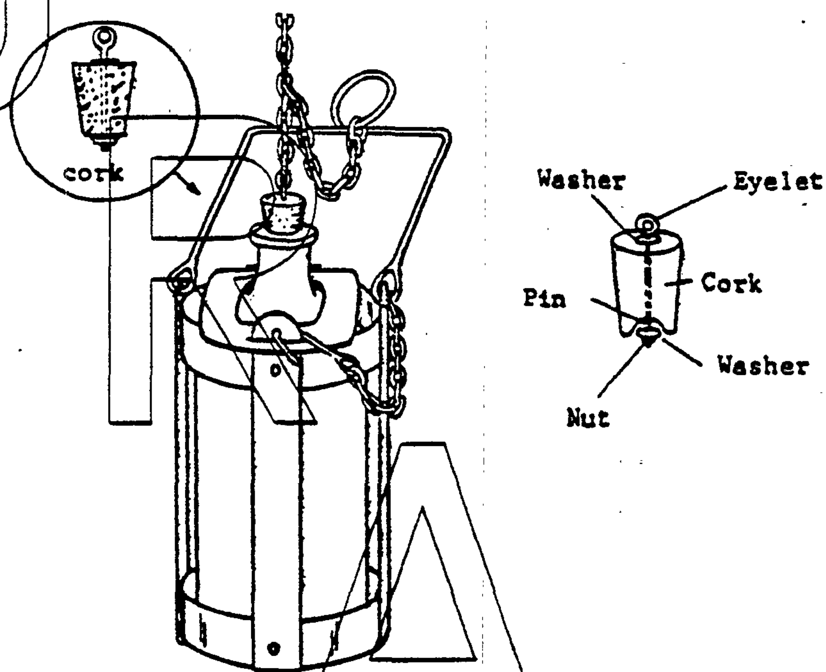
Weighted bottle samplers are used to sample liquids at a particular depth. These samplers are difficult to use in very viscous liquids. In addition, the outside of the bottle is exposed to the waste. This is undesirable if the bottle is used as the sample container. An alternative to the weighted bottle sampler is the Kemmerer bottle.

Sampling Method

1. Gently lower the sampler into the liquid to the desired depth so as not to remove the stopper prematurely.
2. Pull out the stopper with a sharp jerk of the sampler line.
3. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
4. Raise the sampler and cap the bottle.
5. The bottle can be used as the sample container, but it must be thoroughly decontaminated.

FIGURE A-2

WEIGHTED BOTTLE SAMPLER



3. Collection of Samples From Depth with a Kemmerer Bottle

The Kemmerer bottle is a messenger-activated sampling device (see Figure A-3). In the open position, liquid flows easily through the device. Once lowered to the desired depth, a messenger is dropped down the sample line, tripping the release mechanism and closing the bottle. In the closed position, the bottle is sealed, both on top and bottom, from any additional contact with the liquid column and the sample can be retrieved.

Most commercially-available Kemmerer bottles are of brass or plastic construction. Modification of existing systems with non-reactive materials such as Teflon, glass or stainless steel, would only be partially successful due to the complicated machining necessary for the release mechanism. Other modification, such as a stoppered bottom drain, are simpler and useful in minimizing sample disturbance during transfer to the appropriate containers.

Uses

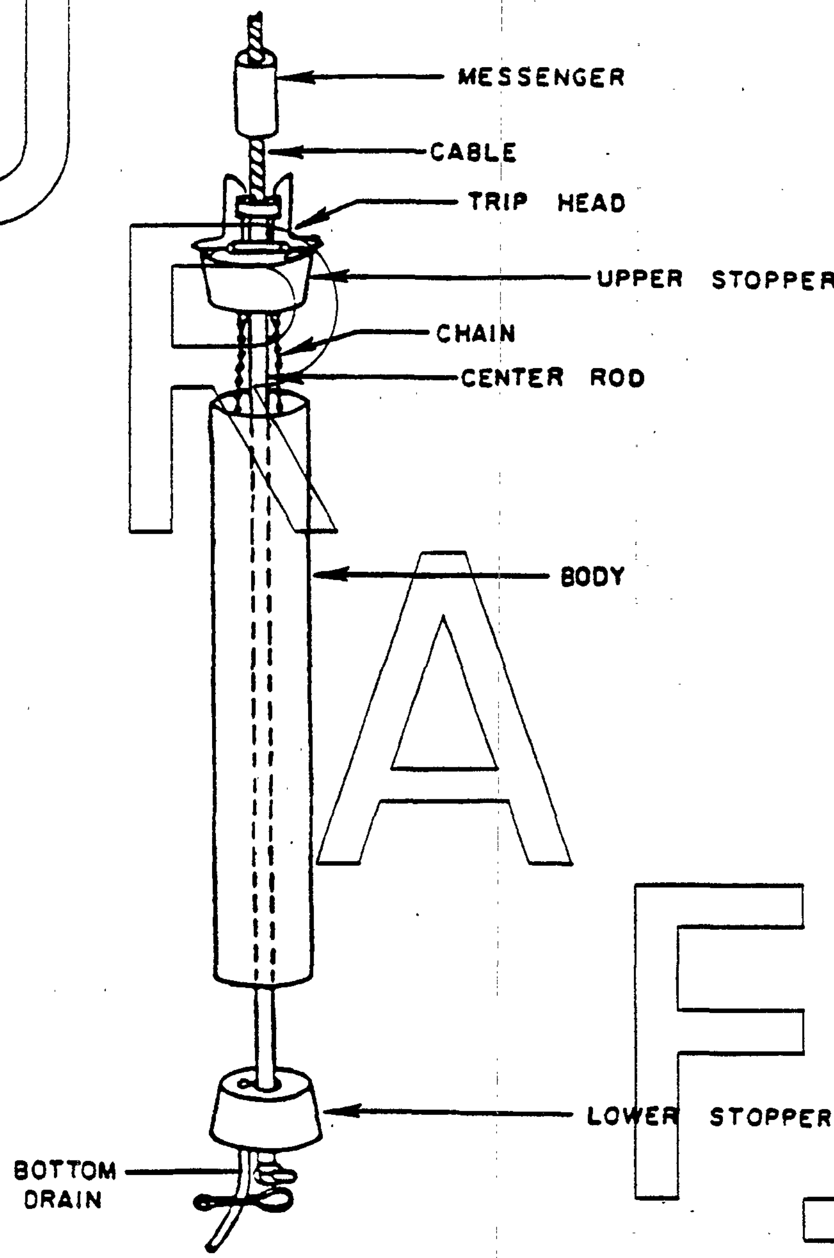
The Kemmerer bottle is currently the most practical method of collecting discrete, at -depth samples for vessels. The application is limited, however, by the incompatibility of various construction materials with some analytical techniques. Proper selection, i.e., all metal assemblies for organic analysis, or all plastic assemblies for trace element analysis, will overcome this deficiency.

Sampling Method

1. Inspect Kemmerer bottle for thorough cleaning and ensure that sample drain valve is closed (if bottle is so equipped).
2. Measure and then mark sample line at desired sampling length.
3. Open bottle by lifting top stopper-trip head assembly.
4. Gradually lower bottle until desired level is reached (predesignated mark from Step 2).
5. Place messenger on sample line and release.
6. Retrieve sampler; hold sampler by center stem to prevent accidental opening of bottle stopper.
7. Rinse or wipe off exterior of sampler body (wear proper gloves and protective clothing).
8. Recover sample by grasping lower stopper and sampler body with one hand (gloved), and transfer sample by either (a) lifting top stopper with other hand and carefully pouring contents into sample bottles, or (b) holding drain valve (if present) over sample bottle and opening valve.
9. Allow sample to flow slowly down side of sample bottle with minimal disturbance.
10. Preserve the sample, if necessary.

FIGURE A-3

MODIFIED KEMMERER SAMPLER



ATTACHMENT B
COLLECTION OF LIQUID CONTAINERIZED WASTES USING GLASS TUBE

Description

Liquid samples from opened containers are collected using lengths of glass tubing. The glass tubes are normally 122 centimeters in length and 6 to 16 millimeters inside diameters. Longer tubes may be used but larger diameters tubing is not effective. The tubing allows inspection of the tank contents for stratification. This method should not be attempted with less than a two-person sampling team.

Uses

This method provides for a quick, relatively inexpensive means of collecting concentrated containerized wastes. The major disadvantage is from potential sample loss, which is especially prevalent when sampling low viscosity fluids. Splashing can also be a problem, and proper protective clothing should always be worn.

Sampling Method

1. Remove cover from sample container opening.
2. Insert glass tubing almost to the bottom of the container. Try to keep at least 30 centimeters of tubing above the top of the container.
3. Allow the waste in the tank to reach its natural level in the tube, then cap the top of the tube with a rubber stopper.
4. Carefully remove the capped tube from the tank and insert the uncapped end in the sample container.
5. Release the thumb or stopper on the tube and allow the sample container to fill to approximately 90 percent of its capacity.
6. Repeat Steps 2 through 6 if more volume is needed to fill the sample container.
7. Cap the sample container tightly with a Teflon-lined cap and affix the label and sample identification tag.

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		Applicability WMSG	
		Prepared Earth Sciences	
Subject SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY		Approved A. K. Bomberger, P.E.	

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1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. Attachment A shows the Chain-of-Custody Record Form used by EPA Region III. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

- Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

  - It is in your actual possession.
  - It is in your view, after being in your physical possession.
  - It was in your physical possession and then you locked it up to prevent tampering.
  - It is in a designated and identified secure area.

- Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

- Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.
- Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.
- Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, ~~a sample~~ is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

Project	EPA Work Assignment Number (can be obtained from the Project Operations Plan).
Station Location	The unique sample number identifying this sample (can be obtained from the Project Operations Plan).
Date	A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
Time	A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.)
Medium	Water, soil, sediment, sludge, waste, etc.
Concentration	The expected concentration (i.e., low, medium, high).
Sample Type	Grab or composite
Preservation	Type of preservation added and pH levels.
Analysis	VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
Sampled By	Printed name of the sampler.
Case #	Case number assigned by the Sample Management Office.
Traffic Report Number	Number obtained from the traffic report labels.
Remarks	Any pertinent additional information.

Using just the EPA work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment B) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a white, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or wire for attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and is provided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the laboratory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

Project Code	EPA Work Assignment Number.
Station Number	The middle portion of the Station Location Number, (between the hyphens).
Month/Day/Year	Same as Date on Sample Label.
Time	Same as Time on Sample Label.
Designate: Comp/Grab	Composite or grab sample.
Station Location	Same as Station Location on Sample Label.
Samplers	Same as Sampled By on Sample Label.
Preservative	Yes or No.
Analyses	Check appropriate box(es).
Remarks	Same as Remarks on Sample Label (make sure the Case No. and Traffic Report numbers are recorded).
Lab Sample No.	For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

5.3 CHAIN-OF-CUSTODY PROCEDURES

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

5.3.1 *Field Custody Procedures*

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and Chain-of-Custody Record exactly.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. The Chain-of-Custody Record Form used in EPA Region III is shown in Attachment A. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Project Operations Plan).

- Sign, date, and enter the time under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the station location number, between the hyphens).

- Check composite or grab sample.

- Enter station location number (the same number as the station location on the tag and label).

- Enter the total number of containers per station number and the type of each bottle.

- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.

- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.

- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.

- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.

- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment D is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.

- Place the seal across the shipping container opening so that it would be broken if the container is opened.

- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

USEPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-7.04, October 30, 1987.

Ebasco Services Incorporated; REM III Field Technical Guideline No. 7.05, October 30, 1987.

7.0 RECORDS

Attachment A - Chain-of-Custody Record Form for use in Region III
Attachment B - Sample Label
Attachment C - Sample Identification Tag
Attachment D - Chain-of-Custody Seal

ATTACHMENT A
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

3-15966

PROJ NO.	PROJECT NAME						
SAMPLERS: (Signature)							
STA. NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CON-TAINERS	REMARKS

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

DRAFT

AR300490

ATTACHMENT B
SAMPLE LABEL

NUS CORPORATION
LABORATORY SERVICES GROUP
5350 CAMPBELLS RUN ROAD
PITTSBURGH, PA 15205

NUS SAMPLE #

Client Name ______________________________

Date Sampled ______________ Time ______________

Client Sample # ______________________________

Sample Source ______________________________

____

ATTACHMENT C
SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

Project Code

Station No.

Month/Day/Year

Time

Designate: Comp | Grab

Station Location

Samplers (Signatures)

Preservative: Yes ☐ No ☐

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD TOC Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

Tag No.	Lab Sample No.
3 60966	

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

ATTACHMENT D
CHAIN-OF-CUSTODY SEAL

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.2	Page 1 of 12
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject SAMPLE PACKAGING AND SHIPPING		Approved A. K. Bomberger, P.E.	

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6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (¥261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (¥261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.
   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS

SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

EBASCO Services Incorporated; REM III Field Technical Guideline No. FT-7.07; January 8, 1986.

7.0 RECORDS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (>13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	D O T PROPER SHIPPING NAME	HAZARD CLASS	CODE		CONTAINER NUMBERS	PIC	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	SS-[illegible]	C	1	✓	
1	55 gal	450 lbs	x	Flammable Liquid, n.o.s.	Flammable Liquid	SS-[illegible]	—	2		✓
1	55 gal	250 lbs	x	Flammable Liquid, n.o.s.	Flammable Liquid	SS-[illegible]	B	3	✓	
1	16-A	12 lbs.	x	Bromine	Corrosive Material	SS-[illegible]	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd. ____
Shipment Date ____ Manifest No. ____
Disposer Work Order ____
Service Order No. ____

 Rev. 1-79

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number: SA-6.3	Page: 1 of 4
		Effective Date: 08/10/88	Revision: 1
		Applicability: WMSG	
		Prepared: Earth Sciences	
Subject: SITE LOGBOOK		Approved: A. K. Bomberger, P.E.	

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1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 DEFINITIONS

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name and EPA Work Assignment Number
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

Ebasco Services Incorporated; REM III Field Technical Guideline No. 13.03. October 30, 1987.

7.0 RECORDS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ______________ DATE: ______________

SITE LEADER: ______________________

PERSONNEL:

NUS	DRILLER	EPA

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

2. Drilling activities at well ______ resumes. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ______.

3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well ______.

4. Well ______ drilled. Rig geologist was ______________. See Geologist's Notebook, No. 2, page ______ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.

5. Well ______ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."

6. EPA remedial project manger arrives on-site at 14:25 hours.

7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit ______.

8. Test pit ______ dug with cuttings placed in dump truck. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ______ resulted in a very soft and wet area. A mound was developed and the area roped off.

9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

____

Field Operations Leader

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.4	Page 1 of 37
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		Applicability WMSG	
		Prepared Earth Sciences	
Subject FORMS USED IN RI ACTIVITIES		Approved A. K. Bomberger, P.E.	

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6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

This procedure contains examples of forms in current use for RI activities, and a brief explanation of the function of these forms. The intent of this procedure is simply to compile and introduce these forms, and not to provide detailed explanations of the Forms.

2.0 SCOPE

Attachment A lists the forms illustrated in this procedure. Forms identified as controlled documents are issued by EPA, are sequentially numbered, and may not be altered. Those which are not listed as controlled documents and not required documents issued by EPA may be altered or revised for project-specific needs, with notification of, or in consultation with ARCS III Project Office.

3.0 GLOSSARY

<u>Controlled Document</u> - A consecutively-numbered form released by EPA for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

4.0 RESPONSIBILITIES

<u>Field Operations Leader</u> - The Field Operations Leader is responsible for ensuring that the appropriate forms illustrated in this guideline are correctly used and accurately filled out. In general, the sampling technician or Field Operations Leader will fill out forms related to sample labeling, shipment and analysis (see Section 5.1); the site geologist/geohydrologist will fill out borings logs, groundwater level and geohydrological test form (see Section 5.2); and the Field Operations Leader, site Health and Safety Officer, or field technicians, will fill out equipment calibration and maintenance records (see Section 5.3).

5.0 PROCEDURES

5.1 SAMPLE COLLECTION, LABELING, SHIPMENT AND REQUEST FOR ANALYSIS

5.1.1 <u>Sample Label</u>

The sample label is a 2-by 4 inch white label with black lettering and an adhesive backing. Attachment B-1 is an example of a sample label. These labels are required on every sample but are not controlled documents. Guidelines for filling out sample labels are contained in SA-6.1

5.1.2 <u>Sample Identification Tag</u>

The Sample Identification Tag (Attachment B-2) must be used with samples collected for Contract Laboratory Program (CLP) analysis. The tag is a white, heavy paper label that is attached to the neck of the sample bottle with a string or wire. The Sample Identification Tag is a controlled document, and is available from the Regional Sample Control Center (RSCC). Procedure SA-6.1 provides the steps in filling out Sample Identification Tags.

5.1.3 <u>Chain-of-Custody Record Form</u>

The Chain-of-Custody Record Form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis, whether on-site or off-site. It is a controlled document. Each EPA Region in

Zone 1 uses a slightly different Chain-of-Custody form. Attachment B-3 illustrates a Chain-of-Custody Record form used by Region III. This form is available from the RSCC. Procedures for filling out Chain-of-Custody Record forms are contained in SA-6.1

5.1.4 Chain-of-Custody Seal

Attachment B-4 is an example of a custody seal. The Custody seal is a 1 by 3 inch adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. It is used whenever samples are shipped with an accompanying Chain-of-Custody Record form. The chain-of-custody seal is available from the RSCC. Procedure SA-6.1 describes the procedures for using chain-of-custody seals.

5.1.5 Bottle Delivery Order (DO) Form

If CLP analyses are requested, a Delivery Order (DO) form (Attachment B-5) is completed by the Authorized Requestor and submitted to the CLP Sample Bottle Repository (see Procedure SA-6.6). This form is required but not a controlled document.

5.1.6 Repository Packing List (PL) Form

The Repository Packing List form (Attachment B-6) is used for CLP analyses. This form is completed by the Sample Bottle Repository when the requested sample bottles are shipped. A copy of the PL is received with the sample bottle shipment and is retained by the Authorized Requestor.

5.1.8 Sample Log Sheet

A Sample Log Sheet is a notebook (3-ring binder) page that is used to record specified types of data while sampling. Attachments B-7 to B-10 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. Guidelines for filling out the Sample Log Sheet are contained in SA-6.6. These forms are not controlled documents.

5.1.9 Traffic Reports (for CLP Laboratory Analyses)

A Traffic Report (TR) is a preprinted form that is provided by the EPA Sample Management Office to each Region through the Regional Sample Control Center (RSCC). These forms are obtained from the RSCC as needed for specific work assignments. These forms are part of the EPA sample-tracking system and are used to trace the shipment of samples for CLP laboratory analysis. Presently, these forms are for two types of samples: organics (OTR) and inorganics (ITR) (see Attachments B-11 and B-12, respectively). The organics and inorganics forms are used to document and identify the collection of low- and medium-concentrations samples for organic and inorganic analysis. Up to 20 samples can be recorded on each traffic report. Guidelines for filling out traffic report forms are contained in SA-6.6

5.1.10 Traffic Report Label

The Traffic Report Label is a small prenumbered white label with black lettering and an adhesive backing. Attachment B-13 provides examples of several traffic report labels. The number which appears on a traffic report label is uniquely numbered and used to track samples for CLP analysis. In addition to the number, each label contains a designation as to the type of analysis to be performed (VOA, etc.) or as to preservation of the sample (preserved unpreserved, etc.). Use of these labels is described in Procedure SA-6.6.

5.1.11 Special Analytical Services (SAS) Packing List

In addition to routine analytical services (RAS), some special analytical services (SAS) are available through the CLP. These may include quick turnaround or verification analyses, non-priority pollutant analyses, analyses requiring lower detection limits than RAS methods provide, or other specific analyses (e.g., EP toxicity testing). For all "all SAS" type of request (in contrast to "RAS plus SAS," see Procedure SA-6.6), the SAS Packing List (Attachment B-14) is used rather than a traffic report. SAS Packing Lists are provided by the SMO to each region through the RSCC, which provides forms as required. Use of the SAS form is further described in Procedure SA-6.6

5.1.12 Dioxin Shipment Record (DSR)

The Dioxin Shipment Record (DSR) provides a record for one shipment batch (up to 24 samples) of dioxin samples to a CLP laboratory. Samples are individually numbered using the pre-printed labels provided with the DSR (see Attachment B-15). DSRs are provided by the SMO to each region through the RSCC. DSRs must be used to track shipment of dioxin samples submitted for CLP analysis. See Procedure SA-6.6 for detailed description of the use of DSRs.

5.1.13 Sample Shipping Log

The sample shipping log, shown in Attachment B-16 is required by Region III EPA and is to be completed whenever samples are shipped to a CLP Laboratory. The sample shipping log is then submitted to the RSCC the week following sample collection.

5.2 GEOHYDROLOGICAL AND GEOTECHNICAL FORMS

5.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 should be filled out for each round of water level measurements at a site. These sheets are not controlled documents.

5.2.2 Data Sheet for Pumping Test (Pumping Well)

During the performance of a pumping test, a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance. This form is not a controlled document.

5.2.3 Data Sheet for Pumping Test (Observation Well) or In-Situ Hydraulic Conductivity Test

This data sheet (Attachment C-3) is similar to that described in Section 5.2.2. However, somewhat different data must be recorded for pumping test observation wells and in-situ hydraulic conductivity tests, as shown on this sheet. This form is not a controlled document.

5.2.4 Packer Test Reporting Forms

A packer test reporting form shown in Attachment C-4 is used for collecting data when conducting packer tests during monitoring well drilling. These sheets are not controlled documents.

5.2.5 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-5) is used for this purpose. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), the results are entered on the boring log at the appropriate depth. The boring log also provides space for entry of the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

The Summary Log of Boring is not a controlled document.

5.2.6 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter sand and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-6 through C-10). The Monitoring Well Construction Details Form is not a controlled document. Guidelines on completing this form are contained in GH-1.7.

5.2.7 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician. Test Pit Logs (Attachment C-11) are not controlled documents.

5.3 EQUIPMENT CALIBRATION AND MAINTENANCE FORMS

5.3.1 Equipment Calibration Log

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, other infrequent. Some are calibrated by the manufacturer, other by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D-1) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. This form is not a controlled document.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Technical Forms in Current Use for Remedial Investigations in the REM III Program (2 sheets)

Attachment B-1 - Sample Label
Attachment B-2 - Sample Identification Tag
Attachment B-3 - Chain-of-Custody Record From, Region III
Attachment B-4 - Chain-of-Custody Seal

Attachment B-5 - CLP Sample Bottle Repository Order Form
Attachment B-6 - Repository Packing List Form
Attachment B-7 - Groundwater Sample Log Sheet Form
Attachment B-8 - Soil Sample Log Sheet Form
Attachment B-9 - Surface Water Sample Log Sheet Form
Attachment B-10 - Container Sample Log Sheet Form
Attachment B-11 - Organics Traffic Report Form
Attachment B-12 - Inorganics Traffic Report Form
Attachment B-13 - Traffic Report Labels
Attachment B-14 - Special Analytical Services (SAS) Packing List
Attachment B-15 - Dioxin Shipment Record Form
Attachment B-16 - Sample Shipping Log
Attachment C-1 - Groundwater Level Measurement Sheet
Attachment C-2 - Pumping Test Data Sheet
Attachment C-3 - Hydraulic Conductivity Testing Data Sheet
Attachment C-4 - Packer Testing Report Form
Attachment C-5 - Summary Log of Boring
Attachment C-6 - Overburden Monitoring Well Construction Sheet
Attachment C-7 - Confining Layer Monitoring Well Construction Sheet
Attachment C-8 - Bedrock (Open Hole) Monitoring Well Construction Sheet
Attachment C-9 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-10 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-11 - Test Pit Log Form
Attachment D-1 - Equipment Calibration Log

ATTACHMENT A

TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

	Attachment Number	Form Usage Described in SOP No.	Controlled/ Required Document
B-1	Sample Label	SA-6.1	Required
B-2	Sample Identification Tag	SA-6.1	Controlled
B-3	Chain of Custody Record, Region III	SA-6.1	Controlled
B-4	Chain-of-Custody Seal	SA-6.6	Controlled
B-5	CLP Sample Bottle Repository Form	SA-6.6	Required
B-6	Repository Packing List Form	SA-6.6	Required
B-7	Groundwater Sample Log Sheet	SA-6.6	Required
B-8	Soil Sample Log Sheet	SA-6.6	Required
B-9	Surface Water Sample Log Sheet	SA-6.6	Required
B-10	Container Sample Log Sheet	SA-6.6	Required
B-11	Organics Traffic Report Form	SA-6.6	Controlled
B-12	Inorganics Traffic Report Form	SA-6.6	Controlled
B-13	Traffic Report Labels	SA-6.6	Controlled
B-14	Special Analytical Services (SAS) Packing Llist	SA-6.6	Required
B-15	Dioxin Shipment Record Form	SA-6.6	Required
B-16	Sample Shipping Log	SA-6.4	Required
C-1	Groundwater Level Measurement Sheet	GH-2.5	Required
C-2	Pumping Test Data Sheet	GH-2.3	Required
C-3	Hydaulic Conductivity Testing Data Sheet	GH-2.4	Required
C-4	Packer Testing Report Form	GH-2.2	Required
C-5	Summary Log of Boring	GH-1.5	Required
C-6	Overburden Monitoring Well Construction Sheet	GH-1.5	Required
C-7	Confining Layer Monitoring Well Construction Sheet	GH-1.5	Required

ATTACHMENT A
TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS
PAGE TWO

	Attachment Number	Form Usage Described in SOP No.	Controlled/ Required Document
C-8	Bedrock (Open Hole) Monitoring Well Construction Sheet	GH-1.5	Required
C-9	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
-10	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
	Test Pit Log	GH-1.8	Required
D-1	Equipment Calibration Log	----	Required

ATTACHMENT B-1

SAMPLE LABEL

NUS CORPORATION
LABORATORY SERVICES GROUP
5350 CAMPBELLS RUN ROAD
PITTSBURGH, PA 15205

NUS SAMPLE #

Client Name ____________________

Date Sampled ____________ Time ____________

Client Sample # ____________________

Sample Source ____________________

____

ATTACHMENT B-2

SAMPLE IDENTIFICATION TAG

☆ GPO 506-552

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Project Code	Station No.	Month/Day/Year	Time	Designate: Comp	Designate: Grab

Station Location

Samplers (Signatures)

Tag No.	Lab Sample No.
3 60966	

Preservative: Yes ☐ No ☐

ANALYSES

BOD Anions	
Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

DRAFT

ATTACHMENT B-3

CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

CHAIN OF CUSTODY RECORD

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

3-15966

PROJ. NO.	PROJECT NAME						
SAMPLERS: (Signature)						NO. OF CON-TAINERS	REMARKS
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION		

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

DRAFT

ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

Signature

Date

CUSTODY SEAL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CUSTODY SEAL

Date

Signature

ATTACHMENT B-5
CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND DELIVERY REQUEST

DRAFT

REQUEST NO. ______________________

Date of Request: ______________

Type of Request:
Routine [ ]
Fast Turnaround [ ] ______________________
Emergency [ ] ______________________
(Date/Time request called in)

From (Name): ______________________
Affiliation: ______________________
Telephone: ______________________
AR Signature: ______________________

TO: I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782/3095

Ship the following items for arrival by: ______________________ (Date)
(If applicable) Ship to arrive no earlier than: ______________________ (Date)

Item		Description	No. of Items Per Case	No. of Cases Requested
A	80-oz.	amber glass bottle	6	
B	40-ml	glass vial	72	
C	1-liter	polyethylene bottle	12	
D	120-ml	wide-mouth glass vial	12	
E	1-oz.	wide-mouth glass jar	12	
F	8-oz.	wide-mouth glass jar	12	
G	4-oz.	wide-mouth glass jar	12	
H	1-liter	amber glass bottle	12	
J	32-oz.	wide-mouth glass jar	12	
K	4-liter	amber glass bottle	4	
L	500-ml	polyethylene bottle	24	

Ship To: ______________________
(Provide ______________________
street address) ______________________
Attention: ______________________
Call before delivery: ______________________
(Phone No.): ______________________

DISTRIBUTION: *White-Repository* *Yellow-Requestor* *Pink-SMO*

ATTACHMENT 8-6

CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND PACKING LIST

REPOSITORY
I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782-3905

DELIVERY REQUEST NO. ______________
Request date: ______________

Type of Request: R ☐ FTA ☐ E ☐

Required Delivery Date: ______________

DESTINATION (from Delivery Request)
Name: ______________
Address: ______________
____
____
Telephone No: ______________

The materials listed below have been shipped as requested.
Date Shipped: ______________
Mode of Shipment: ______________
Shipment ID No: ______________
Signature: ______________

Type of Shipment: ___ Complete ___ Partial ___ Partial/Completes Request

Item No.	Description		No. of Cases Shipped	Lot Number(s)	QC Clearance Number(s)
A	80-oz	glass			
B	40-mL	glass			
C	1-L	poly			
D	120-mL	glass			
E	16-oz	glass			
F	8-oz	glass			
G	4-oz	glass			
H	1-L	glass			
J	32-oz	glass			
K	4-L	glass			
L	500-mL	poly			

—AUTHORIZED REQUESTOR USE ONLY—

Sign below and forward the yellow copy to the Sample Management Office (SMO) within 7 days of shipment receipt. Keep the pink copy for your file.

The above request was received by the designee, inspected, and accepted.

Date of Receipt: ______________ Requestor Signature: ______________

Send yellow copy to: USEPA Sample Management Office
P.O. Box 818
Alexandria, VA 22313

DISTRIBUTION: White—Shipment Designee; Blue—Shipping Contractor; Green—SMO; Yellow—Requestor (for return to SMO); Pink—Requestor; Gold—Repository

ATTACHMENT B-7

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other ____________

Page _____ of _____
Case # ____________
By ____________

Project Site Name ____________ Project Site Number ____________
NUS Source No. ____________ Source Location ____________

	Purge Data				
Total Well Depth:					
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					

	Sample Data			
Sample Date & Time:	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				

Signature(s):

Observations / Notes:

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B-8

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Page ____ of ____

Case # ____________

By ____________

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Lagoon / Pond
- ☐ Other ____________

Project Site Name ____________ Project Site Number ____________

NUS Source No. ____________ Source Location ____________

Sample Method:	Composite Sample Data		
	Sample	Time	Color / Description
Depth Sampled:			
Sample Date & Time:			
Sampled By:			
Signature(s):			

Type of Sample
- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Sample Data

Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)

Analysis:

Observations / Notes

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

DRAFT

ATTACHMENT B-9

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

- ☐ Spring
- ☐ Lake
- ☐ Stream
- ☐ Other ________

Page ____ of ____

Case # ________

By ________

Project Site Name ____________________ Project Site Number ____________

NUS Source No. ____________________ Source Location ____________

	Sample Data			
Sample Method:	pH	S.C.	Temp. (°C)	Color & Turbidity
Depth Sampled:				
Sample Date & Time:				
Sampled By:				
Signatures:				

Type of Sample

- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Analysis:	Preservative

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

ATTACHMENT B-10

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Container Data

Page _____ of _____

Case # __________

By __________

Project Site Name __________ Project Site Number __________

NUS Source No. __________ Source Location __________

Container Source	Container Description
☐ Drum ☐ Bung Top ☐ Lever Lock ☐ Bolted Ring ☐ Other ______ ☐ Bag / Sack ☐ Tank ☐ Other ______	Color ______ Condition ______ Markings ______ Vol. of Contents ______ Other ______

Disposition of Sample	Sample Description	Layer 1	Layer 2	Layer 3
☐ Container Sampled ☐ Container opened but not sampled. Reason ______ Container not opened. Reason ______	Phase	☐ Sol. ☐ Liq.	☐ Sol. ☐ Liq.	☐ Sol. ☐ Liq.
	Color			
	Viscosity	☐ L ☐ M ☐ H	☐ L ☐ M ☐ H	☐ L ☐ M ☐ H
	% of Total			
	Volume			
	Other			

	Type of Sample	
Monitor Reading:	☐ Low Concentration ☐ High Concentration	☐ Grab ☐ Composite ☐ Grab - Composite
Sample Method:		

		Organic	Inorganic
Sample Date & Time:	Traffic Report #		
Sampled By:	Tag #		
Signature(s):	AB #		
	Date Shipped		
Analysis:	Time Shipped		
	Lab		
	Volume		

ATTACHMENT B-11

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS-557-2490

CASE NO:

SAS NO:
(IF APPLICABLE)

ORGANIC TRAFFIC REPORT

(FOR CLP USE ONLY)

TYPE OF ACTIVITY (CIRCLE ONE) ①
SUPERFUND—PA SI ESI RIFS RD RA ER
NPLD O&M OTHER ______
NON-SUPERFUND—______________PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN: ______________

SAMPLING DATE: ④

BEGIN ________ END: ________

DATE SHIPPED: ______ CARRIER: ______ ⑤

AIRBILL NO: ______________

SAMPLE DESCRIPTION ⑥
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5 SEDIMENT
6. OIL (SAS)
7 WASTE (SAS)

TRIPLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	Ⓐ SAMPLE DESCRIPTION (FROM BOX 1) 1 2 3 4 5 6 7	Ⓑ CONCENTRATION L = LOW M = MED H = HIGH (SAS)	Ⓒ RAS ANALYSIS: VOLATILE	BASE/NEUT /ACID	PESTICIDE /PCB		Ⓓ SPECIAL HANDLING	Ⓔ STATION LOCATION

EPA Form 2075-7 (6-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-12

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS-557-2490

CASE NO:

SAS NO:
(IF APPLICABLE)

INORGANIC TRAFFIC REPORT
(FOR CLP USE ONLY)

① TYPE OF ACTIVITY (CIRCLE ONE)
SUPERFUND—PA SI ESI RIFS RD RA ER NPLD O&M OTHER ______
NON-SUPERFUND—__________PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID:

② REGION NO: SAMPLING COMPANY

SAMPLER (NAME)

③ SHIP TO:

ATTN:

④ SAMPLING DATE:
BEGIN: ________ END: ________

⑤ DATE SHIPPED: ______ CARRIER: ______
AIRBILL NO:

⑥ SAMPLE DESCRIPTION
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5. SEDIMENT
6. OIL (SAS)
7. WASTE (SAS)

DOUBLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	Ⓐ SAMPLE DESCRIPTION (FROM BOX 1) 1 2 3 4 5 6 7	Ⓑ CONCENTRATION L = LOW M = MED H = HIGH (SAS)	Ⓒ RAS ANALYSIS: TOTAL METALS	CYANIDE	DISSOLVED METALS	HIGH ONLY (SAS): SULFIDE	pH	CONDUCTIVITY	OXIDANTS	Ⓓ SPECIAL HANDLING	Ⓔ STATION LOCATION

EPA Form 2075-6 (8-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-13

TRAFFIC REPORT LABELS

MAB 342

: 6003

AC 865 · Soil/Sediment (VOA)

ATTACHMENT B-14

U.S. ENVIRONMENTAL PROTECTION AGENCY
CLP Sample Management Office
P.O. Box 818 - Alexandria, Virginia 22313
Phone: 703/557-2490 - FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICE
PACKING LIST

Sampling Office:	Sampling Date(s):	Ship To:	For Lab Use Only
Sampling Contact: (name) (phone)	Date Shipped: Site Name/Code:	Attn:	Date Samples Rec'd: Received By:

Sample Numbers	Sample Description i.e., Analysis, Matrix, Concentration	Sample Condition on Receipt at Lab
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

For Lab Use Only

White - SMO Copy, Yellow - Region Copy, Pink - Lab Copy for return to SMO, Gold - Lab Copy

DRAFT

ATTACHMENT B-15

USEPA Contract Laboratory Program
Sample Management Office
P.O. Box 818 Alexandria, Virginia 22313
FTS 8-557-2490 703-557-2490

CASE NO:	BATCH NO:

CLP DIOXIN SHIPMENT RECORD

Site Name	Sampling Office	Ship To	FOR LAB USE ONLY Date Samples Rec'd
City & State	City & State	Date Shipped	Received By
EPA Site No	Sampling Contact (name)	Transfer To	Date Samples Rec'd
Latitude	Sampling Date		
Longitude	Date Turnaround 15-Day ____ 30-Day ____	Date Shipped	Received By
Tier 1 2 3 4 5 6 7 (circle one)			

SAMPLE NUMBERS	MATRIX: SOIL SEDIMENT	MATRIX: OTHER	DESCRIPTION: FIELD SAMPLE	DESCRIPTION: SAMPLE TO DUPLICATE	DESCRIPTION: SAMPLE TO SPIKE	DESCRIPTION: BLANK	DESCRIPTION: EQUIPMENT RINSATE	DESCRIPTION: OTHER (SAS ONLY)	ADD'L ANALYSIS: SPECIFY (SAS ONLY)	FOR LAB USE: SAMPLE CONDITION ON RECEIPT

WHITE [illegible] YELLOW Region Copy PINK Lab Copy for Return to SMO GOLD Lab Copy

ATTACHMENT B-16

page___ of ___ EPA SAMPLE SHIPPING LOG FOR ALL SAMPLES SENT THROUGH THE CONTRACT LAB PROGRAM (12/85 version)

CASE#_________ SAS#_________ SITE NAME:______________________________

Site Leader:_____________________ EPA Project Officer:____________________
Phone:

SAS REQUEST: (details required)

QC SAMPLE INFO AND/OR COMMENTS	CONC. (low/med/high)	SAMPLE PHASE (aq/sol)	TYPE OF REQUEST org, dio inor, SAS	SAMPLE TRAFFIC REPORT NUMBER	ORGANICS OR INORGANICS LAB NAME	DATE SHIPPED	DATA RECEIVED XX out items not requested VOA	BNA	PEST	TCDD	METALS	CN	LAB NAME	SAS REQUEST (itemize)	DATE SHIPPED	DATA REC'D