CLEAN

Contract No. N62474-88-D-5086

Contract Task Order No. 0283

Navy Engineer-in-Charge: Ronald Yee

PRC Project Manager: Barbara Sootkoos

NAVAL WEAPONS STATION
CONCORD, CALIFORNIA

SOLID WASTE MANAGEMENT UNIT
SITE INVESTIGATION

DRAFT FINAL FIELD SAMPLING PLAN
STANDARD OPERATING PROCEDURES - APPENDIX B

VOLUME II

Prepared By:

PRC ENVIRONMENTAL MANAGEMENT, INC.
135 Main Street, Suite 1800
San Francisco, California 94105
415/543-4880

December 5, 1994

CONTENTS

1.0 INTRODUCTION

This appendix contains 19 standard operating procedures (SOP). Nine SOPs are referenced within these SOPs which are utilized during the site investigation (SI). Four of the nine SOPs (16, 17, 18, and 19) are addressed in the quality assurance project plan (QAPjP). Three of the nine SOPs (8, 46, and 47) will not be used during the SI. Two of the nine SOPs (27 and 28) will not be added since SOP 26 sufficiently addresses soil sample classification.

2.0 SOIL INVESTIGATIONS

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

SAMPLING SOIL AT HAZARDOUS WASTE SITES

SOP NO. 005

REVISION NO. 2

Approved by:

Daniel Ashenberg — 2/2/93

Quality Assurance Officer — Date

Title: **Sampling Soil at Hazardous Waste Sites**

1.0 BACKGROUND

Soil is sampled for three main reasons. First, samples can be obtained for laboratory chemical analysis; second, samples can be obtained for laboratory physical analysis; and finally, samples can be obtained for visual classification and field screening. These three sampling objectives can be achieved separately or in combination. Sampling locations are typically chosen to provide chemical, physical, or visual information in both the horizontal and vertical directions. A sampling and analysis plan is used to outline sampling methods and to provide a preliminary rationale for choosing sampling locations. Sampling locations may be adjusted in the field based on the screening methods being used and the physical features of the area.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish the requirements and procedures for sampling soil at hazardous waste sites.

1.2 SCOPE

This SOP applies to sampling soil using various types of sampling instruments. It also applies to procedures used for test pit, surface, and subsurface soil sampling.

1.3 DEFINITIONS

Bucket augers -- Bucket augers are generally made up of two cutting blades attached to a 3- to 4-inch-diameter core that is 4 to 6 inches long. The bucket is attached to a hard metal shaft generally 4 to 5 feet in length with a perpendicular handle attached for rotating the bucket.

Core samplers -- Core samplers are cylindrical metal implements with diameters of 1/2 inch to 3 inches.

Hand augers -- Hand augers are made up of sharpened, spiral blades attached to a hardened-metal central shaft. The diameters of hand augers are generally in the range of 1 to 1-1/2 inches. They are used to core to depths of 15 feet.

Soil -- Soil is unconsolidated earthen material above bedrock that is not covered by standing water.

Split-spoon sampler -- Split-spoon (or split-barrel) samplers are devices used to obtain subsurface soil samples up to 2.5 feet in length from hollow-stem auger flights, cased borings, and mud holes.

Thin-wall tube samplers -- Thin-wall tube samplers are hollow pipes that are pressed or driven into soil without rotation to obtain core samples of relatively undisturbed soils. Thin-wall tube samplers generally have an inside diameter of 1.875 millimeters, an outside diameter of 2 millimeters, and are 2 to 3 feet long; they are also available in other sizes convenient for sampling. The thin-wall tube sampler has a sharp cutting edge and a positive inside clearance. Thin-wall tubes may be made of metal or acrylic.

Triers -- Triers are tubes cut in half lengthwise; they have sharpened tips that allow the sampler to cut into sticky solids or to loosen soil.

Trowels -- Trowels are implements consisting of scooped blades 4 to 8 inches long and 2 to 3 inches wide attached to handles.

1.4 REFERENCES

Barth, D.S., and B.J. Mason, 1984, Soil Sampling Quality Assurance Users Guide, EPA 600/4-84-043.

DeVara, E.R., and others, 1980, Sampler and Sampling Procedures for Hazardous Waste Streams, EPA 600/2-80-018.

Mason, B.J., 1983, Preparation of Soil Sampling Protocol: Techniques and Strategies, EPA 600/4-83-020.

National Enforcement Investigation Center (NEIC), Manual for Groundwater/Subsurface Investigations at Hazardous Waste Sites.

U.S. Environmental Protection Agency (EPA), 1987, A Compendium of Superfund Field Operations Methods: Volume I.

1.5 REQUIREMENTS AND RESOURCES

Soil sampling requires that one or more of the following types of equipment be used:

Sampling Equipment	Other Required Equipment
Spoons and spatulas	Sample containers and paperwork
Trowel	Logbook
Shovel or spade	Tape for measuring recovery
Trier	Unified Soil Classification System information
Core sampler	Wax for thin-wall tube sampler
Hand auger	Decontamination equipment
Bucket auger	Drilling equipment
Split-spoon sampler	Backhoe
Thin-wall tube sampler	Health and safety equipment
Plastic sheeting	

2.0 PROCEDURES

Three general categories of soil sampling are conducted: test pit, surface soil, and subsurface soil sampling. This SOP presents procedures to be used for these types of sampling. The site sampling plan will specify which of the following procedures will be used. Sampling equipment must be decontaminated before and after collection of each sample in accordance with SOP No. 002, General Equipment Decontamination.

Soil samples for chemical analysis should be collected in the following order: (1) volatile organics, (2) semivolatile organics, and (3) metals. Samples for chemical analysis should be placed in containers before samples for physical analyses. Typical physical analyses include (1) grain size distribution, (2) moisture content, (3) saturated permeability, (4) unsaturated permeability, and (5) Atterberg limits. Visual descriptions of soil samples should also be provided based on the Unified Soil Classification System (USCS) (see SOP No. 028, Visual Classification of Soils). Field tests such as moisture and head space analyses can also be conducted.

Soil samples for chemical analyses can be collected either as grab samples or as composite samples. A grab sample is collected from a discrete location or depth. A composite sample consists of soil combined from more than one discrete location. Typically, composite samples consist of soil obtained from several locations and homogenized in a stainless steel or Teflon pan or tray. Samples for volatile organic analysis (VOA) should not be composited.

2.1 TEST PIT SOIL SAMPLING

Test pit soil is sampled when a complete soil profile is required or as a means of locating visually detectable contamination. This type of sampling provides a detailed description of the soil profile and allows for multiple samples to be collected from specific soil horizons. Test pit sampling procedures are described below.

All sampling tools should be cleaned before and after each use in accordance with SOP No. 002, General Equipment Decontamination. Before sampling, all sampling equipment should be placed on clean plastic sheets in a clean area near the sampling location.

Excavate a test pit or trench by incrementally removing soil material with a bucket. Place excavated soil well away from the edge of the test pit. Do not excavate a test pit to depths greater than 4 feet unless its walls are properly stabilized.

Personnel entering the test pit may be exposed to toxic or explosive gases and oxygen-deficient environments. In these cases, substantial air monitoring is required before entering, and appropriate respiratory gear and protective clothing is mandatory. At least two persons must be present at the immediate site before a sampler may enter the test pit.

Test pits are not practical where a sampling depth of more than 15 feet is desired. If soil samples are required from greater than 15 feet below ground surface, obtain samples through test borings instead of test pits. Test pits are also usually limited to a few feet below the water table. In some cases, a pumping system may be required to control the water level within the pits.

Restrict access to open test pits with flags, tape, or fencing. If a fence is used, erect it at least 6 feet from the perimeter of the test pit. Backfill the test pit as soon as possible after sampling.

Soil samples can be collected from the walls or bottom of a test pit using various equipment. Use a hand auger, bucket auger, or core sampler to obtain samples from various depths. Use a trier, trowel, or spoon to obtain samples from the walls or pit bottom surface.

2.2 SURFACE SOIL SAMPLING

The surface soil sampling techniques presented in this SOP are best suited for sampling depths up to of 3 to 5 feet below ground surface. Sample depth, intended analyses, soil type, and soil moisture will dictate the technique most suitable for sample collection. The following list includes various types of surface soil sampling equipment and uses.

Sampling Method	Effective Depth Range (ft)	Operating Mechanism	Sample Type	Analysis
Hand auger	0-6	Hand operated	Disturbed	Physical, chemical, and visual
Bucket auger	0-4	Power operated	Disturbed	Physical, chemical, and visual
Core sampler	0-4	Hand or power operated	Undisturbed	Physical, chemical, and visual
Shovel	0-6	Hand operated	Disturbed	Physical, chemical, and visual
Trier	0-1	Hand operated	Disturbed	Physical, chemical, and visual
Trowel	0-1	Hand operated	Disturbed	Physical, chemical, and visual
Spoon or Spatula	0-0.5	Hand operated	Disturbed	Physical, chemical, and visual

All sampling tools should be cleaned before and after each use in accordance with SOP No. 002, General Equipment Decontamination. Before sampling, all sampling equipment should be placed on clean plastic sheets in a clean area near the sampling location.

Procedures for using various types of sampling equipment are discussed below.

Hand Auger

Use a hand auger to obtain samples at depths up to 6 feet. If necessary, use a shovel to excavate surface soil to the desired sampling depth. Record the thickness of the excavated surface soil. A hand auger collects disturbed soil samples, often making the exact sampling depth difficult to determine.

Screw the hand auger into the soil at an angle of 45 to 90 degrees from horizontal. When the entire auger blade has penetrated soil, pull the auger from the medium. Remove the auger by lifting it straight up, without turning it, if possible. Use force to remove the sample from the auger. Place the sample in an appropriate container (see SOP No. 017, Sample Collection Container Requirements).

Bucket Auger

Use a bucket auger to obtain disturbed samples at depths up to 4 feet. Use a bucket auger in stony or dense materials that prohibit the use of a hand-operated core or screw auger. Use a bucket auger with closed blades in materials that cannot generally be penetrated or retrieved by a core sampler.

Rotate the bucket auger while applying downward pressure until the bucket is full. Remove the bucket from the boring and transfer the sample to an appropriate container (see SOP No. 017, Sample Collection Container Requirements). Repeat this procedure until the appropriate sampling depth is attained.

Core Sampler

Use a hand-operated core sampler (Figure 1) to obtain samples at depths up to 4 feet in noncompacted materials. The core itself is generally 12 to 18 inches long; use extension rods to obtain cores greater than 1 foot in length. Use a stainless steel core sampler to retrieve undisturbed samples of low concentrations of metals or organics. A polypropylene core sampler is generally not suitable for sampling dense soils or sampling at an appreciable depth.

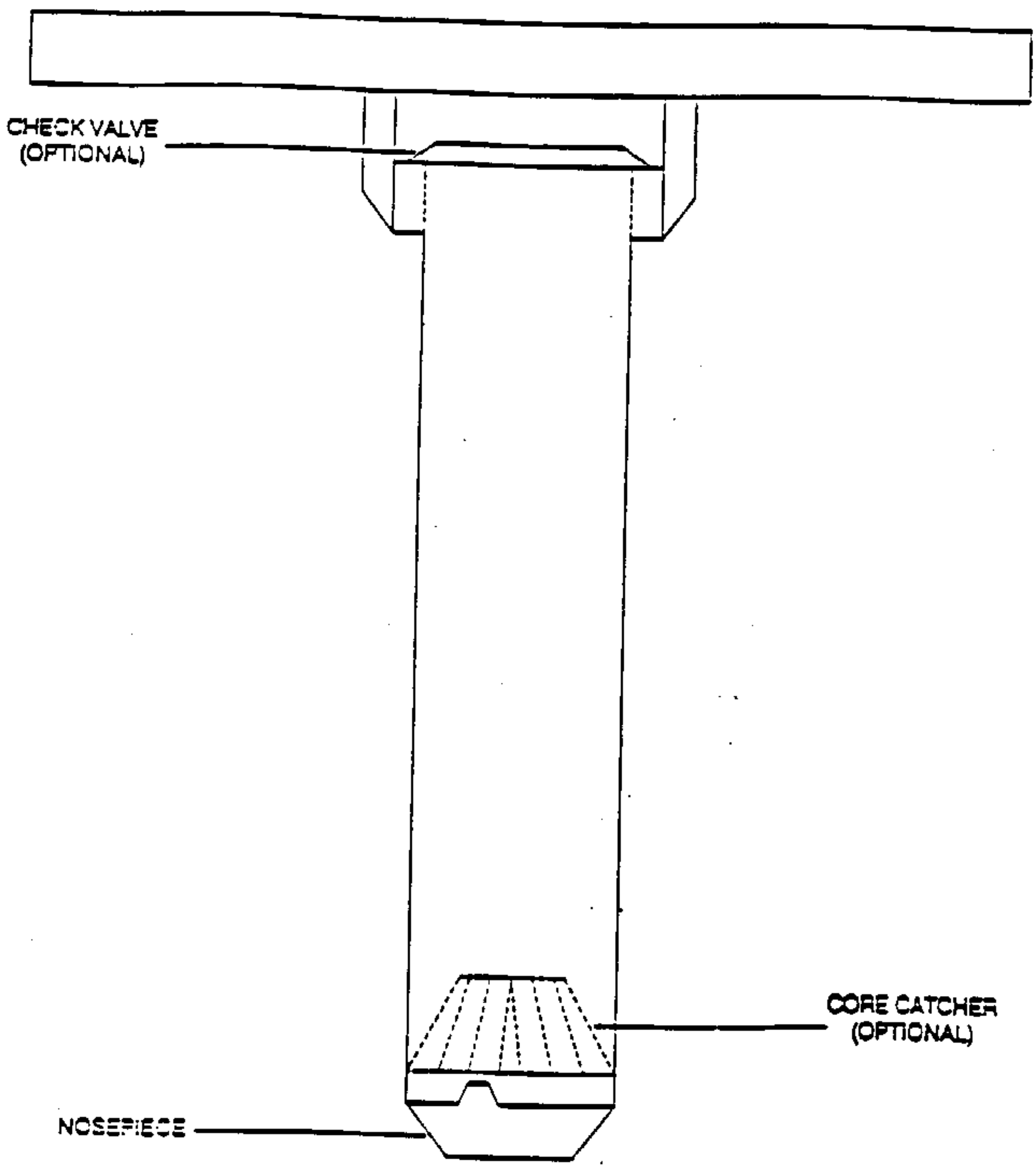
Press the core sampler into the soil at an angle of 45 to 60 degrees from horizontal. When the desired sampling depth is reached, rotate the core sampler. Remove the core and place the sample in an appropriate container (see SOP No. 017, Sample Collection Container Requirements).

Shovel

Use a shovel to obtain large quantities of materials from depths up to 6 feet. A tiling spade (sharpshooter) is recommended for hand excavation and sampling. Use a standard steel shovel for excavation; use either a stainless steel or polypropylene shovel for sampling. When an adequate

FIGURE 1

HAND-OPERATED CORE SAMPLER



sample has been obtained, place the sample material in an appropriate container. Refer to the project quality assurance project plan for sample collection container requirements.

Trier

Use a trier (Figure 2) to obtain samples from depths up to 1 foot. Use a stainless steel or polypropylene trier. A chrome-plated steel trier may be used if samples are to be analyzed for organics and heavy metal content is not a concern.

Obtain samples by inserting the trier into soil at an angle of up to 45 degrees from horizontal. Rotate the trier to cut a core and then pull the trier the material being sampled. Remove the core from the trier and transfer the sampled material to an appropriate sample container. Refer to the project quality assurance project plan for sample collection container requirements.

Trowel

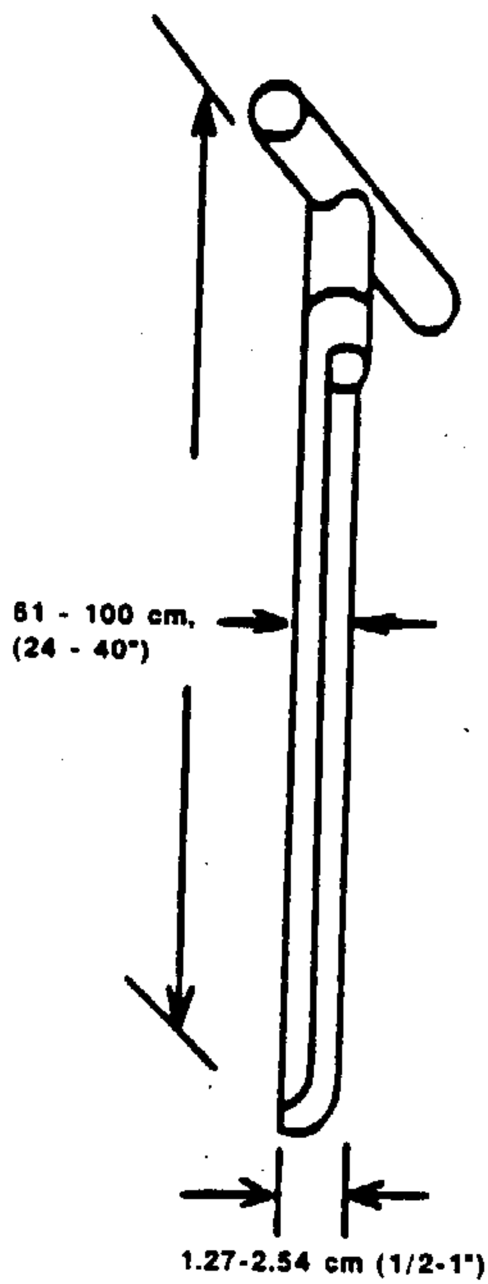
Use a trowel to obtain surface soil samples that do not require more than 1 foot of excavation. A trowel may also be used to collect subsoil samples from profiles exposed in test pits (see Section 2.1). Use of a trowel to obtain sample volumes of 1 pint or less. A trowel should be made of stainless steel and may be purchased from a hardware or garden store. Use a stainless steel trowel to obtain samples to be analyzed for organic content. Transfer sampled material from the trowel to an appropriate sample container. Refer to the project quality assurance project plan for sample collection container requirements.

Spoon or Spatula

Use a spoon or spatula to obtain samples from depths of less than one-half foot. Spoons or spatulas should not be used if excavation is required prior to sampling. Use a stainless steel spoon or spatula to obtain samples to be analyzed for organic content. Transfer sampled material from the

FIGURE 2

TRIER



spoon or spatula to an appropriate sample container (see SOP No. 017, Sample Collection Container Requirements).

2.3 SUBSURFACE SOIL SAMPLING

Subsurface soil sampling, in conjunction with borehole drilling, is required for soil sampling from depths greater than about 5 feet. Subsurface soil sampling is frequently coupled with exploratory boreholes or monitoring well installation (see SOP No. 045, Hollow Stem Auger Drilling; SOP No. 046, Cable Tool Drilling; SOP No. 047, Direct Rotary Drilling; and SOP No. 020, Well Installation).

Subsurface soils may be sampled using a drilling rig or power auger. Selection of sampling equipment depends on geologic conditions and the scope of the sampling program. The types of samplers used with machine-driven augers are discussed below. All sampling tools should be cleaned before and after each use in accordance with SOP No. 002, General Equipment Decontamination. Before sampling, all sampling equipment should be placed on clean plastic sheets in a clean area near the sampling location. The table below illustrates various subsurface soil sampling equipment and uses.

Sampling Method	Geologic Condition	Sample Type	Analysis
Split spoon	Unconsolidated material	Undisturbed	Physical, chemical, and visual
Thin-wall tube	Unconsolidated material	Undisturbed	Physical

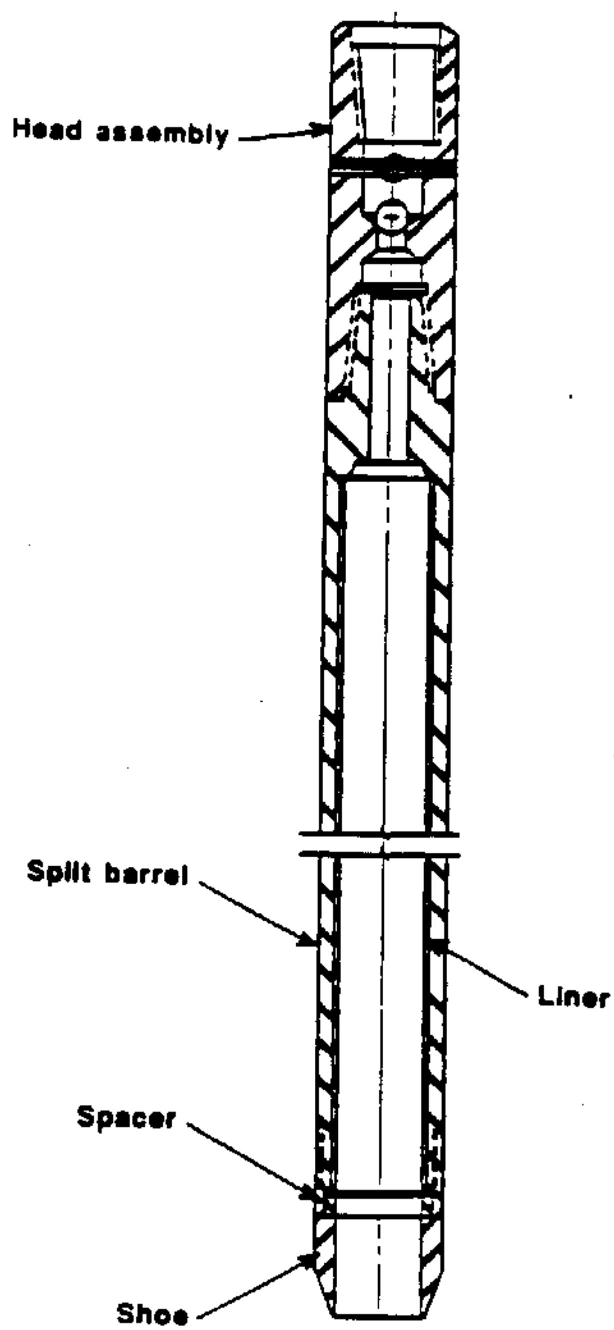
The procedures for using split-spoon sampling equipment are presented below.

<u>Split-Spoon Sampler</u>

Split-spoon samplers (Figure 3) are available in a variety of types and sizes. Site conditions and project needs determine the split-spoon sampler to be used.

FIGURE 3

GENERIC SPLIT-SPOON SAMPLER



Advance the split-spoon sampler into the undisturbed material beneath the bottom of the well casing or borehole using a weighted hammer and a drill rod. The relationship between hammer weight, hammer drop, and number of blows required to advance the split-spoon sampler in 6-inch increments indicates the density or consistency of subsurface soil. After the split-spoon sampler has been driven to its intended depth, remove it carefully to avoid loss of sample material. In noncohesive or saturated soils, a catcher or basket should be used to help retain the sample.

After removing the split-spoon sampler from the casing, detach it from the drill rod. Open the split-spoon sampler lengthwise to expose the sampled material. If samples are to be analyzed for volatile organics, brass sleeves should be used to avoid losses from transferring into containers. Obtain samples for other specific analyses after obtaining samples for volatile organic analysis (VOA). Use the remainder of the material in the split-spoon sampler to visually classify of the sample and place it in an appropriate container for physical analysis. Refer to the project quality assurrance plan for sample collection container requirements. Retain the entire sample for analysis or disposal (except for the top several inches of possibly disturbed material).

Thin-Wall Tube Sampler

A thin-wall tube sampler (sometimes called a Shelby tube) may be pressed or driven into soil inside a hollow-stem auger flight, wash bore casing, or uncased borehole. Press the tube sampler into the soil to the desired depth or until refusal. If the tube cannot be advanced by pushing, it may be necessary to drive it into the soil using a hammer and drill rod. Do not rotate the thin-wall sampler while pressing or driving it into the soil. When the desired sampling depth is reached, rotate the tube sampler to collect the soil from the borehole.

After removing the tube sampler from the drilling equipment, inspect the sampler for adequate sample recovery. Repeat the sampling procedure until an adequate soil core is obtained. Document the soil core in the logbook. Remove any disturbed soil from each end of the tube sampler. If chemical analysis is required, a split spoon sampler will be driven immediately below where the tube sampler was driven. Samples will not be collected by scraping soil from the ends of the tube. Before use and during storage and transport, the tube sampler should be capped with a nonreactive material. For physical sampling parameters, the tube sampler should be sealed by pouring three 0.25-inch layers of liquid wax in each end. Allow each layer of wax to solidify before applying the next. Fill the remaining space at each end of the cylinder with Ottawa sand or other similar sand. Allow the sand to settle and compact. Tape plastic caps over the ends of the cylinder to seal the tube. Label the top and bottom of the tube sampler and store as appropriate (see SOP No. 016, Sample Preservation and Maximum Holding Times).

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

SAMPLING SLUDGE AND SEDIMENT

SOP NO. 006

REVISION NO. 3

Approved by:

Patricia Horner
Quality Assurance Officer

5/8/93
Date

1.0 BACKGROUND

Sludges are semisolid materials ranging from dewatered solids to high-viscosity liquids. Sludges generally accumulate as residuals of water-bearing waste treatment or industrial process systems. Sludges typically accumulate in tanks, drums, impoundments, or other types of industrial containment systems.

Sediments generally are materials deposited in surface impoundments or in natural waterways such as lakes, streams, and rivers.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for sampling sludge and sediment.

1.2 SCOPE

This SOP applies to collection of sludge and sediment samples. It provides detailed procedures for gathering such samples with specific instruments.

1.3 DEFINITIONS

Gravity Corer: A metal tube with a replaceable, tapered nosepiece on the bottom and a check valve on the top

Phleger: A type of gravity corer

Ponar Grab Sampler: A clamshell scoop activated using a counter-lever system

1.4 REFERENCES

American Public Health Association. 1975. *Standard Methods for the Examination of Water and Wastewater*. 14th Edition. Washington DC.

U.S. Environmental Protection Agency. 1984. *Characterization of Hazardous Waste Sites -- A Methods Manual: Volume II -- Available Sampling Methods*. Second Edition. EPA-800 December.

1.5 REQUIREMENTS AND RESOURCES

The following equipment may be required to sample sludge or sediment:

- Plastic sheeting
- Field logbook
- Stainless-steel scoop or trowel
- Glass tubes
- Gravity corers
- Ponar grab sampler
- Stainless-steel or Teflon® tray
- Peristaltic pump
- Hand corer
- Nylon rope
- Sample containers and labels
- Chain-of-custody and shipping materials
- Decontamination materials

2.0 PROCEDURES FOR SLUDGE AND SEDIMENT SAMPLING

This section provides general procedures for sampling sludge and sediment. Sections 2.1 through 2.5 specify the methods and implements to be used for such sampling.

Sampling Sludge

Sludge can often be sampled using a stainless-steel scoop or trowel (see Section 2.1). Frequently sludge forms when components with higher densities settle out of a liquid. When this happens, the sludge may still have an upper liquid layer above the denser components. When the liquid layer is sufficiently shallow, the sludge may be sampled using a pond sampler (see SOP No. 009, "Sampling Surface Water") or a hand corer (see Section 2.2). Use of the hand corer is preferred because it results in less sample disturbance. The hand corer also allows for the collection of an aliquot of the overlying liquid. This prevents drying or excessive oxidation of a sample before analysis. Sludge that develops in 55-gallon drums can be collected using glass tubes provided for liquid sampling (see SOP No. 008, "Sampling Containerized Liquids"). The hand corer may be adapted to hold a brass, polycarbonate plastic, or Teflon® liner.

If a containerized sludge layer is shallow (less than 30 centimeters), hand corer penetration may damage the container liner or bottom. In this case, a Ponar grab sampler may be used because it is generally capable of penetrating only a few centimeters (see Section 2.4). Additionally, a gravity corer may be used to collect samples of most sludges and sediments (see Section 2.3). A gravity corer is capable of collecting an undisturbed sample that profiles the strata present in a sludge or sediment. Depending on the weight of the gravity corer and the density of the substrate, a gravity corer may penetrate up to 75 centimeters.

Sampling Sediment

Sediment can be sampled in much the same manner as sludge; however, a number of additional factors must be considered. In streams, lakes, and impoundments, for instance, sediment is likely to demonstrate significant variations in composition.

For stream sediment sampling, the sampling location farthest downstream should be sampled first. Sediment samples collected in upstream and downstream locations should be obtained in similar depositional environments and, whenever possible, should be obtained from slow-moving pools. In addition, a sediment sample should be collected at approximately the same location as an associated aqueous sample. Aqueous samples should be obtained first to avoid collecting suspended particles that may result from sediment sampling. To avoid disturbing an area to be sampled, sampling locations in streams should always be approached from the downstream side.

Sediment samples collected from lakes and impoundments should also be collected at approximately the same locations as associated aqueous samples. As in stream sampling, aqueous samples should be collected first to avoid collecting suspended particles that may result from sediment sampling. Downgradient and background samples should be collected from similar depositional environments.

Exact sampling locations should be documented using triangulation with stable references on the banks of a stream or lake. In addition, the presence of rocks, debris, or organic material may complicate sampling and may preclude use or require modification of sampling implements. Sediment sampling should be conducted in a manner that reflects these and other variants.

The following subsections specify methods for sludge or sediment sampling with specific implements.

2.1 SLUDGE OR SEDIMENT SAMPLING WITH A SCOOP OR TROWEL

Sludge or sediment samples may be collected with a simple laboratory scoop or garden trowel. This method is more applicable to sludge but can also be used for sediments, provided that the water is very shallow (a few centimeters). However, using a scoop or trowel may disrupt the water-sediment interface and cause substantial sample alteration. This method provides a simple, quick means of collecting a disturbed sample of sludge or sediment.

All sampling equipment should be made of inert and nonreactive materials. Nondisposable equipment should be cleaned before and after each use (see SOP No. 002, "Equipment Decontamination").

The following is the procedure for sampling sludge or sediment with a scoop or trowel:

1. Place all sampling equipment on plastic sheeting next to the sampling location.

2. Affix a completed sample container label to an appropriate sample container (see SOP No. 017, "Sample Collection Container Requirements").

3. Sketch the sampling area or note recognizable features in the field logbook for future reference. Measure and record the distance from the sampling location to fixed structures.

4. Insert a scoop or trowel into the material, and remove the sample. In the case of sludge exposed to air, remove the first 1 to 2 centimeters of material before collecting the sample.

5. When compositing a series of grab samples, use a stainless-steel bowl or Teflon® tray for mixing.

6. Place the sample in the labeled sample container using a stainless-steel laboratory spoon or the equivalent.

7. If required, ensure that a Teflon® liner is present in the sample container cap. Secure the cap tightly. Preserve samples in accordance with SOP No. 16, "Sample Preservation and Maximum Holding Times."

8. Complete all chain-of-custody documents (see SOP No. 018, "Sample Custody"), the field logbook entry, and all sample packaging requirements (see SOP No. 019, "Packaging and Shipping Samples").

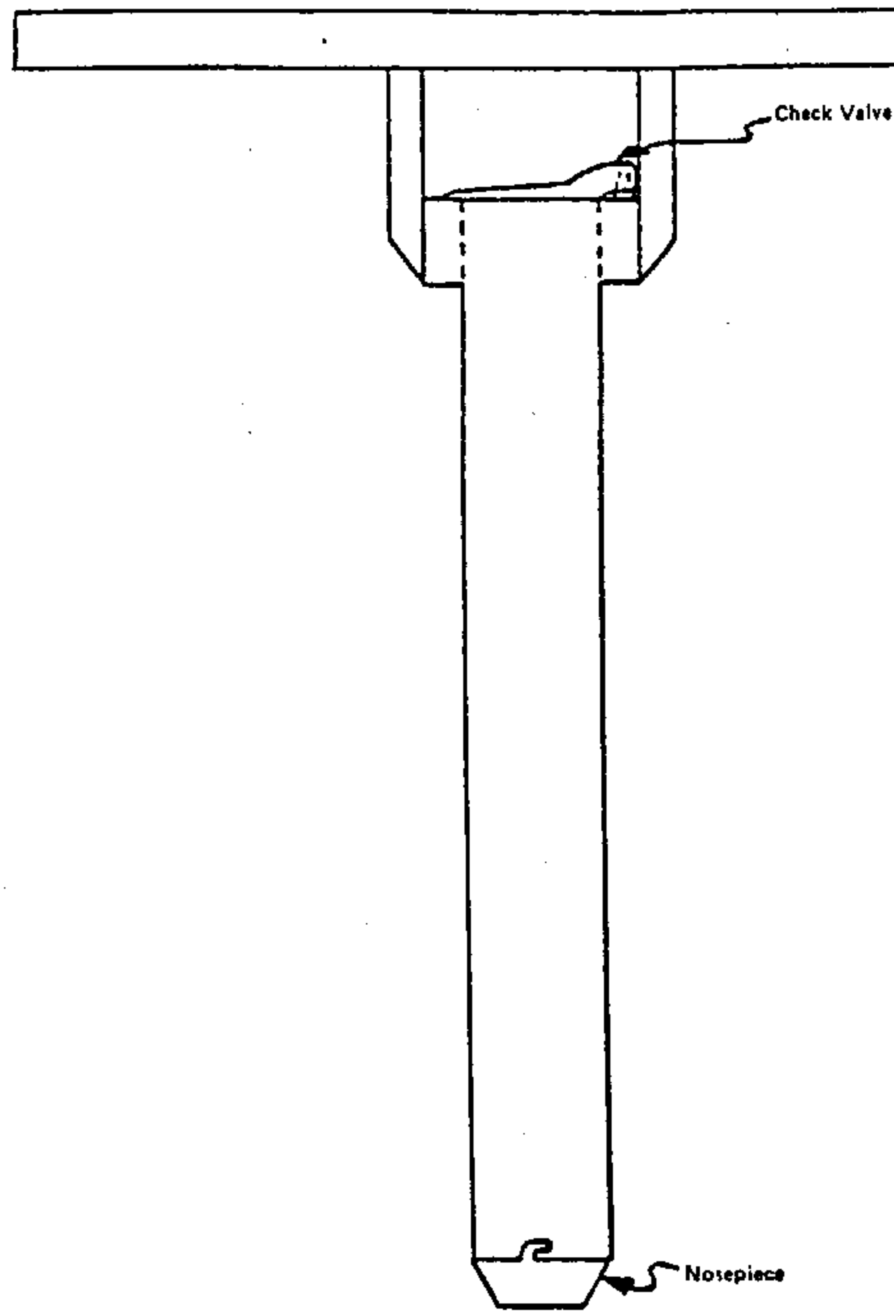
9. Decontaminate all sampling equipment before and after use and between sampling locations in accordance with SOP No. 002, "Equipment Decontamination."

2.2 SLUDGE OR SEDIMENT SAMPLING WITH A HAND CORER

A hand corer is a thin-walled corer with two additions (see Figure 1): a handle to facilitate driving the implement and a check valve on top to prevent washout when retrieving a sample through an overlying water layer.

FIGURE 1

HAND CORER



The hand corer is applicable in the same situations and to the same materials as those described for use of a scoop or trowel in Section 2.1. However, the hand corer may be used to collect an undisturbed sample that can profile any stratification resulting from changes in deposition.

Some hand corers can be fitted with extension handles that allow collection of samples underlying a shallow layer of liquid. Most hand corers can be adapted to hold liners, which are generally available in brass, polycarbonate plastic, or Teflon. A liner material should be chosen that will not compromise intended analytical procedures.

All sampling equipment should be made of inert and nonreactive materials. Nondisposable equipment should be cleaned before and after each use. Liners must require decontamination prior to use. Equipment should be decontaminated in accordance with SOP No. 002, "Equipment Decontamination."

The following is the procedure for sampling sludge or sediment with a hand corer:

1) Place all sampling equipment on plastic sheeting next to the sampling location.

2) Affix a completed sample container label to an appropriate sample container. Refer to the QAjP for sample collection container requirements.

3) Sketch the sampling area or note recognizable features in the field logbook for future reference. Measure and record the distance from the sampling location to fixed structures.

4) Force the hand corer into the material using a smooth, continuous motion.

5) Twist the hand corer and withdraw it in a single, smooth motion.

6) Remove the nosepiece, and withdraw the sample. Place the sample on a clean stainless steel or Teflon tray.

7) Transfer the sample into the labeled sample container using a stainless steel laboratory spoon or the equivalent.

8. If required, ensure that a Teflon liner is present in the sample container cap. Secure the cap tightly. Preserve the sample in accordance with SOP No. 016, "Sample Preservation and Maximum Holding Time."

9. Complete all chain-of-custody documents (see SOP No. 018, "Sample Custody"), the field logbook entry, and all sample packaging requirements (see SOP No. 019, "Packaging and Shipping Samples").

10. Decontaminate all sampling equipment before and after use and between sampling locations in accordance with SOP No. 002, "Equipment Decontamination."

2.2 BOTTOM SLUDGE OR SEDIMENT SAMPLING WITH A GRAVITY CORER

A gravity corer is a metal tube with a replaceable, tapered nosepiece on the bottom and a ball valve or other type of check valve on the top (see Figure 2). The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. The check valve allows water to pass through the sample. Most gravity corers are made of brass or steel. Many can accept plastic liners and additional weights.

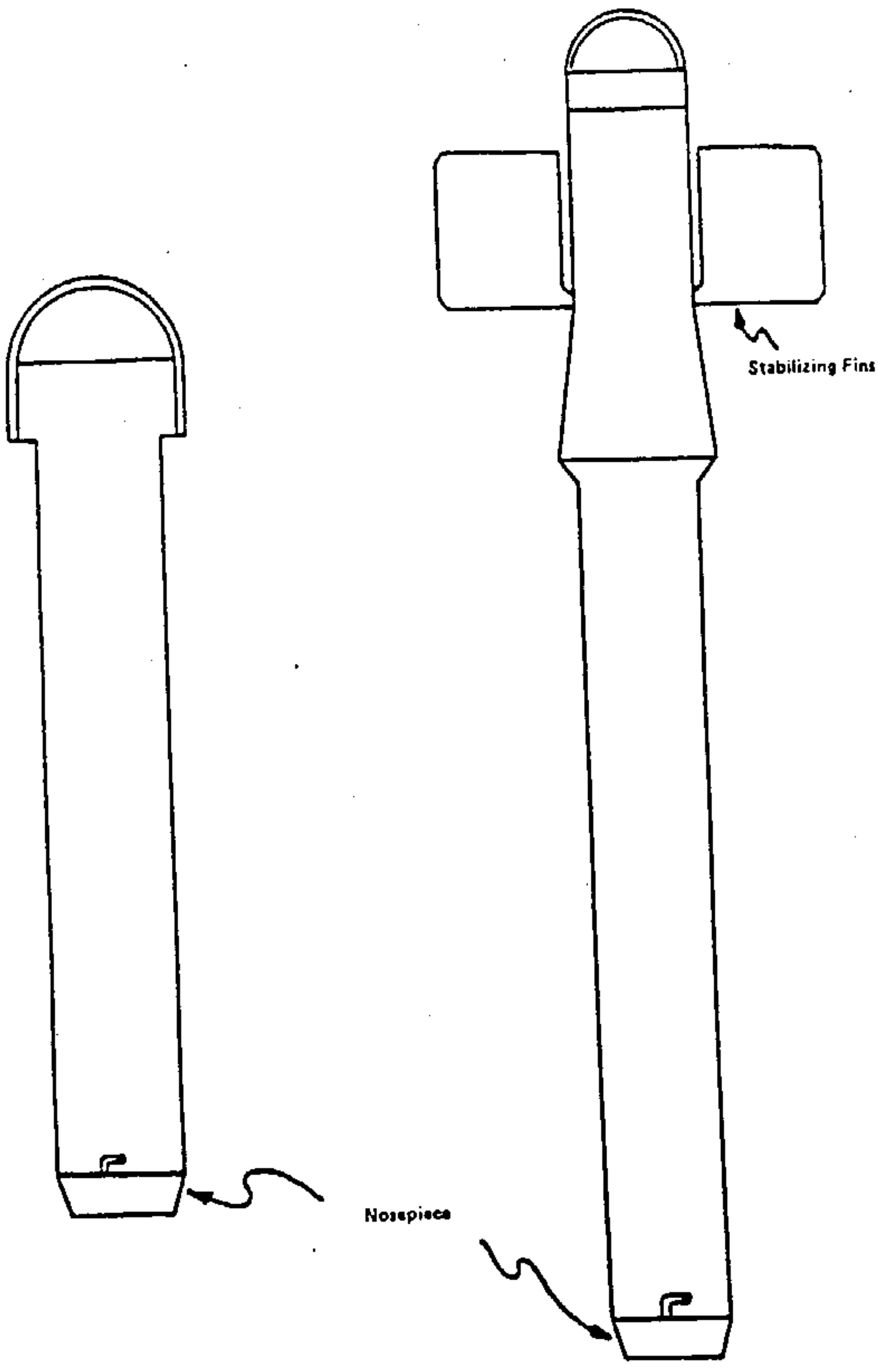
A gravity corer can collect most sludge and sediment samples. It collects essentially undisturbed samples to profile strata that may develope in sediment and sludge during variations in the deposition process. Depending on substrate density and gravity corer weight, penetration to a depth of 75 centimeters is possible.

Gravity corers should be used carefully in vessels or lagoons with liners. A gravity corer could penetrate beyond the substrate and damage liner material.

All sampling equipment should be made of inert and nonreactive materials. Nondisposable equipment should be cleaned before and after each use. Liners must require decontamination prior to use. Equipment should be decontaminated in accordance with SOP No. 002, "Equipment Decontamination."

FIGURE 2

GRAVITY CORER



The following is the procedure for sampling bottom sludge or sediment with a gravity corer:

1. Place all equipment on plastic sheeting next to the sampling location.

2. Affix a completed sample container label to an appropriate sample container (see SOP No. 017, "Sample Collection Container Requirements").

3. Sketch the sampling area or note recognizable features in the field logbook for future reference. Measure and record the distance from the sampling location to fixed structures.

4. Attach a precleaned gravity corer to the required length of sample line. Solid, braided, 5-millimeter (3/16-inch) nylon line is sufficient; however, 20-millimeter (3/4-inch) nylon line, is easier to grasp during hoisting.

5. Secure the free end of the line to a fixed support to prevent accidental loss of the gravity corer.

6. Allow the gravity corer to fall freely through the liquid.

7. Retrieve the gravity corer with a smooth, continuous lifting motion. Do not bump the corer, as this may result in some sample loss.

8. Remove the nosepiece from the gravity corer. Slide the sample out of the corer into a stainless-steel or Teflon® pan.

9. Place the sample in the labeled sample container using a stainless-steel laboratory spoon or the equivalent.

10. If required, ensure that a Teflon® liner is present in the sample container cap. Secure the cap tightly. Preserve samples in accordance with SOP No. 016, "Sample Preservation and Maximum Holding Times."

11. Complete all chain-of-custody documents (see SOP No. 018, "Sample Custody"), the field logbook entry, and all packaging requirements (see SOP No. 019, "Packaging and Shipping Samples").

12. Decontaminate all sampling equipment before and after use and between sampling locations in accordance with SOP No. 002, "Equipment Decontamination."

2.4 SLUDGE OR SEDIMENT SAMPLING WITH A PONAR GRAB

A Ponar grab sampler can be used to sample most types of sludge and sediment (see Figure 3). Its penetration depth usually does not exceed several centimeters. The Ponar grab sampler, like other grab samplers, cannot collect undisturbed samples; therefore, this implement should be used only after all overlying water samples have been collected.

The following is the procedure for sampling sludge or sediment with a Ponar grab sampler:

1. Place all equipment on plastic sheeting next to the sampling location.

2. Affix a completed sample container label to an appropriate sample container (see SOP No. 017, "Sample Collection Container Requirements").

3. Sketch the sampling area or note recognizable features in the field logbook for future reference. Measure and record the distance from the sampling location to fixed structures.

4. Attach a precleaned Ponar grab sampler to the sample line. Braided, 20-millimeter (3/4-inch) nylon line is recommended for ease in hoisting.

5. Measure the distance to the bottom of the liquid overlaying the sludge or sediment. Mark this measurement on the sample line. To avoid unnecessary disturbance of the sampling area by lowering the Ponar grab sampler too quickly, a second mark indicating the proximity of the sample mark is recommended.

6. Open the Ponar sampler's jaws until they are latched. The jaws will be triggered if the Ponar sampler comes in contact with or is supported by anything other than the lift line. Tie the free end of the sample line to a fixed support.

7. Lower the Ponar sampler until the proximity sample mark is reached. Slowly lower the Ponar sampler until it touches the sludge or sediment.

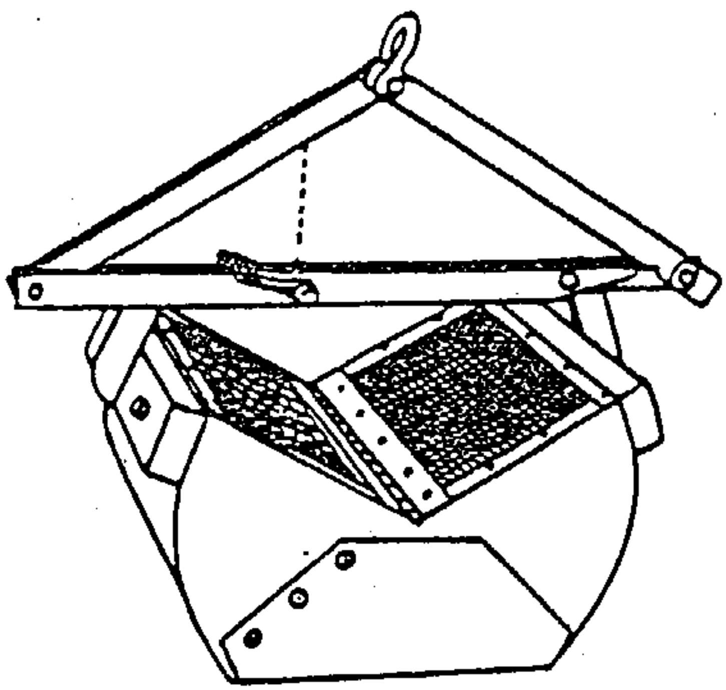
8. Allow the sample line to slacken a few inches; more slack may be required when sampling in strong currents. Release the mechanism to trap the sample and retrieve the sampler.

9. Release the contents of the Ponar sampler onto a stainless-steel or Teflon® tray.

10. Place the sample in an appropriate sample bottle using a stainless-steel laboratory spoon or the equivalent.

FIGURE 3

PONAR GRAB SAMPLER



11. If required, ensure that a Teflon® liner is present in the cap. Secure the cap tightly. Preserve samples in accordance with SOP No. 016, "Sample Preservation and Maximum Holding Times."

12. Complete all chain-of-custody documents (see SOP No. 018, "Sample Custody"), the field logbook entry, and all sample packaging requirements (see SOP No. 019, "Packaging and Shipping Samples").

13. Decontaminate all sampling equipment before and after use and between sampling locations in accordance with SOP No. 002, "Equipment Decontamination."

2.5 SLUDGE OR SEDIMENT SAMPLING WITH A PERISTALTIC PUMP

Sludge or sediment can be sampled with a peristaltic pump as described in SOP No. 009, "Sampling Surface Water." However, this method should only be used to collect slurried samples that are less than about 20 percent solid. The increased weight of more solid material greatly reduces the lift capacity of the pump; thus, it may be useful to laterally extend the reach of the sampler toward the center of a vessel. In slurries that are not fully agitated, a bias may be established toward the liquid portion of the material.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

BOREHOLE LOGGING

SOP NO. 026

REVISION NO. 2

Approved by:

Daniel Ashenberg
Quality Assurance Officer

2/2/93
Date

1.0 BACKGROUND

The objective of logging a borehole is to document the details of the soil and rock recovered from the borehole. These details include soil type, color, grain size variation, grain characteristics, staining, odor, moisture content, plasticity, blowcounts, soil sample interval, soil recovery, and sample numbers. These data are eventually used to reconstruct the stratigraphy under the drill site. It can then be correlated with similar data from other boreholes in the region to draw geological/hydrogeological cross-sections. These sections, various soil characteristics, and additional hydrogeological data are used to prepare models to show the migration of ground water and of any associated contaminants.

PRC Environmental Management, Inc., (PRC) has adopted a modified version of the Unified Soil Classification System (USCS) for borehole logging. A detailed discussion of the USCS is presented in SOP No. 028 (Visual Classification of Soils). The USCS classifies soils based on texture and liquid limits. The system is comprised of 15 soil groups, each identified by a two-letter symbol. The major divisions within the USCS (the first letter in each two-letter symbol) denote particle size: coarse-grained soils are sands (S) and gravels (G); fine-grained soils are silts (M) and clays (C). In coarse-grained soils, the second letter in the classification refers to the grading (sorting) of the soils. Thus (W) represents clean, well graded (poorly sorted) materials, while (P) represents clean, poorly graded (well sorted) materials. In fine-grained soils, the silts and clays are further subdivided in terms of liquid limits, with (L) indicating soils with low liquid limits and (H) representing soils with high liquid limits.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to ensure that all the pertinent information that can be obtained from drilling a borehole is completely and accurately logged and that there is consistency in logging the information when there is a change of personnel at the drill site.

1.2 SCOPE

This SOP applies to all PRC personnel involved in the logging of a borehole. Preprinted borehole log forms are available and all personnel involved in borehole logging will use a form to document field activities. Attachment A contains a sample form.

1.3 DEFINITIONS

Definitions of terms that relate to borehole logging are presented below. Definitions of soil types are taken from American Society of Testing Materials (ASTM, 1985).

Blow Counts -- The number of blows delivered by a 140 pound hammer dropped 30 inches required to drive a 1.5 inch inside diameter core sampler down a certain depth, generally 6 inches.

Unified Soil Classification System (USCS) -- A geotechnical classification in which soils are classified into four major divisions (coarse-grained, fine-grained, organic soils, and peat). The coarse-grained soils are classified according to grain size, whereas the fine-grained soils are classified according to plasticity characteristics. A total of 15 soil types are recognized. Each is indicated by a different two-letter group symbol, such as SP, ML, and GW.

Well Graded Sediment/Soil -- An engineering term describing a soil or unconsolidated sediment consisting of particles of several or many sizes. The opposite is "poorly graded," in which the soil or sediment particles are of nearly the same size. In the geological literature, "well graded" and "poorly graded" sediments/soils are referred to as "poorly sorted" and "well sorted", respectively.

Clay -- A fine-grained soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air dry.

Gravel -- Particles of rock that will pass a 3-inch (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions: coarse - passes a 3-inch (75-mm) sieve and is retained on a 3/4-inch (19-mm) sieve; fine - passes a 3/4-inch (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

Organic Clay -- A clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 percent of its liquid limit value before oven drying.

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

Sand -- Particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions: coarse - passes a No. 4 (4.75-mm) sieve and is retained on No. 10 (2.00-mm) sieve; medium - passes a No. 10 (2.00-mm) sieve and is retained on a

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

Silt – A fine-grained soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry.

1.4 REFERENCES

American Geological Institute (AGI). 1972. Data Sheet. Alexandria, Virginia.

American Society for Testing and Materials. 1985. Annual Book of ASTM Standards. Philadelphia, Pennsylvania.

AGI. 1987. Glossary of Geology. Alexandria, Virginia.

Fetter, C.W., 1988. Applied Hydrogeology. Merrill Publishing Company, Columbus, Ohio.

Holtz, R.D., and W.D. Kovacs, 1981. An Introduction to Geotechnical Engineering. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

1.5 REQUIREMENTS AND RESOURCES

To log the borehole, one person at the drill site should be a geoscientist or someone who has a knowledge of soil types and their physical characteristics. The following supplies will be required at the drill site for borehole logging.

- **Clipboard** -- Provides a backing for the field borelog forms. A 12-inch-by-9-inch hinged, three-leaf metal clipboard is quite suitable. These come in various types but the one with up to 1-inch depth is more desirable because the deep compartment provides convenient space for storing papers, borehole log forms, field notebooks, etc. PRC has laminated a variety of frequently used items such as color chart, USCS table, and soil samples on metal clipboards for use in the field.

- **Borehole Log Form** -- A pre-printed blank form on which all the information is noted. PRC has designed and printed this form for all of its borehole logging purposes. A completed sample borehole log is presented in Attachment A.

- **United Soil Classification System (USCS) Table** -- A USCS table is needed to determine the group to which any retrieved soil belongs. PRC has laminated a copy of this table on metal clipboards for use in the field.

- **Color Chart** -- Contains all the possible rock, sediment, and soil colors with which the material retrieved from the borehole can be compared. In this chart, the color is described (for example, light brownish gray) and given a corresponding color code (for example, 5 YR 6/1). The Munsell Soil Color Chart or the Geological Society of America rock color chart can be used.

- **Hand Lens** -- A pocket-size magnifying glass, with a magnification of approximately 10 to 20 times. It is particularly helpful in examining fine-grained materials in order to accurately describe the composition, shape, size, roundness, and color of the rock/soil particles.

- **Pocket Knife** -- Used to split recovered soil samples in any desired direction. It is also a convenient tool for isolating part of a soil/sediment sample for closer examination.

- **Hammer** -- Has many possible uses at the drill site. It is particularly handy for splitting borehole samples of rocks.

- **Sample Bottles** -- Used to collect soil, soil-gas, and ground-water samples retrieved during boring.

- **Ruler** -- A 1-foot ruler with markings in millimeters and fractions of an inch, will be needed to measure the diameters of coarse-grained sediments.

- **Adhesive Tape, Scissors, and Markers** -- Useful for securing the sample-bottle caps and for labeling the bottles.

- **Soil Samples for Reference** -- Small samples of various soil types that are classified by grain size and roundness. These samples serve as a useful reference in maintaining consistency in classifying borehole soils at the drill site. PRC has laminated some prominent soil samples on metal clipboards for use in the field.

- **Hydrochloric Acid** -- A small bottle of dilute hydrochloric acid, HCl (one part HCl to three parts water). This will be used to identify calcium carbonate bearing soils or sediments.

- **Miscellaneous Reference Charts** -- These charts include explanations and drawings of technical terms that are frequently used in logging boreholes. Examples include a soil description summary table (see Attachment B); cohesive soil consistency chart; blowcounts versus soil-stiffness correlation chart; granular soil density chart; moisture table; percentage-composition estimation chart, and particle roundness sketches. PRC has laminated these charts on metal clipboards for use in the field.

- **Photoionization Detector (PID)** -- Used to monitor possible emissions of hazardous gases from the borehole. The unit comes with an operating instruction manual.

- **Moisture Measuring Unit** -- Used to measure the moisture content of a soil sample in the field. The unit comes with operating instructions.

- **Dräeger Tube** -- Used to detect the presence of carbon tetrachloride and a variety of other harmful chemicals. Allows personnel on site to take necessary health and safety precautions. The unit comes with operating instructions.

- **Combustible Gas Indicator** -- Used to monitor the level of combustible gases that may be present at the drill site. Warns personnel on site of any danger of explosion. It is of special value for drilling at sites that have a potential for emitting methane.

- **Work Table** -- The table is needed to set up equipment, borehole samples, and various supplies.

- **Tent or Canopy** -- Used to protect the borehole log sheets and other documents from rain or snow.

2.0 PROCEDURE

The following subsections detail the procedure for borehole logging.

2.1 GETTING ORGANIZED AT THE DRILL SITE

Borehole logging requires setting up a mini-office and a mini-lab at the drill site. As the borehole material is pulled up and retrieved for sampling, testing, or inspection, a variety of subtasks must be completed in a certain sequence and in a limited time span. It is important, therefore, that all the supplies and equipment be well organized and the tasks be clearly understood by the persons who are supposed to log the borehole.

2.2 LOGGING A BOREHOLE

Preprinted borelog forms are available to ensure that pertinent information is recorded by field personnel. Borelog forms will be completed by field personnel during drilling operations.

Instructions for completing the sample form (see Attachment A) are given below.

1. General: At the beginning of each day, use a new borelog sheet. The new sheet should continue at the depth where previous day's drilling was terminated.

   Where appropriate, use the following abbreviations:

M	=	Missing
NA	=	Not applicable
ND	=	Not done

2. Location of Borehole: Draw a sketch map of the borehole site in the space provided at the upper left corner of the borelog form. Mark the precise location of the borehole with an "X" and clearly label it (for example, BH-12). Also draw and label prominent features in the vicinity of the borehole, such as railroads, streets, buildings, fencelines, and other landmarks. The direction to north should be shown (↑N). Give an approximate scale.

3. Job No., Client, etc.: Enter this information as appropriate. Print the name(s) of the person(s) who logged the segment shown on any particular page of the borelog form.

4. Site/Subsite, Borehole Location, etc.: This part of the form is self-explanatory. Enter "Sheet __ of __," on each page after the borehole is completed.

5. Sampler Type: Choose abbreviations from the following list:

CHP	=	Constant head probe
GP	=	Geoprobe
GWP	=	Ground-water probe
SGP	=	Soil-gas probe
SS	=	Split spoon
ST	=	Shelby tube
__	=	Other (specify)

6. Sample Depth: Record the top and bottom depths of the segment drilled. The fraction of a foot should be recorded in decimals (for example, 5.6 feet) not in inches.

7. Blows/6" Sampler: Record the number of blows in each 6-inch interval. If more than 100 blows are counted in the 6-inch interval, then record only 100. In this column, the hammer-weight should be entered immediately below the blowcount on first entry of each day, after which the hammer-weight should be recorded only if it is changed.

8. Inches Driven/Inches Recovered: This column is self-explanatory.

9. Time: Record the exact time when the sample was collected in military time (for example, 1715 hours)

10. PID Reading: Record the PID reading in parts per million (ppm) units.

11. Analyses (Physical/Chemical): Record the number of containers that will be sent for each type of analysis (physical "Phy" and/or chemical "Chm"). If no sample will be sent for analysis, a zero (0) should be recorded in the appropriate sub-column.

12. Depth in Feet: Enter numerals before or after the preprinted numerals to indicate the depth as multiples of 1 or 10. At the beginning of each day, a new borehole log sheet should be used (see item 1A above). Boxes next to the numerals should be shaded to indicate the exact sample depth.

13. USCS Soil Type: Enter appropriate USCS abbreviations (SW, SP, ML, etc.) based on the soil description in the next column. Complete this column only after the soil types have been described. Consult PRC SOP No. 028, Visual Classification of Soils.

14. Soil Description: Record the soil description noting the following items: soil type, color (with code from the color chart), texture (grain size, roundness, etc.), bedding, odor, consistency (stiffness, plasticity, etc., for cohesive soils), relative density (loose, dense, etc., for granular soils), and moisture content (dry, moist, saturated, etc.). The Field Descriptions for Soil table provided in Attachment B can be used to aid in the description formulation process. Record the depth of the water table where it is encountered. The presence of the water table should be indicated by writing down "saturated at __ feet." Soil classified as "sand" should be further categorized as well graded (SW) or poorly graded (SP). It should be remembered that the term "well graded" in geotechnology is the opposite of "well sorted" in geology. Consult PRC SOP No. 027, Visual Sample Description - Rock, Sediment, Soil for more details. Record the sample media and sample tag number, as necessary.

15. When the borehole is terminated, enter "Borehole terminated at ___ feet."

ATTACHMENT A

SAMPLE FIELD BORELOG FORM

FIELD BORELOG

PRC ENVIRONMENTAL MANAGEMENT, IN

SHEET ____ OF ____

LOCATION OF BOREHOLE

JOB NO.: BOREHOLE DESIGNATION:

CLIENT: SURFACE ELEVATION:

SITE: DEPTH TO WATER:

SUBSITE: LOGGED BY:

DRILLING CO.: DRILLING DATE(S):

DRILLING PERSONNEL/METHOD:

SAMPLER TYPE	SAMPLE DEPTH TOP BOT	BLOWS/ 6" SAMPLER	RECOVERED/ DRIVEN	TIME	PID Rdg	ANLYS [illegible] [illegible]	WELL Info.	DEPTH IN Ft	USCS SOIL TYPE / GRAPHIC LOG	SOIL DESCRIPTION
								1		
								2		
								3		
								4		
								5		
								6		
								7		
								8		
								9		
								0		
								1		
								2		
								3		
								4		
								5		
								6		
								7		
								8		
								9		
								0		

ATTACHMENT B

FIELD DESCRIPTIONS FOR SOIL SUMMARY TABLE

FIELD DESCRIPTIONS FOR SOIL

1. TEXTURAL NAME AND PROPORTIONS OF SOIL CONSTITUENTS

Clay	Silt
Silty Clay	Sandy Silt
Clayey Silt	
Silty Sand	Sandy Gravel
Sand	Gravel
Gravelly Sand	

Where apparent, indicate approximate percentages of each constituent.

Trace (Minor) – 0 to 5 percent
Some – 5 to 25 percent
Abundant (clayey, silty, sandy, gravelly) – 25 to 50 percent

2. PARTICLE SIZE DISTRIBUTION OR RANGE (used to modify the textural name and describe the second major constituent)

Very Fine Sand	0.01 to 0.07 mm
Fine Sand	0.07 to 0.4 mm
Medium Sand	0.4 to 2 mm
Coarse Sand	2 to 4 mm
Very Coarse Sand	4 to 6 mm
Granule	4 to 6 mm
Gravels	6 mm to 7.5 cm
Cobbles	7.5 to 30 cm
Boulders	> 30 cm

3. COLOR

See Munsell Soil Color Chart, or GSA rock color chart

Provide name and code in parentheses;

Where mottled, describe all colors present; where weathered or oxidized, modify with these colors as well

4. SORTING (use to discuss size distribution when coarser grains predominate)

Well Sorted: – 90 percent of particles in 1 or 2 size classes

Moderately Sorted: – 90 percent of particles in 3 or 4 size classes

Poorly Sorted: Unsystematic range of particles sizes; no size class predominates

Sorting = Spread of range or degree of similarity

5. PLASTICITY

Nonplastic: Soil falls apart at any water content (crumbly);

Slightly Plastic: Soil easily crushed with fingers; a thread can barely be rolled; low dry strength

Plastic: Soil difficult to crush with fingers; easily rolled thread up to the plastic limit, failure after reaching the plastic limit; medium dry strength

Very Plastic: Soil impossible to crush with fingers (highly deformable); threads require much time to reach plastic limit, and can be rerolled several times after reaching the plastic limit

Plastic limit = Boundary between the plastic and semisolid state (an Atterberg limit)

6. MOISTURE

Dry	Moist
Slightly Moist	Wet

7. DENSITY/CONSISTENCY

DENSITY OF GRANULAR SOILS:

Very Loose	Dense
Loose	Very Dense
Moderately Dense	

CONSISTENCY OF COHESIVE SOILS:

Very Soft	Stiff (firm)
Soft	Very Stiff (firm)
Moderately Stiff (firm)	Hard (tight)

8. SOIL STRUCTURE

GRADE/UNIFORMITY:

Structureless (homogeneous)	Moderate
Weak	Strong

FORM:

Bedding (describe bed thickness)	Columnar
Stratified	Prismatic
Laminated	Blocky
Banded	Granular
Platy	
Imbricated	

8. SOIL STRUCTURE - Continued

DEFECTS IN SOIL STRUCTURE:

Slickensides	Burrows
Roots	Fissures
Cementation	Weathering (type and extent)
- salts	- fresh
- caliche	- depth of weathering
- hardpan	- color

9. MINERALOGY/ANGULARITY

Pertinent for coarse-grained constituents, including sand grains

GENERAL TERMS:	SPECIFIC TERMS:
Arkosic	Feldspar, Quartz
Felsic (light)	K-Feldspar, Quartz, Plagioclase Feldspar
Mafic (dark)	Augite, Hornblende, Biotite, Pyroxene
Micaceous	Muscovite, Biotite, Phologopite
Plutonic	Granite, Monzonite, Gabbro
Volcanic	Rhyolite, Latite, Basalt
Oxidized	FeO_x, Limonite
Rock Fragments	

ANGULARITY/SHAPE:

Angular	Subrounded
Subangular	Rounded
Flat	Elongated

10. DESCRIPTION OF SECOND MAJOR CONSTITUENT IF APPLICABLE

Refer to horizon boundaries

11. HORIZON BOUNDARY

GENERAL TERMS:	SPECIFIC TERMS:
Gradational	Abrupt
Sharp	Diffuse
Erosional	Smooth
Depositional	Wavy
	Irregular
	Broken

12. ENVIRONMENT OF DEPOSITION

GENERAL TERMS:	SPECIFIC TERMS (DEPOSITS):
Fill Material	Point Bar
Alluvium	Overbank
Colluvium	Channel
Detritus	Turbidity
Lateritic	Alluvial Fan
Landfill Material	Eolian
	Marine/bay
	Lagoonal
	Deltaic

13. ADDITIONAL INFORMATION

SAMPLE DESIGNATIONS:
For soil or ground water samples collected from borehole, including HydroPunch

USCS SOIL TYPE:
(If not provided in field form)

PID READINGS (where taken):
Borehole/headspace/direct sample reading

DRILLING INFORMATION:
Drilling rate/progress

Terminology
- tight - smooth - chattering

Fluid Type/Fluid Loss
- intervals of loss
- quantity lost

Changes in drilling methods

Explanation of downtime

PHOTOGRAPHIC INFORMATION:
Photo number (!!) and description, date, time, photographer

GROUND WATER INFORMATION:
Initial depth to water
Stabilized depth to water

MISCELLANEOUS INFORMATION:
Borehole to be converted to monitoring well, weather conditions

EXAMPLE DESCRIPTIONS:

(1) Silty clay, about equal silt/clay, mottled olive (5 YR 5/3) to yellowish brown (10 YR 5/6), nonplastic (crumbly), dry, dense, with 1 to 2 mm granules and a 2 to 5 cm lens of coarse quartz sand and gravel, gravels are 3 to 4 mm, rounded, crystalline hard siltstone, sharp contact with GC below, probable fill material, HNu = 0-1 (open sample).

(2) Clay or silty clay with abundant gravel (about 50 percent), medium to large pebbles (1 to 2.5 cm), well sorted, subrounded, arkosic; clay/silt hard to distinguish, stained dark gray (10 YR 4/1) to gray (10 YR 5/1) with hydrocarbons, slightly plastic, slightly moist, moderately stiff, uniform, sparse mica or sericite, occasional shell fragments, intertidal marine silts/clays; headspace readings 15-25 ppm; photo #29, stained soils in open split spoon, 10/5/90, 1430, D. West; Sample TP-4 (10-11.5) collected

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

HAND AND POWER AUGERING: SUBSURFACE SOIL SAMPLING METHODS

SOP NO. 044

REVISION NO. 3

Approved by:

Kathleen Homer
Quality Assurance Officer

5/20/93
Date

1.0 BACKGROUND

A hand auger is primarily used to collect soil samples from relatively shallow unconsolidated materials. Generally, hand augers are useful for sampling all types of soil except cohesionless materials below the water table and hard, rocky or cemented soils. The operational limit of a hand auger is usually 5 feet, but deeper borings are possible using auger extensions. A hand auger may be a preferred sampling tool when certain conditions prevail such as when contaminant sources are shallow, when areas are inaccessible to conventional drill rigs, and for quick preliminary studies. Using a hand auger is inappropriate when undisturbed samples are needed or when detailed lithologic information is required.

Power augers may be a preferred tool for drilling when soils are gravelly, compacted, or clayey. Power augers do not permit the discrete sampling of a soil interval. This method may be used in conjunction with hand augering to obtain a soil sample. To do this, a power auger is used to advance to the depth needed and then a hand auger is used to collect the sample. A power auger can also be used for quick, inexpensive drilling of shallow borings. However, these augers are bulky and may be difficult to operate in very coarse materials.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for sampling soil using the hand auger and the power auger methods.

1.2 SCOPE

This SOP applies to all personnel sampling soil with hand or power augers. Samples may be collected for physical or chemical analyses. These methods are limited to shallow depths, usually less than 5 feet, and to soils which are amenable to penetration by these methods.

1.3 DEFINITIONS

Hand Auger: The hand auger is usually composed of a crossbar, auger stem, and head. The auger stem is compatible with a number of different heads. Additional lengths of pipe can be added to the stem as depth increases. Many types of auger heads exist, and their utility depends on the specific type of soil sampling required. Auger head types include: bucket, Iwan, ship (screw), and spiral (open and closed) heads (Figure 1).

Bucket and Iwan Auger Heads: These heads are used when soils are relatively fine grained, dry, and unconsolidated (both of these augers resemble post-hole diggers). These auger heads are ineffective when used for gravelly or clayey soils. The bucket auger head produces a good borehole in competent, cohesive, dry material. The Iwan auger head is most effective in moderately plastic, moist clays. Both augers provide intact depth-discrete samples.

Sampling Auger Head: This head is used when a depth-discrete sample is to be collected. This head is identical to the bucket auger head except that the top of the head is closed and liners can be installed to retain soils for physical or chemical testing. This auger head also is effective in retaining samples in cohesionless soils.

Ship Auger: This head, also called a helical or screw head, is used when a depth-discrete sample is unnecessary and the soil material is competent and dry. This auger head is best applied for exploratory drilling prior to sampling.

Spiral Augers: These augers are used when helical augers do not work well. The closed-spiral is used in dry clays and gravelly soils. The open spiral is most useful in loose unconsolidated sediments.

Power Auger: Generally, power augers are equipped with one type of bit, the solid stem screw auger bit. The power source for a typical post-hole power auger is a gasoline powered engine, but

FIGURE 1

HAND AUGERS

(a)

Ship Auger

(b)

Closed-Spiral Auger

(c)

Open-Spiral Auger

(d)

Iwan Auger

generator-equipped augers with a wheel-mounted motor are available. The power source for a two-man auger is generally located at the top of the auger stem.

Other more sophisticated mobile augers are available. These are capable of drilling to greater depths, but they operate with a similar auger stem. These types of augers have the same limitation -- they cannot be used to obtain discrete samples.

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1984. (*Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods.*) Second Edition. EPA-600/4-84-076. December.

EPA. 1987. *A Compendium of Superfund Field Operations Methods*. OSWER Directive 9355.0-14. EPA/540/P-87/001. December.

1.5 REQUIREMENTS AND RESOURCES

Soil sampling using the hand or power auger method requires that one or more of the following types of equipment be used:

<u>Sampling Equipment</u>

Hand auger with appropriate auger head

Power auger

Power source for power auger

Fuel for gasoline-powered augers

<u>Other Required Equipment</u>

Logbook

Sample containers and paperwork

Spoons or spatulas for sampling

Decontamination equipment

Health and safety equipment

2.0 PROCEDURES

Drilling and sampling methods for the hand auger and the power auger are presented below.

2.1 HAND AUGER DRILLING METHOD

Drilling methods for all hand augers are generally the same. When soil characteristics are unknown, several auger heads should be available. Attach the auger head to the bottom of the length of pipe that has a crossarm at its top. Drill a hole by turning the crossarm while pressing the auger into the ground. When the auger head fills with soil, remove the auger from the hole, then remove the soil from the auger head. Place the soil on a clean, inert tray to physically characterize the soil and assess the material with monitoring equipment. Add additional lengths of pipe as depth increases. Care should be taken not to use too many extensions, as it may become impossible for the operator to remove the auger stem from the ground.

2.2 HAND AUGER SAMPLING METHOD

To obtain a soil sample, first drill as detailed in the previous section. Once the soil is physically characterized, composite and containerize the soil as appropriate. If a volatile organic fraction is collected, it should be containerized before compositing. Specific sampling procedures are outlined below.

1. All sampling equipment will be made of inert material such as Teflon® or stainless steel, and if not disposable, will be decontaminated before each use. The decontamination procedures are given in SOP No. 002, "General Decontamination."

2 Carry sampling equipment to the sampling location. Be sure all equipment rests on plastic sheeting next to the sampling location, if required to prevent sample contamination.

3 Locate the sample area by surveying or sketching and note recognizable features for future reference. Remove all debris from the surface of the sampling area.

4 Affix a completed sampling label to the appropriate sampling jar.

5 Insert the bucket auger into the soil and advance it to the appropriate depth as described above in Section 2.1.

6 Collect the samples for VOC analysis by scooping the sample material directly into the sample jar with a precleaned stainless steel spoon.

7 If the soil samples are to be composited or mixed, transfer the remaining soil sample from the bucket auger into a precleaned stainless steel mixing bowl, aluminum pan, or teflon tray. Mix the sample with a precleaned stainless-steel spoon or equivalent, and remove all foreign material (rocks, wood, debris, etc.). Monitor and record results with the appropriate health and safety equipment.

8 Transfer the sample into an appropriate sample bottle using the stainless steel spoon.

9 If required, check that a Teflon liner is present in the cap. Secure the cap tightly.

10 Complete all chain-of-custody documents, the field logbook, and sample packaging requirements.

11 Decontaminate sampling equipment after use and between sample intervals according to SOP No. 002. "General Decontaminatio." If disposable sampling equipment is used, properly containerize the equipment for disposal.

2.3 POWER AUGER DRILLING METHOD

The power auger should be equipped with a reverse and forward drive. Place the power auger on a flat surface and hold it firmly in place while the drive is engaged. With the one-man auger, the motor attachment should be equipped with a support arm, which stabilizes the auger during drilling. With the two-man auger, each operator should hold the unit from an opposite side and level with the ground surface. When the auger is advanced to the appropriate depth, clear the material from around the borehole to prevent caving, engage the reverse drive to remove the bit from the borehole.

2.4 POWERED AUGER SAMPLING METHOD

As previously discussed, power augering generally does not allow samplers to obtain discrete soil samples. However, power augers can be used in conjunction with hand augers to collect soil samples. To do this, a power auger is used to advance to the depth needed and then a hand auger is used to collect the sample. Hand augering sampling techniques are described in Section 2.2.

3.0 ADVANTAGES AND DISADVANTAGES

The advantages and disadvantages of using the hand auger and the power auger are presented below.

3.1 HAND AUGERING

Hand augering is the method of choice when (1) high mobility is needed at facilities with impaired access, (2) quick and shallow borings are needed for a preliminary survey, or (3) sampling is focused on shallow soft soils of low plasticity.

The disadvantages of hand augering are that: (1) the method makes it difficult to locate changes in soil strata, (2) samples are disturbed, and (3) the method may be very time consuming and labor intensive in rocky or compact soils.

3.2 ADVANTAGES AND DISADVANTAGES OF POWER AUGERING

Many of the advantages and disadvantages of power augers are the same as those of hand augers. Also, the greases, oils, and fuels required for most power augers greatly increase the possibility of sample contamination by these organic compounds. Appropriate field procedures must be practiced to avoid fuel and lubricant contamination of samples.

3.3 CAUTION

Buried utility lines may present a significant hazard during both manual and power augering. Be sure to obtain and document in the logbook, utility clearances for electric lines, gas lines, water lines, product lines, phone cables, and any other utilities before augering is initiated.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

BOREHILL DRILLING - HOLLOW STEM AUGER DRILLING

SOP NO. 045

REVISION NO. 1

Approved by:

____________________________ ____________________________

Quality Assurance Officer Date

Title: **Borehole Drilling, Hollow Stem Auger Drilling**

1.0 BACKGROUND

1.1 PURPOSE

This standard operating procedures (SOP) provides general guidance for the planning and implementation of hollow-stem auger geologic drilling for field investigations of hazardous waste sites. This SOP is not intended for use in site-specific situations. Consult site project plan for step by step procedures.

1.2 SCOPE

Some general considerations should be followed when using the hollow stem auger method. These involve borehole advancement, lithologic sampling, well installation, decontamination procedures, contaminated soil containment, borehole abandonment and health and safety monitoring.

1.3 REFERENCES

Acker, W. L. Basic Procedures for Soil Sampling and Core Drilling. Scranton, Penn: Acker Drill Co., 1976

Barcelona, M.J., J.P. Gibbs, J.A. Helfrid, and E.E. Garske, Practical Guide for Groundwater Sampling. SWS Contract Report 324, Champaign, Illinois: Illinois State Water Survey, 1985

Johnson Division, VOP WC., Groundwater and Wells. St. Paul, Minnesota 1980

National Water Well Association, Water Well Specifications, Berkely, California: Premier Press 1981

1.4 REQUIREMENTS AND RESOURCES

The following equipment are required for hollow stem auger drilling:

- Hollow Stem Auger Drill Rig (w/Associated Drill Tools and Hardware)
- Qualified and Experienced Driller and Helpers

2.0 PROCEDURES

The following procedures should be followed to operate the hollow stem auger.

2.1 GENERAL OPERATION

Hollow-stem augers are used to advance the borehole when discrete soil samples are needed. The augers are advanced by applying downward pressure on the augers as they are rotated. Material is forced to the ground surface around the exterior of the auger (spiral flights bring soil to the ground surface) during drilling. Cuttings are brought to the surface and can be identified. The hollow-stem auger consists of (1) a hollow steel tube with 5-foot spiral flights (internal diameters (IDs) range from 2-1/2 to 13-inches) and (2) a finger-type cutter head at the bottom of the lead auger (drill rods can be removed or inserted through the center of the auger assembly, facilitating soil sampling). A bottom plug can be inserted into the hollow center of the cutter head to prevent loose (unconsolidated) soil from coming up into the auger. This plug also has a pilot cutting head. The plug may be removed from the auger whenever a soil sample from below the cutter head is needed. Lithologic sampling is accomplished by removing the center plug from the auger stem and placing the appropriate sampling device (for example, split-spoon, or Shelby tube (see SOP 005)) at the end of the drill-rod assembly.

The drive stem is inserted through the hollow-stem auger and driven ahead of the augered material by a rig mounted, weighted hammer. The boreholes may be completed as wells or abandoned.

2.1.1. Monitoring Well Installation

Well installation is described in more detail in SOP 020. However, specific well completion methods should be followed when using the hollow-stem auger method. Borehole advancement will proceed to the desired depth. Upon reaching the desired depth, a small-diameter casing and screen can be set inside the hollow stem to produce a monitoring well. The augers are removed by section while the well screen and risers are held in place. Typically, one 5-foot section of auger is removed at a time. Clean sand and gravel pack is installed as the augers are withdrawn. Once the screen is properly covered (usually to 2 feet above the top of the screen), a clay (bentonite) seal should be installed (at least 2 feet of bentonite pellets or pressure grouted bentonite slurry should be placed on top of the filter pack.) As a final step, grout or other impermeable material is tremied in place on top of the clay seal to ground level as the remaining auger sections are removed. Careful installation of clay or grout seals is essential, especially in areas where multiple aquifers are encountered. Aquifer cross-contamination will be avoided, if at all possible.

2.1.2 Borehole Abandonment

In the event that a borehole or well needs to be abandoned, the hole will be filled from the bottom to the surface using a cement-bentonite grout. The cement-bentonite grout will be of the same consistency used to seal off the annular space of a completed well. The depth of the hole will be measured with a steel tape and the volume of grout calculated to plug the hole. The method used to place the grout into the hole will ensure that it is filled from the bottom to the surface (e.g. tremie pipe). Cement-bentonite grout will be pumped into the hole until it rises to within 5 feet of the land surface. It will then be allowed to set overnight before the remainder of the hole is filled with neat cement. An alternative to cement-bentonite grout is straight bentonite grout. A cement cap will be made over the abandoned borehole that will allow any surface water to drain away from the area. The area of the abandoned borehole will be marked for future reference.

2.2 CONSIDERATIONS

Hollow-stem augering allows for drilling through soils below the water table with minimal cross-contamination. However, sediments such as flowing sands may "blow up" into the augers. If this situation is encountered (or will be known to occur), water of known chemical quality may be used to control sediment inflow. This method provides a greater head on the drilled sediments and prevents materials from advancing up through the auger.

The borehole should be advanced without using water unless absolutely necessary. Use of water while advancing through the unsaturated zone should not be necessary. If water is added during boring, it should be obtained from a source that has been analyzed and shows no contamination. It may be advisable to verify the quality of water through testing or by consulting local water authorities. If a sample is to be obtained, the borehole will be advanced by alternately boring a specified interval, removing the drive stem and bit, reinserting the drive stem with a sampler attached, and obtaining a sample. This procedure is continued until the desired depth is reached.

The auger stem, drive stem, and bit will be decontaminated prior to boring at a borehole location. At a minimum, this will include steam cleaning of the auger and drive stem. If a discrete zone of contamination is encountered during drilling, and drilling is to advance through this zone, downhole tools in contact with the contaminated zone will be steam cleaned after boring has proceeded through the contaminated interval. Additionally, to prevent downhole cross-contamination, it may be advisable to install an outer casing, grout the borehole while withdrawing the auger, redrill the hole through the grout using an auger with a smaller diameter auger, and then further advance the borehole.

Contaminated soil or water encountered during boring activities can be containerized within 55-gallon drums at the surface upon removal from the borehole.

Specific health and safety considerations will vary depending on site-specific factors. These considerations will generally be specifically detailed in a work plan, quality assurance project plan (QAPjP), or health and safety plan.

2.3 ADVANTAGES AND DISADVANTAGES

The hollow-stem auger method is the method of choice under the following circumstances:

- The boring is generally less than 100 feet in depth (see Table 1 for drilling method limitations). Depths exceeding 100 feet should be discussed with the drilling contractor.
- Boring is through a single saturated zone or through zones where cross-contamination is not suspected to be a potential problem.
- Locations of ground-water levels are important.
- Drilling must proceed with minimal use of water or boring fluid (little or no water is needed).

- Information concerning depth-discrete downhole contamination or water bearing zones can be easily obtained.
- Small-diameter monitoring wells are to be installed.
- Intact or undisturbed lithologic samples are required.
- Drilling will proceed through unconsolidated or loosely consolidated materials (the augers act like casing).
- Boring of monitoring wells needs to be completed in a short time period.

The disadvantages of the method are as follows:

- There is potential for cross-contamination from higher to lower hydrostratigrahic units.
- The method generally cannot be used for wells deeper than 100 feet (see Table 1 for drilling method limitations).
- The method is difficult to use when large cobbles or flowing sands are encountered.
- The method cannot be used to drill through competent bedrock.
- Hollow-stem augering may smear natural clays into open sands and gravels, thus limiting free flow of fluids into the wells and decreasing the response to hydraulic tests.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

USING THE GEOPROBE SYSTEM

SOP NO. 054

REVISION NO. 1

Approved by:

[signature]
Quality Assurance Officer

3-30-94
Date

1.0 BACKGROUND

This standard operating procedure (SOP) details all procedures for using the Geoprobe System, a hydraulically operated sampling probe, and its specialized sampling tools. The procedures described within this SOP include soil gas sampling, groundwater sampling, and soil sampling procedures as well as procedures for installing piezometers and vapor sampling implants. This SOP also describes general procedures for rod removal, backfilling, and decontamination which are common elements to all sampling procedures. This SOP No. 054 replaces former draft SOP No. 054 (Geoprobe Soil Gas Sampling) and draft SOP No. 055 (Geoprobe Groundwater Sampling).

Use of the Geoprobe System is only one of many sampling techniques used by PRC Environmental Management, Inc. (PRC); however, it is a preferred sampling method when certain conditions prevail. Specifically, Geoprobe sampling should be considered when sampling is limited to relatively shallow depths and any of the following are factors: (1) costs must be kept very low, (2) the time period is short to perform the sampling, (3) maneuverability is important, and (4) the required sampling volume is limited.

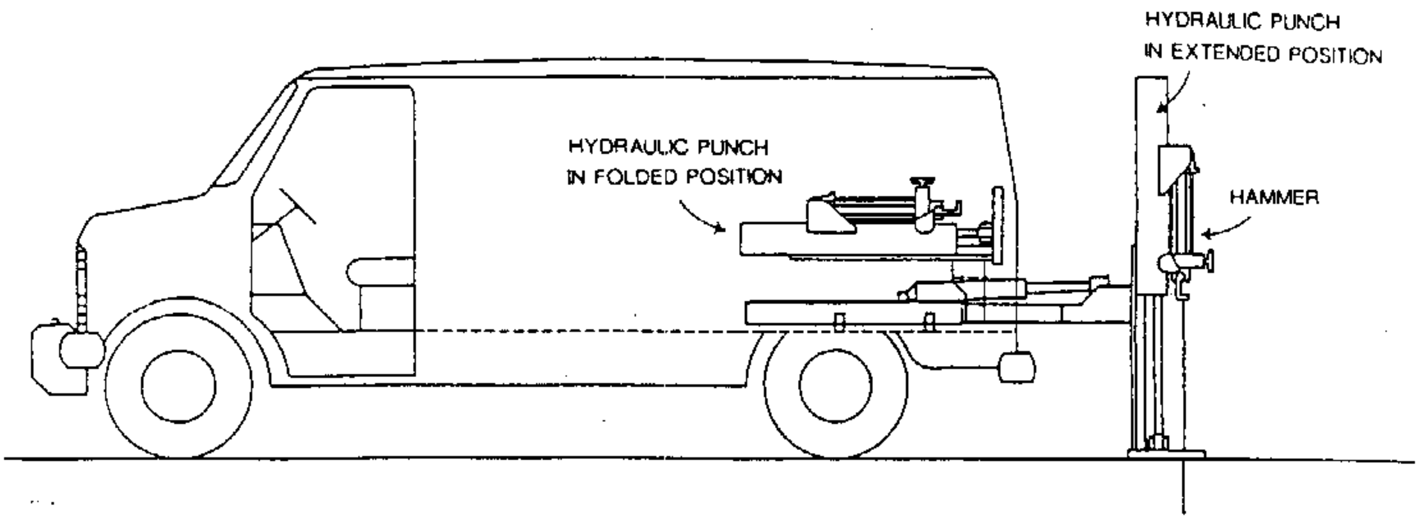
Prior to the use of the Geoprobe equipment, all buried utility lines and other underground structures must be marked because this equipment can penetrate buried piping and tanks. A diagram of the Geoprobe system is shown in Figure 1.

1.1 PURPOSE

The purpose of SOP No. 054 is to establish positioning, preparing, and sampling procedures; piezometer and vapor sampling implant installation procedures; rod removal procedures; backfilling procedures; and decontamination procedures to guide field personnel.

FIGURE 1

GEOPROBE SYSTEM



1.2 SCOPE

The procedures outlined in SOP No. 054 are applicable to all PRC personnel involved in soil gas, soil, or groundwater sampling using the Geoprobe System or any of its specialized equipment. It also is applicable to all personnel using the Geoprobe System to install piezometers and vapor sampling implants. This SOP, in fact, applies to all uses of the Geoprobe System.

1.3 DEFINITIONS

Because Geoprobe Systems is a corporation specializing in an innovative sampling process, many of the terms used to describe its equipment are specialized and specific. For this reason, familiarity with hydraulic system, soil sampling, soil gas sampling, and groundwater sampling terms is necessary. These terms are discussed below.

1.3.1 Hydraulic System Terms

The following terms are principally used to discuss the basic operation of the hydraulic punch and its major components. If terms are encountered while using this SOP that are not listed below, check Sections 1.3.2, 1.3.3, and 1.3.4 below.

Hydraulic Punch — The principal part of the Geoprobe System, the hydraulic punch, looks very much like a small mobile drilling rig and is usually attached to a truck or van. The punch's hydraulic system uses the weight of the vehicle for support and a hydraulic system installed in the vehicle to advance sampling tools into the soil (see Figure 1).

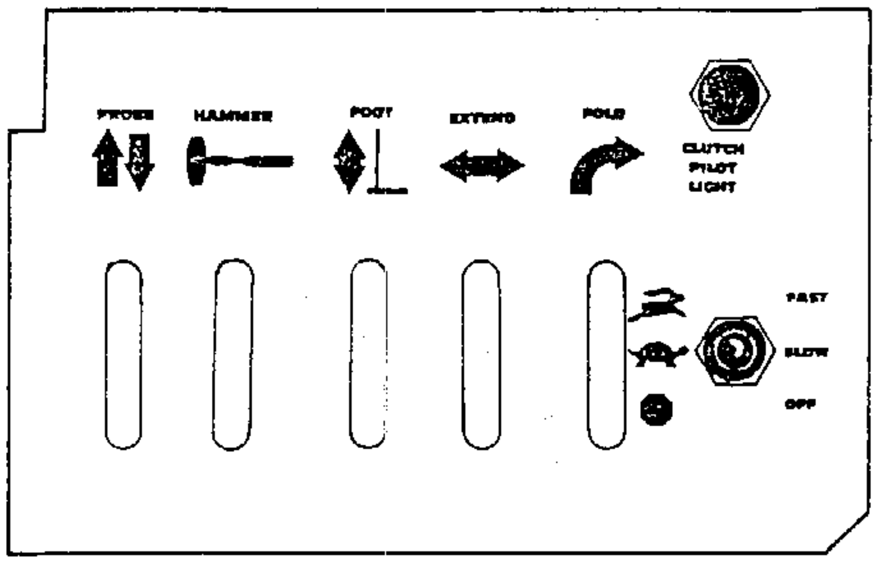
Hammer — The hydraulic hammer pounds the rods and accessories into the soil once the hydraulic punch is unable to push it farther (see Figure 1).

Control Panel — The control panel is located near the hydraulic punch and contains the levers that control the movement of the punch (see Figure 2).

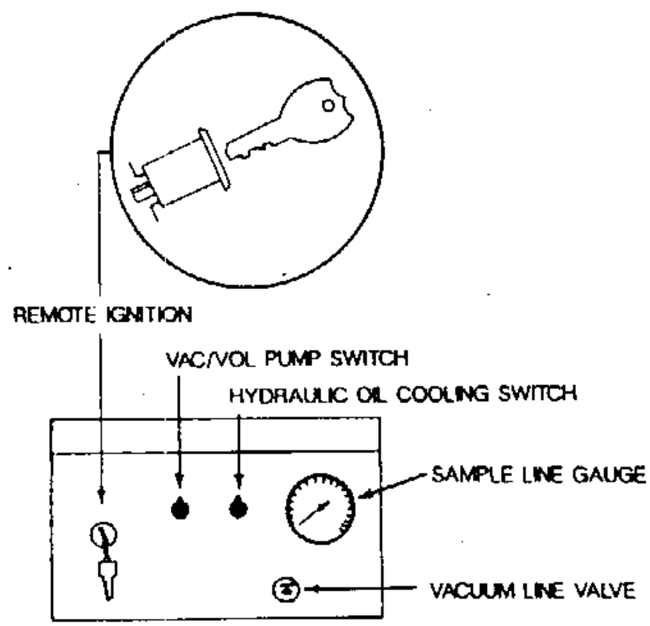
Probe Lever — This lever is found on the control panel and causes the hydraulic punch to push the drive rod and accessories into the soil. Overall, this lever controls the vertical movement of the punch (see Figure 2).

FIGURE 2

CONTROL AND VACUUM SYSTEM PANELS



CONTROL PANEL



VACUUM SYSTEM PANEL

Hammer Lever — This lever is found on the control panel and engages the hydraulic hammer when the hammer release valve is moved to its extended position (see Figure 2).

Hammer Release Valve — This lever is found on the front of the hydraulic punch and allows the hammer to work when in its extended position. If the valve is not extended, pushing the hammer lever will not engage the hammer.

Foot Lever — This lever is found on the control panel and lowers the foot of the hydraulic punch so that it rests on the ground to stabilize the punch (see Figure 2).

Extend Lever — This lever is found on the control panel and controls the horizontal movement of the hydraulic punch. The lever extends the punch out of the van or truck. It also enables the hydraulic punch to extend about 2 feet from the rear of the vehicle (see Figure 2).

Fold Lever — This lever is found on the control panel and folds and unfolds the hydraulic punch so that it can be easily moved and stored (see Figure 2). This lever enables the hydraulic punch to move from the horizontal position to the vertical position.

Electrical Control Switch — This switch is found on the control panel and turns on the Geoprobe System's hydraulic system. None of the other levers work until this switch is turned on. It has slow, fast, and off speed positions (see Figure 2).

Vacuum System Panel — The vacuum system panel is located near the right rear of the vehicle and contains the vacuum system controls, the hydraulic oil cooling switch, and the remote ignition (see Figure 2).

Remote Ignition — This device is found on the vacuum system panel and allows one to start the vehicle's engine from near the hydraulic punch instead of walking around the vehicle and climbing into the vehicle's cab (see Figure 2).

Hydraulic Oil Cooling Switch — This switch is found on the vacuum system panel and turns on the auxiliary cooling system for the hydraulic oil (see Figure 2).

Vacuum/Volume (Vac/Vol) Pump Switch — This switch is found on the vacuum system panel and allows pressure to build up in the vacuum tank (see Figure 2).

Vacuum Line Valve — This valve is found on the vacuum system panel and opens and closes the vacuum line (see Figure 2).

Sample Line Gauge — This gauge is found on the vacuum system panel and registers the sample line pressure in inches of mercury (see Figure 2).

Drive Rod — The Geoprobe drive rod (sometimes called a probe rod) is a high-strength-steel, hollow tube with a 1-inch outer diameter. Though the rods come in 1-foot, 2-foot, and 3-foot lengths, the standard length is 3 feet. Each rod is threaded on both ends and has a male end and a female end (see Figure 3).

Drive Cap — This cap is a steel cap screwed onto the male end of the drive rod so that the rod can be pushed or hammered into the soil without damaging its threads. The drive cap is always installed to the top of the drive rod before advancing probe rods or sampling tools (see Figure 3).

Pull Cap — This cap is a steel cap that screws onto the male end of the drive rod and is used to pull the drive rod from the soil once the sample has been collected (see Figure 3).

Anvil — This piece of steel is placed inside the hydraulic punch at the point where the hammer actually makes contact. The anvil transfers the force of the hammer to the drive cap (see Figure 3).

Rotary-Impact Carbide-Tipped Drill Bit — This 18-inch or 24-inch steel drill bit fits directly into the hydraulic punch and is used to drill through concrete or hard asphalt. The bit does not spin with appreciable torque but is driven by the hammer, spinning only slightly to clear itself of debris (see Figure 3).

Chain-Assisted Pull Cap — This modified pull cap is attached to the hydraulic punch with a chain. It is most useful when the drive rod, for one reason or another, is not aligned directly underneath the hydraulic punch. With this cap, the rod can still be pulled using the punch (see Figure 3).

Rod Extractor — This tool threads onto a drive rod and is sent down into the hole made by a drive rod that has broken in the soil. The rod extractor, which looks a little like a drill bit, is then hammered into the broken rod and is used to pull the broken rod from the soil (see Figure 3).

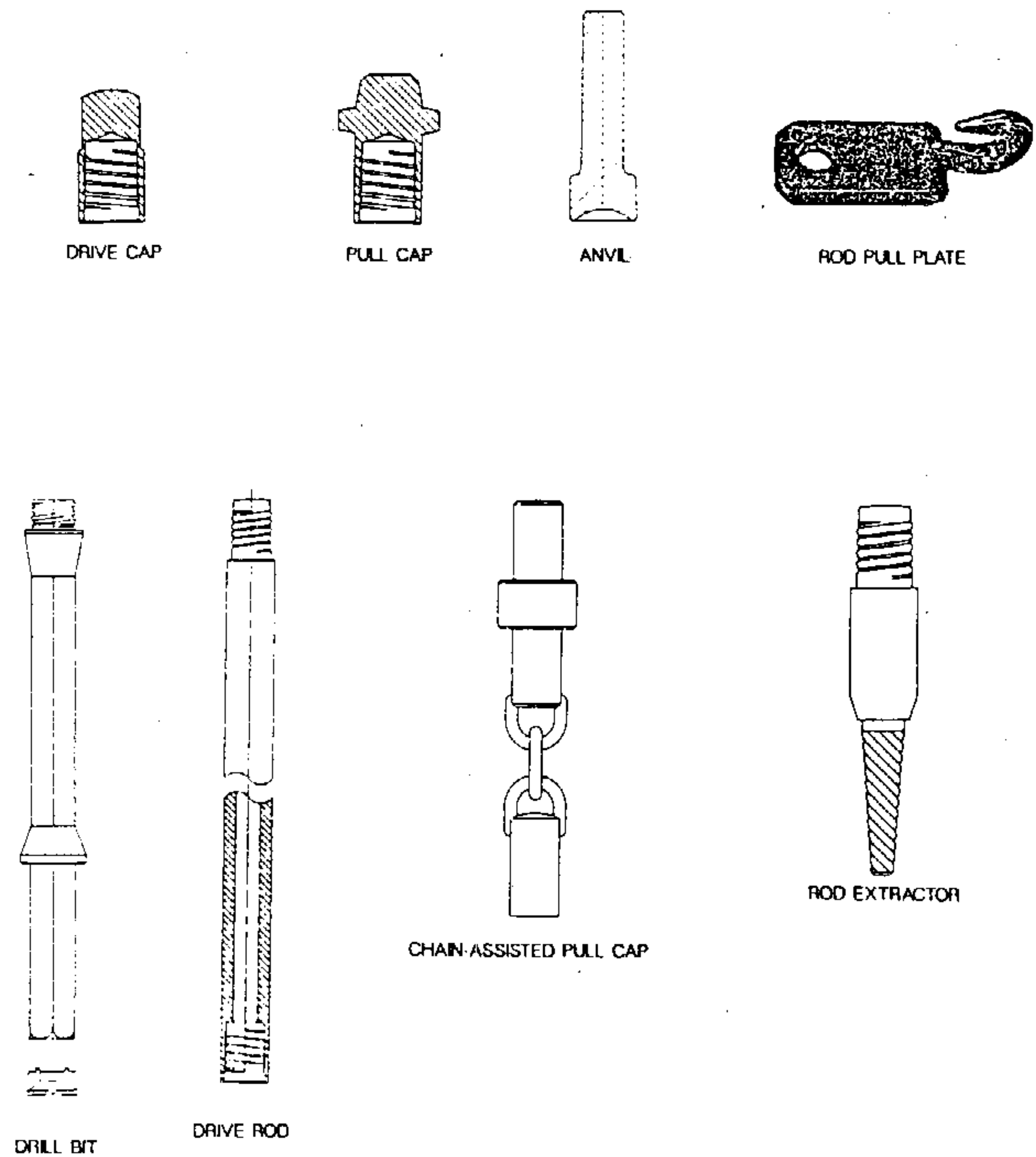
Rod Pull Plate — This steel plate has a hole in its center through which a drive rod can be fitted. It is used to extract drive rods when installing piezometers, soil gas implants, or to expose the screen to groundwater when using a screen point sampler (see Figure 3).

O-Ring — An O-ring is a rubber ring used to seal sections of drive rods or various other Geoprobe tools so that, once together, they are air- and water-tight.

Teflon Tape — This inert, sticky tape can be used to create air-tight seals when pieces of the drive rod or accessories are threaded together. The tape can replace an O-ring.

FIGURE 3

GENERAL ACCESSORY TOOLS



1.3.2 Soil Sampling Terms

These terms are usually used when discussing soil sampling using the Geoprobe System. Sometimes, though, the terms are used when discussing other sampling techniques. If terms are encountered while using this SOP that are not listed below, check Sections 1.3.1 above and Sections 1.3.3 and 1.3.4 below.

Shelby Tube — This tube is used to collect large samples of cohesive soils. Its greatest disadvantages are that it cannot be used to sample from depths greater than about 10 feet and has no mechanism to stay closed until reaching the proper depth (see Figure 4).

Shelby-Tube-Drive Head — This 2-inch diameter piece of steel attaches to the Shelby tube using hex bolts. The Shelby-tube-drive head consists of two parts: a standard 2-inch Shelby tube drive head and a Geoprobe drive rod adapter. This allows the 2-inch wide Shelby tube to be driven by the hydraulic punch, which is actually designed for 1-inch diameter drive rods (see Figure 4).

Hex Bolts — These are the bolts used to attach a Shelby tube to a drive head (see Figure 4).

Extruder Latch — This device secures the Shelby tube to the extruder rack during the extrusion process that removes the soil from the tube (see Figure 4).

Extruder Piston — This piston is threaded onto a drive rod, and with the help of the hydraulic punch, extrudes the soil sample from the Shelby tube (see Figure 4).

Probe-Drive Systems — This sampling system allows samples to be collected at deeper depths than the Shelby tube system. Each probe-drive sampler remains closed until it reaches the depth desired and then is opened by those operating the punch by removing a stop pin (see Figure 5). The sampler is then pushed through the soil at the desired depth and removed. Three types of probe-drive samplers exist: the standard sampler, the Kansas sampler, and the large bore probe-drive sampler.

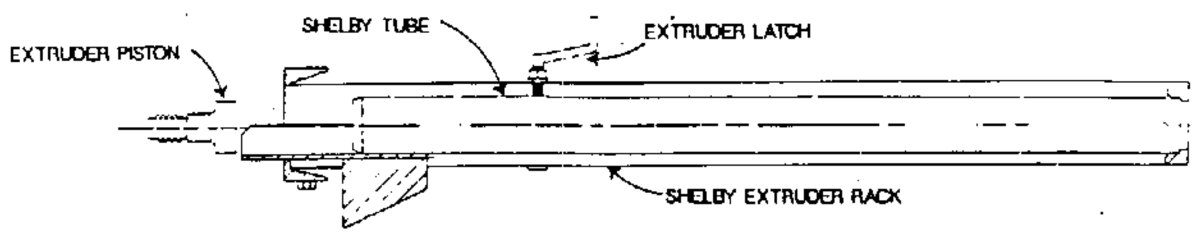
Standard Probe-Drive Sampler — This probe-drive sampler has a diameter of 1 inch and lengths of 10 or 24 inches. Its greatest difference from the other probe-drive sampler is that it does not have a removable cutting shoe (see Figure 5).

Stop Pin — This pin stops the point of a probe-drive sampler from retracting into the sampler tube. Once it is removed, the sample can be collected (see Figure 5).

Piston Rod — This rod connects the drive head of a probe-drive sampler to the sampler's point. Once the stop pin is removed, this rod slides through the sampler, allowing the point to retract inside the tube (see Figure 5).

FIGURE 4

SHELBY TUBE ACCESSORIES



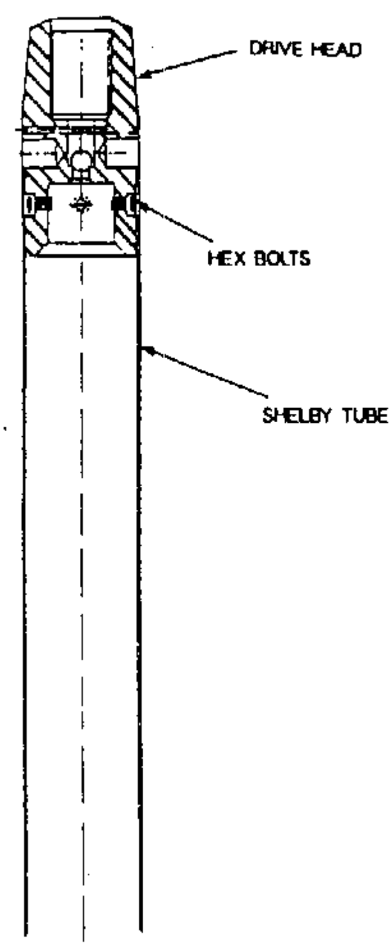
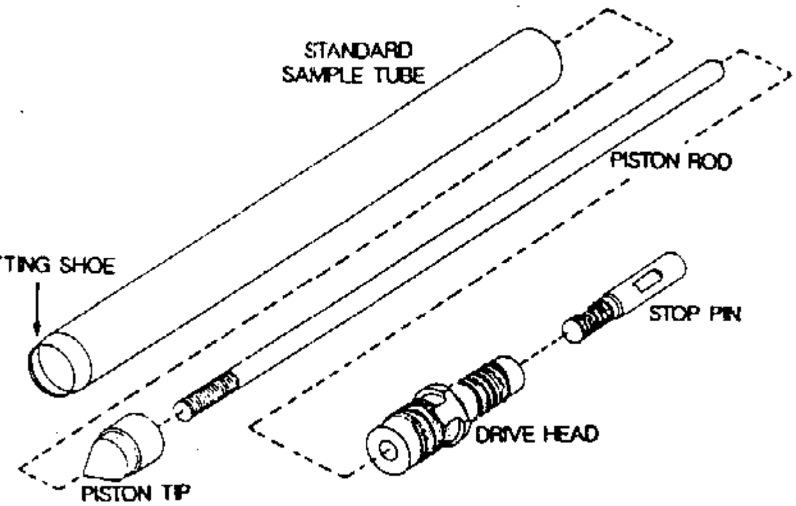
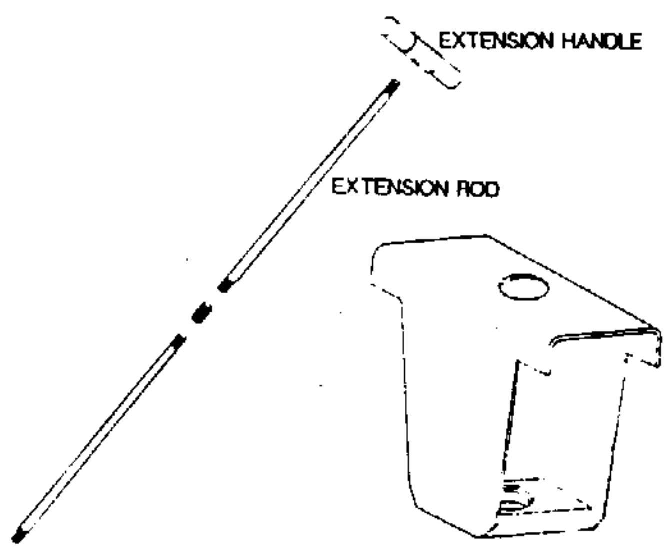


FIGURE 5

PROBE-DRIVE SYSTEM





EXTRUDER RACK

Drive Head — This head is the top of a probe-drive sampler, which allows the piston rod to slide straight up the sample tube after the piston stop has been removed and the drive rod is advanced (see Figure 5).

Cutting Shoe — This portion of the probe-drive sampler cuts through the soil once the point is allowed to retract inside. The Kansas samplers and large-bore sampler have removable cutting shoes (see Figure 5).

Extruder Rack — This device holds soil samplers in place during extrusion. The Shelby tube extruder rack is shown in Figure 4, and the standard probe-drive extruder rack is shown in Figure 5.

Extension Rod — This long, thin, threaded, solid rod is dropped through a drive rod to the probe-drive sampler so that the stop pin can be removed. Often more than one extension rod (an extension rod string) must be put together to reach the stop pin (see Figure 5).

Extension Rod Handle — This small metal handle screws to the top of the extension rod string so that it can be turned easily while being used to remove the stop pin (see Figure 5).

Large-Bore Probe-Drive Sampler — This probe-drive sampler is 1-1/8 inches in diameter and 24 inches long. Its larger width allows for the collection of larger samples. The diameter also allows for acetate or brass liners to be used in sample collection. These liners can make viewing the sample easier and preparing it for analysis simpler.

Kansas Sampler — This specially designed probe-drive sampler has a removable cutting shoe to enable easy extraction of soil and to allow the shoe to be replaced without replacing the complete sampler.

Kansas Stainless Sampler — This sampler has a stainless-steel sampling tube. It works in the same way as the Kansas sampler.

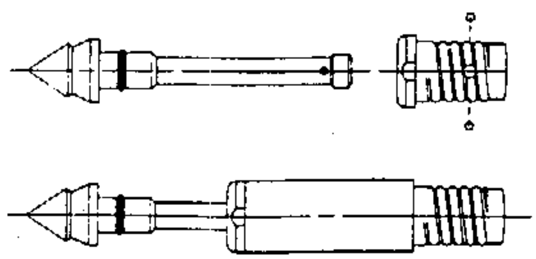
1.3.3 Soil Gas Sampling Terms

The following terms are used principally to discuss soil gas sampling. A few terms, though, are used while discussing groundwater sampling as well. If unfamiliar terms not listed below are encountered while using this SOP, check Sections 1.3.1 and 1.3.2 above and Section 1.3.4 below.

Expendable Point — These points fit into an expendable point holder that has been threaded into the lead drive rod. When the drive rod is pulled back, these points do not move with it, leaving a gap from which soil gas can be collected. The points are ultimately left in the ground (see Figure 6).

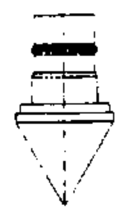
FIGURE 6

STANDARD SOIL GAS TOOLS

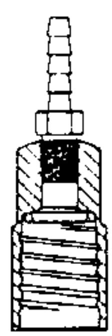


RETRACTABLE POINT HOLDER

EXPENDABLE POINT HOLDER



EXPENDABLE POINT



GAS SAMPLING CAP

Expendable Point Holder — This holder threads into the leading drive rod. It is used for driving expendable points (see Figure 6).

Retractable Point Holder — This holder lifts off its point, leaving a gap so that soil gas can be drawn, but unlike expendable points, the holder does not separate completely and ultimately is retrieved with the lead drive rod (see Figure 6).

Gas Sampling Cap — When using the standard soil gas sampling method, the gas sampling cap replaces the drive cap on top of the drive rod and allows tubing to be connected to the drive rod. A soil gas sample is drawn through the probe rod through this cap and into a sample container (see Figure 6).

Post-Run Tubing (PRT) System — This system collects soil gas drawn directly through a tube instead of through the drive rod itself. The system involves one of two specially designed point holders, each threaded on top so that an adapter that has been attached to the tube can be screwed into it after being advanced down the drive rod string. The two point holders differ in that one uses a retractable point and the other uses an expendable point (see Figure 7).

PRT Expendable Point Holder — This holder is threaded into the leading probe rod and is used for driving expendable points (see Figure 7).

PRT Adapter — The PRT adapter attaches the tubing through which the soil gas is to be drawn to the point holder, which has been driven to the proper sampling depth (see Figure 7).

Polyethylene Tubing — This tubing is the preferred tubing for connecting the PRT system to the sample container. Its stiff nature, however, sometimes makes it difficult to attach to the sample container and a coupler of Tygon tubing is necessary (see Figure 7).

Tygon Tubing — This tubing is the preferred tubing for connecting soil gas sampling containers to the drive rod and vacuum system. It often is also necessary as a coupler sample between the stiff polyethylene tubing used with PRT sampling systems and the sample container.

Glass Bulb — This bulb of glass has valves on each side and a neoprene septum through which gas can be withdrawn. The bulb is used to collect soil gas and can be used as the container in which the gas is taken for analysis (see Figure 8).

Tedlar Bag — This small bag has a valve on it. It is placed in an air-tight chamber, the air in the chamber is evacuated, and the bag fills with soil gas. The bags can then be taken for analysis.

Tedlar Bag Chamber — PRC uses these modified, air-tight kitchen containers as vacuum chambers. These chambers are modified with nipples on each side, which enable it to be attached to a vacuum pump, to a Tedlar bag, and to the Tygon tubing.

FIGURE 7

POST-RUN TUBING (PRT) SYSTEM

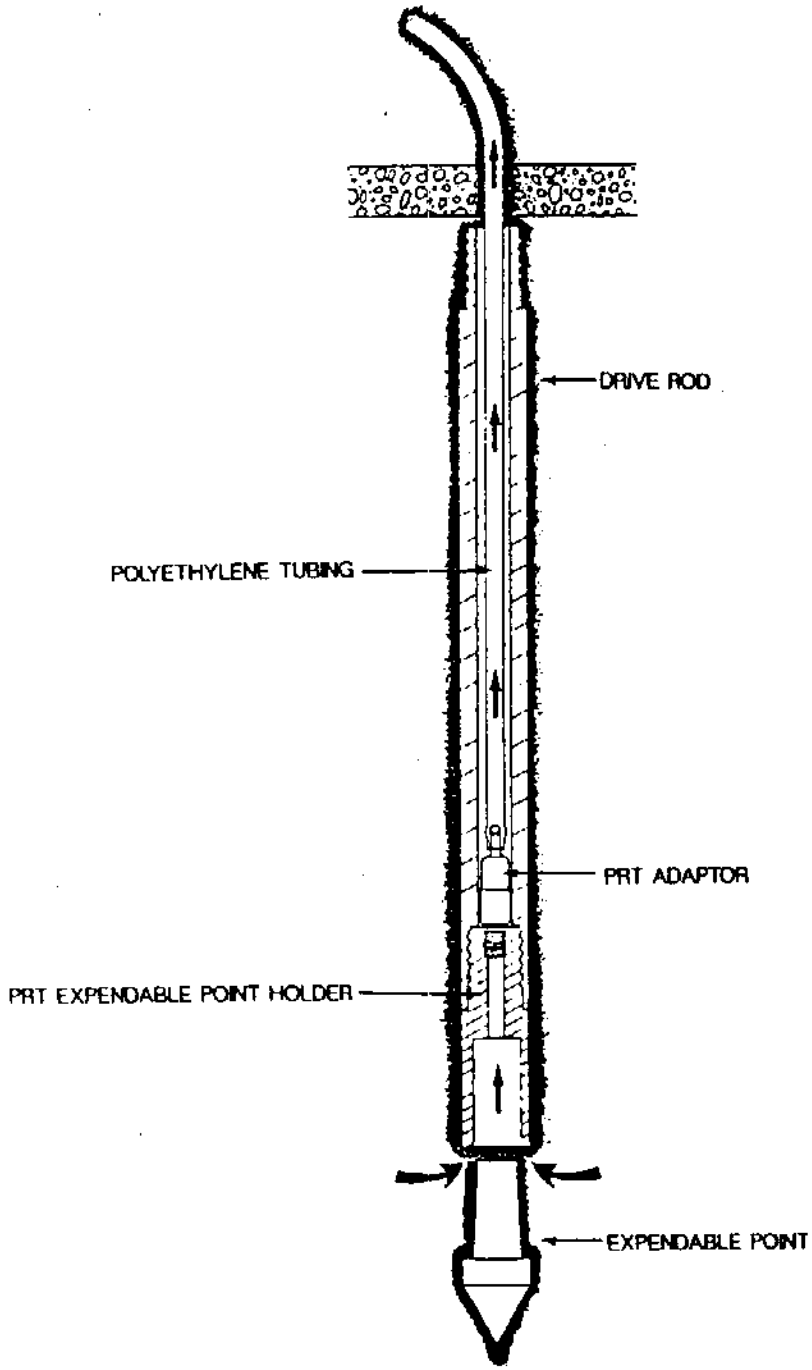
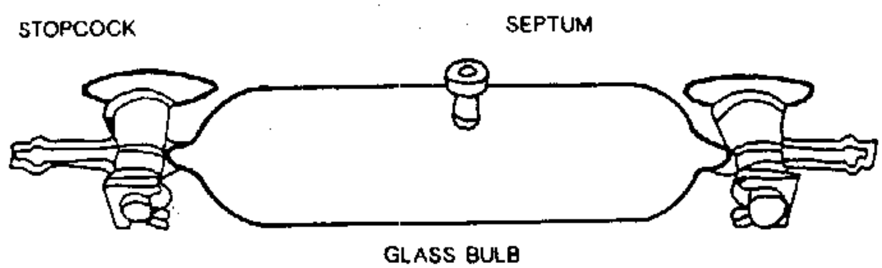


FIGURE 8

SOIL GAS SAMPLE CONTAINER



NOTE: TEDLAR BAGS ARE ALSO USED FOR COLLECTION OF SOIL GAS SAMPLES HOWEVER, THEY ARE NOT SHOWN ON THIS FIGURE

1.3.4 Groundwater Sampling Terms

The following terms are used to discuss groundwater sampling. If unfamiliar terms not listed below are encountered while using this SOP, check Sections 1.3.1, 1.3.2, and 1.3.3 above.

Mill-Slotted Well Point — This 3-foot long tube has 15 mill-cut slots in it, each 2 inches long and 0.020 inches wide. Only the bottom 2 feet of this tube is slotted, and sometimes mill-slotted well points come in two parts: a 2-foot slotted section and a 1-foot unslotted section. The slots allow groundwater to enter (see Figure 9).

Geoprobe Screen Point Sampler — This sampler has a 19-inch screen that encases a perforated stainless-steel sleeve. Once in place, the screen allows the water to enter the tube and prevents coarse sediment from entering the tube (see Figure 9).

Thieving Tube — This tube is used to extract the water from either mill-slotted well points or Geoprobe screen point samplers, PRC uses polyethylene tubing as thieving tubes. This tubing is lowered into the water, capped on top, and then extracted. The result is much like putting a straw into a glass of water, sealing the straw with a finger and lifting it. This method is used primarily for the collection of groundwater samples to be analyzed for volatile organic compounds. A check valve can also be attached to the thieving tube which seals the bottom and holds the groundwater within the tube.

Check Valve — This stainless steel valve has a small ball which, when attached to a thieving tube, floats to the top of the groundwater table and then sinks, ultimately sealing the thieving tube with groundwater. Oscillating the thieving tube will allow groundwater to rise within the tube for larger retrieval volume.

Well Mini-Bailer — This specially designed bailer drops through the drive rods and into the groundwater in the mill-slotted well point or screen point. A small ball in the bailer floats to the top and then sinks, ultimately sealing the bailer after it fills with about 40 milliliters of groundwater.

1.4 REFERENCES

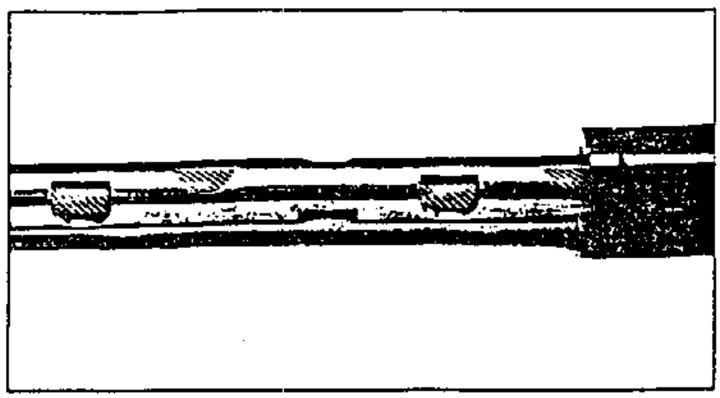
The following references were used to prepare this SOP:

Driscoll, F.G. 1987. *Groundwater and Wells*. Second Edition. Johnson Division. St. Paul, Minnesota.

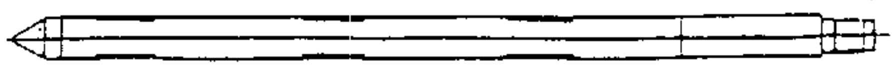
Fisher Scientific. 1991. "The Fisher Catalog of Scientific Instruments."

FIGURE 9

GROUNDWATER SAMPLING TOOLS



SCREEN POINT SAMPLER IN OPEN POSITION



MILL-SLOTTED WELL POINT

Geoprobe Systems. 1990. "8-M Operations Manual." July 27.

Geoprobe Systems. 1991. "Accessory Tools Catalog."

Geoprobe Systems. 1992. "Equipment and Tools Catalog."

2.0 POSITIONING, PREPARING AND SAMPLING PROCEDURES

The Geoprobe System uses a hydraulic punch that is usually installed in the back of a van or truck to first push and then to hammer its hollow drive rod through soils. Depending on which tools are attached to the end of the drive rod and which sampling equipment is attached to it, the Geoprobe can be used to remove soil, soil gas, or groundwater. It can also be used to drill through cement or concrete and can aid in the installation of piezometer wells and vapor sampling implants. The following sections detail the procedures for positioning the Geoprobe unit, preparing the sampling system, and sampling with the Geoprobe unit.

2.1 POSITIONING THE GEOPROBE UNIT

Before the Geoprobe System can be used, the Geoprobe hydraulic punch and accessories must be properly positioned near the sampling site. The hydraulic punch and other equipment also needs to be prepared. In cases where concrete or other hard surfaces hinder sampling, the Geoprobe must be used to reach soil. This section details methods to perform these activities.

To position and unload the Geoprobe System use the following procedures:

1. Drive the vehicle containing the Geoprobe System to the sampling location and align the center of the rear of the vehicle with the point at which the sample will be taken. The rear bumper should be 1 to 2 feet from the sampling point so that the foot of the hydraulic punch can be extended out over it.

2. Shut off the vehicle.

3. Put it in park.

4. Set the emergency brake before proceeding.

5. One person only should operate the hydraulic punch and the assembly and disassembly of probe rods and accessories. A second person is usually necessary to handle the samples and to decontaminate equipment. All personnel present must wear steel-toed shoes, gloves, and eye protection. When drilling through concrete or using the hydraulic hammer, ear protection is also necessary.

6. Once ready to take the sample, start the engine using the remote ignition located in the right rear of the vehicle. As a safety device, the remote ignition will not work unless the vehicle is in park.

7. Activate the hydraulic system by turning on the electrical control switch. The vehicle's engine must be running for the hydraulic system to work.

8. Slowly extend the Geoprobe out of the vehicle using the extend lever. Always use the slow speed on the hydraulic controls when positioning the hydraulic punch. The punch and mast should be far enough out of the van or truck so that the mast will not strike the roof when it is unfolded.

9. Unfold the hydraulic punch out of the vehicle using the fold lever. Once the punch has been lined up perpendicular to the ground surface, lower the foot of the punch using the foot lever until the vehicle itself is raised about 1 foot on its springs. This stabilizes the vehicle and punch. **Never lift the vehicle completely off the ground using the foot lever.** Doing so destabilizes the vehicle and hydraulic punch and may cause damage to equipment or injury to those nearby. Also, as pressure is placed on the rod, tools, and accessories, the foot of the punch may begin to lift. Do not allow it to lift farther than 6 inches from the ground. Allowing it to lift farther than 6 inches may throw the vehicle off balance and cause the rod to bend or break.

The Geoprobe System is now positioned. If it is necessary to drill through concrete or hard asphalt, use the following procedures:

1. Raise the hydraulic punch using the probe lever and then deactivate the hydraulic system by turning the electrical control switch to off. The hydraulic system should always be turned off when the hydraulic controls are not being used.

2. Place the drill bit into the hydraulic hammer. The bit is not used with a drive rod or anvil.

3. Activate the hammer rotation control knob, which is located on the hydraulic hammer, by turning the knob counter-clockwise. This allows the drill bit to rotate when the hammer lever on the control panel is pressed.

4. Activate the hammer release valve, which is located on the hydraulic hammer, by pulling the lever out and down.

5. To drill through solid surfaces, both the probe and hammer mechanisms of the hydraulic punch must be used. The hammer mechanism drives the drill bit in a percussion fashion and causes it to turn slightly. The probe mechanism allows the hammer and bit to be raised and lowered so that the bit can clear itself of debris. Once ready to begin, turn on the hydraulic system.

6. Fully depress the hammer lever. This lever needs to remain depressed throughout the drilling procedure and keeps the bit pounding and rotating.

7. Put pressure on the bit by pressing the probe lever down. Using this lever, advance the bit in small increments through the concrete or other hard surface. If advanced too quickly, the bit will bind and stop rotating. Should this happen, raise the punch slightly to allow the bit to rotate. If too little pressure is placed on the bit, too little percussion will occur, and drilling will be slow.

8. Continue drilling, in small increments, until soil has been reached. At that time prepare for sampling.

2.2 PREPARING THE SAMPLING SYSTEM

Before the hydraulic punch is used to sample, decisions must be made concerning which type of sample will be taken, whether several samples will be taken at varying depths, and which type of Geoprobe sampling equipment will be used. The following sections discuss preparation procedures for soil sampling, soil gas sampling, and groundwater sampling.

2.2.1 Soil Sampling

The samplers attached to the hydraulic punch for soil sampling come in two forms. The first type is the 2-inch diameter Shelby tube system that is common to other soil sampling methods. The second system uses various specially designed probe-drive systems that remain completely sealed while being pushed or driven to a particular depth. They then are opened to allow a sample to be collected. The Shelby tube and probe-drive systems are discussed below.

Shelby Tube System

The Shelby tube is a thin-walled steel tube, 2 inches in diameter and 30 inches long, with four mounting holes around its top. It allows large amounts of soil to be sampled at once, but the soil must be relatively cohesive. Because the tube remains open at all times, the tube cannot be driven to great depths and must be removed and replaced after coring 30 inches of soil. Usually, the Shelby tube system is chosen when large amounts of soil are needed at depths no deeper than 10 feet. Rocky or sandy soils are not conducive to this sampling method.

To prepare for sampling using Shelby tubes, use the following procedures:

1. First attach a Shelby tube to the Shelby-tube-drive head by putting the head's hex bolts through the holes in the tube.

2. Next, screw a Geoprobe drive rod adapter into the top of the drive head to allow the 2-inch-wide Shelby tube to be driven by the hydraulic punch and hammer, which are actually made for 1-inch outer diameter drive rods.

3. A drive cap is then screwed onto the top of Geoprobe drive rod adapter. The tube is now ready to be attached to the hydraulic punch.

4. To attach the tube, raise the hydraulic punch using the probe lever and then turn off the Geoprobe hydraulic system.

5. Lift the hammer latch and insert the anvil inside.

6. Place the assembled Shelby tube sampler so that it is aligned under the anvil.

The hydraulic punch is now ready to drive a Shelby tube and collect a sample core. For collecting soil cores at depths of greater than 30 inches, attach sections of probe rod to an assembled Shelby tube sampler and drive the sampler down the same hole using a new Shelby tube for each 30-inch increment in depth.

Probe-Drive Systems

All of the probe-drive systems work in essentially the same way. A sampler is attached to a hollow drive rod, inserted into the hydraulic punch, and punched or hammered into the soil. Once the sampler reaches the depth at which the sample is to be taken, a stop pin in the sampler is removed using an extension rod that has been dropped through the inside of the hollow drive rod. The release of the stop pin allows the point of the sampler to retract inside the sample tube as the sampler is further advanced into the soil. The probe is then punched through the soil where the sample is to be taken. The rod and probe are then pulled to the surface for sample extraction.

Currently, three types of samplers are used in the probe-drive systems: the standard probe-drive sampler, the Kansas sampler, and the large bore probe-drive sampler. Preparation of each is slightly different. Each is discussed separately below.

Standard Probe-Drive Samplers

The standard probe-drive sampler comes in 10- and 24-inch lengths. The proper length is determined by the size of the sample desired. The point of this sampler is connected to a piston rod that will slide through its length. At its top, the piston rod is connected to the drive head, which keeps it centered and holds the piston stop pin, which stops the piston from sliding.

To prepare the standard probe-drive sampler, use the following procedures:

1. Insure that the sampler is assembled and complete, and that the piston stop pin which is reverse threaded is tightly locked so that the sampler point will not slide into the sampling tube.

2. Attach a shortened Geoprobe drive rod to the sampler so that the total length is nearly the standard 3 feet. If the 10-inch sampler is used, a 2-foot drive rod should be attached, and if the 24-inch sampler is used, a 1-foot drive rod should be attached.

3. Screw a drive cap onto the top of the shortened drive rod. The sampler is now ready for attachment to the hydraulic punch.

4. To insert the probe-drive sampler, raise the hydraulic punch using the probe lever, and then turn the hydraulic system off.

5. Lift the hammer latch and insert the anvil inside.

6. Place the assembled standard probe-drive sampler and shortened drive rod directly under the anvil so that the drive cap touches the anvil and the point of the sampler is aimed at the place where the sample is to be taken. The standard probe-drive sampler and the hydraulic punch should both be vertical.

Kansas Samplers

The Kansas sampler is much like the standard probe-drive sampler. However, it has a removable hardened cutting shoe near its point that allows it to penetrate rockier soils and to be easily replaced and decontaminated. Kansas samplers come in two versions: the Kansas Stainless Sampler, which has a stainless-steel tube, and the Kansas Sampler, which has an alloy steel tube.

To prepare a Kansas sampler, use the following procedures:

1. Ensure that the hardened cutting shoe is in place.

2. Assemble and install the Kansas sampler in the same manner as the standard probe-drive sampler (see Procedures 2 through 7 above).

Large Bore Samplers

The large bore sampler, similar to both types of Kansas samplers, has a removable cutting shoe and works in the same manner. It is slightly larger than the Kansas samplers, usually 24 inches long and 1-1/8 inches wide. The larger bore allows for the use of acetate or brass liners. The soil, therefore, can be removed easily by removing the liner. The acetate liner allows for easy visual examination of the core and can be easily sliced away so that the sample can be prepared for the laboratory. The brass liners come in four 6-inch sections that allow for easy separation and packaging of 6-inch soil samples. Some laboratories accept full 6-inch brass liners, allowing the samples to be collected with a very minimal disturbance to the soil matrix.

To prepare a large-bore sampler, use the following procedures:

1. Place the desired liner into the sampler by unscrewing the cutting shoe and sampler drive head from the two ends and then inserting the liner.

2. Assemble the sampler and attach a 12-inch drive rod to the sampler.

3. Screw a drive cap onto the top of the drive rod.

4. Place the assembled sampler and drive rod under the hydraulic punch in the manner detailed in the section above for preparing standard probe-drive samplers (see Procedures 5, 6, and 7 above).

2.2.2 Soil Gas Sampling

Two main methods are used to collect soil gas using the Geoprobe system: the standard method and the PRT system.

To use the standard method, the drive rods are decontaminated and assembled in an air-tight manner as they are punched into the soil. To ensure an air-tight seal, either Teflon tape or an O-ring can be placed on the male threads of the drive rods. The probe rods are driven approximately 6 inches below the area from where the sample is to be taken. The rods are then lifted approximately 6 inches leaving the expendable point and a small opening between the point and the end of the rod behind. A gas sampling cap is then attached to the top of the rod, a vacuum pump removes the necessary volume of gas, and the sample is collected.

To collect soil gas samples using the PRT system, polyethylene tubing attached to a stainless steel adapter is pushed through the drive rod after the rod is in place. The tubing and adapter is then reverse threaded onto the top of the PRT expendable point holder, and the gas is collected through the tubing. This method increases the accuracy of soil gas sampling, eliminates the potential for leaks in the rod, and simplifies probe rod decontamination.

Standard Method

Only decontaminated drive rods can be used with the standard method. Rods should be decontaminated using the procedures in Section 6.0 of this SOP.

To prepare a decontaminated drive rod for soil gas sampling using the standard method, use the following procedures:

1. Screw an expendable point holder into the female end of a 3-foot drive rod. (Note: a retractable point can also be used with this method; however, decontamination requirements almost always preclude its use.)

2. Place an expendable point into this holder.

3. Screw a drive cap onto the male end of the drive rod.

4. Place the rod into the hydraulic punch.

5. Turn on the hydraulic system.

6. Install the anvil within the hydraulic punch's hammer by lifting the hammer latch and inserting it.

7. Place the assembled drive rod directly under the anvil so that the drive cap faces the anvil and the expendable point is aimed at the desired sampling location.

8. Push sampler and hydraulic punch through the soil to gather the sample.

PRT System

Two types of PRT systems are available. The first uses an expendable point holder and expendable point like the standard method. The second uses a retractable point holder that lifts off of the drive-point without actually separating from it. Both systems allow the threading of a PRT adapter and tubing through the drive rod so that the gas can be taken from the depth required without being sucked through the drive rod.

To prepare the drive rod and sampler for PRT soil gas sampling, use the following procedures:

1. Select the desired PRT sampler (either one with an expendable point or one with a retractable point) and ensure that the PRT adapter easily screws into the threads on top of the sampler. This step is necessary to ensure that the adapter will fit easily when it is affixed from above ground.

2. If using the sampler with an expendable point, attach the point.

3. Screw the sampler to the end of a shortened drive rod so that the total length of the sampler is nearly 3 feet.

4. Screw the drive cap to the other end of the drive rod.

5. Attach the drive rod and sampler to the hydraulic punch using the same procedures detailed in the standard method (see Procedures 4, 5, and 6 above).

2.2.3 Groundwater Sampling

The Geoprobe System offers two systems for collecting groundwater, each with several groundwater sampling options. The first method involves the use of a mill-slotted well point. The second method uses a specially designed Geoprobe screen point sampler.

<u>Mill-Slotted Well Points</u>

The mill-slotted well point is a 2- or 3-foot length of hollow steel tubing with 15-millcut slots in it, each 2 inches long and 0.020 inches wide. Once in place, groundwater enters the tube through these slots. To prepare the mill-slotted well point, use the following procedures:

1. Screw a solid drive point into the female end of the sampler.

2. If a 2-foot well point is being used, screw the sampler to a 1-foot length of drive rod.

3. Screw a drive cap to the other end of the well point or 1-foot drive rod.

4. Place the sampler and rod into the hydraulic punch by raising the punch as much as necessary and turn hydraulic system off.

5. Install the anvil within the hydraulic punch's hammer by lifting the hammer latch and inserting it.

6. Place the mill-slotted well point sampler under the anvil with the drive cap near the anvil and the point aimed at the sampling location.

<u>**Geoprobe Screen Point Sampler**</u>

The Geoprobe screen point sampler has a 19-inch screen encased in a perforated stainless-steel sleeve. The screen remains encased in the sleeve until the screen point sampler reaches the desired depth. The rod is then pulled back approximately 19 inches, leaving the screen exposed to the formation. Flexible tubing can be pushed through the drive rod and attached to the sampler using the adapters for the PRT soil gas system, enabling groundwater to be removed without touching the drive rod. Decontaminating the drive rod is subsequently easier.

To prepare a Geoprobe screen point sampler, use the following procedures:

1. Close the screen on the sampler.

2. Attach its expendable point.

3. Attach the sampler to a shortened drive rod so that the assembly is nearly 30 inches long.

4. Place the sampler into the hydraulic punch using the methods detailed for mill-slotted well points (see Procedures 4, 5, and 6 above).

2.3 SAMPLING

Sampling procedures for the Geoprobe hydraulic punch are similar for all samplers and sampling media. This section presents general procedures that apply to all samplers and sample types, and specific operating procedures for soil, soil gas, and groundwater.

2.3.1 General Procedures

All control panel switches have a slow and fast position. All switches should initially be set at the slow position when positioning the punch and the sampling tools. In all cases, the hydraulic system should be shut off when not in operation and when adapters and additional drive rods are put into place. The hydraulic punch should be turned off any time it is not actually in operation.

The Geoprobe hydraulic punch is designed with a key safety feature that will shut it off if the controls are released. If the operator senses that something is wrong, he or she must release the controls and stop operating the punch until all is well. At no time should the foot of the punch be allowed to lift higher than 6 inches off the ground because the punch will destabilize and may bend the drive rod or sampling tube.

Also, at no time should part of a human body be placed on top of a drive cap while the cap is near the anvil or under the foot of the hydraulic punch.

Once the assembled sampler or drive rod is under the anvil, both it and the hydraulic punch should be vertical. Positioning the drive rod and sampler is critical in order to drive the rod vertically. Not positioning the sampler or drive rod vertically will result in problems when attaching subsequent drive rods needed to reach the proper depth and with rod retrieval.

To begin probing in soils of normal texture, use the following procedures:

1. Activate the hydraulic punch and push down on the probe lever on the control panel so that the probe slowly lowers itself. Always use the slow control on the first rod or sampler.

2. Continue to press on the probe lever until the rod or sampler is completely forced into the soil. The point of the rod will then be nearly 3 feet into the soil.

Soils and other materials are often too hard for the hydraulic punch's probe mechanism to penetrate. When,this occurs, the hammer on the hydraulic punch should be used in accordance with the following procedures:

1. Ensure that the hammer rotation valve is closed.

2. Use the hydraulic punch to put pressure on the rod, sampler, and soil. When the probe rod refuses to move, the foot of the hydraulic punch will begin lifting off the ground. Never allow the foot to lift more than 6 inches off the ground, but never use the hammer with the foot resting on the ground surface.

3. If the probe foot lifts off the ground, the hydraulic punch may no longer be perpendicular. If this occurs, use the machine's fold lever, which is located on the control panel, to correct the punch's position.

4. Press the hammer lever on the control panel. The rod should now advance. Never use the hammer unless there is downward pressure on the drive cap because doing so may damage the equipment.

5. Stop hammering periodically and check to see if the probe rods can be advanced using the probe mechanism only.

When samples are to be taken at depths of greater than 3 feet, additional drive rods must be added to those already in the ground. Shelby tube soil sampling procedures for adding rods are discussed in Section 2.3.2. For all other sampling methods, use the following procedures to add drive rods:

1. Using the probe lever, raise the hydraulic punch off the portion of the drive rod protruding from the ground.

2. Unscrew the drive cap from the drive rod.

3. If using the standard method of collecting soil gas or other sampling methods that will draw the sample through the length of the entire drive rod, wrap the threads of the drive rod with Teflon tape or push an O-ring over the threads to make the drive rod string air- and water-tight.

4. Screw another drive rod onto the first drive rod protruding from the ground. Tighten the rods together with a pipe wrench.

5. Screw a drive cap onto the top of the new drive rod.

6. Place the hydraulic punch over the new drive rod and push the rod farther into the ground.

As the rod string is pushed farther into the ground, it will sometimes begin to loosen. The rods should remain tight so that the threads are not damaged. Occasionally, stop probing and twist the rod string with a pipe wrench to ensure that all of the joints remain tightly sealed.

2.3.2 Soil Sampling

This section presents procedures used to sample soils using either the Shelby tube sampling method or any of the probe-drive systems. In all cases, sampling tools should never be advanced farther than their length once they are opened because the sampler will overfill. If the sampler overfills, it could be damaged or expand, causing it to fall off the drive head.

<u>Shelby Tube Sampling Procedures</u>

Because the Shelby tube does not remain closed until it reaches the desired sampling depth and because it is not connected to a drive rod but to a Shelby drive head, sampling procedures for Shelby tubes differ greatly from soil sampling with other methods. New drive rods cannot be continuously added. Sampling at depths of greater than 30 inches requires a step-like procedure. For example, to sample to a depth of 90 inches, three Shelby tubes are needed. The first is advanced from 0 to 30 inches and then removed. The second is pushed through the hole made by the first and advanced to a depth of 60 inches and removed. The third is also pushed through the 60-inch deep hole and advanced from 60 to 90 inches.

Samplers must be ready to change sampling methods if necessary. For example, if soils are not cohesive, they tend to drop out of the Shelby tube as it is pulled from the ground. Also, if the soils are not cohesive, they tend to collapse into the hole left by the initial tube before the second and third tubes can be pushed into place. For this reason, use of the Shelby tube method is impractical at depths of greater than 10 feet. Rocky soils are also difficult to sample with a Shelby tube sampler because they tend to destroy the sampler while it is being driven into the ground.

To sample using the Shelby tube method, use the following procedures:

1. Turn on the hydraulic system and slowly press the Shelby tube into the soil using the probe lever on the control panel.

2. Once the tube has reached the sampling depth or has been extended to nearly its full 30-inch length, stop the hydraulic punch and raise it off the drive cap and Shelby tube drive head.

3. Unscrew the drive cap.

4. Screw on a pull cap.

5. Lower the hydraulic punch and lift the hammer latch. Remove the anvil. Place the latch around the pull cap so that the latch will hold the cap to the hydraulic hammer.

6. Using the probe lever, raise the hydraulic punch to pull the Shelby tube from the ground.

If the desired sampling depth is greater than 30 inches, additional Shelby tubes and probe rods must be used. The tubes are then prepared for probing using the methods presented in Sections 2.2.1 and 2.3.1 above. To advance the Shelby tube deeper, the tubes are pushed through the hole left by the first tube using the method detailed above.

Once a Shelby tube core has been retrieved from a sampling point, it must be extruded from the Shelby tube sampler using the following procedures:

1. Lower the hydraulic punch using the probe lever so that its mast will not strike the top of the van as it is folded.

2. Lift the foot of the hydraulic punch using the foot lever.

3. Slowly and carefully fold the hydraulic punch using the fold lever.

4. Once the punch is horizontal, the Shelby tube extruder bracket can be placed onto the punch's foot. This bracket will hold the Shelby tube in place and allow the punch to push the soil out of the tube.

To sample using the Shelby tube method, use the following procedures:

1. Turn on the hydraulic system and slowly press the Shelby tube into the soil using the probe lever on the control panel.

2. Once the tube has reached the sampling depth or has been extended to nearly its full 30-inch length, stop the hydraulic punch and raise it off the drive cap and Shelby tube drive head.

3. Unscrew the drive cap.

4. Screw on a pull cap.

5. Lower the hydraulic punch and lift the hammer latch. Remove the anvil. Place the latch around the pull cap so that the latch will hold the cap to the hydraulic hammer.

6. Using the probe lever, raise the hydraulic punch to pull the Shelby tube from the ground.

If the desired sampling depth is greater than 30 inches, additional Shelby tubes and probe rods must be used. The tubes are then prepared for probing using the methods presented in Sections 2.2.1 and 2.3.1 above. To advance the Shelby tube deeper, the tubes are pushed through the hole left by the first tube using the method detailed above.

Once a Shelby tube core has been retrieved from a sampling point, it must be extruded from the Shelby tube sampler using the following procedures:

1. Lower the hydraulic punch using the probe lever so that its mast will not strike the top of the van as it is folded.

2. Lift the foot of the hydraulic punch using the foot lever.

3. Slowly and carefully fold the hydraulic punch using the fold lever.

4. Once the punch is horizontal, the Shelby tube extruder bracket can be placed onto the punch's foot. This bracket will hold the Shelby tube in place and allow the punch to push the soil out of the tube.

4. Insert an extension rod into the drive rod and screw additional extension rods together until the assembly reaches the same depth as the sampler.

5. Attach a small extension rod handle to the top of the extension rod.

6. Rotate the extension rod handle clockwise until the leading extension rod has turned the stop pin and disengaged it.

7. Pull and unscrew each extension rod from the hollow drive rod. The stop pin should be attached to the bottom of the extension rod string. If not, repeat Procedures 1 through 6.

8. To sample, mark the drive rod with tape or chalk about 10 inches above the ground if a 10-inch sampler is used or 24 inches from the ground if a 24-inch sampler is used.

9. Replace the drive cap and start the hydraulic system.

10. Drive the rod until the tape or chalk mark touches the ground. Be careful not to overdrive the sampler. Doing so could compact the soil in the sampler or cause it to balloon outward, making soil removal and extrusion difficult.

11. Raise the hydraulic punch and replace the drive cap with the pull cap. Remove the anvil.

12. Latch the pull cap underneath the hydraulic hammer latch and pull the rods out of the ground, disassembling the rod as needed.

13. Check to ensure that a soil sample is now in the sampler.

Once a soil sample has been removed from the ground, it can be extruded using the Geoprobe. The tools supplied by Geoprobe Systems for extruding soil from probe-drive samplers do not require the Geoprobe to be folded and horizontal. If liners are used with large-bore samplers, extrusion is usually unnecessary. When extrusion is necessary for probe-drive samplers, use the following procedures:

1. Raise the foot of the hydraulic punch off the ground using the foot lever on the control panel.

2. Attach the extruder rack onto the foot of the punch so that its crossbeam rests on top of it.

3. Completely disassemble the sampler. In all cases, remove the piston, point, and drive head of the sampler. If using the Kansas and large-bore samplers, unscrew the removable cutting shoe as well.

4. Insert the sample tube into the extruder with its cutting end up.

5. Insert a disposable wooden dowel or the reusable steel piston above the soil and below the hydraulic punch so that pressure on the dowel or piston from the punch will push the soil out of the bottom of the sample tube.

6. Position proper sampling jars or trays under the sample tube and very slowly use the probe lever to force the soil out of the tube. Injury can result if the soil is quickly forced from the tube.

The soil sample is now ready for packaging or on-site laboratory analysis. For large-bore samplers, the soil may be contained in a plastic sleeve that can be sliced away once the soil is to be packaged or in a brass sleeve that may be capped on both ends and shipped to the laboratory as is. PRC's SOPs on packaging and documenting samples for analysis should be followed when collecting samples using the Geoprobe System.

2.3.3 Soil Gas Sampling Procedures

The standard method and the PRT system are used for collecting soil gas using the Geoprobe System. The standard method requires the drive rods to be sealed together with either O-rings or Teflon tape to ensure an air-tight seal so that soil gas from depths other than the bottom of the drive-rod string cannot penetrate the system.

The PRT system draws soil gas through continuous tubing that is dropped through the drive rod after the drive rod has reached the desired level. The tubing is then attached directly to the point holder at the end of the drive-rod string.

For both methods, the drive rod should be driven to the desired depth. The drive cap should be replaced by the drive pull cap, and the rod should be pulled back out of the hole approximately 6 inches. This 6-inch void is the area where the soil gas sample is collected from. A pipe wrench or vise-grip pliers should be attached to the pipe just above the foot of the hydraulic punch so that the wrench or pliers rests on the foot to stop the drive rod from working its way back down into the hole.

Tygon tubing should be replaced between each sample for both sampling methods to avoid cross contamination.

The standard method and the PRT system sampling procedures are presented below. In addition, procedures for collecting soil gas in Tedlar bags, glass bulbs, and adsorption tubes is also presented below.

Standard Method

To gather a sample using the standard method, raise the hydraulic punch as mentioned above and replace the drive cap with a gas sampling cap. This cap is designed to fit the drive rods and is used to connect them by tube to a vacuum supply. Once the tubing has connected the gas sampling cap to the vacuum supply, remove the volume of air necessary to ensure that none of the gas being drawn was in the rod during probing, and then collect the sample in either Tedlar bags, glass bulbs, or adsorption tubes as discussed below.

PRT System

To use the PRT system (with either an expendable or a retractable point) to collect soil gas samples use the following procedures:

1. Secure the PRT adapter to the end of a piece of polyethylene tubing 1 to 2 feet longer than the total length of the drive-rod string. The adapter must fit tightly within the tubing. If it does not, tape it into place. Also, ensure that the O-ring is in place on the threaded end of the adapter.

2. Remove the drive cap from the probing rod and lower the adapter into it, holding on to the tubing.

3. Grasp the excess tubing and apply downward pressure. Turn the tubing counter-clockwise to engage the adapter threads on the sampler holder.

4. Pull up lightly on the tubing to test engagement of threads. If the adapter has not engaged, try again. If it repeatedly does not engage, soil may have intruded into the drive rod either during probing or, in the case of the retractable point, when the rod was pulled back to leave the point opening. Use the threaded extrusion rods to clean out the threads.

5. In most cases, the adapter will easily screw into place. The sampler is now ready to collect samples in either Tedlar bags, glass bulbs, or adsorption tubes using the procedures presented below. After the sample is collected and the sampler and tube is removed from the ground, the O-ring should be checked to ensure that a good seal exists between the sampler and adapter. If the O-ring is tightly smashed, the seal should be good.

6. Discard polyethylene tubing and use new polyethylene tubing for each sample.

<u>Tedlar Bags</u>

Soil gas can be collected for chemical analysis in a 500-cubic-centimeter Tedlar gas sampling bag by inducing a vacuum on the exterior of the bag. The following procedures should be used to collect soil gas samples in Tedlar bags:

1. For the PRT system, connect a short (6- to 12-inch) piece of Tygon tubing to the free end of the polyethylene tubing protruding out of the drive rod. For the standard method, connect the Tygon tubing to the soil gas sampling cap.

2. Attach the other end of the Tygon tubing to one end of the Tedlar bag chamber. PRC uses modified, plastic, air-tight kitchen containers for these chambers. They are inexpensive and work well.

3. Connect another piece of Tygon tubing 2 feet to 3 feet long to the other end of the Tedlar bag chamber and to the nipple on the bottom of the vacuum system panel.

4. Place the lid on the Tedlar bag chamber.

5. Turn the vacuum/volume (vac/vol) pump switch on and allow pressure to build in the vacuum tank. Make sure that the vacuum line valve is closed before turning on the pump switch.

6. Open the vacuum line valve and purge three times the volume of ambient air out of the Tedlar bag chamber and PRT tubing or probe rods. The equations for determining purge volumes are as follows:

   Probe rods or tubing

   $$V = \pi r^2 H$$

   where

   V = Volume
   π = 3.14159
   r = Radius of tube or rod
   H = Length of tube or rod

   Vacuum chamber

   $$V = LWH$$

   where

   V = Volume
   L = Length of chamber
   W = Width of chamber
   H = Height of chamber

7. Close the line valve.

8. Clamp the Tygon tubing shut with hemostats.

9. Remove the lid from the Tedlar bag chamber.

10. Connect a Tedlar gas sampling bag to the fitting inside the Tedlar bag chamber and open the valve on the gas sampling bag.

11. Place the lid back on the Tedlar bag chamber, seal it tightly, and remove the hemostats.

12. Turn the vac/vol pump switch on and open the vacuum line valve to create a vacuum in the chamber. The Tedlar bag should fill once the vacuum is created. The rate at which the Tedlar gas sampling bag fills depends on the permeability of the soil. The minimum amount of soil gas needed for analysis is approximately 0.5 liter. If less than 0.5 liter is collected after 4 minutes of sampling, raise the soil gas probe 0.5 foot and continue to evacuate the vacuum chamber for another minute. If the minimum required volume of soil gas is not collected, repeat the procedure. If the minimum required volume of soil gas is still not collected, abandon the collection process. All steps conducted should be accurately recorded in the logbook even if no samples are satisfactorily collected.

13. After the soil gas sample is collected in the Tedlar bag, clamp the Tygon tubing with hemostats.

14. Turn off the vacuum pump.

15. Remove the vacuum chamber lid.

16. Close the valve on the Tedlar gas sampling bag and remove the bag from the chamber. Label the Tedlar bag with the appropriate information.

<u>**Glass Bulbs**</u>

The following procedures should be used to collect soil gas in glass bulbs:

1. Turn the vac/vol pump switch on and allow pressure to build in the vacuum tank. Make sure that the vacuum line valve is closed before starting the vacuum pump. The inside scale of the vacuum tank gauge is calibrated in inches of mercury. The outside scale is calibrated for volume in liters (at standard temperature and pressure). Obtain the desired vacuum and turn the vacuum pump off.

2. Connect a short (6- to 12-inch) piece of Tygon tubing to the sample cap or PRT protruding from the drive rod.

3. Connect one end of the labeled glass bulb to the Tygon tubing.

4. Connect another piece of Tygon tubing 3 feet to 5 feet long to the other end of the glass bulb and to the nipple on the bottom of the vacuum system panel.

5. Open the two stopcocks on the glass bulb.

6. Turn off the vacuum pump.

7. Turn the vacuum line valve to its open position.

8. Purge three times the volume of ambient air within the rods, bulb, and tubing. Equations for figuring out volumes are presented in the Tedlar bag discussion.

9. Turn the vacuum line valve to its closed position. Allow the pressure in the sample train to equalize (the sample line gauge should read zero).

10. Close the stopcocks on the glass bulb.

11. Remove the glass bulb and label it with the appropriate information.

<u>Adsorption Tubes</u>

The following procedure should be used to collect soil gas in adsorption tubes:

1. Connect a short (6- to 12-inch) piece of Tygon tubing to the sample cap or PRT protruding from the drive rod.

2. Connect this piece of tubing to the nipple on the bottom of the vacuum system panel and purge three volumes of air from the drive rod or PRT system as described in the discussion of the Tedlar bag method.

3. Use hemostats to clamp the Tygon tubing attached to the drive rod or PRT.

4. Insert the adsorption tube between the Tygon tubing from the drive rod or PRT and the Tygon tubing attached to the vacuum system panel.

5. Remove the hemostats and draw the required volume of air through the adsorption tube.

6. Remove the adsorption tube and place the appropriate caps on the tube ends.

7. Clearly label package, and ship the samples as required by the laboratory or PRC and U.S. Environmental Protection Agency (EPA) SOPs.

Soil Gas Sampling Pointers

If the needle on the vacuum line valve does not move, the soil at the sampling depth may be saturated, pore space may be too tight to yield a sample, or sampling train may be plugged. If the needle moves back to zero very quickly, either the soil at the sampling depth is very permeable or a leak is present in the sampling train.

In some soils, the needle may return to zero very slowly. The time it takes for the needle to return to zero is called the "recovery" time. Recovery time should be noted for each sample taken. This information will allow relative comparison of soil permeability. Recovery times of greater than

10 minutes should be considered suspect. The effect of leakage in the sampling system increases with longer recovery times. After 10 minutes, the operator should consider either changing the sampling depth, location, or length of pullback from the sampling tip, or switching entirely from soil gas sampling to grab sampling and analysis of soil.

2.3.4 Groundwater Sampling

The two options for sampling groundwater using the Geoprobe System follow procedures similar to those presented in Sections 2.3.2 and 2.3.3 above. The sections below detail procedures for using mill-slotted well point samplers and Geoprobe screen point samplers to sample groundwater.

<u>**Mill-Slotted Well Point Sampler**</u>

Once the mill-slotted well point reaches groundwater, the water will begin to flow through the slots. When the sample is to be analyzed for volatile organic compounds, do not use a vacuum to suck groundwater from the drive rod. If the sample is to be analyzed for other parameters such as metals, semivolatiles, pesticides, or explosives, using a vacuum on the drive rod is acceptable. In all cases, polyethylene tubing can be used as a thieving rod by lowering its end into the drive rod, capping or sealing the tube's top, and then removing it. The preferred method for collecting samples for volatile organic analysis is to use a well mini-bailer. To collect groundwater samples with a mini-bailer, use the following procedures:

1. Raise the hydraulic punch, turn off the hydraulic system, and remove the drive cap.

2. Lower a well mini-bailer into the drive rod until it reaches the bottom. As it reaches the bottom, the check ball on the bailer's end will float in the groundwater and then slowly sink to the bottom.

3. Allow a couple of seconds for the ball to sink and set.

4. Pull the well mini-bailer out of the drive rod. The bailer should contain about 20 milliliters of groundwater.

5. Package and document the samples in accordance with PRC SOPs No. 016, 017, 018, and 019, or a similar EPA-approved procedure.

If a bailer is not required and volatile organic samples are not being collected, a foot valve sampler, vacuum trap, or peristaltic pump can be used to collect samples. Once the sample has been removed and packaged, the mill-slotted well point can be removed and decontaminated.

Geoprobe Screen Point Sampler

The Geoprobe screen point sampler contains a screen and screen plug that allows water to enter the rod. To collect groundwater samples with a Geoprobe screen point sampler, use the following procedures:

1. Push the sampler below the depth necessary to reach groundwater.

2. Raise the hydraulic punch and replace the drive cap with a pull cap. Also, remove the anvil.

3. Latch the pull cap under the hammer latch, and use the probe lever to lift the drive rod about 18 inches. Because the sampler has a expendable point, the point should stay at the deepest depth, and the screen and screen connector should fall out of the bottom of the sampler. Sometimes, however, the screen stays within the sampler and is lifted the 18 inches with the drive rod.

4. To ensure that the screen is exposed, attach a vice grip or pipe wrench to the rod above the foot of the hydraulic punch and raise the hydraulic punch. Then remove the pull cap and place an extension rod through the tubing to push the screen into place. Additional extension rods can be attached to reach the desired depth.

To remove the groundwater sample for volatile organic analysis, with a well mini-bailer, follow steps 1 through 5 under the mill-slotted well point section above. Tubing can be used as a thieving rod with or without a check valve to collect groundwater samples as well. If the sampler is supplied with the optional PRT expendable point holder, then a PRT adapter can be pushed through the drive rod and threaded into place by following the PRT system Procedures previously discussed. A vacuum trap system or peristaltic pump can then be used to withdraw the sample. The PRT system method, however, should never be used when the sample is to be analyzed for volatile organic compounds because it involves using a vacuum to remove the sample.

3.0 PIEZOMETER AND VAPOR SAMPLING IMPLANT INSTALLATION PROCEDURES

The Geoprobe System's ability to quickly probe into soil allows for easy installation of both piezometers and vapor sampling implants. Both installation procedures are discussed below.

3.1 PIEZOMETERS INSTALLATION

Piezometers are tubes that extend to groundwater and enable easy sampling of groundwater on a routine basis (see Figure 10). In addition to installing the piezometer, piezometers must be protected from the weather and from contamination. A well-head protector must therefore be installed around them. In some soil types, preparing the well-head protector may be the first step to installing a piezometer. For this reason, the directions below should be read completely before beginning piezometer installation. If a post-hole digger is to be used for well-head protector installation, Procedure 5 should be performed first. The piezometer should then be advanced through this hole.

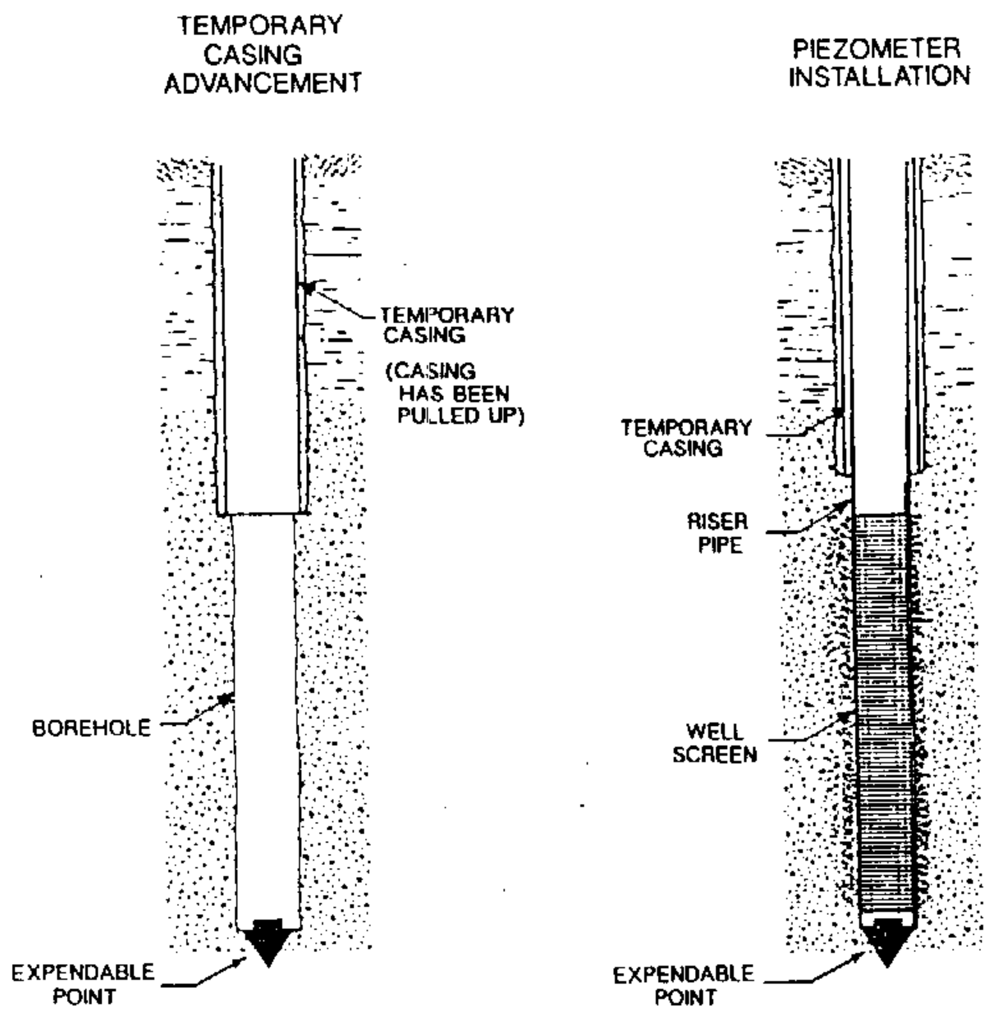
To install temporary or permanent piezometers, use the following procedures:

1. Use the hydraulic punch to drive the temporary casing to the desired piezometer installation depth. Use the general procedures outlined in Section 2.3.1 above for details on driving the piezometer casing. The different temporary casings that can be used are described below. Geoprobe Systems also manufactures special drive caps, expendable points, and pull caps that fit these types and sizes of pipe.

    a) 1-7/16-inch outside diameter by 1-3/16-inch inside diameter, RW-flush threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 25- to 30-foot depth. Two sizes of piezometer wells can be installed inside of the temporary casing: (1) 3/4-inch outside diameter by 1/2-inch inside diameter, polyvinyl chloride (PVC) pipe, or (2) 1-inch outside diameter by 3/4-inch inside diameter, PVC pipe.

FIGURE 10

PIEZOMETER INSTALLATION



b) 1-13/16-inch outside diameter by 1-1/2-inch inside diameter, EW-flush threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 15- to 20-foot depth. Three sizes of piezometer wells can be installed inside of the temporary casing: (1) 3/4-inch outside diameter by 1/2-inch insider diameter PVC pipe, or (2) 1-inch outside diameter by 3/4-inch inside diameter, PVC pipe, or (3) 1-1/2-inch outside diameter by 1-inch inside diameter, PVC pipe.

c) 1-1/4-inch outside diameter by 1-inch inside diameter, NPT-threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 25- to 30-foot depth. Only 3/4-inch outside diameter by 1/2-inch inside diameter, PVC pipe piezometer wells can be installed inside of the temporary casing. If using NPT-threaded pipe, couplers are needed to attach each section of pipe.

2. Once the piezometer casing is at the proper depth, remove the drive cap and install the selected size piezometer pipe inside of the temporary casing.

3. Using a pull plate, remove the temporary casing.

4. If the hole stays open, attempt to install a sand pack around the slotted portion of the piezometer, and then place dry granular bentonite on top of the sand pack as a seal. One foot of bentonite is recommended for a good seal.

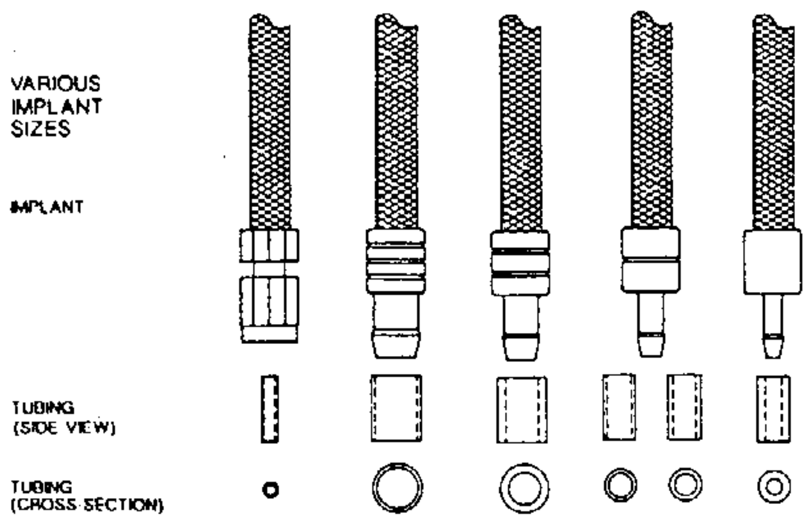
5. Dig an 8-inch nominal-diameter hole around the piezometer pipe. This hole should extend to a depth of 1.5 to 2 feet. A post-hole digger can be used for this procedure if the hole is dug prior to driving the temporary casing. The bottom 6 inches of this hole should be filled with dry granular or slurry bentonite. The remainder of the hole should be filled with concrete. A steel, locking, aboveground or flush-mount well protector should be inserted into the wet concrete to provide well-head security. A concrete pad can also be constructed around the steel well-head protector.

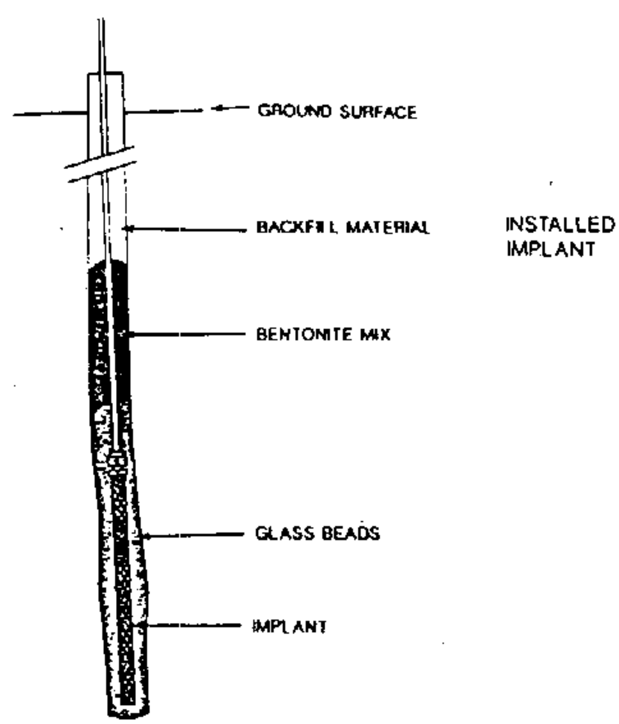
3.2 VAPOR SAMPLING IMPLANT INSTALLATION

Figure 11 presents diagrams of vapor sampling implants. To install vapor sampling implants, first punch a drive rod to the desired depth using an expendable point holder and an expendable point. Once at the desired sampling depth, use the following procedures:

FIGURE 11

VAPOR SAMPLING IMPLANTS





1. Disengage the expendable point and retract the probe rod about 1 foot by raising the hydraulic punch, replacing the drive cap with a pull cap, removing the anvil, latching the pull cap onto the hydraulic hammer using its latch, and raising the hydraulic punch again using the probe lever.

2. Lock the rod into place so that it does not sink back into the hole by using vice grip pliers or a pipe wrench.

3. Unlatch the pull cap and raise the hydraulic punch again, leaving room to work freely.

4. Remove the pull cap.

5. Attach appropriate stainless-steel tubing to the vapor implant. If tubing is precut, allow 48 inches more than the required depth of the implant.

6. Insert the implant and tubing down the inside diameter of the probe rods until it stops. Note the length of the tubing inserted to ensure that the desired depth has been reached. Allow the excess tubing to extend out of the drive rod's top.

7. Pour glass beads down the inside diameter of the probe rod using a funnel to create a permeable layer around the implant.

8. Use the tubing extending from the drive rod to stir the beads into place. Do not lift up on the tubing while doing so.

9. Position the remaining tubing through the hole on a rod pull plate, and then place the drive rod through that hole.

10. Attach the plate to the hydraulic punch using its chain and slowly pull the rod up another 18 to 24 inches. While the punch pulls the rod, push down on the tubing so that it stays in place.

11. Pour bentonite seal mixture down the inside diameter of the probe rod. Stir the mixture using the tubing as before. The initial mixture may also be topped with distilled water to initiate the bentonite seal depending on the site and on the role the vapor implant is to play.

12. Pull the drive rod from the hole using the probe rod pull plate already attached, and then plug the hole using granular bentonite or a bentonite slurry mixture.

The vapor sampling implant should now be in place and the stainless steel tubing connected to it should be protruding from the ground. The vapor implant tubing should be protected by a well-head protector in the same manner as the top of the piezometer. Procedure 5 in Section 3.1 describes well-head protector installation.

4.0 ROD REMOVAL PROCEDURES

Throughout the above discussions, it has occasionally been necessary to remove drive rods and samplers. The standard removal procedures involve raising the hydraulic punch, turning off the hydraulic system, replacing the drive cap with a pull cap, removing the anvil, and then latching the pull cap under the hammer latch. The hydraulic punch can then be used to pull the rod from the ground.

Two deviations to this procedure often occur. The first deviation is necessary when sampling tubes are to be left inside the hole as the drive rod is removed, especially when soil gas implants or piezometers have been installed. Because of the presence of these sampling tubes, a pull cap cannot be screwed onto the top of the drive rod. Instead, a rod pull plate is used. This plate is a piece of steel with a hole in it large enough for a drive rod to fit through it. The plate has a hook on one end. The tubing and rod are pushed through the plate, and the pull plate is attached to the latch on the hydraulic punch by a chain. As the punch pulls up, the plate shifts, and the inside of the hole binds on the rod. This binding usually holds the rod to the plate and results in the rod being pulled up as the punch is raised.

The second deviation occurs when the rods have not been pushed perpendicular to the ground. In these cases, a specially designed chain-assisted pull cap is used. This cap looks like a pull cap but has a chain on it that fits under the latch of the hammer. Once the cap is screwed to the drive rod and latched to the probe, raising the probe raises the rod.

In a few cases, drive rods break while in the ground. To retrieve these rods, a rod extractor is used. This extractor looks something like a drill bit and is screwed to the end of a probe rod. A hammer is then used to pound the extractor into the top of the broken rod. The extractor joins the broken rod to the second drive rod so that they can be pulled out together.

5.0 BACKFILLING PROCEDURES

Unless otherwise specified in the site-specific sampling plan, holes made by sampling with Geoprobe System tools are to be backfilled with dry, fine, granular bentonite. Water may be added to activate the bentonite. Tops of the holes may then be filled with soil or concrete as necessary for each particular site.

6.0 DECONTAMINATION PROCEDURES

Between holes, the probe rods and sampling tools must be decontaminated. Because no provisions for decontamination are included in the Geoprobe System, a separate decontamination station must be provided. A wire brush, a barrel brush for reaming out the rods, and soft brushes will clean sticky soil from the probe rods and sampling tools. Follow PRC SOP No. 002 decontamination procedures when sampling soil or groundwater.

When sampling for soil gas by the standard method, Geoprobe rods and samplers are heated approximately 15 to 20 minutes by a 100,000-British thermal unit heater until they are too hot to touch with the bare hand. They are then allowed to cool before reuse. Do not heat the rods too much or the rod metal will fatigue.

When sampling for soil gas by the PRT method, the probe rods do not have to be decontaminated. However, the PRT expendable point holder and PRT adapter do need to be decontaminated. They can be heated on the dash of the vehicle with the defrost system or scrubbed in Alconox and water. Equipment blank samples can be collected, if necessary, as part of the quality control process.

Sampling plans may have different decontamination requirements. Most plans also require rinsate sample collection as part of the quality control process.

3.0 GROUNDWATER INVESTIGATIONS

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLING

SOP NO. 010

REVISION NO. 2

Approved by:

James Sickles
Quality Assurance Officer

2/8/94
Date

Title: **Groundwater Sampling**

1.0 BACKGROUND

Groundwater sampling may be required for a variety of reasons, such as examining potable or industrial water supplies, checking for and tracking contaminant plume movement in the vicinity of a land disposal or spill site, RCRA compliance monitoring, or examining a site where historical information is minimal or nonexistent, but where it is thought groundwater may be contaminated.

Groundwater is usually sampled through an in-place well, either temporarily or permanently installed. However, it can also be sampled anywhere groundwater is present, as in a seep or spring, pit or a dug or drilled hole.

Occasionally, a well will not be in the ideal location to obtain the needed sample (for example, to track a contaminant plume). In such a case, a temporary or permanent well will have to be installed. An experienced and knowledgeable person, preferably a hydrogeologist, will need to locate the well and supervise its installation so that the samples ultimately collected will be representative of the groundwater.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedure for measuring through groundwater sampling, the quality of groundwater entering or leaving site, or affected by site activities.

1.2 SCOPE

This SOP applies to all groundwater sampling activities conducted in the field.

1.3 DEFINITIONS

Bailer -- A tube of stainless steel or Teflon with valves on either end used to extract water from a well. The bailer is lowered and raised by a cable that may be cleaned and reused, or by means of a disposable rope.

Electrical Water Level Indicator -- An electrical device that has a light or sound alarm connected to an open circuit used to measure the depth to fluid. The circuit is closed when the probe intersects a conducting fluid. The wire used to raise and lower the probe is usually graduated.

Immiscible Phase -- Liquid phases that cannot be uniformly mixed or blended with water. Heavy immiscible phases sink; light immiscible phases float on water.

Interface Probe -- An electrical probe that measures the distance from the surface to air/water, air/immiscible, or immiscible/water interfaces. The immiscible fluid is typically a floating hydrocarbon.

Purge Volume -- The volume of water that needs to be removed from the well to insure that a sample representative of the groundwater is taken.

Riser Pipe -- The length of well casing above the ground surface.

Total Well Depth -- The distance from the ground surface to the bottom of the well.

Water Level -- The level of water in a well. Measured as depth to water or as elevation of water, relative to a reference mark or datum.

1.4 REFERENCES

Korte, N. P. Kearl. "Procedures for the Collection and Preservation of Groundwater and Surface Water Samples and for the Installation of Monitoring Wells." U.S. Department of Energy, Technical Measurements Center, Grand Junction Projects Office. Second Edition, GJ/TMC-08-1985.

U.S. EPA. 1977. *"Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities."* EPA-530/SW-611. August.

U.S. EPA. 1984. "Sampling at Hazardous Materials Incidents." EPA Hazardous Response Support Division, Cincinnati.

U.S.G.S. 1984. *National Handbook of Recommended Methods for Water-Data Acquisition*. Reston, VA.

1.5 REQUIREMENTS AND RESOURCES

There are various options available to obtain groundwater samples. The procedures are outlined in the following section. The equipment needed for these procedures includes:

- Organic vapor analyzer (OVA) or photoionization detector (PID)
- Pipe wrench
- Electrical water level indicator or interface probe
- Steel tape with heavy weight
- Purging device (type needed depends on well depth, casing diameter, type of sample desired)

- Sampling device (type needed depends upon depth to water and type of sample desired)

  - Teflon bailer
  - Stainless steel bailer
  - Teflon bladder pump
  - Stainless steel submersible (nonoil-bearing) pump
  - Existing dedicated equipment
  - Peristaltic pump

- Sample containers

- Wastewater containers of known value

- Logbook

- Stopwatch

Additional equipment will be necessary to complete field measurements of the sample (refer to SOP Nos. 011, 012, and 013). These procedures are performed concurrent with groundwater sampling.

2.0 PROCEDURE

Prior to sampling, a site-specific sampling plan will be developed. The plan will consider the site characteristics and will consist of:

- The specific repeatable well measurement techniques and reference points for the depth to water and the depth to bottom of the well

- The specific method of purging and selection of purging equipment

- The specific method for field analytical measurements and the selection of field analytical equipment

- The specific method of sample collection and selection of sampling equipment

- The order of sample bottle filling
- The sample chemical analytical parameters
- Specific decontamination and cleaning procedures for equipment

2.1 APPROACHING THE WELL

In general, all wells should be assumed to pose a health and safety risk until field measurements determine otherwise. Approach wells from the upwind side. Record well appearance and general condition in the logbook.

Once at the well, the lead person should systematically use the health and safety monitoring instrument to survey the immediate area around the well (from casing to ground and from top of casing to breathing zone) while wearing appropriate respiratory protection equipment. If elevated OVA and PID meter readings are encountered, retreat to a safe area and instruct the sampling team to put on the appropriate safety gear.

Upon opening the well, the lead person should systematically survey inside the well casing from casing to ground, from above well casing to breathing zone, and the immediate area around the well. If elevated OVA and PID meter readings at the breathing zone are encountered, (see health and safety plan for action levels) retreat and put on appropriate safety gear. It is important to remember that action levels are not to be determined by readings within the well casing but at the breathing zone. All health and safety monitoring instrument readings will be recorded in the logbook.

2.2 ESTABLISHING A SAMPLE PREPARATION AREA

In general, survey readings at the well will dictate the appropriate location to set up an area for sample preparation. If no elevated readings are encountered, any area upwind or to either side of the well should be selected. If elevated readings are encountered, this area should be taped off and continuously monitored during sample preparation. If persistent elevated readings in this area are encountered, cease sampling and reestablish the sample area upwind where safe ambient readings are found.

2.3 PRELIMINARY WELL MEASUREMENTS

Several preliminary well measurements should be made before initiating sampling of the well. These include measuring water levels and total well depth, inspecting for the presence of immiscible phases, and calculating purge volumes. All preliminary measurements will be recorded in the logbook as they are made.

2.3.1 Water Level and Total Well Depth Measurements

PRC typically uses an electric water level indicator for water level measurements. This device sounds an alarm or illuminates a light when the measuring probe touches the water surface, thus closing an electrical circuit. The electric cable supporting the probe is usually graduated in feet and can be read at the well site directly. The remaining fraction is measured with a steel tape specifically graduated to 0.01 foot. If the monitoring well is not constructed flush to the ground surface, the distance between the static water level and the top of the riser pipe at the point of water-level measurement is measured and recorded. The height of the riser pipe above ground surface is then subtracted from the total reading to give the depth to static water. To improve the accuracy of the readings, the probe and cables should be left hanging in the well for a series of three readings, and the values averaged.

This procedure helps to eliminate any errors from kinks or bends in the wires, which may change the length when the device is pulled up and let down.

The total well depth can be measured by using a steel tape with a heavy weight attached to the end. The tape is lowered into the well until resistance is met, indicating that the weight has reached the bottom of the well. The total well depth is then read directly from the steel tape to the nearest 0.01 foot fraction. If the well is not constructed flush to the ground surface, the distance between the bottom of the well and the riser pipe at the point of water-level measurement is measured and recorded. The height of the riser pipe above the ground surface is then subtracted from the total reading to give the depth to the bottom of the well. To improve the accuracy of the readings, the weighted steel tape should be left hanging in the well for a series of three readings, and the readings averaged.

Note: Electric water-level indicators and steel measuring tapes must be periodically checked for damage and repaired as necessary, and calibrated and modified as needed.

2.3.2 Assessing If Immiscible Phases Are Present

If immiscible phases (organic floaters or sinkers) are present, the following measurement activities should be undertaken. Organic liquids are measured by lowering an interface probe slowly to the surface of the liquid in the well. When the audible alarm sounds, record the depth. If the alarm is continuous, an organic layer has been detected. To measure the thickness of this layer, continue lowering the probe until the alarm changes to an oscillating signal. The oscillating signal indicates that the probe has detected an aqueous layer. Record this depth as the depth to water and calculate the thickness and the volume of the immiscible layer.

Continue lowering the probe into the well to determine if immiscible dense phases (sinkers) are present. If the alarm signal changes from oscillating to a continuous sound, a heavier immiscible layer has been detected; record this depth.

Continue lowering the probe to the bottom of the well and record the total depth. Separate total depth measurements with a steel tape are not necessary when using an interface probe. Calculate and record the sinker phase volume and total water volume in the well. A chart is provided in Table 1 to assist in these calculations. If immiscible phases are present, immediately refer to Sections 2.5.1 or 2.5.2 of this SOP.

2.3.3 Checking Physical Integrity of the Surface Seal and Redeveloping Wells

Following installation of the well and periodically (every 2 to 3 years, consult with the project manager as to the time period), verify the surface seal of the well and depth of well. The surface seal is checked to verify that surface water cannot infiltrate the well. The well depth is verified to check if sediment has built up in the well. The well should be redeveloped if sediment buildup is indicated. Redevelopment of the well assures that wells are hydraulically connected to the aquifer.

Check the surface seal of the well by slowly pouring 5 gallons of deionized water around the surface of the well. The water level in the well should be continuously recorded while pouring surface water to see if the level shows any leakage of the surface seal. Record water level measurements for 5 minutes after the last of the deionized water is discharged around the well. Prohibit the deionized water from draining into the wells with below-grade well casing.

Wells previously developed should be developed again at an interval selected by the project manager. Develop wells according to PRC's Standard Operating Procedure No. 021.

2.3.4 Calculation of Purging Volume

If the presence of floaters or sinkers does not need to be determined, measure the depth to water and the total depth of the well as described in Section 2.3.1. Once these measurements have been made and recorded, use Table 1 to calculate the total volume of water in the well. Multiply this volume by the purging factor to calculate purging volume. The project-specific standard purging factor is at least three casing volumes but may be superseded by site-specific program requirements and by individual well yield characteristics.

In Table 1, the volume of water in a 1-foot section of a 2-inch-diameter well is 0.16 gallon. This chart can easily be used for any water depth by multiplying all the values in Table 1 by the L value (depth, in feet, of water in the well).

2.4 PURGING THE WELL

Currently, PRC standards allow for six options for purging wells:

1) Teflon bailers
2) Stainless steel bailers
3) Teflon bladder pumps
4) Stainless steel submersible (nonoil-bearing) pumps
5) Existing dedicated equipment (use of these devices must be approved by on-site client representatives)
6) Peristaltic pumps (these devices are for use in shallow wells only and must be approved by the on-site client representative)

TABLE 1

LIQUID VOLUME IN A 1-FOOT SECTION OF WELL CASING

Casing Inside Diameter (inches)	Volume of Liquid		
	(Fluid oz.) $[V=5.22(I.D.)^2]$	(Gallons) $[V=0.408(I.D.)^2]$	(Milliliters) $[V=154.4(I.D.)^2]$
1	5.22	0.04	154.4
1 1/2	11.74	0.09	347.3
2	20.88	0.16	617.5
3	46.98	0.37	1389.4
4	83.52	0.65	2470.0

The volume of water in the well is based on the formula:

$$V = \frac{\pi \times D^2}{4} \times L$$

where:

D = the inside diameter of the well in feet
L = the depth in feet of the water in the well
V = the volume of water in the well in cubic feet
π = 3.14

As previously stated, the established standard purging volume is at least three casing volumes. The exception to this standard (other than program requirements) is in the case of low-yield wells. When purging low-yield wells, purge the well once to dryness. Samples should be collected as soon as the well recovers. When full recovery exceeds 3 hours, samples should be collected as soon as sufficient volume is available.

At no time should the purging rate be high enough to cause the groundwater to cascade back into the well, resulting in excessive aeration and potential stripping of volatile constituents.

The actual volume of purged water can be measured using several acceptable methods:

- When bailers are used, the actual volume of each bailer's contents can be measured using a calibrated bucket.
- If a pump is used for purging, the pump rate can be determined by using a bucket, stopwatch, and the duration of pumping until the necessary volume is purged.
- The volume of purged water and number of casing volumes purged should be recorded.

2.5 SAMPLE COLLECTION

The technique used to withdraw a groundwater sample from a well should be selected based on the parameters for which the sample will be analyzed. To ensure that the groundwater samples are representative, it is important to avoid physically altering or chemically contaminating the sample during collection, withdrawal, or containerization.

The preferred sampling devices for all parameters are double check valve stainless steel or Teflon bailers. A Teflon bladder pump may be used. Additional field measurements should be performed, and results recorded, at the time of sampling. Refer to SOP Nos. 011, 012, and 013.

In some cases, it may become necessary to use dedicated equipment already in the well to collect samples. This is particularly true of high volume, deep wells (> 150 feet) where bladder pumps are ineffective, and bailing is impractical. If existing equipment must be used, however, note the make and model of the pump, and check with the manufacturer concerning component construction materials. If an existing pump is to be used for sampling, make sure the flow volume can be reduced so that a reliable volatile organics analysis (VOA) sample can be taken. Record which specific port, tap, or valve the sample is collected from.

General sampling procedures include the following:

- Clean sampling equipment should not be placed directly on the ground. Use a plastic drop cloth or feed line from clean reels. Never place contaminated lines back on reels.
- Check the operation of the bailer check valve assemblies to confirm free operation.
- If the bailer cable is to be decontaminated and reused, it must be made of Teflon-coated stainless steel. Braided stainless steel is acceptable if used once and disposed.
- Lower sampling equipment slowly into the well to avoid degassing the water and damaging the equipment.
- Bladder pump flow rates should be adjusted to eliminate intermittent or pulsed flow. The settings should be determined during the purging operations.
- A separate sample volume should be collected to measure necessary field data. Samples should be collected and containerized in the order of the parameters' volatilization sensitivity. Table 2 lists the preferred collection order for some common groundwater parameters.

There are two schools of thought on using an intermediate container to prepare VOA samples specifically, and all parameters in general. Until more quantitative data are generated, the project-specific standard is not to use such intermediate containers. PRC will, instead, obtain all replicate VOA samples at a single sampling point or from a single bailer load.

2.5.1 Collection of Light Immiscible Floaters

The approach used when collecting floaters depends on the depth to the floating layer and the thickness of that layer. If the thickness of the floater is 2 feet or greater, a bottom valve bailer is the equipment of choice. Slowly lower the bailer until contact is made with the floater surface, and lower the bailer to a depth less than that of the floater/water interface depth as noted by preliminary measurements with the interface probe.

When the thickness of the floating layer is less than 2 feet and the depth to the surface of the floating layer is less than 15 feet, a peristaltic pump can be used to extract a sample.

TABLE 2
ORDER OF PREFERRED SAMPLE COLLECTION

1. Volatile organics (VOA)
2. Purgeable organic carbon (POC)
3. Purgeable organic halogens (POX)
4. Extractable organics
5. Total metals
6. Dissolved metals
7. Total organic carbon (TOC)
8. Total organic halogens (TOX)
9. Phenols
10. Cyanide
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

However, when the thickness of the floating layer is less than 2 feet and the depth to the surface of the floating layer is beyond the effective "lift" of a peristaltic pump (greater than 25 feet), a bailer can be modified to allow filling from the top only (an acceptable alternative is to use a top-loading Teflon or stainless steel bailer). Disassemble the bailer's bottom check valve and insert a piece of 2-inch-diameter Teflon sheet between the ball and ball seat. This will seal off the bottom valve. Remove the ball from the top check valve, thus allowing the sample to enter from the top. To overcome buoyancy when the bailer is lowered into the floater, place a length of 1-inch stainless steel pipe on the retrieval line above the bailer (this pipe may have to be notched to allow sample entry if the pipe remains within the top of the bailer). Or, as an alternative, use a top-loading stainless steel bailer. Lower the device, carefully measuring the depth to the surface of the floating layer, until the top of the bailer is level with the top of the floating layer. Lower the bailer an additional one-half thickness of the floating layer and collect sample. This technique is the most effective method of collection if the floater consists of only a few inches of material.

2.5.2 Collection of Heavy Immiscible Sinkers

The best method for collection of sinkers is use of a double check valve bailer. The key to collection is slow, controlled, lowering and raising of the bailer to and from the bottom of the well. Collection methods are equivalent to those described in Section 2.5.1 above. Note that both floaters and sinkers must be collected prior to any purging activities.

2.5.3 Collection of Volatile Organics Samples

This section discusses the collection of VOAs using either a bailer or bladder pump.

2.5.3.1 Collection with Bailers

VOAs should be collected from the first bailer removed from the well after purging. The most effective means employees two people. One person should retrieve the bailer from the well and pour its contents into the appropriate number of 40-mL VOA vials held by the second person. Cap the vial and invert. If a bubble exists, discard and repeat. Do not reopen the vial and add additional sample. The sample is transferred from the bailer to the container in a manner that will limit the amount of agitation in order to reduce the loss of volatile organics from the sample.

Always prepare VOA splits from the contents of a single bailer. If the bailer is refilled, samples are not splits.

2.5.3.2 Collection with a Bladder Pump (Well Wizard)

To successfully perform VOA sampling with a Well Wizard bladder pump, the following steps must be completed:

1) Following manufacturer's directions, activate the Well Wizard pump. Full water flow from the discharge tubing will begin after 5 to 15 pumping cycles. These initial pumping cycles are required to purge air from the pump and discharge tubing. The discharge and recharge settings must be manually set and adjusted to pump at optimum flow rates. To activate the bladder, it is best to set the initial cycle at long discharge and recharge rates.

2) Reduce water flow rate for VOA sample collection. To reduce the water flow rate, turn the throttle control valve (located on the left side of the Well Wizard pump control panel) counterclockwise.

3) Collect VOA sample from discharge tubing. VOA vials must be placed beneath the discharge tubing while avoiding direct contact between the vials and the tubing. Never place tubing past the mouth

of the VOA vial. The pump throttle control must be turned as necessary to maintain a trickle of water in order to obtain a meniscus in the vial.

4) Continue with non-VOA sampling. Increase pump flow rate by turning the throttle control knob clockwise.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF WATER TEMPERATURE

SOP NO. 011

REVISION NO. 2

Approved by:

Kathleen Homer
Quality Assurance Officer

5/11/93
Date

1.0 BACKGROUND

Temperature readings are used in the calculation of various forms of alkalinity, in studies of saturation and stability with respect to calcium carbonate, in the calculation of salinity, and in general laboratory operations. Properly measuring temperature, therefore, is important to a wide variety of field operations.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for measuring water temperature in the field.

1.2 SCOPE

This SOP applies to measuring the temperature of surface and groundwater while in the field.

1.3 DEFINITION

National Institute of Standards and Technology Certified Thermometer: A thermometer that carries certification of its temperature-reading precision.

1.4 REFERENCE

U.S. Environmental Protection Agency. 1986. "Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document" September.

1.5 REQUIREMENTS AND RESOURCES

The following equipment may be required for the measurement of water temperature in the field:

- A mercury-filled thermometer with metal case
- An electronic thermistor with accuracy to 0.1°C and with an extension probe
- A National Institute of Standards Technology Certified Thermometer
- A container
- Decontamination materials
- A field logbook

2.0 PROCEDURES

Under normal conditions, temperature measurements may be made with any reliable, glass, mercury-filled thermometer. At a minimum, the thermometer should have a scale etched on the capillary glass every 0.1°C or 0.2°C. The thermometer will have a minimal thermal capacity to permit rapid equilibration. The thermometer will be calibrated at least annually using a precision thermometer certified by the National Institute of Standards and Technology. Certified thermometers are maintained in the company's equipment distribution center. Thermometers will be housed in a metal case to prevent breakage.

In some conditions, temperature measurements may be made with a digital electronic thermistor with an accuracy of 0.1°C. The thermistor must be maintained as described in the manufacturer's operation and maintenance manual. In particular, always check the energy level of the thermistor's battery before each use. If the standard probe is not sufficient for taking temperature readings, then an extension probe may be used. Follow the manufacturer's directions to insure that unbalanced resistance in the extension probe does not distort temperature readings.

Temperature measurements should be taken at the water source. If it is not possible to measure the temperature at the source, collect a sample of the water to be measured and place the sample in an intermediate container. When an intermediate container is used, fill the container with the sample and allow the temperature of the container to equilibrate with that of the sample and record the temperature. Dispose of the sample and collect a new sample. Place the new sample in an intermediate container and repeat the process just described.

Make temperature readings using the thermometer or probe while immersed in water long enough to allow complete equilibration. Depending on the type of thermometer, immerse it to mark or immerse totally. Report results to the nearest 0.1°C or 1.0°C, depending on the project specifications.

Record measurements in the field logbook. After taking the measurements, decontaminate the thermometer or probe according to the requirements in SOP No. 002, "Equipment Decontamination."

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF pH

SOP NO. 012

REVISION NO. 3

Approved by:

Kathleen Homer
Quality Assurance Officer

5/18/93
Date

1.0 BACKGROUND

Determining pH is critical for predicting and interpreting the reactions and migration of dissolved chemical constituents in groundwater or surface water. The pH of groundwater or surface water must be determined when a sample is collected in the field.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for measuring the pH of water samples in the field.

1.2 SCOPE

This SOP applies to the use of pH meters in the field.

1.3 DEFINITIONS

pH Electrode: An electrode that measures the hydrogen ion potential of a solution by comparing it to a standard solution with a known hydrogen ion potential. A thin glass membrane functions as a cation exchange surface. When the electric potential of the interior of the glass membrane is compared to the electric potential of a standard solution kept isolated from the environment, a quantitative determination of the change in the internal solution's electric potential, induced by the external solution, can be made.

Nernst Potential: Nernst Potential is the voltage observed when the glass membrane separates the external solution from the internal solution. Nernst Potential varies depending on the hydrogen ion potential between the external and internal solutions and, therefore, correlates with the pH of the solution.

Because the hydrogen ion content of the internal solution is constant, the changes in Nernst Potential are due to the changes in the external solution.

Buffer Solution: A buffer solution is capable of maintaining the relative concentrations of acids and bases by neutralizing, within limits, added acids or bases. It has a known pH for a specific temperature range.

1.4 REFERENCES

None.

1.5 REQUIREMENTS AND RESOURCES

The pH meters used by personnel in the field should have temperature and slope adjustments and a repeatability of plus or minus 0.01 standard pH unit. Meters used for pH field measurement should be of rugged construction. A foam-lined carrying case is convenient both for transport and for use as a work table. Battery-operated meters with easily replaceable or rechargeable batteries are required. Also, a spare pH electrode should be available in the field. Both the spare and working electrodes should be immersed in a pH 4 or pH 7 buffer solution when not in use.

The following are recommended for field measurement of pH:

- pH meter with repeatability of ± 0.01 standard pH unit
- Buffer solutions of pH 4, 7, and 10
- pH electrode (probe)
- Electrode filling solution
- Electrode holder
- Thermometer
- Deionized water and wash bottle

- Disposable beakers
- Logbook or field sheets

2.0 PROCEDURES

Meter calibration and field measurement procedures are outlined in the following subsections.

2.1 CALIBRATION

Commercially prepared buffer solutions should be used for calibration. Solutions traceable to the National Bureau of Standards can be purchased inexpensively from any major laboratory supply house. These solutions are certified with an accuracy of plus or minus 0.01 pH unit at a specific temperature, usually 25° C. Theoretically, buffer solutions are stable indefinitely. However, they are susceptible to contamination, and old, partially full bottles should be replaced.

Because various terms are used to describe the pH meter calibration process, providing a detailed set of instructions for each type of instrument is not practical. Always refer to the manufacturer's instructions when using a particular instrument. The following general procedure should be used to calibrate any pH meter:

1. Calibrate the meter with two buffer solutions to determine if the electrodes are in working order. The slope cannot be adjusted with a one-point calibration.

2. To calibrate the meter, use one buffer solution with a pH greater and one buffer solution with a pH less than the anticipated pH of the sample. For example, for an anticipated pH of 6, calibrate with pH 4 and pH 7 buffers; for an anticipated pH of 8, calibrate with pH 7 and pH 10 buffers.

3. Ensure that the buffers are at the same temperature as the sample. Pour aliquots into small containers; never put the electrode into the buffer storage bottles.

4. Adjust the instrument to read the pH 7 buffer accurately. Adjust the temperature compensator according to the manufacturer's instructions. Be sure to rinse the probe with deionized water after taking the calibration measurement.

5. Repeat steps 4 and 5 adjusting the zero and slope until both buffers read correctly without further adjustment.

6. Adjust the instrument to read the second buffer. Adjust the slope to obtain the correct reading. If the slope deviates greatly from its theoretical value, check for a defective electrode or contaminated buffer solution.

7. The meter must be calibrated before the start of work each day. Check calibration periodically and recalibrate if necessary.

2.2 FIELD MEASUREMENT

Do not filter field samples prior to analysis. When measuring the pH of the groundwater samples, use a submersible pump or bladder pump to obtain the samplet to minimize the release of gas from the sample.

The following procedure should be used for field measurement of pH:

1. Calibrate the instrument according to the manufacturer's instructions. Set the temperature compensation according to procedures provided in Section 2.1.

2. Collect the sample to be measured in a pre-rinsed jar or beaker or a flow-through cell.

3. Measure the temperature of the sample to the nearest 1.0°C, following procedures outlined in SOP No. 11, "Field Measurement of Water Temperature."

4. Set the temperature compensation on the pH meter to the temperature of the sample, following the manufacturer's instructions.

5. Rinse the electrode with deionized water.

6. Immerse the electrode in the sample. Record the pH value indicated. If the sample is being pumped through a closed container, wait for the temperature and pH to stabilize. Stop sample flow to eliminate streaming potential. Record the pH value indicated.

7. Record measurements in log book, on field sheets, or as specified in the project work plan.

3.0 POTENTIAL PROBLEMS

Temperature, atmospheric contamination, and ionic strength are factors that may affect pH measurements. Each of these three factors are discussed below. Color, turbidity, and colloids will not affect pH measurements.

Temperature: As indicated on Table 1, pH is affected by temperature. To prevent this from causing incorrect pH readings, the temperature compensator on the pH meter must be set to the temperature of the sample. Also, the meter must be calibrated at approximately this same temperature. The temperatures of the buffer and the unknown liquid should both be recorded at the time of measurement. Ideally, their temperatures should be within 2 °C of each other.

Atmospheric Contamination: Atmospheric contamination can be a significant problem when sampling the pH of groundwater. When the sample is exposed to air, dissolved oxygen and carbon dioxide can change a sample's pH. To insure that this problem does not affect the pH measurement, a groundwater sample should ideally be pumped through a closed container in which pH and temperature probes are immersed. The measurements should not be recorded until both temperature and pH have stabilized. The sampling pump should be stopped before recording the data because a streaming potential will affect the measurement in a flowing sample.

Ionic Strength: Because of the potential for errors due to ionic strength, pH measurement should always be accompanied by a measurement of specific conductance, as discussed in SOP No. 13, "Field Measurement of Specific Conductance."

TABLE I

pH OF BUFFER SOLUTIONS AS A FUNCTION OF TEMPERATURE

Temperature (°C)	Buffer Solution pH		
Standard	4.0	7.0	10.0
0	4.01	7.13	10.34
5	3.99	7.10	10.26
10	4.00	7.07	10.19
15	3.99	7.05	10.12
20	4.00	7.02	10.06
25	4.00	7.00	10.00
30	4.01	6.99	9.94

In general terms, pH is a measure of hydrogen ion activity. Normally, water samples are assumed to be ideal solutions in which other ions do not affect hydrogen ion activity. However, if the ionic strength is too high, this assumption does not hold true. Some site investigations include sampling of waste ponds or other highly contaminated water that has very high ionic strength. Because buffer solutions used in the field are not made with a similarly high concentration of dissolved ions, pH measurement of highly contaminated water will be inaccurate. Similarly, pH measurement of samples with very low ionic strength will be inaccurate because the low ionic strength of the sample approaches the level of resistance in the glass electrode. To reduce this problem, samples with very low ionic strength should be stirred for a few seconds before taking a reading. Even then, several minutes may be required for the reading to stabilize.

High sodium concentration also may produce errors in pH measurement because of the high ionic strength of these solutions. To measure the pH of such solutions, a special electrode is needed. Such an electrode can be purchased from any of several electrode manufacturers.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF SPECIFIC CONDUCTANCE

SOP NO. 013

REVISION NO. 2

Approved by:

Kathleen Homer
Quality Assurance Officer

5/18/93
Date

1.0 BACKGROUND

Specific conductance is a widely used parameter for evaluating groundwater and surface water quality. It is a simple indicator of change within a system and provides useful information to laboratory personnel performing other measurements on a water sample.

1.1 PURPOSE

Specific conductance should be determined at the time the sample is collected. This standard operating procedure (SOP) establishes the requirements and procedures for measuring specific conductance in groundwater or surface water while in the field.

1.2 SCOPE

This SOP applies to the use of specific conductance meters in the field.

1.3 DEFINITIONS

Specific Conductance: Specific conductance is the reciprocal of electrical resistivity. The values of electrical resistivity and specific conductance depend on the number of ions in a solution. Pure water has 100 percent resistivity and no specific conductance. As ions are added to a solution, resistivity drops and specific conductance increases.

1.4 REFERENCES

U.S. Environmental Protection Agency. November 1986. "Test Methods for Evaluating Solid Waste, Volume 1C: Laboratory Manual Physical/Chemical Methods, SW-846."

American Society for Testing and Materials Annual Book of Standards. "Standard Test Methods for Electrical Conductivity and Resistivity of Water, Method D-1125."

U.S. Geological Survey. 1977. (*National Handbook of Recommended Methods for Water Data Acquisition*).

1.5 REQUIREMENTS AND RESOURCES

Specific conductance meters should measure temperature, have a temperature compensator, and read directly in micromhos per centimeter (μmhos/cm), corrected to 25 °C. For field measurements, a probe-type unit is preferred over a pipet-type unit. Specific conductance meters should have a foam-lined carrying case and should be battery-operated with easily rechargeable or replaceable batteries. A relative accuracy of plus or minus 3 percent is adequate.

The following are required for calibrating a specific conductance meter and for the field measurement of specific conductance:

- A probe-type specific conductance meter meeting the requirements given above
- Deionized water and wash bottle
- Disposable beakers
- Reagent-grade potassium chloride (KCl) or a commercially-prepared standard 0.01 mole (M) per liter KCl solution
- Sampling containers
- Sampling equipment
- One-liter mixing container
- A thermometer calibrated according to SOP No. 011, "Field Measurement of Water Temperature"
- Logbook

2.0 PROCEDURES

Meter calibration and field measurement procedures are outlined in the following subsections.

2.1 METER CALIBRATION

Reagent-grade KCl is the universal standard for calibrating specific conductance equipment. The electrodes are calibrated by reading the specific conductance of standard KCl solutions. A concentration of 0.01 M KCl should be used because its specific conductance is closest to that of most natural samples.

The measuring circuit of the specific conductance meter is calibrated either by the manufacturer or with a calibrating resistor. The manufacturer's instructions for the particular instrument should be followed for calibration.

Individual manufacturers may use slightly different terminology, but the following general procedure will always apply:

1. Prepare a 0.01 M KCl solution by dissolving 0.745 gram of pure, dry KCl in 1 liter of deionized water. The base conductivity for the prepared solution is 1,408.1 μmhos/cm at 25 °C; if the deionized water has any conductance, it must be corrected to 25 °C and added to the value of the solution. Alternatively, commercially prepared solutions can be used.

2. Measure the temperatures of the 0.01 M KCl solution and the deionized water used for the dilution. They should be at the same temperature.

3. Using Table 1, determine the expected specific conductance of the 0.01M KCl solution at the temperature measured.

4. Measure the specific conductance of the 0.01M KCl solution and of the deionized water.

TABLE 1

RELATIONSHIP OF TEMPERATURE AND SPECIFIC CONDUCTANCE FOR 0.01 M POTASSIUM CHLORIDE

Temperature (°C).	Expected Specific Conductance of 0.01 M KCl Solution (μmhos/cm).
15	1,141.5
16	1,167.5
17	1,193.6
18	1,219.9
19	1,246.4
20	1,273.0
21	1,299.7
22	1,326.6
23	1,353.6
24	1,380.8
25	1,408.1
26	1,436.5
27	1,463.2
28	1,490.9
29	1,518.7
30	1,546.7

5. Use the following equation to check the cell constant specified by the manufacturer:

$$K = \frac{C_1 + C_2}{10^6 \times C_3}$$

where

K = the cell constant
C_1 = the specific conductance of the deionized water
C_2 = the specific conductance of the 0.01 M KCI solution
C_3 = is the expected specific conductance from the Table 1

6. A measured cell constant different from that specified by the manufacturer generally indicates that the electrodes are dirty. If this is the case, clean and replatinize the electrodes according to instructions found in the manufacturer's manual or in the American Society for Testing and Materials Method D-1125, Section 8.3

7. After verifying that the cell constant is acceptable, measure the specific conductance of samples according to the procedure given in Section 2.2.

2.2 FIELD MEASUREMENT

Do not filter samples before analysis. To minimize gas releases from groundwater samples, a submersible pump or bladder pump should be used to obtain samples.

The following procedure should be used for field measurement of specific conductance:

1. Calibrate the instrument and check the cell constant according to the manufacturer's instructions and the procedure provided in Section 2.1.

2. Collect the sample in a prerinsed jar or beaker or a flow-through cell.

3. Rinse the specific conductance meter probe with deionized water.

4. Using a thermometer or the specific conductance meter itself, measure and record the temperature of the sample in degress Centigrade. Follow the guidelines in SOP No. 011, "Field Measurement of Water Temperature."

5. Immerse the specific conductance meter probe in the sample. Record the reading in μmhos/cm.

6. Record measurements in the logbook or as specified in the project work plan.

3.0 POTENTIAL PROBLEMS

Principal problem areas for specific conductance measurement are the temperature effect, determination of the cell constant, and allowance for very high ionic strengths. A change in temperature of 10 °C can cause a 20 percent change in the measured specific conductance. Reported data should note whether temperature correction has been applied. Some instruments perform temperature correction automatically, but this, too, should be noted in reported data. To ensure uniformity of readings, all data should be corrected to 25 °C.

Field personnel must be aware that a significant change in the cell constant indicates that the electrodes require cleaning or replatinizing. The constant should be checked at each calibration, as described in Section 2.1.

Specific conductance varies directly with ion concentrations up to a specific conductance of about 5,000 μmhos/cm (*National Handbook of Recommended Methods for Water Data Acquisition 1977*). Samples collected at most sites seldom have a specific conductance greater than 5,000 μmhos/cm. Readings above this level should not be considered accurate. However, such readings can still provide useful information about the relative levels of conductance and should still be noted.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

STATIC WATER LEVEL, TOTAL DEPTH, AND IMMISCIBLE LAYER MEASUREMENT

SOP NO. 014

REVISION NO. 1

Approved by:

James Sickles
Quality Assurance Officer

7/9/94
Date

Title: **Static Water Level, Total Depth and Immiscible Layer Measurement**

1.0 BACKGROUND

The measurement of static water level, total depth, and any immiscible layers is necessary before a well can be sampled and groundwater flow direction can be determined. If an immiscible layer is present, its depth, and thickness, must be measured. If an immiscible layer is not present, the static water level and total depth of a well are needed to calculate a purging volume.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide guidelines for field personnel measuring static water levels and total depths of monitoring wells or piezometers. This SOP also provides guidelines for measuring immiscible layers in such wells.

1.2 SCOPE

This SOP describes the methodologies for measuring static water level, total well depth and immiscible layer thickness.

1.3 DEFINITIONS

To clarify the methodologies presented in this SOP, the following definitions are presented:

Electrical Water Depth Indicator -- An electrical probe used to measure the depth to fluid. The probe has a light or sound alarm connected to an open circuit. The circuit is closed and the alarm is activated when the probe contacts a conducting fluid such as water.

Interface Probe -- An electrical probe used to measure the thicknesses of light or dense non-aqueous phase liquids in the water column of a well.

Ionization Detectors -- A photoionization detector (PID) or a flame ionization detector (FID) is used to measure the level of volatile compounds in the gaseous phase. These units are generally not compound specific and thus measure total volatile compounds. The PID generally cannot detect as complete a range of compounds as the FID. This difference is caused by the relative ionization energies of the two detectors. Most photoionization units cannot detect methane but the flame ionization unit can.

1.4 REFERENCES

None.

1.5 REQUIREMENTS AND RESOURCES

The equipment required for measuring static water levels, total depths, and immiscible layers is as follows:

- Pipe wrench
- Electrical water depth indicator
- Interface probe
- PID or FID
- Steel tape with a securely fastened heavy weight at the bottom

2.0 PROCEDURES

The following procedures to be followed include: static water level, total depth and immiscible layer measurement.

Techniques for measuring depth to water and depth to the bottom of a well should be selected in the planning phase of field work. Measuring devices should be chosen, and an individual should be assigned to take and record measurements.

All measurement instruments should be decontaminated before and after use and between measurement locations. Refer to SOP No. 002 (General Equipment Decontamination).

Prior to initiation of any measuring activities, it is necessary to monitor the ambient air at a well head for possible emissions of volatile compounds. To accomplish this monitoring, a PID or a FID should be used. The HNu and Microtip are examples of photoionization units. The Foxboro organic vapor analyzer (OVA) is an example of a flame ionization unit. The health and safety plan required for on-site activities should provide action levels and the rationale for the selection of either unit.

Appropriate respiratory protection equipment should be worn by the sampling team. Wells should be approached from the upwind side. When opening the well, the sampling team should systematically survey inside the well casing, from the casing to the ground, from above the well casing to the breathing zone, and the area around the well. If OVA readings are above action levels the sampling team should retreat to a safe area and put on appropriate safety gear. The site-specific health and safety plan should be consulted for action levels. Readings for comparison to action levels should be taken not within the well casing but in the breathing zone.

2.1 STATIC WATER LEVEL MEASUREMENT

The following procedure should be followed to conduct static water well measurement.

An electric water level indicator is typically used for static water level measurement. This instrument has a light or sound alarm that is activated when its probe touches the water surface. The cable supporting the probe is usually graduated in feet and can be read directly at the well site. The remaining fraction is measured with a steel tape specifically graduated to 0.01 foot. If the monitoring well top is not flush with the ground surface, the distance between the static water level and the top of the riser pipe at the point of water-level measurement should be measured and recorded. The height of the riser pipe above ground surface is then subtracted from the first reading to calculate the depth to static water below grade. If surveyed elevations are available, they should be used to establish the water level elevation. To ensure measurement accuracy, the probe and cable should be left hanging in the well; a series of three readings should be taken and the values averaged.

2.2 TOTAL DEPTH MEASUREMENT

The following procedure should be followed to conduct total depth measurement.

The total well depth measurement can be done using a steel tape with a heavy weight attached to the end. The tape should be lowered into the well until resistance is met, indicating that the weight has reached the bottom of the well. The total well depth is then read directly from the steel tape to the 0.01-foot fraction. If the well top is not flush with the ground surface, the distance between the bottom of the well and the top of the riser pipe at the point of water-level measurement should be measured and recorded. The height of the riser pipe above ground surface is then subtracted from the first reading to calculate the depth to the bottom of the well. To ensure measurement accuracy, the weighted steel tape should be left hanging in the well; a series of three readings should be taken and the values averaged.

2.3 IMMISCIBLE LAYER DETECTION AND MEASUREMENT

The following procedure should be followed to conduct immiscible layer detection and measurement.

An immiscible layer in a monitoring well is detected by slowly lowering an interface probe to the surface of the water in the well. When the audible alarm sounds, the depth of the probe should be recorded. If the alarm is continuous, an immiscible layer has been detected. To measure the thickness of this layer, the probe should be lowered until the alarm changes to an oscillating signal. The oscillating alarm indicates that the probe has reached a water layer. The probe depth at the time the alarm begins oscillating should be recorded as the depth to water. The thickness of the immiscible organic layer may now be determined by subtracting the depth at which a continuous alarm occurred from the depth at which the alarm began to oscillate. These readings should be repeated three times and the resultant depths and thicknesses averaged.

To assess whether a dense immiscible layer is present, the probe should be lowered further into the well. If the alarm changes from an oscillating to a continuous signal, a heavier immiscible layer has been detected. The probe depth should be recorded. The probe should then be lowered to the bottom of the well and the total depth recorded. The thickness of this dense layer can be calculated in a similar fashion as described above. The depth at which the alarm became continuous should be subtracted from the total well depth. This results in an estimate of the thickness of the dense layer in the well only. These measurements should be made three times and the thicknesses averaged to produce a mean estimate.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

MONITORING WELL INSTALLATION

SOP NO. 020

REVISION NO. 2

Approved by:

James Sickles
Quality Assurance Officer

2/9/94
Date

1.0 BACKGROUND

Monitoring well type, well construction, and well installation methods will vary with drilling method, well utility, subsurface characteristics, or other site-specific criteria. Specifications for well installation will be identified within a site work plan, sampling plan, or Quality Assurance Project Plan (QAPjP). A Monitoring Well Installation Record (see Attachment A) will be completed for each well installed by PRC. This standard operating procedure (SOP) discusses general types of wells and minimum standards for well installation for PRC Environmental Management, Inc. (PRC) projects.

Specific boring protocols are detailed in individual SOPs. Well installation methods will depend somewhat on the boring method. In turn, the boring method will depend on site-specific geology and hydrogeology. Boring methods include:

- hollow-stem auger
- cable tool
- rotary (mud, reverse, or air)
- rock coring
- jetting

The hollow-stem auger method is preferred in areas where subsurface materials are unconsolidated or loosely consolidated and the depth of the boring will be generally less than 100 feet. This maximum depth is dependent on the diameter of the augers, the formation characteristics, and the strength and durability of the drilling equipment. This method is preferred because it is quick and inexpensive, addition of water into the subsurface is limited, and continuous samples can easily be collected.

Cable tool drilling is a preferred method when the subsurface contains boulders, coarse gravels, or flowing sands, or when the operational depth of the hollow-stem auger is exceeded. This method, however, is time consuming.

Rotary methods are generally used when other methods cannot be used. The use of drilling fluids, or large amounts of water to maintain an open borehole, and the difficulty in obtaining representative samples limit this method's utility. However, this method can be used to quickly and effectively drill deep wells through consolidated or unconsolidated materials. Modifications of this method such as dual-tube drilling, drill through casing hammers, or eccentric type drill system can reduce the amount of fluids introduced into the well borehole.

Rock coring is an effective method when drilling in competent consolidated rock. Intact, continuous cores can be obtained, and limited amounts of fluid are required if the formations are not fractured.

1.3 DEFINITIONS

None.

1.4 REFERENCES

California State Water Resource Department. Bulletins 7481 and 7490. California Well Standards.

Driscoll, Fletcher G. 1986. Groundwater and Wells, 2nd. Edition. Johnson Division, St. Paul, Minnesota, p. 438-442.

National Well Water Association (NWWA), 1989. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. NWWA, p. 145-246.

1.5 REQUIREMENTS AND RESOURCES

- Monitoring Well

2.0 PROCEDURES

This section details the minimum general monitoring well installation criteria and procedures. Site-specific geologic regimes may result in departures from this procedure. Specific procedures should be detailed in a sampling plan, work plan, or QAPjP. Figure 1 shows the typical completed general monitoring well.

All wells will be equipped with factory slotted screen. Casings and screens should be threaded and flush coupled and watertight joints should be used. Casings and screens will be selected in accordance with criteria set forth in Section 2.1. Annular seals are described in Sections 2.2 and 2.3. General monitoring well installation should follow these steps:

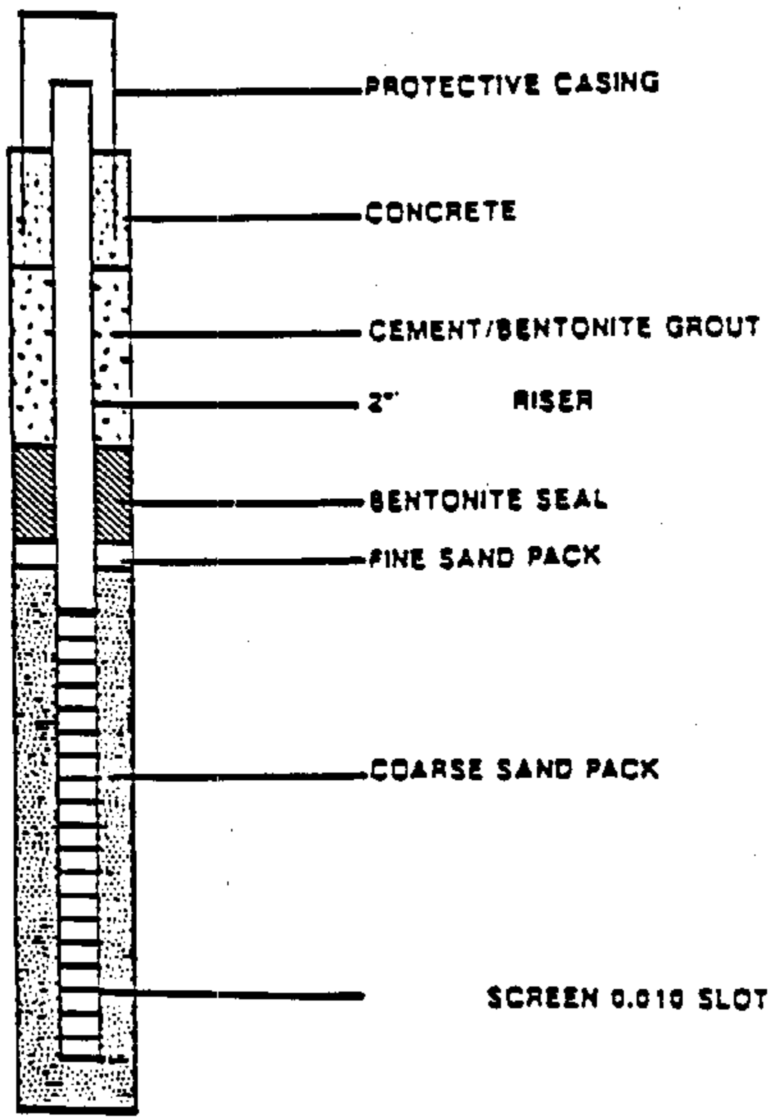
1) Prior to the installation of any casing or screen into the borehole the material should be decontaminated. PRC SOP No. 002 explains decontamination rationale and procedures.

2) Well casing and screens should be anchored within the borehole using centralizers.

3) The filter pack and other annular sealing materials should be installed through the auger stem or borehole casing. A tremie pipe should be used to install this material and a weighted tape should be used to tamp material. The tremie pipe is slowly raised as material is added to the annular space. When wells are constructed in temporary casing, such as hollow stem augers, the augers should be lifted when 1 to 2 feet of construction material has accumulated in the annulus. The casing should be lifted enough so that the accumulated material settles to within 2 to 4 inches of the bottom of the temporary casing.

FIGURE 1

TYPICAL WELL CONSTRUCTION DIAGRAM



4) Screens will be placed within a filter pack. This filter pack will be constructed in the manner detailed in Section 2.2 and will extend a minimum of 2 feet above and 2 feet below the screened interval.

5) A fine sand collar should be installed to 2 feet above the top of the filter pack.

6) A minimum 2-foot thick bentonite slurry seal will be placed above the filter pack.

7) A bentonite cement slurry should be pumped through a tremie pipe into the annular space up to a point about 2 feet below the ground surface.

8) A protective outer casing and locking cap should then be placed in the borehole and a cement surface seal should be installed. The cement surface seal will form a pad around the monitoring well.

9) Borings and/or wells should not be left unattended or if necessary, may be temporarily protected with barricades, secured fences, or watchmen, as appropriate, until the well construction is completed. When the well construction is complete, a locking cap or cover should be provided to deny unauthorized access.

2.1 CASINGS AND SCREENS

The following procedure should be followed in selecting casings and screens.

The selection of well casing and screen materials must take into account environmental factors such as: 1) geologic environment, 2) natural geochemical environment, 3) anticipated well depth, and 4) types and concentrations of known or suspected contaminants. Other non-environmental factors that will impact the material selection include: 1) anticipated life of the monitoring well, 2) drilling and installation methods, 3) cost, and 4) availability.

Inner casings and well screens should be constructed of inert, durable materials, such as stainless steel, epoxy-fiberglass or polyvinyl chloride (PVC) casing and screen. At minimum, well construction materials should be selected so that they are not expected to chemically interact with the expected contaminants, or that if interactions are possible, the levels of end products are within acceptable ranges for the purpose of groundwater monitoring.

Epoxy-fiberglass well construction materials are relatively new to the environmental monitoring field; however, preliminary data suggests they are comparable to stainless steel but approximately half the cost. Due to the recent introduction of this material into the groundwater monitoring field, local regulatory authorities should be consulted prior to the use of this material. Several states, EPA regions, and Army Corps of Engineers Districts are using this material as an alternative to stainless steel. PVC may be used if the contaminants of interest do not react with PVC or the well life is expected to be short.

Casing and screen joints should be threaded, and Teflon tape should be used to assure a tight seal with Teflon or stainless steel components. Epoxy-fiberglass and PVC joints typically are fitted with rubber O-rings to provide a tight seal. Teflon tape may also be applied to these joints to assure a prolonged tight seal. Under no circumstances should joints be glued or solvent sealed.

Screens will be factory-slotted. The screen slot size will be dependent on the required flow rates for the well and the texture of the formation. When sieve analysis information is available for well packing material, slot sizes should be capable of retaining 90 percent of the filter pack material (see Section 2.2). When no such information is available, a default screen size of 0.01-inches (No. 10 slot) will be used.

Screen length and well diameter will depend on site-specific considerations such as intended well use, contaminants of concern, and hydrogeology. Some considerations are as follows:

- Water table wells should have screens of sufficient length and thickness to monitor the water table and provide sufficient sample volume during high and low water table conditions.

- Wells with low recharge should have screens of sufficient length and width so that adequate sample volume can be collected.
- Wells should be screened over short enough distances to allow for monitoring of discrete migration pathways.
- Where light non-aqueous phase liquids (LNAPL) or contamination in the upper portion of a hydraulic unit are being monitored, the screen should be set so that the upper portion of the water-bearing zone is below the top of the screen.
- Where dense non-aqueous phase liquids (DNAPL) are being monitored, the screen should be set within the lower portion of the water bearing zone, just above a relatively impermeable lithologic unit.
- The screened interval should not extend across an aquiclude or aquitard.
- If contamination is known to be present and concentrated within a portion of a saturated zone, the screen should be constructed in a manner that minimizes the potential for cross contamination within the aquifer.
- If downhole geophysical surveys are to be conducted the casing and screen material must be of sufficient diameter and constructed of the appropriate material to allow effective use of the geophysical survey tools.
- If aquifer tests are to be conducted in a monitoring well, the slot size must allow sufficient flux to produce the required drawdown and recovery. The diameter of the well must be sufficient to house the pump and or monitoring equipment, and allow sufficient water flux (in combination with the screen slot size) to produce the required drawdown or recovery.

In many instances it may be necessary to isolate stratigraphically higher portions of the subsurface, during drilling, from the zone being monitored. In these cases special types of drilling may be necessary. An example of this is the use of a temporary or permanent borehole casing that is telescoped to smaller diameters with depth. With this approach, a large diameter casing is installed through the zone to be isolated and drilling is continued to depth through this casing. If necessary, additional smaller diameter casing can be installed to stabilize the formation or isolate progressively deeper stratigraphic units. Another alternative involves the drilling of a large diameter borehole to the base of the zone to be isolated. This borehole is then sealed with a cement-bentonite grout. When the grout has cured the well installation borehole is drilled through the grout down to its final completion depth. As with the casing approach described above, progressively deeper units can be isolated by the grouting of the portion of the borehole which penetrates overlying layers and then advancing the borehole through the hardened grout.

Prior to their installation, the casing and screen should be fitted with centralizers to assure a uniform thickness of the annular seals. The annular seal is composed of the filter pack, sand collar, bentonite seal, and cement-bentonite grout. The annular seal should have a uniform thickness around the casing and screen of between two to four inches. Thinner seals increase the possibility that the well screen may be exposed to the formation, and thicker seals may interfere with the aquifer hydraulics around the screen. Selection of the centralizer material should be based on the same criteria used to select the casing and screen material. Centralizers should be spaced at closer intervals for smaller diameter casing and screen. Two-inch casing and screen should have centralizers installed every 10 to 15 feet.

2.2 FILTER PACK

The filter pack will be composed of chemically inert, uncontaminated material. The preferred filter pack material is pure silica sand.

The methods for choosing the filter pack grain size should be clearly outlined in the work plan, sampling plan, or QAPjP. The filter pack material must be tailored to the formation material. One method for choosing the filter pack grain size is based on the method proposed by National Water Well Association (NWWA) (1989). Using this method, at least one standard sieve analysis of formation material is obtained. The grain size that retains 70 percent of the material is noted. This grain size is multiplied by a factor of 4 or 6. The factor of 4 is used for coarse poorly sorted formations, and the factor 6 is used for fine grained, well sorted formations. The resultant grain size is used as the 70 percent retained point for the grain size of the filter pack. A second more conservative approach is described by Driscoll (1986). In this approach, the filter pack size is based on multiplying the 50 percent retained formation grain size by 2. If formation particle size distribution information is not available, an Ottawa grade sand American Society for Testing and Materials (ASTM) C-778 sand, or equivalent can be considered for use. The use of a default size filter pack becomes more tenuous in increasingly finer grained formations. The uniformity coefficient of the filter pack should not exceed 2.5. The filter pack should have a finished uniform thickness of 2 to 4 inches.

The filter pack should extend 2 feet above the top of the well screen. A sand collar should be installed on top of the filter pack. The sand collar should be constructed from a fine silica sand (.0021 to .0041 inch-diameter) and it should extend 2 feet above the filter pack. This sand collar is intended to prevent intrusion of bentonite and grout into the filter pack.

2.3 SLURRY AND GROUT

A bentonite slurry should be placed in the annular pack for a minimum of 2 feet above the fine sand collar. This slurry should be mixed at a ratio of approximately 22 pounds of dry bentonite to 7 gallons of water. This procedure should result in a bentonite slurry mix weighing 10- to 11-pounds per gallon. The bentonite slurry will act as a formation seal for the monitoring well borehole.

A cement and bentonite grout will be placed in the annular space above the bentonite slurry, generally to a point approximately 2 feet below ground surface. Sufficient time should be allowed for the bentonite slurry to gel to a strength able to support the cement and bentonite gout. When mixing the slurry with a low shear device such as the grout pump or a drill rig, 30 to 60 minutes of mixing should be conducted prior to placing the slurry into the well annulus. After 30 to 60 minutes of low shear mixing, the slurry should be thick enough to support the cement-bentonite grout. The cement and bentonite grout will consist of a mixture of 8 gallons of water, 5 pounds of bentonite powder, and a 94-pound sack of Portland cement. An alternative cement-bentonite grout would be a premixed commercially equivalent material. A cement surface seal will be placed at the surface. Specific construction criteria may vary. These criteria should be detailed in the work plan or QAPjP.

The bentonite slurry used as a formation seal above the filter pack and sand collar can be replaced with a seal composed of bentonite pellets or chips. These materials should be added to the annulus slowly to prevent bridging. Lifts of 3 to 4 inches high should be separated by sufficient time to allow settlement. Past experience has shown that natural bentonite chips have slower hydration characteristics and are not as prone to bridging as formed bentonite pellets.

Bentonite seals are not always appropriate. If they are installed in the vadose zone they may never fully hydrate or they can dry creating desiccation cracks. Both situations cause seal failure. Groundwater with high chloride concentrations or total dissolved solids less than 500 parts per million (ppm) may inhibit the full hydration of the bentonite. This could limit the effectiveness of the annular seal. The case of bentonite in areas were the seal may be exposed to high concentrations of organic solvents, hydrocarbons, organic acids, basic and natural polar-organic compounds, and neutral non-polar organic compounds may result in a several order-of-magnitude increase in the permeability of the seal. Neat cement is an alternative to bentonite seals given any of the above environmental conditions. Neat cement is a mixture of Portland cement (ASTM C-150) and water in the ratio of 5 to 6 gallons of water to 94 lbs. of cement. Type I Portland cement is the most commonly used material for this application.

2.4 OTHER COMPONENTS

The procedures below should be followed under specific circumstances.

Several other well components which may be necessary depending of project specifications are listed below:

- Locking well caps and outer protective casings. These will be placed on all completed wells. These can either be above ground or flush mount.
- Bumper posts or well head protection. Protective bumper posts or other types of protective barriers should be placed around each completed well.
- Grout baskets. Grout baskets may be necessary when drilling proceeds through voids or open spaces (such as underground mines).
- Telescoping or conductor casing. Telescoping or conductor casing is used when wells are drilled to fairly deep depths when drilling proceeds through several separate saturated intervals, or when drilling through grossly contaminated intervals.

3.0 OTHER TYPES OF WELLS

This section discusses other types of wells which may be installed in special cases. These include well points, wells installed through multiple saturated zones, and well nests.

3.1 WELL POINTS

Under certain conditions it may be necessary to install well points. These wells are driven directly into the subsurface. Applications include use as vadose zone monitoring or shallow piezometer wells. However, the geologic subsurface must be compatible with this method. The utility of this method is limited because the annular space is generally not sealed to the surface. These types of wells are not acceptable for permanent monitoring well installations and should only be used under special circumstances.

3.2 WELLS INSTALLED THROUGH MULTIPLE SATURATED ZONES

When wells are installed through multiple saturated zones, special well construction methods have to be used to assure well integrity and to limit the potential for cross-contamination. Generally, these types of wells are necessary if hydraulic units are separated by relatively impermeable layers. Two procedures which may be used are described below.

The borehole is advanced to the base of the first saturated zone. Casing is then anchored in the impermeable layer below and grouted to the surface. After the grouting has cured, a smaller diameter borehole is drilled through the grout. This procedure is repeated until the zone of interest is reached. After this zone is reached, a conventional well screen and riser casing is set. A typical well constructed in this manner is shown on Figure 2.

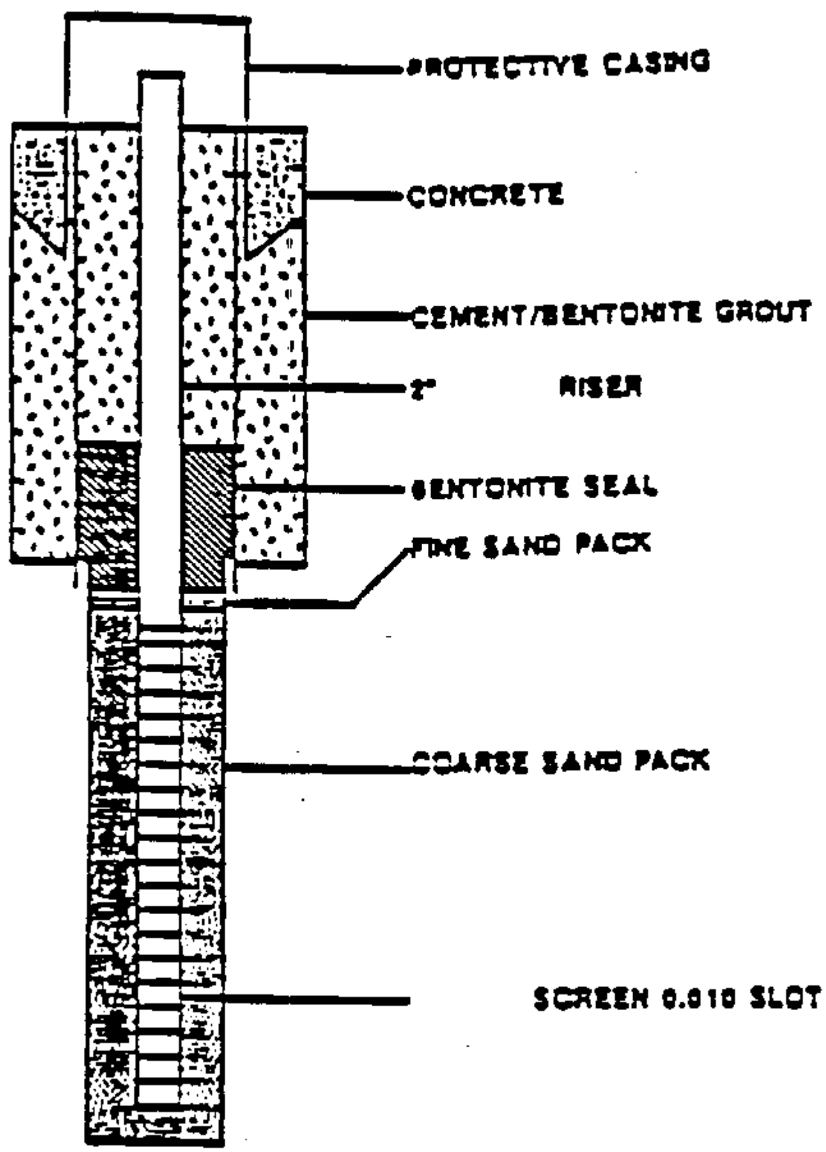
Another acceptable procedure involves driving a casing through several saturated layers while drilling ahead of the casing. This method, however, is not acceptable when a competent aquitard or aquiclude may be structurally damaged by the driven casing, because this method may result in cross contamination of two saturated layers.

3.3 WELL NESTS

Well nests are installed when several distinct intervals in the aquifer are to be sampled at each groundwater sampling location. These wells can be completed similarly to those described in Section 2.0. These wells can be installed in a single borehole or in close proximity to each other. When installing multiple wells in a single borehole, extreme care should be exercised when placing bentonite slurry seals above the filter packs. These seals must prevent flow between the wells in the single borehole

FIGURE 2

TYPICAL WELL COMPLETED
THROUGH SEVERAL SEPARATED WATER BEARING UNITS



ATTACHMENT A

MONITORING WELL INSTALLATION RECORD

PRC
ENVIRONMENTAL MANAGEMENT, INC.

MONITORING WELL INSTALLATION RECORD
NONTELESCOPING WELL

WELL LOCATION INFORMATION

WELL NO. ____________
BOREHOLE NO. ____________
SITE ____________
SUBSITE ____________
DATE ____________
RECORDED BY ____________
WELL PERMIT NO. ____________

SURFACE COMPLETION INFORMATION

TYPE OF INSTALLATION
- ☐ ABOVE GROUND INSTALLATION
  - ☐ PROTECTIVE POSTS INSTALLED
- ☐ FLUSH MOUNT INSTALLATION
  - TYPE ____________
  - ☐ TRAFFIC RATED
  - ☐ WATERTIGHT SEAL
  - ☐ WATERTIGHT WELL CAP

TYPE OF PROTECTIVE CASING
- ☐ STEEL SIZE ____________
- ☐ ____________

SURFACE SEAL
- ☐ NONSHRINKING CEMENT
- ☐ CONCRETE
- ☐ ____________
- ☐ CHECKED FOR SETTLEMENT
- ☐ INTERNAL MORTAR ADDED

GROUND SURFACE ELEVATION
- ☐ SURVEYED
  - DATE ____________

MEASURING POINT
- ☐ TOP OF WELL CASING
- ☐ TOP OF PROTECTIVE CASING
- ☐ GROUND SURFACE
- ☐ ____________ ____________

DRILLING INFORMATION

DRILLING COMPANY/PERSONNEL
____
____
____

DRILL RIG ____________

DRILLING METHOD
- ☐ HOLLOWSTEM AUGER
- ☐ AIR ROTARY
- ☐ MUD/WATER ROTARY
- ☐ ____________

DRILLING BEGAN
DATE ________ TIME ________

WELL COMPLETION BEGAN
DATE ________ TIME ________

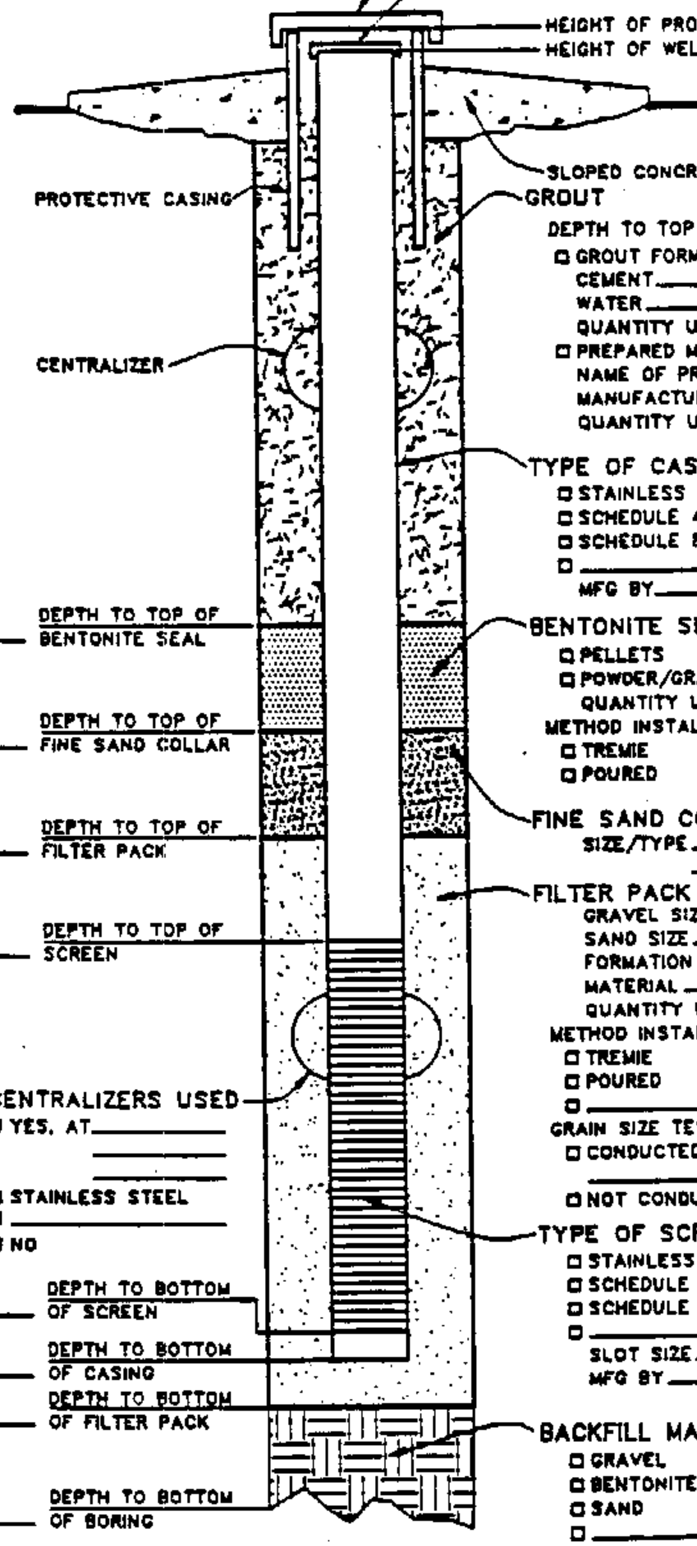
WELL COMPLETION FINISHED
DATE ________ TIME ________

DRILLING FLUID TYPE
- ☐ BENTONITE ☐ WATER
- ☐ POLYMER ☐ ________

DRILLING FLUID LOSS
- ☐ YES ________ GALLONS
- ☐ NO

WATER ADDED DURING COMPLETION
- ☐ YES ________ GALLONS
- ☐ NO

TOTAL FLUID LOSS TO FORMATION
________ GALLONS



LOCKABLE COVER

VENTED CAP (WATERTIGHT CAP FOR FLUSH MOUNT)

HEIGHT OF PROTECTIVE CASING ________

HEIGHT OF WELL CASING ________
- ☐ ABOVE GROUND
- ☐ BELOW GROUND

SLOPED CONCRETE PAD/SURFACE SEAL

PROTECTIVE CASING

GROUT
DEPTH TO TOP OF GROUT
- ☐ GROUT FORMULA (PROPORTION OF EACH)
  - CEMENT ________ BENTONITE ________
  - WATER ________ OTHER ________
  - QUANTITY USED ________
- ☐ PREPARED MIX
  - NAME OF PRODUCT ________
  - MANUFACTURED BY ________
  - QUANTITY USED ________

CENTRALIZER

TYPE OF CASING
- ☐ STAINLESS STEEL
- ☐ SCHEDULE 40 PVC
- ☐ SCHEDULE 80 PVC
- ☐ ________

CASING DIAMETER
INSIDE ________
OUTSIDE ________

MFG BY ________

________ DEPTH TO TOP OF BENTONITE SEAL

BENTONITE SEAL
- ☐ PELLETS ☐ SLURRY
- ☐ POWDER/GRANULAR ☐ ________
- QUANTITY USED ________

METHOD INSTALLED
- ☐ TREMIE ☐ ________
- ☐ POURED ☐ NOT USED

________ DEPTH TO TOP OF FINE SAND COLLAR

FINE SAND COLLAR (OPTIONAL)
SIZE/TYPE ________
____

________ DEPTH TO TOP OF FILTER PACK

FILTER PACK
- GRAVEL SIZE ________; ________ TO ____ FT
- SAND SIZE ________; ________ TO ____ FT
- FORMATION COLLAPSE: ________ TO ____ FT
- MATERIAL ________
- QUANTITY USED ________

METHOD INSTALLED
- ☐ TREMIE
- ☐ POURED
- ☐ ________

GRAIN SIZE TESTS FOR FILTER PACK
- ☐ CONDUCTED; FOR REPORT, REFER TO ________
- ☐ NOT CONDUCTED

________ DEPTH TO TOP OF SCREEN

CENTRALIZERS USED
- ☐ YES, AT ________
  - ________
  - ________
- ☐ STAINLESS STEEL
- ☐ ________
- ☐ NO

TYPE OF SCREEN
- ☐ STAINLESS STEEL
- ☐ SCHEDULE 40 PVC
- ☐ SCHEDULE 80 PVC
- ☐ ________

SCREEN DIAMETER
INSIDE ________
OUTSIDE ________

SLOT SIZE ________
MFG BY ________

________ DEPTH TO BOTTOM OF SCREEN

________ DEPTH TO BOTTOM OF CASING

________ DEPTH TO BOTTOM OF FILTER PACK

BACKFILL MATERIAL
- ☐ GRAVEL ☐ FORMATION COLLAPSE;
- ☐ BENTONITE MATERIAL ________
- ☐ SAND ________
- ☐ ________

________ DEPTH TO BOTTOM OF BORING

DIAMETER OF BOREHOLE ________

TOTAL LENGTH OF CASING AND SCREEN ________

DEPTH TO WATER FOLLOWING INSTALLATION (TOC) ________

NOTES:
1. SCALE: NONE
2. RECORD FRACTIONAL FEET IN DECIMAL, NOT IN INCHES
3. RECORD CONSTRUCTION DEPTHS BELOW GROUND LEVEL

DATE: 02/21/91 JAA FILE NAME: G:\STAND\INSTAL00.DWG

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

MONITORING WELL DEVELOPMENT

SOP NO. 021

REVISION NO. 2

Approved by:

James Sickles
Quality Assurance Officer

2/9/94
Date

Title: **Monitoring Well Development**

1.0 BACKGROUND

Well development is an attempt to remove the finer grained material, typically clays and silts, from the geologic formation near the well screen and filter pack. These fine-grained particles may interfere with water quality analyses, and alter the hydraulic characteristic of the filter pack and hydrologic unit adjacent to the well screen.

All drilling methods impair the ability of an aquifer to transmit water to a drilled hole. Typically, this impairment is a result of the invasion of drilling fluids or solids into the aquifer during the drilling process. Nonetheless, the impact to the hydrologic unit surrounding the borehole must be remediated if the well hydraulics and sampling of the monitoring well are to be representative of the aquifer.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedure for monitoring well installation and development.

Well development improves the hydraulic characteristics of the filter pack and borehole wall by performing the following functions:

- Reduce the compaction and the intermixing of grain sizes produced during drilling by removing fine material from the pore spaces.
- Remove the filter cake or drilling fluid film that coats the borehole, and remove much or all of the drilling fluid and natural formation solids that have invaded the formation.
- Create a graded zone of sediment around the screen, thereby stabilizing the formation so that the well can yield sediment-free water.

1.2 SCOPE

This SOP applies to the specifications and methodologies of monitoring well development.

1.3 DEFINITIONS

Aquifer -- A geologic formation, group of formations, or part of a formation that is saturated, and is capable of storing and transmitting water.

Bailer -- A hollow tubular receptacle used to facilitate withdrawal of fluid from a well or borehole.

Conductance (Specific) -- A measure of the ability of the water to conduct an electric current. It is directly proportional to the total concentration of ionizable solids (anions, cations, including hydronium ions) in the water. It is inversely proportional to electrical resistance.

Drilling Fluid -- A fluid (liquid or gas) that may be used in drilling operations to remove cuttings from the borehole, to clean and cool the drill bit, and to maintain the integrity of the borehole during drilling.

Hydraulic Conductivity -- The volume of water that will move in unit time under unit gradient through a unit area measured at right angles to the direction of flow.

Hydrologic Units -- Geologic strata that can be distinguished on the basis of capacity to yield and transmit fluids. Aquifers and confining units are types of hydrologic units. Boundaries of a hydrologic unit may not necessarily correspond laterally or vertically to lithostratigraphic formations.

Oil Air Filter -- A filter or series of filters placed in the air flow line from an air compressor to reduce the oil content of the air.

Oil Trap -- A device used to remove oil from the compressed air discharged from an air compressor.

Riser -- The pipe extending from the well screen to or above the ground surface.

Static Water Level -- The elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, hydrologic testing, or nearby pumpage.

Transmissivity -- The rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. NOTE: It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths.

Well Screen -- A filtering device used to retain the filter pack; usually a cylindrical pipe with openings of a uniform width, orientation, and spacing.

Well Screen Jetting (Hydraulic Jetting) -- When jetting is used for development, a jetting tool with nozzles and high pressure pump is used to force water outwardly through the screen, the filter pack, and sometimes into the adjacent geologic unit.

1.4 REFERENCES

American Society of Testing and Materials (ASTM). 1989. "Proposed Recommended Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers." *Annual Book of ASTM Standards*. Philadelphia, Pennsylvania.

Driscoll, F.G. 1986. "Ground Water and Wells." Johnson Division, UOP, Inc., St. Paul, Minnesota.

National Well Water Association, (NWWA). 1989. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells, NWWA.* EPA 600/4-89/034.

1.5 REQUIREMENTS AND RESOURCES

There are various options available to develop monitoring wells. The procedures and equipment required are outlined in the following sections.

2.0 WELL DEVELOPMENT PROCEDURES

Methods of well development vary with the physical characterization of hydrologic units in which the monitoring well is screened, well design, and with the drilling method used. The most common methods of well development include mechanical surging, pumping or over-pumping, air lift pumping, backwashing, and jetting. Air surging should never be attempted. Factors such as well design and hydrogeologic conditions will determine which well development method will be most practical and cost-effective. The most common and effective methods of well development are described in Sections 2.1 to 2.5.

A Well Development Data Sheet (see Attachment A) can be used to document the site-specific data.

2.1 MECHANICAL SURGING

Mechanical surging is a very effective method for developing monitoring wells. This method forces water to flow in and out of the well screen by operating a plunger (or surge block) or bailer in the casing, similar to a piston in a cylinder. The surge block is typically attached to a drill rod or drill stem and is of sufficient weight to cause the block to drop rapidly on the down stroke, forcing water contained in the borehole into the aquifer surrounding the well. In the recovery stroke or upstroke, water is lifted by the surge block, allowing the flow of water and fine sediments back into the well from the aquifer. A typical surge block is schematically represented in Figure 1.

The surge block should be lowered into the well 10 to 15 feet beneath the static water level and above the well screen depending on the hydrologic conditions of the aquifer. The water column will effectively transmit the action of the block to the filter pack and hydrologic unit adjacent to the well screen. The initial surging action should be relatively gentle, allowing any material blocking the screen to break up, go into suspension, and then move into the well. As water begins to move easily both into and out of the screen, the surging tool is usually lowered in increments to a level just above the screen. As the block is lowered, the force of the surging movement should be increased. In wells equipped with long screens, it may be more effective to operate the surge block in the screen to concentrate its actions at various levels. Development should begin above the screen and move progressively downward to prevent the tool from becoming sand locked in the well.

Periodically a pump or bailer should then be used to remove dislodged sediment that may have accumulated at the bottom of the well during the surging process.

Surging can disturb the formation and or filter pack, altering the hydraulic properties of these units. In formations with high clay and silt contents, surging can cause the screen to become clogged with fines. In all applications surging should be used with caution to prevent casing and screen damage.

2.2 OVERPUMPING

Overpumping involves pumping the well at a rate substantially higher than it will be pumped during well purging and groundwater sampling. This method is most effective on coarse-grained formations. Overpumping is commonly implemented by means of a submersible pump. In cases were the water table is less than 30 feet from the top of the casing it is possible to overpump the well with a centrifugal pump. The intake pipe is lowered into the top of the water table and water is extracted.

FIGURE 1

SCHEMATIC DRAWING OF A SURGE BLOCK

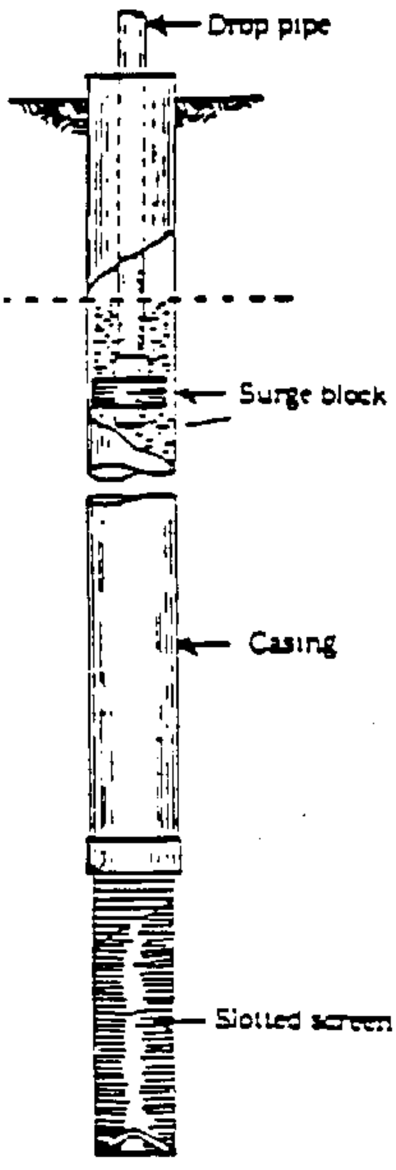


Figure 1. Development with a surge block

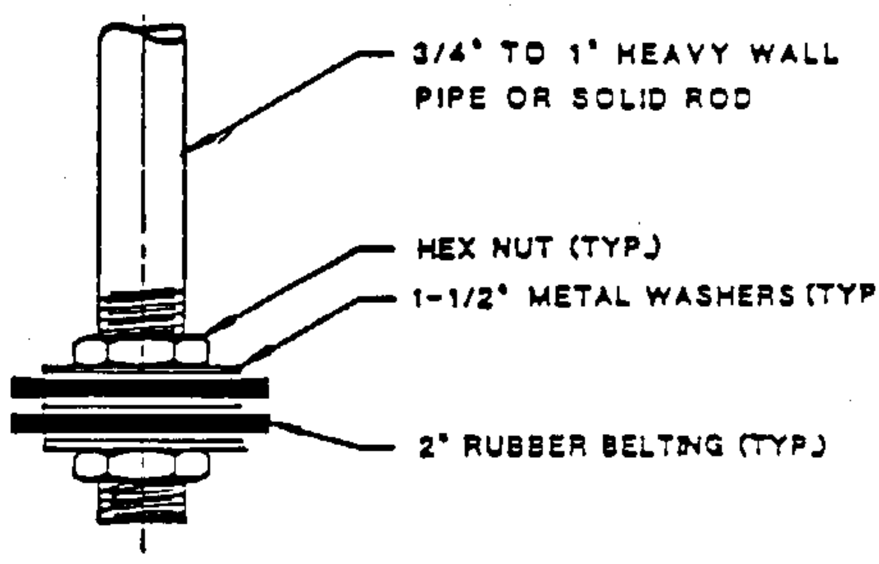


Figure 2. Typical design for a surge block used in a 2-inch I.D. monitoring well

Withdrawal of water from the top of the water table results in the same inflow at the screen as is achieved with a submersible pump. Either method of overpumping will induce a high velocity water flow, resulting in the flow of sand, silt, and clay into the well; clogged opening screen slots; and cleaning formation voids and fractures. The movement of these particles at high flow rates should eliminate particle movement at the lower flow rates used during well purging and sampling. The bridging of particles against the screen because of the flow rate and direction created by over pumping may be overcome by using mechanical surging or backwashing in conjunction with this method.

Effective overpumping involves the discharge of large amounts of groundwater. This may be a problem where groundwater extracted during well development is contaminated with hazardous constituents. If the hazardous constituents are organic compounds, this problem can be largely overcome by passing the groundwater through an activated carbon filter before final discharge.

2.3 AIR LIFT PUMPING

Air lift pumping uses a two pipe system where an air injection pipe is installed alongside a discharge or educator pipe. The air injection pipe is bent up into the bottom of the discharge pipe. Air is discharged directly into the discharge pipe. In this manner, air never enters the well casing or screen. Pumping air into the filter pack and adjacent hydrologic unit may cause air to lodge there and inhibit future sampling efforts and may alter ambient water chemistry. The well riser should not be used as the educator pipe to prevent possible air injection into the formation. Air is injected through the inner pipe at sufficient pressure to bubble out directly into the surrounding discharge pipe. The bubble formed causes the column of water in the discharge pipe to be lifted upward and allows water from the aquifer to rush into the well. The American Standards for Testing Materials (ASTM, 1989) describes the method of air lift pumping. In this method, an air lift pump is operated by cycling the air pressure on and off for short periods of time. This operation will provide a surging action that will dislodge fine-grained particles. Applying a steady, low pressure will remove the fines that have been drawn into the well by the surging action. The air discharged to the well should be filtered to remove any compressor lubricant entrained in the air. Air pressures required for this technology are relatively low, 14.8 pounds per square inch (psi) air pressure should move a 30-foot column of water.

2.4 BACKWASHING (RAWHIDING)

Effective development procedures should cause flow reversals through the screen openings that will agitate the sediment, remove the finer fraction, and then rearrange the remaining formation particles. Backwashing overcomes the bridging that results from overpumping by allowing the water that is pumped to the top of the well to flow back through the submersible pump and out through the intake portion of the well. The backflow portion of the backwashing cycle breaks down bridging, and the inflow then removes the fine material toward the screen and into the well.

Some wells respond satisfactorily to backwashing techniques, but in many cases the surging effect is not vigorous enough to obtain maximum results. As in the case of the overpumping technique, the surging effects may be concentrated only near the top of the screen or in the most permeable zones. Thus, the lower part of a long screen may remain relatively undeveloped.

A variation of backwashing may be very effective in low permeability formations. After the filter pack is installed on a monitoring well, water is circulated down through the well screen and filter pack and up the open borehole prior to the placement of the grout or seal in the annulus (NWWA 1989). Flow rates should be controlled to prevent floating the filter pack. Because of the low hydraulic conductivity of the formation, negligible amounts of water will infiltrate into the formation. Immediately after this procedure the seal should be installed and the non-formation water should be pumped out of the well and filter pack.

2.5 WELL JETTING

Well jetting is effective in developing monitoring wells in both unconsolidated and consolidated formations. Well jetting can open fractures and remove drilling mud that has penetrated the aquifer. This discharge force of the jetting tool is concentrated over a small area of the well screen. As a result, the tool must be rotated constantly while it is raised and lowered in very small increments to be sure that all portions of the screen are exposed to the jetting action. Like a surge block, the jetting nozzles should fit closely to the inside of the screen because the velocity of the jet stream is dissipated within a few inches. Jetting is relatively ineffective on screens with slot sizes less than 0.02 inch (NWWA, 1989). Jetting will generally not affect the interface of the filter pack and the borehole. This interface, especially in fine grained formations or when drilling fluids are used, is a critical target for well development. If jetting is used, serious consideration should be given to the effect of introducing water into the formation.

The major disadvantage of jetting is that an external supply of water is needed. The water added during well jetting will alter the natural, ambient water quality. Therefore, the water added in this development procedure should be obtained from a source of known chemistry.

3.0 OVERALL CONSIDERATIONS

Other methods of well development are also available. For small-diameter and small-volume wells, a bailer can be used in place of a submersible pump in the overpumping method. Similarly, a bailer can be used in much the same fashion as a surge block in small-diameter wells. Wells can be backwashed by simply adding water to agitate and remove fines plugging the screen and formation.

3.1 INITIATION OF WELL DEVELOPMENT

Regardless of the well development method selected, a few considerations are universally applicable. First, well development should be initiated gently. As flow is established through the intake portion of the well, the degree of agitation can be slowly increased. Second, there should be no time limit placed on well development. Well development should be considered completed when the flow is reasonably clear and free of sediment and when pH, temperature, and specific conductivity have stabilized. This threshold should be rechecked at least once after letting the well sit undisturbed until it has achieved 95% water elevation recovery. These considerations are described in greater detail in sections 2.6.2 to 2.6.3, which were adopted from the "Proposed Recommended Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers" (ASTM, 1989).

3.2 WELL DEVELOPMENT FACTORS TO BE CONSIDERED

An important factor in any method is that the development work start slowly and gently and increase in vigor as the well is developed. Most methods of well development require the application of sufficient energy to disturb the filter pack, thereby freeing the fines and allowing them to be drawn into the well. The coarser fractions then settle around and stabilize the screen.

Development procedures for wells completed in fine sand and silt strata should involve methods that are relatively gentle so that the strata material will not be incorporated into the filter pack. Vigorous surging for development can produce mixing of the fine strata and filter pack and produce turbid samples from the installation. Also, development methods should be carefully selected based upon the potential contaminant(s) present, quality of waste water generated, and requirements for containerization or treatment of waste water.

For small diameter and small volume wells, a bailer can be used in place of a submersible pump in the pumping method. Similarly, a bailer can be used in much the same fashion as a surge block in small diameter wells.

Wells can be backwashed by simply adding water to agitate and remove fines plugging the screen and formation.

Any time an air compressor is used, it should be equipped with an oil air filter or oil trap to minimize the introduction of oil into the screen area. The presence of oil impacts the organic constituent concentrations of the water samples.

3.3 DURATION OF WELL DEVELOPMENT

Well development should begin after the monitoring well is completely installed and prior to water sampling. Development should be continued until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction is obtained. Representative water is assumed to have been obtained when pH, temperature, and specific conductivity readings stabilize and the water is visually clear of suspended solids. The minimum duration of well development should vary in accordance with the method used to develop the well. For example, surging and pumping the well may provide a stable, sediment free sample in a matter of minutes, whereas bailing the well may require several hours of continuous effort to obtain a clear sample. Once the well is initially considered developed, it should be left to recover to at least 95% of its natural water elevation. Once this is achieved, the development procedure should be restarted and if the physical chemical parameters used to verify successful well development have not changed, the well can be considered developed.

ATTACHMENT A

WELL DEVELOPMENT DATA SHEET

WELL DEVELOPMENT DATA SHEET

BORING NO. __________ WELL NO. __________

Project ______________________
Project No. ______________________
Date(s) of Installation ______________________
Date(s) of Development ______________________
Personnel/Company ______________________

Type of Rig Used ______________________

Casing Diameter/Type ______________________
Borehole Diameter ______________________
Screened Interval(s) ______________________
Total Length of Well Casing ______________________
Measured Total Depth (TOC) Initial ____________
Final ____________
Initial Depth to Water
(TOC) ____________ Date __________ Time _____
Stabilized Depth to Water
(TOC) ____________ Date __________ Time _____

DEVELOPMENT

TECHNIQUE(S) EQUIPMENT TYPE/CAPACITY

____ Jetting (Airlift) ______________________
____ Surge Block ______________________
____ Bailing ______________________
____ Pumping ______________________
____ Other ______________________

PURGE VOLUME CALCULATION

Casing Volume:
________ Ft. of water x ______ Gallons/Foot
= ____________ (a) Gallons per Single Casing Volume

Sand Pack Volume:
________ (b) Ft. of Saturated Sand Pack
x ________ Gallons/Foot (borehole diameter)
= ________ Gallons (in borehole)
- ________ Gallons of Casing Vol. for Saturated Interval (a :
= ________ x 0.3 (assuming porosity = 30%)
= ________ Gallons Within Sand Pack

FLUIDS ADDED

Lost Drilling Fluid: ____________ Gallons
Lost Purge Water: ____________ Gallons
Water During Installation: ____________ Gallons
Total Fluids Added: ____________ Gallons
Source of Added Water: ______________________
Ground Water Quality Parameters of
Added Water Measured: Y N
Sample Collected of Added Water: Y N
Sample Designation of Added Water: ____________

Single Purge Volume: ____________ Gallons (Casing Vol. +
Sand Pack Vol. + Fluids Adde
Minimum Purge Volume: ______________ Gallons
Actual Purge Volume: ______________ Gallons
Volume Measured by: ______________________
Rate of Development ____________ Gallons/Minute (Hour,D.
Pumping Rate/Depth ____________ @ _____ Ft. (Below Gr
Immiscible Phases Present: Y N Thickness ________

INSTRUMENT CALIBRATION

Calibration Date ______________ See Sheet _____ of __

pH Meter: ______________________ Spec. Conductance Meter: ______________________
pH 4.0 = ________ @ _____ °C Standard ____________ μmhos/cm@ 25°C
pH 7.0 = ________ @ _____ °C Reading ____________ μmhos/cm @ _____ °C
pH 10.0 = ________ @ _____ °C Turbidity Meter: ______________________
Dissolved Oxygen Meter: ______________________ Other: ______________________

Total Volume Discharged	Rate of Discharge	Time	Temp	pH	Specific* Conductance	Turbidity or D.O.	Clarity, Odor PID Readings, Other

Development Completed at ____________ Gallons Discharged. Date: __________ Time: ____________
Criteria: ______________________________ Personnel: ______________

* Specific Conductance readings temperature compensated to 25°C, if not, report temperatures at which reading obtained.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLING -HYDROPUNCH

SOP NO. 070

REVISION NO. 0

Approved by:

Quality Assurance Officer   Date

Technical Information & Application Guidelines

HYDROPUNCH™

Groundwater Sampling Without Wells

PRC ENVIRONMENTAL TRAINING CENTER

INTRODUCTION

The HydroPunch™ is a stainless steel and Teflon' sampling tool. The HydroPunch provides a rapid, cost effective means to collect chemically representative ground water samples without the installation, development, and sampling of a ground water monitoring well. The resulting data can be used to help determine the vertical and horizontal extent of contamination and to accurately quantify the concentration of pollutants in the ground water. Ground water samples collected by the HydroPunch can be used to eliminate unnecessary ground water monitoring wells and to minimize the number of wells that are ultimately required for permanent ground water monitoring purposes. Savings of up to seventy percent (70%) of the cost of conventional well sampling have been reported.

Cost Comparison

Activity	Conventional Well Installation	HydroPunch with Penetrometer Rig	Hydropunch with Drill Rig
Mobilization	$ 200	$ 100	$100
Drilling & Well Installation*	3,200	800	1,200
Well Development	500	—	—
Field Supervision	1,000	400	600
Sampling	600	425	425
Total Cost	$5,500	$1,725	$2,325
Total Time	3 days	1 day	1.2 days

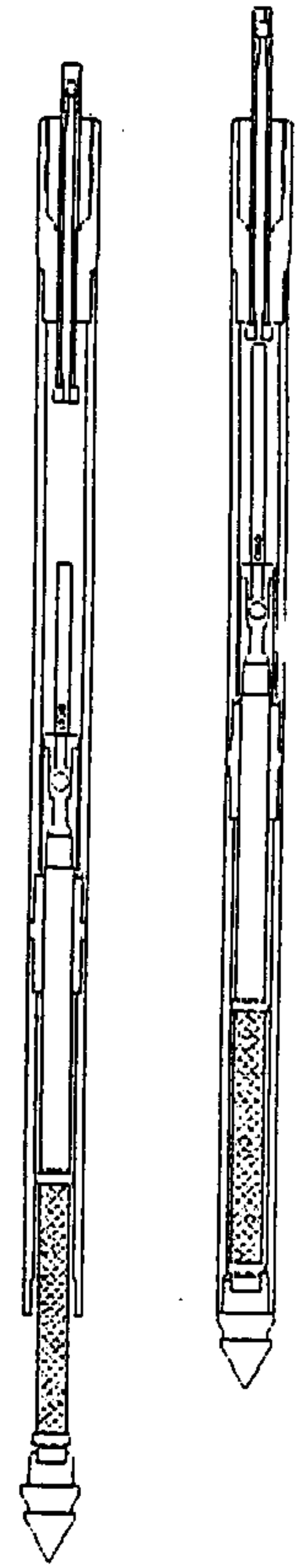
*Number of Groundwater Wells - 5

Depth to Groundwater - 25 feet

GENERAL TECHNICAL INFORMATION

The HydroPunch ground water sampling tool can be used in two modes, utilizing either cone penetrometer equipment or conventional drilling equipment to push or drive the tool to the desired sampling depth. The sampler is constructed entirely of stainless steel and Teflon, is easily cleaned in the field, and will collect approximately 500 ml of sample. The HydroPunch has a stainless steel drive point, a perforated section of stainless steel pipe for sample intake, a stainless steel and Teflon sample chamber, and an adapter to attach the unit to either penetrometer push rods or standard soil sampling drill rods.

As the unit is pushed or driven through the soil, the sample intake pipe is shielded in watertight housing that prevents contaminated soil or ground water from entering the unit. The shape of the sampler and its smooth exterior surface prevent the downward transport of the surrounding soil and liquid as the tool is advanced. When the desired sampling depth is reached, the sampler is retracted approximately 1.5 feet; the perforated intake pipe is exposed to the water-bearing zone, permitting ground water to flow through the screen and into the sample chamber. During sampling, no foreign materials (i.e., gravel pack, drilling fluid or cuttings) are introduced into the zone being sampled, minimizing the contaminants.



'Teflon is a registered trademark of E.I. duPont de Nemours

1.0 BACKGROUND

The HydroPunch provides a rapid, cost effective way to collect groundwater samples without installing monitoring wells. The results of the chemical data can be used to determine the distribution of contaminants in water bearing zones and to aid in the placement of monitoring wells. HydroPunch sampling can reduce the number of monitoring wells installed at a site and ultimately reduce the cost of an investigation.

1.1 PURPOSE

The purpose of this SOP is to provide guidance and practical information regarding the HydroPunch groundwater sampling system.

1.2 SCOPE

This SOP applies to all PRC employees using the HydroPunch sampling system. Drilling methods that the HydroPunch is used in conjunction with, should be described in the site specific work plan and sampling plan and detailed in other PRC SOPs.

1.3 DEFINITIONS

Definitions will be included as necessary within the body of the SOP.

1.4 REFERENCES

Three references are attached to this SOP. They are: (1) Technical Information & Application Guidelines, (2) HydroPunch Operation Manual, and (3) HydroPunch Users Guide all developed by QED Environmental Systems, Inc.

1.5 REQUIREMENTS AND RESOURCES

See attached guidelines and manuals.

2.0 PROCEDURE

The procedures for operating the HydroPunch groundwater sampling system are presented the attachments to this SOP.

HYDROPUNCH®

USER'S GUIDE

Contents

LIST OF TABLES

LIST OF FIGURES

HYDROPUNCH® USER'S GUIDE

by

Kent E. Cordry*

QED Ground Water Specialists

I. INTRODUCTION

HydroPunch I (HP-I) *(Patent #4669554)* and HydroPunch II (HP-II) *(patent pending)* are specialized field screening tools that are capable of collecting a representative ground water sample without requiring the installation of a ground water monitoring well. The tool is a drive sampler used to obtain ground water samples.

The HydroPunch provides a fast, inexpensive method to determine the presence or absence of ground water contamination and, if present, to define the vertical and horizontal extent of the contamination. **The HydroPunch is not intended to replace monitoring wells but is used to reduce the number of monitoring wells needed to complete the hydrogeologic investigation.** HydroPunch samples enable the user to determine if long term monitoring wells are needed and, when needed, to optimize the location of the wells. While a monitoring well can collect hundreds of samples from a single location, a single HydroPunch can collect hundreds of samples from different locations. In short, the tools enable the user to get away from using monitoring wells to locate monitoring wells. A summary of the advantages of using the HydroPunch for site screening, as opposed to the traditional approach of installing monitoring wells, is outlined in Table 1 on the following page.

* *This manual has been prepared by Kent E. Cordry, the inventor of the HydroPunch, to aid your use of this tool. If you have any questions or suggestions for this manual, contact Kent through QED.*

TABLE 1
HYDROPUNCH ADVANTAGES

Speed	HydroPunch samples can be collected in one-half to one-tenth the time it takes to install, develop, purge and sample a monitoring well and the samples are available immediately for analyses, not days, weeks or months later, as is the case with monitoring wells.
Economy	Since samples can be collected at a much faster rate using the same equipment as well installation methods, the user realizes a substantial reduction in cost. Well development or purging is not necessary prior to sampling, consequently there is no need to containerize and dispose of excess water. Costs for projects can be one-half to one-tenth the cost of installing monitoring wells to obtain the same geochemical data.
Quality	Numerous technical papers have been published which compare HydroPunch samples to monitoring wells completed at the same locations. The results indicate a strong correlation between the monitoring wells and the HydroPunch samples. Findings thus far suggest that the HydroPunch samples minimize volatization at low levels of VOC contamination. This probably is because the HydroPunch collects a sample from a discrete zone with a minimum of aeration and agitation of the sample.
Environmental Impact	Since a permanent well is not installed, the disturbance to the surrounding environment is minimized during HydroPunch sampling, especially if the HydroPunch is pushed or driven from the surface to collect the sample. The low environmental impact is extremely valuable when tracking off-site plumes or when sampling needs to be as unobtrusive as possible.
Safety	The HydroPunch is a one time sampling system. Once the sample has been collected and the HydroPunch removed, the remaining hole can be effectively sealed from the bottom up by means of pressure grouting. This eliminates cross-contamination of aquifers as well as the need for well abandonment (necessary if wells are improperly constructed or become obsolete).

Other Screening Systems (general)

Prior to the availability of the HydroPunch, the only field screening tools available to define the extent of ground water contamination consisted of various geophysical systems and soil gas analysis. Unfortunately, developing a correlation between the results of the soil gas or geophysical investigation and concentrations of contaminants in the ground water is difficult, if not impossible, unless site and contaminant conditions are ideal. By comparison, the HydroPunch provides a physical sample of the ground water. This sample can be directly correlated with concentrations found in a monitoring well installed at the same location.

Well points and screened hollow stem augers are sometimes used for site screening, but both share a common problem. The screened intakes of the tools are exposed as they are being advanced, permitting outside contamination to enter and subsequently be carried down to the sample zone. As a result, large quantities of water need to be removed during development and purging prior to sampling. Even after development and purging are completed, there is no way to be positive that all contamination from the overlying zones has been removed. When a screened auger is used, an additional problem is that the auger does not seal itself in the borehole. The loose fit within the borehole permits contamination to enter the sample zone from above via the annulus between the flights of the auger and the wall of the borehole.

II. HOW THE HYDROPUNCH SYSTEM WORKS

1. General Information

Currently, two models of the HydroPunch are available. The general operation principles of HP-I and HP-II are the same. The tools are designed to be pushed or driven into the aquifer either from the ground surface or from the bottom of a drilled borehole. Typically this is accomplished by using a drill rig or a cone penetrometer rig. Both units utilize an air-tight and water-tight sealed intake screen and sample chamber which is isolated from the surrounding environment as the tool is advanced.

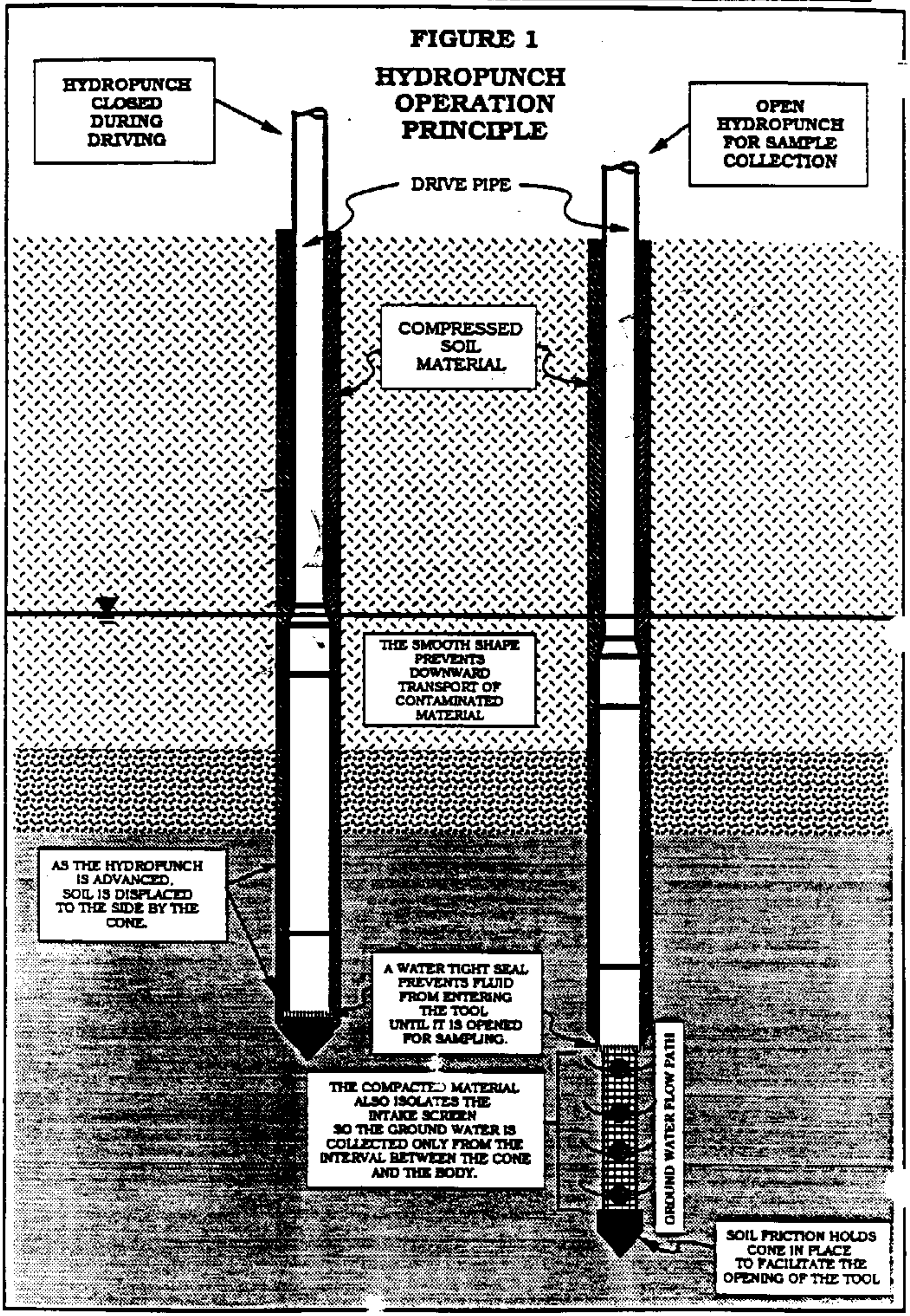


FIGURE 1
HYDROPUNCH OPERATION PRINCIPLE
HYDROPUNCH CLOSED DURING DRIVING
OPEN HYDROPUNCH FOR SAMPLE COLLECTION
DRIVE PIPE
COMPRESSED SOIL MATERIAL
THE SMOOTH SHAPE PREVENTS DOWNWARD TRANSPORT OF CONTAMINATED MATERIAL
AS THE HYDROPUNCH IS ADVANCED, SOIL IS DISPLACED TO THE SIDE BY THE CONE.
A WATER TIGHT SEAL PREVENTS FLUID FROM ENTERING THE TOOL UNTIL IT IS OPENED FOR SAMPLING.
THE COMPACTED MATERIAL ALSO ISOLATES THE INTAKE SCREEN SO THE GROUND WATER IS COLLECTED ONLY FROM THE INTERVAL BETWEEN THE CONE AND THE BODY.
GROUND WATER FLOW PATH
SOIL FRICTION HOLDS CONE IN PLACE TO FACILITATE THE OPENING OF THE TOOL

The shape and smooth exterior surface of the HydroPunch prevent the downward transport of contamination as the tool is advanced (Figure 1). As the tool is pushed deeper into the soil it cleans itself as the soil particles are displaced to the side and adhere to the surrounding soil material. As the soil is displaced, it compacts into the walls of the hole. This not only cleans the tool as it moves downward but also produces a very tight annular seal around the tool. The tight seal enables the HydroPunch to collect a very discrete sample from a specific depth by sealing off ground water from above and below the zone to be sampled (Figure 1). It should be noted that in fine-grained materials with very thin water bearing zones, the compression of the soil particles displaced by the HydroPunch may sometimes lower the permeability of the material to a degree where ground water samples may not be collected in a reasonable amount of time (i.e, < 1 hour). Handling conditions like this will be covered later in more detail.

When the desired depth for collection of a ground water sample is reached, the HydroPunch is opened by pulling back on the body of the tool (Figure 1). Soil friction holds the drive cone in place as the body moves back. Once the O-ring seal between the drive cone and the body of the tool is broken, ground water flows from the surrounding formation into the sample chamber. No foreign materials (i.e. gravel pack, drilling fluid or cuttings) are introduced, minimizing the possibility of outside contamination. As the sample is collected, the drive cone and the sample chamber are tightly sealed against the borehole walls. This "packer" effect isolates the intake from ground water above and below and results in a very discrete vertical sample interval. Once open, the HydroPunch fills from the bottom with no aeration and minimal agitation of the sample.

With HP-I, and when HP-II is used in the water sampling mode, the sample is collected and transported to the surface within the body of the tool. As the tool is pulled upward, increased hydrostatic head within the tool closes lower and upper check valves which retain the sample within the body of the Hydro-Punch. Once at the surface, the HydroPunch is inverted and the sample is decanted through a top discharge valve and tubing.

When the HP-II is used in the hydrocarbon sampling mode, the tool is connected to the surface using a hollow drive pipe of large enough inside diameter (I.D.) to permit the passage of a thin bailer. The sample is collected by lowering the bailer from the surface through the drive pipe and retrieving the sample. This configuration permits sampling of floating contaminants and also allows an unlimited quantity of sample to be collected.

III. OPERATION: HYDROPUNCH I

The HP-I is pushed or driven into the undisturbed soil to the desired sampling depth either from the surface or from the bottom of a drilled borehole (Figure 2). It is then pulled back about two feet. Soil friction holds the drive cone in place, which in turn pulls the intake screen out of the sample chamber and exposes it to the formation. Once the O-ring seal on the cone is broken, ground water flows through the intake screen, past the lower check valve and into the sample chamber. Once open, the HydroPunch fills from the bottom with no aeration and minimal agitation of the sample. When the tool is full, the sample is collected by pulling the tool towards the surface. This increases the hydrostatic pressure within the tool, closing the two check valves. At the surface, the HydroPunch is inverted and the sample is decanted through an upper discharge valve and tubing into a sample container.

The main features which differentiate HP-I from HP-II are the diameter of the tool, the attached cone and intake screen, and the fact that HP-I can only be used in one sampling mode.

The diameter of HP-I is smaller because the tool is designed to be used by cone penetrometer rigs, as well as with drilling rigs. A cone penetrometer rig is a very heavy vehicle (approximately 20 tons) with a set of powerful hydraulic rams which are used to push logging tools or a HydroPunch from the surface into the soil (Figure 3). The weight of the rig is used to offset the upward thrust as the tools are pushed into the ground. In order to be used effectively by the cone penetrometer rig, the outside diameter (O.D.) of HP-I was kept under 1.75 inches. This is about the maximum diameter usable without increasing the soil resistance to the point that the tool becomes ineffective because of depth limitations. HP-II, designed to be used primarily with drilling rigs, has a 2-inch O.D.

FIGURE 2

HYDROPUNCH I

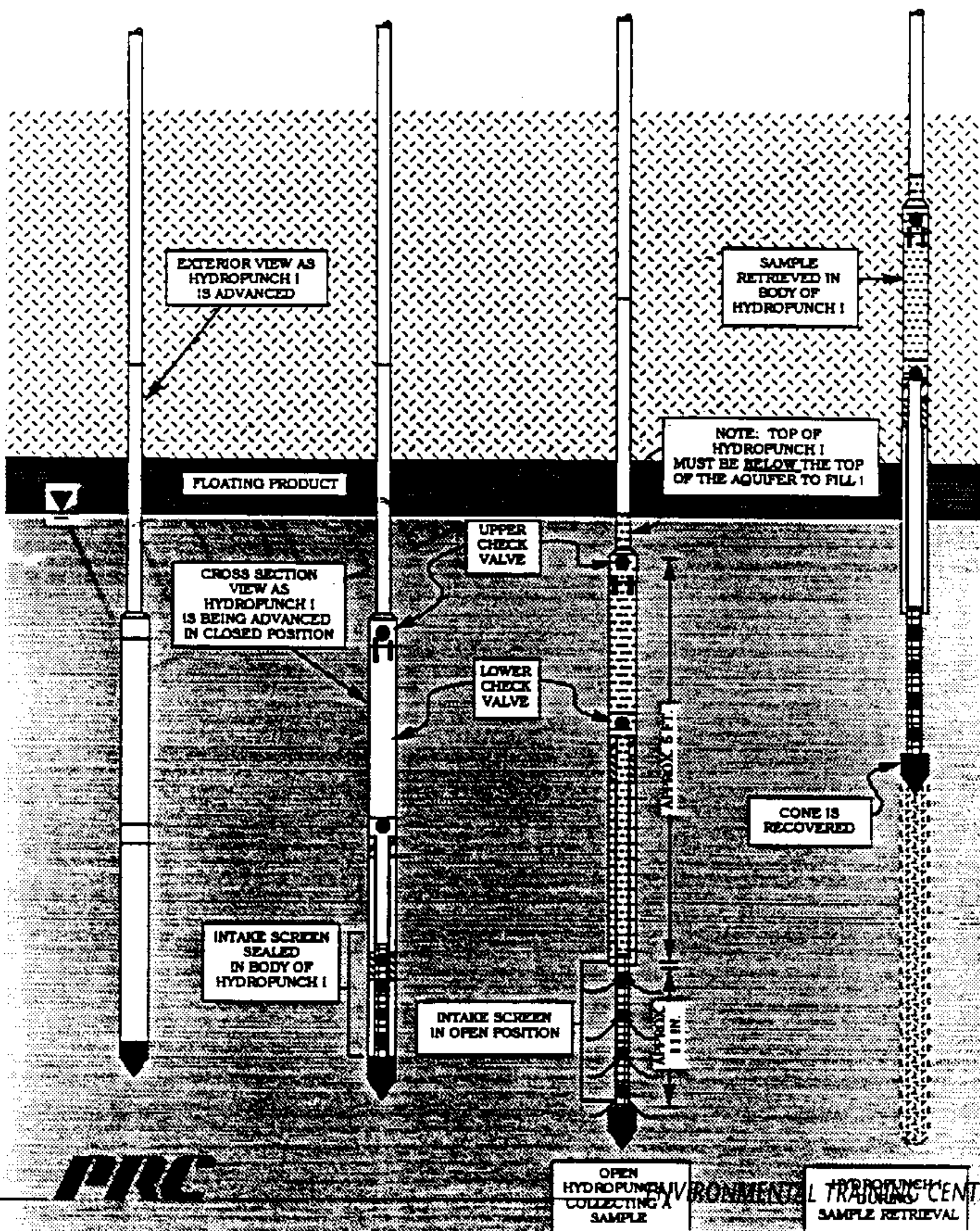
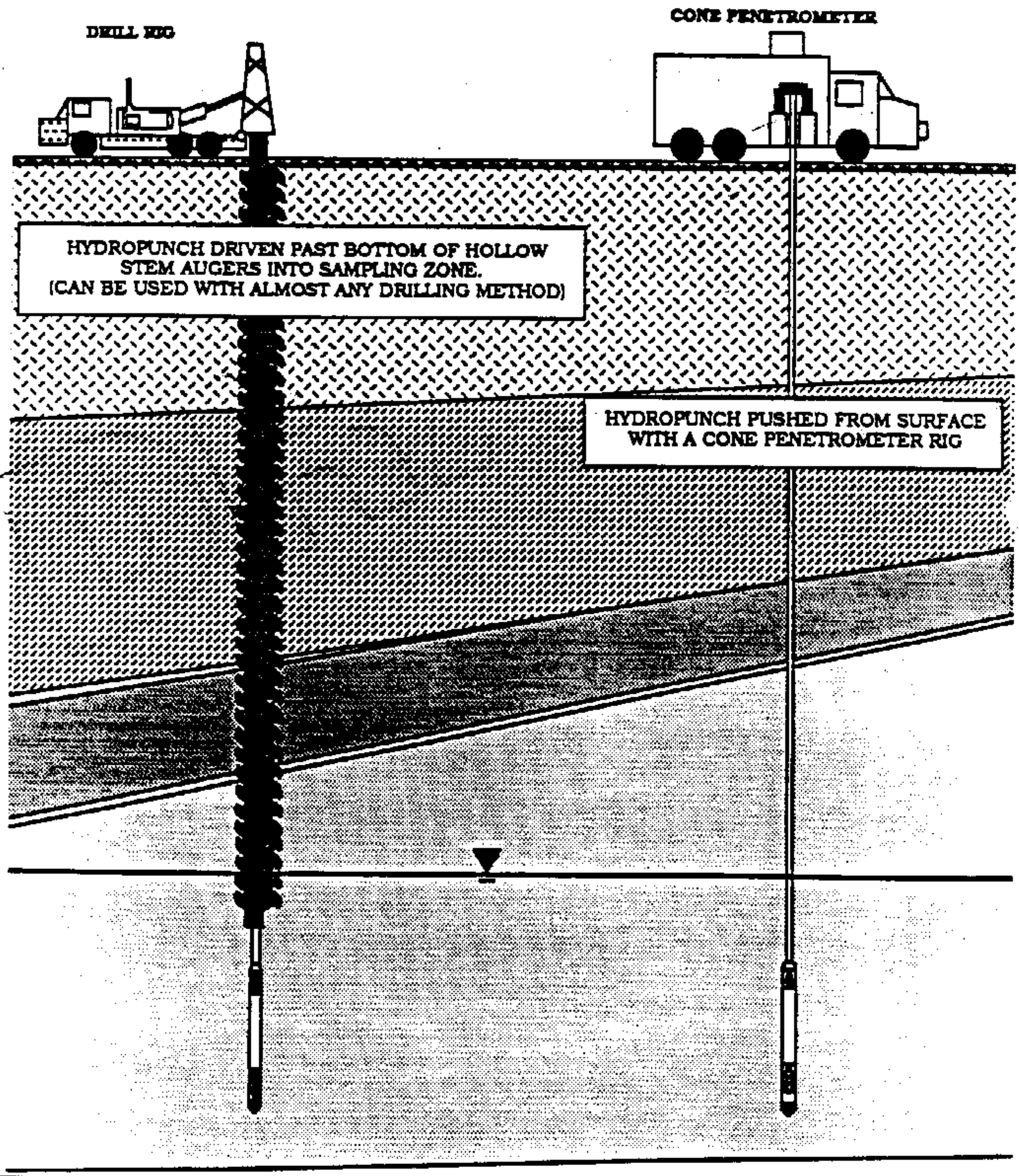


FIGURE 3

HYDROPUNCH USED WITH DRILL RIG AND CONE PENETROMETER TRUCK



Unlike HP-II, which utilizes sacrificial cones and intake screens, these components are attached to the body of HP-I in such a manner that they are retrieved when the tool is pulled to the surface (Figure 2). This design not only reduces the cost of expendable items required to complete an investigation, it also permits numerous samples to be collected from the same borehole without the concern of drilling or pushing through the sacrificial screen and cone which would be left in the hole if HP-II were used. (Note: Some drilling systems, such as auger drilling and mud rotary drilling using drag bits, do not encounter problems in drilling through expendable cones and screens. Rotary roller bits and core bits normally cannot drill past the steel cones.)

HP-I is designed to collect a ground water sample in only one mode. The sample is collected within the sample chamber and retrieved when the tool is brought to the surface. The fact that the tool fills under an in-situ hydrostatic head means that the top of the sample chamber must be below the top of the aquifer (Figure 2) to collect a sample (similar to a bailer which must be completely immersed within the water to collect a full sample). Since the HP-I is approximately five feet long, the intake screen must be five feet below the water table to collect a full sample. Often this is too deep to collect floating product, or if the water bearing strata are less than one foot thick, it puts the intake screen below the aquifer.

The open intake area for the HP-I is about 11 inches, meaning that the ground water flow into the HP-I is limited to an 11-inch zone. There is a possibility of missing the water bearing zones with the intake screen when sampling in soils with thin water bearing zones interbedded between low permeability material. In some cases the water bearing zones may not be thick enough or have enough hydraulic pressure to fill the tool.

TABLE 2

COMPARISON OF HP-I AND HP-II (ADVANTAGES AND LIMITATIONS)

	HP-I	HP-II
ADVANTAGES	1. Small diameter—can be used with cone penetrometer rig. 2. Reusable cone. 3. Vertical profiling from a single borehole without concern about drilling through disposable cones and screens.	General: 1. Simpler design and fewer parts for fast decontamination. 2. No moving parts are attached permanently to the tool making it more durable and reliable. 3. Removable check valves providing 2 sample modes which increases flexibility. Hydrocarbon Mode: 1. Can collect sample at top of aquifer, including product. 2. Can collect an unlimited volume of sample. 3. Can collect sample from thin aquifer. 4. Can directly measure fill rate. Ground Water Mode: 1. Tool does not have to be driven on special casing. 2. Only tool needs to be decontaminated. 3. Tool can be driven using downhole wireline hammers.
LIMITATIONS	1. Thin diameter and sliding parts with close tolerances make tool susceptible to damage when driven by drilling rig. 2. Short intake interval (11-inch) makes sampling from thin water bearing zones difficult. 3. The intake screen must be at least 5 feet below the top of the aquifer to collect a complete sample. 4. Sample volume is limited to approxi-mately 500 ml.	Hydrocarbon Mode: 1. Hollow drive pipe must extend to surface. 2. Drive pipe must be decontaminated. 3. A cone and screen is lost each time the tool is used. Ground Water Mode: 1. The intake must be at least 5 feet below the top of the aquifer to obtain a full sample. 2. Direct monitoring of the tool fill rate is difficult. 3. Sample volume is limited to 1.2 liters.

IV. OPERATION: HYDROPUNCH II

While HP-I was designed to be used by both cone penetrometer rigs and drilling contractors, HP-II is a more durable tool intended to be used primarily by drilling contractors. The diameter of the tool is approximately 2-inches O.D. with a wall thickness of 1/4-inch. The additional diameter of the HP-II greatly increases its rigidity; however, its large diameter limits its effective depth when pushed from the surface with cone rigs. HP-II can be used in two modes, hydrocarbon and water sampling. In the second configuration, the water sampling mode, the sample is collected in the same manner as HP-I with the exception that a cone is lost each time the tool is used. In the hydrocarbon mode, samples, including floating product, can be collected at the very top of the aquifer. In addition, an unlimited quantity of sample can be collected by additional pumping or bailing.

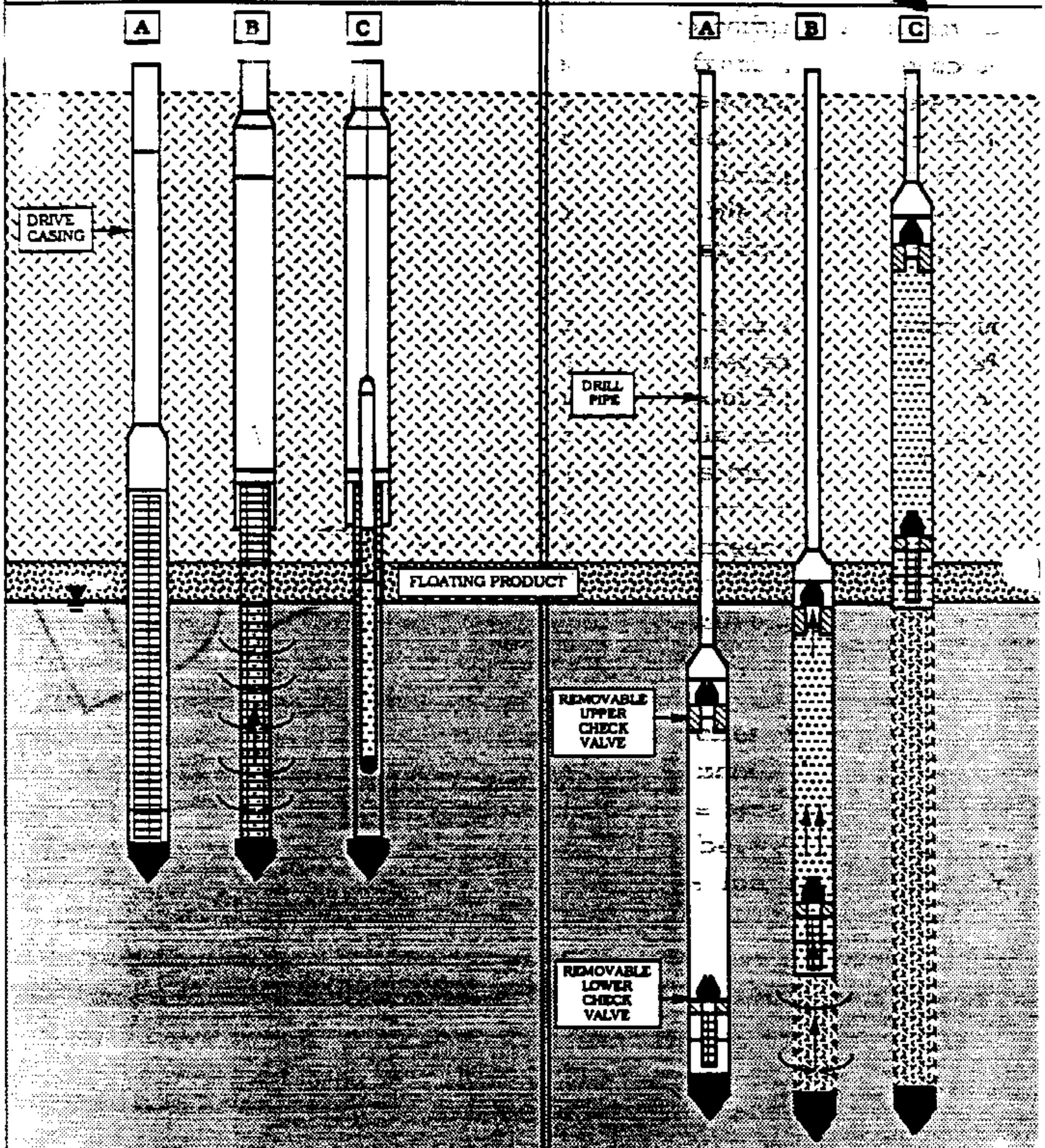
1. Hydrocarbon Mode Sampling with HydroPunch II

The HP-II is used in the hydrocarbon mode primarily when a sample of floating product is needed. Additionally, the HP-II can be used to collect ground water samples when: 1) a sample must come from the uppermost portion of the aquifer, 2) the water bearing strata are very thin, or 3) a large volume of sample is required (Figure 4). However, the hydrocarbon mode is less suitable for collecting sensitive, low concentration level samples because it is then open to solid and/or liquid contaminants from the drive rod above.

In this configuration the check valves are removed from the body of the tool. A sacrificial screen (approximately 5 feet long) is attached to a disposable cone. The screen and internal parts of the tool are sealed from the exterior by an O-ring seal at the base of the cone when the tool is in the closed position. The screen is large enough in diameter to permit a small bailer to pass through it. The screen, with the cone attached, is inserted into the body of the HP-II until the O-ring on the cone is seated in the body. When the HP-II has been advanced to the desired sample depth, the body is pulled back. Soil friction holds the cone in position while the screen telescopes out of the body of the tool. The drive casing (typically EW casing) is approximately the same I.D. as the HP-II. This permits a small O.D. bailer to be lowered through the casing and the body of the HP-II into the screened zone for sam

FIGURE 4
HYDROPUNCH II

HYDROCARBON SAMPLING	WATER SAMPLING



LEGEND: HYDROCARBON SAMPLING

[A] HydroPunch II closed while being driven into position.

[B] Tool opened and 5 foot screen telescopes into position for collection of hydrocarbon or water sample at the very top of the aquifer.

[C] Hydrocarbon sample being collected using bailer lowered through drive casing.

LEGEND: WATER SAMPLING

[A] HydroPunch II closed while being driven into position.

[B] Cone separated and tool open to collect sample.

[C] Check valves closed as sample is retrieved within body of tool.

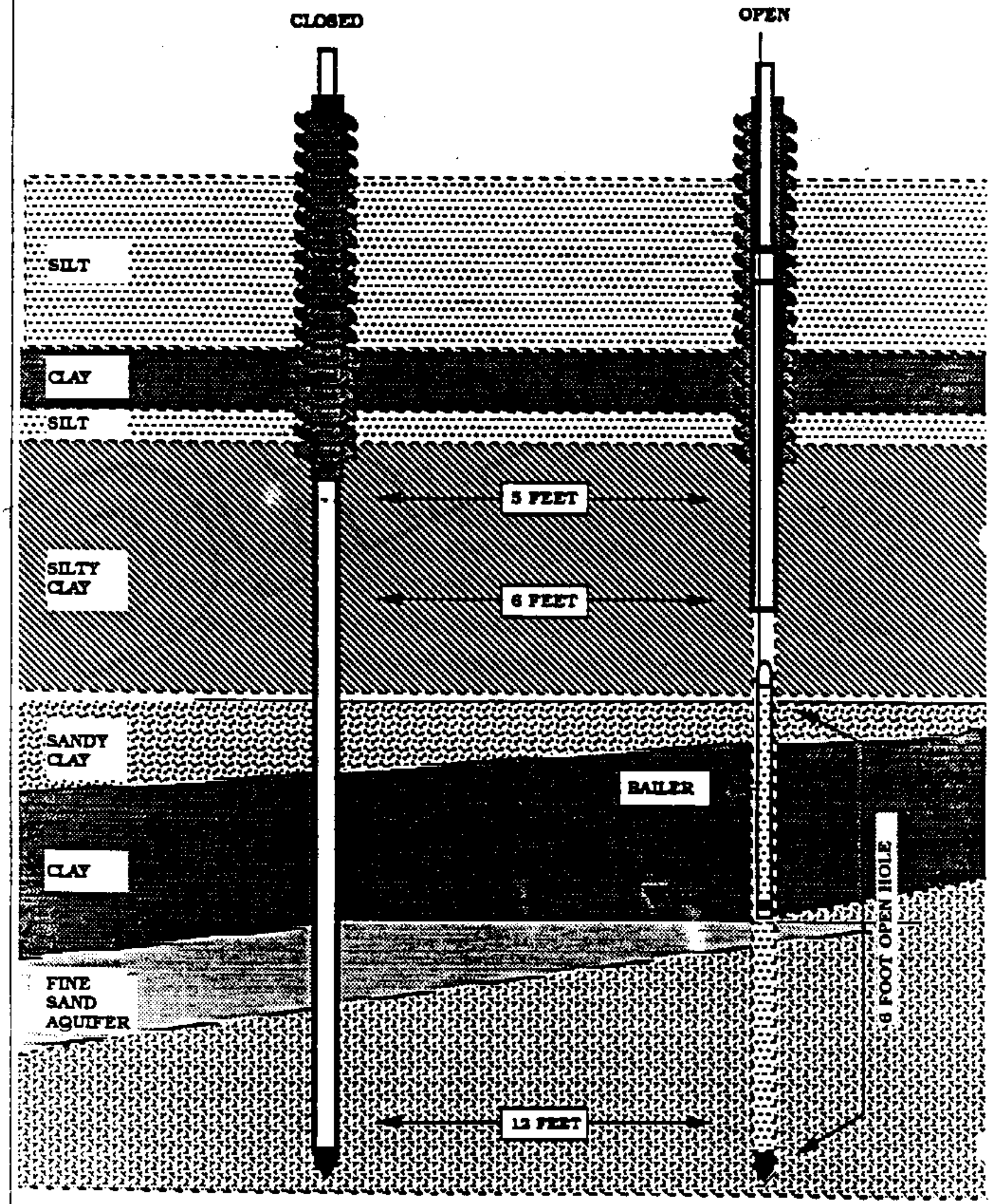
material has been introduced into the sample zone, the screen does not need to be purged prior to sample collection.

2. Ground Water Mode Sampling with HydroPunch II

The HP-II is used in the ground water sampling mode when a sample can be collected from 5 feet or more below the top of the water table and when 1.2 liters of sample volume is adequate. In this mode a lower check valve with an attached filter screen is inserted in the bottom of the tool and an upper check valve is placed in the top of the body. A disposable point is inserted into the drive shoe. The tool is pushed or driven into the undisturbed soil to the desired sampling depth either from the surface or from the bottom of a drilled borehole (Figure 4). The body of the tool is then pulled back about 2 feet. Soil friction holds the drive cone in place. Once the O-ring seal on the cone is broken, ground water flows into the open end of the HP-II through the intake screen, past the lower check valve, into the sample chamber, and finally out the upper check valve. When open, the HydroPunch fills from the bottom with no aeration and minimal agitation of the sample. When the tool is full, the sample is collected by pulling the tool toward the surface. This increases the hydrostatic pressure within the tool, closing the two check valves. At the surface, the HP-II is inverted and the sample is decanted through an upper discharge valve and tubing into a sample container.

FIGURE 5

SAMPLING THIN WATER BEARING ZONES IN COHESIVE SOIL WITHOUT SCREEN



HydroPunch II: Advantages and Limitations (see Table 2)

Advantages:

1) With a detachable cone and screen, the design of the HP-II is much simpler with fewer parts. HP-I has over 20 parts as opposed to 6 for HP-II. HP-II has no moving parts which are attached permanently to the tool.
2) The lack of moving parts with tight tolerances greatly increases the durability and reliability of the tool, particularly when subjected to hard driving, typically encountered when used with drilling rigs.
3) The removable check valves of HP-II provide greater flexibility during sampling than the HP-I. By using the tool in the hydrocarbon sampling mode, ground water samples can be collected at the top of the water table and floating product can be captured.
4) In addition, an unlimited volume of sample can be obtained either by bailing or pumping the sample from the tool. The filling of the system can be closely monitored either visually at shallow depths or by using various types of commonly available water level measuring devices. Samples can also be collected from thin water bearing strata in this mode.
5) For sampling in low permeability, cohesive soils where the borehole will stand open, the HP-II can be used with the detachable cone without the screen. By eliminating the screen, the intake zone of the sampling tool can be any length, not limited by the length of the screen but only by how far the tool can be pushed into the sample zone (Figure 5). By increasing the length of the open area (the cavity between the cone and the sample chamber) the chances of intercepting thin water bearing zones within low permeability material is greatly increased. The open bore below the water bearing layers also serves as a collection sump for the sample, enabling samples to be collected from permeable zones only inches thick.

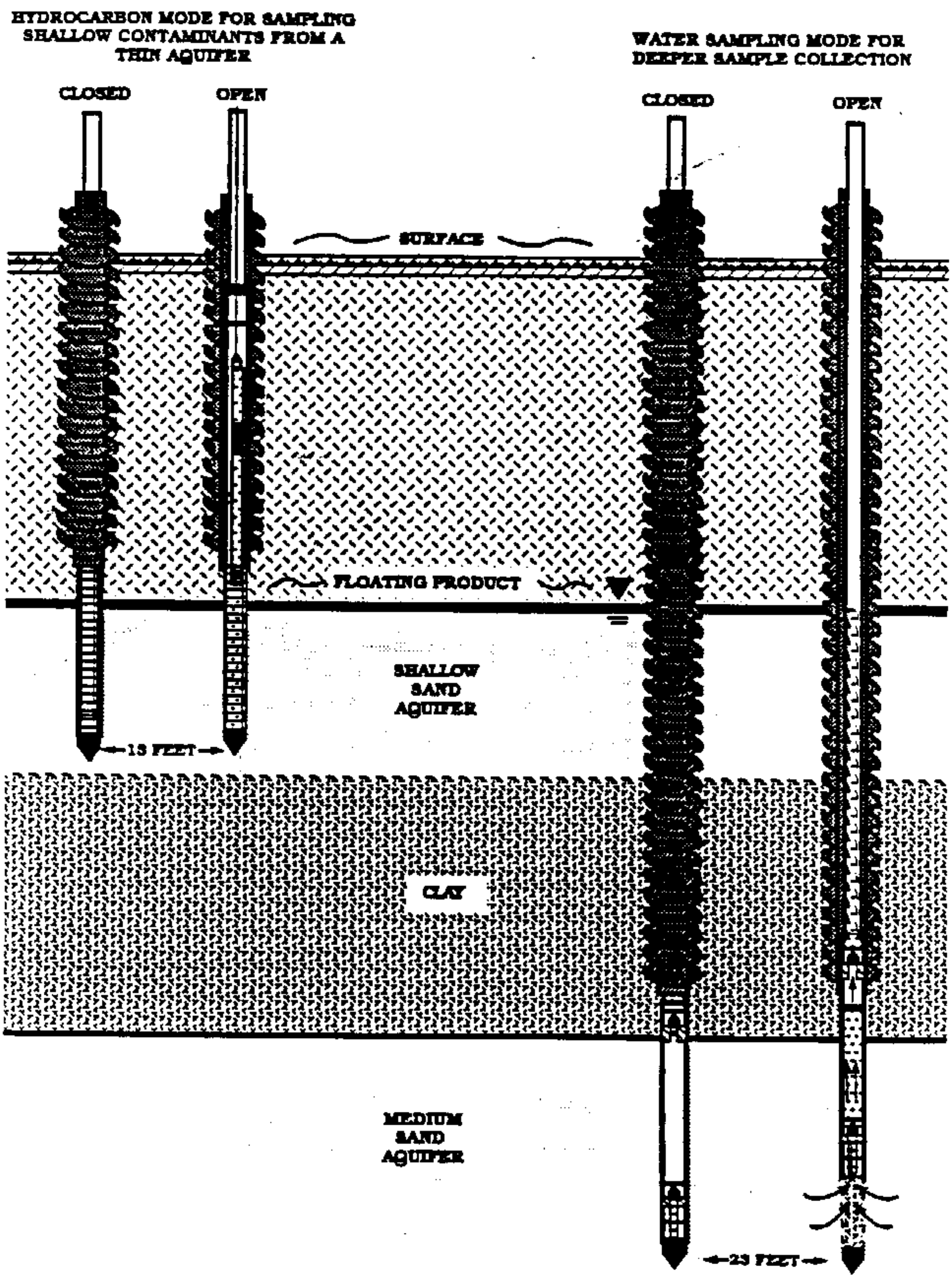
Limitations:

1) A cone is lost each time the tool is used.
2) Hollow drive pipe must extend to surface. *(slow)* (Hydrocarbon Only)
3) All drive pipes must be decontaminated. *(slow)* (Hydrocarbon Only)

3. Field Procedures: Sampling with HydroPunch II

The hollow stem auger drilling system is by far the most prevalent drilling method used for environmental hydrogeologic investigations. The HP-II has been designed to be used with the auger drilling rig to collect ground water samples in much the same manner as soil samples are collected with drive samplers. Although the following section is targeted for hollow stem auger drilling, the same general guidelines apply to other drilling techniques.

FIGURE 6
HYPOTHETICAL FIELD INVESTIGATION



HYPOTHETICAL SAMPLING PLAN

The following is a brief description of the typical sampling procedures for collecting a sample at the top of the aquifer using the HP-II in the hydrocarbon mode, and collecting a second sample 15 feet below the top of the aquifer using the same tool in the water sampling mode.

HYPOTHETICAL GEOLOGY

The first sample is collected from a thin (3 foot thick) aquifer of fine, clean sand occurring 10 feet below ground surface. The first water bearing zone is sandwiched between a very low permeability, sandy clay extending from the surface to 10 feet and occurring again from 13 feet to 20 feet. At 20 feet below ground surface the sandy clay overlies a very clean medium-grained sand aquifer about 40 feet thick. The second sample is to be collected from this second aquifer (Figure 6).

SAMPLING IN HYDROCARBON MODE

The first sample will be collected using the HP-II in the hydrocarbon mode.

TIP: *Because the HydroPunch must be pushed into undisturbed material in the zone to be sampled, the drilling procedure must stop somewhere above the sample point. Consequently, it is very helpful to have some idea of the depth at which the sample is to be collected. If little is known of the site hydro-geology, it is often a very good idea to use the initial boring as a pilot boring to determine: 1) exactly where the water bearing zones are, 2) the permeability of the sample zone, 3) the density of the soil, and 4) other relevant factors.*

1. The hydrocarbon mode was selected because a sample is needed as close to the top of the aquifer as possible and, with only a 3-foot thick upper aquifer, it is the only mode that can assure that a full sample will be collected. In order to collect a sample in the water sampling mode, the HydroPunch intake has to be a minimum of 5 feet below the top of the water table for the tool to fill. At this site the intake screen would be open in the confining layer below the aquifer, resulting in an extremely slow fill time or no

2. The contractor augers to 9 feet (one foot above the water table).

3. To prepare the HP-II for sampling, a disposable 5-foot polypropylene screen is pushed over the barbed end of the cone. (Note: Make sure the O-ring is on the cone.) The screen and cone are inserted into the drive shoe end of the HP-II. (Note: In this mode internal check valves are not used—refer to assembly sheet in the Field User's Guide.)

4. To make sure the point and screen do not accidently open as the tool is lowered inside the hollow stem auger, an exterior rubber sleeve is stretched over the cone and bottom of the drive shoe. The sleeve frictionally holds the cone in place and additionally provides a grit seal for the O-ring on the drive cone. When the tool reaches the bottom of the borehole, and pushing or driving commences, the sleeve will peel back and slide up the body of the HydroPunch. It does not contact the water being sampled. Once the sleeve is in position, the drive rods (typically EW casing) are attached to the upper subassembly of the HydroPunch and the tool is lowered downhole as additional casing is added.

   TIP: It is very helpful to have lengths of the drive pipe in 2 foot and 3 foot sections, as well as standard 5 foot sections. The short sections enable the driller to have a manageable casing height above the top of the augers after the tool has been driven into place and opened.

5. Once the tool rests on the bottom of the borehole, it will be driven or pushed four feet from the bottom of the augers (at 9 feet) to 13 feet. The drive casing is marked at the surface so the exact depth the tool is driven/pushed and retracted is known.

6. At this point the user needs to know the three most important rules of HydroPunch use.

TABLE 3

DRILLER'S RULES

1) **DO NOT SET THE HYDROPUNCH DOWN ON THE BOTTOM OF THE BOREHOLE AND THEN PICK IT UP.** THIS WILL OPEN THE TOOL, RUIN THE SAMPLE INTEGRITY AND, IF IT IS DRIVEN AFTER BEING OPENED, MAY DAMAGE THE HYDROPUNCH. BE CAREFUL NOT TO BACKHAMMER WHEN DRIVING FOR THE SAME REASON.

2) **ALWAYS ACCURATELY MEASURE THE DISTANCE THE TOOL IS PUSHED OR DRIVEN AND THE DISTANCE PULLED BACK.**

3) **NEVER PULL THE HYDROPUNCH BACK FURTHER THAN IT IS PUSHED OR DRIVEN INTO THE UNDISTURBED SOIL.** TO EFFECTIVELY ISOLATE THE SAMPLE FROM OUTSIDE CONTAMINATION, THE BODY OF **THE HYDROPUNCH MUST REMAIN IN THE HOLE IT MADE DURING DRIVING OR PUSHING.**

7. It was determined from the blow count during soil sampling that the soil density will require that the HydroPunch be driven into position using a 140-pound hammer. If the material had been soft, the HydroPunch could have been pushed from the bottom of the augers using the hydraulic downfeed on the drill rig. The HydroPunch will typically require 2 to 4 times as many blows to advance the same distance as a 2-inch split barrel sampler. The reason for this is that all soil is displaced to the side with the advance of the HydroPunch whereas, when utilizing a split barrel sampler, the majority of the soil passes into the sampler .

TIP: Where soil conditions permit, it is preferable to push, rather than drive, the tool into position. Pushing allows very accurate control of the depths the tool is advanced and retracted, is easier on the driller, and is frequently quicker than driving. If the tool is to be pushed into position, it is best to make sure that the driller has an adapter which will enable him to push and retract the drive pipe before he gets into the field.

If soils are soft enough to enable the HP-II to be pushed from the surface into the sample zone, a considerable amount of time can be saved. When the HP-II is used in this manner, no drill cuttings are generated and there is no handling of augers, etc. The only major activity is to add casing as the tool is being *rapidly pushed into the ground. If pushed from the surface, sampling time can often be cut in half.*

8. To drive the HydroPunch in the hydrocarbon mode, the contractor will need an adapter to go from the drive casing (typically EW) to the thread on his drive hammer. Although the adaptors are readily available, it is best to make sure the contractor has one prior to mobilizing to the site. As mentioned earlier, the casing should be marked in one-foot increments to monitor the driving process.

9. The driller commences driving and continues until the tool has been advanced four feet. During driving the driller very carefully makes sure he does not inadvertently backhammer the HydroPunch. If the tool is backhammered it will open and the next hit will force soil between the screen and body of the tool, destroying sample quality (if a sample can be collected at all). The tool may also be damaged if it is driven without the cone attached. When the sample depth is reached, in this case 13 feet, the tool is allowed to set for a few seconds prior to being pulled back. This permits the formation to expand around the cone and increases the soil friction on the cone. The tool is then pulled back about three feet, extending the screen from 13 feet to 10 feet. During pull back, the driller is careful to not pull back more than the four feet that the tool was driven (Driller's Rule 3). Also, the driller must never pull back further than the length of screen attached to the cone, in this case 5 feet.

   TIP: *If the aquifer material is very loose and does not pull the cone from the drive shoe during retraction, it is helpful to use the drive hammer to backhammer for the initial pull back. The upward snap on the tool during the backhammering process is often enough to separate the cone and pull the screen from the body.*

10. When the tool has been retracted the full distance, the casing is clamped into place to assure it does not slide back down over the exposed screen. Chain type vise grips work well for this. Disconnect the hammer or remove the adapter from the drive pipe and check to see if the screen is filling with ground water.

    TIP: *With HP-II there is rarely a problem with the cone detaching and the screen not being exposed to the formation. Should the tool be used in a formation where there is a problem, it is helpful to measure the internal length of the casing and the tool just prior to pull back and then immediately after pull back is completed. The distance measured inside the tool should increase by whatever the distance* *pulled back. Example: Distance to cone from top of drive casing as measured inside the casing with tape prior to pull back is 13.5 feet. Pull back three feet. Distance to the cone immediately after pull back is 16.5 feet from top of drive casing, indicating the cone has telescoped out of the HydroPunch body three feet.*

TIP: *When used in the hydrocarbon sampling mode, the filling process of the HydroPunch can be closely monitored. At shallow depths this can be done using a bright flashlight or a mirror to shine light down into the casing. At greater depths an electronic water level indicator can be used.*

11. When an adequate volume of water has flowed into the screen, a small diameter bailer is lowered through the drive pipe into the screened portion of the HydroPunch to collect the sample. Since there is minimum disturbance to the sample zone and no foreign material has been introduced, purging prior to sampling is not required. The sample is collected from the HydroPunch in the same fashion as a monitoring well. It should be noted that most HydroPunch samples will be more turbid than monitoring wells installed in the same formation because there are no filter packs to remove fines. To minimize the turbidity, gently lower and retrieve the bailer through the water to reduce the surging effect as the sample is collected.

DECONTAMINATION

Decontamination of the HydroPunch is quite simple. Lay the HydroPunch body and the drive casing on suitable supports and decontaminate the pieces, using the brushes and rods supplied with the tool and/or by steam cleaning. When cleaning the tools, particular attention should be paid to the HydroPunch body and the bailer, since these are the pieces which come into direct contact with the sample.

TIP: *Always attempt to disassemble the HydroPunch while it is still wet. The water serves as a lubricant and prevents damage to the stainless steel parts. For decontamination, saw horses or some similar supports help make cleaning easier. Also, a plastic bucket and a mesh basket, such as a fry basket, can retain small parts during steam cleaning and prevent them from flying all over when subjected to the high pressure steam.*

SAMPLING IN THE GROUND WATER MODE

1. As mentioned earlier, the second sample is to be collected from the deeper, medium sand aquifer starting at 20 feet below the surface. The static water level in the deep aquifer is 10 feet below the surface. In this case a sample will be collected at about 23 feet using the HP-II in the water sampling mode. The water mode is selected because the sample is to be collected at a depth of greater than 5 feet below the top of the aquifer and because it would be inefficient to handle and decontaminate 23 feet of drive casing. In the hydrocarbon mode all drive casing must be decontaminated because it contacts the bailer and is open to the HydroPunch.

2. The drilling contractor augers to 20 feet in the same borehole.

   TIP: Prior to drilling through the polypropylene screen and drive cone left from the previous sample, pull the cutter head of the auger to a point above the top of the screen, then lower the center bit into position and drill through the screen and cone. This procedure ensures that the screen and cone are drilled to the side, carried up the flights of the augers, and do not become jammed in the hollow stem of the lead auger.

3. The HydroPunch is prepared for water sampling by inserting the stainless steel plug with the upper check valve into the top of the tool, reed valve pointing up. The upper subassembly going from the HydroPunch thread to the AW box is threaded over the upper check valve holding it in place. (Note: Detailed assembly instructions can be found in the Field User's Guide.)

4. Next, the inlet assembly is unthreaded from the screen cartridge sleeve and the short stainless steel screen is threaded onto the lower portion of the inlet assembly. The inlet assembly with the screen attached is threaded back into the screen cartridge sleeve. As with the upper check valve assembly, the cartridge sleeve is inserted into the bottom of the HydroPunch body with the reed valve pointed up and the drive shoe threaded onto the body to hold the cartridge sleeve in place.

5. Insert the cone (without the polypropylene screen attached) into the end of the drive shoe, making sure that the O-ring is on the cone. As in the

hydrocarbon mode, stretch the rubber sleeve over the cone and body of the tool to make sure that the cone does not separate as the tool is lowered down the borehole.

6. For collecting the second sample in the ground water sampling mode, the HydroPunch can be advanced using a wireline downhole hammer. When the tool reaches the bottom of the drilled borehole, the cable used to raise and lower the hammer is marked with the hammer in the down position.

7. Again the three Driller's Rules apply (Table 3). Since sampling is well below the top of the aquifer, the tool is only driven a few feet into the undisturbed soil below the borehole. The distance the tool is driven is closely monitored by watching the marks on the cable as the tool is advanced. Once again the contractor must be careful not to hammer upward while driving the tool (Driller's Rule 1).

8. When the HydroPunch reaches its final depth, in this case driven three feet below the bottom of the augers (23 feet below surface), the hammer is gently pulled to its up position and the cable marked to monitor the pull back procedure.

9. The HydroPunch is backhammered one foot. As soon as the tool moves upward, the cone separates from the body. This allows the formation water to flow through the intake screen, past the lower check valve assembly, into the sample chamber, and finally out the upper check valve.

10. Essentially, the open HydroPunch becomes a dual check valve bailer that has been driven into position. After a period of time, based on the estimated formation permeability, the tool is pulled back to the surface. As the tool is retrieved the hydrostatic head changes, closing both check valves and trapping the sample within the body of the tool.

11. At the surface, the upper subassembly (AW adapter) is unthreaded and the top check retainer is threaded onto the body of the tool to hold the the upper check valve and disk in place. The reed valve barb is unthreaded from the disk and the Teflon stopcock of the discharge assembly is threaded into the

disk. The HydroPunch is then inverted and the sample discharged through the stopcock into a sample container.

TIP: If the HydroPunch is used in a sand formation and the material has a tendency to flow into the augers, always sound the interior prior to lowering the tool into the augers. Driving the HydroPunch through a sand plug in the bottom of the augers is almost impossible. As the tool is driven, the sand is compressed into the space between the HydroPunch and the inside wall of the augers, greatly increasing the resistance to driving. This sometimes results in damage to the tool and will occasionally lock the HydroPunch inside of the augers.

A simple method that can be used at most sites is to drill to just above the sample zone with the augers and then back the augers out to a point where the sand is no longer inside. The HydroPunch can often be easily driven or pushed through the zone disturbed by the drilling process and then an additional distance into the undisturbed formation to the sample point. HydroPunches have been pushed through as much as 35 feet of collapsed sand in a borehole to collect a sample from the undisturbed material below the drilled portion. Other solutions to this problem include: 1) the use of one way sand catchers or trap valves in the bottom of the augers, 2) filling the augers with drilling mud, and 3) drilling using mud rotary drilling techniques.

TABLE 4

STEPS IN PREPARING THE HP-II FOR SAMPLING

THE HYDROCARBON MODE STEPS
1) Make sure O-rings are on each end of HP-II body.
2) Thread drive shoe on one end of the body and the EW casing adapter on the other end. (The EW casing thread has a larger inside diameter than the AW rod adapter.) Make sure that both fittings are tightened by hand as much as possible.
3) Push the barbed end of the drive cone into the 5-foot long polypropylene screen.
4) Insert the screen into the drive shoe end of the HP-II and seat the O-ring and cone in the drive shoe.
5) Stretch the rubber retainer sleeve over the cone and body to hold the cone in place as the tool is lowered downhole.
6) Attach the HP-II to the EW casing (or other drive casing) using the appropriate adapter. Be sure that the drive casing is thoroughly cleaned before attaching the HydroPunch.

THE GROUND WATER MODE STEPS
1) Insert the stainless steel plug with upper check valve into the top of tool.
2) Upper subassembly from the HP-II, threaded to the AW adapter, is threaded over the upper check valve.
3) Inlet assembly is unthreaded from screen cartridge sleeve.
4) Thread short stainless steel screen onto lower portion of inlet assembly.
5) Inlet assembly with screen attached is threaded back into screen cartridge sleeve.
6) Insert cartridge sleeve into bottom of HP-II body.
7) Thread drive shoe onto body to hold cartridge sleeve in place.
8) Insert cone (without screen attached) into end of drive shoe. Make sure O-ring is on cone.
9) Stretch rubber sleeve over cone and body of tool to hold cone in place as tool is lowered downhole.

FIGURE 7
GROUND WATER MODE ASSEMBLY INSTRUCTIONS

A. Place O-rings (2) in groove on sleeve cartridge assembly (1) and in groove on inlet (3). Thread open end of screen (4) onto threaded portion of inlet (3). Push reed valve (5) over barb on inle

B. Thread inlet and screen assembly into sleeve cartridge assembly.

C. Place large O-rings (2) on each end of HydroPunch body (6.) Insert complete assembly into body of to

D. Thread drive shoe (7) onto body. Place O-ring on drive cone (8) and push into end of drive shoe.

E. Place O-ring in groove on check disc (9). Thread modified barb (10) into check disc (9). Push reed check valve (5) over modified barb (10).

F. Insert check disc assembly into body of tool (6).

G. Thread AW adapter (11) onto body. Stretch rubber retainer sleeve (12) over cone and body.

H. To discharge sample, remove AW adapter from top of body and thread retainer cap (13) onto body.

I. Unthread modified barb (10) and thread teflon stopcock (14). Attach discharge tube (15) to stopcock Invert the tool and open stopcock to discharge the sample.

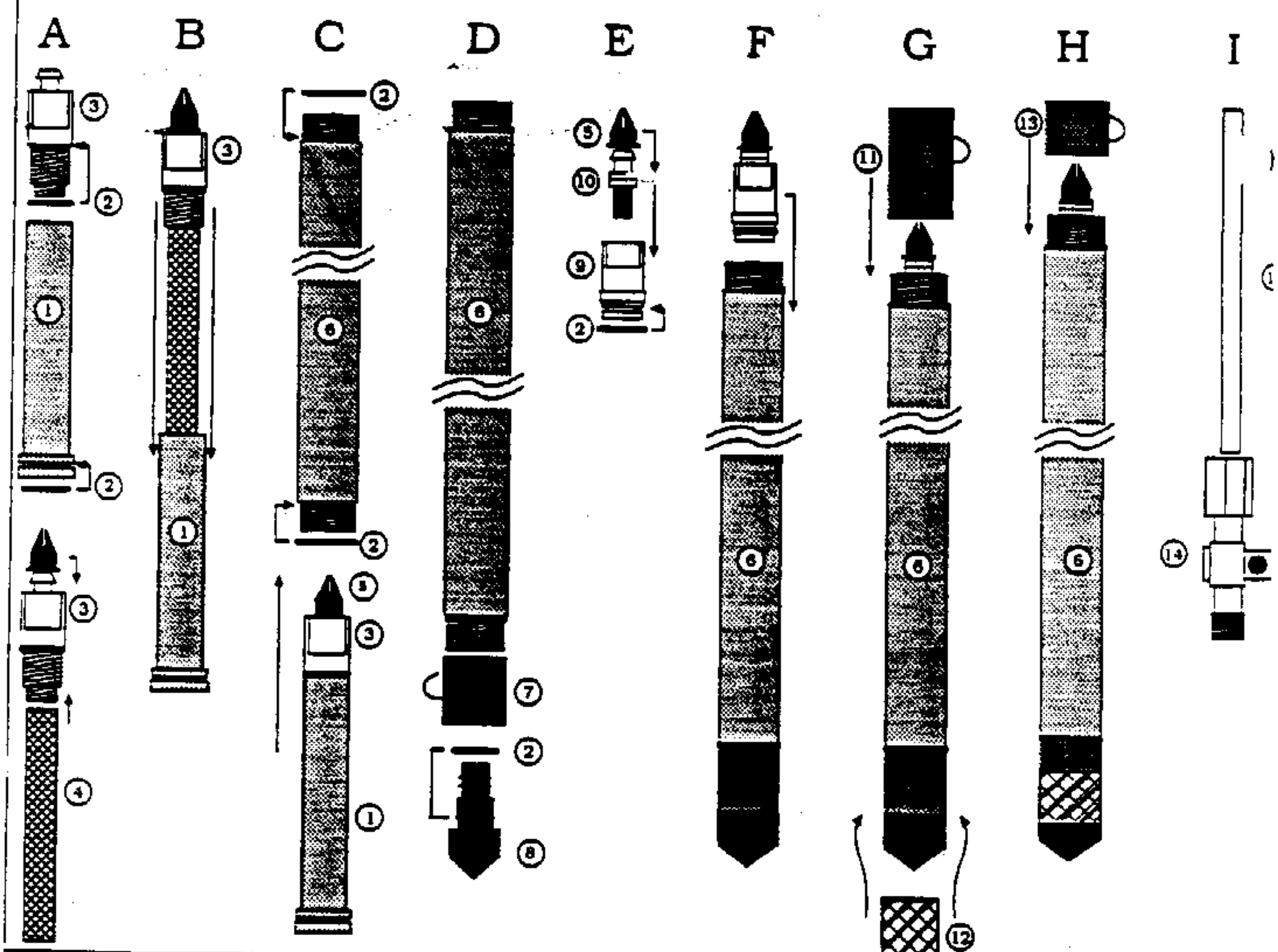


FIGURE 8
HYDROCARBON MODE ASSEMBLY INSTRUCTIONS

A. Place O-rings (1) on each end of HydroPunch II (HP-II) body (2).

B. Thread drive shoe (3) onto one end of body (2) and EW casing adapter (4) onto other end. Tighten both fittings by hand as much as possible. (NOTE: The EW casing adapter has a larger inside diameter than the AW rod adapter which is used in the Ground Water mode).

C. Push the barbed end of the drive cone (5) into the 5-foot long polypropylene screen (6) making sure the O-ring is on the cone first.

D. Insert the screen (6) and drive cone (5) assembly into the drive shoe end of the HP-II and seat the O-ring and cone in the drive shoe.

E. Stretch rubber retainer sleeve (7) over cone and body to hold cone in place when tool is lowered downhole.

F. Attach HP-II to EW casing (or other drive casing) using appropriate adapter. (NOTE: Be sure drive casing is thoroughly cleaned before attaching to the HydroPunch.)

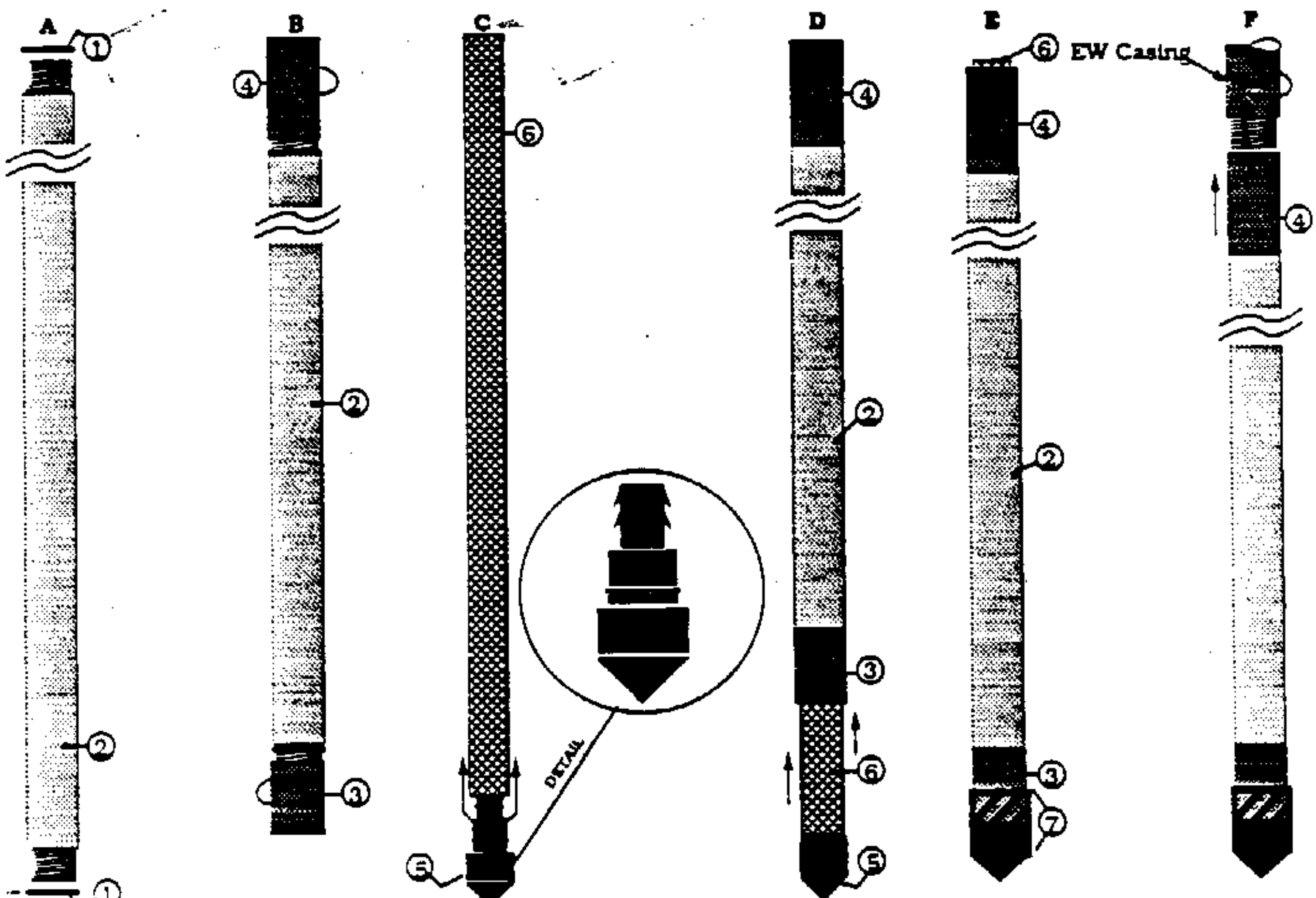


TABLE 5A
HYDROPUNCH II—WATER SAMPLING MODE

BASIC OPERATING PROCEDURES		
STEP #	**PROCEDURE**	**COMMENTS**
1	Drill to a point just above the desired sample depth.	If site conditions permit pushing the tool from the surface to the sample point, go to Step #3.
2	Attach assembled HP-II to the drive rod or downhole hammer.	Be sure to use the rubber retainer sleeve to hold the cone onto the drive shoe if the tool is lowered downhole.
3	Lower the tool to the bottom of the borehole.	*Once on the bottom of the hole, DO NOT PICK UP THE TOOL.* (Driller's Rule 1)
4	Drive or push HP-II a minimum of one foot past bottom of borehole to final sample point.	1. If pushing or driving the HP-II from the surface, advance the tool directly to the selected sample depth. 2. Remember that when sampling in the water mode, the bottom of the HP-II must be at least 5 feet below the water table to collect a full sample. 3. WHEN DRIVING OR PUSHING, CAREFULLY COUNT AND MARK THE ROD OR CABLE SO YOU KNOW EXACTLY WHERE THE END OF THE TOOL IS.
5	When the final depth has been achieved, pull back on the drive rods or hammer to pull the cone out of the body of the tool, permitting ground water to enter the HP-II.	***DO NOT PULL THE TOOL BACK FURTHER THAN IT HAS BEEN DRIVEN*** (Driller's Rule 3). For example, if the tool is driven or pushed 2-1/2 feet, do not pull the tool back more than 2 feet. A minimum of 6 inches of the body of the tool needs to be in the driven hole to provide a good annular seal.
6	Clamp the drive casing at the surface.	This prevents the body of the HP-II from sliding back down to the bottom of the hole and plugging with soil.
7(a)	If hollow drive rods are used to advance the tool, a water level indicator can be lowered down the rods to determine when the tool is full.	The rods must be watertight.
7(b)	If hollow drive rods are not used, wait approximately 20 minutes for the first sample.	Adjust the fill time based on the quantity of sample and the estimated permeability of the formation.
8	Pull the HP-II to the surface, unthread the upper subassembly and replace it with the thread retainer cap.	
9	Unthread the upper check valve and replace it with the Teflon stopcock and tubing.	
10	Invert the tool, open the stopcock and decant the sample.	
11	Disassemble the HP-II while it is still wet.	Water lubricates the parts which reduces the potential for galling.
12	Decontaminate the tool according to your cleaning protocol.	

TABLE 5B
HYDROPUNCH II—HYDROCARBON SAMPLING MODE*

BASIC OPERATING PROCEDURES

STEP #	PROCEDURE	COMMENTS
1	Drill to a point just above the desired sample depth. If sampling floating product, be sure to stop drilling above the top of the aquifer.	If site conditions permit pushing the tool from the surface to the sample point, go to Step #3.
2	Attach assembled HP-II to the drive casing.	Be sure to use the rubber retainer sleeve to hold the cone onto the drive shoe if the tool is lowered downhole.
3	Lower the tool to the bottom of the borehole.	*Once on the bottom of the hole,* ***DO NOT PICK UP THE TOOL.*** (Driller's Rule 1)
4	Drive or push the HP-II a minimum of one foot (3 to 5 feet is better) past the bottom of the borehole to the final sample point.	1. If pushing or driving the HP-II from the surface, advance the tool directly to the selected sample depth. 2. When driving or pushing, carefully count and mark the casing so you know exactly where the end of the tool is.
5	When the final depth has been achieved, pull back on the drive casing to pull the cone and screen out of the body of the tool, permitting ground water to enter the HP-II.	1. ***DO NOT PULL THE TOOL BACK FURTHER THAN IT HAS BEEN DRIVEN*** (Driller's Rule 3). For example, if the tool is driven or pushed 3-1/2 feet, do not pull the tool back more than 3 feet. 2. A minimum of 6 inches of the body of the tool needs to be in the driven hole to provide a good annular seal. 3. Additionally, since the screen is 5 feet long, the tool cannot be pulled back more than 5 feet without separating the screen from the body.
6	Clamp the drive casing at the surface.	This prevents the body of the HP-II from sliding back down over the exposed screen.
7	Disconnect the drive casing from the hammer (or push adapter) and check to see if tool is filling.	A mirror to reflect light down the casing or a water level indicator can be used.
8	When an adequate volume of water has filled the tool, lower a small diameter bailer through the drive casing to collect the sample.	There is no need for development or purging prior to sample collection.
9	After completing sample collection, pull the drive casing and the HP-II to the surface. The cone and screen will normally stay downhole.	<u>Should the screen be recovered, do not attempt to reuse it.</u> It cannot be decontaminated and, if reused, will likely affect the integrity of subsequent samples.
10	Disassemble the HP-II while it is wet.	Water lubricates the parts which reduces the potential for galling.
11	Decontaminate the tool according to your cleaning protocol.	In the Hydrocarbon mode, the drive pipe as well as the tool and bailer need to be thoroughly decontaminated.

*Prior to using HP-II in the hydrocarbon mode, be sure the drive casing is thoroughly decontaminated. In this mode, the casing contacts the sampling bailer and is in communication with the sample chamber.

V. TROUBLESHOOTING

As with all drilling/sampling methods, occasional problems will arise with the use of the HydroPunch. Most of these problems relate to obtaining an inadequate sample for analysis. With the development of the simpler and more robust HP-II, the majority to the problems are directly related to a site's unique hydrogeologic conditions and few problems are the result of mechanical malfunctions of the tool. The following discussion breaks the problem areas into two groups: mechanical malfunction and hydrogeologic problems. The mechanical area will be addressed first.

MECHANICAL PROBLEMS

Drive Cone Does Not Separate From Body

1. In rare instances the cone will fail to separate from the body of the tool during the pull back procedure. This usually occurs when very fine sand manages to work its way between the cone and the drive shoe as the tool is being driven. The sand grains "sand lock" the cone in the drive shoe. The problem can be alleviated by making sure the rubber exterior sleeve is used over the cone and the drive shoe. Using this sleeve ensures that sand will not enter until the driving process begins. Once the drive or push commences, make sure the tool is not lifted or accidently backhammered as it is being advanced. The upward motion may slightly separate the cone from its seat and the subsequent hammering may drive sand into the seal area.

2. In very loose formations, such as extremely loose, quicksand-like material, there may not be enough soil friction for the cone to separate if it is pulled back in the normal fashion. In these situations, initiate the pull by a sharp backhammer; the sudden shock and upward motion of the tool will separate the cone from the body of the HydroPunch.

3. The most common cause of cones not separating is the result of utilizing homemade sleeves instead of the sleeves provided with the HP-II. The substitute material stretches as the tool is being driven and works itself between the cone and the seat in the drive shoe. When this happens, the

cone will almost always lock in position making it extremely difficult to pull free, even using wrenches and a vise. To prevent this from occurring, always use the sleeves provided with the tool.

Drive Cone Separates Too Soon

1. The most common cause of early cone separation is the result of the tool being pulled back prematurely by backhammering or being picked up after being placed on the bottom of the borehole. See DRILLER'S RULE 1 (Table 3). *Be careful.*

2. When lowering the tool down an open borehole, always use the exterior rubber friction sleeves provided with the tool to make sure the cone stays in place.

Leaking Check Valve

1. The check valves in the HydroPunch are designed to handle grit saturated water and consequently do not usually leak to the degree where there is a critical loss of sample. Often, if the water is extremely sediment laden, the sediment itself will collect on the check valve and seal the sample in the tool. If a leak does occur, it is almost always very slow. The best way to correct the problem is to retrieve the tool and decant the sample as rapidly as possible.

HYDROGEOLOGY RELATED PROBLEMS

Sample Collection from Low Permeability Aquifers and Thin Water Bearing Zones

1. As the HydroPunch is driven or pushed into position, the soil is displaced to the side and compacts into the walls of the hole. The process cleans the tool as it moves downward and also produces a very tight annular seal around the tool. The consolidation of the soil particles around the tool can also result in a reduction of the permeability of the soil. The tight seal and reduced permeability enables the HydroPunch to collect a very discrete

sample from a specific depth by sealing off ground water from above and below the zone to be sampled.

In some fine-grained silts and clays with very thin water bearing zones, the compression of the soil particles may lower the permeability of the saturated zone to a degree where ground water samples may not be collected in a reasonable amount of time (i.e., < 1 hour). It is important to remember that the HydroPunch collects a very discrete sample from a fairly short sample interval (usually less than 5 feet) versus a monitoring well which normally collects from an interval of 10 feet or more. Consequently, fill times are usually longer than that of a monitoring well completed in the same formation.

2. When sampling thin (< 5 feet) water table aquifers, it is important to know the exact location of the saturated zone. If detailed site hydrogeologic information is not available, it is best to start the investigation at the site with a pilot boring to accurately identify the target zone. Once the HydroPunch has been driven or pushed into position, the annular seal is so effective that missing the water bearing zone by inches can make the difference between a dry hole and the tool filling in minutes. If the water bearing zone is thin and has less than 5 feet of head, the HP-II must be used in the hydrocarbon sampling mode. The HP-II in the water sampling mode will not have enough hydraulic head (5 foot minimum) to fill.

   When working with thin water bearing zones or low permeability aquifers in cohesive soils (soils where the hole will stand open after the drilling tools are removed), the HydroPunch can be used in the hydrocarbon sampling mode without attaching the polypropylene screen to the cone (Figure 5). This enables the intake interval to be any length desired. A hypothetical example would be: A 6-inch thick water bearing silty sand layer occurs between 7 and 10 feet below the surface at a site. The layer is over- and underlain by a very low permeability silty clay. To maximize the possibility of intercepting the thin water bearing zone, the HydroPunch is pushed or driven from 5 feet to 12 feet (or if the soil is soft, the tool is advanced from the surface to 12 feet). Because the formation will stand open and no screen is used, the HydroPunch can be pulled back from 12 feet to 6 feet, leaving an open hole between the cone (12 feet) and the bottom of the tool (6 feet). The open hole serves as the intake screen and intercepts the water bearing layer. The portion of the hole in and below the saturated zone will collect water. A bailer is lowered into the open hole for sample collection. Frequently, thinly bedded water bearing formations occur at shallow depths in soft, cohesive soils. These conditions make pushing the tool easy and investigations frequently can be accomplished by pushing or driving from the surface.

Intrusion of Drilling Mud or Outside Ground Water

1. There is the possibility that outside fluid will be forced into the sample chamber if the HydroPunch is used in the water sampling mode in: 1) a mud filled borehole, or 2) is used to collect a sample from a deep aquifer and, during retrieval is pulled back through an upper aquifer with a higher hydrostatic head.

   As an example, assume the tool is lowered into a mud-filled borehole and is driven 3 feet into the underlying formation for a sample. The water table for the aquifer is 30 feet and the sample was collected at 40 feet. When the HydroPunch is filled with sample it has 10 feet of head above the sample (the depth the tool is below the top of the aquifer). The borehole has about 40 feet of drilling mud in it. When the HydroPunch is pulled from its hole and exposed to the drilling mud in the borehole, the mud, having much higher hydraulic head (40 feet vs. 10 feet), displaces the sample in the tool and forces it up the drive pipe. The same process can occur when the tool is retrieved from a low head, deep aquifer through a borehole filled with water from a shallow aquifer with a higher head.

2. To prevent this from occurring, two things can be done:

   a) The tool can be used in the hydrocarbon sampling mode. In this configuration the sample is collected prior to the intake being exposed to the fluid in the borehole.

   b) A barbed adapter is available which attaches to the top check valve of the tool in the water sampling mode. This adapter enables thin tubing (usually 1/8 inch vinyl) to be attached to the check valve. By using special crossover adapter, the tubing can be run from the upper check valve through the wall of the crossover adapter and up alongside the drive pipe. The tubing vents the HydroPunch to the surface. This configuration provides two capabilities: 1) As the tool fills with sample, the air is displaced from the body and is forced up the tubing and discharged at the surface. By monitoring the air discharged (this can be as simple as holding the end of the tube in a cup of water and watching how fast the air bubbles out) the fill rate can be measured and when the tool is filled can be determined. When the tool is filled and ready to be retrieved, apply enough pressure (usually compressed air or nitrogen) to the tubing to compensate for the head of mud in the borehole. The pressure closes the upper check valve, which in turn prevents the lower check valve from opening as the tool is pulled through the drilling mud.

TABLE 6

TROUBLE SHOOTING GUIDE

MECHANICAL PROBLEMS

PROBLEM	CAUSE	SOLUTION
Drive Cone Does Not Separate from Body	1) Very fine sand has worked its way between cone and drive shoe as tool is being driven.	a) Make sure the rubber exterior sleeve is used over the cone and drive shoe. b) Make sure tool is not lifted or accidentally backhammered as it is being advanced.
	2) In very loose formations there may not be enough soil friction to separate the cone as it is pulled back.	a) Initiate pullback by a sharp backhammer. The sudden shock and upward motion will cause separation.
	3) Utilizing a "homemade" sleeve instead of the sleeve provided with the HydroPunch.	a) Use the sleeves provided with the tool.
Drive Cone Separates Too Soon	1) Tool is pulled back prematurely or was picked up after being placed on bottom of borehole.	a) Driller's Rule 1 (Table 3).
	2) Rubber friction sleeve was not used.	a) Always use rubber sleeves provided with the tool.
Leaking Check Valve	1) Sediment clogs on check valve.	a) Retrieve tool and decant sample as rapidly as possible.

HYDROGEOLOGY RELATED PROBLEMS

PROBLEM	CAUSE	SOLUTIONS
No Sample Due to Low Permeability Conditions	In some fine-grained silts and clays or formations with very thin water bearing zones, the compression of soil particles may lower permeability of the saturated zone causing the collection of ground water samples to take a longer period of time than "normal" (>1 hour). In some low permeability conditions, sample collection may not be possible.	Many low permeability conditions occur in fine-grained cohesive soils. Often these soils will "stand open" after the drilling tools are removed. If the HydroPunch hole stands open, it is possible to use the tool in the HydroCarbon mode without a screen attached to the cone. This permits the open area to be as long as possible—not limited to the 5-foot screen length. The long open hole provides a greater intake area and a collection sump for the sample. The increased intake reduces the time required for the tool to fill.
Intrusion of Drilling Mud or Outside Ground Water	If the HydroPunch is used in the water sampling mode in a mud filled hole or is retrieved through a zone with a higher head than the sample zone, the foreign fluid will displace the sample in the HydroPunch.	1. Vent tubing can be run from the top check valve of the HydroPunch to the surface. The tubing vents the tool while filling. After the tool is filled, gas pressure is applied to the tube which seats the check valves. This prevents outside fluid from entering as the tool is withdrawn. 2. Use the tool in the HydroCarbon mode and collect the sample before the tool is withdrawn through the fluid.

VI. SCHEDULING (General Guidelines)

As with all drilling projects, HydroPunch sampling rates are dependent upon site conditions, depth of sampling, equipment available, and personnel experience. However, some general guidelines can be used. Based on a sample depth of 30 feet or less and easy drilling or pushing conditions, rough sampling rates outlined in Table 7 may be used. The slow first day rates reflect set up time and getting a feel for the tool and the site, particularly if no hydrogeologic information is available.

TABLE 7

SCHEDULING GUIDELINES

DAILY SCHEDULE	NUMBER OF SAMPLES COLLECTED	
	Inexperienced Crew	Experienced Crew
First Day	3 Samples	3 - 8 samples
Following Days	4-10 Samples *(depending on depth of sample and drilling rate)*	5 - 10 samples *(depending on depth of sample and drilling rate)*

As the sample is collected, the drive cone and the sample chamber are flush against the borehole walls, serving as packers which isolate the intake screen from ground water above and below the zone being sampled. The sample is collected under in-situ hydrostatic pressure with no agitation. Once the sample chamber is filled, the HydroPunch is pulled towards the surface. This increases the hydrostatic pressure in the unit, which closes the two Teflon check valves and retains the sample within the sample chamber. Upon retrieval, the cone is removed and a simple stainless steel and Teflon sample discharge device is inserted for transferring the groundwater sample to a sample container.

Unlike geophysical monitoring techniques or soil gas sampling, which are sometimes used to screen for ground water contamination plumes, the HydroPunch provides a ground water sample consistent with sampling requirements for all priority pollutants. The sample provided by the HydroPunch is not subject to extraneous influences (i.e., changes in soil type, vadose zone contamination, etc.) which can affect the remote sensing techniques and often complicate the data interpretation. In addition, the potentiometric surface of the aquifer being sampled can be determined from the stabilized water level inside the rods used to drive or push the HydroPunch.

PLEASE NOTE:
HydroPunch samples and groundwater samples collected from monitoring wells installed in same borehole. Site referenced is a landfill located in N. California. Some variables exist between samples: 1) Samples were not collected from the HydroPunch and well concurrently, consequently chemical conditions may have changed between samples; 2) HydroPunch and well samples were not collected from exactly the -me intervals. Screened intervals e 10-30 feet, while HydroPunch .ects a sample from approximately a two-foot interval.

Comparison of HydroPunch and Monitoring Well Water Samples

Well Number	A-1		A-2		A-3		A-4		A-5		A-6	
Source of Sample	HydroPunch	Well	HydroPunch	Well	HydroPunch	Well	HydroPunch	Well	HydroPunch	Well	HydroPunch	Well
Depth of Sample (Feet)	35	40	121	101-131	125-127	105-135	81.5-83.5	55-65	140	134-144	134.5-136	122-132
Volatile Priority Pollutants (Concentration µg/l)												
Benzene	0.3	0.1	12	20	5	12	0.1	ND	0.1	0.1	1.2	0.3
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND
Dibromochloromethane	ND	ND	4.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	0.1	0.1	ND	ND	ND	ND	0.3	0.2	ND	ND	ND	1
1,1—Dicloroethane	0.1	0.1	30	45	22	42	0.2	0.8	ND	ND	4.7	8.4
1,2—Dichloroethane	ND	ND	2.5	2.5	ND	ND	ND	ND	ND	0.3	0.5	0.5
1,1—Dichloroethene	ND	ND	2.5	2.5	ND	ND	ND	0.1	ND	ND	ND	0.1
1,2—Dichloropropane	ND	ND	2.5	2.5	ND	2.5	ND	ND	ND	ND	ND	1
Ethylbenzene	0.2	ND	ND	ND	ND	ND	ND	ND	0.1	0.1	0.1	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15	10
Tetrachloroethene	0.6	0.7	23	48	28	42	0.6	1.5	2.3	3	5.5	12
Toluene	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	0.2	ND	ND	ND	ND	ND
1,1,2,-Trichloroethane	0.1	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethane	0.2	0.3	16	30	ND	25	0.1	0.3	0.2	0.2	2.8	5.3
Vinyl Chloride	ND	ND	ND	32	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	2.5	ND	5	ND	ND	ND	ND	0.2	0.2
Volatile Non-Priority Pollutants												
p—Xylenes	0.7	0.1	ND	2.5	ND	2.5	0.1	ND	0.3	0.1	0.3	ND
—Xylene	0.1	ND	ND	2.5	ND	ND	ND	ND	0.1	ND	ND	ND
cis-1,2-Dichloroethene	2.4	2.6	48	75	38	65	ND	ND	0.3	0.3	4.2	2.3

GEOLOGIC GUIDELINES FOR USING THE HYDROPUNCH

General Application

The HydroPunch is a ruggedly constructed sampling tool designed to be pushed or driven into position. Although the HydroPunch is designed for durability, some basic guidelines should be followed to maximize the usage life of this tool.

As a general rule, the HydroPunch can be driven into position in formations where a standard 2 inch split barrel (spoon) soil sampler can be driven. Suitable geologic materials would include unconsolidated clays, silts, sands and fine gravels. It is often helpful to drive a split barrel sampler immediately above the zone where the HydroPunch sample is to be collected. This permits an estimate of the permeability of the formation to be made from the textural characteristics of this soil sample and also provides an estimate of the resistance to driving the HydroPunch.

Blow counts of over thirty (30) blows per six inches with the 2 inch split barrel sampler may indicate that damage might occur while driving the HydroPunch. This would be more likely to occur if very hard materials (i.e., cobbles, rock layers, etc.) were mixed in with a matrix of softer material than if the HydroPunch is being advanced through a uniformly dense material. In dense formations it is better to drive the HydroPunch using frequent blows with a standard 140 pound hammer than to increase the hammer weight. This is because the length of the tool (5.38 ft.) will be left unsupported and the heavier hammer may induce more lateral stress on the unit, resulting in bending of the body. The deeper the body of the HydroPunch is in the soil, the less likely bending is to occur. This same principle is true for pushing the HydroPunch. As a general rule it is not a good idea to push the HydroPunch from the surface into the soil with the entire barrel unsupported. If thrust moves out of the vertical plane or an obstruction is encountered, the unit may be damaged by bending.

Hydrologic Considerations

An important feature of the HydroPunch is that it is designed to fill using the aquifer's hydrostatic pressure. Consequently the HydroPunch will only fill as fast as the formation will yield water. The discrete sampling intake of the HydroPunch (the area between the drive cone and the body when the tool is in the open position) must be in hydraulic contact with a water bearing zone for a sample to be collected.

The location of the sample chamber above the intake requires that the HydroPunch be pushed a minimum of five (5) feet below the static water level for a sample to be collected. Attempts to collect samples with less than five feet of penetration into the aquifer will likely result in very slow fill times, inadequate sample volume or improper function of check valves, due to extremely low hydrostatic pressure.

QED Environment Systems, Inc.
P.O. Box 3726, Ann Arbor, MI 48106
800/624-2026
In Michigan, 313/995-2547
In Canada, 519/485-0290

HYDROPUNCH

Groundwater Sampling Without Wells

QED Environmental Systems, Inc.
P.O. Box 3726, Ann Arbor, MI 48106
800/624-2026 In Michigan, 313/995-2547

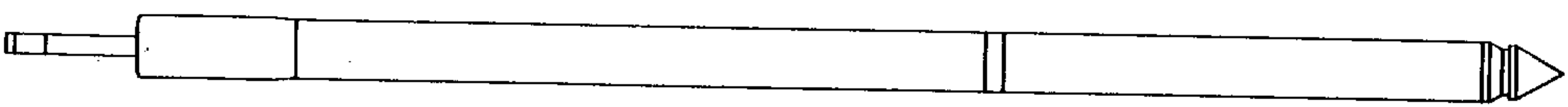
QED Environmental Systems, Inc.
P.O. Box 3726 • Ann Arbor, MI 48106

HYDROPUNCH (R) OPERATION MANUAL

INDEX

SPECIFICATIONS

1. HYDROPUNCH IS EQUIPPED WITH AN "AW" BOX THREAD. ANY SUB-ADAPTER OR DRIVE ROD USED WITH HYDROPUNCH MUST HAVE A MINIMUM OF 9/16" INSIDE DIAMETER BY 4" DEEP ABOVE TOP OF HYDROPUNCH TO ALLOW CLEARANCE FOR TOP CHECK.
2. MAXIMUM DIAMETER: 1.75"
3. LENGTH: CLOSED– 64.50"
   OPEN– 76.50"
4. WEIGHT (HYDROPUNCH ONLY): 24 LBS.
5. SHIPPING WEIGHT: 49 LBS.
6. SAMPLE VOLUME: 500 ML (NOMINAL)



QED Environmental Systems, Inc.
P.O. Box 3726 • Ann Arbor, MI 48106

OPERATING THE HYDROPUNCH (R) GROUNDWATER SAMPLING SYSTEM

GENERAL OPERATION

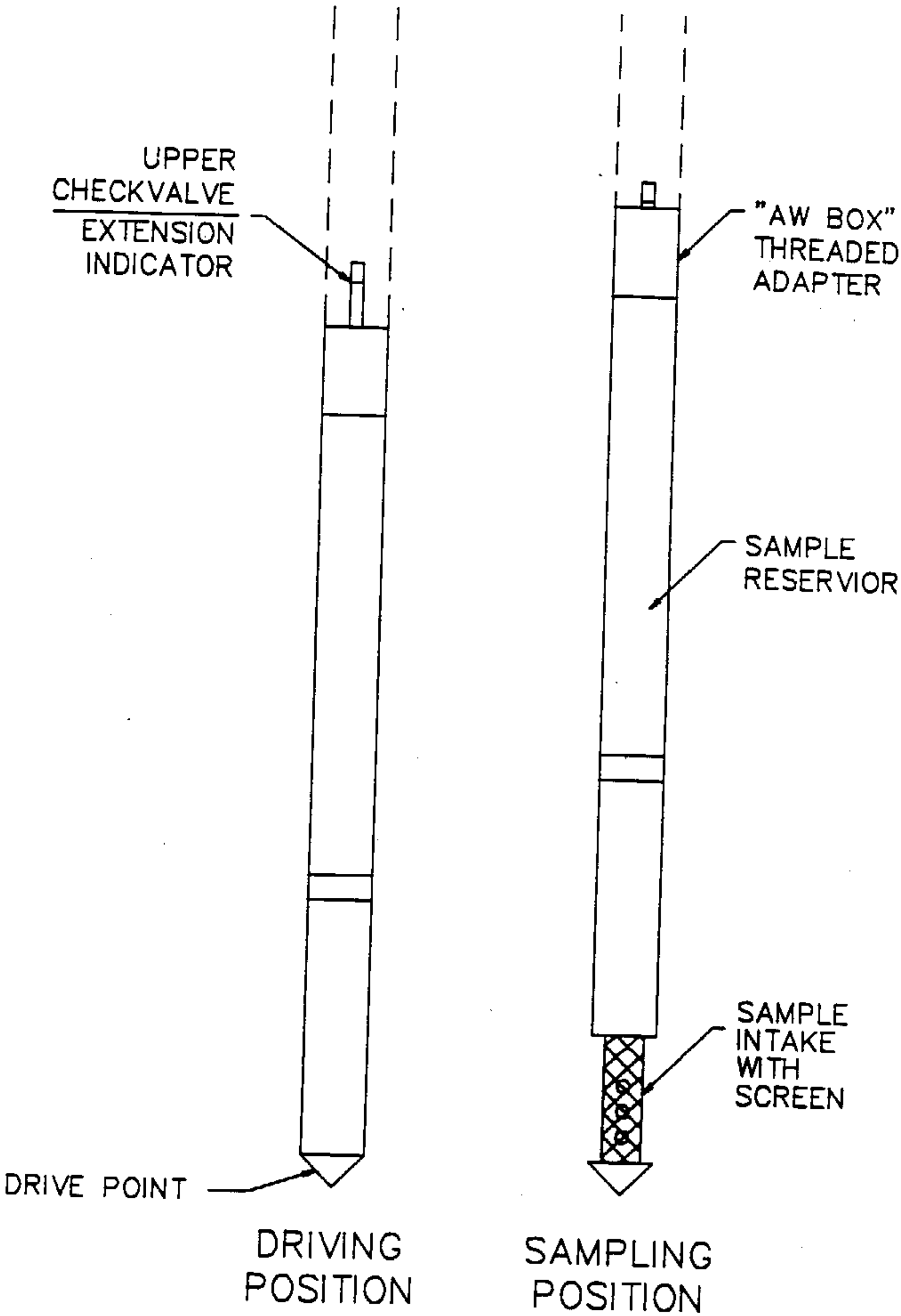
The HydroPunch is used to gather representative groundwater samples without installing complete monitoring wells. The HydroPunch is pushed/driven through the undisturbed soil into a water bearing zone, the outer body is retracted slightly to allow liquid to enter into the sample chamber, the HydroPunch is pulled to the surface and the sample is removed for analysis. The HydroPunch is then cleaned prior to collecting the next groundwater sample.

USE WITH CONE PENETROMETER EQUIPMENT

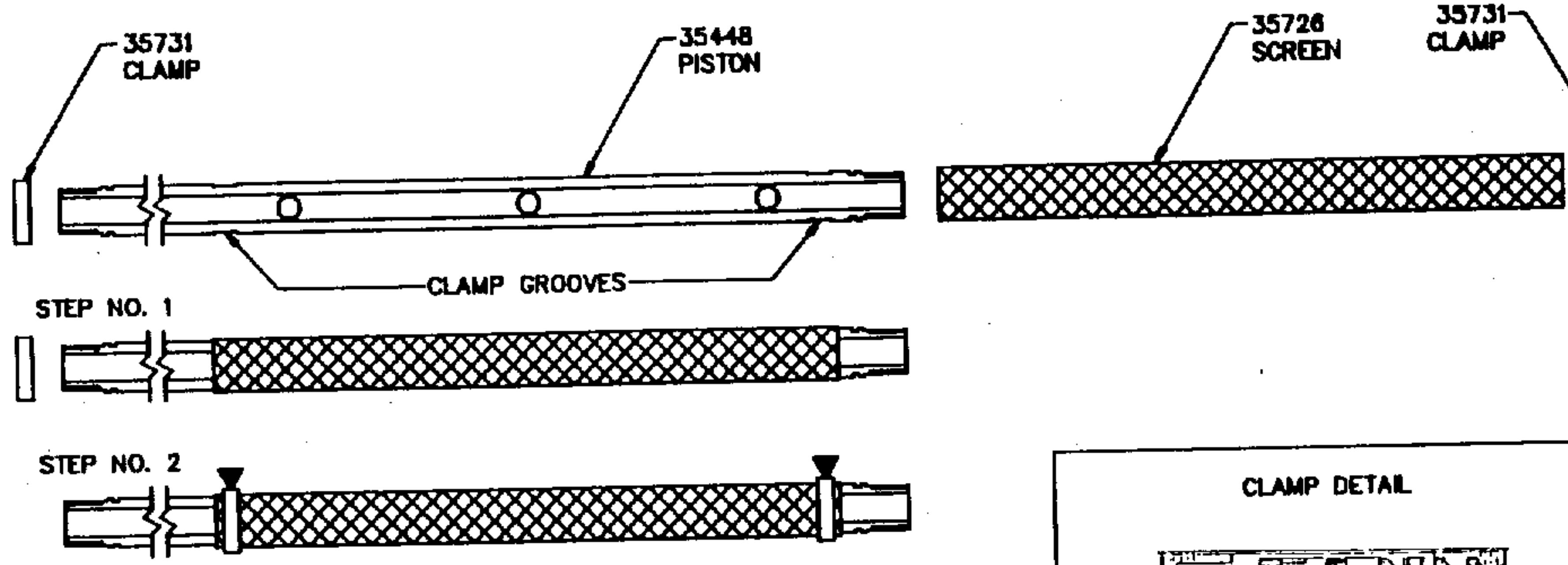
1) Attach the clean HydroPunch (via the AW Box thread at the top) ahead of the drive string. (See Diagram on Page 3.)
2) Push the HydroPunch a minimum of 5.5 feet into the water bearing zone.
   NOTE: Pre-punching the hole to just above the water bearing zone will increase the useful life of the HydroPunch.
3) Retract the HydroPunch approximately 1.5 feet to allow the sample to enter. (See Diagram on Page 3.)
   NOTE: Pulling upward on the drive string should retract the outer body and allow the sample to enter. Depending upon the soil conditions, the point may not remain in place when the outer body is retracted. Solid push rods or a weight on cable can to used to lightly tap ("tunk") the top check valve to assist in point extension and to verify extension.
4) The fill rate is dependent on the formation permeability. Fill times of 10 to 40 minutes are normal.
5) Pull the HydroPunch to the surface when filled.
6) Rinse the HydroPunch off before removing the sample.
7) Remove the sample from the HydroPunch using the top discharge device. (See Pages 11 and 12.)
8) Rinse any dirt/sand from unit before disassembly for cleaning. Dirt can lock and gall stainless steel threads.

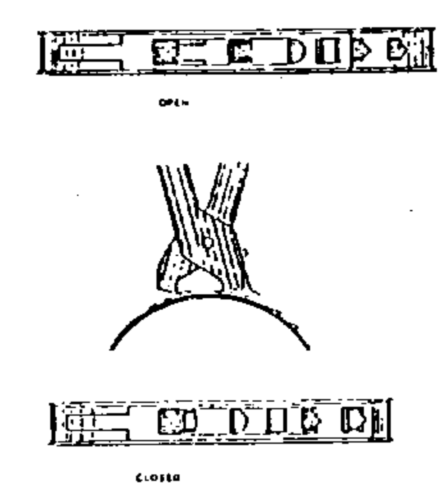
USE WITH DRILLING EQUIPMENT

1) Drill the initial hole to just above the water bearing zone.
2) Attach the clean HydroPunch (via the AW Box thread at the top) to the drive rods. (See Diagram on Page 3)
3) Drive the HydroPunch a minimum of 5.5 feet into the undisturbed water bearing zone.
   NOTE: The HydroPunch is driven into position in the same manner as a 2" split barrel soil sampler, normally using a 140 lb. hammer.
4) Follow Steps 3 thru 8 listed under "USE WITH CONE PENETROMETER EQUIPMENT".


UPPER
CHECKVALVE
EXTENSION
INDICATOR
"AW BOX"
THREADED
ADAPTER
SAMPLE
RESERVIOR
SAMPLE
INTAKE
WITH
SCREEN
DRIVE POINT
DRIVING
POSITION
SAMPLING
POSITION

SCREEN ASSEMBLY

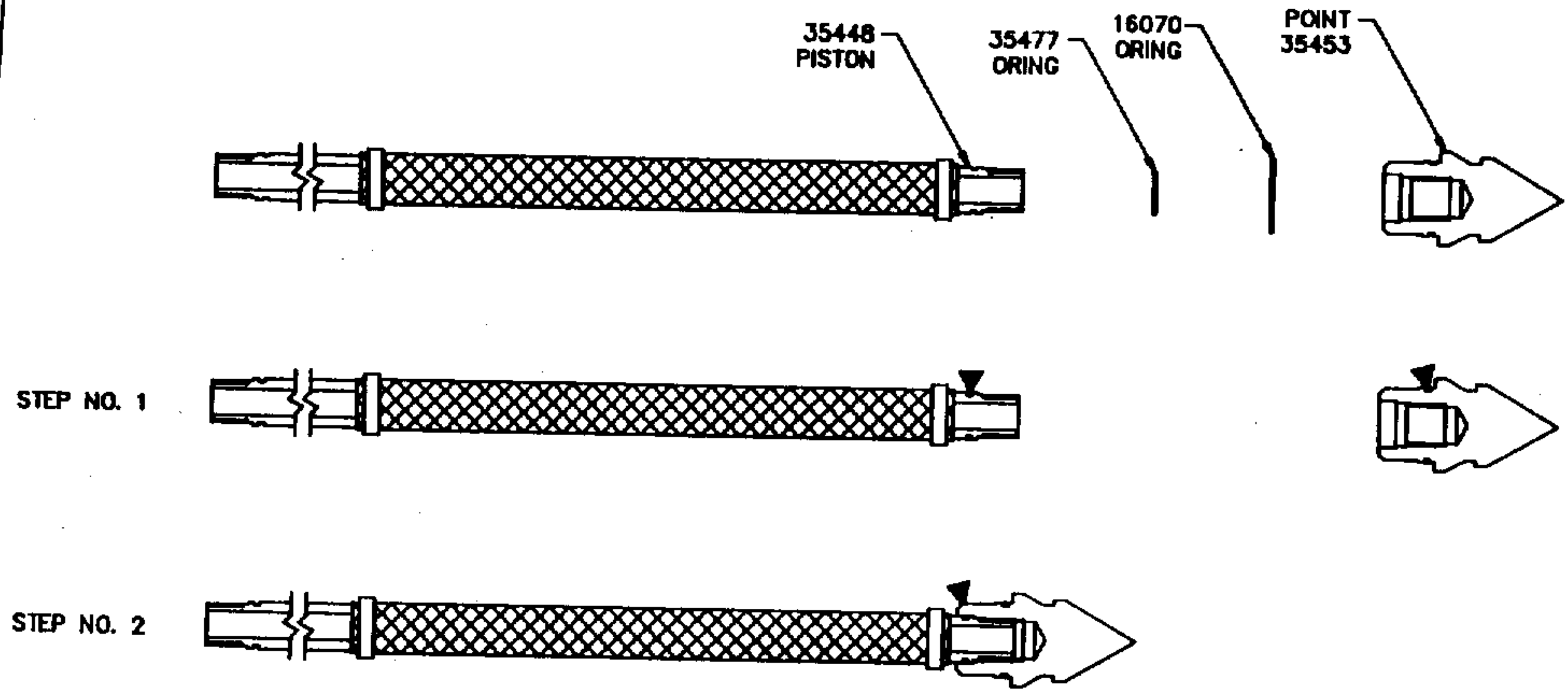




INSTRUCTIONS:

1. SLIDE STAINLESS STEEL SCREEN (35726) OVER THE 3 CROSS-HOLES ON THE PISTON (35448). NOTE THE LOCATION OF THE CLAMP GROOVES ON EITHER SIDE OF THE 3 CROSS-HOLES.
2. USING CLAMP TOOL (35052), INSTALL 1 CLAMP (35731) ON EACH END OF THE SCREEN. CLAMPS (35731) SHOULD BE LOCATED OVER CLAMP GROOVES ON PISTON (35448).

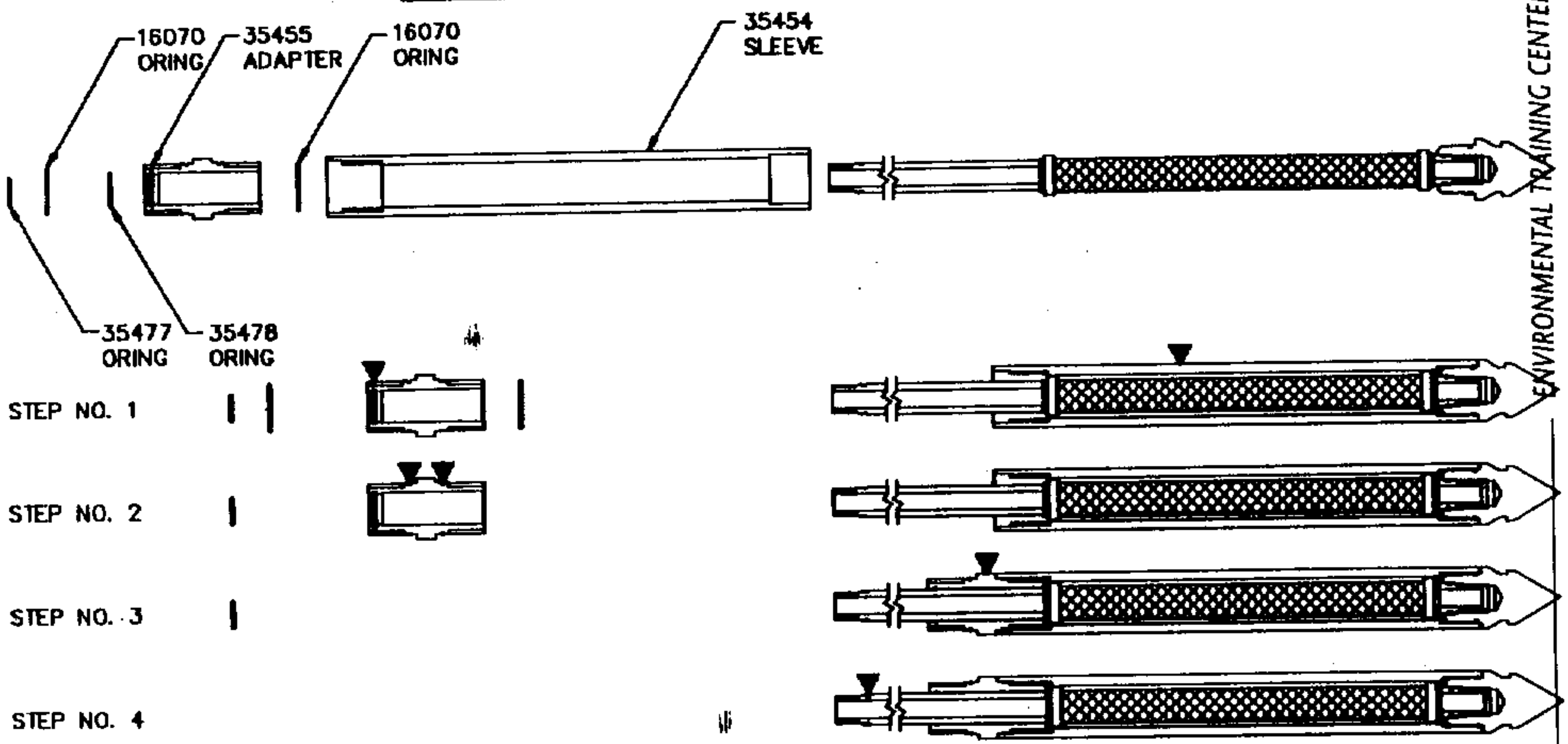
POINT ASSEMBLY



INSTRUCTIONS:

1. INSTALL ORING (35477) ON END OF PISTON (35448) LOCATED NEAR SCREENED END. INSTALL ORING (16070) ON POINT (35453).
2. SCREW POINT (35453) ONTO PISTON (35448) UNTIL SEAL IS MADE. WHEN SCREWING POINT ONTO PISTON <u>DO</u> <u>NOT</u> HOLD ON TO SCREEN AREA.

SLEEVE AND ADAPTER ASSEMBLY



INSTRUCTIONS:

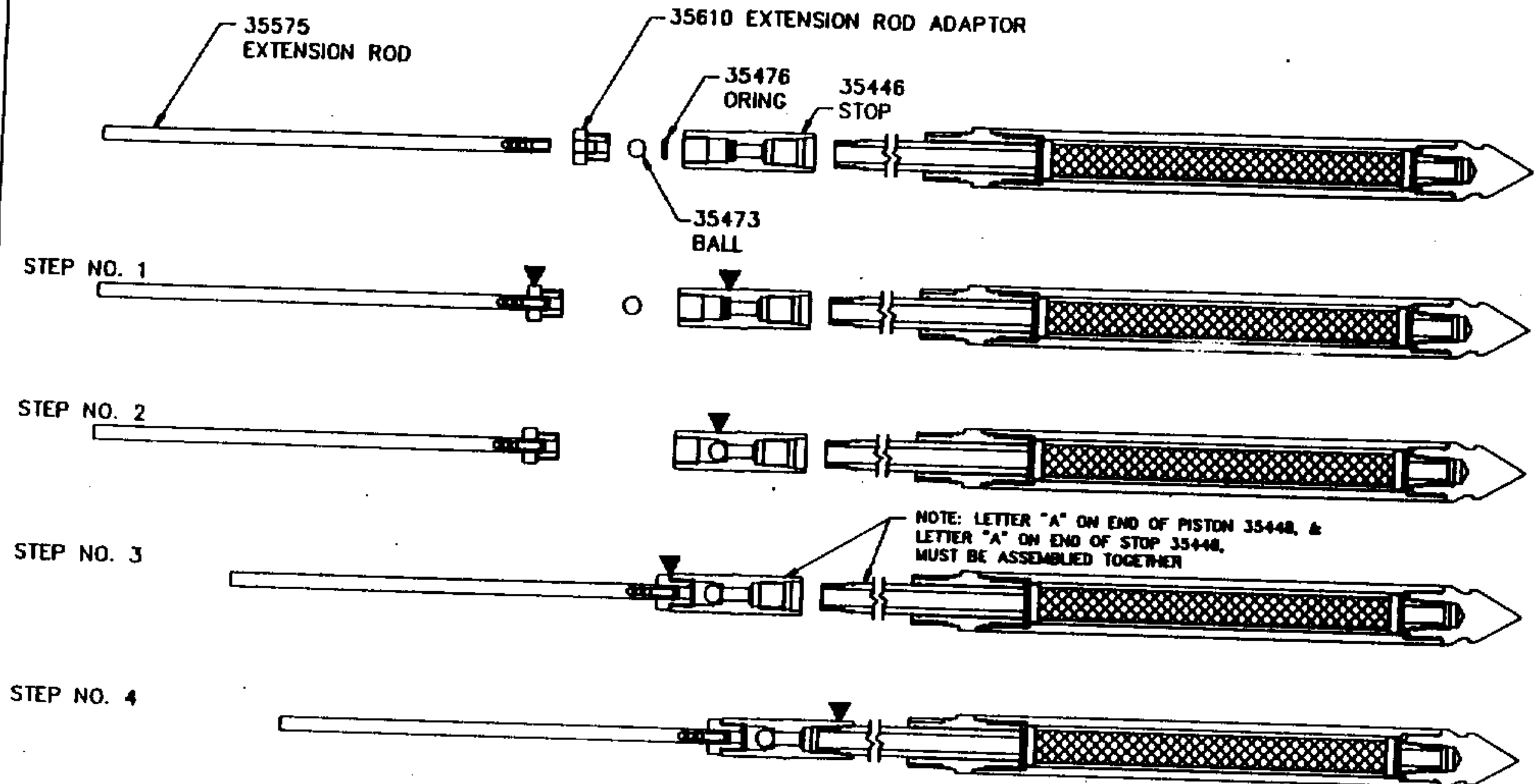
1. SLIDE SLEEVE OVER SCREEN/POINT SUB-ASSEMBLY. THREADED END OF SLEEVE (35454) SHOULD BE OPPOSITE POINT. INSTALL ORING (35478) INSIDE OF INTERNAL ORING GROOVE IN ADAPTER (35455).
2. INSTALL 2 ORINGS (16070) IN EXTERNAL ORING GROOVE ON BOTH ENDS OF ADAPTER (35455).
3. CAREFULLY SLIDE ADAPTER SUB-ASSEMBLY OVER THE END OF THE PISTON (35448). SLOWLY ROTATE ADAPTER SUB-ASSEMBLY WHILE INSTALLING ON PISTON (35448) TO PREVENT TEARING INTERNAL ORING (35478). CAREFULLY THREAD ADAPTER SUB-ASSEMBLY INTO SLEEVE (35454). SLOWLY TURN ADAPTER SUB-ASSEMBLY BACK AND FORTH TO SEAT ORING AS IT ENTERS SLEEVE.
4. IN 'LL ORING (35477) ON END OF PISTON (35448).

NOTE:
IF ANY RESISTANCE, DUE TO SAND, GRIT OR METAL BURRS, IS ENCOUNTERED WHILE ASSEMBLING STAINLESS STEEL COMPONENTS, DO NOT FORCE! DISASSEMBLE COMPONENTS AND DETERMINE CAU OF RESISTANCE BEFORE ANY FURTHER ASSEMBLY. FORCING STAINLESS STEEL PARTS TOGETHER WIL CAUSE GALLING AND THE PARTS MAY BE RUINE

ENVIRONMENTAL TRAINING CENTER

PRC

STOP/EXTENSION ROD ASSEMBLY FOR TOP DISCHARGE

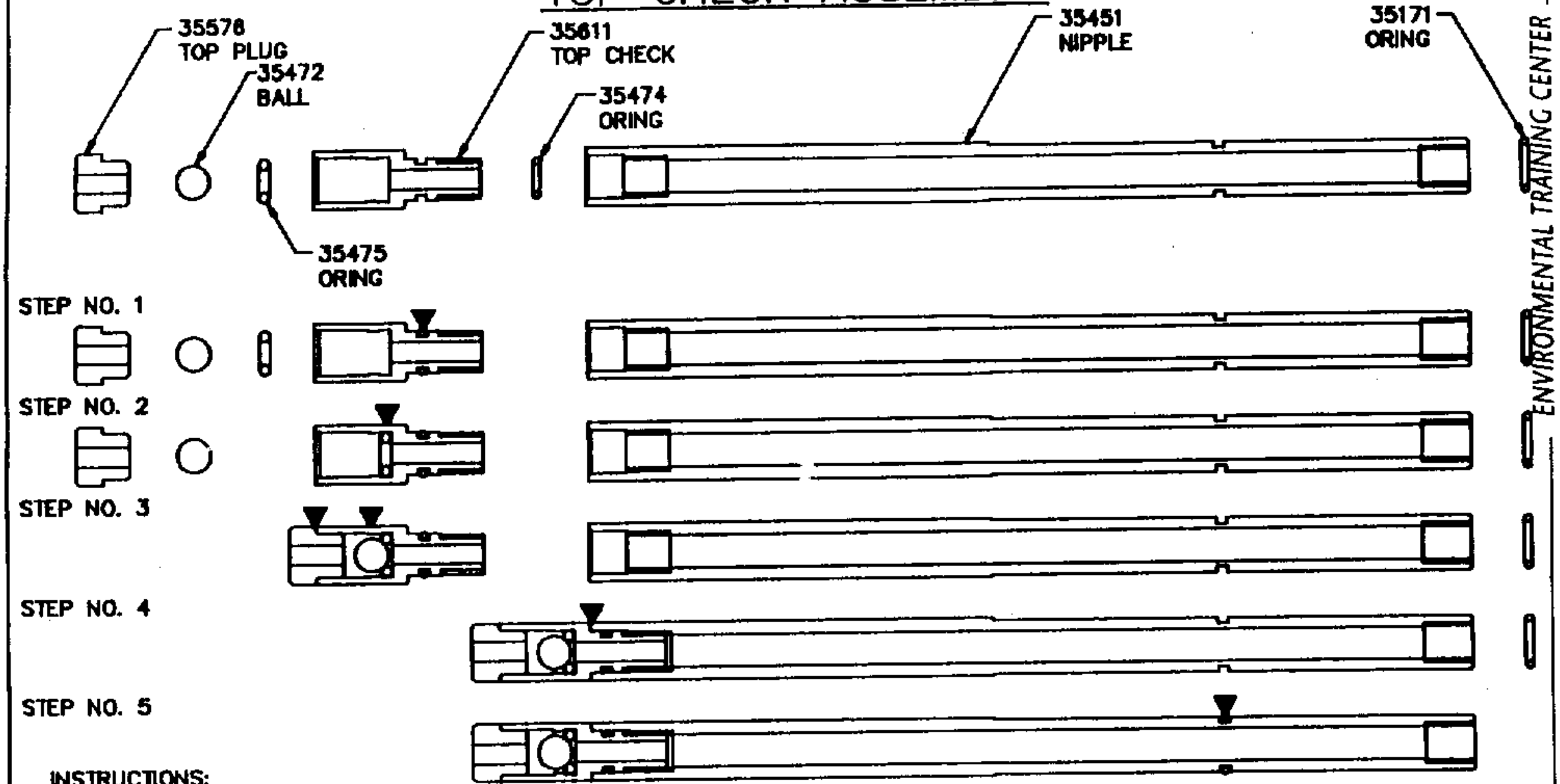


INSTRUCTIONS:

1. SCREW EXTENSION ROD (35575) INTO EXTENSION ROD ADAPTOR (35610). INSTALL ORING (35476) INTO ORING GROOVE IN STOP (35446). MAKE SURE ORING IS SEATED.
2. PLACE 1/2" DIAMETER BALL (35473) IN STOP (35446) AND SEAT ON ORING (35476).
3. SCREW EXTENSION ROD SUB-ASSEMBLY INTO STOP SUB-ASSEMBLY.
4. INSTALL STOP/EXTENSION ROD SUB-ASSEMBLY ON END OF PISTON (35448).

NOTE:
EXTENSION ROD (35575) IS ONLY USED WHEN VARIFICATION THAT THE HYDROPUNCH HAS OPENED, IS DESIRED. IF VARIFICATION IS NOT REQUIRED THEN LEAVE EXTENSION ROD (35575) OUT. THIS WILL INCREASE YOUR SAMPLE CHAMBER VOLUME BY 100 ML.

TOP CHECK ASSEMBLY

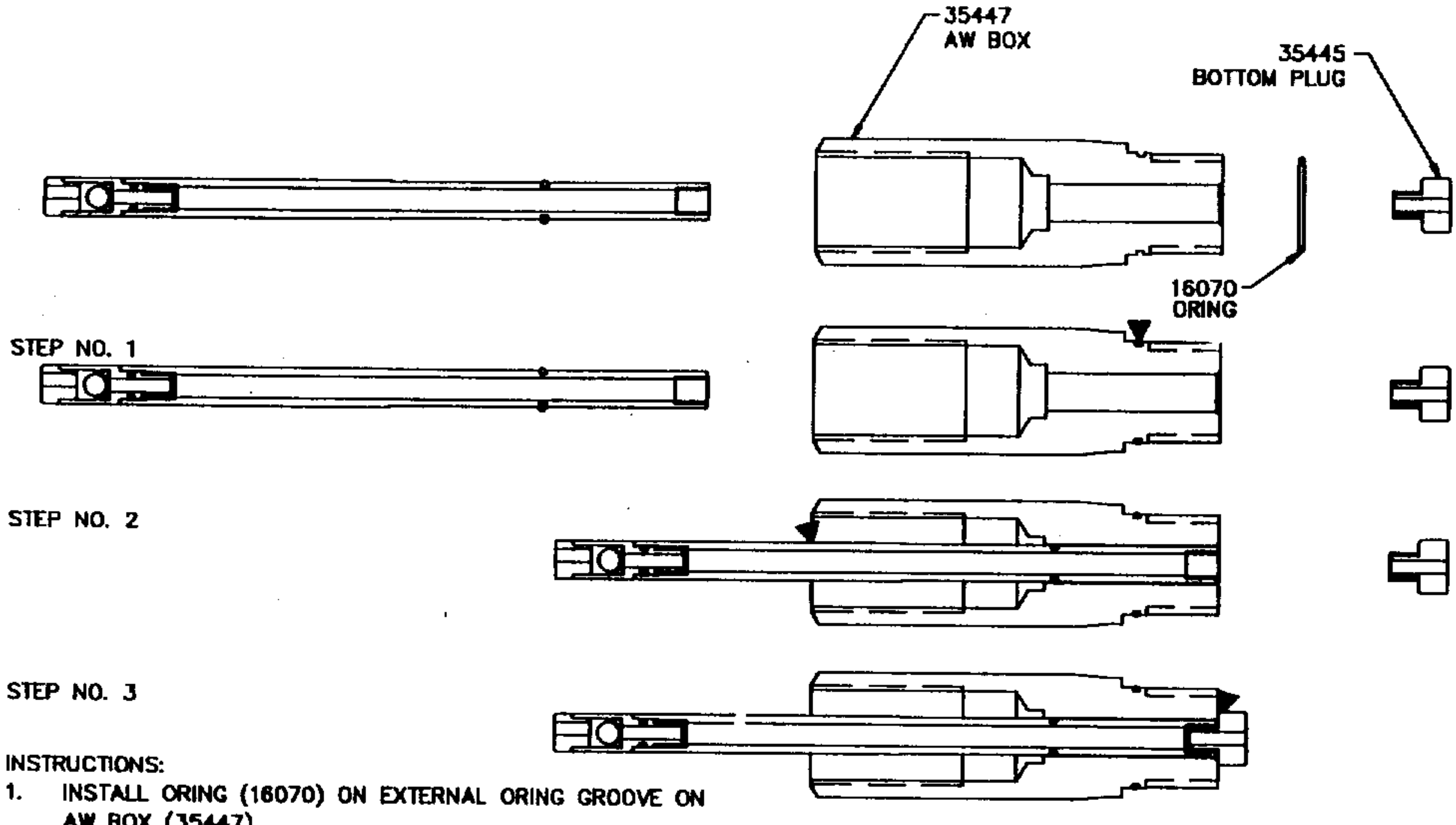


INSTRUCTIONS:

1. INSTALL O-RING (35474) ON TOP CHECK (35611).
2. INSTALL O-RING (35475) IN TOP CHECK (35611). MAKE SURE ORING IS SEATED.
3. PLACE 5/16" DIAMETER BALL (35472) IN TOP CHECK (35611). THREAD TOP PLUG (35576) INTO TOP CHECK (35611).
4. SCREW NIPPLE (35451) INTO TOP CHECK (35611). NOTE: THE TOP CHECK CAN BE SCREWED INTO BOTH ENDS OF NIPPLE, BUT ONLY ONE END WILL MAKE A SEAL. THE CORRECT END IS THE ONE LOCATED FARTHEST FROM THE EXTERNAL ORING GROOVE ON THE NIPPLE. IT IS ALSO THE LARGEST DIAMETER ON THE NIPPLE.
5. I[illegible]LL ORING (35171) ON NIPPLE (35451).

PRC ENVIRONMENTAL TRAINING CENTER

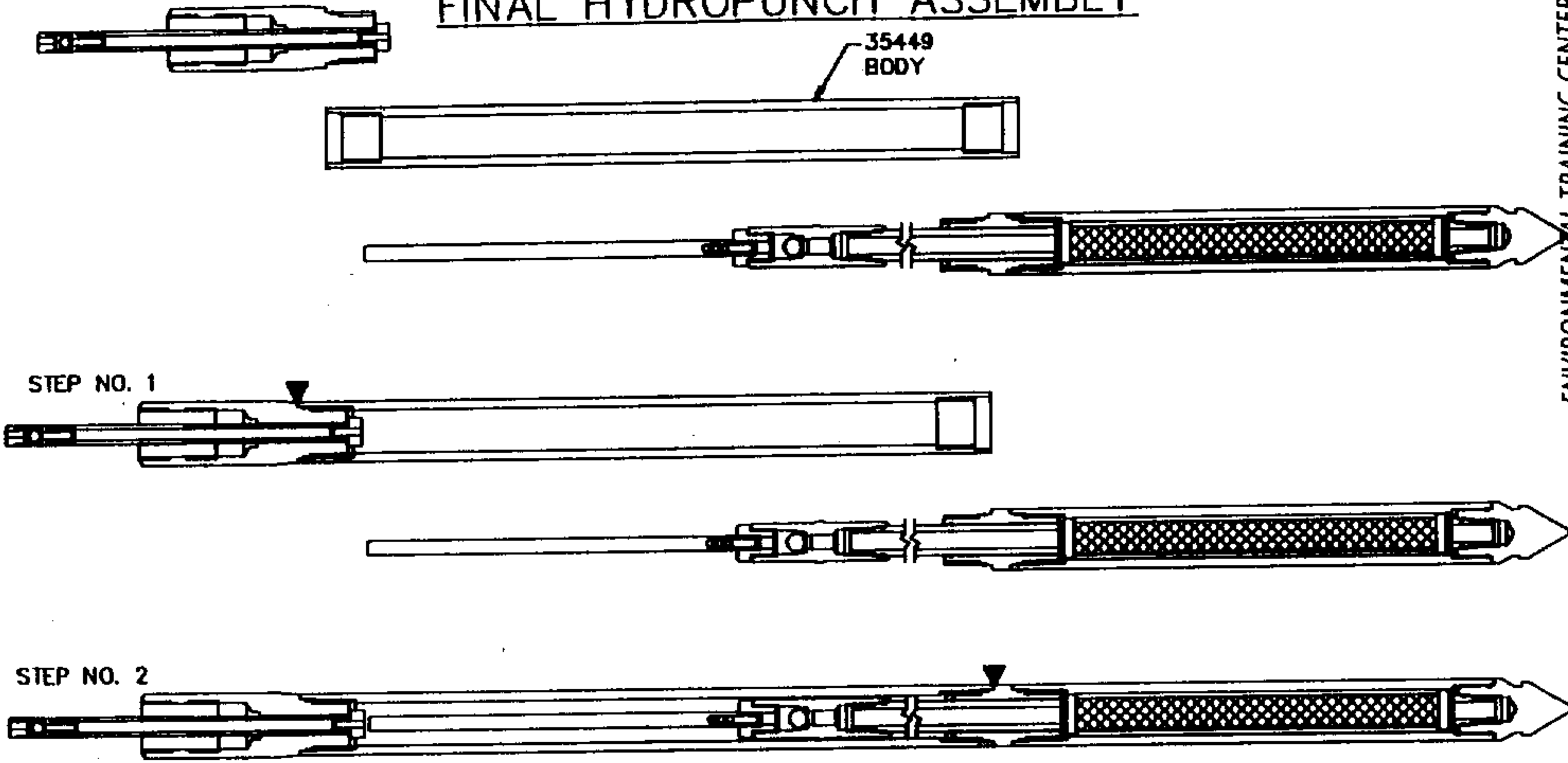
AW BOX/TOF CHECK ASSY.



INSTRUCTIONS:

1. INSTALL ORING (16070) ON EXTERNAL ORING GROOVE ON AW BOX (35447).
2. INSERT TOP CHECK/NIPPLE SUB-ASSEMBLY INTO AW BOX (35447) BORE. SLOWLY ROTATE NIPPLE WHILE INSERTING INTO AW BOX.
3. SCREW BOTTOM PLUG (35445) INTO NIPPLE SUB-ASSEMBLY.

FINAL HYDROPUNCH ASSEMBLY

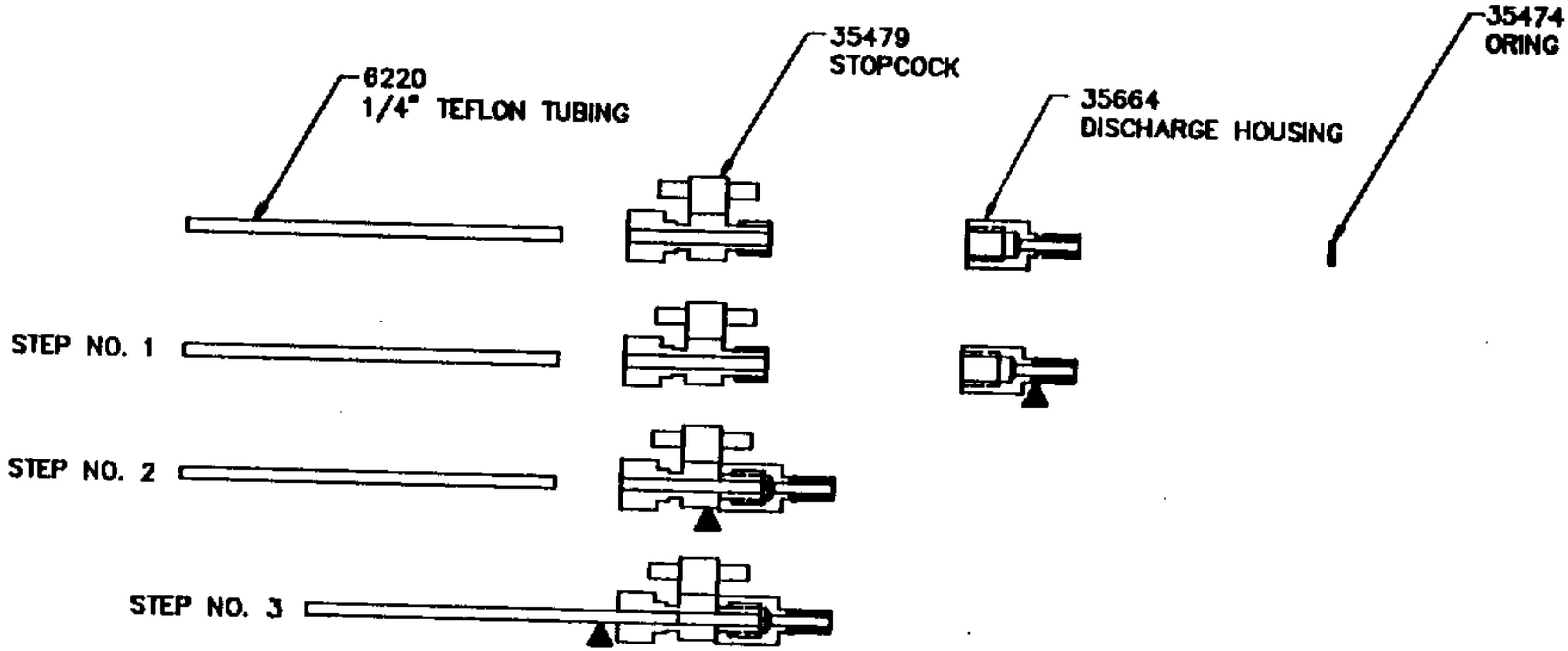


INSTRUCTIONS:

1. INSTALL AW BOX SUB–ASSEMBLY INTO BODY (35449). SLOWLY TURN AW BOX SUB–ASSEMBLY BACK AND FORTH TO SEAT ORING AS IT ENTERS BODY (35449).
2. INSTALL POINT SUB–ASSEMBLY INTO BODY (35449). SLOWLY TURN POINT SUB–ASSEMBLY BACK AND FORTH TO SEAT ORING AS IT ENTERS BODY (35449).
3. THE HYDROPUNCH IS NOW READY FOR USE.

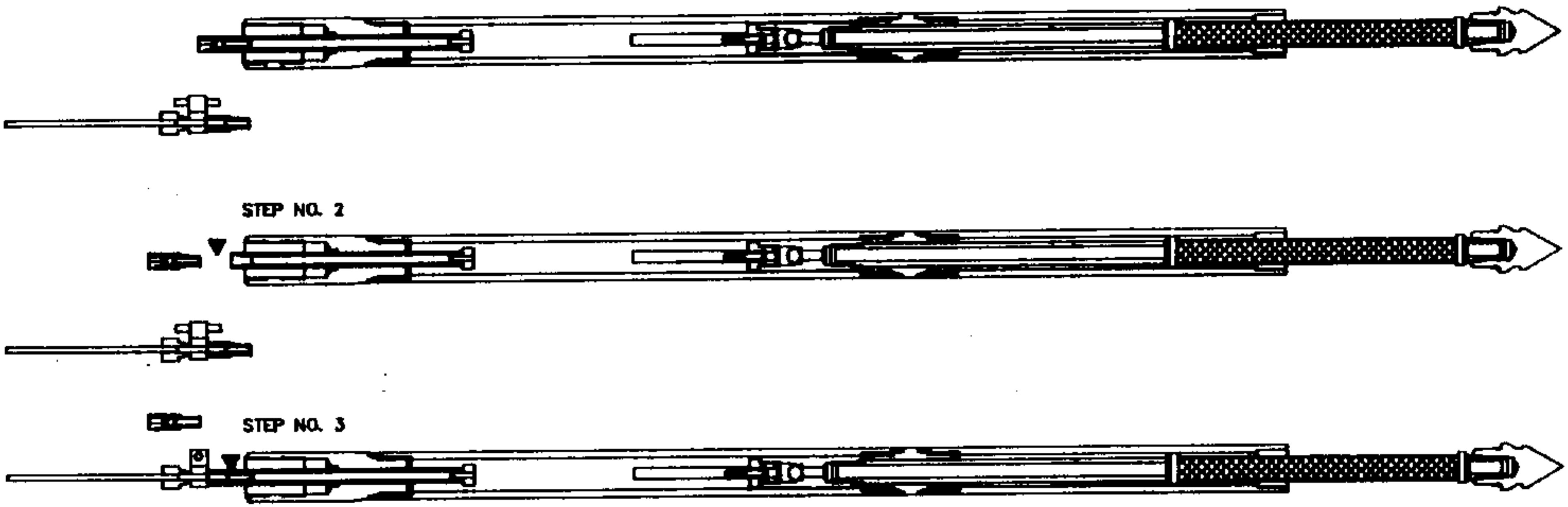
NOTE:
IF ANY RESISTANCE, DUE TO SAND, GRIT OR METAL BURRS, IS ENCOUNTERED WHILE ASSEMBLING STAINLESS STEEL COMPONENTS, DO NOT FORCE! DISASSEMBLE COMPONENTS AND DETERMINE CAUSE OF RESISTANCE BEFORE ANY FURTHER ASSEMBLY. FORCING STAINLESS STEEL PARTS TOGETHER WILL CAUSE GALLING AND THE PARTS MAY BE RUINED.

TOP DISCHARGE DEVICE ASSEMBLY



INSTRUCTIONS:
1. INSTALL (1) O-RING (35474) ON DISCHARGE HOUSING (35664).
2. SCREW THE TEFLON STOPCOCK (35479) INTO THE THREADED END OF THE DISCHARGE HOUSING (35664).
3. INSERT A 6" PIECE OF 1/4" TEFLON TUBING (6220) INTO THE COMPRESSION NUT ON THE TEFLON STOPCOCK (35479). TIGHTEN THE COMPRESSION NUT.

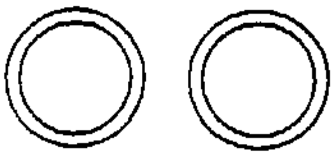
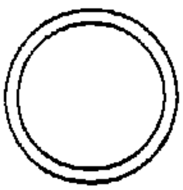
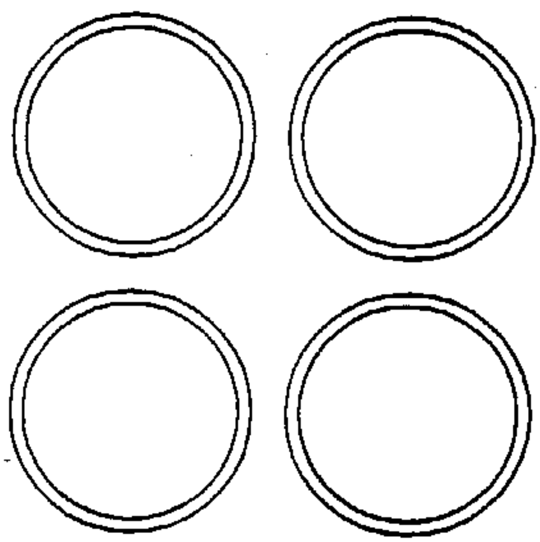
USE OF TOP DISCHARGE DEVICE



INSTRUCTIONS:

1. HOLD HYDROPUNCH IN A VERTICLE POSITION. MAKING SURE HYDROPUNCH DOES NOT REST ON POINT
2. REMOVE TOP CHECK ASS'Y
3. SHUT OFF STOPCOCK. INSERT TOP DISCHARGE DEVICE AND THREAD INTO END OF NIPPLE
4. ROTATE HYDROPUNCH 180 DEGREES AND OPEN STOPCOCK TO OBTAIN SAMPLE

ORING IDENTIFICATION CHART

	OUTSIDE DIAMETER (IN.)	INSIDE DIAMETER (IN.)	THICKNESS (IN.)	QUANTITY	Q.E.D. PART NUMBER	ORING SIZE
	.379	.239	.07	2	35474	2–010
	.504	.364	.07	1	35171	2–012
	.754	.614	.07	2	35477	2–016
	.941	.801	.07	1	35478	2–019
	1.318	1.176	.07	4	16070	2–025
	.412	.206	.103	1	35475	2–107
	.568	.362	.103	1	35476	2–110

QED Environmental Systems, Inc.
P.O. Box 3726 • Ann Arbor, MI 48106

HYDROPUNCH (R) REPLACEMENT PARTS LISTS

PART NUMBER	DESCRIPTION	REFERENCE PAGE
35540	Kit, HydroPunch O-Ring (Includes 1 Replacement Set)	
35760	Kit, HydroPunch Screen (Includes 12 Replacement Sets)	
34895	Bag, 4 x 6	
35052	Clamp Tool	4
35445	Bottom Plug	9
35446	Stop	7
35447	AW Box	9
35448	Piston	4,5
35449	Body	10
35576	Top Plug	8
35451	Nipple	8
35611	Top Check	8
35453	Point	5
35454	Sleeve	6
35455	Adapter	6
35610	Ext. Rod Adapter	7
35575	Extension Rod	7
35472	Ball, 5/16"	8
35473	Ball, 1/2"	7
35479	Teflon Stopcock	11
35480	O-Ring Extractor	
35483	Brush, 1/4" Nylon	
35484	Brush, 3/8" Nylon	
35485	Brush, 1/2" Nylon	
35486	Brush, 3/4" Nylon	
35487	Brush, 7/8" Nylon	
35488	Brush, 1.25" Nylon	
35489	Brush, 1/4" Nylon	
35511	Handle, 24"	
35512	Handle, 45"	
35513	Handle, 48"	
6220	Tubing, 1/4" Teflon	
35664	Adapter, Discharge	11

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF WATER TURBIDITY

SOP NO. 088

REVISION NO. 1

Approved by:

Kathleen Hamer 5/20/93

Quality Assurance Officer Date

1.0 BACKGROUND

Turbidity is the appearance of opaqueness or cloudiness in a liquid resulting from the presence of suspended solid matter. The measurement of turbidity offers an indirect way to evaluate the concentration of suspended solid matter. PRC Environmental Management, Inc. (PRC), uses a LaMotte Company Model 2008 Turbidity Meter or equivalent to measure the turbidity of aqueous samples. Typically, turbidity measurements help evaluate the effectiveness of monitoring well development procedures or well purging procedures prior to sampling.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for obtaining turbidity measurements in the field.

1.2 SCOPE

This SOP applies only to use of the LaMotte Company Model 2008 Turbidity Meter. The model 2008 operator's manual should be consulted for a more detailed description of the instrument. Equivalent instrumentation may be used if the Model 2008 is not available.

1.3 DEFINITIONS

Nephelometry: the measurement of the amount of light scattered at right angles when a beam of light is passed through a water sample. The measurement is reported in nephelometric turbidity units (NTUs).

1.4 REFERENCES

LaMotte Company Model 2008 Turbidity Meter's operator's manual.

1.5 REQUIREMENTS AND RESOURCES

The equipment required to obtain turbidity measurements in the field are as follows:

- LaMotte Company Model 2008 Turbidity Meter or equivalent with standard solutions
- One 40-mL volatile organics analysis (VOA) clear glass sample vial
- Lint-free absorbent wipes

2.0 PROCEDURE

The following sections describe both the calibration and sample measurement techniques to be used with the LaMotte Company Model 2008 Turbidity Meter (Figure 1). Specifications for the Model 2008 are given in Table 1.

2.1 CALIBRATION

The LaMotte Company Model 2008 Turbidity Meter is actually calibrated at the factory; however, two standard solutions are supplied with the instrument to check the calibration of the meter in the field. To check the calibrations the standard solution closest to the anticipated sample reading is placed in the meter. The standardize control (Figure 1) is then used to adjust the meter so the display reads the known value of the standard selected. Standardizing the meter is typically completed before a series of measurements to assure the accuracy of the readings.

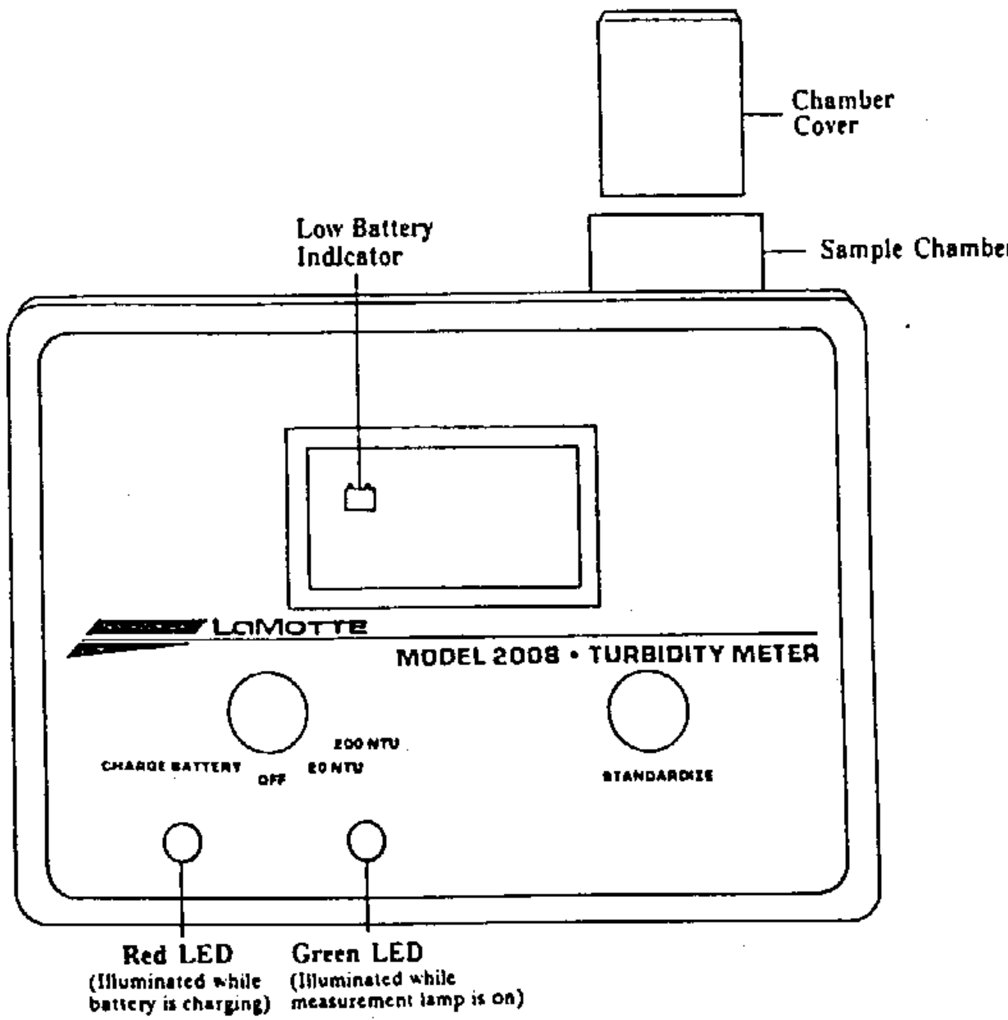
2.2 OPERATION

The instrument operation procedures are as follows:

1. Pour a small amount of sample into the 40-mL VOA sample vial to rinse the vial, and then discard the rinse liquid. Fill the sample vial to its neck, taking care to pour the sample gently down the side to avoid creating air bubbles.

FIGURE 1

LAMOTTE COMPANY MODEL 2008 TURBIDITY METER



Reproduced from LaMotte Company, Chestertown, Maryland.

TABLE 1

SPECIFICATIONS FOR THE MODEL 2008 TURBIDITY METER

METER	
Range:	0-19.99 and 0-199.9 NTU Full Scale
Measurement Accuracy:	±2% of reading or 0.05 NTU, whichever is greater.
Display:	0.5" Liquid Crystal Display
Warm Up Time (to specified accuracy):	less than 15 seconds
PHOTOMETRIC DATA	
Photodetector:	Silicon photodiode, centered at 90° to the incident light path.
Lamp:	Tungsten, lens-end long life, operated at a color temperature of 2230°K. Distance traversed by incident light and scattered light within the sample tube is 2.5 cm.
Lamp Life:	Approximately 10,000 hours
CONTROL PANEL	
Range Selector:	4-position: Charge only/Off/0-20 NTU/0-200 NTU
Standardize:	For standardizing instrument with AMCO™ standards.
POWER REQUIREMENTS	
Operates from internal Ni-Cad rechargeable batteries (not user replaceable)	
D.C. Operation:	Requires 9V, 500 ma (nominal) source - operation is possible on any D.C. source between 9 & 16 volts capable of supplying at least 300 ma.
A.C. Operation:	Is possible via A.C. adapter (120 VAC input, 9V, 500 ma output)
METER HOUSING	
Material:	ABS
Dimensions:	7 1/2"L x 5 3/8"H x 2 3/4"W
Weight:	2.4 lbs.
OPTIONAL CARRYING CASE	
Material:	High Density Polyethylene Case
Dimensions:	10"L x 13 1/2"W x 6 1/8"H
Weight:	8 lbs.

Reproduced from LaMotte Company, Chestertown, Maryland.

2. Cap the sample vial and, while holding the sample vial by the cap only, wipe the outside surface of the vial with a clean, lint-free, absorbent wipe until the sample vial is dry and smudge free. Handling the sample vial only by its cap will avoid problems from fingerprints. Set the sample vial aside on a clean surface that will not contaminate or scratch the bottom of the sample vial.

3. Select the appropriate range on the meter (0-20 NTU or 0-200 NTU).

4. Insert the sample vial into the sample chamber. Make sure the sample vial is seated on the bottom and the chamber is capped. The reading should stabilize within 15 seconds. Record the reading in the logbook and withdraw the sample vial.

5. Decontaminate the vial in accordance with SOP No. 002, "General Decontamination," between samples.

When the batteries in the turbidity meter are low, the indicator light will come on. Initially the instrument, though, will continue to function and provide accurate readings. At the end of the useful charge, readings will appear to drift. The batteries must be recharged at this point, or they may not recharge properly. The instrument can be operated while being recharged.

4.0 SOIL AND GROUNDWATER INVESTIGATIONS

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

SITE RECONNAISSANCE AND CHARACTERIZATION

SOP NO. 001

REVISION NO. 2

Approved by:

Kathleen Homer

Quality Assurance Officer

5-13-93

Date

1.0 BACKGROUND

The site reconnaissance and characterization (investigation) will involve a visual site inspection to evaluate the presence of conditions at hazardous waste sites which may pose potential health and safety hazards to employees engaged in field work. These conditions may include physical hazards, insufficient oxygen levels, exposure to flammable vapor levels, high or toxic concentrations of gases or chemicals, or high levels of nuclear radiation. Evaluation of health and safety hazards consists of (1) reviewing and summarizing existing site data and preparing a site health and safety plan (HSP); and (2) performing the investigation using monitoring or sampling equipment.

1.1 PURPOSE

This standard operating procedure (SOP) was developed to promote uniformity in investigating and evaluating potential health and safety hazards at hazardous waste sites before employees begin field work.

1.2 SCOPE

This SOP applies to the investigative teams conducting investigations at hazardous waste sites to determine potential health and safety hazards that employees may be exposed to during field work. Each investigation will consist of a visual site inspection, the use of monitoring or sampling equipment, and the use of appropriate personal protective equipment.

1.3 DEFINITIONS

None.

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." OSWER Directive 9355.0-14 (EPA/540/p-87/001).

EPA. 1985. "Characterization of Hazardous Waste Sites - A Methods Manual." Volume 1. (EPA/600/4-84/075).

1.5 REQUIREMENTS AND RESOURCES

The requirements and resources needed to complete an investigation are discussed in the following subsections.

1.5.1 Personal Protection Equipment

Members of the investigative team must comply with the site HSP, which will specify the necessary personal protection equipment. This equipment may consist of the following items:

- Protective clothing (coveralls, Tyvek®, Saranex®, or splash suits)
- Hard hat and face shield
- Rubber or steel-toe boots
- Rubber gloves with liners
- Full-face respirator (air-purifying chemical cartridge or supplied air respirator)

1.5.2 Instrumentation

The instrumentation that may be used during an investigation includes:

- Organic vapor monitor
- Oxygen and explosivity meter
- Radiation survey meters

- Respirable dust monitors
- Colorimetric indicator detector tubes (Draeger tubes)

1.5.3 Sample Collection Equipment

It may be necessary during an investigation to collect environmental or source material samples for laboratory analysis. The following equipment may be needed to collect samples:

- Field logbook
- Sample jars and bottles
- Sample collection tools (augers, trowels, pipettes)
- Colorimetric indicator detector tubes
- Chain-of-custody records

2.0 PROCEDURES

The procedures to be followed when conducting an investigation are discussed in the following subsections.

2.1 HEALTH AND SAFETY PLAN

Before an investigation may begin at a hazardous waste site, a site-specific HSP must be completed which satisfies the requirements of the Occupational Safety and Health Administration as defined in the Code of Federal Regulations (29 CFR 1910.120). The HSP must be reviewed and signed by all members of the investigative team prior to arriving on site.

2.2 VISUAL SITE INSPECTION

The investigative team will visually inspect the site during a walkover of the site. Ambient air monitoring will be conducted if needed. The subsections below discuss establishing a staging area, evaluating potential health and safety hazards, and decontaminating equipment.

2.2.1 Establishing a Staging Area

The investigative team will prepare for the visual site inspection at a staging area judged to be clean on or near the site. This area will be used to don personal protective equipment, zero instruments and take background readings if needed, and serve as the decontamination center. The staging area should be upwind of potential contaminant sources.

2.2.2 Evaluating Health and Safety Hazards

The entire site, including bulk storage vessels, confined spaces, waste lagoons, drum storage areas, and other points of interest will be monitored and sampled as needed to detect the presence of potentially hazardous conditions (for example, oxygen deficiency, explosive atmospheres, high vapor or radioactivity levels, or physical hazards). Locations of health and safety hazards or instrument readings exceeding background readings will be written in a field logbook.

Conditions that may lead to potential health and safety hazards are discussed in the following paragraphs. Background information about hazardous materials or waste handled at the site will be used to determine if any or all of the conditions described below need to be monitored.

1. Oxygen Deficiency

   The entire site, but particularly confined spaces, may be monitored for oxygen deficiency. Readings should be taken at ground, waist, and head levels. Any area with an oxygen level of less than 19.5 percent must be avoided. Confined spaces must be entered only by investigative team members using air-supplied respirators. Under no circumstance should an air-purifying respirator be used in confined spaces or oxygen-deficient atmospheres. An additional note of caution is that an explosivity meter will not function properly in oxygen-deficient atmospheres. An oxygen-deficient atmosphere may be explosive, but the explosivity meter will not respond properly in this atmosphere. Treat oxygen-deficient atmospheres as potentially explosive.

2. <u>Explosivity</u>

Continuous, ground, waist, and head level readings may be obtained in confined spaces or areas where explosive gases are suspected. If readings approach or exceed 10 percent of the lower explosive limit (LEL), extreme caution should be used in continuing the investigation. If readings approach or exceed 25 percent of the LEL, the investigative team should withdraw from the area immediately. Be aware that explosivity meters will go offscale and readings will drop as the concentration of explosive gases increases. Before resuming any on-site activities, the investigative team should consult with fire protection experts or the local fire department and then develop explosion prevention procedures for safe site work. (Refer to the discussion of oxygen-deficient atmospheres and the explosivity meter caution in the Oxygen Deficiency paragraph above).

3. <u>Chemical Vapors</u>

Organic chemical vapor levels may be monitored using an organic vapor monitor. Inorganic chemical vapors may be monitored using colorimetric indicator detector tubes or compound-specific detectors such as the Monotox cyanide sampler. When working in an unknown environment (for example, an environment in which atmospheric compounds are not known) and wearing air-purifying respirators, vapor concentrations can not exceed 5 parts per million (ppm) for a 5-minute time weighted average period. If vapors exceed 5 ppm, the site must be evacuated. Re-entry will only be allowed with the use of air-purifying respirators. Atmospheric concentrations can not exceed 500 ppm for continuous site work to occur. If atmospheric concentrations exceed 500 ppm, the site should be evacuated and appropriate experts contacted to determine additional personal protective equipment or other safety precautions required for continued site work.

When working in a known environment (for example, atmospheric compounds are known), vapor concentrations can not exceed the threshold limit value for the compound if no respiratory protective equipment is being used. Air-purifying respirators may be worn only when the vapor concentration is below the recommended level of the respirator cartridge being used and below the immediately dangerous to life and health concentration. Areas in which high levels of vapor concentrations are encountered should be avoided if possible. When specific chemical vapors are known to exist on site, colorimetric indicator detector tubes specific to those chemicals should be used.

4. Radioactivity

The site may be monitored for radiation levels. If radioactivity levels approach 10 milliroentgen/hour (mR/hr), a detailed radiological site survey should be conducted. If radioactivity levels are greater than 10 mR/hr, the site should be evacuated and the assistance of a radiation health physicist should be obtained prior to site re-entry. Normal background radioactivity levels are about 0.02 mR/hr; however, levels up to 10 mR/hr are acceptable for investigations of short duration.

5. Physical Hazards

Physical hazards may include electrical (down or exposed power lines), unsafe structures or deteriorated buildings, tanks, supports, or beams that are in the process of collapsing (or based on physical evidence may collapse at any time); pits (open or closed); trenches; buried tanks or structures; or any other type of elevated, surface, or subsurface structure that may fall, cause an employee to trip or fall, or cause an employee to fall into it. Other physical hazards of concern may include heavy equipment (backhoe, drill rig, and so on); biological hazards (plants and insects); noise hazards; and weather (lightning, heat, and cold stress). All such hazards should be identified and described in a field logbook.

2.2.3 Decontaminating Equipment

Disposable personal protective clothing should be worn during an investigation. Prior to leaving the site, all disposable clothing will be placed in large industrial-grade plastic bags or 55-gallon drums. Boots and other nondisposable items will be decontaminated in the staging area using portable water basins and industrial-grade, water-based detergents. Decontaminated equipment and clothing will be placed in plastic bags prior to leaving the site. All contaminated equipment will remain on site.

3.0 CAUTIONS

Seemingly safe sites or situations may still present life-threatening conditions. Even the best monitoring equipment can not replace astute observation and common sense. Be alert and aware of surroundings and conditions at all times.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

GENERAL EQUIPMENT DECONTAMINATION

SOP NO. 002

REVISION NO. 2

Approved by:

Daniel Ashenberg
Quality Assurance Officer

2/2/93
Date

Title: **General Equipment Decontamination**

1.0 BACKGROUND

All nondisposable sampling, personnel, and well drilling and monitoring equipment must be cleaned before and after each use at each sampling location to obtain representative samples and to reduce the possibility of cross contamination.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for decontaminating general equipment in the field.

1.2 SCOPE

This SOP applies to decontaminating general nondisposable equipment. To prevent contamination of samples, all sampling equipment must be thoroughly cleaned prior to each use.

1.3 DEFINITIONS

Alconox or Liquinox – nonphosphate soaps

1.4 REFERENCES

U.S. Environmental Protection Agency, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, pages 106-107.

1.5 REQUIREMENTS AND RESOURCES

The following equipment is required for decontamination:

- Scrub brushes
- Long-bristle brushes
- Large wash tubs or buckets
- Alconox or Liquinox
- Tap water
- Distilled water
- Steam cleaner
- Aluminum foil
- Plastic bags
- Plastic sheeting
- Methanol, hexane, or isopropanol, if necessary
- Nitric acid, if necessary
- Drums or containers for decontamination water

2.0 PROCEDURE

This procedure applies to decontaminating all nondisposable personnel, drilling, monitoring, and sampling equipment.

2.1 DECONTAMINATING PERSONNEL EQUIPMENT

Personnel working in the field are required to follow specific procedures for decontamination prior to leaving the work area so that contamination is not spread off site or to clean areas. All used disposable protective clothing, such as Tyvek® coveralls, gloves, and booties, will be containerized for later disposal. Decontamination water will be containerized in 55-gallon drums. Personnel decontamination procedures will be modified based on the level of protection required. The decontamination procedures outlined below are applicable to personnel working in Level D.

Personnel decontamination procedures will be as follows:

1. Wash neoprene boots (or neoprene boots with disposable booties) with Liquinox or Alconox solution and rinse with clean tap water. Remove booties and retain boots for subsequent reuse.

2. Wash outer gloves in Liquinox or Alconox solution and rinse in clean tap water. Remove outer gloves and place into plastic bag for disposal.

3. Remove Tyvek® or coveralls. Containerize Tyvek® for disposal and place coveralls in plastic bag for reuse.

4. Remove air purifying respirator (APR), if used, and place spent filters in a plastic bag for disposal. Filters should be changed at least daily depending on use and application. Wash entire mask in clean warm water or disinfect with APR wipes at the end of each day. Place respirator in a separate plastic bag after cleaning and disinfecting.

5. Remove disposable gloves and place them in plastic bag for disposal.

6. Thoroughly wash hands and face with clean tap water and facial soap.

2.2 DECONTAMINATING DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT

All drilling equipment should be decontaminated at a designated location on site before drilling begins, between borings, and at project completion.

Monitoring well casings, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned on-site prior to placement downhole. The drilling subcontractor will furnish the steam cleaner and water.

After cleaning the drilling equipment, field personnel should place the drilling equipment, well casings and screens, and any other equipment that will go into the hole on clean polyethylene sheeting.

The drilling auger, bits, drill pipe, temporary casing, surface casing, and other equipment should be decontaminated by the drilling subcontractor by hosing them down with a steam cleaner until thoroughly clean. Drill bits and tools that still exhibit particles of soil after the first washing should be scrubbed with a wire brush and then rinsed again with a high-pressure steam rinse.

All wastewater from decontamination procedures should be collected in 55-gallon drums or similar containers.

2.3 DECONTAMINATING BOREHOLE SOIL SAMPLING EQUIPMENT

Soil sampling and groundwater sampling equipment should be decontaminated after each use as follows:

1) Prior to sampling, scrub the split-barrel sampler, sampling tools, bailers, and liners in a bucket using a stiff, long bristle brush and Liquinox or Alconox solution.

2) Clean sampling equipment over the rinseate tub with distilled water and allow it to air dry. If convenient, bailers and split-barrel samplers may be thoroughly steam cleaned at a designated decontamination station rather than being washed by hand.

3) Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.

4. Containerize all water and rinsate.

5. Decontaminate all temporary well material and pipes placed down the hole as described for drilling equipment.

2.4 DECONTAMINATING WATER-LEVEL MEASUREMENT EQUIPMENT

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing from each well. The following decontamination procedures should be used:

1. Wipe the sounding cable with a disposable soap-impregnated cloth or paper towel.

2. Rinse with deionized, organic-free water.

2.5 DECONTAMINATING GENERAL SAMPLING EQUIPMENT

All nondisposable sampling equipment must be decontaminated using the following procedures:

1. Select an area downwind and downgradient from sampling locations to avoid cross contamination between sampling points.

2. Maintain the same level of protection as was used for sampling.

3. To decontaminate a piece of equipment: use an Alconox or Liquinox wash; a tap water wash; a solvent rinse (methanol, hexane, or isopropanol), if applicable, or a dilute (0.1N) nitric acid rinse, if applicable; and a distilled water rinse. Allow to air dry. Use a methanol, hexane, or isopropanol rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox wash).

4. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.

5. Containerize all water and rinsate.

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

SAMPLING SURFACE WATER

SOP NO. 009

REVISION NO. 3

Approved by:

Kathleen Homer
Quality Assurance Officer

5/19/93
Date

1.0 BACKGROUND

Surface water sampling is conducted to determine the quality of surface water entering, leaving, or affected by a site. Surface water bodies that can be sampled include streams, rivers, and lakes. This standard operating procedure (SOP) discusses common methods of collecting grab samples that represent water quality in a water body at a particular point in time.

A series of grab samples also can be composited to represent water quality over a longer period of time. Composite samples can be flow proportional or time proportional. The details of compositing water samples are not included in this SOP.

1.1 PURPOSE

This SOP establishes the requirements and procedures for surface water sampling.

1.2 SCOPE

This SOP applies to surface water sampling and the instruments and methods used to collect the samples.

1.3 DEFINITIONS

Kemmerer Sampler: A messenger-activated water sampling device. Water flows through the device until the release mechanism is triggered to close the container.

Peristaltic Pump: A pumping device characterized by its low suction and rhythmic nature, and by the fact that the pump does not come into direct contact with the water being sampled.

Pond Sampler: A sampling device fabricated by using an adjustable beaker clamp to attach a beaker to a telescoping, heavy-duty aluminum pole.

1.4 REFERENCES

deVera, E.R., and others. 1980. "Samplers and Sampling Procedures for Hazardous Waste Streams." EPA 600-2-80-018. January.

GCA Corporation. No date. "Quality Assurance Plan, Love Canal Study - Appendix A, Sampling Procedures." Prepared under EPA Contract 68-02-3168.

U.S. Environmental Protection Agency. 1977. "Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities." EPA-530/SW-611. August.

EPA. 1984. "Characterization of Hazardous Waste Sites -- A Methods Manual, Volume II. Available Sampling Methods." Second Edition. EPA-600/4-84-076. December.

1.5 REQUIREMENTS AND RESOURCES

Surface water sampling requires a variety of procedures and instruments. The choice of procedure should be determined by site-specific conditions, such as the type of surface water body, the sampling depth, and the sample location's distance from shore.

Samples can be collected from shallow depths by submerging the sample container. An intermediary disposable collection container or one constructed of a nonreactive material also may be used. A pond sampler, a peristaltic pump, or a Kemmerer sampler may be used to provide extended reach. The following equipment may be required to sample surface water:

- Decontamination materials
- Sample containers and labels
- Point-source bailer
- Dipper
- Boat
- Pond sampler
- Peristaltic pump
- Silicone tubing

- Heavy-wall Teflon® tubing
- Kemmerer sampler
- Logbook or field sheets
- Chain-of-custody documentation

2.0 PROCEDURE

Safe access, handling, and other physical limitations should be influential factors during surface water sampling. A site-specific sampling plan should delineate which of the procedures described below will be used. Any deviations from the sampling plan should be recorded in the site-specific field logbook.

The following subsections provide detailed procedures for surface water sampling using specific instruments and methods. In all cases, select a sampling location where the water quality will best represent the water chemistry of the water body. Avoid stagnant or fast-moving areas. Do not sample immediately downstream of incoming tributaries, because of the likelihood of incomplete mixing.

2.1 SAMPLING SURFACE WATER BY SUBMERGING THE SAMPLE CONTAINER

Samples from shallow depths should be collected by submerging the sample container. This method is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container.

All sampling equipment should be made of inert and nonreactive materials. Nondisposable equipment should be cleaned before and after each use. Refer to SOP No. 002, "Equipment Decontamination."

The following is the procedure for sampling surface water by submerging the sample container:

1. Place all equipment on plastic sheeting next to the sampling location.

2. Affix a completed sample container label to an appropriate sample container. Sample containers should be selected according to the requirements in SOP No. 017, "Sample Collection Containers Requirements."

3. Before collecting the sample, measure the temperature, pH, and specific conductivity of the water body, using procedures in SOPs No. 011, 012, and 013, respectively. Record this information on the field sheet or in the logbook.

4. For stream sampling, sample the location farthest downstream first. Orient the mouth of the sample container upstream while standing downstream so as not to stir up any sediment that would contaminate the sample.

5. For a larger body of surface water, such as a lake, collect samples near the shore, unless boats are feasible and permitted. Collect samples from shallow depths by submerging the sample container. Collect samples from deeper depths using a point-source bailer, dipper, or similar transfer device.

6. Collect surface water samples at each location before collecting sediment samples to avoid contaminating the water samples with excess suspended particles generated during sediment sampling.

7. Continue delivery of the sample until the container is almost full. Leave adequate ullage to allow for expansion. If sampling for volatile organics analysis, however, the container must be completely filled leaving no head space.

8. Ensure that a Teflon® liner is present in the cap of the sample container, if required. Secure the cap tightly. Preserve the sample according to requirements in SOP No. 016, "Sample Preservation and Maximum Holding Times."

9. Record the information in the field logbook and complete chain-of-custody documents.

2.2 SAMPLING SURFACE WATER WITH A TRANSFER DEVICE

A dipper or other device made of inert material, such as stainless steel or Teflon®, can be used to transfer liquid samples from their source to a sample container. This prevents contamination of the outside of the sample container as a result of direct immersion in surface water. Depending on the sampling application, the transfer device may be either disposed of or reused. If reused, the device should be thoroughly rinsed and decontaminated prior to sampling a different source.

A transfer device can be used in most sampling situations but should not be used in situations where aeration of the sample must be avoided, such as when sampling for volatile organic analysis, or where a significant amount of contaminants may be lost because of adhesion to the transfer device.

All sampling equipment should be made of inert and nonreactive materials. Nondisposable equipment should be cleaned before and after each use.

Following is the procedure for sampling surface water with a dipper or other transfer device:

1. Place all equipment on plastic sheeting next to the sampling location.

2. Affix a completed sample container label to an appropriate sample container.

3. Before collecting the sample, measure the temperature, pH, and specific conductivity of the water body, using procedures in SOPs No. 011, 012, and 013, respectively. Record this information on the field sheet or in the logbook.

4. With minimal surface water disturbance, submerge a precleaned stainless-steel dipper or other transfer device.

5. Allow the device to fill slowly and continuously.

6. Retrieve the device from the surface water with minimal disturbance.

7. Remove the cap from the sample container. Slightly tilt the mouth of the container below the edge of the device.

8. Empty the device slowly, allowing the sample to flow gently down the inside of the container with minimal entry turbulence.

9. Continue delivery of the sample until the container is almost full. Leave adequate ullage to allow for expansion. If sampling for volatile organics analysis, however, the container must be completely filled leaving no head space.

10. Ensure that a Teflon® liner is present in the cap of the sample container, if required. Secure the cap tightly. Preserve sample according to requirements in SOP No. 016, "Sample Preservation and Maximum Holding Times."

11. Record the information in the field logbook and complete the chain-of-custody documents.

12. Decontaminate the equipment prior to reuse or storage (see SOP No. 002, "Equipment Decontamination").

2.3 SAMPLING SURFACE WATER WITH A POND SAMPLER

A pond sampler may be used to collect liquid samples from ponds, pits, and lagoons.

The pond sampler is not commercially available, but it is easily and inexpensively fabricated. To construct a pond sampler, use an adjustable clamp to attach a sampling beaker to the end of a two- or three-piece telescoping aluminum tube. The telescoping tube serves as the handle. All sampling equipment should be made of inert and nonreactive materials. Nondisposable equipment should be cleaned before and after each use. Refer to SOP No. 002, "Equipment Contamination."

The following is the procedure for sampling surface water with a pond sampler:

1. Place all equipment on plastic sheeting next to the sampling location.
2. Affix a completed sample container label to an appropriate sample container.
3. Before collecting the sample, measure the temperature, pH, and specific conductivity of the water body, using procedures in SOPs No. 011, 012, and 013, respectively. Record this information on the field sheet or in the logbook.
4. Assemble the pond sampler. Ensure that the sampling beaker, bolts, and nuts securing the clamp to the pole are tightened properly.
5. Collect the sample by slowly submerging the precleaned beaker with minimal surface water disturbance.
6. Retrieve the pond sampler from the surface water with minimal disturbance.
7. Remove the cap from the sample container. Slightly tilt the mouth of the container below the edge of the beaker.
8. Empty the beaker slowly, allowing the sample to flow gently down the inside of the container with minimal entry turbulence. Continue delivery until the container is almost full. Leave adequate ullage to allow for expansion. If sampling for volatile

organics analysis, howoever, the container must be completely filled leaving no head space.

9. Ensure that a Teflon® liner is present in the cap of the sample container, if required. Secure the cap tightly. Preserve the sample according to requirements in SOP No. 016, "Sample Preservation and Maximum Holding Times."

10. Record the information in the field logbook and complete the chain-of-custody documents.

11. Decontaminate the equipment prior to reuse or storage (see SOP No. 002, "Equipment Decontamination").

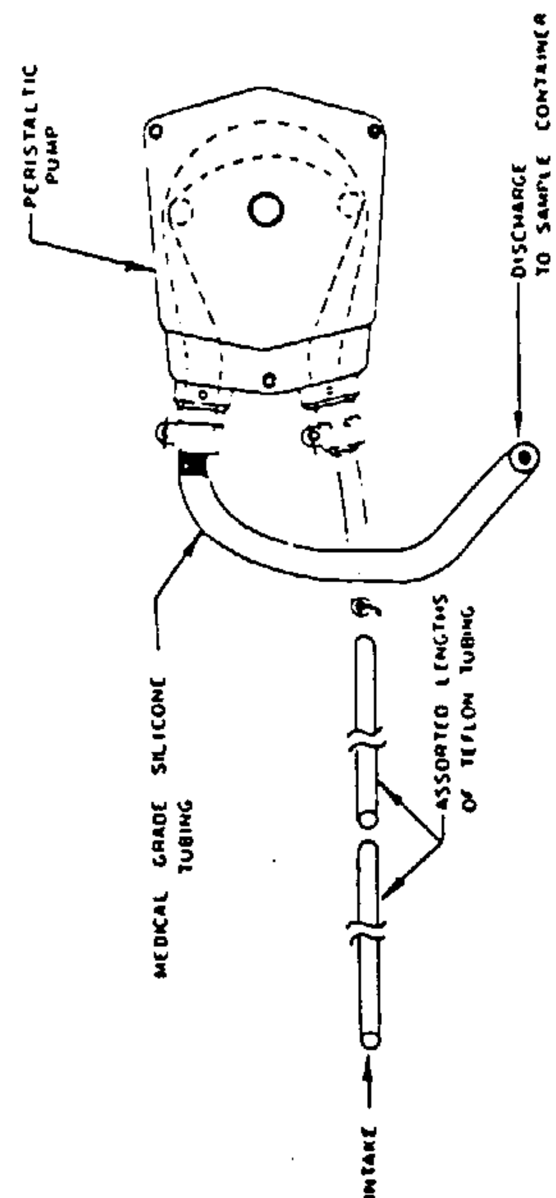
2.4 SAMPLING SURFACE WATER WITH A PERISTALTIC PUMP

To extend reach in sampling efforts, a small peristaltic pump can be used (see Figure 1). A peristaltic pump draws the sample through heavy-wall Teflon® tubing and pumps it directly into the sample container. Use of a peristaltic pump allows the operator to reach out into a liquid body, to sample from a depth or to sweep the width of a narrow stream.

If medical-grade silicone tubing is used in the peristaltic pump, it is suitable for sampling almost any parameter, including most organics. However, some volatile stripping may occur, and even though the pump may have a high flow rate, some sample material may be lost on the tubing. The pump requires electricity to operate so a battery-operated pump is preferable because it eliminates the need for a direct current generator or alternating current inverter.

FIGURE 1

PERISTALTIC PUMP FOR LIQUID SAMPLING



11. Allow the pump to drain, and then disassemble it. Decontaminate the tubing before reuse (see SOP No. 002, "Equipment Decontamination") or dispose of it.

2.5 SAMPLING SURFACE WATER WITH A KEMMERER SAMPLER

The Kemmerer sampler (see Figure 2) is used to collect surface water samples when the required sample depth is greater than that which can be sampled with a pump. A Kemmerer sampler may be constructed of various materials to be compatible with the required analytical technique.

All sampling equipment should be made of inert and nonreactive materials. Nondisposable equipment should be cleaned before and after each use. Refer to SOP No. 002, "Equipment Decontamination".

The following is the procedure for sampling surface water with a Kemmerer sampler:

1. Place all equipment on plastic sheeting next to the sampling location.

2. Affix a completed sample container label to the appropriate sample container.

3. Before collecting the sample, measure the temperature, pH, and specific conductivity of the water body, using procedures in SOPs No. 011, 012, and 013, respectively. Record this information on the field sheet or in the logbook.

4. Inspect the body of the Kemmerer sampler to ensure that the drain valve is closed. Measure and mark a sample line at the desired sampling depth.

5. Open the bottle by lifting the top stopper-tip head assembly.

6. Gradually lower the bottle into the surface water until the sample liquid reaches the sample line.

7. Place a messenger on the sample line and release.

8. Retrieve the sampler. Prevent accidental opening of the bottom stopper by holding the center stem of the sampler.

9. Rinse or wipe off the exterior of the sampler. Recover the sample by grasping the bottom stopper and sampler body with one hand. Transfer the sample by lifting the top stopper with the other hand and pouring the contents into the sample container. If a drain valve is present, hold the drain valve over the sample container, and open the valve to release the sample.

10. Transfer the sample slowly, allowing it to flow gently down the inside of the container with minimal entry turbulence. Continue delivery until the container is almost full.

11. Ensure that a Teflon® liner is present in the cap of the sample container, if required. Secure the cap tightly. Preserve the sample according to requirements in SOP No. 016, "Sample Presservation and Maximum Holding Times."

12. Record the information in the field logbook and complete the chain-of-custody documents.

13. Decontaminate the equipment prior to reuse or storage (see SOP No. 002, "Equipment Decontamination").

SOP APPROVAL FORM

PRC ENVIRONMENTAL MANAGEMENT, INC.

STANDARD OPERATING PROCEDURE

RECORDING NOTES IN THE FIELD LOGBOOK

SOP NO. 024

REVISION NO. 1

Approved by:

Quality Assurance Officer

Date 5/15/93

1.0 BACKGROUND

The field logbook should contain detailed records of all the field activities, interviews of people, and observations of conditions at a site. Entries should be described in as much detail as possible, so that personnel can accurately reconstruct the activities and events which have taken place during field assignments. Field logbooks are considered accountable documents in enforcement proceedings and may be open to review. Therefore, the entries in the logbook must be accurate, detailed, and reflect the importance of the field events.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide guidance to ensure that logbook documentation for any field activity is correct, complete, and adequate. Logbooks are used for identifying, locating, labelling, and tracking samples. A logbook should document any deviations from the project approach, work plans, quality assurance plans, safety plans, sampling plans, and any changes in project personnel. They also serve as documentation of any photographs taken during the course of the project. In addition, the data recorded in the logbook may assist in the interpretation of the analytical results. A complete and accurate logbook also aids in maintaining good quality control. Quality control is enhanced by the proper documentation of all observations, activities, and decisions.

1.2 SCOPE

This SOP establishes the general requirements and procedures for recording notes in the field logbook.

1.3 DEFINITIONS

None.

1.4 REFERENCES

Compton, R.R. 1985. *Geology in the Field*. John Wiley and Sons. New York, N.Y.

1.5 REQUIREMENTS AND RESOURCES

The following items are required for field notation:

- Field logbooks
- Ballpoint pens with permanent ink
- 6-inch ruler (optional)

Field logbooks should be bound (sewn) with water resistant and acid-proof covers; they should have preprinted lines and wide columns. They should be approximately 7 1/2 by 4 1/2 inches or 8 1/2 by 11 inches in size. Loose-leaf sheets are not acceptable for field notes. If notes are taken on loose paper, they must be transcribed as soon as possible into a regular field logbook by the same person who took the notes.

Logbooks can be obtained through the Document Control Administrator (DCA) for each office. The DCA will have assigned each logbook an identification number. The DCA will make sure the pages in the logbooks are preprinted with consecutive numbers or are consecutively numbered by hand. If the numbers are written by hand, then numbers should be circled so that they are not confused with data.

2.0 PROCEDURES

The following subsections provide the general layout of a field logbook and detailed procedures for completing a field logbook.

2.1 GENERAL GUIDELINES

- A separate field activity logbook must be maintained for each project. If a site consists of multiple subsites, designate a separate logbook for each subsite. For special tasks, such as periodic well water-level measurements, data from multiple subsites may be entered into one logbook which contains only one type of information.

- All logbooks must be bound and contain consecutively numbered pages.

- No pages can be removed from the logbook for any purpose.

- All field activities, meetings, photographs, and names of personnel must be recorded in the site logbook.

- All logbooks pertaining to a site or subsite should be assigned a serial number based on the date the logbook is issued to the project manager. The first logbook should be assigned number 1, the next logbook issued assigned number 2, and so on. The project manager is to maintain a record of all logbooks issued under the project.

- All information must be entered with a ballpoint pen with waterproof ink. Do not use pens with "wet ink," because the ink may wash out if the paper gets wet. Pencils are not permissible for field notes because information can be erased. The entries should be written dark enough so that the logbook can be easily photocopied.

- Do not enter information in the logbook that is not related to the project. The language used in the logbook should be factual and objective.

- Begin a new page for each day's notes.

- Write notes on every line of the logbook. If a subject changes and an additional blank space is necessary to make the new subject title standout, skip one line before beginning the new subject. Do not skip any pages or parts of pages unless a day's activity ends in the middle of a page.

- Draw a diagonal line on any blank spaces of four lines or more to prevent unauthorized entries.

2.2 LOGBOOK FORMAT

The layout and organization of each field logbook should be consistent with other field logbooks. Guidelines for the cover, spine, and internal pagination are discussed below.

2.2.1 FORMAT OF THE COVER AND SPINE OF FIELD LOGBOOKS

Write the following information in clear capital letters on the front cover of each logbook. An example of the cover of a logbook is included as Figure 1.

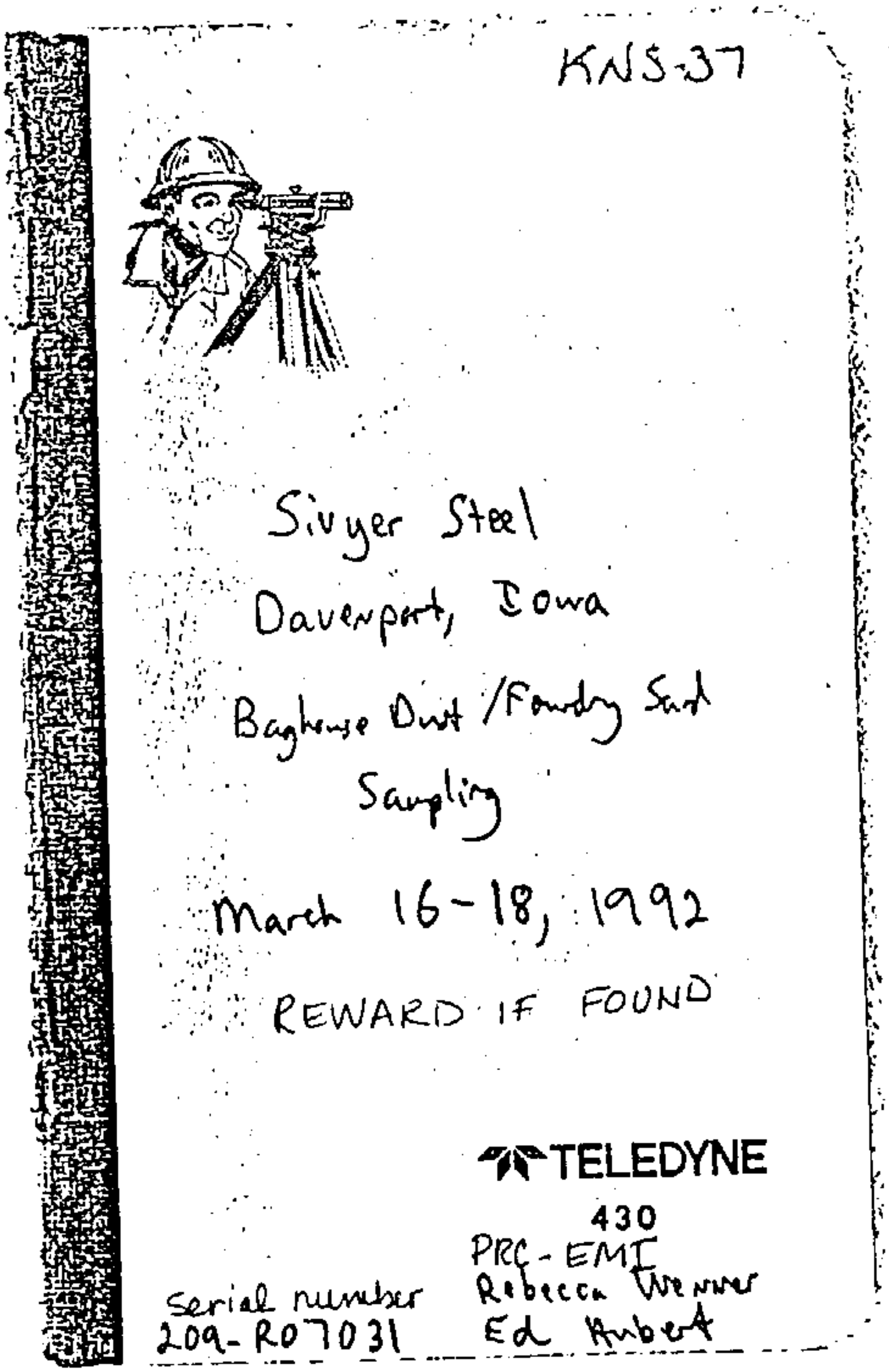
- Logbook identification number (assigned by the DCA)
- The serial number of the logbook (assigned by the project manager)
- Name of the site, city, and state
- Name of subsite if applicable
- Type of activity
- Beginning and ending dates of activities entered into the logbook
- "PRC EMI," City and State
- "REWARD IF FOUND"

Some of the information listed above, such as the list of activities and ending dates, should be entered after the entire logbook has been filled or after it has been decided that the remaining blank pages in the logbook will not be filled.

The spine of the logbook should contain an abbreviated version of the information on the cover. For example: "1, Col. Ave., Hastings, 5/88 - 8/88."

FIGURE 1

COVER OF THE FIELD LOGBOOK



2.2.2 First Page of the Field Logbook

Spaces are usually provided on the inside front cover (or the opening page in some logbooks), for the company name ("PRC EMI"), address, and telephone number. If preprinted spaces for this information are not provided in the logbook, write the information on the first available page.

2.3 ENTERING INFORMATION IN THE LOGBOOK

Enter the following information at the beginning of each day or whenever warranted during the course of a day:

- Date
- Starting time
- Specific location
- General weather conditions and approximate temperature
- Names of personnel present at the site. Note the affiliation(s) and designation(s) of all personnel.
- Equipment calibration and equipment models used.
- Changes in instructions or activities at the site.
- Levels of personal protective clothing and equipment.
- A general title of the first task undertaken (for example, well installation at MW-11, decon at borehole BH-11, groundwater sampling at MW-11).
- Provide an approximate scale for all diagrams. If this can't be done, write "not to scale" on the diagram. Indicate the north direction on all maps and cross-sections. Label features on each diagram.
- Corrections should be made by drawing a single line through the entry being corrected. Initial and date any corrections made in the logbook.
- The person recording notes is to initial each page after the last entry. No information will be entered in the area following these initials.

- At the end of the day, the person recording notes is to sign and date the bottom of the last page. Indicate the end of the work day by writing "Left site at (time)." A diagonal line will be drawn across any blank space to the bottom of the page.

The following information should be recorded in the logbook after taking a photograph:

- Time, date, location, direction, and if appropriate, weather conditions
- Description of the subject photographed and the reason for taking the picture
- Sequential number of the photograph and the film roll number
- Name of the photographer

The following information should be entered into the logbook when taking samples:

- Location description
- Sampler's name
- Collection time
- Designation of samples as a grab or composite sample
- Type of sample (water, sediment, soil gas, etc.)
- On-site measurement data (pH, temperature, specific conductivity)
- Field observations (odors, colors, weather, etc.)
- Preliminary sample description
- Type of preservative used
- Instrument readings

2.4 PRECAUTIONS

Custody of field logbooks must be maintained at all times. Field personnel must keep the logbooks in a secure place (locked car, trailer, or field office) when the logbook is not in personal possession. Logbooks are official project documents and must be treated as such.