5.3 Non-aqueous Sampling Equipment

Sampling of non-aqueous matrices encompasses several different types of wastes, from solids in drums and containers to soil and sludge. There are many factors involved when choosing the proper sampling equipment for these materials.

The most important aspect of non-aqueous sampling is to retrieve a representative sample of all horizons present. An attempt must be made to maintain sample integrity by preserving its physical form and chemical composition. The proper use of appropriate sampling equipment lends to the accomplishment of these goals.

This portion of Chapter 5 is separated into three subparts: soil, sediment/sludge and containerized solids/waste piles. The three subparts deal with samplers designed for the specific materials involved. See Chapter 6, *Sample Collection*, Sections 6.1, *General Information Applicable to all Sampling Events*, 6.2, *Soil Sampling*, and 6.2.7, *VOC Sample Collection for Soils* for more information on the process of collecting soil samples.

5.3.1 Soil Sampling Equipment

Soil sampling is performed for a number of reasons. These include determination of soil contamination, identifying the horizontal and vertical extent of contamination and investigating the relationship between soil and ground water contamination. Soil can be sampled at the surface or below surface depending on the type of information required. Soil is typically divided by depth into two categories: surface and subsurface. Surface soils include the zone between ground level and 24 inches. Subsurface soils include any depth below 24 inches (please note that for radiological sampling, surface soils are considered to be in the top 6 inches, or 15 centimeters only). There are several different types of samplers that can be used to collect a soil sample at any depth.

5.3.1.1 Scoop/Trowel

The trowel or scoop (Figure 5.31) can be used to collect surface soil samples. They can also be used for homogenizing soil or for collecting a variety of other solid waste samples. A trowel looks like a small shovel. A laboratory scoop is similar to the trowel, but the blade is usually more curved and has a closed upper end to permit the containment of material. Scoops come in different sizes and makes. Some are coated with chrome paint, which can peel off and get into the sample: these are unacceptable. Stainless steel scoops are preferred however, scoops made from alternative materials may be applicable in certain instances (e.g., polyethylene for trace element sampling in sediments). The decision for equipment material of construction other than stainless steel will be made at the discretion of NJDEP. Samples can be put directly into sample containers or be processed through sieves to acquire the desired grain size. Stainless steel trowels and scoops can be purchased from scientific or environmental equipment supply houses.

Figure 5.31 Scoop/Trowel. (Photograph by D. Dibblee)

Procedures for Use:

i. At specified intervals, take small, equal portions of sample from the surface and immediately below the surface.

ii. Transfer samples into laboratory cleaned sample bottles and follow procedures for preservation and transport (see Chapter 2., Appendix A., *Tables of Analytical Methods*).

Advantages:

- easy to use and clean

Disadvantages:

- can not be used to collect samples for volatile organic analysis.

5.3.1.2 Bucket Auger Return to TOC

The bucket auger (Figure 5.32 [Art's Manufacturing and Supply]) consists of a stainless steel cylindrical body with sharpened spiral blades on the bottom and a framework above allowing for extension rod and T-handle attachments. When the tool is rotated clockwise by its T-handle, it advances downward as it cuts into the soil and moves loosened soil upward where it is captured in the cylindrical body. Cutting diameters vary. The overall length of an auger is about 12 inches and extensions can extend the sample depth to several feet. There are three general types of augers available: sand, clay/mud, and augers for more typical mixed soils.

Figure 5.32 Bucket Augers (Photograph by D. Dibblee)

Depending on soil characteristics, chose the auger best suited for your needs. These tools can be purchased from scientific or forestry equipment supply houses.

The auger is particularly useful in collecting soil samples at depths greater than 8 cm (3 in.). However, this sampler destroys the cohesive structure of soil and clear distinction between soil collected near the surface or toward the bottom may not be readily apparent as a result of the mixing effect. It is not approved, therefore, when an undisturbed soil sample for volatile organics (VOA) is desired. It should be noted that this exception does not include analysis of other organics e.g., base neutrals, acid extractables, pesticides, PCBs, total petroleum hydrocarbons, and total organic carbon. Bucket augers are also perfectly acceptable for inorganic analysis.

Procedures for Use:

i. Remove unnecessary rocks, twigs, and other non-soil materials from selected sampling point.

ii. Attach the bucket and handle to an extension rod.

iii. Begin turning the auger with a clockwise motion and continue until the desired sampling depth is obtained.

iv. Use a second auger to collect the sample. The auger utilized for hole advancement is not acceptable for sample collection.

v. Transfer the sample into laboratory cleaned sample containers using a clean decontaminated stainless steel spoon or trowel.

vi. When collecting samples at depths greater then 12 inches, it is advisable to discard one-half inch of material in the top portion of the auger due to cave-in

vii. Follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- relatively speedy operation for subsurface samples

Disadvantages:

- destroys soil horizons as it samples
- not approved for sampling soils for volatile organic analysis

5.3.1.3 Soil Coring Device

The soil-coring device (Figure 5.33 [Art's Manufacturing and Supply]) consists of a stainless steel, machined split-cylinder with threaded ends, cutting shoe and end cap with a slide hammer used for advancement into the soil. The cutting shoe and end caps of the corer are also constructed of stainless steel. Use of a plastic collection tube and soil-retaining basket is optional. Once the desired depth is reached, the slide hammer can be used to assist in pulling back the device. Caution should be used when back hammering so as not to loosen soil captured within the barrel if a liner/retaining basket is not used. This device may be used in conjunction with a soil auger if core analysis of depth profiles need to be performed.

Once opened and screened with a Photo or Flame Ionization Detector (PID or FID), a subsample of soil can be collected for volatile organic analysis soil using an En Core® or other sampler. See Chapter 6, *Sample Collection*, Sections 6.1, *General Information Applicable to all Sampling Events*, 6.2, *Soil Sampling*, and 6.2.7*, VOC Sample Collection for Soils* for more information on collection of soil samples.

Procedures for Use:

i. Assemble the split barrel and screw on cutting shoe and end caps. Liner and basket retainers are optional.

ii. Place the sampler in position with the bit touching the ground.

iii. Drive with slide hammer until unit is completely advanced. Avoid sample compression

iv. After reaching the required depth, use the slide hammer to back out device using caution so as not to lose sample.

v. Remove both ends and tap barrel to break open split sections.

vi. Use a utility hook knife to open plastic liner.

Figure 5.33 Soil Coring Device (Photograph by J. Schoenleber)

vii. Field screen using a PID or FID.

viii. Record visual observations in boring log.

ix. For volatile organic analysis use an En Core® sampler to sample and preserve, or one of the devices discussed in Chapter 6, *Sample Collection*, to collect the sample prior to preservation.

x. Follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- can be used in various substances
- core sample remains relatively intact
- bit is replaceable

Disadvantages:

- depth restrictions
- not useful in rocky or tightly packed soils
- only soil coring devices of stainless steel construction are recommended for collection of soils for chemical analysis

5.3.1.4 Split Spoon Sampler Return to TOC

A split spoon sampler (Figure 5.34) is utilized to collect representative soil samples at depth. The sampler itself is a length of carbon or stainless steel tubing split longitudinally and

Figure 5.34 Split Spoon Sampler (Photograph by D. Dibblee)

equipped with a drive shoe and a drive head. These are available in a variety of lengths and diameters and are typically advanced by blows of a 140-lb. hammer dropped 30 inches from a drill rig mast.

Procedures for Use:

i. Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe with retainer on the bottom and the heavier headpiece on top.

ii. Place the sampler in a perpendicular position on the material to be sampled.

iii. Drive the tube utilizing a sledgehammer or well drilling rig if available. Do not drive past the bottom of the headpiece as this will result in compression of the sample.

iv. Record the length of the tube that penetrated the material being sampled and the number of blows required obtaining this depth.

v. Withdraw the sampler and open by unscrewing drive shoe and head and splitting barrel. If split samples are desired, a decontaminated stainless steel knife should be utilized to divide the tube contents in half longitudinally.

vi. Collect volatile organic sample first per procedures discussed in Chapter 6, *Sample Collection*, Section 6.2.7, *VOC Sample Collection for Soils*.

vii. Transfer sample into laboratory cleaned sample bottles, or, into bowl for homogenization for non-volatile analysis using a stainless steel scoop or trowel and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

viii. When split tube sampling is performed in order to gain geologic information, all work should be performed in accordance with ASTM # D 1586-84 (re-approved 1974).

Advantages:

- easily available
- strong
- ideal for split sample collection

- preferred sampling device for volatile organic sample collection

Disadvantages:

- requires drilling or tripod for deeper samples

Return to TOC

5.3.1.5 Shelby Tube Sampler

A Shelby tube is used mainly for obtaining geological information but may be used in obtaining samples for chemical analysis.

The Shelby tube consists of a thin walled tube with a tapered cutting head. This allows the sampler to penetrate the soil and aids in retaining the sample in the tube after the tube is advanced (without excessive force) to the desired depth.

Procedures for Use:

i. Place the sampler in a perpendicular position on the material to be sampled.

ii. Push the tube into the soil by a continuous and rapid motion, without impact or twisting. In no instance should the tube be pushed further than the length provided for the soil sample.

iii. Let sit for a few minutes to allow soils to expand in the tube.

iv. Before pulling out the tube, rotate the tube at least two revolutions to shear off the sample at the bottom. If the sample is to be shipped for further geologic analysis, the tube must be appropriately prepared for shipment. Generally this is accomplished by sealing the ends of the tube with wax in order to preserve the moisture content. In such instances, the procedures and preparation for shipment shall be in accordance with ASTM # D 1586-83.

Advantages:

- inexpensive
- tube may be used to ship the sample without disturbing the sample
- provides core sample
- easily cleaned

Disadvantages:

- sometimes difficult to extract sample
- not durable encountering rocky soils

5.3.1.6 En Core® Sampler

The En Core® sampler (Figure 5.35) is the only approved soil sampling tool which can be used to collect a sub-sample from an intact soil core for volatile organic analysis and submitted directly to the laboratory. See Chapter 6, *Sample Collection*, Section 6.2.7, *VOC Sample Collection for Soils* for more specific information on collection procedures for volatile organics in soil.

Figure 5.35 En Core® Sampler with T Handle (Photograph by C. Van Sciver)

Procedures for use:

i. Open foil package containing 5-gram En Core® Sampler.

ii. Insert 5-gram Teflon® sampler into En Core® T-handle.

iii. DO NOT pull plunger back prior to use.

iv. Set device aside on a clean surface.

v. In controlled setting, open coring device and expose core for field screening with direct reading instrument.

vi. Once a 6-inch increment for sampling is identified, carefully prepare soil core surface for sub-core sampling by scraping away a small portion of soil with a stainless steel spatula.

vii. Position En Core® with T-handle squarely over the prepared surface and press into soil to a depth of approximately 5/8" to achieve 5-gram sample.

viii. Remove and with a clean SS spatula eliminate any excessive soil from end of sampler that may interfere with obtaining a tight and complete seal when capped. Also remove any excess soil from outside surface of 5-gram sampler allowing O-ring inside the cap to secure seal.

ix. Cap sampler.

x. Remove sampler from T-handle and lock plunger by inserting plunger stem into the specially designed hole found on T-handle and give a 1/4 turn. If the stem does not turn, it's an indication that the plunger did not completely retract and a full 5 grams has not been collected.

xi. Return to foil package, seal, label and cool to 4° C.

xii. Ship to laboratory the same day as sample collection to ensure 48 hour holding time (time of sample collection to methanol extraction in the laboratory) is not exceeded.

Advantages:

- The only DEP approved device to collect a soil sample for volatile organic analysis that eliminates the need for field preservation.
- Engineered to maintain integrity of soil sample without loss of volatile organics.

Disadvantages:

- Plunger is designed to open as it is pressed into the soil core. Depending on the cohesive nature of the substrate being sampled, obtaining a full 5-gram sample in one movement may be difficult.
- Cores consisting of small rocks, shale, cobble or similar material can not be effectively sampled.

5.3.1.7 Power Auger

In and of itself, the power auger is not a tool for sample collection. Instead, a power auger is used in lieu of a bucket auger to reach the depth of a desired sample interval. The power auger is composed of a length of auger flight, usually three feet; attached to a power source which turns the auger either hydraulically or mechanically. Various sizes and types of power sources are available, from one man to truck mounted units. Additional auger flights can be used to increase the depth obtainable by the unit.

The power auger is used to bore just above the desired sampling depth. A bucket auger or coring device, smaller in diameter than the auger flight, is then used to obtain the sample.

Advantages:

- reduces sampling time
- samples at depth easily obtainable

Disadvantages:

- initial expense
- use of gasoline powered engine increases possibility of contamination of sample
- not useful in rocky soils
- Extensive decontamination procedure (high pressure, hot water cleaning of auger flights)

5.3.1.8 Direct Push Technology

Return to TOC

Use of Direct Push technology to obtain soil samples has gained wide acceptance. The relative ease to collect minimally disturbed soil cores at the surface or at depth plus the ability to provide a wide array of geotechnical options has made this system attractive. While various manufacturers make and distribute their own equipment and accessories, the same general principles still apply when collecting soil samples. Chief among them is following NJDEP required decontamination procedures. When using Direct Push technology you must apply, at a minimum, the Cold Regions decontamination procedure discussed in Chapter 2, *Quality Assurance*, Section 2.4, *Decontamination Procedures*.

The Technical Requirements for Site Remediation N.J.A.C. 7:26E-3.6(a)4.(ii), instruct one to select a six-inch increment of soil for volatile organic laboratory analysis based on field screening (direct reading PID/FID) measurements of an exposed core using criteria relative to the instrument's initial background readings. If a boring is continuously cored to 20 feet below grade where ground water is first encountered, then 4 to 5 individual 48" - 60" soil core segments will have to be opened and screened before determination as to which six-inch increment is to be selected for sampling and analysis. Special attention must be paid to labeling and storage of individual core samples when continuous soil samples are collected from a single boring. In many instances soil cores can be produced faster than they can be opened, logged, screened and sampled by a technician. In those instances when a backlog of cores are being generated, care must be made to protect the cores from direct sunlight, excessive ambient temperatures and rain. These conditions may have an adverse effect on highly sensitive volatile organics within the core or the instruments used for screening. Always keep the cores labeled so that the up/down orientation is not lost. Proceeded carefully, but quickly when field screening. If necessary, log soils for lithology information *after* sample collection. Always calibrate the direct reading instrument at the start of each day.

Another other option is to select a six-inch increment from every individual core segment, collect a sample, and only submit the sample required for analysis as directed in 7:26E-3.6(a)4(ii). This option can be more costly as several En Core® samplers will have to be discarded at the end of the each boring. If other preservation techniques are used, several laboratory bottles with preservative will have to be discarded and if methanol is the preservative, then disposal could be an issue. Sampling every individual core first, prior to determining which increment to ship for laboratory analysis will also require additional labor. This particular option, to collect a representative six-inch incremental sample from every individual segment of

a continuous core with its associated cost, makes the first option to carefully protect and manage the cores to control the loss of volatile organics even more critical.

For more information related to direct push technology, see Sections 5.2.1.12, 6.4, 6.9.2.1, and Appendix 6.1 (A.6.1.3.3) or go to the following USEPA web site: *http://www.epa.gov/superfund/programs/dfa/dirtech.htm#vendor*

5.3.2 Sediment and Sludge Sampling Equipment

Factors that contribute to the selection of a sediment/sludge sampler include the width, depth, flow, and the bed characteristics of the area or impoundment to be sampled. In collecting sediment/sludge samples from any source, care must be taken to minimize disturbance and sample washing as it is retrieved through the liquid column above. When retrieving a sample through a water column of 4-inches or more, and/or fast stream flow, it is necessary to use sampling equipment that is capable of capturing the sample with minimal loss of sediment fines. When cleaning, at a minimum, use the Three-Step or Cold Regions decontamination procedures described in Chapter 2, *Quality Assurance*, Subsections 2.4.2 and 2.4.3, respectively.

Several samplers, which are used for other types of non-aqueous sampling, may be adapted for use as sediment/sludge collection devices. These include the scoop/trowel, bucket auger, soil coring device, and split spoon sampler, which have all been previously described above. This section describes additional samplers that are specifically designed for sediment sample collection. For more information on sample collection and sediment see, Chapter 6, *Sample Collection*, Section 6.8, *Surface Water and Sediment Sampling* and Subsection 6.8.2, *Freshwater Biological Monitoring Program* and Table 5.2.

5.3.2.1 Benthic Grab Samplers

Benthic samplers can be divided into three general types based upon their mechanical action: center pivot grabs, clamshell pivot grabs and drags, sleds and scoops. While their primary use is for the collection of macroscopic bottom fauna, they can be used for the collection of bottom sediment for chemical analysis. Choosing the correct device requires a fore knowledge of the bottom's physical and flora condition. It requires a prior understanding of the analysis to be conducted and how the results will be used. It also depends upon the mechanical action and material of construction of the device (sample disturbance), and finally, correct selection depends on whether the device will be used in fast or slow moving, fresh or salt-water environments.

Figure 5.36 Ponar Dredge. Illustration published with permission of Wildco®

5.3.2.1.1 Ponar Dredge

The Ponar dredge (Figure 5.36) is an example of a center pivot device whose scoops keep disturbance of bottom sediments to a minimum. The shell is opened and latched in place and lowered to the bottom. When tension is released

on the lowering cable, the latch releases and the lifting action of the cable attached to the center pivot closes the device. Ponars are best suited for hard bottoms (sand, gravel, consolidated marl or clay) in fresh or salt water (stainless steel construction). They are available in a "Petite" version with a 232 square centimeter sample area that is light enough to be operated without a winch or crane. Penetration depths will usually not exceed several centimeters. Grab samplers, unlike corers, are not capable of collecting totally undisturbed samples. As a result, material in the first centimeter cannot be separated from that at lower depths. The sampling action of these devices causes agitation currents, which may temporarily suspend some settled solids. This disturbance can be minimized by slowly lowering the sampler the last half-meter and allowing a very slow contact with the bottom. Collection of sludge or sediment samples must be done after all overlying water samples have been obtained.

Procedures for Use:

i. Attach a decontaminated stainless steel Ponar to the necessary length of sample line.

ii. Measure and mark the distance to bottom on the sample line. A secondary mark, 1 meter shallower, will indicate proximity so that lowering rate can be reduced, thus preventing unnecessary bottom disturbance.

iii. Open sampler jaws until latched. From this point on, support sampler by its lift line or the sampler will be tripped and the jaws will close.

iv. Tie free end of sample line to fixed support to prevent accidental loss of sampler.

v. Begin lowering the sampler until the proximity mark is reached.

vi. Slow rate of descent through last meter until contact is felt.

vii. Allow sample line to slack several centimeters. In strong currents more slack may be necessary to release mechanism.

viii. Slowly raise dredge clear of surface.

ix. Drain excess liquid through screen.

x. Place dredge into a stainless steel or Teflon® tray and open.

xi. Collect a suitable aliquot with stainless steel spoon or equivalent and place into the appropriate sample container. Care should be taken to collect material, which has not contacted the dredge's sides.

xii. Transfer sample into laboratory cleaned sample bottles and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- ability to sample most types of sludge and sediment from silts to granular material.
- light weight
- large sample can be obtained intact, permitting further intervals

Disadvantages:

- shock wave from descent may disturb fine sediments on the surface

- not capable of collecting undisturbed samples
- can lose possible contaminants when pulling samples through water column
- possible incomplete closure of jaws can result in sample loss

Other examples of center pivot samplers are the Ekman Grab, Shipek®, and Box Corer.

5.3.2.1.2 Ekman Grab Sampler

The Ekman Grab sampler (Figure 5.37) is best suited for soft, finely divided, shallow, littoral trash-free bottoms with little current. Sticks, decayed leaves and mixtures of sand and stone may prevent the jaw from closing properly. Two thin, hinged overlapping lids on top open during descent to let water pass through. They close during retrieval and are held shut by water pressure to reduce washout. Ekmans can be purchased in various sizes by volume and with additional weights to accommodate sampling needs. Stainless steel construction allows for chemical analysis of sediments in both fresh and salt water.

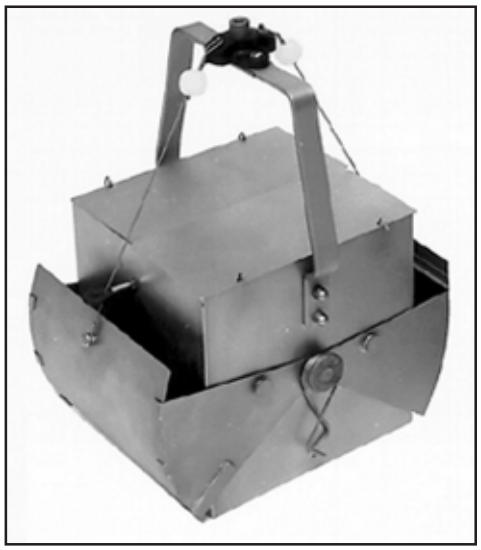

Figure 5.37 Ekman Grab Sampler. Illustration published with permission of Wildco®

5.3.2.1.3 Box Corer

The Box Corer (Figure 5.38), also an example of a center pivot scoop, is designed to work in hard bottoms of finely divided muck, clays, mud ooze, submerged marl or fine peaty materials without the use of spring powered grabs. This device can weight over 100 lbs. without the use of additional weights and over 200 lbs. with weights. Using the Box Corer requires the use of a winch. Options include acrylic liner and wash frame for sample separation on deck. Stainless steel construction allows for chemical analysis of sediments in both fresh and salt water.

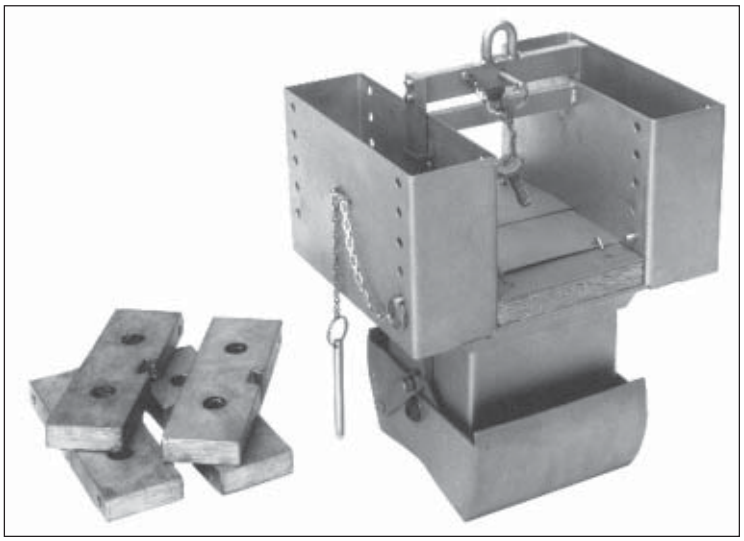

Figure 5.38 Box Corer. Illustration published with permission of Wildco®

5.3.2.1.4 Shipek®

The Shipek® (Figure 5.39) is yet another example of a center pivot grab sampler. This unusual looking device is designed to collect an undisturbed sample of unconsolidated sediment, from soft ooze to hard-packed silts. Sample volume

can range up to 3000 ml. It consists of two concentric half cylinders, one of which is fixed into the body of the device. A cocking wrench is used for winding the torsion springs. A safety hook prevents premature release. Cast into each end of the frame are large stabilizing handles which, along with its weight, hold the sampler upright during descent. When the grab touches bottom, inertia from a self-contained weight releases a catch and helical springs rotate the inner half cylinder by 180°. Because the rotation of the half cylinder is extremely rapid, its shear strength is far greater than the sediment strength, thus cutting cleanly. After turning, the scoop remains closed preventing washout and thus provides an undisturbed sample. Because the Shipek is spring-loaded and its scoop is very dangerous when closing, use extreme caution. Operation needs 2 strong people due to its size and weight (134 lbs.). Its stainless steel construction allows for chemical analysis of sediments in both fresh and salt water.

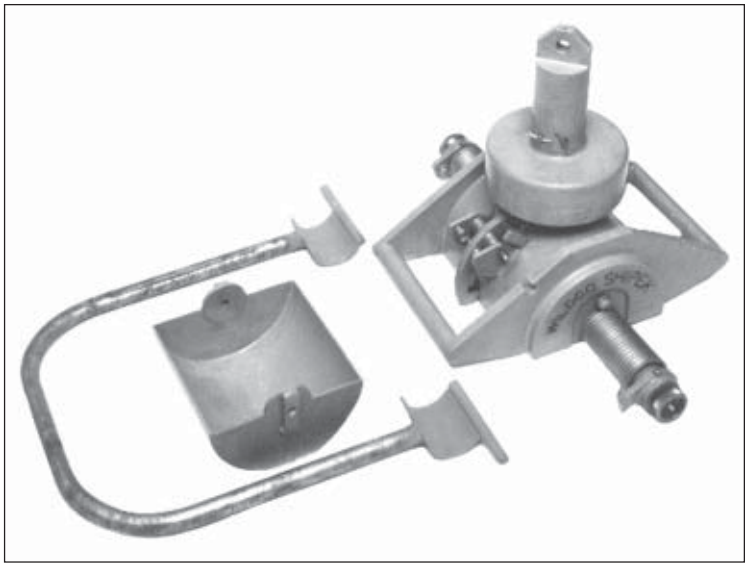

Figure 5.39 Shipek® Grab Sampler. Illustration published with permission of Wildco®

5.3.2.1.5 Van Veen

An example of a clamshell pivot, the Van Veen grab (Figure 5.40) is lightweight and suited to take large samples in soft bottoms. The long lever arms allow it to cut deep into softer bottoms. The top is covered with a stainless steel screen for water to flow through during descent. The screen is covered with a neoprene rubber flap to prevent sample washout during retrieval.

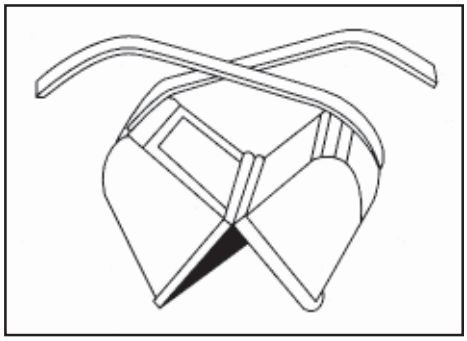

Figure 5.40 Van Veen Grab. Illustration published with permission of Wildco®

5.3.2.1.6 Petersen Grab

The Petersen grab (Figure 5.41), another clamshell pivot device, is typically used for fresh water qualitative or quantitative macroscopic fauna sampling in hard bottoms. Zinc plating on heavy steel construction prohibits the use of this device for sediments requiring chemical analysis. Since this device has been used for grab sampling sediment for over 70 years, it makes comparative study where other Petersen grab samplers have been used ideal.

Figure 5.41 Petersen Grab. Illustration published with permission of Wildco®

5.3.2.2 Sediment Core Samplers

Sediment corers differ from benthic grab samplers by their ability to retain the integrity of sediment horizons with minimal disturbance. This allows for discrete sampling of horizons or zones of interest. They are also capable of collecting samples at greater depths than grab samplers. They generally provide less sample volume than grab samplers and user degree-of-difficulty increases when samples are collected under several feet of water from a boat or barge. Various manufacturers provide a wide range of devices capable of collecting sediment cores from specific environments. Understanding your specific needs and the conditions of the medium will assist in choosing the proper tool. While more expensive than chrome or zinc plated devices, stainless steel corers can better withstand the rugged field handling and corrosive environments and also compliment chemical analysis. As with grab samplers, when cleaning, at a minimum, use the Three-Step or Cold Regions decontamination procedures described in Chapter 2, *Quality Assurance*, Subsections 2.4.2 and 2.4.3, respectively.

5.3.2.2.1 Hand Corer

The Hand Corer (Figure 5.42), used for collecting sediment samples, has been modified from a standard single barrel soil core sampler by the addition of a handle to facilitate driving the core and a check valve on top to create a partial vacuum which prevents wash out during retrieval through overlying water. It should be noted, however, that this device can be disruptive to the water/sediment interface and might cause significant alterations in sample integrity if extreme care is not taken. The hand corer is available in stainless steel construction allowing for chemical analysis of sediments in both fresh and salt water.

Figure 5.42 Hand Corer (Photograph by J. Schoenleber)

Hand corers can be used for sludges as well as sediments provided the water is shallow. Some hand corers can be fitted with extensions allowing collection of samples beneath a shallow layer of liquid (to about 15 feet). Most of the corers can be adapted to hold liners.

Wildco® Supply manufactures the Ogeechee™ Sand Corer for special-

ized hand coring in firm or sandy bottoms in fresh, salt or brackish swiftly moving waters. They also manufacture the K-B® Core Sampler which has a specially designed valve that is locked open during descent thus creating minimal frontal wave and minimal warning to fauna at the water/bottom interface. The Ogeechee™ Sand Corer can be used in fast moving waters as deep as 15 feet with the use of extensions. The K-B® Core Sampler can be used in water as deep as 300 ft. Both can be outfitted with stainless steel tube bodies allowing for the chemical analysis of sediments in both fresh and salt water.

Procedures for Use:

i. Decontaminate prior to use.

ii. Force corer in with a smooth, continuous motion.

iii. Twist corer and withdraw in one motion.

iv. Remove nosepiece and withdraw sample.

v. Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

vi. Transfer sample into laboratory cleaned sample bottles and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- easy to use
- minimal risk of contamination

Disadvantages:

- can disrupt water/sediment interface
- does not work well in sandy sediments

5.3.2.2.2 Russian Peat Borer

The Russian Peat Borer (Figure 5.43), manufactured by Aquatic Research Instruments, can be used for paleoecological analysis of bog and salt marsh sediments, collection of uncompressed core in poorly decomposed woody peat and in shallow water applications. One wall of the core tube is sharpened to longitudinally cut through sediments when sampler is turned clockwise while a solid Delrin® core head and bottom point support a stainless steel cover plate which freely rotates inside the core tube. The stainless steel cover plate is curved and sharpened to minimize disturbance when inserted into the sediment.

A complete Environmental Technology Verification (ETV) Program Report on the Russian Peat Borer (EPA/600/R-01/010, Dec. 1999) produced by the USEPA, can be obtained by going to *http://www.epa.gov/etv/pdfs/vrvs/99_vr_ari_peat.pdf*. This document contains "how to" information as well as advantages and limitations. A quality assurance/quality control comparison to reference sediment sampling devices rounds out a critical look as to the Russian Peat Borer's effectiveness. The 134 page report indicates that, "Based on the demonstration results, the Russian Peat Borer can be operated by one person with minimal skills and training and does not require support equipment such as a winch and power source, even when collecting sediment

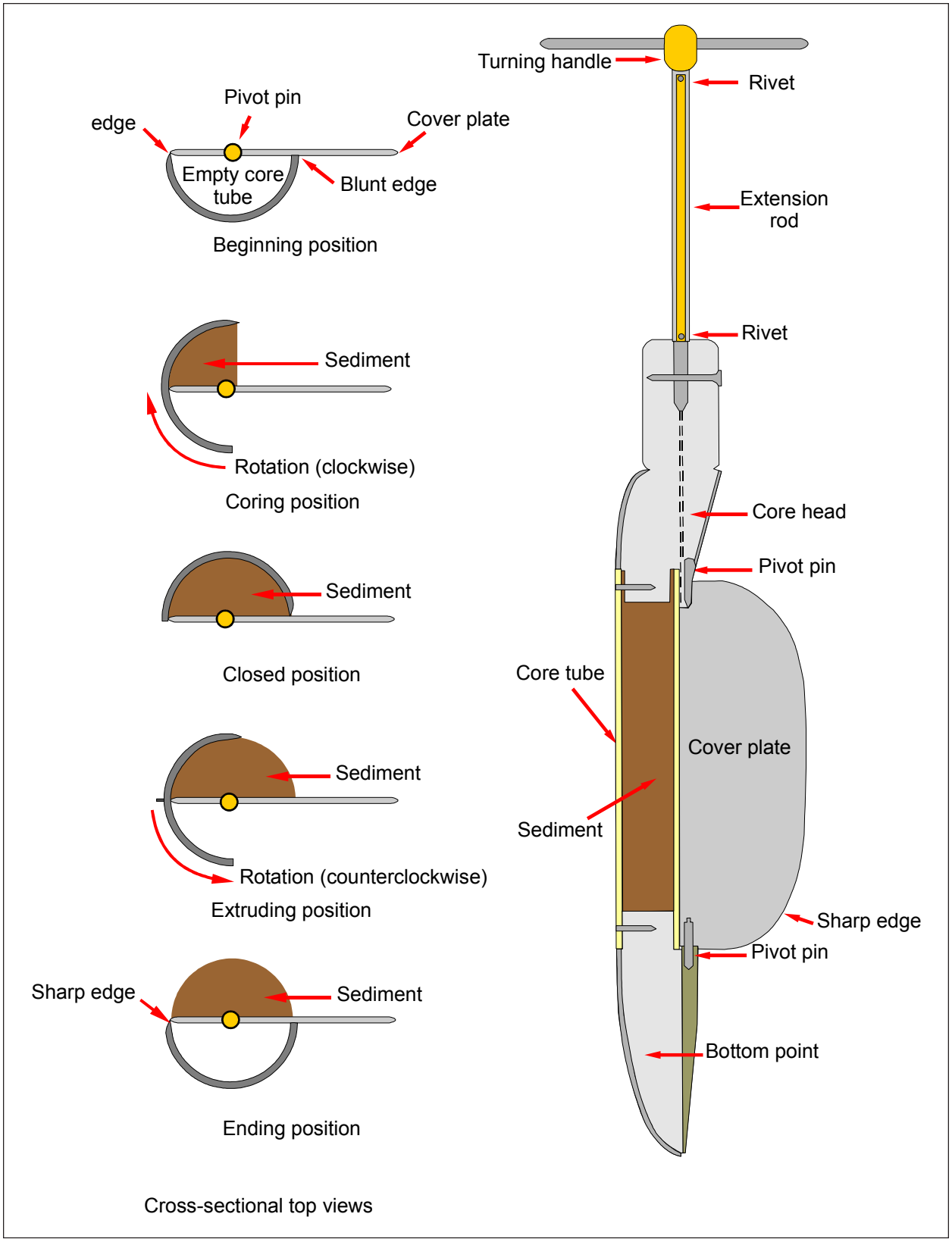

Figure 5.43 Russian Peat Borer. Illustration published with permission of Aquatic Research Instruments

samples at depths up to 11 feet below sediment surface. The sampler can collect representative and relatively uncompressed samples of consolidated sediment in discrete depth intervals. The sampler preserves sediment stratification in consolidated sediment samples, but sediment stratification may not be preserved in unconsolidated sediment samples. The Russian Peat Borer is a superior alternative to conventional sediment samplers, particularly for sampling consolidated sediment. As with any sampler selection, the user must determine the appropriate sampler for a given application based on project-specific data quality objectives."

5.3.2.2.3 Split Core Sampler

The Split Core Sampler (Figure 5.44), manufactured by Art's Manufacturing and Supply, is designed to collect sediment submerged under several feet of water. What separates this device from other core samplers is the ability to open the core longitudinally. This eliminates any complications that may arise when extruding sample from fixed core barrels. Joining like sections together end to end can extend the length of this core sampler up to 48 inches. Additionally, consideration has been made for the adaptive use of an electric hammer to provide a source of vibration to reduce friction during advancement into the sediment.

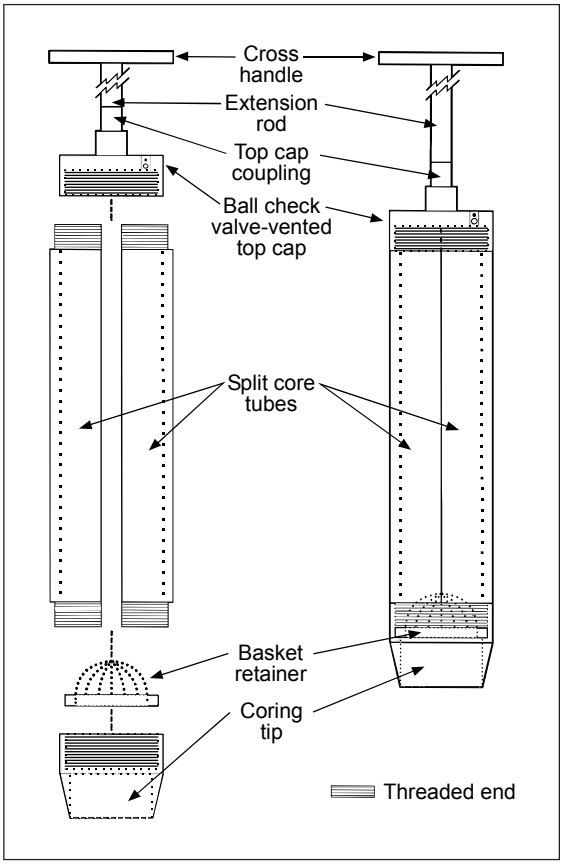

Figure 5.44 Split Core Sampler. Illustration published with permission by Art's Manufacturing & Supply

A complete Environmental Technology Verification (ETV) Program Report on the Split Core Sampler (EPA/600/R-01/009, Dec. 1999) produced by the USEPA, can be obtained by going to *http://www.epa.gov/etv/pdfs/vrvs/99_vr_art_split.pdf*. This document contains "how to" information as well as advantages and limitations. A quality assurance/quality control comparison to reference sediment sampling devices rounds out a critical look as to the Split Core Sampler's effectiveness. The report indicates that, "Based on the demonstration results, the Split Core Sampler can be operated by one person with minimal skills and training. For more efficient recovery of samples, an electric hammer should be used to induce vibrations in the sampler. When more than two extension rods are used, a winch is recommended for sampler operation. The sampler is designed to collect sediment samples up to a maximum depth of 4-feet below sediment surface and based on visual observations, collects partially compressed samples of both consolidated and unconsolidated sediments from the sediment surface downward; sample representativeness

may be questionable because of core shortening and core compression. The sampler preserves sediment stratification in both consolidated and unconsolidated sediment samples. The Split Core Sampler is a good alternative to conventional sediment samplers. As with any sampler selection, the user must determine the appropriate sampler for a given application based on project-specific data quality objectives."

5.3.2.2.4 Gravity Corer

A gravity corer (Figure 5.45) is a weighted metal or rigid plastic tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents washout during recovery. Gravity corers are capable of collecting samples of most sludges and sediments. They collect essentially undisturbed samples at considerable depth, which represent the profile of strata that may develop in sediments and sludges during variations in the deposition process. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. What separates a gravity corer from a sediment corer are design features that allow the gravity corer to free fall through an unlimited water column, remain upright on contact and pierce the sediment with enough downward force to produce a core sample up to 30 inches or more. Density of the substrate and weight factor into penetration depths. Advanced designs take into consideration frontal wave reduction, additional weight and check valve anti-fouling

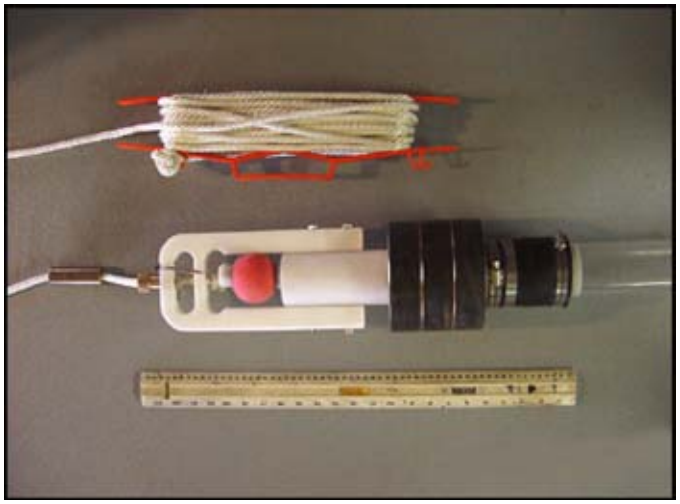

Figure 5.45 Gravity Corers. Illustration published with permission from Aquatic Research Instruments

Care should be exercised when using gravity corers in vessels or lagoons that have liners since penetration depths could exceed that of substrate and result in damage to the liner material.

Aquatic Research Instruments also manufactures other sediment coring devices, among them a Gravity Corer which uses a polycarbonate core tube and a Piston Sediment Corer which is designed primarily for paleoecologic analysis. For more information on these devices go to *http://www.aquaticresearch.com/*.

Procedures for Use:

i. Attach decontaminated corer to the required length of sample line.

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

iii. Allow corer to free fall through liquid to bottom.

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

v. Remove nosepiece from corner and slide sample out of corer into stainless steel or PTFE (e.g., Teflon®).

vi. Transfer sample into appropriate sample bottle with a stainless steel lab spoon or equivalent.

vii. Follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

viii. Decontaminate before use at next location.

Advantages:

- collects undisturbed samples

Disadvantages:

- may damage membrane liners in vessels or lagoons

5.3.2.2.5 Vibracorer

Vibracoring is a highly specialized form of sediment core sampling. While not a new tool in the sediment sampling arsenal (reportedly used in the 1950s), its advancement was slow due to the availability of vibrators that adapted easily to underwater use. Generally, there are three types of vibrators that can be applied to this system of sediment sampling: pneumatic, hydraulic and electric. While conceivably the least complicated and easiest to adapt, pneumatic vibracore systems have a considerable limitation, i.e., the deeper the application, the larger the volume of air is needed to overcome surrounding water pressure. Hydraulic vibrators do have a certain appeal, as there is some application of resonant drive capability, however, these systems along with pneumatic vibracores require an umbilical line to the surface and an independent power source at the surface either in the form of a hydraulic pump or large air compressor. Electric vibracores (Figure 5.46), the most versatile, generally rely on a readily available power system aboard a vessel and with today's safety features, the risks of using electrical current underwater have been reduced.

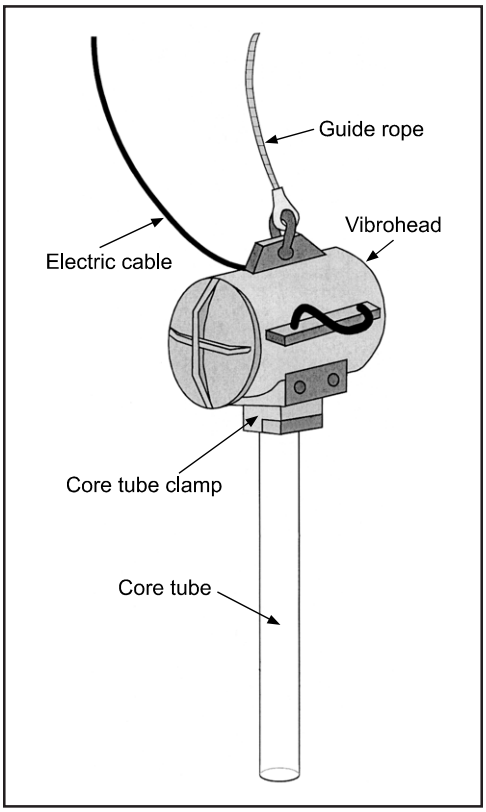

Figure 5.46 Vibracorer (Source USEPA, ETV Program Report)

In the extreme, vibracores can collect samples at depths exceeding 4000 meters (over 2-miles) and retrieve a single continuous sediment core down to 35-feet below sediment surface. And while these applications serve a host of specialized needs worldwide, vibracoring on the small scale for more "localized" work in estuaries, lakes and rivers is quite common. Vibracoring requires the use of a working platform, an A-frame and winch and at least two people to operate. The typical weight of a fully equipped vibracorer, with vibrohead and core is about 150 lbs. Core tube dimensions generally range

from 4-inches in diameter by 15-feet in length to 3-inches in diameter by 20-feet in length. Once the vibracorer has been assembled and lowered to the sediment floor, the vibrating head creates the energy necessary to overcome the two forces opposing advancement: frontal resistance and wall friction. The energy from the vibrohead is transferred down the core and at the point of contact along the core tube sediment pore-pressure is raised and a thin layer of liquefaction is created. The check valve and core nose keep the sediment within the tube during retrieval and once on deck the tube can be opened with a saw or, if a tube liner is used, the sediment is removed from the tube in one long segment. To learn more about vibracores and their application, go to either ETV hyperlink listed above (EPA/600/R-01/009, Dec. 1999), as the vibracorer was one of the reference devices that the Russian Peat Sampler and Split Core Sampler were compared against or, go to *http://www.aquasurvey.com/Services/Vibracoring/vibracoring.html*

5.3.2.2.6 Sediment Sieve

Sediment sieves are used to process bottom material to a desired grain size (USGS recommends that sub-samples be processed through a maximum mesh size of 2.0 mm). Use the US Geological Survey's, Book 9, *Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter 8A, *Bottom Material Samples*, 8.3.1.B. *Sieves*, (*http://water.usgs.gov/owq/FieldManual/*) for additional information on sieving sediment. Sieves consist of a measured mesh screen and a collection pan and can be constructed of various materials. Stainless steel is preferred unless collecting samples for metals analysis. Such samples should be processed through polyethylene sieves, which have been acid rinsed.

Procedures for Use:

i. Rinse equipment with water from the body of water from which the sediment will be collected.

ii. Collect sediment subsamples with the appropriate scoop or trowel.

iii. Process the samples through the mesh and into the collection pan

iv. When the desired amount of subsamples are processed into the collection pan, mix the sediment to achieve a homogeneous sample.

v. With the scoop or trowel, remove sediment from the collection pan and place it into the appropriate sample container.

vi. Clean equipment using the recommended procedure (see Chapter 2, *Quality Assurance*).

Table 5.2 General Characteristics of Selected Grab and Core Samplers

[Penetration depth, sample volume, and applications are presented in English units because equipment is constructed to English-unit specifications: 1 inch = 2.54 centimeters, 1 pound = 0.4536 kilogram, 1 foot = 0.3048 meter, D, diameter; L, length; W, width; PDC, plastic dip coated; *, trade name; I.D., inside diameter; na, not applicable; mm, millimeter; ft, feet, SS, stainless steel; PVC, polyvinyl chloride; ft/s, feet per second; <, less than]

Sampler designation	Sampler construction material	Sampler dimensions (inches)	Sampler weight (pouinds)	Suspension	Penetration depth (inches)	Sample volume (cubic inches)	Application
Grab Samplers							
USBMH-53	SS body, brass piston	2 D x 8 L	7,5	46-inch-long rod	0-8	0-25	Wadable water, loosely consolidate material less than 0.063 mm.
USBMH-60	Cast aluminum body, SS rotary scoop, rubber gasket	8 x 4.5 x 22	32	Hand line or winch and cable	0-1.7	0-10.7	Wadable to water of slow velocity (<1 ft/s) and moderate depth; firm unconsolidated to loosely consolidated materials, less then 16 mm; PDC version available; sampler must be equipped with safety yoke.
USBMH-80	SS rotary scoop	2.75 D x 32.5 W	8	56-inch-long rod	0-1.75	0-10.7	Wadable water; unconsolidated to loosely consolidated material, less than 16 mm.
USBM-54	Cast steel body, SS rotary scoop, rubber gasket	8.5 x 7 x 22	100	Winch and cable	0-1.7	0-10.7	Water of moderate velocity and depth; firm unconsolidated to loosely consolidated material, less than 16 mm; PDC bersion available, sample must be equipped with safety yoke.
Ponar* (2 sizes)	SS body, zinc-plated steel weights and neoprene flaps	6x6 or 9x9	15-22 or 45-60	Hand line or winch and cable	0-4	0-146.4 or 0-500	Weight dependent; wadable to water of slow velocity (<1 ft/s) and moderate depth; unconsolidated loosely consolidate material, less then 16 mm; susceptible to loss of fines.
Petersen*	Zinc-plated steel	12 x 12	39-93	Hand line or winch and cable	0-12	600	Weight dependent; wadable to water of slow velocity and moderate depth; unconsolidated to consolidated material, less then 16 mm; susceptible to loss of fines
Birge-Ekman* (4 sizes)	SS or brass	6x6x6 or 6x6x9 or 9x9x9 or 12x12x12	16-25 or 21-35 or 47-68 or 100-150	Rod, hand line, or winch and cable	0-3 or 0-4 or 0-5 or 0-6	0-216 or 0-323 or 0-729 or 0-1,726	Wadable to water of slow velocity (<1 ft/s) and moderate depth; soft unconsolidated to consolidated material, less than 0.50 mm; susceptible to loss of fines' PDC version available

Table 5.2 General Characteristics of Selected Grab and Core Samplers (continued)

[Penetration depth, sample volume, and applications are presented in English units because equipment is constructed to English-unit specifications: 1 inch = 2.54 centimeters, 1 pound = 0.4536 kilogram, 1 foot = 0.3048 meter, D, diameter; L, length; W, width; PDC, plastic dip coated; *, trade name; I.D., inside diameter; na, not applicable; mm, millimeter; ft, feet, SS, stainless steel; PVC, polyvinyl chloride; ft/s, feet per second; <, less than]

Sampler desig-nation	Sampler construc-tion material	Sampler dimensions (inches)	Sampler weight (pouinds)	Suspen-sion	tration depth (inches)	Sample volume (cubic inches)	Application
Grab Samplers							
Shipek*	Cast alloy steel	4x6x6 or 18.6 x 25.1x 17.4	11 or 135	Hand line or winch and cable	0-1.2 or 0-4	0-30.5 or 0-183	Wadable to water of moderate velocity and depth; unconsolidated to consolidated material, less than 0.50 mm; susceptible to loss of fines; PODC versions available.
Van Veen* (2 sizes)	SS body, zinc-plated steel chain, neoprene flaps	13.8 x 27.6 or 19.7 x 39.4	66-88 or 143-187	Cable	0-12	0-11 or 0-46	Wadable to water of moderate velocity and depth; soft unconsolidated material less than 0.25 mm.
Core Samplers							
Hand	SS or SS core tubes; Lexan* or SS nose piece and SS or plastic core catcher	2.1D. 20-96L	10-60	Handle 0-15 ft. L	0-96	0-300	Wadable to diver application, water of slow velocity (<1 ft/s); soft to semi-firm unconsolidated material less than 0.25 mm; 2-inch core liners available in plastic and SS.
Ogeechee * (sand corer)	SS or SS core tubes; Lexan or SS nose piece and SS or plastic core catcher	2 I.D. 20-96 L	10-60	Hand corer	0-96	0-300	Wadable to diver application, water of slow velocity (<1 ft/s); soft to semi-firm unconsolidated material less than 0.25 mm; 2-inch core liners available in plastic and SS.
Kajak-Brinkhur-st (K-B)* (gravity corer)	SS, Lexan, or SS core tubes; Lexan or SS nose piece, SS or plastic core catcher, neoprene valve	2 I.D. 20,30 L	15-48	Hand line or winch and cable	0-30	0-90	Water with very slow velocity (<1 ft/s); loosely consolidated material less than 0.063 mm; 2-inch core liners available in plastic and SS.

Table 5.2 General Characteristics of Selected Grab and Core Samplers (continued)

[Penetration depth, sample volume, and applications are presented in English units because equipment is constructed to English-unit specifications: 1 inch = 2.54 centimeters, 1 pound = 0.4536 kilogram, 1 foot = 0.3048 meter, D, diameter; L, length; W, width; PDC, plastic dip coated; *, trade name; I.D., inside diameter; na, not applicable; mm, millimeter; ft, feet, SS, stainless steel; PVC, polyvinyl chloride; ft/s, feet per second; <, less than]

Sampler designation	Sampler construction material	Sampler dimensions (inches)	Sampler weight (pouinds)	Suspension	Penetration depth (inches)	Sample volume (cubic inches)	Application
Core Samplers							
Phleger*-(gravity corer)	SS core tube, nose piece, core catcher; neoprene valve	1.4 I.D.20L	17.6-33	Hand line or winch and cable	0-20	0-40	Water with a very slow velocity (<1 ft/s); soft to firm unconsolidated material less than 0.50 mm; core liners available in plastic.
Ballchek* (gravity corer)	Bronze head, SS or PVC core tubes; Lexan* or SS nose piece and SS or plastic core catcher; plastic/polyurethane valve	2-5 I.D. 30-96 L	Variable depending on size and construction material	Hand line or winch and cable	0-96	0-750	Water with very slow velocity (<1 ft/s); loosely consolidated material, less than 0.063 mm; core liners available in plastic and SS.
Benthos* (gravity corer)	Steel core tube, nose piece, and core catcher	2.6 I.D. 120 L	55-320	Winch and cable	120	0-490	Water with very slow velocity (<1 ft/s); loosely consolidated material less than 0.063 mm; core liners available in plastic
Alpine*(-gravity corer)	Steel core tube, nose piece, core catcher, and neoprene valve	1.6 I.D. 72 L	242-342	Winch and cable	72	0-180	Water with very slow velocity (<1 ft/s); loosely consolidated material less than 0.063 mm; core liners available in plastic; inconsistant vertical penetration.
Box	SS with optional acrylic box liner	6x6x9	31-100	Winch and cable	9	0-300	Water with very slow velocity (<1 ft/s); loosely consolidated material less than 0.25 mm.
Piston	SS or plastic core tubes; Lexan or SS nose piece; SS or plastic core catcher	1-5 I.D. 40-800 L	25-500	Hand line or winch and cable	0-80	0-6,200	Water with very slow velocity (<1 ft/s); loosely consolidated material less than 0.25 mm; core liners available in plastic.
Vibra-corer*	Variable	2-3 I.D. 40-500 L	100-300	Frame	0-500	0-2,300	Water with very slow velocity (<1 ft/s); loosely consolidated material less than 16 mm; assembly might require scuba divers.

Table taken from US Geological Survey's, Book 9, *Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter 8A, *Bottom Material Samples*, (*http://water.usgs.gov/owq/FieldManual/*)

5.3.2.3 Sludge Samplers

Several of the sediment devices listed above may be used for the collection of sludge. Caution however, must be taken when using grab or coring samplers for sludge collection as these devices may puncture liners in controlled settings. Additionally, safety precautions must be considered when using the sludge sampling devices listed below as often times these samples are collected from manholes, tanks, lagoons, out-fall pipes and other areas prone to slip, trip or fall scenarios.

5.3.2.3.1 Lidded Sludge/Water Sampler

A lidded sludge/water sampler (Figure 5.47) can be used to collect viscous sludge or waste fluids from tanks, tank trucks or ponds at a specific depth. It can sample liquids, multi-layer liquid wastes and mixed-phase solid/liquid wastes. Sample volume can be up to 1 liter. It consists of a removable glass sample bottle situated inside a holder that is suspended gimbal-like within a stainless steel framework, which is attached to a rod and handle.

The conical shaped bottom allows the sampler to be lowered into the material being sampled. At the desired depth to the sample bottle is opened and closed by rotating the top handle. The device is then carefully retrieved from the material and the sample bottle removed by lifting it from the holder

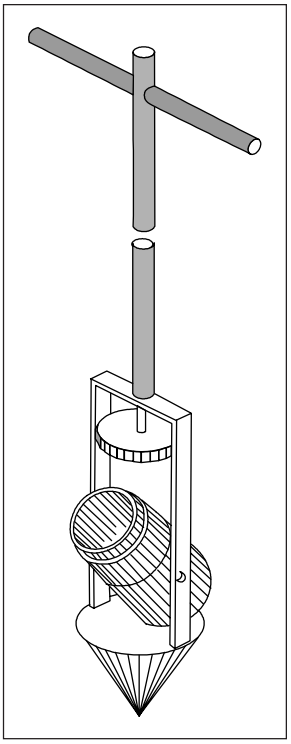

Figure 5.47 Lidded Sludge/Water Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

Procedures for Use:

i. Place the sample bottle into the holder.

ii. Lower the sampler to the desired depth.

iii. Open the sample bottle using the handle, and allow the sample vessel to fill.

iv. After the bottle has had time to fill, turn the handle again to close.

v. Remove sampling device from sludge.

vi. Remove sample bottle from holder and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- can be used in heavy sludge
- can collect discrete samples at depth
- bag liner can be used with sampler
- easily decontaminated with steam cleaner or solvent wash

Disadvantages:

- heavy

5.3.2.3.2 Liquid Grab Sampler

A liquid grab sampler (Figure 5.48) can be used to collect sludge or slurry samples from surface impoundments, ponds, lagoons or containers. Grab samples can be obtained at discrete depths. The sampler is available for use with wide or narrow necked sample bottles and has large access port openings to allow the sample to enter the bottle. Sample volumes can range from 0.5 to 1.0 liters. The sample bottle is attached to the end of the 6-ft. long handle. The control valve is operated from the top of the handle once the sampler is at the desired depth.

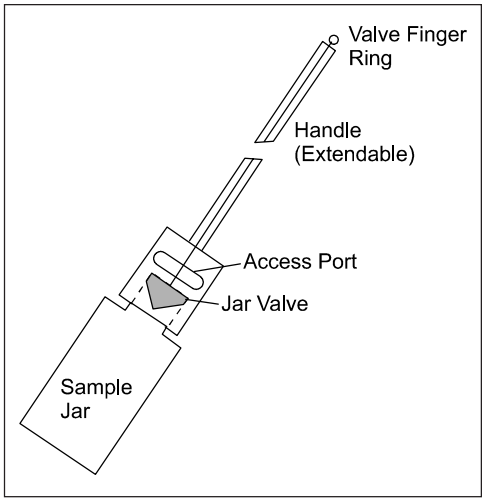

Figure 5.48 Liquid Grab Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

Procedure for Use:

i. Assemble the sampler.

ii. Operate the sampler several times to ensure proper adjustment, tightness of the cap, etc.

iii. Submerge sampler into liquid to be sampled.

iv. When the desired depth is reached, pull valve finger ring to open control valve and allow sample to enter container.

v. Retrieving sampler.closes valve.

vi. Transfer sample into laboratory cleaned sample bottles and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- allows discrete samples to be taken at depth

Disadvantages:

- depth of sampling is limited by length of pole
- not useful in very viscous sludges
- hard to decontaminate

5.3.2.3.3 Swing Jar Sampler

The swing jar sampler (Figure 5.49) is a surface sampler that may be used to collect liquids, powers, or small solids at a distance of up to 12 feet. It can be used in a variety of settings to collect samples from drums, surface impoundments, tanks, pipe/point source discharges, sampling ports and storage bins. Sample volume ranges from 0.5 to 1.0 liters. It is normally used with high-density polyethylene sample jars and has an extendable

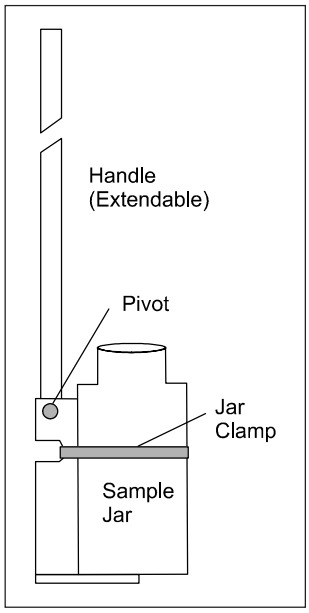

Figure 5.49 Swing Jar Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

aluminum handle with a pivot at the juncture of the handle and jar holder. The jar is held in the holder with an adjustable clamp. The pivot allows samples to be collected at different angles.

Advantages:

- Easy to use
- Easily adaptable to samples with jars of different sizes and materials.

Disadvantages:

- Cannot collect discrete depth samples

5.3.2.3.4 A sludge judge (Figure 5.50) is useful for obtaining a core of sludge, or water and sludge. This may be useful in determining the physical state (% solids) of a tank's contents or its volume of sludge. However, this device is commonly constructed of PVC and its use is limited in hazardous waste sampling due to possible reactivity and quality assurance considerations. The sludge judge is a long narrow tube with a check valve on the bottom. Typically the device is sold in 3, 5-foot sections and one 3-foot section for a total combined length of 18 feet when fully assembled.

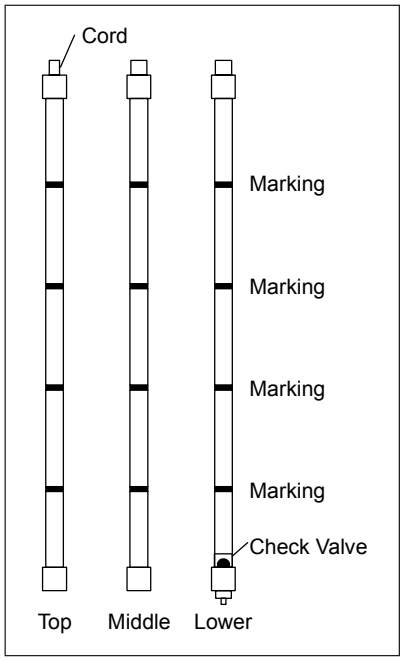

Figure 5.50 Sludge Judge (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

Procedures for Use:

i. Slowly insert the sampler into the material being sampled.

ii. When the sampler has filled with material, pull back on the sampler to close the valve and retrieve the sample.

iii. Transfer the sample (by pouring from the top or a release valve from the bottom) into a laboratory cleaned sample bottle and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- easy to use
- delineates amount of settled sludge or physical state of medium

Disadvantages:

- use is limited due to PVC construction
- hard to decontaminate
- not useful in thick sludges

5.3.3 Containerized Solids and Waste Pile Sampling Equipment

Waste materials are sometimes found on-site in containers or in waste piles. Sampling of containerized solids includes powdered, granular, or coarse materials in drums, barrels, or other similar

containers. Waste piles may be found in various sizes, shapes, structure and compactness.

The type of sampler chosen should be compatible with the waste so as to collect a representative material for proper analysis. Table 5.1 at the end of this chapter lists NJDEP recommended waste material samplers and their application.

In addition to the equipment and methodology presented below, scoops and trowels are commonly used when sampling containerized solids/waste piles.

5.3.3.1 Grain Sampler

The grain sampler (Figure 5.51) is used for sampling powdered or granular wastes or materials in bags, fiber drums, sacks, or similar containers. This sampler is most useful when the solids are no greater than 0.6 cm (1/4") in diameter.

This sampler consists of two slotted telescoping tubes, usually made of brass, stainless steel or high-density polyethylene. The outer tube has a conical, pointed tip on one end that permits the sampler to penetrate the material being sampled. The sampler is opened and closed by rotating the inner tube. Grain samplers are generally 61 to 100 cm (24 to 40 in.) long by 1.27 to 2.54 cm (1/2 to 1 in.) in diameter and they are commercially available at laboratory supply houses.

Figure 5.51 Grain Sampler (Photograph by J. Schoenleber)

Procedures for Use:

i. While the sampler is in the closed position, insert it into granular or powdered material or waste being sampled from a point near a top edge or corner, through the center, and to a point diagonally opposite the point of entry.

ii. Rotate the inner tube of the sampler into the open position.

iii. Wiggle the sampler a few times to allow materials to enter the open slots.

iv. Place the sampler in the closed position and withdraw from the material being sampled.

v. Place the sampler in a horizontal position with the slots facing upward.

vi. Rotate and slide out the outer tube from the inner tube.

vii. Transfer sample into laboratory cleaned sample bottles and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- ease of operation

Disadvantages:

- not desirable for moist or sticky samples
- provides a low volume

5.3.3.2 Waste Pile Sampler

The waste pile sampler (Figure 5.52) is used for sampling wastes in large heaps with cross-sectional diameters greater than 1 m (39.4 in.). It can also be used for sampling granular or powdered wastes or materials in large bins, barges, or soils where the grain sampler or sampling trier is not long enough.

This sampler is essentially a large sampling trier. It is commercially available but it can be easily fabricated from sheet metal or plastic pipe. A length of PVC pipe 1.52 m (5 ft.) long by 3.2 cm (1 1/4 in.) in diameter by 0.32 cm (1/8 in.) wall thickness is adequate. The pipe is sawed lengthwise (about 60/40 split) until the last 10 cm (4-in.). The narrower piece is sawed-off and hence forms a slot in the pipe. The edges of the slot and the tip of the pipe can be sharpened to permit the sampler to slide into the waste material being sampled. The unsplit length of the pipe serves as the handle. The plastic pipe can be purchased from hardware stores.

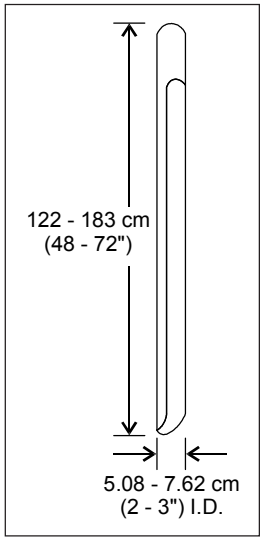

Figure 5.52 Waste Pile Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

Procedures for Use:

i. Insert the sampler into the waste material being sampled at 0° to 45° from horizontal.

ii. Rotate the sampler two or three times in order to cut a core of the material.

iii. Slowly withdraw the sampler, making sure that the slot is facing upward.

iv. Transfer the sample into a laboratory cleaned sample container with the aid of a spatula and/or brush.

v. Follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- easily fabricated
- disposable
- inexpensive
- can be fabricated to site-specific needs

Disadvantages:

- does not collect representative samples when the diameters of the solid particles are greater than half the diameter of the tube.

5.3.3.3 Sampling Trier

A sampling trier (Figure 5.53) is used for sampling soils, powdered or granular wastes or materials in bags, fiber drums, sacks, or similar containers.

A typical sampling trier is a long tube with a slot that extends almost its entire length. The tip and edges of the tube slot are sharpened to allow the trier to cut a core of the material to be sampled when rotated after insertion into the material. A spiral attachment may be used to advance a hole when sampling at depth. Sampling triers are usually made of stainless steel with wooden handles. They are about 61 to 100 cm (24 to 40 in.) long and 1.27 to 2.54 cm (1/2 to 1 in.) in diameter. They can be purchased readily from laboratory or forestry supply houses

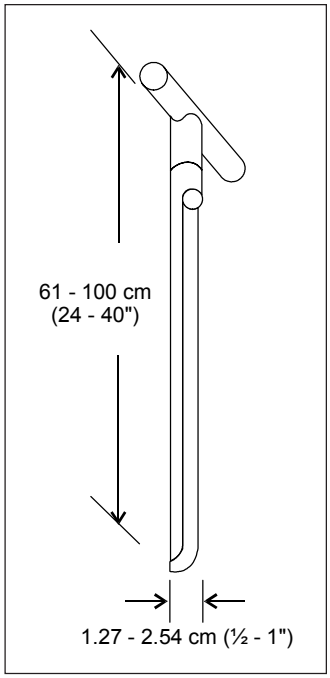

Figure 5.53 Sampling Trier (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

Procedures for Use:

i. Insert the trier into the material to be sampled at a 0º to 45º angle from horizontal. This orientation minimizes the spillage of sample from the sampler. Extraction of samples might require tilting of the container.

ii. Rotate the trier once or twice to cut a core of material.

iii. Slowly withdraw the trier, making sure that the slot is facing upward.

iv. Transfer the sample into a laboratory cleaned sample container with the aid of a spatula.

v. Follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- preferred for moist or sticky samples

Disadvantages:

- relatively difficult to use in stony, dry, or sandy soil
- if sample is excessively moist or loose and powdery, difficulty may be encountered when removing the sampler

Table 5.3 Samplers Recommended for Various Types of Waste

Waste Type	Recommended Sampler	Limitations
Liquids, sludges, and slurries in drums, vacuum trucks, barrels and similar containers	COLIWASA Open Tube (Thief), Stratified sample (Thief)	Not for containers over 1.5 m (5 ft) deep
	a) Plastic	Not for wastes containing ketones, nitrobenzene, di-methylformamide, mesityl oxide, or tetrahydrofuran.
	b) Glass	Not for wastes containing hydrofluoric acid and concentrated alkali solutions
	c) PTFE	None
Liquids, sludges, and slurries in drums, vacuum trucks, barrels, and similar containers	Open tube	Not for containers 1.5 m (5 ft.) deep
	a) Plastic	Not for wastes containing ketones, nitrobenzene, di-methylformamide, mesityl oxide, or tetrahydrofuran.
	b) Glass	Not for wastes containing hydrofluoric acid and concentrated alkali solutions
Liquids and sludges in ponds, pits, lagoons, or treatment units	Pond	Cannot be used to collect samples beyond 3.5 m (11.5 ft.) Dip and retrieve sampler slowly to avoid bending the tubular aluminum handle.
Powdered or granular in bags, drums, barrels and similar containers	a) Grain sampler	Limited application for solids sampling of moist and sticky solids with a diameter over 0.6 cm (1/4 in.)
	b) Sampling trier	May incur difficulty in retaining core sample of very dry granular materials during sampling
Dry wastes in shallow containers and surface soil	Trowel or scoop	Not applicable to sampling deeper than 8 cm (3-in.). Difficult to obtain reproducible mass of samples
Waste piles	Waste pile sampler	Not applicable to sampling solid wastes with dimensions greater than half the diameter of the sampling tube
Solid deeper than 8-cm (3-in)	a) Soil auger	Does not collect undisturbed core sample
	b) Sampling trier	Difficult to use on stoney, rocky, or very wet soil
Wastes in storage tanks	a) Weighted bottle sampler	May be difficult to use on very viscous liquids
	b) Bacon Bomb	Volume restriction 1 L maximum
	c) Kemmerer sampler	May need extra weight

(Adapted from USEPA document EPA 600/2-80-018 *Samplers and Sampling Procedures for Hazardous Waste Streams*, 1980).

Return to TOC

References

Acker, W.L. III, *Basic Procedures for Soil Sampling and Core Drilling,* Acker Drill Company, Scranton, PA, 1974.

American Society for Testing and Materials, *Standards Related to Environmental Site Characterization, Sponsored by ASTM Committee D-18 on Soil and Rock*, ASTM, West Conshohocken, Pennsylvania, 1997.

American Society for Testing and Materials, *Standard Practice for Diamond Core Drilling for Site Investigation, D 2113-83*, ASTM, West Conshohocken, Pennsylvania, 1987.

American Society for Testing and Materials, *Standard Practice for Using the Disposable En Core Sampler for Sampling and Storing soil for Volatile Organic Analysis, D 6418-99*, ASTM West Conshohocken, Pennsylvania, 1999.

American Society for Testing and Materials, *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process*, E 1527-00, 2000.

American Society for Testing and Materials, *Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds, D 4547-98*, ASTM West Conshohocken, Pennsylvania, 1998.

American Society for Testing and Materials, *ASTM Standards on Ground Water and Vadose Zone Investigations, sponsored by ASTM Committee D-18 on Soil and Rock*, *second edition*, ASTM West Conshohocken, Pennsylvania, 1994.

American Society for Testing and Materials, *Test Method for Sieve Analysis of Fine and Coarse Aggregates,* ASTM C136-92.

American Society for Testing and Materials, *Test Method for Particle-Size Analysis of Soils*, ASTM D422-63.

American Society for Testing and Materials, *Practice for Soil Investigation and Sampling by Auger Borings*, ASTM D1452-80, 1996.

American Society for Testing and Materials, *Test Method for Penetration Test and Split-Barrel Sampling of Soils*, ASTM D1586-84, 1992.

American Society for Testing and Materials, *Classification of Soils for Engineering Purposes (Unified Soil Classification System),* ASTM D2487-93.

American Society for Testing and Materials, *Practice for Description and Identification of Soils (Visual-Manual Procedure),* ASTM D2488-93.

American Society for Testing and Materials, *Standard Guide for Sampling Waste Piles*, D6009-96. 1996.

American Society for Testing and Materials, *Guide for Soil Sampling from the Vadose Zone*, ASTM D4700-91.

American Society for Testing and Materials, *Guide for Field Logging of Subsurface Explorations of Soil and Rock*, ASTM D5434.

American Society for Testing and Materials, *Test Method for Particle-Size Analysis of Soils*, ASTM D422-63.

American Society for Testing and Materials, *Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh-Water Invertebrates*, ASTM E-1706-00, 2000.

American Society for Testing and Materials, *Standard Guide for Documenting a Ground Water Sampling Event*, ASTM D6089-97e1.

Anderson, G., *Coring and Core Analysis Handbook*, PennWell Books, Tulsa, OK, 1975.

Applegate, Joseph L., Fitton, Douglas M., *Rapid Site Assessment Applied to the Florida Department of Environmental Protection's Dry Cleaning Solvent Cleanup Program*, Conference Proceedings, HazWaste World Superfund XVIII., Vol. 2, December 1997.

Bailey, Dr. Renata, *Improving Sampling Techniques for the Analysis of Lead in Ground Water: Determining Optimal Filtration Conditions*, State of New Jersey, Department of Environmental Protection, Division of Science, Research and Technology, Final Report 2002.

Barcelona, M.J., J.P. Gibb, J.A. Helfrich, and E.E. Garske, *Practical Guide for Ground-Water Sampling*, Illinois State Water Survey, ISWS Contract Report 314, 1985.

Barcelona, Gibb and Miller, *A Guide to the Selection of Materials for Monitoring Well Construction and Ground Water Sampling*, Champaign, Il., US Government Printing Office, August 1983.

Barcelona, M.J., J.A. Helfrich, E.E. Garskey, and J.P. Gibb, *A Laboratory Evaluation of Ground Water Sampling Mechanisms*, in Ground Water Monitoring Review, Spring, Vol. 4, No. 2, pp. 32-41. 1984.

Barcelona, M.J., J.A. Helfrich, E. E. Garske, and J.P. Gibb, *Field Verification of Sampling Methods and Materials Selection for Ground Water Contamination Studies*, Presented at: Symposium for Ground Water Contamination Studies and Their Standardization, ASTM, Cocoa Beach, Fla., Feb. 1986.

Barth, D.S. and B.J. Mason, *Soil Sampling Quality Assurance and the Importance of an Exploratory Study*, ACS Symposium Series 267, Environmental Sampling for Hazardous Waste, ACS Publications, American Chemical Society, Wash. D.C., 1984.

BP Corporation North America and USEPA Region 4 and Region 5., *Monitoring Well Comparison Study: An Evaluation of Direct-Push versus Conventional Monitor Wells*, May, 2002.

Brady, N. and R. Weil, *The Nature and Property of Soils*, 12th ed., Prentice Hall.

Burmister, D.M., *Suggested Methods of Tests for Identification of Soils*, 1950.

Burton Jr., G. S. and P. F. Landrum, *New Standard Guide for Collection, Storage, Characterization and Manipulation of Sediments for Toxicological Testing, Draft 5*, Wright State University, Dayton, Ohio, December 1989.

California State University, Sacramento School of Engineering, *Water Treatment Plant Operation – A Field Study Training Program*, Sacramento, California, pp. 485-488, 1983.

Christensen, Thomas H., Bjerg, Poul L., Kjeldsen, P., *Natural Attenuation: A Feasible Approach to Remediation of Ground Water Pollution at Landfills?*, Ground Water Monitoring Review, Winter, 2000.

Church, Peter E., and Granato, Gregory E., *Bias in Ground Water Data Caused by Well-Bore Flow in Long-Screen Wells*" Ground Water, Vol.34, No.2, pp. 262-273, 1996.

Cohen, Robert M., Bryda, Anthony P., Shaw, Scott T., Spalding, Charles P., *Evaluation of Visual Methods to Detect NAPL in Soil and Water*, Ground Water Monitoring Review, Fall, 1992.

deVera, Emil R., Bart P. Simmons, Robert D. Stephens and David L. Storm, *Samplers and Sampling Procedures for Hazardous Waste Streams*, Cincinnati, USEPA Municipal Environmental Research Lab EPA-600/2-80-018, 1980.

Dragun, J., R.Gambino and W. Kuhn, *Coloration Changes of Geologic Media After Addition of Gasoline, Diesel Fuel, and Ethylbenzene,* The Journal of Soil Contamination, Vol. 5, No. 1, pp. 1 - 8, 1996

Dragun, J., *The Fate of Hazardous Materials in Soil, What Every Geologist and Hydrogeologist Should Know,* Part 1, HMC, March/April 1988

Driscoll, F.G., *Ground Water and Wells*, Second Edition, H.M. Smyth Company Inc., St. Paul, Minnesota, 1986

Elton, E.L. and E. Fendley, *Installing the Perfect Monitoring Well:Identifying, Quantifying, and Mitigating Interferences from Monitoring Well Installation Techniques*, Presented at: Symposium for Ground Water Contamination Studies and Their Standardization, ASTM Cocoa Beach, Fla., February 1986.

Environmental Research Laboratory, Robert S. Kerr, *Practical Guide for Ground Water Sampling*, Ada. OK, US Government Printing Office, EPA-600/2-85/104, 1985.

Fetter, C.W., Jr., *Contaminant Hydrogeology*, 1993

Fink, Michael J., Boyajian, Ralph T.*, Decontamination Procedures for Ground Water Sampling Equipment*, Proceedings of the Third National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, May 1989.

Folk, R.L., *Petrology of Sedimentary Rocks,* Hemphill Publishing Company, 1974.

Foster, M., Stefanov, J, Bauder, T., Shinn, J., and Wilson, R., *Piezometer Installation Using a Cone Penetrometer* Ground Water Monitoring Review Fall, 1995.

Franson, MaryAnn H., Managing Ed., *Standard Methods for the Examination of Water and Wastewater 16th Edition*, Port City Press, Baltimore, Md., 1985.

Franson, Mary Ann H., Managing Ed.*, Standard Methods for the Examination of Water and Wastewater 20th Edition*, American Public Health Association, Washington, D.C., 1998.

Gallant, R.F., J.W. King, P.L. Levins, J.F. Piecewicz, *Characterization of Sorbent Resins for Use in Environmental Sampling*, Research Triangle Park, N.C., US Government Printing Office, EPA-600/7-78-054, 1978

Gerlach, Robert W., Dobb, David E., Raab, Gregory A., and Mocerino, John M., *Gy Sampling Theory in Environmental Studies. 1. Assessing Soil Splitting Protocols*, Journal of Chemometrics, Vol. 16, pp. 321-328, 2002.

Gibbs, J., Brown, Allan G., Turner, Kenneth S., MacLeod, Cecilia L., Jelinski, James C., Koehnlein, Susan A., *Effects of Small-Scale Vertical Variations in Well-Screen Inflow Rates and Concentrations of Organic Compounds on the Collection of Representative Ground-Water Quality Samples*, Ground Water, Vol. 31, No.2, March-April, 1993.

Gibb, J.P., and M.J. Barcelona, *The Development of Effective Ground Water Sampling Protocols,* Presented at: Symposium of Field Methods for Ground Water Contamination Studies and Their Standardization, ASTM, Cocoa Beach, Fla., Feb. 1986.

Gibs, J., and Imbrigiotta,Thomas E., *Well Purging Criteria for Sampling Purgeable Organic Compounds*, Ground Water Vol.28, No. 1, pp 68-78, 1990.

Gibs, J., Imbrigiotta, Thomas E., Ficken, James H., Pankow, James F., Rosen, Michael E., *Effects of Sample Isolation and Handling on the Recovery of Purgeable Organic Compounds*, Ground Water Monitoring Review, Spring, 1994.

Gillham, R.W., M.J.L. Robin, J.F. Baker, and J.A. Cherry, *Ground Water Monitoring and Sample Bias*, American Petroleum Institute, APR Publication 4367, p 206, 1983.

Hacket, Glen, *Drilling and Constructing Monitoring Wells with Hollow-Stem Augers, Part 2 Monitoring Well Installation*, Ground Water Monitoring Review, pages 60 - 68, 1988

Hart, Barbara F., Tomlinson, Rodger B., and Chaseling, J., *Using the Stabilization Plateau to Estimate Optimum Well Purge Volume*, Ground Water Monitoring Review, Summer, 2000.

Hewitt, A.D.. *Enhanced Preservation of Volatile Organic Compounds in Soil with Sodium Bisulfate*, U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Special Report 95-26, 1995.

Hewitt, Alan D., Jenkins, Thomas F., Grant, Clarance L., *Collection, Handling and Storage: Keys to Improved Data Quality for Volatile Organic Compounds in Soil,* American Environmental Laboratory, February 1995.

Hewitt, Alan D., Lukash, Nicole J.E., *Obtaining and Transferring Soils for In-Vial Analysis of Volatile Organic Compounds*. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Special Report 96-5, 1996.

Hewitt, Alan D., *Chemical Preservation of Volatile Organic Compounds in Soil*, Environmental Science and Technology, Vol. 31, No. 1, 1997

Hewitt, Alan D., *Dynamic Study of Common Well Screen Materials*, Ground Water Monitoring Review, Winter, 1994.

Hewitt, Alan D., *Storage and Preservation of Soil Samples for Volatile Organic Compound Analysis*, U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Special Report 99-5, 1999

Hewitt, A. D., Myers, K. F., *Sampling and On-Site Analytical Methods for Volatiles in Soil and Groundwater-A Field Guidance Manual*, U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Special Report 99-16, 1999.

Hewitt, Alan D., *Frozen Storage of Soil Samples for VOC Analysis*, Environmental Testing and Analysis, Vol. 8, No. 5, 1999.

Hewitt, Alan D., *Methods of Preparing Soil Samples for Headspace Analysis of Volatile Organic Compounds: Emphasis on Salting Out*, Proceedings of the Waste Testing and Quality Assurance Symposium, pp. 323-329, 1996.

Hewitt, Alan D., Jenkins, Thomas F., Grant, Clarance L., *Collection Handling and Storage: Keys to Improved data quality for Volatile Organic Compounds in Soil*, American Environmental Laboratory, February, 1995.

Hyman, Jennifer A., McLaughlin, Dennis G., *Multi-Level Sampling for Naphthalene In a Shallow, Sandy Aquifer*, Ground Water Management, Proceedings of the Fifth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods. 1991.

Hutchins, Stephen R., Acree, Steven D., *Ground Water Sampling Bias Observed In Shallow, Conventional Wells*, Ground Water Monitoring Review, Winter, 2000.

Hutzler, Neil J., *Processes Controlling the Transport and Fate of VOCs in Soil*, National Symposium on Measuring and Interpreting VOCs in Soils: State of the Art and Research Needs, Las Vegas, Nevada, January 12-14, 1993.

Hutchins, Stephen R., Acree, Steven D., *Ground Water Sampling Bias Observed In Shallow, Conventional Wells*, Ground Water Monitoring Review, Winter, 2000.

Imbrigiotta, Thomas E., Gibs, J., Fusillo, T.V., Kish, George R., Hochreiter, Joseph J., *Field Evaluation of Seven Sampling Devices for Purgeable Organic Compounds in Ground Water*, Ground-Water Contamination: Field Methods, ASTM STP 963, A.G. Collins and A. J. Johnson, Eds., American Society for Testing and Materials, Philadelphia, PA 1998.

Jury, W.A., Russo, D., Streile, G., Sesham, E.A., *Evaluation of Volatilization by Organic Chemicals Residing Below the Soil Surface*. Water resources Research, Vol. 26, No. 1 pp.13-20, 1990.

Kaplan, E., Banerjee, S., Ronen, D., Magaritz,M., Machlin, A., Sosnow,M., Koglin, E., *Multilayer Sampling in the Water-Table Region of a Sandy Aquifer*, Ground Water, Vol. 29, No.2, 1991.

Kerri, Kenneth D., Proj. Dir., *Operation of Wastewater Treatment Plants, Sacramento, Ca*., California State University, 1983.

Kerri, Kenneth D., Proj. Dir., *Industrial Waste Treatment, Sacramento, Ca*., California State University, 1987.

Kerri, Kenneth D., Proj. Dir., *Pretreatment Facility Inspection, Sacramento, Ca*., California State University, 1988.

Lapham, W.W., F.D. Wilde, and M.T. Koterba, *Guidelines and Standard Procedures for Studies of Ground-Water Quality: Selection and Installation of Wells, and Supporting Documentation*, U.S.G.S. Water-Resources Investigations Report 96-4233, 1997.

Liikala, Terry L., Olsen, Khris B., Teel, Steven S., Lanigan, David C., *Volatile Organic Compunds: Comparison of Two Sample Collection and Preservation Methods*, Environmental Science and Technology, Vol. 30, No. 12, 1996.

McAllister, P.M., Chiang, C.Y., *A Practical Approach to Evaluating Natural Attenuation of Contaminants in Ground Water*, Ground Water Monitoring Review, Spring, 1994

Mackiewicz, Michael C., *A Simple 11 Step Procedure to Document the Accuracy, Precision and Significance of Measurements by Field Instrumentation*, Proceedings of the Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, Ground Water Management, 1990.

McCall, W., Stover,S., Enos, C., Fuhrmann,G., *Field Comparison of Direct Push Prepacked Screen Wells to Paired HAS 2" PVC Wells*, Conference Proceedings, HazWaste World Superfund XVIII, December, 1997.

McGinnis Services, *Engineered Technical Approach for the Installation & Sampling of the SVE/AS Well Project, Routes 532 & 72*, Woodland Private Study Group Site, 1998.

Millson, M., Eller, P.M., Ashley, K., *Evaluation of Wipe Sampling Materials for Lead In Surface Dust*, Journal of American Industrial Hygiene,Vol. 55, No.4 p.339-1994.

Montgomery, John H., Welkom, Linda M., *Groundwater Chemicals Desk Reference*, Lewis Publishers, Chelsea, Michigan, 1990.

Morrison, Robert D, *Ground Water Monitoring Technology: Procedures, Equipment, and Applications*, Prairie DuSac, Wis., TIMCO Mfg., Inc., 1983.

Neilson, David M. and Gillian L. Yeates, *Comparison of Sampling Mechanisms Available for Small-Diameter Ground Water Monitoring Wells*, Ground Water Monitoring Review vs.Vol. 4, No. 2 pp. 83-99, Spring, 1984.

Newell, Charlse J., Lee, Robert S. Spexet, AnnMarie H., *No-Purge Ground Water Sampling: An Approach for Long-Term Monitoring*, American Petroleum Institute, October, 2000.

NJDEP, *Alternative Ground Water Sampling Techniques Guide*, July, 1994.

New Jersey Department of Environmental Protection and Energy, *Field Sampling Procedures Manual*, pp. 134-135, May, 1992.

New Jersey Department of Environmental Protection*, Field Procedures Manual for Water Data Acquisition*, Division of Water Resources, 1987.

New Jersey Department of Environmental Protection, *New Jersey Safe Drinking Water Act, N.J.A.C. 7:10-1.3.* Division of Water Resources.

New Jersey Department of Environmental Protection, *The Technical Requirements for Site Remediation*, N.J.A.C. 7:26E *et seq*.

New Jersey Register, Proposed New Rules: *N.J.A.C. 7:9D*, Monday, August 7, 2000.

Nyer, E.K., and Gearhart, M.J., *Plumes Don't Move*, Ground Water Monitoring Review,Winter, 1997.

Oneacre, John., and Figueras, Debbie., *Ground Water Variability at Sanitary Landfills Causes and Solutions, Proceedings of Uncertainty*, Geotechnical Engineering Division/ASCE,1996.

Parker, Louise V., *The Effects of Ground Water Sampling Devices on Water Quality: A Literature Review*, Ground Water Monitoring Review, Vol. 14, No. 2, pp. 130-141, 1994.

Parker, L.V. and T.A. Ranney, *Sampling Trace-Level Organics with Polymeric Tubings: Part 1. Static Studies*, Ground Water Monitoring and Remediation, Vol. 17, No. 4, pp. 115-124, 1997.

Parker, L.V. and T.A. Ranney, *Decontaminating Groundwater Sampling Devices*, Special Report 97-25, CRREL, 1997.

Parker, L.V. and T.A. Ranney, *Decontaminating Materials Used in Groundwater Sampling Devices*, Special Report 97-24, CRREL, 1997.

Parker, L.V. and T.A. Ranney, *Sampling Trace-Level Organics with Polymeric Tubings: Part 2. Dynamic Studies*, Ground Water Monitoring and Remediation, Vol. 18, No.1, pp. 148-155, 1998.

Parker, L.V. and T.A. Ranney**,** *Decontaminating Materials used in Ground Water Sampling Devices: Organic Contaminants*, Ground Water Monitoring and Remediation, Vol. 19, No. 1, pp. 56-68, 2000.

Paul, Cynthia J., and Puls, Robert W., *Impact of Turbidity on TCE and Degradation Products in Ground Water*, Ground Water Monitoring Review, Winter, 1997.

Pettijohn, F.J., *Sedimentary Rocks*, Harper & Row, 1975.

Public Service Electric and Gas Company, *Generic Remedial Investigation Work Plan*, Rock Coring - Standard Operating Procedure 310, November, 1997.

Public Service Electric and Gas Company, *Phase III Remedial Investigation Report for the Former Paterson Gas Plant, Paterson, NJ*, Woodward-Clyde Consultants.

Puls, Robert W., and Barcelona, Michael J., *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, USEPA Report, EPA/540/S-95/504, April, 1996.

Puls, Robert W., Eychaner, James H., *Sampling of Ground Water for Inorganics – Pumping Rate, Filtration, and Oxidation Effects*, Ground Water Management Proceedings of the Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods, 1990.

Radcliffe, M.J., B.W. Rehm, C.S. Peters, T.R. Stolzenburg, and S.D. Johannsen, *Sample Handling: The Impact of Filtering Ground Water Samples*, Proceedings of the Fourth Annual Hazardous Materials Management Conference, Atlantic City, NJ, June 1986.

Rajagopal, R., Williams, L. R., *Economics of Sample Compositing as a Screening Tool*, Ground Water Quality Monitoring, Vol. 9, No. 1, 1989.

Ranney, T.A. and L.V. Parker, *Comparison of Fiberglass and Other Polymeric Well Casings: Part III. Sorption and Leaching of Trace-Level Metals*, Ground Water Monitoring and Remediation, Vol. 18, No. 3, pp. 127-133, 1998.

Ranney, T.A. and L.V. Parker, *Comparison of Fiberglass and Other Polymeric Well Casings: Part II. Sorption and Leaching of Trace-Level Organics*, Ground Water Monitoring and Remediation, Vol. 18, No. 2, pp. 107-112, 1998.

Ricker, Michael J., *Determining Volatiles in Soils: A New Sampling Procedure*, Environmental Testing and Analysis, Vol. 8, No. 4, 1999.

Robbins, Gary A., Martin-Hayden, James M., *Mass Balance Evaluation of Monitoring Well Purging* Journal of Contaminant Hydrology, Vol. 8, pp. 203-224, 1991

Robbins, Gary A., Henebry, Brent J., Cummins, Timothy M., Goad, Christopher R., Gilbert, Edward J., *Occurrence of MTBE in Heating Oil and Diesel Fuel in Connecticut*, Ground Water Monitoring Review, Fall, 2000.

Robin, M.J.L., and Gillham, R.W., *Field Evaluation of Well Purging Procedures*, Ground Water Monitoring Review, Fall, 1987.

Rose, S., and Long, A., *Monitoring Dissolved Oxygen in Ground Water: Some Basic Considerations*, Ground Water Monitoring Review, Winter, 1998.

Ryan, Robert G., and Dhir, V.K., *The Effect of Interfacial Tension on Hydrocarbon Entrapment and Mobilization Near a Dynamic Water Table*, Journal of Soil Contamination, Vol. 5, No.1 pp.9-34. 1996.

Scalf, Marion R. et. seq., *Manual of Ground Water Sampling Procedures*, USEPA and National Well Water Association, Worthington, OH, pp. 92-93, 1981.

Schumacher, Brian A., Ward, Steven, E., Q*uantitation Reference Compounds and VOC Recoveries from Soils by Purge and Trap GC/MS*., Environmental Science and Technology, Vol. 31, No. 8, 1997.

Schumacher, B.A., Shines, K.C., Burton, J.V., Papp. M.L., *A Comparison of Soil Sample Homogenization Techniques*, Hazardous Waste Measurements, Chapter 4. Lewis Publishers, Michigan, 1991.

Seanor, A.M. and L.K Brannaka, *Influence of Sampling Techniques on Organic Water Quality Analysis,* Presented at: Management of Uncontrolled Hazardous Waste Sites Conference, Washington, DC., Oct., 1984.

Siegrist, Robert L., *Measurement Error Potential and Control When Quantifying Volatile Hydrocarbon Concentrations in Soils*, Hydrocarbon Contaminated Soils, Vol. I, Lewis Publishers, pp. 205-215, 1991.

Siegrist, Robert L., Jenssen, Petter D., *Evaluation of Sampling Method Effects on Volatile Organic Compound Measurements in Contaminated Soils*, Environmental Science and Technology, Vol. 24, No. 9, 1990.

Sorini, Susan S., Schabron, John F., Rovani, Joseph F., Evaluation of VOC Loss From Soil Samples Contaminated Soil Sediment and Water, April/May, 2002.

Steila, D. and T. Pond, *The Geography of Soils, Formation, Distribution and Management,* 2nd edition, Rowman & Littlefield Publishers, Inc., 1989.

Stevenson, T.J., *Design of a Quality Assurance Program for the Assessment of Ground Water Contamination,* Presented at: NWWA Conference on Ground Water Management, Orlando, Fla., October, 1984.

Stone, William J., *Low Flow Ground Water Sampling-Is It a Cure-All?*, Ground Water Monitoring Review Spring, 1997.

Storch Engineers, *Standard PCB Transformer Sampling Procedures,* in SOP, 1986.

Testa, Stephen M., and Winegardner, Duane L., *Restoration of Contaminated Aquifers*, Lewis Publishers, New York, New York, 1991.

Tai, Doreen Y., Turner, Kenneth S., and Garcia, Lisa A., *The Use of a Standpipe To Evaluate Ground Water Samplers,* Ground Water Monitoring Review, Winter, 1991.

Thomas, J.M., J.R. Skalski, L.L. Eberhardt, and M.A. Simmins, *Field Sampling for Monitoring*, *Migration and Defining the Areal Extent of Chemical Contamination*, Presented at: Management of Uncontrolled Hazardous Waste Sites Conference, Washington, DC., Oct. 1984.

Triplett, Laura D., Burford, P., Sielaff, B., Clark, R.C., *Sampling Procedures for Ground Water Monitoring Wells*, State of Minnesota, Minnesota Pollution Control Agency, 1997.

United States Department of Interior, *Ground Water Manual, A Water Resources Technical Publication*, Bureau of Reclamation, Chapters 16 and 17, 1985.

United States Environmental Protection Agency, *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*, Office of Research and Development, EPA/600/4-89/034, Washington, D.C., March, 1991.

USEPA, *Field Analytical and Site Characterization Technologies Summary of Application*s EPA-542-R-97-011, November, 1997.

USEPA, *Characterization of Hazardous Waste Sites: A Methods Manual Vol. II Available Sampling Methods*, EPA-600/4-83-040 Environmental Monitoring and Support Laboratory Las Vegas, NV, 1983.

USEPA, *Handbook for Sampling and Sample Preservation of Water and Wastewater*, EPA-600/4-82-029 Environmental Monitoring and Support Laboratory, Cincinnati OH, 1982.

USEPA, *Field and Laboratory Methods for Macroinvertebrate and Habitat Assessment of Low Gradient Non-Tidal Streams*, Mid-Atlantic Coastal Streams Workgroup, Environmental Services Division, Region 3, Wheeling, WV 26003, 23 pp.,1997.

USEPA, Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling, *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish*, Second Edition, EPA 841-B-99-002, USEPA Office of Water, Washington, DC, 1999.

USEPA, *Methods for Measuring The Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates*, Second Edition. EPA/600/R-99/064, USEPA Office of Research and Development and Office of Water, Washinton, DC, 2000.

USEPA, *Ground Water Monitoring Guidance for Owners and Operators of Interim Status Facilities*, EPA-SW-963, Office of Solid Waste and Emergency Response Washington, DC, 1983.

USEPA, *Handbook for Sampling and Sample Preservation of Water and Wastewater*, Cincinnati, OH, 1982.

USEPA, *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*, Office of Water Engineering and Analysis Division, April, 1995.

USEPA, *Suggested Operating Procedures for Aquifer Pumping Tests*, EPA/540/S-93/503, Office of Research and Development, Washington, DC, 1993.

USEPA, *Immunoassay Guidelines for Planning Environmental Projects*, USEPA Quality Assurance Unit Staff, Office of Environmental Measurement and Evaluation, October, 1996.

USEPA, *Light Non-Aqueous Liquids*, EPA/540/S-95/500, Office of Solid Waste and Emergency Response, 1995.

USEPA, *Non-Aqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling and Remediation*, EPA/540/S-95/503, Office of Solid Waste and Emergency Response, 1995.

USEPA, *Suggested Operation Procedures for Aquifer Pumping Tests*, EPA/540/s-93/503, Office of Solid Waste and Emergency Response, February, 1993.

USEPA, *Standard Operating Procedure for Elemental Analysis Using the X-Met 920 Field X-Ray Fluorescence Analyzer*, Office of Environmental Measurement and Evaluation, November, 1996.

USEPA, *Soil Sampling and Analysis for Volatile Organic Compounds*, EPA/540/4-91/001, Office of Solid Waste and Emergency Response, 1991.

USEPA, *Lead in Drinking Water-Should You Be Concerned?*, Office of Water, February 1987.

USEPA, *NPDES Compliance Inspection Manual*, Washington, D.C., 1984.

USEPA, *NPDES Compliance Sampling Manual*, Washington, D.C., 1977.

USEPA, *Contract Lab Program (CLP) Statement of Work (SOW) for Organic Analysis, Multi-Media, Multi-Concentration*, Document OLMO4.1. 1998.

USEPA, *Rapid Bioassesment Protocols for Use In Streams and Rivers*, 1989.

USEPA, *Test Methods for Evaluating Solid Waste Physical/Chemical*, SW-846 Final Update3 to the 3rd Edition, 1996.

USEPA, *Standard Operating Procedures, Model 5400 GeoprobeÔ Operation*, SOP 2050, 1996.

USEPA, *Clarification Memorandum from Elizabeth Cotsworth to Regions I-X Regarding Use of SW-846 Methods*, Office of Solid Waste, 1998.

USEPA, *Contract Lab Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration*, Document OLMO4.2A Corrections/Modifications/Clarifications. 2000.

USGS, *Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water Quality Samples and Related* Data, U.S. Geological Survey Report 95-399. 1995.

USGS, *Field Guide for Collecting Samples For Analysis of Volatile Organic Compounds In Stream Water for the National Water Quality Assessment Program*, U.S. Geological Survey Report 97-0401, 1997.

USGS, *Field Guide for Collecting and Processing Stream-Water Samples for the National Water-Quality Assessment Program*, U.S. Geological Survey Report 94-455, 1994.

University of Arizona, College of Agriculture, *Field Manual for Water Quality Sampling*, March, 1995.

Urban, Michael J., Smith, James S., Schultz, Elizabeth.K., Dickenson, Randall K., *Volatile Organic Analysis for a Soil, Sediment or Waste Sample*, Fifth Annual Waste Testing and Quality Assurance Symposium, July 24-28, Washington, D.C.,pp. II-87 to II-101, 1989.

United State Geological Society, *Field Guide for Collecting Samples for Analysis of Volatile Organic Compounds in Stream Water for the National Water-Quality Assessment Program*, US Geological Survey Report 97-401, 1997.

USGS, *Ground-Water Data – Collection Protocols and Procedures for the National Water-Quality Assessment Program: Selection, Installation, and Documentation of Wells, and Collection of Related Data*, U.S. Geological Survey, Report 95-398, 1995.

USGS, *Guidelines for Collecting and Processing Samples of Stream Bed Sediment For Analysis of Trace Elements and Organic Contaminants for the National Water Quality Assessment Program*, US Geological Survey Report 94-458, 1994.

USGS, *Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data,* August, 1998.

USGS, *U.S. Geological Survey Protocol for the Collection and Processing of Surface Water Samples for the Subsequent Determination of Inorganic Constituents in Filtered Water*, USGS Report 94-539, 1994.

USGS, *Quality-Control Design for Surface-Water Sampling in the National Water-Quality Assessment Program*, US Geological Survey Report 97-223, 1997.

USGS, *Use of an Ultra-Clean Sampling Technique with Inductively Coupled Plasma-Mass Spectrometry to Determine Trace-Element Concentrations in Water from The Kirkwood-Cohansey Aquifer System, Coastal Plain, New Jersey*, US Geological Survey Report 96-142, 1996.

Vroblesky, Don A., Borchers, James W., Campbell, Ted R., Kinsey, W., *Investigation of Polyethylene Passive Diffusion samplers for Sampling Volatile Organic Compounds in Ground Water at Davis Global Communications, Sacramento, California, August 1998 to February 1999*, U.S. Air Force Center for Environmental Excellence, 2000

Vroblesky, Don A. Hyde, Thomas W., *Diffusion Samplers as an Inexpensive Approach to Monitoring VOC's in Ground Water*, Ground Water Monitoring Review, Summer, 1997.

Vroblesky, Don A., *User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells*, Part 1 and Part 2., USGS Reports 01-4060 and 01-4061, 2001.

Vroblesky, Don A., Petkewich, Matthew D., *Diffusion Sampler Testing at Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, November 1999 to May, 2000*

Vroblesky, Don A. and Peters, Brian C., *Diffusion Sampler Testing At Naval Air Station North Island, San Diego County, California, November 1999 to January 2000*, USGS Water Resources Investigation, Columbia, South Carolina, 2000

Wells, R.B., *Cores, Cores, Cores*, National Drillers Buyers Guide, pp. 47, August ,1991.

West, Olivia R., Siegrist, Robert L., Mitchell, Toby J., Jenkins, Rodger A., *Measurement Error and Spatial Variability Effects on Characterization of Volatile Organics in the Subsurface*, Environmental Science and Technology, Vol. 29, No. 3, 1995.

Wickramanayake, Godage B., Gavaskar, Arun R., Kelley, Mark E., Nehring, Karl W., *Risk, Regulatory, and Monitoring Considerations Remediation of Chlorinated and Recalcitrant Compounds*, The Second International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 2000

Wilson, Neal, *Soil Water and Ground Water Sampling*, Chapter 3, Lewis Publishers, 1995

Wisconsin Department of Natural Resources, *Ground Water Sampling Desk Reference*, Report PUBL-DG-037 96, September, 1996.

Wisconsin Department of Natural Resources, *Ground Water Sampling Field Manual*, Report PUBL-DG-038 96, September, 1996.

29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response: Interim Final Rule*, Occupational Safety and Health Administration.

USGS Links of Interest

http://water.usgs.gov/owq/FieldManual/
USGS National Field Manual for the Collection of Water-Quality Data

http://toxics.usgs.gov/pubs/FS-075-01/#4
USGS information on packer application

http://water.usgs.gov/nrp/proj.bib/paillet.html
USGS National Research Program: *Borehole Geophysics as Applied to Geohydrology*

http://ca.water.usgs.gov/pnsp/pest.rep/voc.html
USGS Open-File Report 97-401. A *Field Guide for Collecting Samplers for Analysis of VolatileOrganic Compounds in Stream Water for the National Water-Quality Assessment Program.*

http://water.usgs.gov/pubs/wri/wri004252/
USGS Water-Resources Investigations Report 00-4252. *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation and Reporting.*

http://water.usgs.gov/admin/memo/QW/qw97.03.html
USGS Memorandum on proper cleaning of churn splitters when trace metal analysis is required.

http://water.usgs.gov/owq/FieldManual/mastererrata.html#Chapter4
USGS Field Manual Errata on how to repair churn splitter leakage at the spigot.

http://toxics.usgs.gov/pubs/FS-075-01/#4
USGS National Research Program: *Characterizing Ground-Water Chemistry and Hydraulic Properties of Fractured-Rock Aquifers Using the Multifunction Bedrock-Aquifer Transportable Testing Tool (BAT³)*

http://energy.usgs.gov/factsheets/Core/crc.html
USGS Core Center Research: *Sample and Data Rescue at the Core Research Center*

http://geology.cr.usgs.gov/crc/
USGS Core Center Research: *About the Core Research Center*

http://water.usgs.gov/owq/pubs/wri/wri964233/wri964233.pdf
USGS Water Resoures Investigation Report 96-4233: *Guidelines and Standard Procedures for Studies of Ground-Water Quality: Selection and Installation of Wells and Supporting Documentation*.

USEPA Links of Interest

http://www.epa.gov/superfund/programs/dfa/dirtech.htm,
USEPA Direct Push Information Web Page

http://epa.gov/swerust1/pubs/esa-ch5.pdf
USEPA Chapter 5 "Direct Push Technologies" *From: Expedited Site Assessment Tools For Underground Storage Tank Sites: A Guide for Regulator, EPA 510-B-97-001* – Released by the Office of Underground Storage Tanks.

http://www.epa.gov/etv/index.html
USEPA ETV Home Page

Other URLs of Interest

Soil Science

http://www.astm.org/DATABASE.CART/PAGES/D2113.htm
ASTM Document Summary: D-2113-99, *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation.*

http://www.astm.org/DATABASE.CART/PAGES/D2487.htm
ASTM Document Summary: D-2487-00, *Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)*

http://www.astm.org/DATABASE.CART/PAGES/D5079.htm
ASTM Document Summary: D-5079-02, *Standard Practices for Preserving and Transporting Rock Core Samples.*

http://www.astm.org/DATABASE.CART/PAGES/D6032.htm
ASTM Document Summary: D-6032-02, *Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core.*

http://www.fact-index.com/g/gr/grain_size.html
Wikipedia Fact Index: *Grain Size*

http://scholar.lib.vt.edu/theses/available/etd-32398-73623/unrestricted/appendixB.pdf
Unified Soil Classification Chart*: Relationship between Swell Index and Attenberg Limits*

http://www.dlwc.nsw.gov.au/care/soil/soil_pubs/soil_tests/pdfs/usc.pdf
Soil Survey Standard Test Method, Unified Soil Classification System: *Field Method*

http://www.itc.nl/~rossiter/Docs/FM5-410/FM5-410_Ch5.pdf
Soil Classification

http://www.brookes.ac.uk/geology/8320/sst-text.html
Oxford Brookes University, *Geology: Textures in Terrigenous Clastic Rocks*

http://www.seafriends.org.nz/enviro/soil/rocktbl.htm#soil%20properties
Classification of Common Rocks, Soil and More

http://csmres.jmu.edu/geollab/Fichter/SedRx/sedclass.html
James Madison University Geology Lab: *A Basic Sedimentary Rock Classification*

http://www.eos.ubc.ca/courses/eosc221/sed/sili/siligsize.html
University of British Columbia, *Siliciclastics: Grain Size*

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10931
US Dept. of Labor, Occupational Safety and Health Admin., Regulation (Standards - 29 CFR), *Soil Classification - 1926 Subpart P, Appendix A.*

http://www.hawaiiasphalt.com/HAPI/modules/06_design_factors/usc.htm
Hawaii Asphalt Paving Industry's Table depicting the *Unified Soil Classification System*

http://web.stclair.k12.il.us/splashd/soiltype.htm
Soil Type Decision Tree

http://www.civil.columbia.edu/%7Eling/burmister/burmister.html
Biography of Donald Burmister

Sediments

http://www.epa.gov/ost/cs/
USEPA Water Science: *Contaminated Sediments*

http://www.epa.gov/OST/pc/csnews/
USEPA Water Science: *Contaminated Sediments Newsletters (Archived)*

http://el.erdc.usace.army.mil/dots/
US Army Corps of Engineers: *Dredging Operations Technical Support Program*

http://www.epa.gov/glnpo/sediments.html
USEPA, *Great Lakes Contaminated Sediments Programs*

http://www.nap.edu/books/0309054931/html/
National Academy of Science, Contaminated Sediments in Ports and Waterways*: Cleanup Strategies and Technologies*

http://www.sednet.org/
European Sediment Research Network

http://www.smwg.org/
Sediment Management Work Group: *Home Page*

http://www.rtdf.org/
Remediation Technologies Development Forum: *Home Page*

Manufacturers/Vendors of Environmental Sampling Equipment

http://geoprobe.com,
Geoprobe Home Page

http://www.ams-samplers.com/main.shtm?PageName=welcome.shtm.
ARTS Manufacturing Home Page

http://www.generaloceanics.com/
General Oceanics Home Page

http://www.aquaticresearch.com/
Aquatic Research Instruments Home Page

http://www.fultzpumps.com/
Fultz Pumps Home Page

http://www.wildco.com/
Wildlife Supply Company Home Page

http://www.geotechenv.com/
Geotech Home Page

http://www.bennettsamplepump.com/
Bennett Sample Pumps Home Page

http://www.qedenv.com/
QED Environmental Systems

http://www.isco.com/
ISCO

http://eonpro.com/
EON Home Page

http://www.caslab.com/
Columbia

General

http://www.state.nj.us/dep/srp/regs/techrule/index.html
NJDEP "Tech Rules" N.J.A.C. 7:26E *Technical Requirements for Site Remediation*

http://www.animatedsoftware.com/pumpglos/pumpglos.htm
The Internet Glossary of Pumps (Animated)