Chapter 5
Sampling Equipment

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5.1 Introduction

Collection of environmental and waste samples often requires various types of sampling equipment to compliment specific situations encountered in the field. Selection of approved sampling equipment is based on the sample type, matrix, and physical location of the sample point and other site-specific conditions. Consideration must also be given to the compatibility of the material being sampled with the composition of the sampler.

This chapter addresses sampling equipment for the following types of environmental samples: soil, sediment, ground water, surface water and air; wastewater samples; biological samples; and residual and waste samples which are comprised of process wastes or other man-made waste materials. This chapter is divided into two sections: *Aqueous and Other Liquid Sampling Equipment*, which is further divided into ground water, wastewater, surface water, and containerized liquids and; *Non-Aqueous Sampling Equipment*, which is further divided into soil, sediment, sludge, and containerized solids/ waste piles. Table 5.3, at the end of this chapter, lists NJDEP recommended waste material samplers and their application.

In order to minimize interference and cross contamination, all environmental, residual and waste sampling equipment used for the collection of environmental samples should be of polytetrafluoroethylene (PTFE, e.g., Teflon®), stainless steel or of a material approved or required for a specific parameter. PTFE is always the preferred material, but may not always be practical. Therefore, there are specific conditions under which material other than PTFE may be used. Some of these include the use of stainless steel equipment for soil and sediment sampling, carbon steel split spoons for soil sampling at depth, or disposable bailers constructed of polyethylene for the collection of ground water samples being analyzed for inorganics. In some cases of surface water, potable and wastewater sampling, collection directly into the laboratory provided sample container eliminates the need for sampling equipment, as well as field blank quality assurance samples. Use Table 5.1 as a guide for construction material of ground water sampling equipment.

While the preferred material of construction for sampling equipment used in waste sampling is PTFE or stainless steel, collection of some waste samples may not be possible with standard equipment. Therefore, alternate equipment constructed of different material may be necessary (e.g. glass COLOWASA or drum thieve). In all cases, the material of construction should be compatible with the sample being collected and should not interfere or be reactive with the parameters of concern.

This chapter lists and describes a wide variety of sampling equipment, their application, and a brief description of how to use them. Not all equipment presented here is applicable in all sampling situations. This chapter should be used along with the information provided in Chapter 6, *Sample Collection*, to assist in selecting the most appropriate sampling equipment. It is recognized that the dynamics of environmental sampling and related technological advances bring to the market sampling equipment that may not be included in this text. Aside from the NJDEP, the USEPA, U.S. Geological Survey, the U.S. Department of Defense, the U.S. Army Corps of Engineers, the American Society for Testing and Materials and other state and federal governmental agencies are continually active in testing and reviewing various types of sampling equipment and methodologies. Check the URLs at the end of this chapter for web sites offering reviews or discussion related to sampling equipment. Should interest in a novel approach be considered, it is recommended that the assigned NJDEP site or case manager grant approval before proceeding. Participants orchestrating sampling episodes under

Table 5.1 Materials of Construction for Ground Water Sampling Equipment			
Construction Material for Sampling Equipment (Does Not Apply to Well Casing)		**Target Analyte(s)**	
Material	**Description**	**Inorganic**	**Organic**
Plastics[1]			
Fluorocarbon polymers[2] (other varieties available for differing applications)	Chemically inert for most analytes.	√ (Potential source of fluoride.)	√ (Sorption of some organics.)
Polypropylene	Relatively inert for inorganic analytes.	√	**Do not use.**
Polyethylene (linear)	Relatively inert for inorganic analytes.	√	**Do not use.**
Polyvinyl chloride (PVC)	Relatively inert for inorganic analytes.	√	**Do not use.**
Silicon	Very porous. Relatively inert for most inorganic analytes.	√ (Potential source of Si.)	**Do not use.**
Metals[3]			
Stainless Steel 316 (SS-316)	SS-316 Metal having the greatest corrosion resistance. Comes in various grades. Used for submersible pump[3] casing.	√ (Potential source of Cr, Ni, Fe, and possibly Mn and Mo. **Do not use** for surface water unless encased in plastic (does not apply to submersible pumps).	√ Do not use if corroded.[4]
Stainless Steel 304	Similar to SS-316 but less corrosion resistant.	**Do not use**	√ Do not use if corroded.[4]
Other metals: brass iron, copper, aluminum, galvanized and carbon steels	Refrigeration-grade copper or aluminum tubing are used routinely for collection of $^{3}H/^{3}He$ and CFC samples	**Do not use**	√ Routinely used for CFCs. Do not use if corroded.
Glass			
Glass, borosilicate (laboratory grade)	Relatively inert. Potential sorption of analytes.	√ Potential source of B and Si.	√

1. Plastics used in connection with inorganic trace-element sampling must be uncolored or white.

2. Fluorocarbon polymers include materials such as Teflon™, Kynar™, and Tefzel™ that are relatively inert for sampling inorganic or organic analytes.

3. Most submersible sampling pumps have stainless steel components. One can minimize effects on inorganics sample by using fluorocarbon polymers in construction of sample-wetted components (for example, for a bladder, stator, or impeller) to the extent possible.

4. Corroded/weathered surfaces are active sorption sites for organic compounds.

√ Generally appropriate for use shown; Si, silica; Cr, chromium; Ni, nickel; Fe, iron; Mn, manganese; Mo, molybdenum; 3H/3He, tritium/helium-3; CFC chlorofluorocarbon; B, boron.

Table taken from the U.S. Geological Survey's Book 9, *Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter A2, *Selection of Equipment for Water Sampling*, (*http://water.usgs.gov/owq/FieldManual/*)

the auspices of the Site Remediation Program may contact the Bureau of Environmental Measurements and Site Assessment with related equipment questions. Sample collection inquiries of a more ecological nature may contact the Bureau of Freshwater and Biological Monitoring. The Technical Requirements for Site Remediation (N.J.A.C. 7:26E) offer an avenue for contractors to proceed with an innovative sampling approach should that technique be documented in peer reviewed scientific journals.

Selection of sampling equipment should always take into consideration its proper decontamination before use and, in the case of ground water sampling, the dedication of decontaminated equipment to individual wells for each day's sampling. Where general rules do not apply and alternate equipment is necessary, acceptability of its use will be determined on a case by case basis by NJDEP.

5.2 Aqueous And Other Liquid Sampling Equipment

Liquids, by their aqueous nature, are a relatively easy substance to collect. Obtaining representative samples, however, is more difficult. Density, solubility, temperature, currents, and a wealth of other mechanisms cause changes in the composition of a liquid with respect to both time and space. Accurate sampling must be responsive to these dynamics and reflect their actions.

The following discussion is subdivided into four sections: ground water; wastewater; surface water; and containerized liquids. The ground water section is concerned with obtaining samples from subsurface waters. The wastewater section previews manual and automatic samplers. The surface water section includes any fluid body, flowing or otherwise, whose surface is open to the atmosphere. The containerized liquid section will address sampling of both sealed and unsealed containers of sizes varying from drums to large tanks. Overlap may occur between sections as some equipment may have multiple applications; when in doubt, all sections should be consulted.

5.2.1 Ground Water Sampling Equipment

The importance of proper ground water sampling cannot be over emphasized. Even though the monitor well or temporary well point may be correctly located and constructed, precautions must be taken to ensure that the collected samples are representative of the ground water at that location. Extreme care must be taken to ensure that the sample is neither altered nor contaminated by the sampling equipment, sampling process or the sample handling procedure. This care extends to any purging equipment chosen to prepare the well for sampling.

Water within the well casing and filter pack may not be entirely representative of the overall ground water quality at the site. At the screened interval, this may be due to the presence of drilling fluids or general substrate disturbance following construction. Within the water column above the screen, physical and chemical conditions may vary drastically from conditions in the surrounding water-bearing zones. For these reasons, *one* of the following three general procedures must be employed prior to sample collection: 1) standing water above the screened interval must be evacuated *from the top* of the water column; 2) water within the screened interval must be removed until well stabilization is observed or; 3) a non-purge sampling technique may be employed, but only after pre-approved. (See Chapter 6, *Sample Collection*, Section 6.9., *Ground Water Sampling Procedures*, for more on sampling collection). Choosing the proper purging and sampling equipment will depend upon the chosen sampling technique which, in turn, will be determined by the sampling objectives.

5.2.1.1 Bottom Fill Bailer

One of the oldest and simplest methods of monitor well sampling is bailing. Bailer design is simple and versatile, consisting of a cylindrical length of PTFE or stainless steel with a check valve at the bottom. Bailers (Figures 5.1 and 5.2) are available in numerous dimensions to accommodate a wide variety of well diameters. Their low relative cost allows them to be utilized for a one-time use per well per sampling episode.

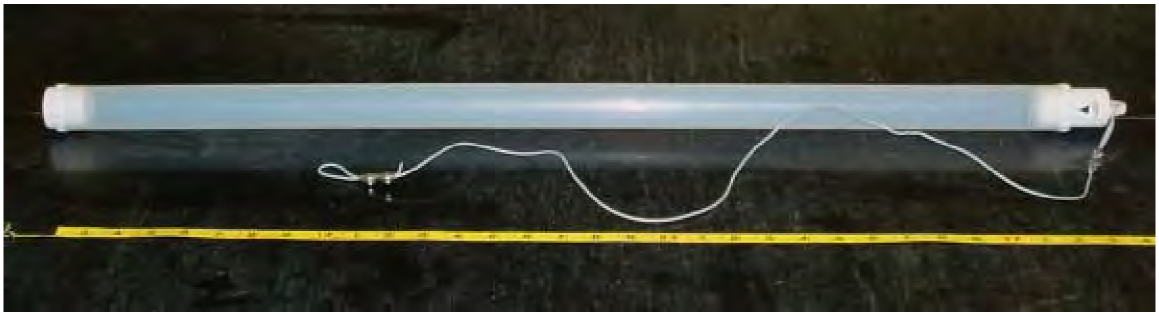

Figure 5.1 Bottom fill bailer with Teflon® coated stainless leader (Photograph by J. Schoenleber)

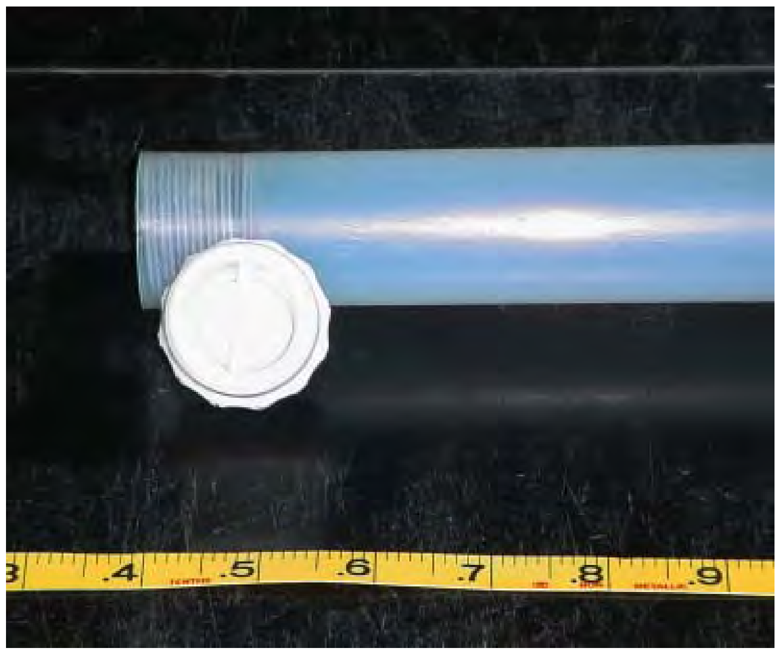

Figure 5.2 Teflon® constructed baler with Teflon® ball check valve (Photograph by J. Schoenleber)

The leader or bailer line that comes in contact with the water must be constructed of PTFE coated stainless steel. Above the leader, dedicated polyethylene cord is acceptable, if it does not contact the water.

The bailer, and any other equipment entering the well, must be laboratory cleaned and handled with new surgical gloves to prevent cross contamination. Surgical gloves must be changed between each sample location. Clean sampling equipment and any other objects entering the well should not be allowed to contact the ground or any other potentially contaminated surfaces (e.g. gasoline-fueled generators). If this should occur, that item should not be placed in the well or utilized for sampling. It is always a good practice to have extra laboratory cleaned bailers available at the site. Additionally, bailers and sample bottles must be physically separate from pumps or generators during transport and storage.

Disposable bailers are available in Teflon® and polyethylene construction. Teflon® disposable bailers can be used for any analysis, however, polyethylene disposable bailers can only be used for metals analysis. Disposable bailers are typically decontaminated by the manufacturer and must be provided in a sealed polyethylene bag. The manufacturer must be prepared to provide certification that the bailers are clean and state in writing the methods used to achieve decontamination. These bailers may then be acceptable for use depending on site-specific objectives and conditions.

Despite their attractive nature, bailers, even when carefully handled, result in some disturbance of the sample. Samples collected with bailers must be recovered with a minimal amount of aeration. This can be accomplished if care is taken to gradually lower the bailer *until* it contacts the water surface and is then allowed to fill as it slowly sinks in a controlled manner. However, despite the care taken to control aeration during the fill process, filling and emptying the bailer *will* alter dissolved oxygen concentrations. Due to these reasons (operator induced turbulence and air exposure) this device can not be relied upon to deliver accurate and reproducible measurements of any air sensitive parameter including, but not limited to, dissolved oxygen, pH, carbon dioxide, iron and its associated forms (ferric and ferrous). In addition, volatile organic analytical results may be biased low (due to aeration) and metals analytical results may be biased high (due to turbidity). Regardless, if this device is approved for use to collect analytical samples for data submission to the Department, it can not be used for data submission of the air sensitive parameters mentioned above. The Technical Requirements for Site Remediation (N.J.A.C. 7:26E-3.7) require that monitor well purge data accompany every ground water sample collected. Since bailers, by their nature, cannot provide for certain aspects of that requirement, a variance request for collection of any air sensitive parameter measurement by a bailer must be submitted for approval prior to sampling. Use the, US Geological Survey's, Book 9, *Handbooks for Water-Resources Investigations*, *National Field Manual for the Collection of Water-Quality Data*, Chapter 6A, *Field Measurements*, 6.2.1.C, *Measurement/Ground Water*, (*http://water.usgs.gov/owq/FieldManual/*), or, chose one of the references at the end of this chapter for documentation upon which to base the variance request.

Procedures for Use:

i. Remove laboratory decontaminated dedicated bailer from protective covering and connect to laboratory decontaminated dedicated leader/cable.

ii. Lower bailer slowly using polyethylene line until it contacts the water surface.

iii. Allow bailer to sink and fill with a minimum of disturbance to the sample.

iv. Slowly raise the bailer to the surface. Avoid contact of the bailer line to the well casing and/or ground.

v. Tip the bailer to allow a slow discharge from the top gently down the side of the sample bottle to minimize turbulence. A bottom-emptying device may also be utilized and may prove more useful when sampling for volatile organics. When applicable, always fill volatile organic sample vials first, to zero headspace, with the first bailer full of water.

vi. Repeat steps ii. to v. until a sufficient sample volume is acquired.

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

viii. Place used bailer in bag for return to lab for decontamination and dispose of polyethylene line.

ix. Procure an additional lab decontaminated bailer and proceed to the next sampling location. Repeat procedure.

x. When split sampling is required, sample from the bailer is used to alternately fill each bottle for every parameter of concern between all interested parties.

Advantages:

- no external power source required
- economical enough that a separate laboratory cleaned bailer may be utilized for each well, therefore eliminating cross contamination
- available in PTFE or stainless steel construction
- disposable bailers acceptable when material of construction is appropriate for contaminant
- simple to use, lightweight, portable

Disadvantages:

- limited volume of sample collected
- unable to collect discrete samples from a depth below the water surface
- field cleaning is not acceptable
- may not be used for well evacuation
- representativeness of sample is operator dependent
- reusable polyethylene bailers are not acceptable sampling devices for chemical analysis:
- ball check valve function susceptible to wear, dimension distortion and silt buildup resulting in leakage. This leakage may aerate succeeding sample and may gather unwanted material by rinsing unwanted material from well casing.
- cannot provide reliable or reproducible data for air sensitive parameters, e.g., dissolved oxygen, pH, carbon dioxide or iron and its associated forms. As a result, operator must submit to the Department a request for a variance from the Technical Requirements for Site Remediation Regulations (N.J.A.C. 7:26E-3.7), which requires the sampler to measure, record and submit well purging data.
- volatile organic analytical results may be biased low (due to aeration) and metals results may be biased high (due to turbidity).
- dedicating a bailer and leaving it in a well for long term monitoring is not recommended due to the potential risk of accumulated contamination.

5.2.1.2 Peristaltic Pump

Return to TOC

A peristaltic pump (Figure 5.3) is a self-priming suction lift (negative air pressure) pump utilized at the ground surface, which consists of a rotor with ball bearing rollers. One end of dedicated tubing is inserted into the well. The other end is attached to a short length of flexible tubing, which has been threaded around the rotor, out of the pump, and connected to a discharge tube. The liquid moves totally within the tubing, thus no part of the pump contacts the liquid. Tubing used for well evacuation may also be used for sample collection. Teflon®-lined polyethylene tubing is recommended for sampling. Medical grade silastic tubing is recommended for tubing in contact with the rotors. Based upon the required analysis and sampling objectives other materials are acceptable, but must first be approved on a case by case basis.

Due to the undesirable effects of negative pressure, which this pump continuously imparts to a sample, accurate and reproducible measurement of air sensitive parameters can not be obtained. This bias is extended to samples collected for, but not limited to, the following analyses: volatile organics, dissolved oxygen, pH, carbon dioxide, iron and its associated forms (ferric and ferrous). As a result, this device is restricted from the collection of surface and ground

Figure 5.3 Geopump™ Peristaltic Pump (Photograph by J. Schoenleber)

water samples for volatile and semi-volatile organic analysis. Since the Technical Requirements for Site Remediation (N.J.A.C. 7:26E-3.7) require that field measurements of dissolved oxygen, pH, temperature and specific conductivity accompany all sample collection data and, since this device is incapable of accurately delivering these measurements, a variance from the Technical Requirements must be obtained by the sampler. Use the US Geological Survey's Book 9, *Handbook for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter A6, *Field Measurements*, 6.2.1.C, *Measurement/Ground Water* for documentation on which to base the variance request (*http://water.usgs.gov/owq/FieldManual/*).

For the reasons stated above, this device may not be employed when utilizing the low-flow purging and sampling technique. Since some air sensitive parameters may support a scientific basis for choosing Monitored Natural Attenuation as a remedial strategy, use of this device may lead to unfounded decisions.

Procedures for Use

i. Check tubing at rotor for cracks or leaks, replace if necessary.

ii. Thread flexible length of tubing through rotor/pump.

iii. Insert dedicated length of tubing in well and attach to flexible tubing at rotor.

iv. Tubing depth introduced into the water column should not exceed 12 inches.

v. If necessary, add a small stainless steel weight to tubing to aid introduction of tubing into well casing (especially helpful in 2-inch diameter wells).

vi. Attach evacuation line to outlet of flexible pump tubing such that the discharge is directed away from pump and well.

vii. Engage pump and commence evacuation. Pump speed must be maintained at a rate that will not cause significant drawdown (>0.3 ft.). After well has been properly evacuated begin sampling.

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

Advantages:

- may be used in small diameter wells (2")
- sample does not contact the pump or other sampling equipment other than tubing prior to collection
- ease of operation
- speed of operation is variably controlled
- commercially available
- no decontamination of pump necessary (however, all tubing must be changed between wells)
- can be used for sampling inorganic contaminants
- purge and sample with same pump and tubing when analysis is limited to inorganics

Disadvantages:

- depth limitation of 25 feet
- potential for loss of volatile fraction due to negative pressure gradient, therefore volatile, semivolatile and air sensitive parameters cannot be collected through this device
- cannot provide reliable or reproducible data for air sensitive parameters e.g. dissolved oxygen, pH, carbon dioxide or iron and its associated forms. As a result, operator must submit to the Department a request for a variance from the Technical Requirement for Site Remediation Regulations (N.J.A.C. 7:26E-3.7), which requires the sampler to measure, record and submit well purging information associated with above parameters.
- may not be used as a pump in a low-flow purging and sampling scenario

5.2.1.3 Bladder Pump

◂ Return to TOC

An example of positive-displacement, the bladder pump (Figure 5.4) consists of a PTFE (e.g., Teflon®) or stainless steel housing that encloses a flexible Teflon® membrane. Below the bladder, a screen may be attached to filter any material that may clog check valves located above and below the bladder. The pumping action begins with water entering the membrane through the lower check valve and, once filled, compressed gas is injected into the cavity between the housing and bladder. Utilizing positive-displacement, water is forced (squeezed) through the upper check valve and into the sample discharge line. The upper-check valve prevents back flow into the bladder. All movement of gas and sample is managed through a series of regulators housed in a control mechanism at the surface. The source of gas for the bladder is either bottled (typically nitrogen or ultra zero air) or via an on-site oil-less air compressor. Flow rates can be

Figure 5.4 Example of a Teflon® constructed bladder pump, complete (top) and exploded version illustrating internal Teflon® bladder (Photograph by J. Schoenleber)

reduced to levels much like the variable speed centrifugal submersible pump without fear of motor stall.

Bladder pumps must be laboratory cleaned and dedicated to each well. This means that bladder pumps are permanently installed for long-term monitoring as long as the bladder is made of material not affected by long-term exposure to contaminants.

Field cleaning of bladder pumps is acceptable only if the following conditions are met: 1) the bladder pump housing is constructed of stainless steel with an internal disposable bladder and 2) one of either the eight-step, Cold Regions or ultra clean decontamination methods are employed.

Procedures for Use:

i. Check all fittings for tightness.

ii. Lower decontaminated pump and dedicated tubing into the well below the water table.

iii. Connect compressor to power source ensuring the power source is downwind to prevent fumes from entering sampling area. If compressor is not used, connect to external air source.

iv. Engage air source (compressor or external) via control box. Full water flow will begin after five to fifteen pumping cycles. After stabilization of well water has been observed and recorded, sampling may begin.

v. Adjust the refill and discharge cycles to optimize pumping efficiency. This can be performed by the following process:

vi. Adjust the refill and discharge cycles to 10-15 seconds each. Measure the water volume discharged in a single cycle.

vii. Shorten the discharge cycle time until the end of the discharge cycle begins to coincide with the end of water flow from the pump outlet.

viii. Shorten refill cycle period until the water volume from the discharge cycle decreases 10-25% from the maximum value measured in the first step.

ix. Reduce the flow rate, by adjusting the throttle control, to 100-150 ml/min or less while sampling volatile and semi-volatile organics.

x. Collect sample directly from discharge line into laboratory cleaned sample bottles after well has stabilized and follow procedures for preservation and transport (see Chapter 2, Appendix 2.1, *Tables of Analytical Methods*).

Advantages:

- positive-displacement
- acceptable for well evacuation and sample collection for all parameters
- simple design and operation
- operational variables are easily controlled
- minimal disturbance of sample
- in-line filtration possible
- available in a variety of diameters

- no variances from the Technical Requirements for Site Remediation necessary

Disadvantages:

- large gas volumes may be needed, especially for deep installations
- only pumps with disposable bladders may be field cleaned for portable use when approved decontamination methods are employed

5.2.1.4 Variable Speed Submersible Centrifugal Pump Return to TOC

Improvements in the design of submersible centrifugal pumps over the last decade have resulted in pumps significantly reduced in overall size with variable speed discharge control. These two key features, coupled with stainless steel and Teflon® construction have enhanced the desirability of this pump for application of low-flow purging and sample collection. The Grundfos® Redi-Flo 2 (Figure 5.5) is one of the more common models of this style pump commercially available for sample collection. However, there are some limitations to this model pump, which when properly identified and anticipated, will allow the user to overcome commonly encountered situations.

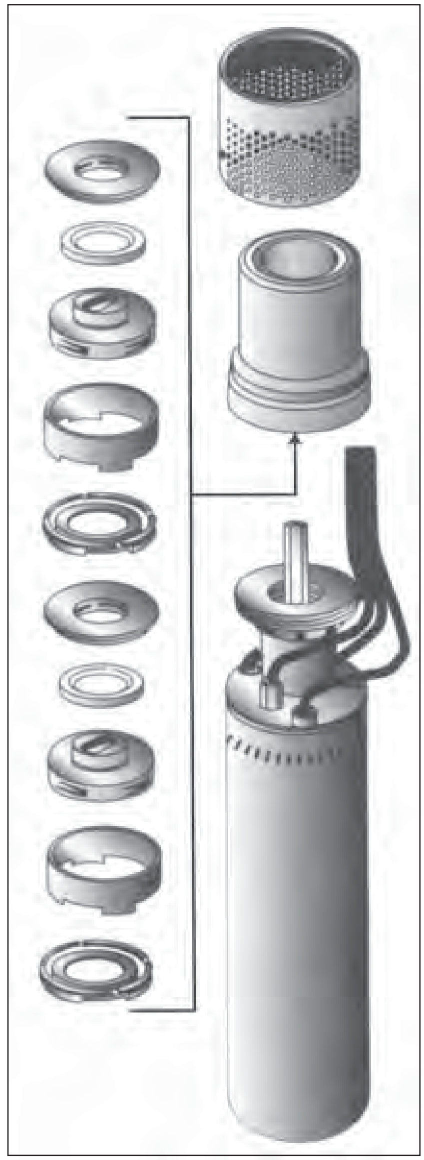

Figure 5.5 Grundfos® Pump. Illustration published with permission of Grundfos® Pumps Corporation

The variable speed feature is one of the key design items, which allows for application of low-flow purging and sample collection. In order to compensate for the reduction in impeller dimension without significant loss of pump capacity, the motor must turn at a high rate of speed. In the process of achieving high speed, low-end torque (power) has been sacrificed. The result is that to start, or restart the pump, the speed control has to be increased considerably to overcome head pressure, especially if water must open a check valve. This sudden and increased change in flow rate may mobilize unwanted material from the surrounding formation. To address this potential "restart" issue, especially during the course of a low-flow purging and sampling episode, one must make sure that the generator supplying power to the pump is properly fueled to avoid power loss. In addition, when selecting check valves, look for valves that open with the least amount of resistance and can be placed in-line at the surface. Accessibility to a check valve at the surface may eliminate the need to pull the pump from the well in order to remove the standing column of water within the tubing. Pulling the pump from the well to relieve head pressure will result in extending the time it takes to reach stabilization due to unwanted disturbance of the well.

Low yielding wells can also test the limits of variable speed design. When low yield wells are encountered and excessive drawdown restricts flow rates to100 ml/min or less, pump speed control becomes sensitive. In these conditions, the pump may stall and the flow rate cease altogether creating another "restart" situation where pump speeds have to be increased significantly to overcome head pressure. This is not the desired scenario when attempting low flow purging and sampling. To avoid this circumstance, make sure that the control box is equipped with a "ten-turn-pot" frequency control knob. This accessory will allow for much better control over flow rates and incidental pump stoppage when sampling low yield wells.

Reduced overall pump dimension and high turning motor speeds make temperature control critical to overall performance. The pump is designed to use water flowing along the surface of the pump housing to prevent an increase in motor temperature. Elevated water temperature generated by the motor must be considered especially when a low-flow purging and sampling technique is being utilized. Well casing diameters play a factor in the control equation. For large-diameter cased wells (> 4 inch), where flow to the pump intake is more horizontal than vertical, Grundfos® manufactures a sheath attachment to redirect flow patterns and control heat buildup. In small-diameter wells, movement is more conducive to the design function until low-yielding conditions are encountered. For those instances where temperature is being monitored and there is a steady and significant increase in temperature, do not alternately turn the pump on and off to control temperature buildup. This action will only serve to disrupt the well. Instead, make note of the condition in the field log and disregard any attempt to achieve temperature stabilization prior to sample collection. Where there is a significant increase in temperature, the Department may qualify the VOC and SVOC data accordingly.

When using variable speed submersible pumps to collect the field blank, one must follow the same general rules for all ground water sampling equipment. This includes the requirement that "all" sampling equipment, which comes in contact with the sample, must also come into contact with the field blank water. To overcome some of the difficulties that sampling through the inside of a pumping system creates, the following procedure is strongly recommended. Prepare field blank collection by filling a 1000ml decontaminated graduated glass cylinder with method blank water supplied by the laboratory performing the analysis. Place a properly decontaminated pump into the graduated cylinder with sample tubing and plumbing fittings attached. Activate the pump and collect the required field blank samples. As the water is removed from the cylinder, replace with additional method blank water. This procedure will require that the laboratory supply field blank water in a non-traditional manner: bulk water in liter or 4-liter containers. The traditional requirement that field blank water be supplied in the same identical containers as the sample being collected can not be practically satisfied in this circumstance. The identical bottle to bottle field blank requirement is waived for this sampling technique procedure only.

Finally, this particular pump (Grundfos® Redi Flo 2) is designed to utilize a coolant fluid (deionzed water) that is stored internally to assist in heat movement. This fluid is separated from the sample intake by a Viton® seal through which the spinning motor shaft passes. Wear on this seal can allow for fluid exchange with the sample intake. For this reason, proper decontamination of this pump is critical and includes the complete disassembly of the motor shaft from the stator housing (Figure 5.6). For proper cleaning, use the decontamination procedures for ground water sampling equipment (see Chapter 2, *Quality Assurance*, and read the Redi Flo 2 manufacturer's instructions). Always refill the housing with fresh distilled/deionized water. Note: always move (jiggle) the motor shaft while filling to ensure any trapped air is displaced by water, otherwise damage to the motor through overheating is possible. Replace the Viton® seal periodically and remember that care must also be taken with this pump during periods of

Figure 5.6 Grundfos® Pump being prepared for decontamination (Photograph by J. Schoenleber)

cold weather to avoid freezing of the coolant water. Proper decontamination and maintenance not only helps to ensure more reliable data; it also prolongs the life of any pump.

Procedures for use:

i. Decontaminate pump, electrical leader and all associated fittings.

ii. For low-flow purging and sampling, attach precut tubing whose length has been predetermined based upon well-specific pump intake depth (See Chapter 6, *Sample Collection*, for specifics regarding low-flow procedures).

iii. For volume-average sampling, set the pump either within three feet of the top of water column, or, immediately above the well screen depending on chosen method.

iv. Install pump slowly through water column wiping down tubing with DI saturated paper towel.

v. If a portable gasoline generator is used, it should be placed downwind. The generator should not be operating while a sample is being collected.

vi. Initiate purge based on procedure selected.

vii. After purging, collect sample as specified in approved sampling plan.

Advantages:

- Positive-displacement
- Versatile and light weight
- Variable speed control at surface allows for fine tuning of flow rate
- Stainless steel and Teflon® construction

- Complete disassembly allows for access to all parts for thorough decontamination
- Acceptable for low-flow purging and sampling

Disadvantages:

- During low-flow purging and sampling temperature increases may be observed
- At extremely low-flow rates, motor stall possible. To reestablish flow, high pumping rate may be needed to restart
- Should manufacturer's disassembly instructions for decontamination not be followed, cross-contamination of well is possible.

5.2.1.5 Gear Pump

A positive-displacement pump, this small lightweight pump manufactured by Fultz Pumps, Inc, also has the capacity for variable speed control (Figure 5.7). The applications of this pump are similar to the variable speed submersible centrifugal pump. Choose a pump with stainless steel housing and Fluorocarbon polymer rotors or gears (Figure 5.8). Internal parts (gears) are not readily accessible, therefore careful attention must be made when cleaning. This must be considered when choosing to use this pump for a portable application. Many are designed with the power supply molded into the sample tubing. This makes custom length of tubing based on

Figure 5.7 Fultz Pump. Illustration published with permission of Fultz Pumps, Inc.

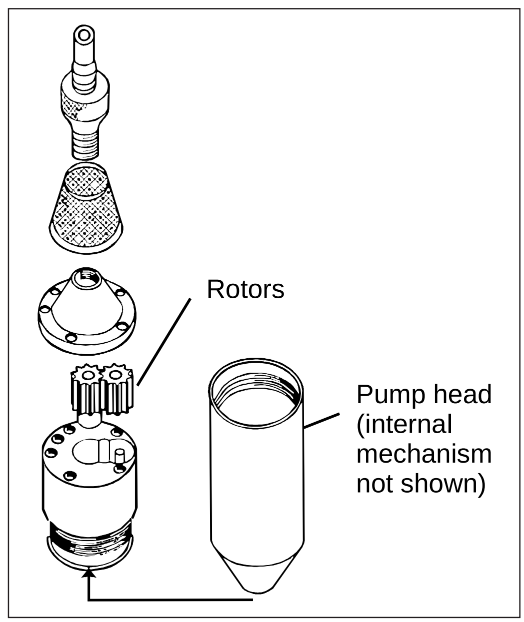

Figure 5.8 Gear Pump. Illustration published with permission of Fultz Pumps, Inc.

individual well requirements impractical during a portable application. Single molded power supply and sample tubing is also difficult to decontaminate when using this pump on a portable basis. Instead, choose pumps whose power supply and pump discharge lines are separate. This pump may be best applied when used in a dedicated system.

Procedures for use:

i. Decontaminate pump, electrical leader and all associated fittings

ii. For low-flow purging and sampling, attach precut tubing whose length has been predetermined based upon well-specific targeted zone of influence information. (See Chapter 6, *Sample Collection*, for specifics regarding low-flow procedures)

iii. For volume average sampling, set the pump either within three feet of the top of water column, or, immediately above the well screen depending on chosen method.

iv. Install pump slowly through water column wiping down tubing with DI saturated paper towel

v. Initiate purge based on procedure selected

vi. At end of purge, collect sample as specified in approved sampling plan.

Advantages:

- Positive-displacement
- Light weight
- Good variable speed control, especially at low rates
- Acceptable for Low-flow Purging and Sampling

Disadvantages:

- For portable sampling, many designed with power supply molded into tubing, which is difficult to decontaminate.
- Turbid purge water wears on Fluorocarbon gears

5.2.1.6 Progressing Cavity Pump

Another example of positive-displacement pump, progressing cavity pumps (Figure 5.9) are lightweight, manufactured in a variety of sizes and materials and pump rates are controllable at the surface. This is another example of a pump whose power delivery may be molded into the discharge tubing creating the need to decontaminate tubing between each sample. Choose pumps with stainless steel housings, chemically resistant stators and whose power and discharge tubing is separate. Many are powered by 12-volt battery and are limited to depths of approximately 150 feet.

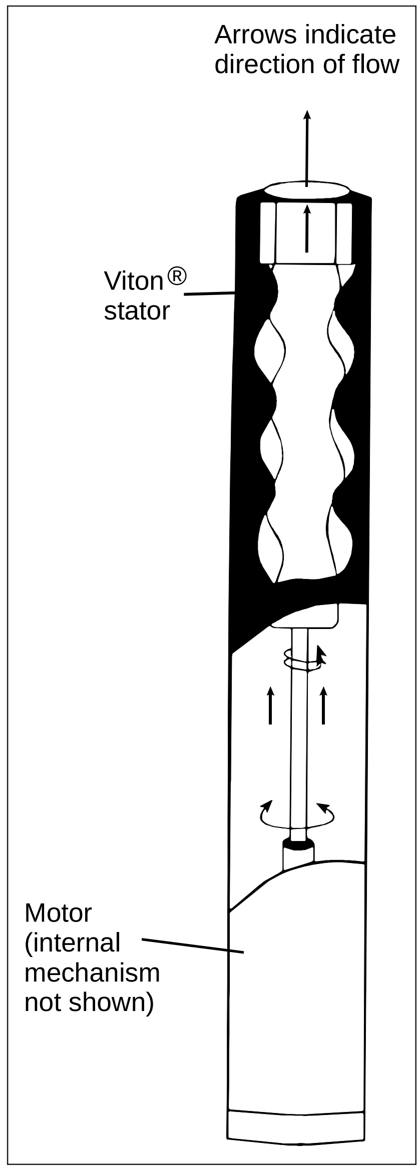

Figure 5.9 Progressive Cavity Pump. Illustration published with permisison of Geotech Environmental Equipment, Inc.

Return to TOC

Procedures for Use:

i. Decontaminate pump, electrical leader and all associated fittings

ii. For low-flow purging and sampling, attach precut tubing whose length has been predetermined based upon well-specific targeted zone of influence information. (See Chapter 6, *Sample Collection*, for specifics regarding low-flow procedures)

iii. Initiate purge based on procedure selected

iv. At end of purge, collect sample as specified in approved sampling plan.

Advantages:

- Positive-displacement
- Light weight
- Good variable speed control, especially at low rates
- Housing available in stainless steel construction with stator of highly inert material
- Acceptable for low-flow purging and sampling

Disadvantages:

- For portable sampling, many are designed with power supply molded into tubing, which is difficult to decontaminate and less appealing for portable sampling scenarios.

5.2.1.7 Reciprocating Piston Pump

A positive-displacement pump, this device utilizes a piston whose movement within a valved chamber draws, and then forces, water to the surface with minimal agitation (Figure 5.10). Driven by compressed air supplied at the surface, single piston pumps will operate to depths approaching 500 ft. (double piston pumps operate to depths up to 1000 ft.). Smaller 1.8 inch diameter models require 3/8" air supply and ½" air exhaust lines with a ½" diameter water discharge line. Restricting air supply controls flow rates. Air supply lines can be purchased either fused forming a single unit or as two separate lines. Tubing and flow control may be set up on a reel assembly. Pictured is a Bennett Pump (Figure 5.11).

Procedures for Use:

i. Decontaminate pump, outside of air supply/exhaust lines, sample discharge line and all associated fittings

ii. Dispense pump and all lines from reel

iii. Lower pump slowly through water column wiping down tubing with DI saturated paper towel

iv. For volume average sampling, set the pump either within three feet of the top of water column, or, immediately above the well screen depending on chosen method.

v. For low-flow purging and sampling set pump at predetermined depth within well screened interval

vi. Control air pressure via regulator and gauge to adjust sample flow rates

vii. Air pressure supplied by portable air compressor (5.2 cfm @ 140 psi for 1.8" diameter model)

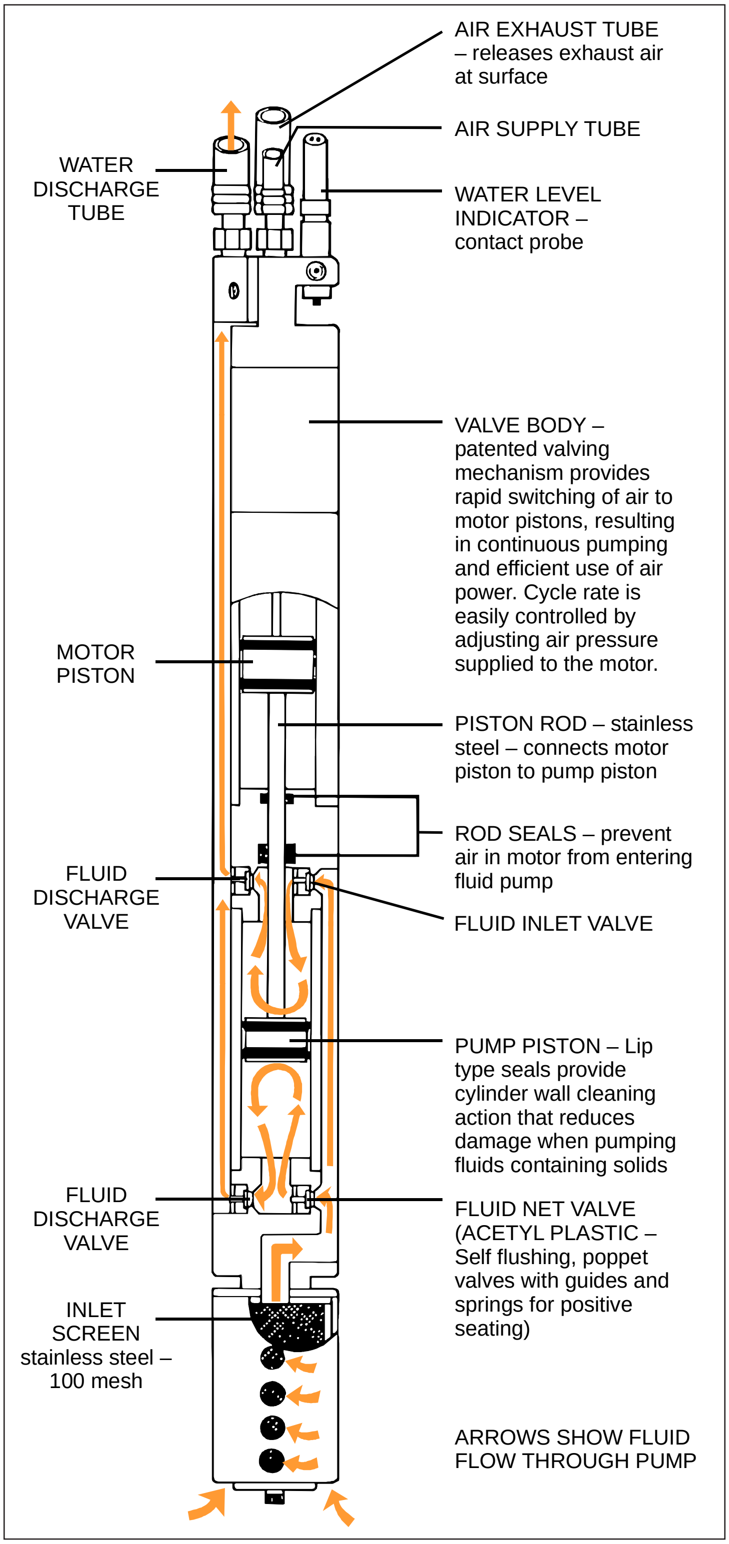

Figure 5.10 Reciprocating Piston Pump

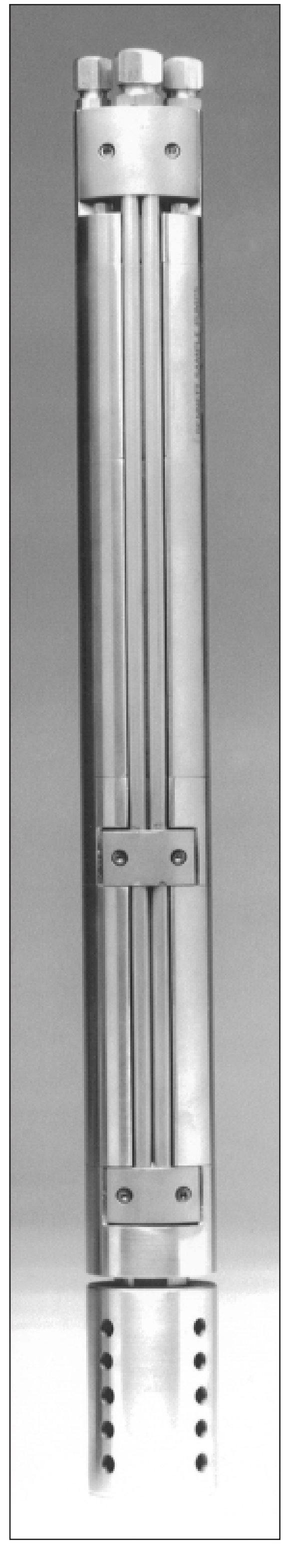

Figure 5.11
Bennett Pump

Illustrations published with permission of Bennett Sample Pumps.

Advantages:

- Stainless steel construction of pump body and piston.
- Variable speed control
- Positive-displacement
- Portable or dedicated sampling options
- Flow rates as low as 0.75 liters per minute
- Pump disassembly possible for decontamination purposes

Disadvantages:

- Large sample discharge (½" diameter) on 1.8 inch diameter model
- Operation from reel in portable mode makes decontamination of tubing difficult
- Worn parts may allow compressed air to cross into sample or result in loss of pump efficiency

5.2.1.8 Inertial Pump

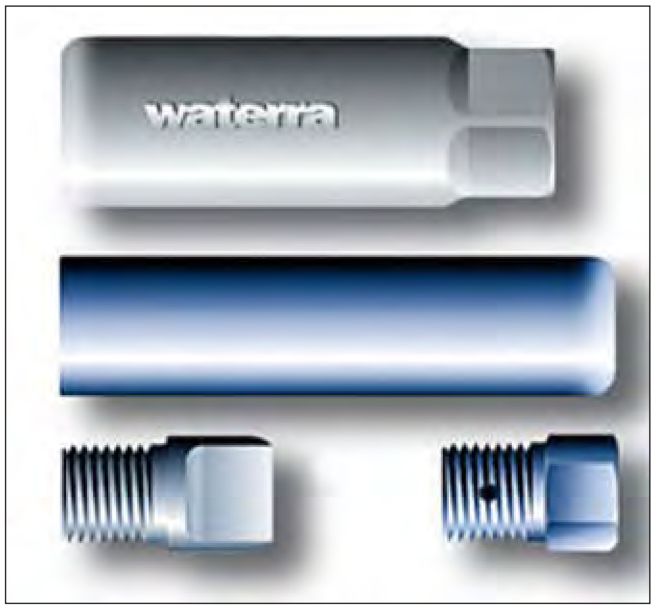

Figure 5.12 Waterra Pump. Illustration published with permission of Waterra.

As the name implies, this pump works on the principle of inertia. The pump consists of polyethylene or Teflon® tubing with a foot or ball-check valve attached at one end (Figure 5.12). The foot or ball-check valve allows water to enter the tubing, but prevents water from draining out. Simply raising and lowering the tube over a short distance operates the pump. Movement on the downstroke forces the valve open allowing water to enter the tubing. On the on the upstroke, the valve closes trapping water inside the tubing. Continued up and down movement advances water upward due to inertia. There is virtually no pressure gradient at the valve, however there may be considerable disturbance within the well casing, which limits the value of the technique. Using this technique in wells established in silty geologic settings may produce sample results that are biased high for inorganic analysis. Sporadic non-laminar sample delivery into the container at the surface may bias volatile analysis low. The operation can be performed manually or automatically utilizing a power unit. The automatic mode does allow for some control on well disturbance and sample delivery. The technique does have favorable application for field screening of narrow diameter (>1 inch) temporary wells and field screening for vertical delineation of contaminant plumes utilizing direct push technology (Figure 5.13).

Procedures for Use:

i. Attach decontaminated Teflon® foot check valve or stainless steel ball check valve to end of tubing

ii. Wipe tubing with paper towel and DI water as tubing is lowered into well

iii. Begin up and down movement at desired depth avoiding disturbance of well casing to best ability

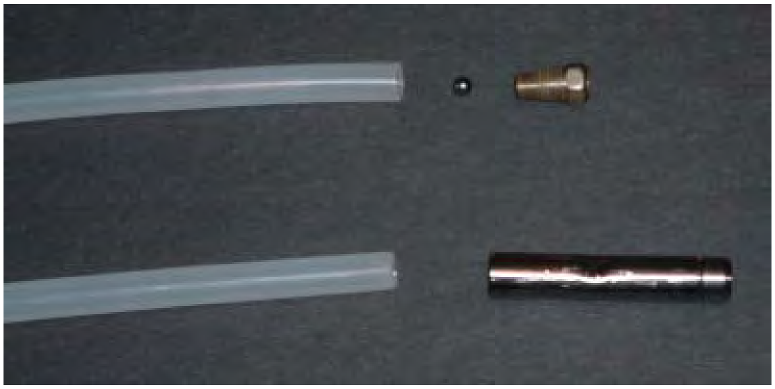

Figure 5.13 Two styles of foot check valves offered by Geoprobe® for narrow diameter temporary well points (Photograph by J. Schoenleber)

Advantages:

- Inexpensive
- Ease of operation
- Decontamination of valves relatively simple
- Best use limited to field screening of volatiles when utilizing direct push technology and narrow diameter temporary well points

Disadvantages:

- Manual use is labor intensive
- Use produces considerable agitation and turbid conditions
- Uneven sample delivery
- May cause VOC loss due to agitation
- Use in slow-recharge narrow-diameter temporary well points may cause the water level to drop significantly and result is aeration of the water column

5.2.1.9 Syringe Sampler

◂ Return to TOC

Syringe samplers are specialized devices designed to capture and preserve in-situ ground water conditions by precluding sample aeration and pressure changes from sample degassing (escape of VOCs) or outgassing (escape of inorganic gases). Their use, while not widely applied to general monitor well sampling, does have application when attempting to collect a discrete, non-purged sample. Examples may include collecting an undisturbed aliquot of dense non-aqueous phase liquid from the very bottom of a well, or, targeting a zone for field analytical measurement.

Measurement of water quality indicator parameters made in discrete or nonpumped samples are more vulnerable to bias from changes in temperature, pressure, turbidity and concentrations of dissolved gases than measurements using a downhole or flow through-chamber system. As a result, subsamples can be used for conductivity, pH and alkalinity but should not be used for reported measurements of temperature, dissolved oxygen, Eh or turbidity.

The device shown in Figure 5.14, manufactured by General Oceanics (http://www.generaloceanics.com/), is constructed of stainless steel and glass components and is designed to universally accept standard off the shelf medical syringes of varying volumes. The stainless steel and glass construction allows for more through cleaning when sampling between monitor wells. Another model manufactured by General Oceanics is constructed of polycarbonate material and as a result can only be used on a one-time basis.

Advantages:

- Can sample at discrete depths
- Interior of sampler not exposed to water column
- Potential for use as a collection device for field screening techniques

Disadvantages

- Small sample volume renders comparison of duplicate and quality assurance samples inconclusive
- Not recommended for analysis of volatile organics from samples collected in monitor wells due to potential volatile loss
- Use of this no-purge device must be approved on a case by case basis.

Figure 5.14 Syringe Sampler. Illustration published with permission of General Oceanics, Inc.

5.2.1.10 Suction-lift Pumps

Suction-lift pumps (e.g., diaphragm, surface-centrifugal and peristaltic) are pumps situated at the ground surface with tubing (polyethylene or flexible PVC) inserted into the well leading from the pump to the top of the water column. Diaphragm and surface-centrifugal pumps are used only to evacuate wells prior to sampling. Peristaltic pumps can be used to sample inorganic contaminants. All tubing must be new and dedicated to a particular monitor well. As the tubing is inserted into the well, it must be wiped down with paper towels and distilled/deionized water. Tubing associated with surface-centrifugal pumps should be equipped with a decontaminated foot check valve to avoid having aerated water within the pump fall back into the well prior to sampling. Should a check valve not be employed, then the pump must continue to operate during removal of tubing to avoid purged water remaining in the tubing and pump chamber from falling back into the well.

These evacuation only pumps are typically associated with volume-averaged sampling where three-to-five standing water volumes are removed from the well prior to sampling with a bailer. Again, ground water can not be collected through suction lift pumps for chemical analysis with the exception of inorganic analysis via peristaltic pumps. When using surface centrifugal pumps for purging, care must be taken to ensure that the entire pump impeller housing chamber is drained after use and then is thoroughly rinsed to remove build up of suspended materials.

The main limitation exhibited by these types of pumps is their inability to overcome the physical constraints imposed by one atmosphere of pressure. Generally, water within the well casing must be twenty-five feet from the ground surface or the pump's efficiency in pulling water to the surface diminishes dramatically. Note: If priming the pump is necessary, care must be taken as to the source of the water used. ONLY potable water is acceptable.

5.2.1.11 Passive Diffusion Bag Samplers (PDBs)

Return to TOC

5.2.1.11.1 Deployed In Monitor Wells

When confronted with sampling a monitor well that displays little or virtually no recharge capability during well evacuation (where historic data indicate drawdown exceeds 3 tenths of a foot while purging at flow rates that are equal to or below 100 ml per minute), the option to use this no-purge sampling technique may be justified. More appropriately, there may be instances where long term monitoring during the operation and maintenance phase of remediation justifies their use. Whatever the reason, use of passive diffusion bags must be granted prior approval, as there are well-defined limitations to this sampling technique that must be understood by the sampler, as well as the end user of data. Due to the limited number of contaminants PDB samplers are capable of detecting, these devices are not recommended for initial investigations where a more complete understanding of the contaminants of concern remains to be determined. In addition, PDB samplers are not recommended for sampling sentinel wells. For more information on NJDEP sampling policy and procedures related to this device consult Chapter 6, *Sample Collection*, Section 6.9, *Ground Water Sampling Procedures*, Subsection 6.9.2.5.1, *Passive Diffusion Bag Samplers*, before using PDBs.

PDB samplers are made of low-density polyethylene plastic tubing (typically 4 mil), filled with laboratory grade (ASTM Type II) deionized water and sealed at both ends (Figure 5.15). The samplers are typically about 18 to 20 inches in length and can hold from 220 ml to 350 ml of water. Vendors can usually modify the length and diameter of a sampler to meet specific sampling requirements.

Teflon® coated stainless-steel wire is preferable for deploying the samplers in the well. Teflon® coated stainless-steel wire can also be reused after proper decontamination. As an alternative to Teflon® coated stainless steel wire, synthetic rope may be

Figure 5.15 Eon PDB Sampler with accessories (Photograph by J. Schoenleber)

used as the deployment line for single-use applications if it is low stretch, non-buoyant, and sufficiently strong to support the weight of the sampler(s). An example of acceptable rope would be uncolored (white) 90-pound, 3/16-inch-braided polyester. Extreme care must be exercised when using rope as a deployment line in deep wells due to the potential for the deployment line to stretch, which may result in improper location of the PDB sampler within the well screen or open hole of the well. Deployment lines consisting of material other than Teflon® coated stainless steel wire may not be used in another well and must be properly disposed of after a one-time use.

The sampler is positioned at the desired depth interval in the well by attachment to a weighted deployment line and left to equilibrate with the water in the well. Many VOCs equilibrate within 48 to 72 hours, however, the minimum recommended equilibration period for PDBs is 2 weeks. This is to allow the formation water and well water to re-stabilize after deployment of the samplers, and to allow diffusion between the stabilized well water and the PDB sampler to occur. In low-yielding formations, additional time may be required for the well to re-stabilize.

If quarterly sampling is being conducted, it is acceptable to leave PDB samplers in the well for up to three months so that samplers can be retrieved and deployed for the next monitoring round during the same mobilization. Unfortunately, data are currently unavailable to support longer deployment periods (i.e., semi-annual or annual). Leaving samplers in a well for longer than 3 months is not recommended. If future data become available which demonstrate longer deployment timeframes are appropriate, this condition will be modified.

Advantages:

- Purge water associated with conventional sampling reduced or eliminated.
- The devices are relatively inexpensive.
- Simple deployment and recovery reduces the cost and the potential for operator error.
- Monitoring well stability parameters are not required which reduces associated cost.
- PDB samplers are disposable.
- The stainless steel weights and Teflon® coated wire are the only pieces of equipment needing decontamination.
- Quick deployment and recovery is a benefit when sampling in high traffic areas.
- Multiple PDB samplers can be deployed along the screened interval or open borehole to detect the presence of VOC contaminant stratification.
- Has been shown to deliver accurate dissolved oxygen measurement.
- Since alkalinity conditions in the well are not transferred across the membrane, effervescence associated with HCl preservation is avoided.

Limitations:

- PDB samplers provide a time-weighted VOC concentration that is based on the equilibration time of the particular compounds; usually that period is 2 to 3 days.

This is a limitation if sampling objectives are to identify contaminant concentrations at an exact moment the sample is collected. The time-weighted nature of the PDBS may be a factor in comparison with low-flow sampling if concentrations have been shown to be highly variable over time.

- PDB samplers have a limited detection capability.
- PDB samplers work best when there is unrestricted horizontal movement of ground water through the well-screen or open hole. If filter packs or screens are less permeable than the surrounding formation, ground water flow lines may not enter the well and PDB samples may not be able to provide a representative sample.
- As with low-flow samples, PDB samplers represent a point sample. Contamination migrating above or below the targeted depth interval will not be detected.
- Membrane limitations restrict accurate pH, specific conductance or temperature data.
- In some cases, heavy biofouling of the bag may inhibit sampler performance

5.2.1.11.2 Deployed in Lake, Stream, River or Estuarine Sediment

While the primary application of passive diffusion bag sampling is intended for monitor well investigation, the device can be modified for application in steam sediment when investigating ground water discharge areas. The same limitations regarding the physical chemistry of contaminant diffusion across polyethylene membranes apply to sediment settings. In addition, the lithology of the streambed, the “gaining” relationship between the stream and investigation area and the remedial phase pose further limitations that must be examined before approval of this adaptive PDB application can be granted. In “gaining” situations, transect deployment of PDBs over a two week period may indicate areas of concern that were previously overlooked. Since the nature of PDB construction does not lend itself to the rough handling and deployment into sediments, a protective housing constructed of 2-inch diameter PVC slotted well screen material offers a means to deploy without damage to the bag (Figure 5.16). (Note: Air in bag artifact of long time storage.)

Figure 5.16 PDB for Sediments using bag provided by Columbia. (Photograph by J. Schoenleber)

The slotted well screen serves as a protective barrier for the PDBs while allowing the free flow of ground water to come into contact with the sampler. A two-inch PVC cap can be placed on each end of the well screen. The bottom cap should be secured with a standard 5/16-inch zinc plated bolt to assure that the cap will stay in place. A smaller diameter through-hole can be drilled in the top cap and a short length of Teflon® coated stainless steel braided wire can be looped through the cap, creating a "handle" while holding the top cap securely in place.

Using a length (measurement based on need) of 4-inch diameter Schedule 80 PVC pipe, drive18 to 24-inches into the sediment with a sledgehammer. This will form a barrier (cofferdam) from any standing or moving water. Use a 4-inch Teflon® bailer to remove the standing water within the coffer casing. This removal of water from the casing will facilitate the use of a 3-inch stainless steel bucket auger to begin the removal of sediment. Intermittently, the bailer may have to be used again to remove any water that infiltrates the casing during the removal of sediment. Once the desired depth into the sediment has been reached with the auger, the assembled PDB device can be lowered through the casing into the open hole. A 6-foot length of polyethylene line should be tied to the coated stainless steel braided wire to act as means to relocate and assist in pulling the device from the sediment when the time comes for retrieval. The auger can then used again to ensure the device is resting at the bottom of the augured hole and to confirm the sampler's depth.

A small amount of clean sorted coarse #2 sand should be poured from a stainless steel bucket into the casing. This will create a type of filter pack around the device and enhance contact with the surrounding formation. The sand also reduces the friction when it comes time to remove the device from the sediment. After enough sand is used to fill in the voids around the entire sample device, the native stream bed sediment that was originally removed from the hole must be placed back on the top of the device to complete the boring seal. The assembled device should be buried vertically to a depth that allows for approximately 6-inches of coverage by native sediment. Use extreme caution when removing the 6-inch casing as the PDB device may want to follow along with the casing's removal. An exact record of the location of the sample device must be obtained using a global positioning satellite unit or measured triangulation.

5.2.1.12 Direct Push Technology

Use of direct push technology to obtain ground water samples via temporary well points has gained wide acceptance. The relative ease to collect minimally disturbed ground water samples depth plus the ability to provide other hydrogeological data has made this system attractive. While various manufacturers make and distribute their own ground water equipment and accessories, the same general principles still apply when collecting ground water 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*.

One of the special applications of direct push technology relative to ground water sampling is the ability to obtain vertical profile information while working the same bore hole. This process only further stresses the need to eliminate all possible sources of extraneous or cross contamination, especially when contaminant levels are on the order of only 1 or 2 parts per billion. High pressure, hot water (100° C) cleaning is the only acceptable means to decontaminate sampling equipment and maintain confidence that data is not influenced by unwanted variables. In addition, equipment must be maintained in good working order to insure its performance. This means (but is not limited to) all rods used for boring advancement must have unworn O-rings at each connection and undamaged threads to insure that each connection can be drawn tight, all downhole equipment must be decontaminated between each use and sample collection tubing must not be reused. Operators must have boring certification in good standing from the Bureau of Water Systems and Well Permitting and all permit approvals must be on-site. Extreme caution must be taken to insure that communication between various water bearing zones within the same boring does not take place, therefore, all grouting must be tremied under pressure starting from the bottom of the boring and completed at the surface using grout of the required density. Finally, no boring work can begin without first contacting New Jersey One Call service to secure utility mark-outs

General guidance on the construction of temporary wells installed via direct push technology can be referenced through this manual, ASTM D6001-96, *Direct Push Water Sampling for Geoenvironmental Investigations*, and via the following Internet links: *http://www.epa.gov/superfund/programs/dfa/dirtech.htm*, *http://epa.gov/swerust1/pubs/esa-ch5.pdf*, *http://geoprobe.com*, and *http://www.ams-samplers.com/main.shtm?PageName=welcome.shtm*.

5.2.1.13 Packers

Packers, an accessory deployed in conjunction with pumps designed for sample collection, are used to isolate portions of a well for sampling or other hydrogeological purposes. Expandable rubber bladders, arranged singularly or in pairs, are designed to allow discharge and power supply lines to pass through with the pump sandwiched in between. They deflate for vertical movement within the well and inflate when the desired depth is reached.

Under certain circumstances, ground water contamination in bedrock aquifers can migrate to significant depths. The presence of contaminants denser than water, high angle fractures, nearby pumping wells, or a downward hydraulic gradient within the aquifer can facilitate the downward migration of contaminants. Packers may be used to focus the investigation to a particular fracture. Present NJDEP policy limits the length of bedrock well open borehole or screen length to 25 feet.

To facilitate vertical contaminant delineation in bedrock aquifers, packer testing of a bedrock borehole is commonly performed. Packer testing of a bedrock borehole can be conducted in two different ways. The first method entails advancing the borehole to a pre-determined depth. Once the borehole has been completed, information generated from drilling such as: changes in borehole yield, changes in drilling rate, occurrence of weathered zones, presence of odors or sheens, and the occurrence of elevated PID/FID readings, are used to determine the intervals chosen for packer testing. Portions are then sectioned off using an upper and a lower packer. Conducting down-hole video work, down-hole caliper logging or vertical flow measurement may also be used to determine the borehole depths to set the packers.

The second method involves alternating the advancement of the borehole with packing off the bottom and collecting a sample. Only one packer is needed to create a barrier at the top of the newly drilled section (the bottom of the borehole completes the interval). Since the use of the packer is undertaken in an alternating fashion with advancement of the borehole, the length of the intervals is usually predetermined. This method is less prone to leakage but it is usually slower and more expensive than other methods.

Pumping of water from within the packed interval can be used to estimate yield of the selected zone, and the analysis of samples collected from each zone can be used to determine the vertical extent of ground water contamination. If samples are to be collected for field screening or laboratory analysis, volume averaging or low-flow sampling techniques can be employed before sample collection. The resolution of the ground water quantity and quality within the borehole is based on the length of the bedrock borehole interval tested and usually does not exceed 20 feet in length.

If packers are not seated properly, water will leak around the system during the test. To determine if leakage around the packer is occurring, transducers should be placed above and below each packer. If the water level above the upper packer or below the lower packer drops while the interval is being pumped, it is likely that water leakage around the packer is occurring. Packers used in cored bedrock are less likely to develop leakage problems due to the uniformity and smoothness of the borehole. Where the borehole intersects vertical or high angle fractures, leakage of water around the packer via the fracture may be unavoidable. For more information on packer application go to the following USGS web site: *http://toxics.usgs.gov/pubs/FS-075-01/#4*.

Procedures for Use:

i. Packers are assembled at the surface with the selected pump sandwiched between individual bladders.

ii. Assembled unit is lowered to a predetermined depth by cable.

iii. Bladders are inflated from air-lines originating at the surface.

Advantages:

- isolates a portion of well for sampling at discrete transmission zones within an open borehole or long screen
- decreases purge volume of a well

Disadvantages:

- sampler must be aware of background regarding contaminants and other well characteristics
- packers are constructed of rubber and may deteriorate with time, releasing undesirable organics into the ground water
- should not be used for initial sampling episodes prior to identification of contaminants of concern
- sampler needs to know the stratigraphy and hydrology to be sure area packered is isolated from other water bearing zones
- the decontamination of packers is critical due to their multiple reuse from site to site
- packers used inside a well screen will not prevent water from flowing through the filter pack from above and below the packers.

5.2.2 Wastewater Sampling Equipment

Wastewater sampling equipment is typically designed to collect aqueous samples from influent and effluent sources at a treatment facility. Since large volumes of water are being monitored over time, their ability to composite samples makes them most suitable. These devices may also be adapted for characterizing mainstreams of rivers, estuaries, coastal areas, lakes or impoundments.

Samples may be collected manually or with automatic samplers. Whichever technique is adopted, the success of the sampling program is directly related to the care exercised during sample collection. Optimum performance will be obtained by using trained personnel.

5.2.2.1 Manual Sampling

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There is minimal initial cost involved in manual sampling. The human element is the key to the success or failure of any manual-sampling program. It is well suited to the collection of a small number of samples, but is costly and time consuming for routine and large sampling programs

Advantages:

- low capital cost
- can compensate for various situations
- note unusual conditions
- no maintenance
- can collect extra samples in short time

Disadvantages:

- probability of increased variability due to sample handling
- inconsistency in collection
- high cost of labor when several samples are taken daily
- repetitious and monotonous task for personnel

5.2.2.2 Automatic Sampling

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Automatic samplers are favored because of their cost effectiveness, versatility, reliability, increased capabilities, greater sampling frequency and application to monitoring requirements specific to discharge permits. Automatic samplers are available with widely varying levels of sophistication, performance, mechanical reliability and cost. However, no single automatic sampling device is ideally suited for all situations. For each application, the following variables should be considered in selecting an automatic sampler:

- Variation of water or wastewater characteristics with time.
- Variation of flow rate with time.
- Specific gravity of liquid and concentrations of suspended solids.
- Presence of floating materials.

Selection of a unit should also be preceded by careful evaluation of the range of intended use, the skill level required for installation and the level of accuracy desired. There are usually five interrelated subsystems in the design of an automatic sampler to consider. These are the sample intake, gathering, transport, storage, and power subsystems.

The reliability of a sample intake subsystem can be measured in terms of: freedom from plugging or clogging; non-vulnerability to physical damage; minimum obstruction to flow; rigid intake tubing or facility to secure or anchor; multiple intakes; and construction materials compatible with analysis.

Commercial automatic samplers commonly use either a vacuum or a peristaltic pump. Figures 5.17 and 5.18 illustrate two versions of the ISCO® sampler for composite and sequential collection, respectively.

Most commercially available composite samplers have fairly small-diameter tubing in the sample train, which is vulnerable to plugging due to the buildup of fats, solids, and other

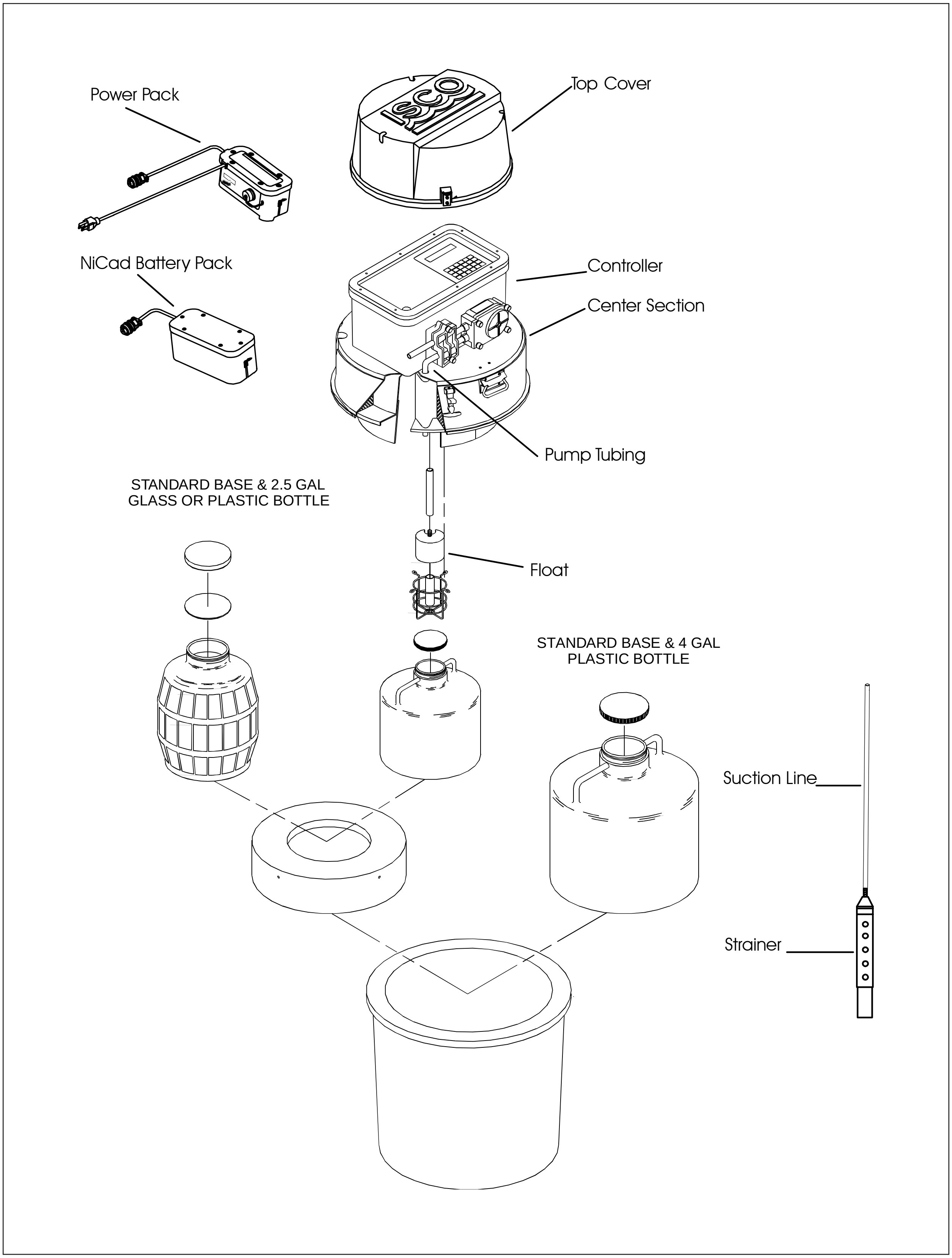

Figure 5.17 ISCO® 3700 Series Sampler for composite collection. Illustration published with permission of Teledyne ISCO.

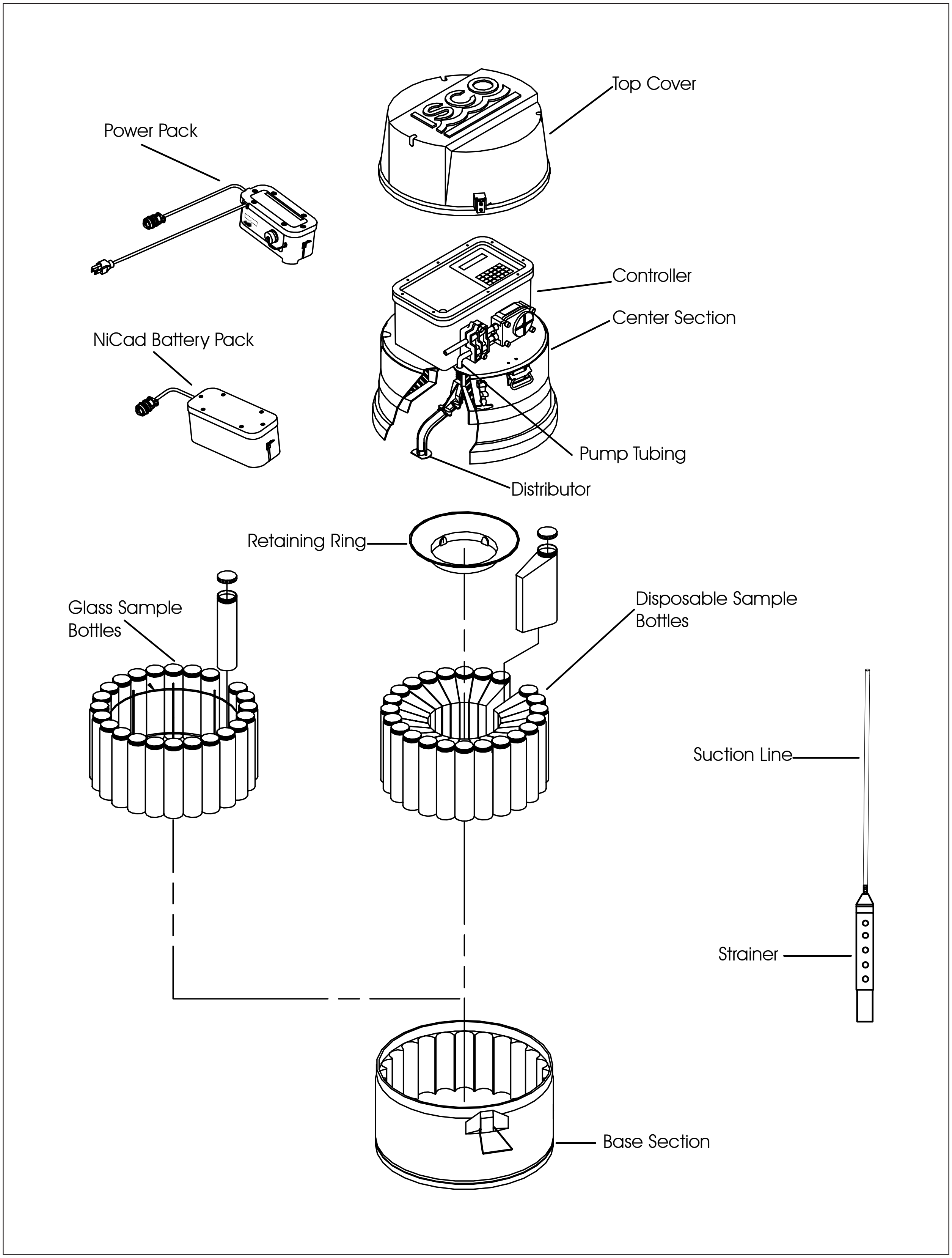

Figure 5.18 ISCO® 3700 Series Sampler for sequential collection. Illustration published with permission of Teledyne ISCO.

insoluble components. Adequate flow rates must be maintained throughout the sampling train to effectively transport suspended solids.

Discrete samples are subject to considerably more error introduced through sample handling, but provide opportunity for manual flow compositing and time history characterization of a waste stream during short period studies. The desired features of sample storage subsystems include flexibility of discrete sample collection with provision for a single composite container; minimum discrete sample container volume of 500 ml and a minimum composite container capacity of 7.5 liters. Storage capacity of at least 24 discrete samples, containers of conventional polyethylene or borosilicate glass of wide mouth construction, and adequate insulation for the sampler to be used in either warm or freezing ambient conditions.

Finally, various power and control features may be necessary depending upon whether the sampler is at a portable or a permanent installation. These include but may not be limited to: 1) capacity for either AC or DC operation; battery life for 2 to 3 days of reliable hourly sampling without recharging; 2) battery weight of less than 20 pounds and sealed so no leakage occurs; 3) solid-state logic and printed circuit boards; 4) timing and control systems contained in a waterproof compartment and protected from humidity; 5) controls directly linked to a flow meter to allow both flow-proportional sampling and periodic sampling at an adjustable interval from 10 minutes to 4 hours; 6) capability of multiplexing, (i.e., drawing more than one sample into a discrete sample bottle to allow a small composite over a short interval); 7) capability for filling more than one bottle with the same aliquot for addition of different preservatives; and 8) capability of adjusting sample size and ease in doing so.

Procedures for Use:

i. All parts of the device, which come in contact with the sample, must be decontaminated following the eight-step decontamination procedure described in Chapter 2, Quality Assurance. A distilled water rinse may not be necessary between setups on the same sample waste stream.

ii. When a sampler is installed in a manhole, secure it either in the manhole (e.g., to a rung above the high water line) or outside the manhole to an above ground stake by means of a rope.

iii. Place the intake tubing vertically or at such a slope to ensure gravity drainage of the tubing between samples, avoiding loops or dips in the line.

iv. Inspect the intake after each setup and clean, if necessary.

v. Exercise care when placing the intake(s) in a stream containing suspended solids and run the first part of the sample to waste.

vi. Maintain sufficient velocity of flow at all times to prevent deposition of solids.

vii. When a single intake is to be used in a channel, place it at six-tenths of the channel's depth (point of average velocity). For wide or deep channels where stratification exists, set up a sampling grid.

viii. Maintain electrical and mechanical parts according to the manufacturer's instructions.

ix. Replace the desiccant as needed.

x. If a wet-cell lead-acid battery is used, neutralize and clean up any spilled acid.

xi. Position the intake in the stream facing upstream. Limit the head-on orientation of the intake 20 degrees on either side. Secure the intake by a rope at all times with no drag placed on the inlet tubing.

xii. After the installation is complete, collect a trial sample to assure proper operation and sample collection. The sample device must give replicate samples of equal volume throughout the flow range. If the sampler imposes a reduced pressure on a waste stream containing suspended solids, run the first part of the sample to waste.

xiii. During winter operation place the unit below the freezing level or in an insulated box. When AC is available, use a light bulb or heat tape to warm device. Be certain to place the intake line vertically or at such a slope to ensure gravity drainage back to the source. Even with a back purge system, some liquid will remain in the line unless gravity drainage is provided. If an excess length of tubing exists cut it off. Keep all lines as short as possible. Do not use catalytic burners to prevent freezing since vapors can affect sample composition. When power is unavailable, use an well-insulated box containing the device, a battery and small light bulb to prevent freezing.

xiv. Parameters requiring refrigeration to a specific temperature must be collected with an automatic compositor, which provides that refrigeration for the entire compositing period. This can be accomplished by packing the lower tub of the compositor with ice. Care must be taken to avoid flooding the tub with melted ice in warm months and freezing the samples during the cool months.

Advantages:

- consistent samples
- probability of decreased variability caused by sample handling
- minimal labor requirement
- has capability to collect multiple bottle samples for visual estimate of variability and analysis of individual bottles

Disadvantages:

- considerable maintenance for batteries and cleaning
- susceptible to plugging by solids
- restricted in size to the general specifications
- inflexibility
- sample contamination potential
- subject to damage by vandals

5.2.3 Surface Water and Liquid Sampling Equipment

Surface water sampling includes collection of samples from lakes, ponds, streams, and rivers. It may also be necessary to collect liquid samples from lagoons, surface impoundments, sewers, point source discharges, wastewater and leachate seeps.

Sampling situations encountered in the field vary greatly and therefore the sampling device to be chosen and procedures to be followed may be varied to best fit each situation. Safety concerns will play the primary role in determining which sampling device is most appropriate. That said, the most important goal of surface water or liquid sampling is the collection of a sample representative of all the horizons or phases present. Selection of the proper equipment rests with these two factors. Additional information on liquid/sludge samplers can be found in Section 5.3, *Non-Aqueous Sampling Equipment*, Subsection 5.3.2, *Sediment and Sludge Sampling Equipment* of this chapter. Refer to Chapter 6, *Sample Collection*, Section 6.8, *Surface Water and Sediment Sampling*, for information related to the collection procedures associated with this matrix.

The USGS notes that the two primary types of surface water samplers are the isokinetic depth-integrating samplers and nonisokinetic samplers. Isokinetic depth-integrated samplers are designed to accumulate a representative water sample continuously and isokinetically (that is, stream water approaching and entering the sampler intake does not change in velocity) from a vertical section of a stream while transiting the vertical at a uniform rate. Isokinetic depth-integrated samples are divided into two groups based on the method of suspension: hand-held and cable-and-reel samplers. Discussed in detail, examples of the US DH-81, US D-77, US D-95 and D-77 samplers can be found in the US Geological Survey's Book 9, *Handbooks for Water Resources Investigations*, *National Field Manual for the Collection of Water-Quality Data*, Chapter A2, Section 2.1.1, *Surface-Water Sampling Equipment* at *http://water.usgs.gov/owq/FieldManual/*.

Nonisokinetic samplers include open-mouth samplers, thief samplers, single-stage samplers and automatic samplers and pumps. Discussed below are examples of open-mouth samplers. These include the laboratory cleaned sample bottle, pond sampler, weighted bottle sampler and the Wheaton-Dip sampler. Also discussed below are examples of the following thief samplers: the Kemmerer, Van-Dorn and double-check valve bailer. Discussion on automatic samplers and pumps can be found above in the wastewater sampling section. Finally, for discussion and examples of single-stage samplers, go to the US Geological Survey's Book 9, *Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter A2, Section 2.1.1, *Surface-Water Sampling Equipment* at *http://water.usgs.gov/owq/FieldManual/*.

5.2.3.1 Laboratory Cleaned Sample Bottle

The most widely used method for collection of surface water samples is simple immersion of the laboratory cleaned sample bottle. Using the sample bottle for actual sampling eliminates the need for other equipment. This method also reduces the risk of introducing other variables into a sampling event. A low-level contaminant metal sampling requires the usage of an acid-rinsed container as per USGS. To learn more, refer to the US Geological Survey's Book 9, *Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter A3, *Cleaning of Equipment for Water Sampling*, at *http://water.usgs.gov/owq/FieldManual/*.

Procedures for Use:

i. Make sure bottles are intact with a good fitting lid.

ii. Proceed to immerse bottle by hand into surface water and allow water to run slowly into bottle until full. (Collect samples for volatile organics analysis first to prevent loss of volatiles due to disturbance of the water. Fill vials to zero headspace.)

iii. Use care not to create sediment disturbance, especially when trace metals sampling is included in the requested analysis.

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

Advantages:

- easy hand operation
- no field decontamination necessary
- no other equipment needed
- eliminates need for a field blank

Disadvantages:

- outside of bottle comes in contact with sample
- labeling may be compromised due to submersion
- may not be possible when bottles are pre-preserved

Return to TOC

5.2.3.2 Pond Sampler

The commercially available pond sampler (a.k.a. Dipper) (Figure 5.19) is used to collect liquid waste samples from disposal ponds, pits, lagoons, and similar reservoirs.

Figure 5.19 Pond Sampler (Photograph by J. Schoenleber)

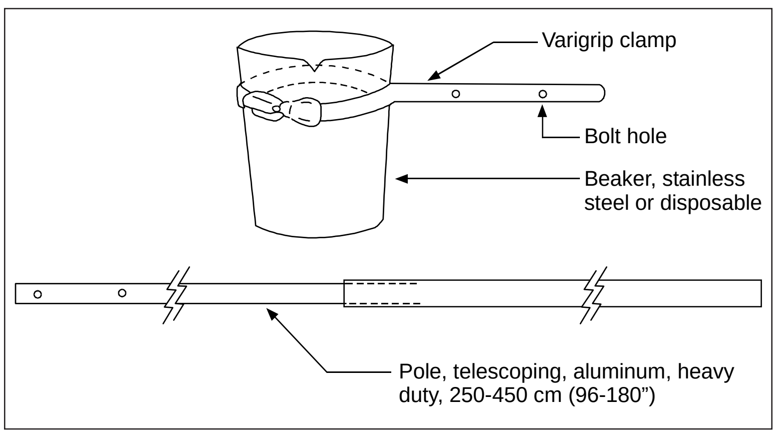

Figure 5.20 Fabricated Pond Sampler

The pond sampler may consist of an adjustable clamp attached to the end of a two or three piece telescoping aluminum tube that serves as the handle. The clamp is used to secure a sampling beaker. Other pond samplers may be a single molded polyethylene handle with a 500-ml Teflon® cup fixed on the end. The sampler is easily and inexpensively fabricated. The tubes can be readily purchased from most hardware or swimming pool supply stores. The adjustable clamp and sampling beaker (stainless steel or PTFE) can be obtained from most laboratory supply houses. The materials required to fabricate the sampler are given in Figure 5.20.

Procedures for Use:

i. Assemble the pond sampler. Make sure that the sampling beaker or sample bottle and the bolts and nuts that secure the clamp to the pole are tightened properly.

ii. Slowly submerge the beaker with minimal surface disturbance.

iii. Retrieve the pond sampler from the surface water with minimal disturbance.

iv. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper/device edge.

v. Empty the sampler slowly, allowing the stream to flow gently down the inside of the bottle with minimal entry turbulence. When applicable, always fill VOA vials first and fill to zero headspace.

vi. Repeat steps ii - v until sufficient sample volume is acquired.

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

viii. Dismantle the sampler and store in plastic bags for subsequent decontamination.

Advantages:

- relatively inexpensive to fabricate
- can sample depths or distances up to 3.5m

Disadvantages:

- difficult to obtain representative samples in stratified liquids
- difficult to decontaminate when viscous liquids are encountered

5.2.3.3 Weighted Bottle Sampler

The weighted bottle sampler (Figure 5.21) can be used to sample liquids in storage tanks, wells, sumps, or other reservoirs that cannot be adequately sampled with another device. This sampler consists of a bottle, usually glass or plastic, a weight sinker, and a bottle stopper. Equal-depth and equal-width increment sampling procedures typically associated with ambient surface water data collection do not require a bottle stopper. To learn more see the US Geological Survey's Book 9, *Handbooks for Water-Resources Investigations*, *National Field Manual for the Collection of Water-Quality Data*, Chapter A4, *Collection of Water Samples*, at *http://water.usgs.gov/owq/FieldManual/*. Samplers used for trace element (metal) sampling should not be constructed of metal. Weighted bottle samplers can be constructed of polyvinyl chloride for this purpose. To learn more see the *National Field Manual for the Collection of Water-Quality Data*, Chapter A2, *Selection of Equipment for Water Sampling*, at *http://water.usgs.gov/owq/FieldManual/*.

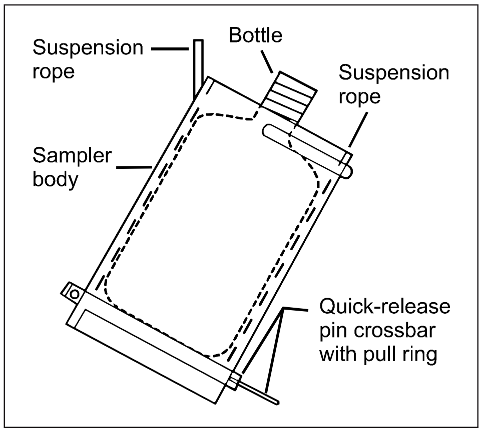

Figure 5.21 US WBH-96 Weighted Bottle Sampler. Illustration from Federal Interagency Sedimentation Project, Waterways Experiment Station, Vicksburg, Miss.

Procedures for Use:

i. Assemble the weighted bottle sampler.

ii. Lower the sampling device to the predetermined depth.

iii. When the sampler is at the required depth, pull out the bottle stopper with a sharp jerk of the sampler line and allow the bottle to fill completely. (This is usually evidenced by the cessation of air bubbles.)

iv. Retrieve sampler.

v. Transfer sample into laboratory cleaned sample bottles (if applicable, fill VOA vials first) or churn splitter and follow procedures for preservation and transport (see Chapter 2, *Quality Assurance*).

vi. For equal-depth or equal-width increment sampling follow the procedures in found in the US Geological Survey's Book 9, *Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter A4, Collection of Water Samples, at *http://water.usgs.gov/owq/FieldManual/*.

Advantages:

- sampler remains unopened until at sampling depth (if equipped with a bottle stopper)
- samples can be taken from bridges when streams are inaccessible or too deep to wade

Disadvantages:

- cannot be used to collect liquids that are incompatible with the weight sinker, line or actual collection bottle
- laboratory supplied bottle may not fit into sampler, thus requiring additional equipment (constructed of PTFE or stainless steel)
- some mixing of sample may occur when retrieving the sampler from depth

5.2.3.4 Wheaton Dip Sampler

The Wheaton Dip Sampler (Figure 5.22) is useful for sampling liquids in shallow areas. It consists of a glass bottle mounted on a metal pole of fixed length. Attached to the bottle's screw cap is a suction cup mounted on another metal pole. When the sampler is lowered to the desired sampling depth, the bottle cap is released by turning the metal pole attached to the suction cup. When the bottle is full (usually evidenced by the cessation of air bubbles), the cap is screwed back on to seal the sampling container and the bottle is retrieved.

Figure 5.22 Wheaton Dip Sampler (Photograph by J. Schoenleber)

Procedures for Use:

i. Assemble the sampler in accordance with the manufacturer's instruction.

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 desired depth is reached, open sample bottle.

v. Once sample is collected, close sample bottle.

vi. Retrieve sampler

vii. Transfer sample into laboratory cleaned sample bottles (if applicable). Note: volatile organic samples must be collected first. Follow procedures for preservation and transport (see Chapter 2, *Quality Assurance*).

Advantages:

- sample bottle is not opened until specified sampling depth is obtained
- sampler can be closed after sample is taken ensuring sample integrity
- ease of operation

Disadvantages:

- depth of sampling is limited by length of poles
- exterior of sample bottle (to be sent to lab) may come in contact with sample
- laboratory supplied sample bottle may not fit into the apparatus, thus requiring additional equipment (constructed of PTFE or stainless steel)

5.2.3.5 Kemmerer Depth Sampler

Aside from depth sampling in open bodies of water for macrophytes, the Kemmerer depth sampler (Figure 5.23) can be used to collect liquid waste samples in storage tanks, tank trailers, vacuum tanks, or other situations where collection depth prevents use of other sampling devices.

Figure 5.23 Kemmerer Depth Sampler (Photograph by J. Schoenleber)

This sampling device consists of an open tube with two sealing end pieces. These end pieces can be withdrawn from the tube and set in open position. These remain in this position until the sampler is at the required sampling depth and then a weighted messenger is sent down the line or cable, releasing the end pieces and trapping the sample within the tube.

Procedures for Use:

i. NOTE: The sampler described above may generally be operated from a boat launched onto the lake, pond, lagoon or surface impoundment with the sample collected at depth. If the lagoon or surface impoundment contains known or suspected hazardous substances, the need to collect samples vs. the potential risk to sampling personnel must be considered. If the sampling is determined to be necessary, appropriate protective measures (flat-bottomed boat for increased stability, life preservers, back-up team, etc.) must be implemented.

ii. Set the sampling device so that the sealing end pieces are pulled away from the sampling tube, allowing the substance to pass through the tube.

iii. Lower the pre-set sampling device to the predetermined depth.

iv. When the sample is at the required depth, send down the messenger, closing the sampling device.

v. Retrieve sampler.

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

Advantages:

- ability to sample at discrete depths
- ability to sample great depths

Disadvantages:

- open sampling tube is exposed while traveling down to sampling depth
- transfer of sample into sample bottle may be difficult

5.2.3.6 Van Dorn Sampler

The Van Dorn sampler (Figure 5.24) usually is the preferred sampler for standing crop, primary productivity and other quantitative plankton determinations because its design offers no inhibition to free flow of water through the cylinder. In deep-water situations, the Niskin bottle is preferred. It has the same design as the Van Dorn sampler except that the Niskin sampler can be cast in a series on a single line for simultaneous sampling at multiple depths with the use of auxiliary messengers. Because the triggering devices of these samplers are very sensitive, avoid rough handling. Always lower the sampler into the water; do not drop. Kemmerer and Van Dorn samplers have capacities of 0.5 L or more. Polyethylene or polyvinyl chloride sampling devices are preferred to metal samplers because the latter liberate metallic ions that may contaminate the sample. Use polyethylene or glass sample storage bottles. Metallic ion contamination can lead to significant errors when algal assays or productivity measurements are made.

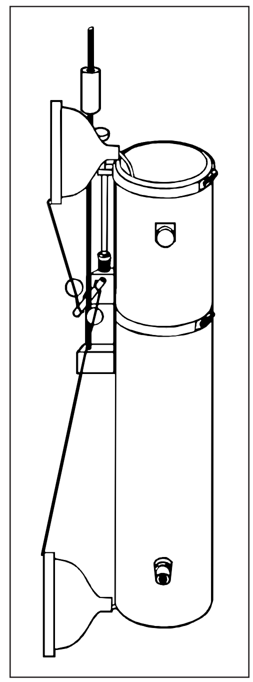

Figure 5.24 Van Dorn Sampler. Illustration from Standard Methods for Examination of Water and Wastewater, 20th Edition. Copyright 1992 by the American Public Health Association, the American Water Works Association and the Water Environment Federation.

Procedures for Use:

Similar to Kemmerer

5.2.3.7 Other Water Bottle Samplers

There are several variations of water bottle and trap samplers readily available on the market. Vertical and horizontal water bottle samplers come in various cylindrical dimensions ranging from 2 to 8 liters in volume. Materials of construction range from PVC to transparent acrylics. All are triggered by messengers. Their primary purpose is to measure physical (temperature), chemical (dissolved gases, nutrients, and metals) and biological (phyto- microzoo- and bacterio-plankton) constituents at depth. Check with the manufacturer on the combinations of construction materials to suite your sampling needs. Vertical samplers can be arranged in series or a carousel setup when the objective is multiple depth sampling. Horizontal samplers are designed to focus on narrow layers (e.g., thermoclines).

Juday and Schindler-Patalas are larger trap samplers that range in collection volume from 10 to 30 liters. These are preferred for zooplankters and larger copepods. These can be fitted with nets where qualitative data or large biomass is needed. Schindler-Patalas traps are typically transparent and have no mechanical closing mechanism making them convenient for cold-weather sampling.

5.2.3.8 VOC Sampler

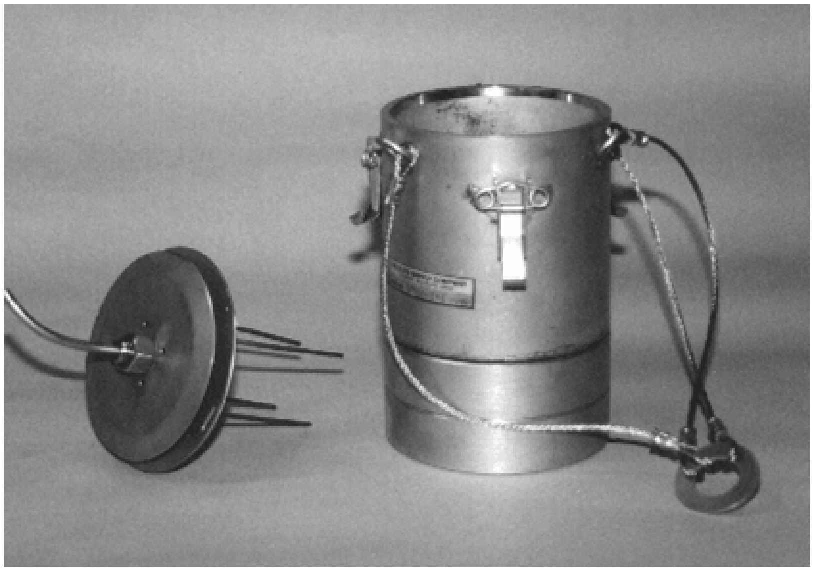

Figure 5.25 VOC Sampler. Illustration published with permission from Wildco®

This device, manufactured by Wildco for the USGS, is used to collect stream and open-water samples for VOC analysis (Figure 5.25). The device has been tested for analyte loss, reproducibility and contaminant carryover in the laboratory and under field conditions. Made of stainless steel and refrigeration-grade copper, it is designed to collect samples representative of environmental conditions in most streams. An important function of the sampler design is to evacuate air and other gases from the sampler before sample collection. The device weights 11 lbs. and can be suspended by hand from a short rope or chain while wading a stream. During periods of high flow, 10 lb. weights can be added to keep the sampler vertical when suspended from a bridge or cableway.

The sampler is designed to collect a sample at a single point in a stream or open body of water. The stainless-steel device holds four 40 ml vials. Copper tubes extend to the bottom of each vial from the inlet ports on the top of the sampler. The vials fill and overflow in to the sampler body, displacing the air in the vials and in the sampler through the exhaust tube. The total volume is eight times larger then the vials; therefore, the vials are flushed seven times before the final volume is retained in the vial. The small (1/16th inch inside diameter) copper inlet ports results in a slow (3 - 4 minutes) filling time. This feature helps to produce a representative sample and allows sufficient time to place the sampler at the desired depth. The sampler begins to fill as soon as it enters the stream; however, the final sample is retained in the vial during the last 15 - 20 seconds of the filling process. A cover over the inlet ports prevents contamination from surface oil and debris when the sampler is removed from the stream.

A complete description can be found in the Open-File Report 97-401, *A Field Guide for Collecting Samplers for Analysis of Volatile Organic Compounds in Stream Water for the National Water-Quality Assessment Program*. (or visit *http://ca.water.usgs.gov/pnsp/pest.rep/voc.html*. This device is not designed for nor can it be applied to monitor well investigations.

Approval of a device of similar operation targeted for use in monitor wells is currently pending further evaluation to determine its appropriate application. Manufactured by SIBAK Industries, the Kabis sampler has undergone preliminary testing published by the USEPA and an unpublished review by the NJDEP. The USEPA Environmental Technology Verification Report (EPA/600/R-00/054) identified inconsistencies in sample analysis when the device passed through a dirty zone within a controlled water column. The report also identified a low analytical bias for certain contaminants. The NJDEP identified additional inconsistencies resulting in a lack of confidence in the device's ability to meet data quality objectives. Finally, the USACE, Cold Regions Research and Engineering Laboratory, has examined the Kabis and other discrete ground water sampling devices and their observations can be reviewed in (ERDC/CRREL TR-02-12).

5.2.3.9 Double Check Valve Bailer

Double check valve bailers (Figure 5.26) are similar in construction to bottom check valve bailers, but have the addition of a second check valve located at the top. The procedures for use are similar to that of the bottom fill bailer except when the dual check valve bailer is used as a modified point source sampler. In this case, the dual check valve bailer is lowered to the desired depth and the check valves automatically close upon retrieval allowing for sample collection at discrete depths. Aside from sampling surface waters at depth, the dual check valve bailer can be used to sample dense, non-aqueous phase liquids (DNAPLs) which can accumulate in the bottom of monitor wells. The same restrictions regarding dissolved oxygen and other air sensitive parameters that apply to single check valve bailers above apply to the dual check valve bailer as well.

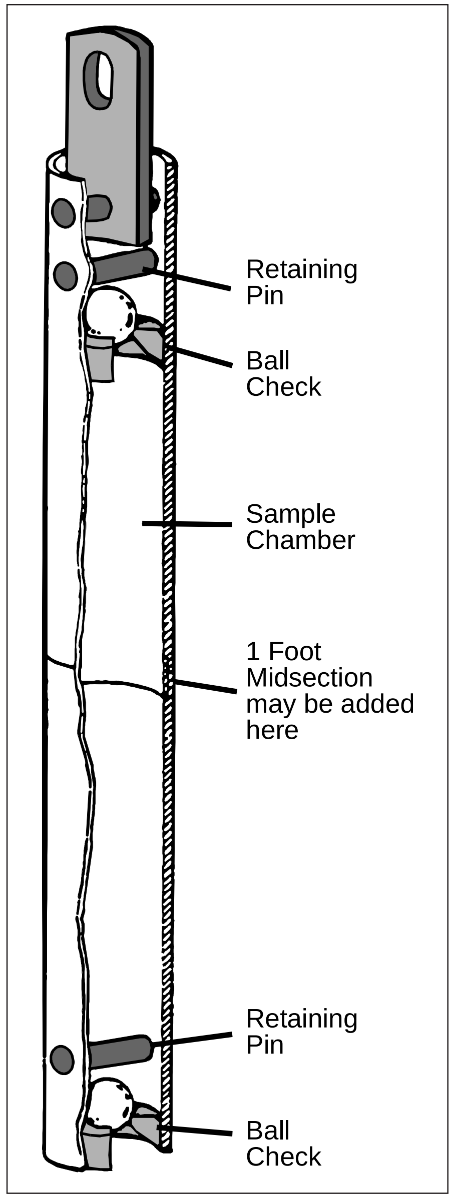

Figure 5.26
Double Check Valve Bailer

Procedures for Use:

i. Unwrap laboratory-decontaminated bailer and connect to decontaminated PTFE coated leader/cable for lowering.

ii. Lower the bailer slowly until the depth to be sampled is reached.

iii. Slowly raise the bailer. The ball check valves will both close automatically as the bailer is lifted.

iv. Tip the bailer to allow a slow discharge from the top gently down the side of the sample bottle to minimize turbulence. A bottom-emptying device may also be utilized and should be used when sampling for volatile organics. When applicable, always fill organic sample vials first, to zero headspace, with the first bailer full of water.

v. Repeat steps iii. to v. until a sufficient sample volume is acquired.

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

vii. Place used bailer in bag for return to lab for decontamination.

viii. Procure an additional lab decontaminated bailer and proceed to the next sampling location. Repeat procedure.

Advantages:

- measure the depth and thickness of DNAPL, if present.
- economical and convenient enough that a separate laboratory cleaned bailer may be utilized for each well therefore eliminating cross contamination
- available in PTFE or stainless steel construction
- relatively simple to use, lightweight

Disadvantages:

- aeration of sample as: 1) the sample is transferred from the bailer to the sample container over the top check valve, and 2) air becomes trapped between check valves when the bailer is turned upright causing agitation of the sample
- limited volume of sample collected
- field cleaning is not acceptable
- ball check valve function susceptible to wear, dimension distortion and silt buildup resulting in leakage. This leakage may aerate proceeding sample and may gather unwanted material by rinsing unwanted material from well casing.
- when used as a point source device, considerable mixing may occur
- representativeness of sample is operator dependent
- can not be used for well evacuation
- cannot provide reliable or reproducible data for air sensitive parameters e.g. dissolved oxygen, pH, carbon dioxide or iron and its associated forms. As a result, operator must submit to the Department a request for a variance from the Technical Requirement for Site Remediation Regulations (N.J.A.C. 7:26E-3.7), which requires the sampler to measure, record and submit well purging information associated with above parameters.

5.2.3.10 Bacon Bomb Sampler

Figure 5.27 Bacon Bomb Sampler (Photograph by J. Schoenleber)

The Bacon bomb sampler is a widely used, commercially available sampler, designed for sampling petroleum products. It is very useful for sampling large storage tanks because the internal collection chamber is not exposed to product until the sampler is triggered.

The Bacon bomb sampler (Figure 5.27) is constructed of brass or stainless steel and is available in two sizes: 1.5 inches or 3.5 inches in diameter. These range in volume from 4 oz. up to 32 oz. It is equipped with a trigger, which is spring loaded. When opened, the trigger allows liquid to enter the collection chamber. When the trigger is released, liquid is prevented from flowing into or out of the collection chamber.

Procedures for Use:

i. Lower the Bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.

ii. Release the trigger line and retrieve the sampler. Transfer the sample to the laboratory cleaned sample container by pulling upon the trigger. If applicable, fill VOA vials first.

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

Advantages:

- sampler remains unopened until at sampling depth
- stainless steel construction facilitates proper decontamination

Disadvantages:

- difficult to decontaminate
- difficulties in transferring sample to container
- tends to aerate sample
- brass construction may not be appropriate in certain analysis

5.2.3.11 Continuous Water-Quality Monitors

A continuous water-quality monitor such as a data sonde is essentially a multi-meter, which is placed in a body of water for a prolonged period of time. The monitor is capable of taking continuous field measurements for a variety of parameters depending upon which probes it is equipped with e.g., pH, dissolved oxygen, specific conductance, turbidity, chlorophyll-a, etc. Continuous water-quality monitors are intensely more dynamic than simple flow-through cells used for monitoring well stability prior to sample collection. Use the URL below to gain a better understanding.

For more information regarding flow-through cells see Chapter 6, *Sample Collection*, Section 6.9, *Ground Water Sampling Procedures*, Subsection 6.9.2.2.4.5, *Flow-Through Cell*.

Procedures for Use

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

5.2.3.12 Churn Splitter

A churn splitter is essential for compositing surface water samples. It can be either an 8L, or, a 14L plastic container with a lid, spigot and churning paddle. See the US Geological Survey's Book 9, *Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data*, Chapter A2, *Selection of Equipment for Water Sampling*, Section 2.2.1.A, *Churn Splitter*, at *http://water.usgs.gov/owq/FieldManual/* for proper application. For proper cleaning when trace metal analysis is required see *http://water.usgs.gov/admin/memo/QW/qw97.03.html*. Should you experience water leakage at the spigot, go to *http://water.usgs.gov/owq/FieldManual/mastererrata.html#Chapter4* for tips on how to prevent.

Procedures for use:

i. Clean churn using the appropriate method for the constituents which will be analyzed, e.g., trace element analysis requires an acid soak.

ii. Churn should be kept double-bagged in clear plastic bags at all times after being cleaned including sample collection.

iii. Rinse churn 3 times with 1 liter of sample water before collecting any samples. Be sure to allow the water to drain through the spigot each time.

iv. Fill churn with the appropriate number of sub-samples. Be careful to keep lid on at all times except when depositing sub-samples.

v. The contents of the churn should be composited by moving the paddle up and down at least 10 times prior to opening the spigot. A churning rate of 9 inches per second should be achieved before drawing off any samples. Once the rate is achieved, continue to churn the sample, open the spigot and collect raw samples. Filtered samples are taken directly from the churn's main compartment using a peristaltic pump and the appropriate tubing and filter.

5.2.3.13 Sample Collection and Preservation Chamber

A sample collection chamber is a containment system consisting of a white polyvinyl chloride framework with a clear plastic bag forming a barrier to ambient conditions. It is used create a clean environment in order to collect and preserve samples susceptible to contamination from ambient air deposition (i.e., affords protection to water quality samples in which constituents of concern occur at extremely low trace levels). Instructions from the USGS's Hydrologic Instrumentation Facility on how to construct your own sample and preservation chamber are available at the end of this chapter in Appendix 5.1, *Sample Collection and Preservation Chamber*. See the US Geological Survey's Book 9, Handbooks for Water-Resources Investigations, *National Field Manual for the Collection of Water-Quality Data*, Chapter A2, *Selection of Equipment for Water Sampling*, Section 2.2.2, *Processing and Preservation Chambers* for more information at *http://water.usgs.gov/owq/FieldManual/*.

5.2.4 Containerized Liquid Sampling Equipment

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One of the most difficult liquids to sample is that which is stored in a container. Several factors play an important role in determining the sampling method to be used. These include the location of the container, the location and size of the opening on the container, and the type of equipment that is available for sampling. Health and safety of sampling personnel also plays a key role in determining the choice of and which sampling tool will be used.

No matter what type of sampler is chosen, it must be utilized in such a manner that allows collection of all horizons present in the container. Rarely does a container hold a homogeneous mixture of material.

Sampling devices for containerized liquids and their procedures for use are presented below. Other sampling devices, which may be considered appropriate, include the Bacon Bomb, Kemmerer, or a Weighted Bottle Sampler, previously explained above in Section 5.2.3 of this chapter.

5.2.4.1 Coliwasa

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The Composite Liquid Waste Sampler, or COLIWASA, (Figure 5.28) is one of the most important liquid hazardous waste samplers. It permits the representative sampling of multiphase wastes of a wide range of viscosity, corrosivity, volatility, and suspended solids content. Its simple design makes it easy to use and allows for the rapid collection of samples, thus minimizing the exposure of the sample collector to potential hazards from the waste.

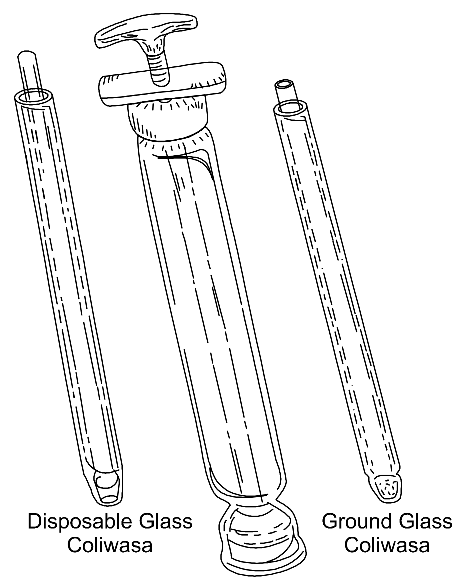

Figure 5.28 Coliwasa

Three types of COLIWASA samplers are generally available based on materials of construction. These include those made of plastic, PTFE or glass. The plastic type consists of a translucent plastic sampling tube. This COLIWASA is used to sample most containerized liquid wastes except wastes that contain ketones, nitrobenzene, dimethylforamide, mesityl oxide, and tetrahydrofuran. The glass type uses a borosilicate glass plumbing pipe as the sampling tube and glass or PTFE for a stopper rod. This type is used to sample all other containerized liquid wastes that cannot be sampled with the plastic COLIWASA except strong alkali and hydrofluoric acid solutions.

Procedures for Use:

i. With the sampler in the open position, insert it into the material to be sampled.

ii. Collect the sample at the desired depth by rotating the handle until one leg of the T is squarely perpendicular against the locking block.

iii. Withdraw the sampler and transfer the sample(s) into laboratory cleaned sample bottles.

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

Advantages:

- inexpensive
- simplicity of operation
- versatile

Disadvantages:

- problems encountered with fluids of very high viscosity
- difficulty in cleaning

5.2.4.2 Open Tube Thief Sampler

The open tube thief sampler (Figure 5.29) is basically a hollow glass or rigid plastic tube, which is anywhere from four to five feet in length. It generally has an inside diameter of 1/4" or ½". Chose a diameter based on the viscosity of the liquid to be sampled.

The plastic open tube sampler (Thief) is used to sample most containerized liquid wastes except waste that contains ketones, nitrobenzene, dimethylforamide, mesityl oxide, and tetrahydrofuran.

The glass open tube sampler (Thief) is used to sample all other containerized liquid waste that cannot be sampled with the plastic open tube sampler except strong alkali and hydrofluoric acid solutions.

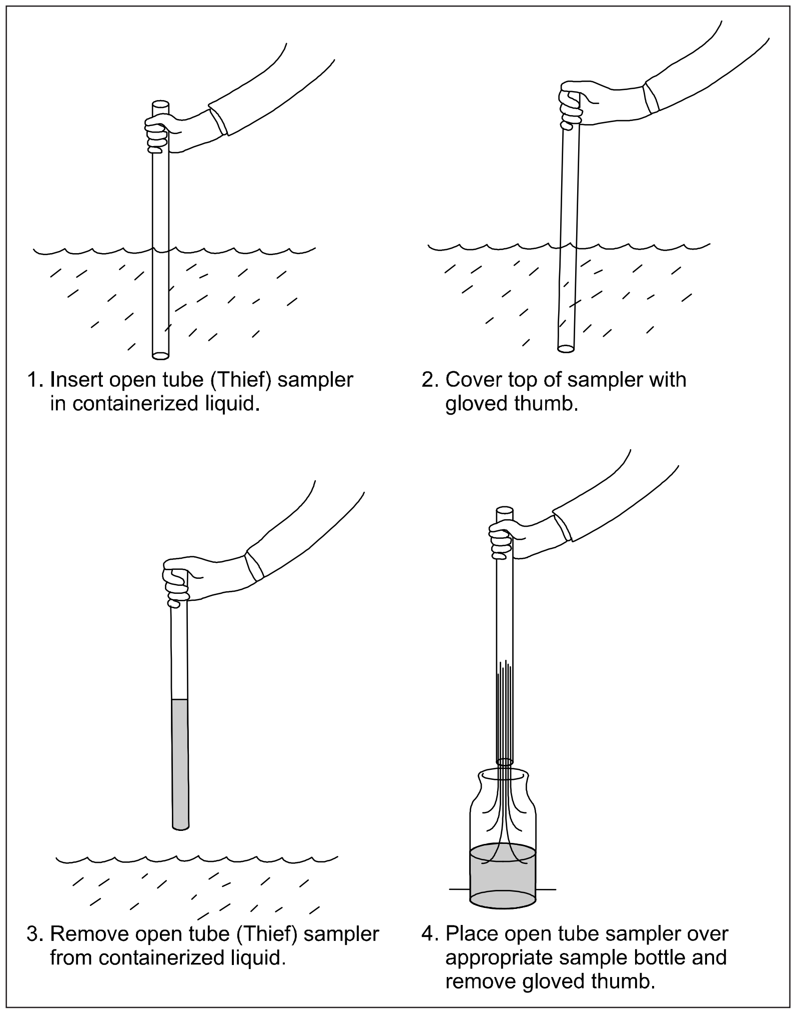

Figure 5.29 Open Tube Thief Sampler

Procedures for Use:

i. Insert the sampler into the material to be sampled to the depth desired.

ii. Place gloved thumb securely over open end of tube and carefully withdraw the sampler.

iii. 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:

- inexpensive
- simplicity of operation
- versatile, e.g. may be used to sample water from sump areas in homeowner basements
- disposable

Disadvantages:

- sample leakage
- small sample volume

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5.2.4.3 Stratified Thief Sampler

The stratified thief sampler (Figure 5.30) uses discs or wipers to hold stratified liquids in position while the tube is slipped past them. The wipers keep the inside of the tube from carrying portions of the upper fluid down into other layers.

The plastic stratified sample thief is used to sample most containerized liquid hazardous waste except waste that contains ketones, nitrobenzene, dimethylforamide, mesityl oxide, and tetrahydrofuran. It is particularly useful for highly viscous, stratified liquids.

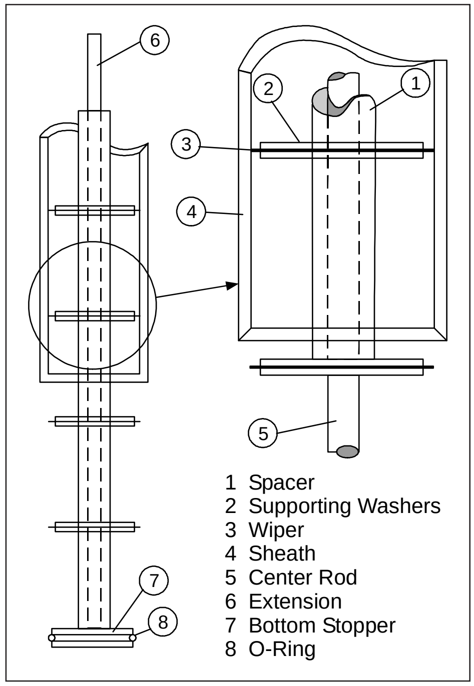

Figure 5.30 Stratified Thief Sampler

Procedures for Use:

i. Insert the sampler into the material to be sampled with the outer sheath raised to the open positions.

ii. When the desired depth is reached, slide outer sheath down over center section.

iii. Withdraw the sampler and transfer discrete samples into laboratory cleaned sample bottles.

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

Advantages:

- simplicity of operation
- representative sample obtained in viscous, stratified liquids

Disadvantages:

- plastic is not compatible with certain substances
- some difficulty in transferring sample to sample container

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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

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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

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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

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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

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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.

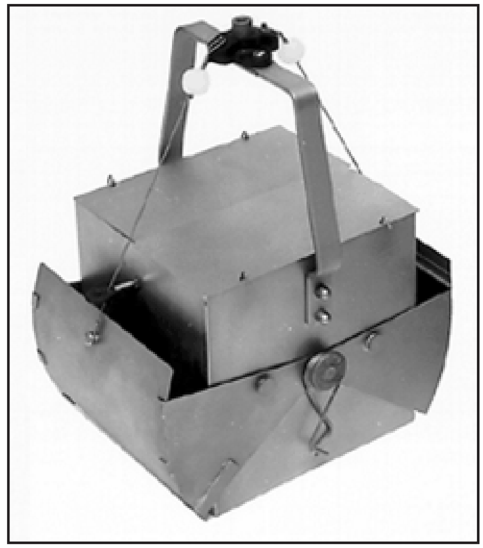

Figure 5.37 Ekman Grab Sampler. Illustration published with permission of Wildco®

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.

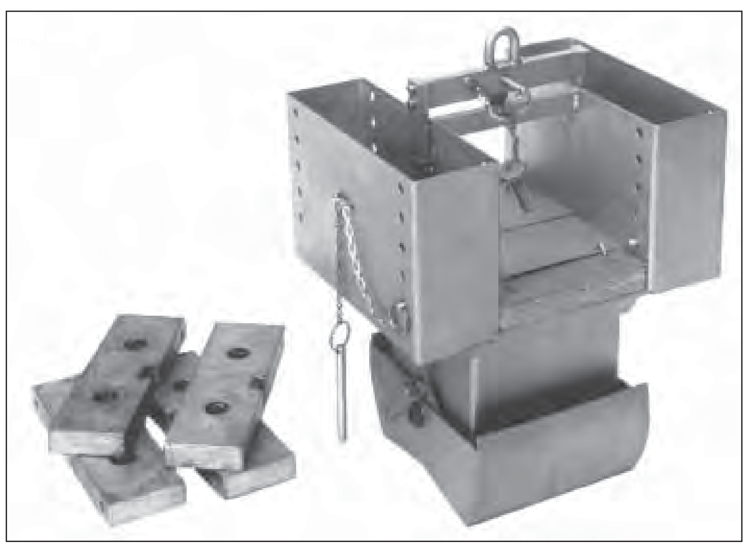

Figure 5.38 Box Corer. Illustration published with permission of Wildco®

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.

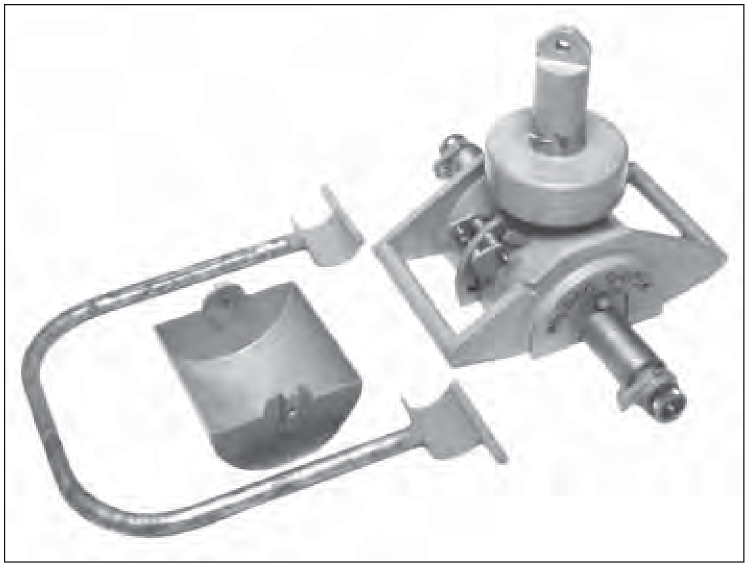

Figure 5.39 Shipek® Grab Sampler. Illustration published with permission of Wildco®

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.

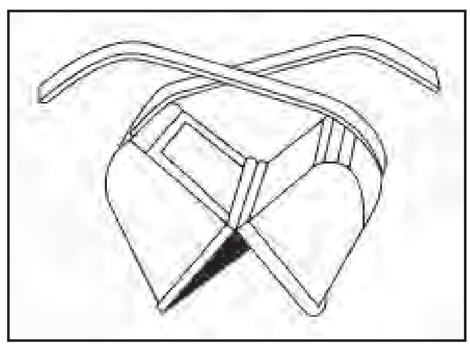

Figure 5.40 Van Veen Grab. Illustration published with permission of Wildco®

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 specialized 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

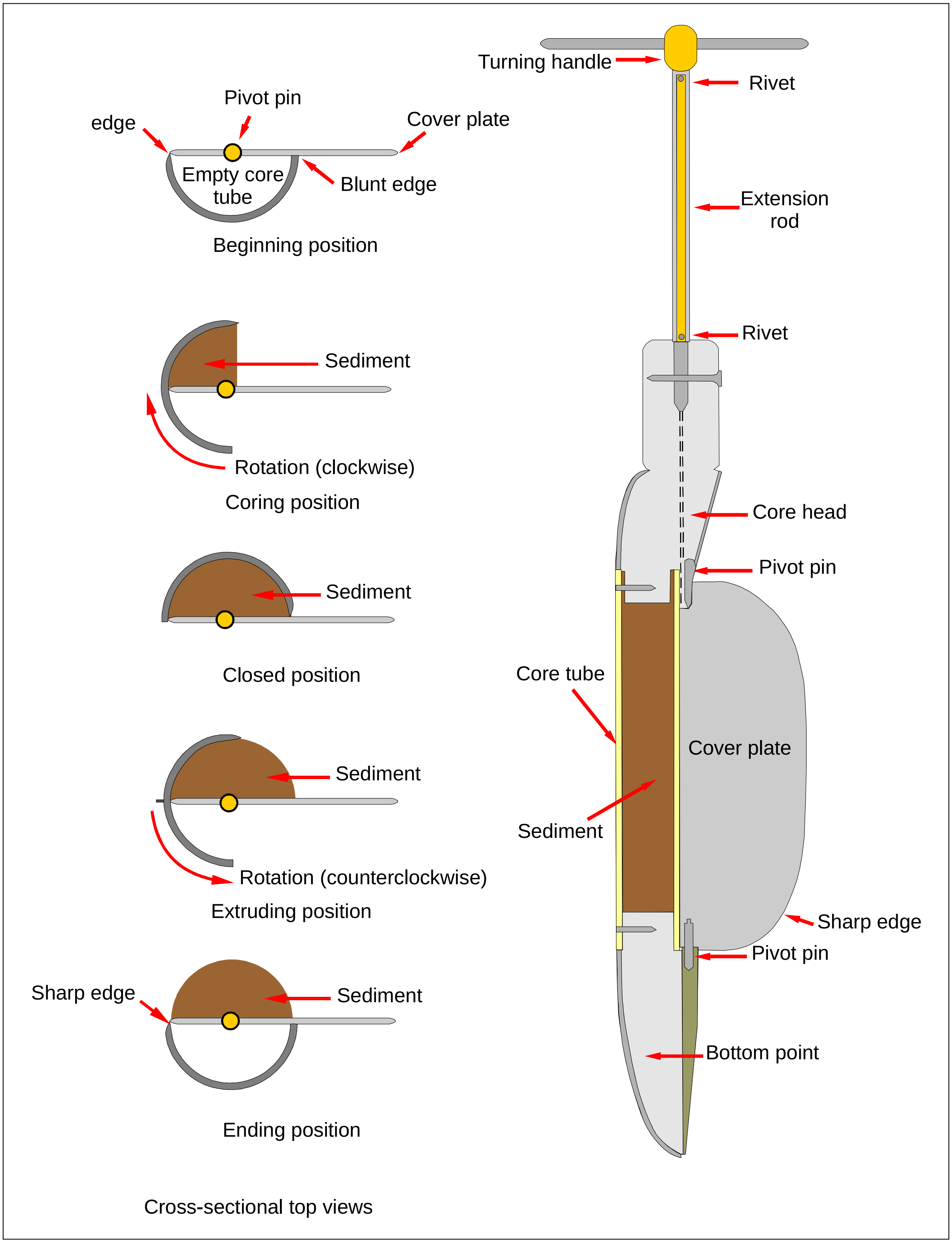

Figure 5.43 Russian Peat Borer. Illustration published with permission of Aquatic Research Instruments

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.

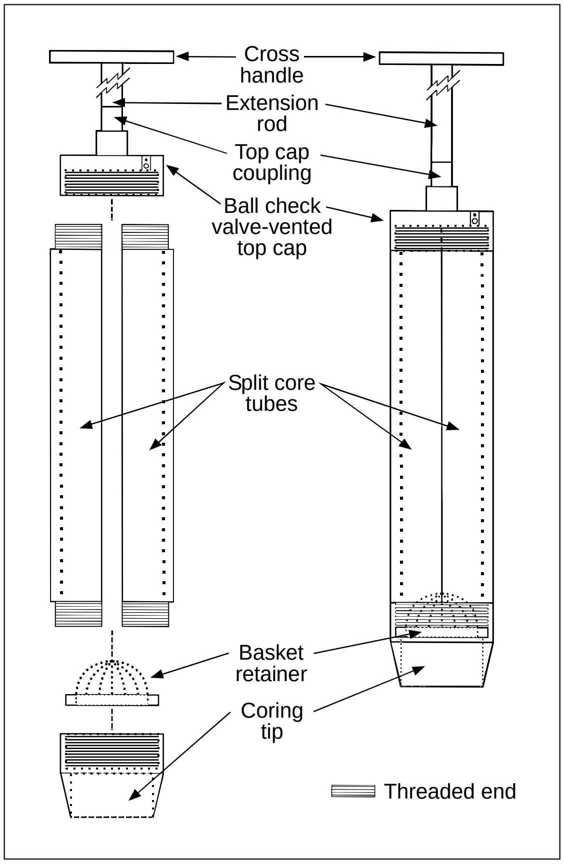

Figure 5.44 Split Core Sampler. Illustration published with permission by Art's Manufacturing & Supply

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

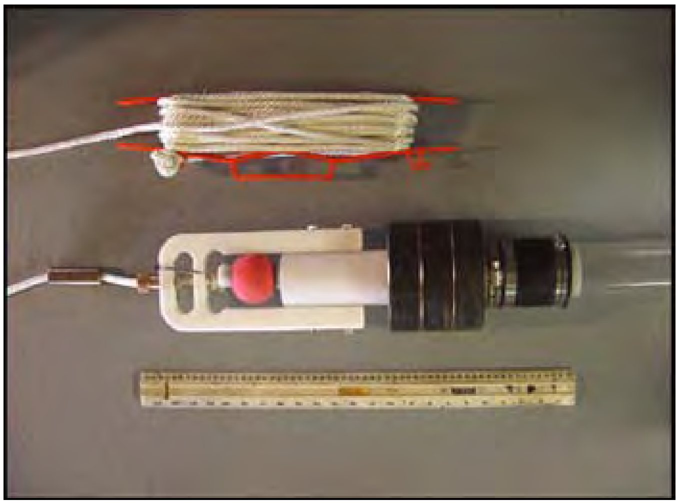

Figure 5.45 Gravity Corers. Illustration published with permission from Aquatic Research Instruments

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.

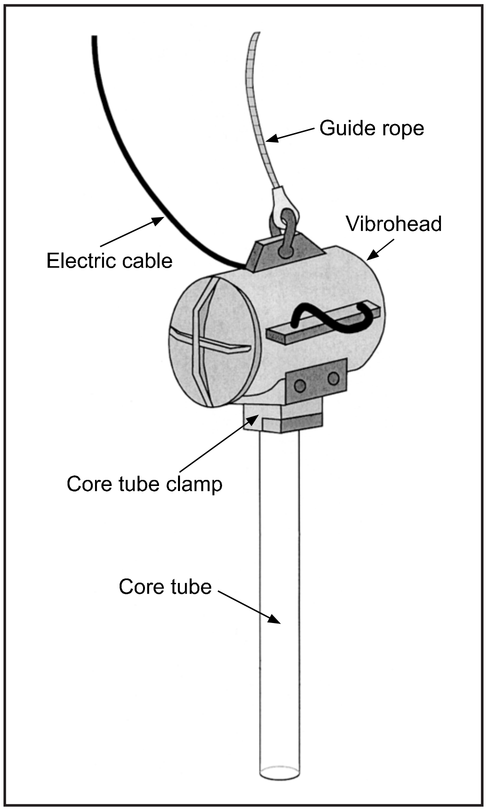

Figure 5.46 Vibracorer (Source USEPA, ETV Program Report)

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 (pounds)**	**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 designation	Sampler construction material	Sampler dimensions (inches)	Sampler weight (pouinds)	Suspension	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-Brinkhurst (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 (pounds)	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 frame-work, 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

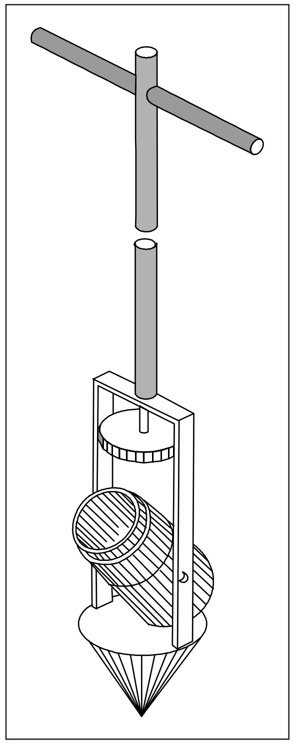

Figure 5.47 Lidded Sludge/Water Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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.

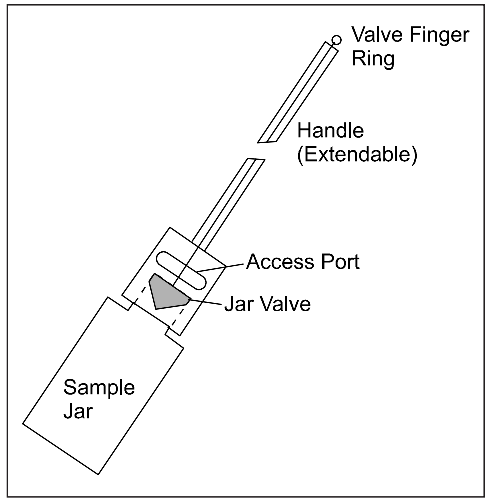

Figure 5.48 Liquid Grab Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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

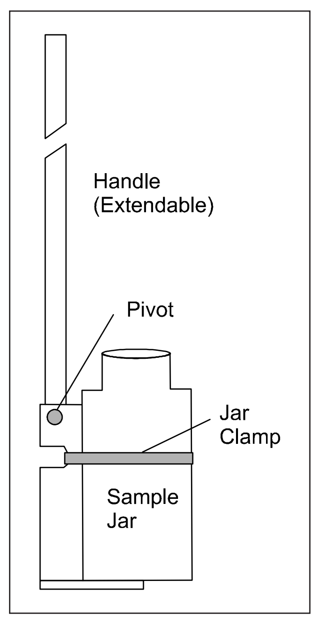

Figure 5.49 Swing Jar Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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.

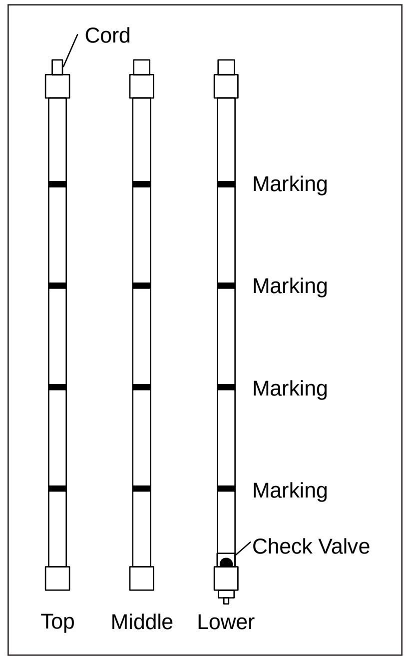

Figure 5.50 Sludge Judge (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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.

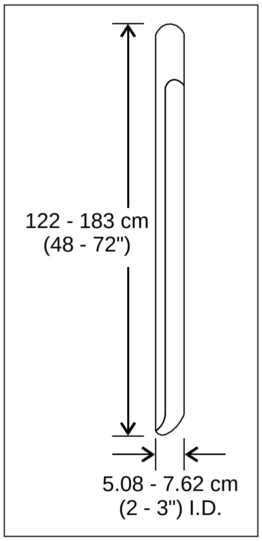

Figure 5.52 Waste Pile Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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

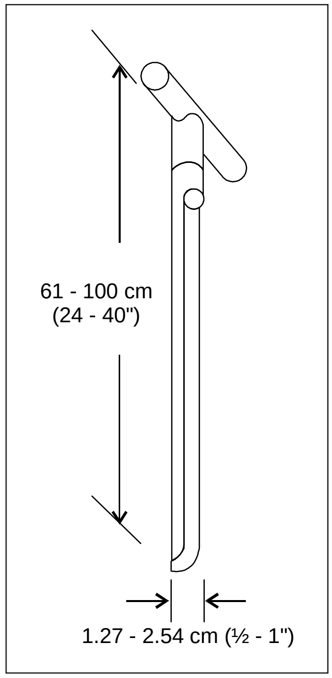

Figure 5.53 Sampling Trier (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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).

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Return to TOC

Appendix 5.1 – Sample Collection And Preservation Chamber

Purpose: To collect water samples in a clean environment.
Consisting of: Two sections.

- Section 1: sample-wetted parts.
- Section 2: the chamber framework, field fabricated PVC or CPVC tube frame

Section 1: Sample wetted parts.
Consisting of: Teflon valve, Teflon Tee, Teflon rubbing (.500 and .625 OD sizes)

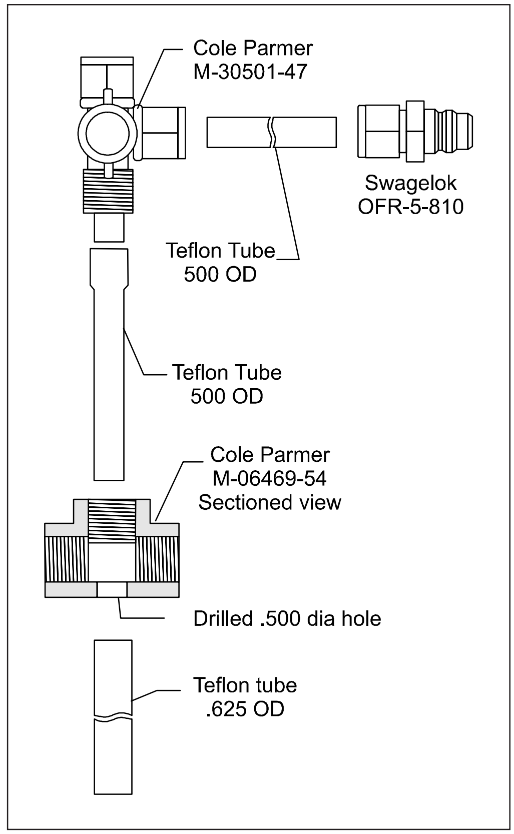
Item	Description	Unit	Quantity
1	Valve, Teflon, Three-Way Stopcock to fit .500 OD tube to fit .500 OD tube Cole-Parmer P/N M-30501-47	ea	1
2	Flaring tool required to assemble tube to valve: Cole-Parmer P/N M-07148-47 **NOTE:** One flaring tool is required to assemble the tube to the valve.	ea	1
3	Tee, Teflon, Cole-Parmer P/N M-06469-54	ea	1
4	Tubing, Teflon, smooth wall .500 OD x .062 wall (.375 ID) x 42" long Cole-Parner #06375-07	ea	1
5	Tubing, Teflon, smooth wall .625 OD x .062 wall (.500 ID)	ft	1
6	Quick-Connect Stem, SS, Full-Flow type (No shutoffs either end) with Swagelok fitting to fit .500 OD tube Swagelok P/N SS-QF8-S-810	ea	1
7	Nylon tie straps, .140 wide x 8 (nominal) long Thomas & Betts P/N TY-5242M Package of 10	pkg	1

Assembly Procedure
Section 1: Sample-wetted parts

Fabrication and Assembly Required:

1. Drill a .500-diameter hole through the back of the Teflon tee.
   Do this by running the drill bit straight down the branch of the Tee, then drilling through the opposite site (back) of the Tee.
   NOTE: Do not damage the threads in the branch of the tee.
2. Cut a 4-inch-long piece of .500 OD Teflon tube, and flare one end.
   Ensure that the free end of the tube has a clean, 90 degree cut end.
   Remove the nut from one of the run fittings of the valve, and slide the flared end of the tube onto the valve.

3. Insert the free end of the tube from step 2 into the branch of the Tee until the tube extends through the hole drilled in the rear of the Tee, and the threads on the valve engage the threads in the branch of the Tee. Thread the valve into the Tee until snug.
4. Cut a piece of .625 OD Teflon tube, 5 inches long.
5. Slide the .625 OD Teflon tube over .500 OD tube extending through the drilled hole in the Tee. Push the .625 tube until it gets tight or until it bottoms against the tee.
6. Flare one end of the remaining 36" piece of .500 OD Teflon tube.
7. Assemble the flared end of the .500 OD x 36: long Teflon tube to the branch fitting of the valve.
8. Assemble the Swagelok quick-connect stem to the free end of .500 OD x 36: tube



Section 2: Framework.
Consisting of: ½-inch schedule 40 CPVC pipe, elbows and tees:

All parts (except item 5) are readily available at most hardware stores, and are to be obtained locally.

Item	Description	Unit	Quantity
1	Pipe, CPVC, ½-inch schedule 40, 21 feet long (stock length-can be cut for transport)	ea	1
2	Elbow, CPVC, ½-inch schedule 40 'Slip' style for assembly with PVC primer and cement	ea	8
3	Tee, CPVC, ½-inch schedule 40 'Slip' style for assembly with PVC primer and cement	ea	4
4	Male adapter, CPCX, ½-inch schedule 40 'Slip' style one end, ½-NPT male threads other end.	ea	2
5	Teflon Tee, (from Assembly #8, section 1) "sample-wetted parts", with ½-NPT female threads.	ea	1
6	PVC/CPVC pipe primer		
7	PVC/CPVC pipe cement		

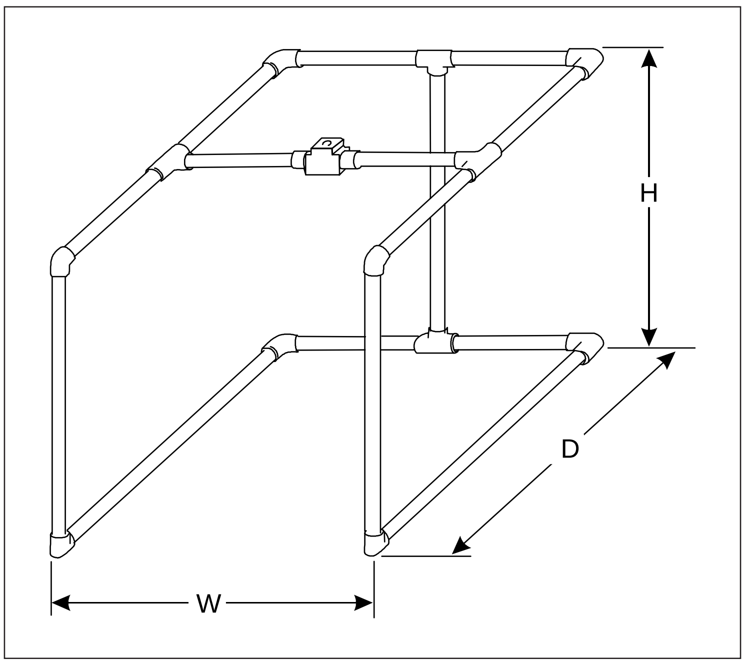
Note: If primer and cement are used, then the glued frame should be cured several days in a warm, well-ventilated area away from other sampling equipment. After curing, do a liquinox/tap water wash, tap-water rinse(3x) to remove detergent solution, DI-water rinse to remove tap-water residue, air dry in a clean environment, and bag for storage before use. When storage bag is re-opened check to ensure no glue residue aroma can be detected.

Assembly Procedure
Section 2: Framework

Fabrication and Assembly Required:
Cut and glue* the CPVC pipe and fittings together to make the assembly shown in the sketch. Suggested overall dimensions are 16W x 16H x 16D. This will allow this frame to be 'nested' with the three frames of Assembly #12 for ease to transport.

Note that the male adapters should be assembled to the threaded Tee before the short cross-bar Pipes are glued to the adapters. There is considerable flexibility in the order in which the frame assembly can be glued together, but **be sure that you DO NOT leave installing the threaded Tee for last!**

*Some sampling units prefer to not glue the frame together. This allows them to 'knock-down' the frame for transport.



This appendix is taken directly from the U.S. Geological Survey's Hydrologic Instrumentation Facility (HIF) at the Stennis Space Center, MS. http://wwwhif.er.usgs.gov/