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 complement specific situations encountered in the field. The selection of appropriate sampling equipment should consider sample type, matrix, 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 sampling equipment.

This chapter addresses sampling equipment for the following types of environmental samples: soil, sediment, ground water, and surface water; wastewater; biological; 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 5.4, at the end of this chapter, lists New Jersey Department of Environmental Protection (NJDEP) recommended waste material samplers and their application. For information regarding soil gas/ambient air sampling equipment and methodology please see Chapter 9 of the FSPM and the Vapor Intrusion Technical Guidance.

The field of environmental sampling is constantly evolving. These changes may include, but are not limited to, changes in the analytes tested (e.g., emerging contaminants), changes due to the development of new sampling equipment, changes developed through scientific studies, and changes in analytical capability or regulatory standards. Given the diversity of possible changes, it is impossible to develop a guidance document that is always up to date. Questions concerning NJDEP required sampling should be directed to the Bureau of Environmental Measurements and Site Assessment (609-376-9419).

The NJDEP maintains a library of guidance manuals on its website at https://www.nj.gov/dep/srp/guidance/. It is recommended the reader access the website and review the guidance manuals pertinent to the respective task. Additional guidance may also be found at websites of the USEPA (United States Environmental Protection Agency), ITRC (Interstate Technology and Regulatory Council), USGS (United States Geologic Survey), and the American Society for Testing and Materials (ASTM). Examples of some of the relevant guidance manuals and web pages pertaining to this chapter are:

Soil Investigation Technical Guidance: https://www.nj.gov/dep/srp/guidance/#si_ri_ra_soils;

Ground Water Technical Guidance: https://www.nj.gov/dep/srp/guidance/#pa_si_ri_gw;

Ecological Evaluation Technical Guidance: https://www.nj.gov/dep/srp/guidance/#eco_eval;

Quality Assurance Project Plan Technical Guidance:
https://www.nj.gov/dep/srp/guidance/#analytic_methods;

Vapor Intrusion Technical Guidance: https://www.nj.gov/dep/srp/guidance/#vi;

NJDEP Quality Management Plan: https://www.nj.gov/dep/enforcement/oqa/qap.html; and

Occupational Safety and Health Administration (OSHA): https://www.osha.gov.

5.1.1 Sampling Equipment Disclaimer

The names and descriptions of specific products or brands used in this document are for illustrative or descriptive purposes only and do not constitute a recommendation or requirement for a specific product or company. The NJDEP is cognizant that the process of environmental sampling is an evolving science, and that new or re-designed sampling equipment is always coming to market. As such, it is not practical for this document to be all-inclusive nor stay up to date. Now that Licensed Site Remedial Professionals (LSRPs) are responsible for making sure that NJDEP rules and Guidance are followed, and remedial objectives met, it is the responsibility of the sample collector to make sure that samples are collected with as little negative bias (bias that underestimates analyte concentrations) as possible. This is especially important with respect to the collection of samples for VOCs. Actions that should be taken to minimize negative bias include, but are not limited to:

- following manufacturer's instructions;
- using sampling equipment appropriate for the contaminant(s) being tested; and
- implementing sampling procedures appropriate for the contaminant(s) being tested.

Where samples are collected using a procedure or device that is not specifically discussed in this manual, documentation on how the samples were collected should accompany the sampling results in any report containing the sampling results that is submitted to the NJDEP. It is recommended that the documentation be included in the aforementioned reports as an appendix. The documentation should describe the sampling device and the process used during sample collection. Documentation should be as specific as possible and may include, but is not limited to:

- make and model of the sampling device;
- composition of the sampling device;
- volume of sampling device;
- manufacturer's instructions;
- published studies about the sampling device;
- depth in water column of sample collection;
- total volume purged prior to sample collection;
- residency time of sampling device in the water column;
- purge rate; and
- maximum well draw-down produced prior to sampling.

Inappropriate application of a sampling device, or failure to provide adequate supporting documentation to the NJDEP, can result in rejection or downgrade (i.e., lowering of data to screening quality) of the data by the NJDEP.

Sample results generated by procedures or equipment that are "not recommended", or not "recommended" by the NJDEP for a specific type of compound (e.g., VOCs) may be rejected or viewed as screening quality data. The data generated from this action should be clearly identified as being collected by a "not recommended" action, or an action that is not "recommended". This label should be used any time the data are presented or referenced.

Where professional judgement is argued to justify the use of equipment, procedures, or applications that are listed as "not recommended" in this Field Sampling and Procedures Manual, supporting technical or scientific justification shall be submitted to the NJDEP in submittals that include the generated data. The justification language shall be clearly identified in the submittal.

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 appropriate for a specific parameter. PTFE is the preferred material but may not always be practical. 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, rigid plastic liners associated with macro-core and sonic drilling, High Density Polyethylene (HDPE) or Low Density Polyethylene (LDPE) bladders in bladders pumps, HDPE for PFAS sampling, or disposable bailers constructed of polyethylene for the collection of ground water samples being analyzed for inorganics.

If polyethylene tubing is going to be used in the sampling setup to collect a groundwater sample, the NJDEP recommends that HDPE (see Table 6.14) be used over LDPE due to its lower adsorption-desorption characteristics. The lower adsorption-desorption properties of HDPE are due to the development of internal structure, which results in greater rigidity. See section 6.9 for more details.

LDPE may also be used as the sampling material when appropriate. While it is generally accepted that LDPE has greater absorption/desorption capacity than PTFE or HDPE , the adsorption process comes to equilibrium with the surrounding fluids over time. For example, if an equilibrium (diffusion) sampler made of LDPE is submersed in a large volume of water, such as an aquifer or surface water body, the effects of adsorption are negated when equilibrium is reached. See section 6.9 for more details.

> The issue of sampling material's adsorption/desorption capacity becomes more important the lower the contaminant concentration, and the lower the pertinent GWQS concentration. At low groundwater contaminant concentrations and GWQS's, the effect of adsorption or desorption could change the interpretation of the data (i.e., exceedance vs no exceedance). This issue should be discussed in documents where HDPE or LDPE is used, and the sampling data are presented.

In some cases of surface water, potable, and wastewater sampling, collection directly into the laboratory-provided sample container eliminates the need for transfers from sampling equipment that potentially compromises the integrity of the sample, as well as eliminating the need for 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 COLIWASA or drum thief). In all cases, the sampling device 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, ASTM International, ITRC, and other organizations are continually active in testing and reviewing various types of sampling equipment and methodologies. Additional information/links relating to sampling equipment is available at the end of Chapter 5.

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 with the exception of per fluorinated and/or polyfluorinated organic parameters.	√ (Potential source of fluoride.)	√ (Sorption of some organics.) NJDEP preferred material. Recommended for sampling where regulatory decisions may be made on data. Not recommended for PFAS sampling.
High Density Polyethylene (HDPE, including Linear High Density Polyethylene (LHDPE))	Relatively inert for inorganic analytes.	√	Generally acceptable where the sampling goal supports the decision. **Acceptable for use with HDPE bladders and no purge samplers. See 6.9.6 for additional information.**
Low Density Polyethylene (LDPE, including Linear Low Density Polyethylene (LLDPE))	Relatively inert for inorganic analytes.	√	**Not recommended except LDPE bladders and no purge samplers. May be acceptable for sampling where the sampling goal supports the decision.**
Polypropylene	Relatively inert for inorganic analytes.	√	**Not recommended.** Except for no purge samplers with polypropylene components.
Polyvinyl chloride (PVC)	Relatively inert for inorganic analytes.	√	**Not recommended.**
Silicone	Very porous. Relatively inert for most inorganic analytes.	√ (Potential source of Si.)	**Not recommended.**
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, 5]

Table 5.1 Cont.			
Construction Material for Sampling Equipment (Does Not Apply to Well Casing)		**Target Analyte(s)**	
Material	**Description**	**Inorganic**	**Organic**
Metals (cont.)			
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.)	√ Not recommended for PFAS sampling because of the potential for adsorption.

1. Plastics used in connection with inorganic trace-element sampling should 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.
5. If corrosion is found, justification for use should be provided in metals analysis.

√ 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 modified 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/).

5.1.2 Sampling for PFAS Compounds

While Teflon has historically been one of the recommended construction materials for sampling equipment due to its inert behavior and lower adsorption-desorption properties, it is not recommended to use sampling devices or tubing containing Teflon or other fluoropolymers when sampling for PFAS.

As the requirements and procedures for PFAS sampling are still evolving at this time, general information about PFAS and other emerging contaminants can be found at the NJDEP website: https://www.nj.gov/dep/srp/emerging-contaminants/. Specific questions concerning PFAS sampling should be directed to the Bureau of Environmental Measurements and Site Assessment (609-376-9419). Sample collection inquiries of a more ambient/ecological nature may contact the Bureau of Freshwater and Biological Monitoring (609) 292-0427). Contact the Bureau of Evaluation Environmental Risk

Assessment (609-633-6801) for questions about ecological risk evaluations. 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. Additional information about PFAS in drinking water is available from the New Jersey Department of Health at: https://www.nj.gov/health/ceohs/documents/pfas_drinking%20water.pdf.

5.2 Decontamination Procedures

An important aspect of quality control is the decontamination of field sampling equipment. Improperly cleaned and prepared sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination.

In addition, sampling equipment left in-situ for purposes of obtaining multiple samples over a period of time (e.g., periodic sampling for permit compliance) will often need to be cleared of accumulated contaminants, silt, soot, dust etc. This will assure that the samples are free of such material as may accumulate on the sampling equipment itself between uses.

The following four sampling equipment cleaning procedures form the basis of the standard NJDEP requirements.

- The Eight-Step Decontamination Procedure (aqueous and non-aqueous sampling equipment)
- The Three-Step Decontamination Procedure (non-aqueous sampling equipment only)
- Decontamination Procedures Using Heat (for use primarily on aqueous sampling equipment)
- The USGS Decontamination Procedure for Low Level Contamination

These four procedures cover decontamination of aqueous and non-aqueous equipment over a broad range of contaminant exposures for all programmatic needs and are chosen when preparing a sampling plan. Matrix, level of contamination, and programmatic considerations drive selection. The Eight-Step, the Three-Step and a third, Decontamination Procedures Using Heat, apply to levels of contamination encountered in New Jersey. The fourth, the decontamination procedure used by USGS, applies specifically to the cleaning of ground and surface water sampling equipment when analyzing for trace levels of inorganic, organic, biological, or toxicological constituents and interference from extraneous sources of contamination needs to be highly controlled. This procedure is treated separately from the others in this section and is included in this manual by reference to the USGS manual. There should be no crossover or mixing of procedures once an appropriate task-specific decontamination procedure is chosen.

Provided at the end of this section are general considerations intended to raise decontamination awareness when cleaning pumps, heavy equipment, equipment related to direct push technology, monitor well casings and screens, and selection of cleaning location. This is followed by discussion on the disposal of decontamination fluids and drill cuttings. Any exceptions to the following procedures should be documented and justified in the final report.

In most instances fixed laboratory decontamination serves as the preferred alternative to field decontamination.

Advantages:

- Decontamination takes place in a controlled environment
- Reduced need to transport, handle, or dispose cleaning solvents, acids, or wash water
- More attention can be focused upon sampling with field decontamination labor reduced or eliminated
- Reduced probability of cross-contamination due to improperly field decontaminated equipment
- Laboratory documentation of cleaning procedures and materials used

Limitations:

- Relative cost to scope of sampling event
- Constraints meeting demands in emergency situations
- Logistics

While the option exists to use field decontamination procedures for almost all non-aqueous sampling and certain aqueous sampling equipment (e.g., foot check valves, filtering equipment, stainless steel/ Teflon® pumps, automatic wastewater composite samplers), field decontamination of bailers is not acceptable. Bailers are required to be laboratory cleaned, packaged and dedicated for exclusive use at one sample location for that day's sampling (see definition of "laboratory cleaned" in the glossary). Field decontamination of bailers elevates the potential of cross-contamination to unacceptable levels. The possibility of contaminating a clean well is also of concern when using improperly cleaned sampling devices.

In certain instances, the use of "disposable" bailers presents an option to circumvent the logistics associated with decontamination of standard reusable bailers. To ensure quality control over these devices, disposable bailers must be decontaminated at the source of manufacture and proof of decontamination must accompany their purchase. They must be sealed in a protective covering prior to shipment from the manufacturer. Since these bailers will be used on a one-time only basis, inflexibility as to standard material of construction requirements may be waived. For example, in approved instances, disposable bailers constructed of polypropylene are acceptable when sampling for trace metal analysis.

Generally, sampling devices should be protected from ambient contact during storage and remain protected until used in the field. Non-aqueous equipment may be wrapped in aluminum foil when sampling for organics only and/or sealed in plastic bags or equivalent material when sampling for inorganics, then custody sealed for identification. Equipment should be handled as little as possible prior to use and disposable gloves must be worn at all times when handled. Sampling equipment must never be stored near solvents, gasoline, exhaust emissions, or other equipment and/or materials that may impact the integrity of prepared sampling instruments. A record should be kept of the date and time when cleaned and this information should be labeled on the sampling device.

Exhaust producing equipment must be situated in such a manner as to not compromise the decontamination process. The decontamination station must also be set up in such a way as to not adversely impact a clean environment.

Whenever sampling, regardless of how equipment has been cleaned, always start sampling in the area of the site with the lowest contaminant probability and proceed to the areas of highest known or suspected contamination. Following this procedure will add another measure of quality control keeping cross contamination interference to a minimum.

All equipment utilized for sampling must be decontaminated using high purity distilled or deionized water. Through distillation, all ionized solids and a broad range of organic constituents will be removed, thus making it an ideal solvent for use when sampling for organic parameters. Deionized water (DI) is water that has been effectively freed from any existing ionic impurities. For field decontamination procedures, commercially available distilled water is typically sufficient for many sampling objectives. However, if water free from ionic impurities or if a certificate of analysis is deemed to be necessary to meet project goals (e.g., trace level analysis), water that has been both distilled and deionized should be used. For laboratory-based decontamination procedures, distilled and deionized water should be used as specified in section 5.2.1. The use of distilled and deionized water, commonly available from commercial vendors, is acceptable provided that the lot number and the associated analysis are available upon request to the NJDEP, and it meets ASTM Type I or II specifications.

5.2.1 Eight-Step Decontamination Procedure for Aqueous and Non-Aqueous Sampling Equipment – Laboratory Only

Note that the term "laboratory" for the purposes of this section on decontamination procedures, refers to a controlled environment (typically indoors) and not necessarily an NJDEP-certified laboratory. This procedure is based, in part, upon the American Society for Testing and Materials, *Standard Practice for Decontamination of Field Equipment Used at Waste Sites*, number D 5088-15a.

The first step, a detergent and water wash, is to remove all visible particulate matter and residual oils and grease. This may be preceded by a steam or hot water, high pressure water wash to facilitate residual removal. A generous tap water rinse and a distilled and deionized water rinse to remove the detergent follow this. If aqueous sampling is to be performed, the following additional steps must be completed. An acid rinse, included if metals samples are to be collected, provides a low pH media for trace metals removal. It is followed by another distilled and deionized water rinse. If the sample is not to be analyzed for metals, the acid rinse and water rinse can be omitted. Next, a high purity solvent rinse is designated for trace organics removal. Acetone has been chosen because it is an excellent solvent, miscible in water and is not a targeted analyte in Priority Pollutant Analysis. If acetone is known to be a contaminant at a given site or Target Compound List analysis is to be performed, Methanol or another solvent may be substituted on a case-by-case basis with approval from NJDEP. Note, methanol cannot be used when sampling gasoline and its' byproducts. The solvent should be allowed to evaporate and then a final distilled and deionized water rinse is performed. This rinse removes any residual traces of the solvent.

The sampling equipment cleaning and decontamination procedures are as follows:

- **i.** Laboratory grade glassware detergent plus tap water wash (consider detergent and tap water composition when sampling)
- **ii.** Generous tap water rinse
- **iii.** Distilled and deionized (ASTM Type I or II) water rinse
- **iv.** 10% nitric acid rinse (trace metal or higher grade HNO_3 diluted with distilled and deionized (ASTM Type I or II) H_2O)
- **v.** Distilled and deionized (ASTM Type I or II reagent) water rinse[1]
- **vi.** Acetone (pesticide grade) or appropriate solvent rinse[2]
- **vii.** Total air dry or pure nitrogen blow out
- **viii.** Distilled and deionized (ASTM Type I or II) water rinse

All sampling equipment decontaminated via this procedure must be laboratory cleaned, wrapped and/or sealed, and dedicated to a particular sampling point or location during a sampling episode. In instances

[1] Only if sample is to be analyzed for metals.
[2] Only if sample is to be analyzed for organics.

where laboratory cleaning is not feasible, permission for field cleaning must be obtained from the NJDEP prior to the collection of any samples and be referenced in the approved quality assurance project plan. Sampling devices should be numbered in a manner that will not affect their integrity. Equipment should be custody sealed and information concerning decontamination methodology, date, time, and personnel should be recorded in the field logbook.

The use of distilled and deionized water commonly available from commercial vendors may be acceptable for sampling equipment decontamination. NJDEP may require specific lot numbers from containers or analytical verification that the distilled and deionized water meets ASTM Type I or II specifications.

Hexane is not a necessary solvent for dioxin, PCB, or other chlorinated organic sampling. The cleaning procedure outlined above is adequate for all sampling episodes. In those instances where acetone is a parameter of concern another solvent may be used. All substitutes must be approved by NJDEP.

In the field, decontamination should be carried out over a container and the material properly disposed off-site. Decontamination wastes must be disposed of properly.

5.2.2 Three-Step Equipment Decontamination Procedure Non-Aqueous Matrix Only – Laboratory and Field

While it is preferred that all non-aqueous field sampling equipment be laboratory cleaned, wrapped, and dedicated to a particular sampling point or location during a sampling episode, field cleaning may be more practical. Refer to the general field decontamination considerations above. The first step, a detergent and water wash, is to remove all visible particulate matter and residual oils and grease. This may be preceded by a steam or high-pressure water wash to facilitate residual removal. A generous water rinse and a distilled or deionized water rinse to remove the detergent follow this. If visual contamination persists, or gross contamination is suspected, the full eight-step decontamination procedure is required.

The field sampling equipment cleaning and decontamination procedures are as follows:

- **i.** Laboratory grade glassware detergent and water scrub to remove visual contamination
- **ii.** Generous water rinse
- **iii.** Distilled or deionized (ASTM Type I or II) water rinse
- **iv.** Solvent rinse if appropriate to the analysis method

All sampling equipment decontaminated via this procedure must be wrapped and/or sealed during storage and prior to use. Appropriate wrapping should be selected based on the analytical parameters (e.g., aluminum foil should not be used for PCB, PFAS, and metals sampling). Information concerning decontamination methodology, date, time, and personnel should be recorded in the field logbook.

In the field, decontamination should be carried out over a container and the residual liquid material must be properly disposed. Decontamination wastes must be disposed in accordance with current NJDEP policy (see Section 5.2.5.7, *Disposal of Development, Purge, Pump Test and Decontamination Water).*

When analysis for metals is required, it may be necessary to use carbon steel split spoon sampling devices instead of stainless steel. If this is the case and it is necessary to utilize the acid rinse for removal of visible contamination, the nitric acid rinse may be lowered to a concentration of 1% instead of 10% to reduce the possibility of leaching metals from the spoon itself.

5.2.3 Decontamination Procedures Using Heat

(For use primarily on aqueous sampling (or ground-water sampling) equipment – laboratory and/or field exclusively for organics including pesticides)

This section discusses decontamination procedures that include a step involving heat such as the use of a drying oven, hot water, or steam. A common use of these procedures would be for direct-push drilling equipment decontamination with a steam-cleaning or hot water pressure washing step. This specific procedure is further discussed in Sections 5.2.5.2 and 5.2.5.3.

The US Army Corps of Engineer's Cold Regions Research and Engineering Laboratory concluded that organic contaminants (including pesticides) could be removed from non-permeable stainless steel and rigid PVC surfaces using a hot detergent wash and deionized or distilled water rinse, thereby eliminating the commonly practiced step of an acetone, methanol, or hexane solvent rinse (Parker and Ranney, 2000).

Other polymeric materials, such as plastics or fluoropolymers (e.g., PTFE) were generally less readily decontaminated. Decontamination of polymers is a function of analyte, rigidity, porosity, sorptive capacity, and contact time for sorption and desorption. A hot water detergent wash and a deionized or distilled water rinse remove organic contaminants from less sorptive rigid PVC. More sorptive PTFE required additional oven drying to remove selected VOCs. Oven drying speeds diffusion of adsorbed contaminants out of the polymer.

Their findings strongly suggest that solvent rinsing for organic contaminant removal (use of acetone, methanol or hexane) may not be necessary for devices of stainless steel and rigid PVC construction. They did note that removal of pesticides from low-density polyethylene was aided somewhat by solvent use, however the hot water detergent wash procedure followed by hot air oven drying outperformed solvent use.

Hot air oven drying is a departure from currently accepted procedures and is offered here as an alternative if the following steps are performed without exception. Exposure of ground water sampling equipment to hot air drying should be conducted over a 24-hour period for most pieces of equipment. Temperatures should be maintained at 110°C (approx. 230°F). This includes devices of polymer construction such as bailers and bladder pumps. In the field, an air-drying oven can be set up inside a trailer or building to facilitate this logistical consideration. For ground water sampling pumps, check with the manufacturer for heat tolerance of sealed internal electrical parts or size and shape distortion tolerances for bladder pumps constructed of permeable materials.

Sampling equipment constructed of polymers may be heat sensitive in terms of distortion tolerance (USACE observed warping in the oven although they did not observe any problems when rigid PVC was heated). When distortion or uneven heat distribution are of concern, the use of a hot-water (100°C) high-pressure washer may offer an alternative to hot water/heated drying. Hot-water (100°C) high-pressure cleaning may be applied to large dimensional sampling equipment constructed of stainless and/or carbon steel equipment typically associated with direct push sampling technology. Sampling equipment, whether rigid PVC, stainless steel, or other permeable plastic materials, exposed to neat compounds or contaminants at high concentrations pose limitations to the effectiveness of this, or any, decontamination technique. This specific procedure is considered most effective when contaminant concentrations are 100 parts per million or less. If this decontamination procedure is the chosen method in instances of equipment exposure to contaminant levels above 100 ppm, then the collection rate of quality control field (equipment) blanks should be increased. For rigid PVC or stainless-steel sampling equipment, collect an additional field (equipment) blank if organic concentrations in the last sample collected exceeded 100 ppm.

These decontamination procedures are not applicable to any forms of tubing, as USACE has never demonstrated this technique as an effective means to decontaminate tubing of any construction material.

The field sampling equipment cleaning and decontamination procedures are as follows:

i. For permeable polymeric materials (Teflon®, Teflon®-lined PE, Polyethylene)

1. Laboratory grade glassware detergent and hot (approx. 100°C) DI water scrub to remove visual contamination from extruded or machine shaped pieces
2. Generous DI water rinse for extruded or machine shaped pieces
3. Exposure to hot air (117°C) drying for 24-hour period

ii. For rigid PVC and stainless steel

1. Laboratory grade glassware detergent and hot (approx. 100°C) DI water scrub to remove visual contamination
2. Generous DI water rinse
3. Optional use of hot-water (100°C) high-pressure washing[3]

5.2.4 USGS Decontamination Procedure for Low Level Contamination – Laboratory or Field

These procedures for cleaning ground and surface water sampling equipment are adapted from the US Geological Society *National Field Manual for the Collection of Water-Quality Data* and are not typically used by the NJDEP's Site Remediation Program. The USGS decontamination procedure is recommended when contaminant and general chemistry levels are being measured at the lowest method detection levels and the user requires analytical data that is free from any conceivable sample equipment interference. Most NJDEP site investigations document levels of contamination that are above the lowest detection levels and have data quality objective plans which assure sampling equipment interference can be quickly identified and rectified. These procedures are designed to address contaminants not normally associated with SRP investigations e.g., inorganic indicators of water quality like cobalt, copper, zinc, manganese, and iron. Therefore, the most likely SRP-use scenarios would include measurement of those lowest of contaminant concentration investigations where long-term trends of environmental and ambient sensitive constituents are being monitored, e.g., parameters associated with Monitored Natural Attenuation.

However, the NJDEP Bureau of Freshwater and Biological Monitoring and the Geological and Water Survey (NJGWS) Element, routinely use these cleaning procedures. Their investigations of ambient surface and ground water are geared to monitor long terms changes of constituents whose sensitive analytical nature dictate the use of such an intensive decontamination procedure. The cleaning procedures can be found in the USGS *National Field Manual for the Collection of Water-Quality Data, Book 9, Chapter A3.* For complete details visit the USGS Internet address: (http://water.usgs.gov/owq/FieldManual).

5.2.5 General Decontamination Considerations

The following discussion is intended to assist personnel engaged in the decontamination of select equipment. Unless item-specific decontamination procedures are described below, use one of the above four procedures as it relates to the device's aqueous or non-aqueous nature and the sampling objectives. Any exceptions to the procedures in this manual should be documented and justified in the final report.

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[3] Hot water (100°C) high-pressure washing of large dimensional rigid PVC, stainless steel and direct push technology sampling equipment is acceptable.

5.2.5.1 Decontamination of Pumps

5.2.5.1.1 Submersible Pumps

When submersible pumps (gear, reciprocating, progressive cavity or centrifugal) are only used to evacuate stagnant ground water in the well casing (volume-average sampling), they should be cleaned and flushed prior to and between each use. This cleaning process consists of an external laboratory grade glassware detergent wash and tap water rinse, or steam cleaning of pump casing and cables, followed by a 20-gallon flush of potable water through the pump. This flushing can be accomplished by the use of a clean plastic overpack drum or a plastic garbage can be filled with potable water. This should be followed by a distilled and deionized rinse of the outside of the pump. For submersible pumps smaller than four inches in diameter, the recommended number of gallons required for flushing may be proportionately reduced (i.e., three-inch 15-gallons, two-inch 10-gallons). For Grundfos® Redi Flo 2 pumps, follow the manufacturer's *Installation and Operating Instruction* manual for cleaning the inside of the stator housing by completely removing the motor shaft and to achieve a *complete* replacement of motor fluid (distilled/deionized water). It is recommended that rented pumps be decontaminated prior to use. Pumps constructed of plastic parts or sealed inner workings are not an equipment option for consideration because of their limited ability to be decontaminated thoroughly and their demonstrated ability to sorb and desorb contaminants.

> Technical Note:
>
> Inspect the integrity of the seals and O-rings on the pump-motor/pump-body housing. Water inside the motor housing may indicate that methanol vapors could enter the motor. Direct-current motors inherently spark because of the commutator ring. AC motors might spark if the insulation is frayed or burnt on the motor windings or any associated wiring.
>
> If flammable liquids are required for cleaning electrical pump systems, use extreme caution. Vapors from solvents such as methanol can ignite if a disruption in the motor lead-insulation system occurs in the vapor-enriched zone. (Ignition from a spark from an AC induction-type motor in good operating condition is not a concern if rated as using the National Electrical Code (NEC) at Class 1, Group 5.)

Exercise caution to avoid contact with the pump casing and water in the drum while the pump is running (do not use metal drums or garbage cans) to avoid electric shock. Always disconnect the pump from power source before handling. Surface pumps (centrifugal and diaphragm) used for well evacuation need not be cleaned between well locations if a check valve is used. New tubing should be used for each well and discarded after use. If the evacuation tubing is not disposed between locations, it must also be decontaminated in the same manner as the pump. The submersible pump and tubing should always be placed on clean polyethylene sheeting to avoid contact with the ground surface. All tubing must be rinsed/wiped with distilled and deionized water and paper towels to remove any residual material during installation. (Refer to ASTM D-5088-90, *Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites*.)

5.2.5.1.2 Surface Centrifugal and Diaphragm Pumps

When surface centrifugal and/or diaphragm pumps are used for purging, there is no need for decontamination of the pump or diaphragm housings. It is, however, a good practice to flush the housing/diaphragms with potable water between wells to control the buildup of silt or other debris inside the housing/diaphragm. This practice will prolong the life of the pumps and maintain operating efficiency by reducing the potential for excessive wear.

5.2.5.1.3 Bladder Pumps

Bladder pumps that cannot readily be disassembled for decontamination should only be used for a single well (dedicated use). Only bladder pumps that are constructed of easy to clean parts and disposable bladders should be employed for sampling on a well-to-well basis. Proper decontamination should include exchanging the used bladder with a new bladder and a thorough decontamination procedure of the pump between wells.

5.2.5.2 Decontamination of Heavy Equipment

Heavy equipment associated with a sampling episode must be cleaned prior to usage. Items such as drill rigs, well casing, auger flights, and backhoes all present potential sources of interference to environmental samples. These items may come in contact with the materials adjacent to the matrix being sampled or may be attached to actual sampling equipment that has been cleaned in accordance with procedures set forth above. Heavy equipment may potentially retain contaminants from other sources such as roadways, storage areas, or from previous job sites that may not have been removed. In addition to initial on-site cleaning, these items must be cleaned between use at each sample location. (Refer to ASTM D-5088-15a).

Two options are available to accomplish cleaning of heavy equipment: steam cleaning and manual scrubbing. The use of a steam generator can remove visible debris and has several advantages. Steam generators using potable water provide a heated and high-pressure medium that is very effective for residuals removal. They are also efficient in terms of ease of handling and generate low volumes of wash solutions. Potential disadvantages include the need for a fixed or portable power source, and they may not be cost effective for use on small pieces of equipment or for one day sampling events.

A second option involves manual scrubbing of equipment using a solution of laboratory grade glassware detergent followed by a thorough water rinse. This procedure can be as effective as steam cleaning or preferred in situations where steam cleaning fails to remove visible materials. The disadvantages to manual scrubbing include intensive labor and generation/disposal of wash and rinse solutions.

The above requirements for cleaning heavy equipment should be incorporated into Field Sampling – Quality Assurance Project Plans where applicable.

5.2.5.3 Decontamination of Direct Push Equipment

Direct push technology can be applied to the collection of samples from aqueous and non-aqueous matrices. This versatility can be extended to samples collected for either fixed laboratory analysis or field analytical methods. Regardless of the sampling objectives, decontamination of the equipment is imperative since this equipment contacts the sample directly. At a minimum, to effectively clean the type of heavy equipment associated with the technology, a hot water high-pressure system should be utilized after a pre-soap and water wash to clean all equipment. Logistically, this will require additional support equipment to be on-site, typically a trailer with a steam generator/pressure washer or equivalent and water tank capable of holding several tens of gallons of potable water. As with general heavy on-site equipment, all sampling equipment should be initially cleaned upon arrival at the site and again between each sample location. If vertical delineation is driving the investigation, each interval should be sampled with decontaminated equipment.

If the required sampling involves collection strictly from a non-aqueous source, the decontamination procedure may be abbreviated to the Three Step procedure discussed in Section 2.4.2 of this chapter. If, however, heavy organics are visibly encountered, and a hot water high-pressure system is not on-site, then incorporation of solvents (e.g., acetone) should be included into the decontamination procedure. For large heavy equipment, this will require large amount of the solvent to be on-site and consideration for drying time and disposal should also be factored. In addition, if the Three-Step procedure is chosen over the USACE method, additional field (equipment) blanks beyond the normal QA/QC requirement should be considered and included in the QAPP.

All decontamination should take place in an area removed from close proximity to all sample locations. Consideration for disposal of spent decontamination fluids should be made prior to site activity. In most instances use of hot water high-pressure systems generates limited volumes of decontamination fluids and if those fluids can be controlled from leaving the site or from creating an erosion issue, then adsorption back into the soil is generally acceptable. Only in cases where contamination may threaten to leave the site or when creation of a possible erosion issue is unavoidable should containerization of fluids be considered.

5.2.5.4 Decontamination of Monitor Well Casing and Screen

Before installation, well casings should be inspected and if needed, field cleaned by manually scrubbing to remove foreign material and steam cleaning, inside and out, until all traces of oil and grease are removed. Special attention to joints may be necessary to remove cutting oil or weld burn residues. The casing should then be handled and stored in such a manner so as to prevent cross contamination prior to installation.

5.2.5.5 Cleaning Location

It is preferred, given site-specific conditions, that cleaning of all equipment take place in one central location on-site. A designated area or decontamination pad should be established to conduct all cleaning. All equipment such as drill rigs, backhoes, and other mobile equipment should receive an initial cleaning ***prior*** to use at a site. The frequency of subsequent cleanings while on-site will depend on how the equipment is actually used in relation to collecting environmental samples. Unless otherwise specified and approved, all wash/rinse solutions should be collected and contained on-site. The actual fate of this material will be determined after review of analytical data generated from samples and on-site discharge impacts have been evaluated.

5.2.5.6 Disposal of Investigation Derived Waste (IDW)

Investigation Derived Waste (IDW) is any waste material generated during investigation or remediation activities. These items could include (list not exhaustive):

- Purged Groundwater
- Drill Cuttings
- Decontamination Water and Rinse Water
- PPE (disposable glove, tyvek suits, booties, etc.
- Disposable Bailers, Soil Scoops, Mixing Spoons
- Acetate Sleeve from Soil Core
- Absorbent Pads/Booms

It is recommended that an IDW plan be included with the workplan. The materials need to be handled according to local, state and/or federal waste handling rules. If purge water or drilling soils are to be drummed for offsite disposal, check with the disposal company for their specific waste classification sampling requirements. All drums need to be labeled prior to placement of waste into the drums. Disposal of PPE and sampling equipment is specific to the level of contamination at the site. Check with the local solid waste facility if this type of material is accepted or if needs to be disposed of at a specialized facility.

All haulers and disposal facilities should be licensed and approved to accept the waste being sent to them and the hauler should provide documentation for collection and disposal unless incidental supplies, i.e., gloves, are disposed of within municipal waste stream.

It is also important to take into consideration the storage of the materials, especially for offsite activities. All precautions should be made to secure the material from access by the public to protect from exposure, theft, vandalism etc. Be sure that an offsite property owner has provided authorization for waste storage.

For consideration in the IDW Plan it is recommended that the person conducting the investigation:

- Determine what waste will be generated and if it will be hazardous or non-hazardous.
- How it will be managed, i.e., drummed, bagged, stockpiled, etc.
- What sampling is required; what labeling is required.
- Where will it be stored
- Is waste disposal included in the project budget
- Is the person completing the work trained in RCRA or other waste transportation rules
- Is the stored waste accessible for pick up by the waste hauler
- How long can the waste be stored

For more detailed guidance check https://www.epa.gov/sites/default/files/2015-06/documents/Management-of-IDW.pdf

Disposal of Drill Cuttings

During the routine course of site investigation, where materials are known (via field instrumentation or visual observation) or suspected (historic information) to be contaminated, sampling activity (i.e., soil boring or installation of monitoring wells) will produce waste intrinsic to the site.

Pursuant to the Technical Requirements for Site Remediation 7:26E-1.5, excavated soil from drill cuttings or test pit excavations may be returned to the original location provided that:

1. Drill cuttings are returned in accordance with the Well Construction and Maintenance; Sealing of Abandoned Wells rules, N.J.A.C. 7:9D;
2. Neither free product nor residual product is present;
3. The contamination present is addressed as part of the remediation of the area of concern in compliance with this chapter; and
4. The replacement of the soil does not pose any additional threat to public health, safety, or the environment.

If any of the above conditions cannot be met on-site, the materials must be placed in containers (drums, roll offs, etc.) and stored in a secure area of the site (fenced or access by unauthorized persons prevented) or transported to a central, secured location. The need to perform analyses of the secured material will be determined by the investigator. The material will be retained for remediation or disposal in accordance with regulations as part of the selected site remedy.

Holes produced from soil borings are to be grouted in accordance with the "*Subsurface and Percolating Waters Act*," N.J.S.A. 58:4A-4.1 et seq., their implementing regulations (N.J.A.C. 7:9D-1.1 et seq.) and any NJDEP-approved changes to these specifications including repeals, new rules and amendments. Holes less than 25 feet in depth may be filled with sufficient quantities of uncontaminated soil material to make up for the amount of soil sampled and account for settling, thus allowing the hole to return to natural grade.

When materials of a noncontaminated nature are to be disposed of on-site, the following guidelines should be considered:

- disposed cuttings, soil or water will not erode or flow off-site; and
- disposed water will not flow through an area of contamination and thereby spread it to a clean area.

Finally, at off-site (i.e., background) locations where no contamination is expected, the primary consideration is the wish of the property owner. If acceptable to the property owner, drill cuttings and mud from well installation may be raked into adjacent soils. If the property owner requests the uncontaminated material be removed from the site, it is to be properly contained and removed to the site under investigation and disposed of or stored per decision of the NJDEP. If drill cuttings and/or development water are expected to be contaminated, they are to be removed from the off-site location to a secure on-site location and retained for remediation or disposed of per applicable regulations.

5.2.5.6.1 Water

Installation, Development, Purge, Pump Test, and Decontamination Waters

Well development and purge water may be discharged to the ground per N.J.A.C. 7:14A-7.5. This rule authorizes water generated from the installation, development, and sampling of monitoring wells to be discharged to the ground under a permit-by-rule. No written approval from NJDEP is needed for implementation of this permit-by-rule discharge. For more information about this option, consult the June 2007 "*NJPDES Discharges to Ground Water Technical Manual for The Site Remediation Program*" At: https://www.nj.gov/dep/srp/guidance/#njdeps_dgw_tech_manual.

Similar to drill cuttings, an initial determination as to whether these wastewaters should be considered contaminated should be made by evaluating field instrumentation readings or by previous analytical information. Additional field-tests to assist in that determination (e.g., pH, color, other physical or chemical characterizations) should be utilized to the maximum extent possible.

Water generated that is not considered to be contaminated may be re-applied directly to the ground surface and permitted to percolate back into the ground water system. Care should be taken, however, to avoid nuisance situations where the discharge may cause undue concern on the part of property owners or the community. In such cases, it is advisable to dispose of the water into a local stormwater or sanitary sewer system, or collect and discharge the water slowly to avoid such a condition. Please note that all discharges of pollutants to surface water and/or the sanitary sewer are subject to the permit requirements contained in the NJPDES regulations.

Where the water is considered to be contaminated, note the following limitations:

- Water generated from onsite operations should not be allowed to migrate off-site.
- Contaminated ground water may be discharged to ground in an area where the surface soils are contaminated with similar contamination.
- Where the discharge is to non-contaminated soils, the discharge should not result in the

contamination of the soils above any soil standard.

- Contaminated groundwater may be discharged to ground in an area where the shallow aquifer is contaminated with similar contamination, but the soil is not contaminated, when the level of groundwater contamination will not result in the development of contaminated soil.
- Contaminated ground water should ***not*** be discharged to non-contaminated soil at concentrations that could result in the development of contaminated soil, ***unless*** the water is treated to levels that will not result in the development of contaminated soil.
- Contaminated ground water from a deeper aquifer should ***not*** be discharged to ground in an area where the water-table aquifer is not contaminated, ***unless*** the water is treated to remove the contamination. Treatment could include portable units that air strip, bubble aerate, or adsorb (e.g., granular activated carbon filtration) the contaminants prior to discharge.

If the above conditions cannot be met, the water may be collected and secured at a single location (preferably the primary site under investigation).

If the collected water is determined to be non-contaminated, the water may be re-applied to the ground surface anywhere on the site or shipped offsite for proper disposal. If the water is determined to be contaminated, arrangements for proper offsite disposal should be considered.

If the collected ground water is determined to be contaminated, discharges of development, purge, and decon waters could take place at a known contaminated area on-site. In cases where such an area cannot be located, as with contaminated well field projects, discharges may occur as close to the well or sampling location as reasonably possible.

In addition to the above considerations, the requirements of the New Jersey Pollutant Discharge Elimination System (NJPDES) must be followed for all discharges of pollutants to ground water and stormwater. The NJPDES Regulations requires the issuance of either an individual or general permit, or a permit-by-rule authorization (see N.J.A.C. 7:14A-7.5), for these discharges.

If an individual NJPDES Discharge to Ground Water permit has already been issued for the facility, all discharges from the development and sampling of monitoring wells, done in accordance with the permit, are deemed to have a permit-by-rule without any additional written approval required [see N.J.A.C. 7:14A-7.5(a)4]. A NJPDES DGW permit-by-rule may also be available at other facilities for on-site disposal of development, purge, pump test and decontamination waters generated during the course of a site remediation. The most current NJPDES regulations at N.J.A.C. 7:14A-7.5 should be consulted. An unofficial version of the NJPDES regulations can be accessed via the NJDEP web site at: http://www.nj.gov/dep/dwq/714a.htm, however it may not include the most recent changes. NJDEP staff familiar with the most recently promulgated regulations should be consulted.

5.3 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 should 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 of 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.

5.3.1 Ground Water Sampling Equipment

The importance of proper ground water sampling cannot be over-emphasized. Even though the monitoring well or temporary well point may be correctly located and constructed, precautions should be taken to ensure that the collected samples are representative of the ground water at that location. Extreme care should 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 quality within the well casing may not be representative of the adjacent ground water. Within the water column above the well intake interval, 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 should be employed prior to sample collection:

1) standing water above the screened interval should be evacuated ***from the top*** of the water column;
2) water within the screened interval should be removed until well stabilization is observed or;
3) a non-purge sampling technique may be employed within the well intake interval. (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.

5.3.1.1 Submission of Well Purging Information

When sampling methods are used that require purging of the well, information on the purging of each well should be recorded, and that information submitted to NJDEP on a sampling log form or table. Information generated during the purging event should include depth to water, amount of well drawdown induced during well purging, well intake interval, and sometimes groundwater chemistry (i.e., water quality indicator parameters). Water quality indicator parameters must be collected by a certified laboratory or business pursuant to N.J.A.C. 7:18. For additional information please see Chapter 6.9.3.7.

From a reviewer's perspective, assessing the amount drawdown in the well intake interval is critical information to evaluate the potential loss of pressure sensitive compounds. Additionally, comparing the well purge rate to well drawdown data may allude to the well recharge capacity. Changes in the water quality parameters during purging show the difference in water quality within the well and the surrounding formation. The changes in water quality parameters should be evaluated when considering implementing a no-purge sampling method.

Based on the above, NJDEP considers the submission of well purging information critical to a proper understanding and assessment of the sampling event and its results. As such, forms or tables of the well purging field data should be included in all reports submitted to NJDEP that contain the well sampling results. Where a report contains ground water sampling results from multiple sampling events, or provides tables of historical sampling results, well purging information should be included for all the well sampling results. The well purging information can be included in the report as an appendix.

5.3.1.2 Purge Sampling Equipment

5.3.1.2.1 Negative Pressure Pumping Equipment (Vacuum)

Negative pressure, in terms of ground water sampling equipment, generally refers to the development of pressures lower than the relative atmospheric pressure. A negative pressure pump withdraws air to facilitate the movement of fluids through tubing by development of a vacuum (e.g., drinking from a straw). Negative pressure pumps are always located at the ground surface outside the well as water is drawn to the point of the low pressure. Unless a check-valve is installed at the bottom of the tubing placed in the well, the pump should remain on while the tubing is being removed from the well. This action should be taken to prevent water in the tubing from draining back into the well.

5.3.1.2.1.1 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 should be new and dedicated to a particular monitoring well. As the tubing is inserted into the well, it should 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 should 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 column volumes are removed from the well prior to sampling with a bailer. Again, ground water should 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 should be taken to ensure that the entire pump impeller housing chamber is drained after use and then is thoroughly rinsed to remove buildup 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 within twenty-five feet of the ground surface for the pump to operate. **Note:** If priming the pump is necessary, it is recommended that potable water be used.

5.3.1.2.1.2 Peristaltic Pump

A peristaltic pump (Figure 5.1) 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 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 may be acceptable.

Due to the undesirable effects of negative pressure (e.g., degassing), which this pump continuously imparts to a sample, accurate and reproducible measurement of volatile compounds (organic and inorganic) and air sensitive parameters cannot be obtained. This bias is extended to samples collected for, but not limited to, the following analyses: volatile organics, dissolved oxygen, pH, carbon dioxide, and iron and its associated forms (ferric and ferrous). As a result, this device is not recommended for the collection of surface and ground water samples for volatile organic compounds (VOC) and higher vapor pressure semi-volatile organic compound (SVOC) analysis. For the reasons stated above, this device is not recommended when utilizing the low-flow purging and sampling technique. Since some air sensitive parameters are commonly evaluated when assessing Monitored Natural Attenuation as a remedial strategy, data generated from the use of this device may lead to unfounded conclusions/decisions and is not recommended.

Figure 5.1 Geopump™ Peristaltic Pump

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
- Case of operation
- Speed of operation is variably controlled
- Commercially available
- No decontamination of pump necessary (however, all tubing should be changed between wells)
- Can be used for sampling inorganic contaminants and some low volatility organics (e.g. PAHs, 1,4-Dioxane)
- Purge and sample with same pump and tubing when analysis is limited to inorganics

Limitations:

- Lift limitation approximately 25 feet (peristaltic pump has limit of depth to water)
- Due to the inflexibility of the tubing, a small stainless steel weight can be added to tubing to aid introduction of tubing into well casing (especially helpful in 2-inch diameter wells)
- Potential for loss of volatile compounds due to the vacuum in the sampling line (e.g., VOCs, higher vapor pressure SVOCs (e.g., naphthalene, 2-methylnaphthalene, etc.), dissolved gasses (dissolved oxygen, methane, carbon dioxide), etc.)
- Not recommended for analytes whose solubility is sensitive to pH or dissolved oxygen

such as some metals (e.g., iron and manganese)

- Cannot provide reliable or reproducible data for vacuum sensitive water quality parameters (e.g., dissolved oxygen, pH, or carbon dioxide), therefore, peristaltic pumps are not recommended for Monitored Natural Attenuation (MNA) parameter sampling

5.3.1.2.2 Positive Pressure Pumping Equipment

Positive pressure, in terms of ground water sampling equipment, generally refers to the development of pressures greater than the relative atmospheric pressure. This equipment develops an internal spot of high pressure through the inflation of a bladder, turning of a gear, or rotation of an impeller that forces ground water up a section of tubing. If the sample is not collected directly from the pump discharge line, a check-valve should be installed just above the pump to keep the discharge line from draining into the well during removal of the pump.

5.3.1.2.2.1 Bladder Pump

Figure 5.2 Bladder pump with a polyethylene bladder

The bladder pump (Figure 5.2) consists of a PTFE (e.g., Teflon®) or stainless steel housing that encloses a flexible bladder. The bladder may be composed of PTFE, LDPE, or Linear Low Density Polyethylene (LLDPE). 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 bladder through the lower check valve and, once filled, compressed gas is injected into the cavity between the pump 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. Once the water has passed the upper check valve, the pressure around the bladder is released to atmospheric pressure, the pressure head differential pushes water into the bladder and the cycle is repeated.

Since the bladder fills due to differential pressure between the water level outside the bladder pump and the water level inside the bladder, water levels lower than the top of the bladder will result in the bladder becoming less efficient, producing less water per cycle.

The pumping depth is dependent on the amount of lift (distance from the water surface to the discharge elevation), the air pressure available to overcome the lift, and the pressure rating of the bladder and connections. As a rough rule of thumb, it takes about 0.50 PSI to lift 1 foot of water when the pump is operating efficiently. Portable bladder pumps are available with smaller, portable compressor/controller units that typically generate a maximum of about 100psi and therefore the maximum pumping water depth for a portable setup is about 180 feet of lift. Some bladder pumps are designed with thicker bladders and stronger connections to withstand greater air pressures, which allows pumping from depths (lift) of about 1000ft. Pumps for depths exceeding about 180ft are typically less portable and tend to be dedicated to the well.

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. The compressor can be built into the controller or separate, however the maximum pressure of the air source must not exceed the rated capacity of the pump or the pump may fail.

The speed with which the bladder fills is a combination of the pressure and the volume of air generated by the air source. Lower air volumes require longer time to fill the space around the bladder and squeeze the contents up the tubing.

Bladders are available in Low Density Polyethylene (LDPE) and LLDPE (Linear Low Density Polyethylene) for general sampling. Bladders are also available in Poly Tetrafluoroethylene (PTFE) which is a generic Teflon® type of material and may be less interactive with certain contaminants than polyethylene, though it is recommended that PTFE is not used when sampling for PFAS.

Field personnel should ensure the correct pumps, bladder material, bladder rating, and compressor output be compatible with the conditions and contaminants.

Field decontamination is acceptable if the bladder pump is constructed of stainless steel and contains removable parts including a disposable bladder.

If a bladder pump does not have a replaceable/disposable bladder, the bladder pump must be dedicated to a well or be lab cleaned between wells.

After pump use, the check valve at the top of the bladder pump prevents water remaining in the discharge tubing from draining. During winter periods water in the discharge line near or above the ground surface may freeze, damaging the tubing. To prevent this damage, the water needs to be removed from the upper portion of the discharge tubing. Please consult the manufacturer for guidance on how to remove the shallow water from the discharge tubing.

Tips for Use:

- Check all fittings for tightness. The water level in the tubing should not fall between pump cycles.
- To address turbidity, adjust the refill and discharge cycles to optimize pumping efficiency. Follow manufacturer's instructions for specific instructions.
- Flow rate can be reduced to 150 ml/min or less while sampling volatile and semi-volatile organics to minimize volatilization.

Advantages:

- Positive displacement
- Acceptable for sample collection for all parameters
- Simple design and operation
- Operational variables are easily controlled
- Minimal disturbance of sample
- The compressed gas does not come in contact with the sample
- In-line filtration possible
- Available in a variety of diameters
- Able to be adjusted to very low flow rates
- Air tubing does not need to be compatible with the contaminants of concern as it does not come in contact with the sample

Limitations:

- Large gas volumes may be needed, especially for deep installations.
- Pump should be field decontaminated between sample locations.
- The bladder pump requires hydrostatic pressure to work, as such, the water level should be maintained above the top of the bladder. Pump cycle times may need to be increased in wells with slow recharge or when the pumping water level is close to the intake.
- When operating at a depth to water greater than 180’ higher air pressures may be needed. In this situation the various components of the system (e.g., bladder, airline, air source, controller, etc.) should be rated for the higher pressure.
- Bladder pumps with Teflon bladders are not recommended for PFAS sampling. O-rings and other components may also be made from fluoropolymers. Use is not recommended for PFAS sampling without equipment blank data to support lack of PFAS contamination from pump.

5.3.1.2.2.2 Variable Speed Submersible Centrifugal Pump

Figure 5.3 Grundfos® Pump with control box

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 5.3) 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. Other pumps are also available that use a 12-volt power supply.

The variable speed feature is one of the key design items, which allows for application of low-flow purging and sample collection. 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 to remove the standing column of water within the tubing.

If the work plan calls for the well to be purged by a positive displacement pump and sampled via another device, action should be taken to prevent water draining out of the pump and associated discharge line during their removal. The most common action is the installation of a one-way check valve just above the pump. It should be noted that maintaining a head of water above the check valve may make it harder to re-start the pump should it stop operating. The pump may need to be raised to the surface, and the system drained and lowered back down into the well to re-start the pump. 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 to 100 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 flowrates 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 (greater than 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 an increase in water temperature that may be related to the sampling pump, the NJDEP 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 cannot be practically satisfied in this circumstance and should be documented in the field log. The identical bottle to bottle field blank requirement is waived for this sampling technique procedure only.

Finally, the Grundfos® Redi Flo 2 is designed to utilize a coolant fluid (deionized 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 5.4).

For proper cleaning, use the decontamination procedures for ground water sampling equipment (see section 5.2, 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 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.

Figure 5.4 Grundfos® Pump being prepared for decontamination (Photograph by J. Schoenleber)

Tips for Use:

- A stainless steel hose clamp can be used to secure the tubing to the pump connector.
- Pumps constructed from plastic are not recommended for sampling due to decontamination issues, however, use of plastic pumps for purging is acceptable.
- Install pump slowly through water column wiping down tubing and electrical line with DI saturated paper towel.

- When lowering or removing the pump from the well be sure to pull out tubing and electrical lines at the same time, maintaining equal tension on both lines. Having excess tubing or electrical line in the well when the pump is being moved could cause the pump to become pinched/wedged in the well.
- Tape should not be used to attach the lines however zip ties or stainless steel clips can be used.

Advantages:

- Positive displacement
- Versatile and lightweight
- Variable speed control at surface allows for fine tuning of flowrate
- Stainless steel and Teflon® construction
- Complete disassembly allows for access to all parts for thorough decontamination
- Acceptable for low-flow purging and sampling

Limitations:

- 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
- Some submersible pumps require a separate generator with a regulated power supply or a separate power source

5.3.1.2.2.3 Gear Pump

A positive-displacement pump, this small lightweight pump manufactured by Fultz Pumps, Inc, also has the capacity for variable speed control (Figure 5.5). 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 5.6). 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 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

Figure 5.5 Fultz Pump. Illustration published with permission of Fultz Pumps, Inc.

pumps whose power supply and pump discharge lines are separate. This pump may be best applied when used in a dedicated system.

Tips for use:

- Install pump slowly through water column wiping down tubing with DI saturated paper towel.
- Make sure the electric leads are fully plugged in and secure prior to use.

Advantages:

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

Limitations:

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

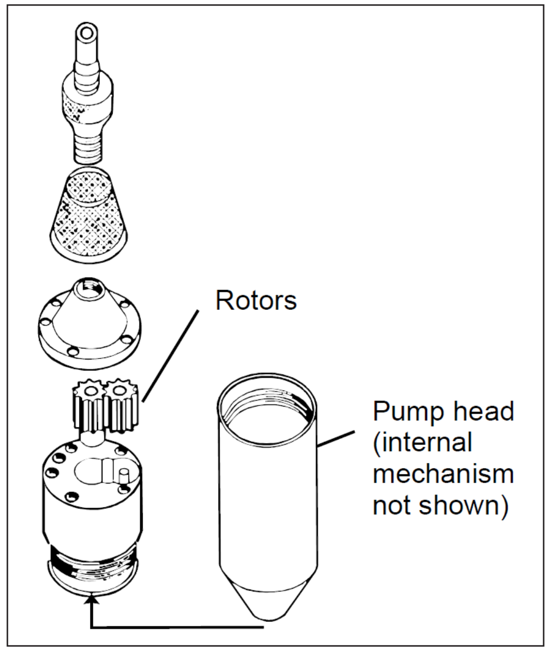

Figure 5.6 Gear Pump. Illustration published with permission of Fultz Pumps, Inc.

5.3.1.2.2.4 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 5.7). 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 5.8).

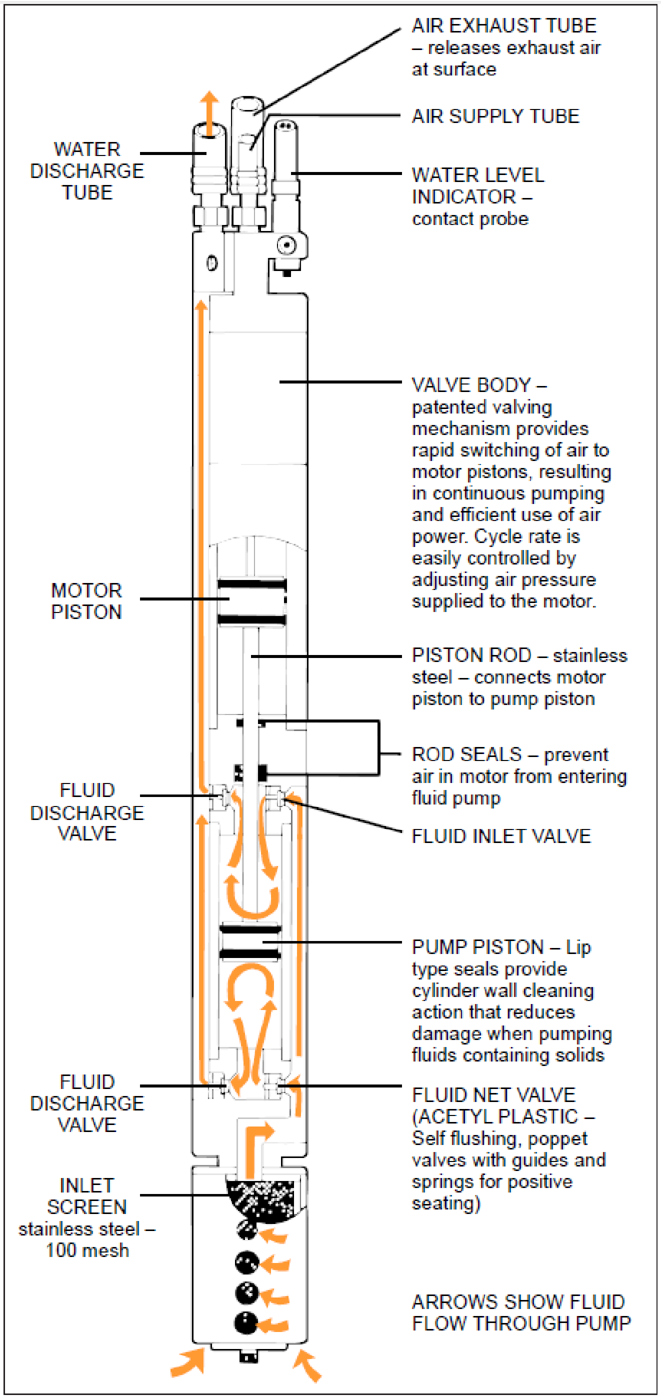

Figure 5.7 Reciprocating Piston Pump

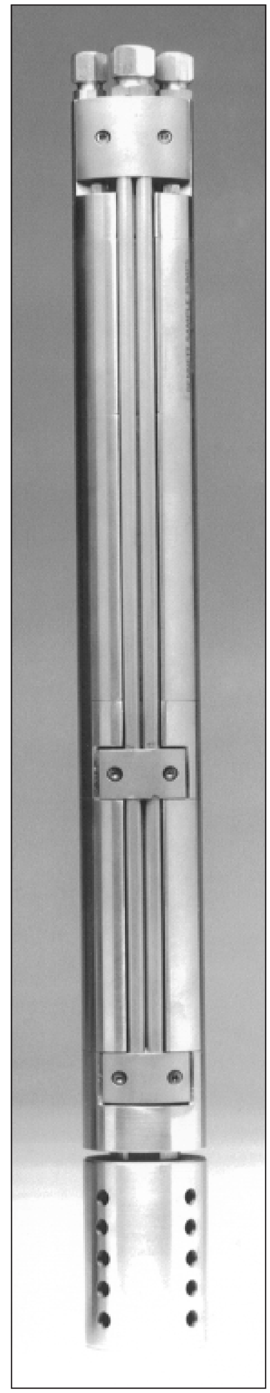

Figure 5.8 Bennett Pump

Illustrations published with permission of Bennett Sample Pumps.

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 within three feet of the top of water column.
- **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.** Supply air pressure via portable air compressor (5.2 cfm @ 140 psi for 1.8" diameter model).

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

Limitations:

- 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

5.3.1.2.2.5 Inertial Pump

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 5.9). 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 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.

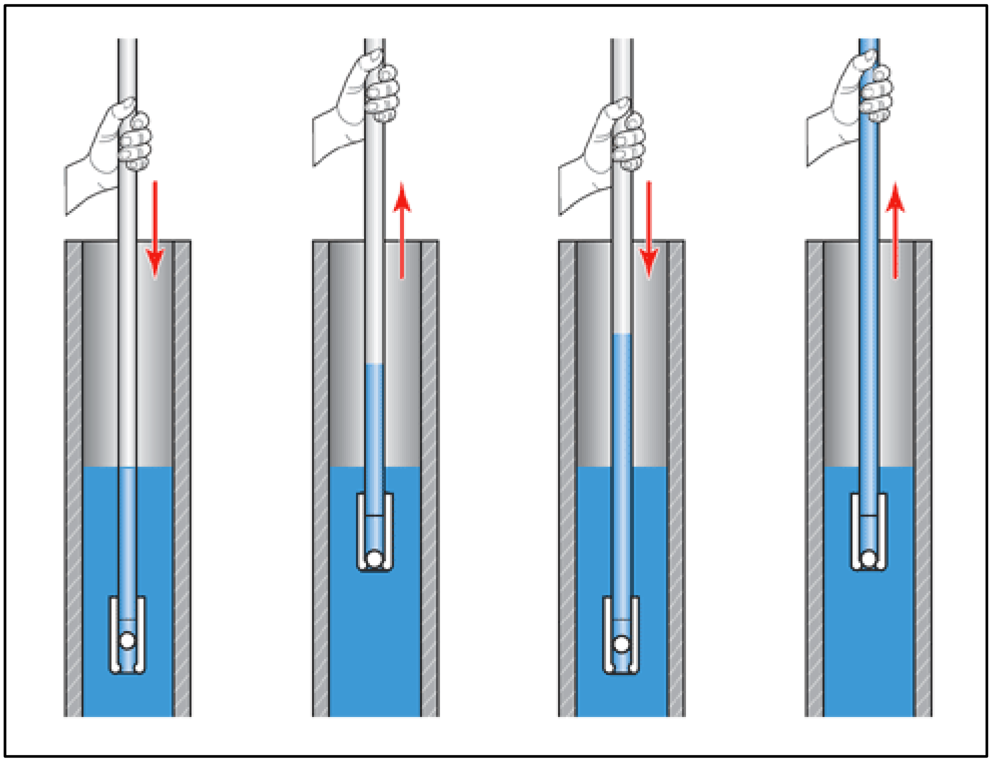

Figure 5.9 Inertial Pump.
Illustration published with permission of Waterra Pump

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 over 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 5.10).

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 5.10 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

- Can be used with direct push technology and narrow diameter temporary well points

Limitations:

- Manual use is labor intensive
- Use produces considerable agitation and turbid conditions
- Uneven sample delivery
- Limited to field screening of volatiles
- 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

5.3.1.2.3 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 or zone. Present NJDEP policy limits the length of bedrock well open borehole or screen length to 25 feet. If the borehole or screen length needs to be greater than 25 feet, prior approval from NJDEP Bureau of Water Allocation is required.

To facilitate bedrock characterization, 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.

Borehole geophysical investigation may also be conducted 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 packered zone can be used to estimate yield, 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 (i.e., packered zone) 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. For additional related information see sections on vertical profiling in chapter 6.

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

Limitations:

- 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 thorough 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

5.3.1.2.4 Bottom Fill Bailer

Bailer design is simple and versatile, consisting of a cylindrical length of PTFE, polyethylene, or stainless steel with a check valve at the bottom. Bailers (Figure 5.11) 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.

Bailers are available in non-weighted and weighted configurations. Polyethylene bailers have a specific gravity of less than 1 and will only submerge about 90% of their length, so all water taken using a non-weighted polyethylene bailer is from the top of the water column. Weighted bailers will sink within the water column.

The samples taken from bailers may not represent the specific depth interval to which the bailer is lowered. Water entering the bailer doesn't necessarily enter the bailer at the rate at which it is lowered.

The bailer, and any other equipment entering the well, should be laboratory cleaned and handled with new surgical gloves to prevent cross contamination. Surgical gloves should 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 should be physically separate from pumps or generators during transport and storage.

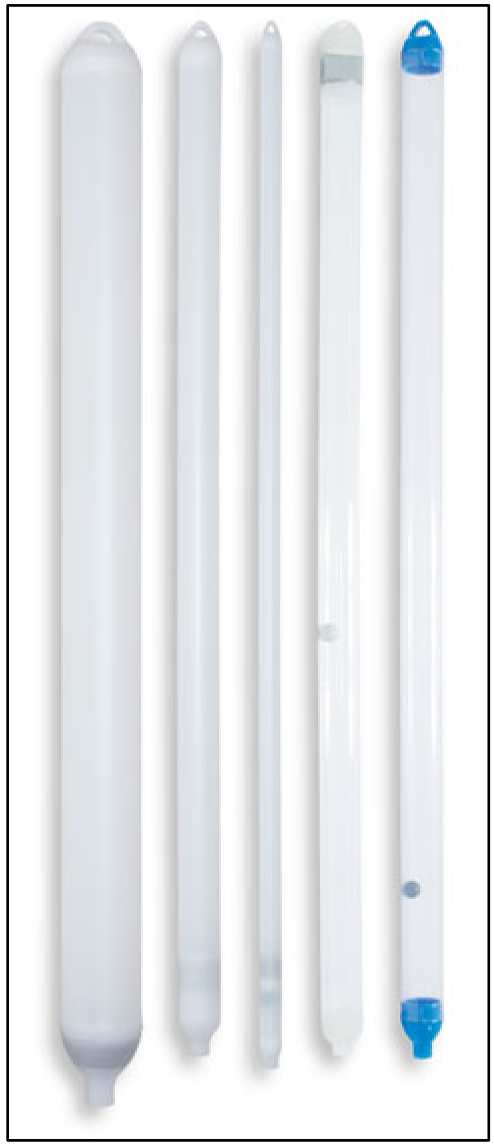

Figure 5.11 Bottom fill bailers

Disposable bailers are available in Teflon® and polyethylene construction. Teflon® disposable bailers are recommended for any analysis except PFAS. Polyethylene bailers have a greater adsorption capacity which could affect the results of water with low-level organic contamination. As such, it is recommended that polyethylene bailers not be used for the collection of organic samples that could be used to make regulatory decisions (e.g., detection, delineation, close-out sampling, etc.). Acceptable use of polyethylene bailers for sampling of organics could include routine sampling related to permits, operation and maintenance, and trend analysis. Polyethylene disposable bailers can be used for metals analysis. As discussed in other sections of this manual, adsorption/desorption issues result in a preferred bailer compositional of stainless steel> fluoropolymer> HDPE>LLDPE>LDPE when sampling for organics. Disposable bailers are typically decontaminated by the manufacturer and should be provided in a sealed polyethylene bag. The manufacturer should 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 should 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. Once in contact with the water surface the bailer is then allowed to fill as it slowly sinks in a controlled manner. Depth-to-water should be measured before using the bailer. To minimize impact of the bailer on the water surface, the depth to water may be marked on the polyethylene sampling rope after the bailer and associated leader line have been attached. 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 cannot 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). Because bailers remove water from a well in a slug type fashion, bailers should not be used to purge wells where the water level is in the well intake interval, especially if the well is low yielding, or of a small diameter as this action may result in significant instantaneous drawdown in the well intake interval. As such, bailers should not be used for the collection of air sensitive water quality indicator parameters, or the purging of water table wells. The NJDEP recommends that monitoring well purge data accompany every ground water sample collected.

> The greatest loss of VOCs typically occurs during the transfer of the sample from the bailer to the sample vial. Whether collecting the sample from the top or bottom of the bailer, the more the sample stream is agitated or exposed to air during the transfer, the greater the loss of VOCs.

Because bailers remove water from a well in a slug type fashion, bailers should not be used to purge wells where the water level is in the well intake interval, especially if the well is low yielding, or of a small diameter, as this action may result in significant instantaneous drawdown in the well intake interval. As such, it is recommended that bailers should not be used for purging low yielding monitoring wells.

Advantages:

- No external power source required
- Economical enough that a separate laboratory cleaned bailer may be utilized for each well, therefore eliminating cross contamination
- Single use disposable bailers do not require decontamination
- simple to use, lightweight, portable

Limitations:

- Limited volume of sample collected
- Unable to collect discrete samples from a depth below the water surface
- Representativeness of sample is operator dependent
- Field decontamination is not acceptable
- Not recommended to be used for well evacuation due to loss of VOCs and increased turbidity
- Cannot provide reliable or reproducible data for air sensitive parameters, e.g., dissolved oxygen, pH, carbon dioxide or iron and its associated forms
- 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

5.3.1.2.5 Double Check Valve Bailer

Double check valve bailers (Figure 5.12) 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 point source sampler below the water table. Because of potential mixing of well water within the bailer as it is lowered through the water column, double check valve bailers do not necessarily contain a sample that represents the targeted depth interval, but may represent some type of composite of the water column the bailer was lowered through. The aerodynamic configuration of the fill nozzle cause some of the water to go around, not in the nozzle during lowering. There is inertia and friction involved with opening the check valve and water flowing past the check valves that result in water moving slower through the bailer than the bailer passes through the water. 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 monitoring 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.

As discussed in other sections of this manual, adsorption/desorption issues result in a preferred bailer compositional of stainless steel> fluoropolymer> HDPE>LLDPE>LDPE when sampling for organics.

Because bailers remove water from a well in a slug type fashion, bailers should not be used to purge wells where the water level is in the well intake interval, especially if the well is low yielding, or of a small diameter, as this action may result in significant instantaneous drawdown in the well intake interval. As such, it is recommended that bailers should not be used for purging low yielding monitoring wells.

Procedures for Use:

i. Unwrap laboratory-decontaminated bailer and connect to disposable line 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.

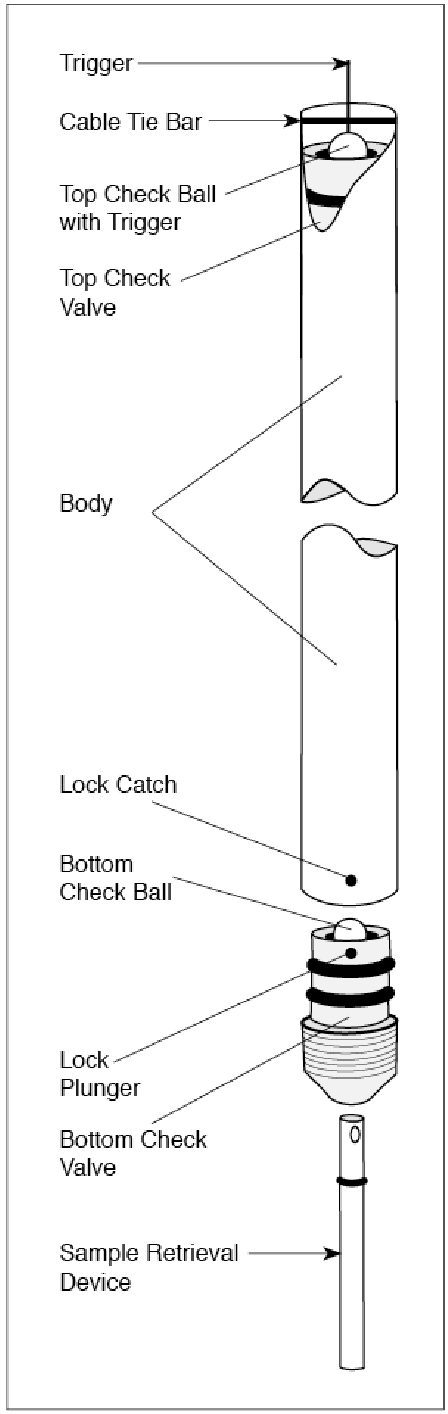

Figure 5.12 Double Check Valve Bailer

iv. Tip the bailer slowly to allow a controlled discharge from the top of the bailer 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 method-specific procedures for preservation and transport .

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

Limitations:

- 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
- Cannot 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

5.3.1.3 No-Purge (Passive) Sampling Equipment

No-purge sampling, sometimes referenced as point source sampling, is a technique that utilizes a device specifically designed to obtain a sample of limited volume within the well intake interval without purging the well prior to sample collection. No-purge samplers can be divided into two general categories, passive and active samplers. No-purge passive samplers can be further subdivided into three categories: diffusion samplers, passive-grab samplers, and accumulation samplers. An example of a no-purge active-grab sampler is the HydraSleeve sampler.

These devices should only be used once the contaminants of concern have been identified and the specific zone(s) of contaminant flow in the well intake interval has also been identified. There are limitations to use with respect to analytes. It is recommended that users refer to manufacturer directions and the most recent published studies as well as this manual when determining if a no-purge sampling technology is suitable to meet project objectives.

5.3.1.3.1 Grab Sampling Technologies

5.3.1.3.1.1 HydraSleeve

HydraSleeves are a type of no-purge active-grab sampler that collect a grab sample representing the groundwater at a specific depth interval in the saturated well screen at a point in time. Samples should only be collected after the well has returned to the undisturbed flow conditions that existed prior to the installation of the sampler.

HydraSleeves consist of a thin-walled, flexible polyethylene tube which is sealed at the bottom and contains a reed valve at the top. HydraSleeves are deployed empty and flattened much like a ribbon, as such, they are designed to minimize well disturbance and prevent intrusion of water into the sampler during installation. To collect a sample, the HydraSleeve is pulled rapidly upward (~1ft per second), which forces water through the reed valve and into the sampler until the tube is fully expanded and filled. Once the sampler is filled, the reed-valve closes, and the sample is isolated inside the tube (Figure 5.13).

Figure 5.13 Hydrasleeve

Samples are collected directly from the saturated screen interval of the well. **The HydraSleeve is deployed immediately below the desired sample collection interval in the saturated screen.** The sample zone extends upward from the initial deployment position for a length approximately equal to the length of the sampler and a short additional length as a "safety-zone" to account for variations in the filling rate of the sampler. The length of saturated well screen must therefore be long enough that the sampler is completely full before pulling it out of the saturated screen to avoid sampling aerated water or stagnant water in the well casing.

It is recommended that HydraSleeves are installed and left in place for a period of time prior to sampling to allow the well to stabilize and return to normal flow conditions after being disturbed by HydraSleeve placement, and to allow the sampler materials time to chemically equilibrate with the groundwater quality prior to sample collection. The equilibration period should be based on the time it takes for the polyethylene to come to chemical equilibrium with any constituent concentrations in the groundwater. The time needed to achieve equilibrium could vary based on the aquifer and well conditions. A minimum of 48 hours between deployment and sampling is recommended although additional time may be warranted based on aquifer conditions. Technical justification should be provided if less than 48 hours between deployment and sampling is conducted.

To eliminate wait times, a HydraSleeve may be installed in a well immediately after that well has been sampled, and left in place until the next sampling event, at which time it will be pulled up rapidly to collect a sample, and then a new HydraSleeve deployed. There is no recommended maximum time limit between deployment and sample collection.

Some HydraSleeve models are designed to minimize the disturbance of the water column to reduce well stabilization times, however, the NJDEP still recommends that an equilibration period be utilized. The re-stabilization time frame should be recorded and submitted on field sampling forms.

Advantages:

- Purge water associated with conventional sampling reduced or eliminated
- Collects sample of groundwater that can be sampled for any parameter

Limitations:

- Detailed well construction information must be known including well intake interval length, distance between top of casing and ground surface, presence of a sump, etc.
- Must allow for equilibration
- Potential for operator error
  - care must be taken to use retrieval technique that will collect full Hydrasleeve
  - if a HydraSleeve is pulled up and is not filled enough to collect sufficient sample volume, the device must be redeployed and the well allowed to stabilize again
  - deployment and retrieval can be more difficult when water column is short
- HydraSleeve 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 HydraSleeve samples may not be able to provide a representative sample.
- HydraSleeve samplers represent a point sample. Contamination migrating above or below the targeted depth interval will not be detected.
- If the check valve does not perform as expected, then the HydraSleeve has the potential to collect water from an incorrect depth interval
- If samples require field filtration, groundwater would have to be transferred to another device

5.3.1.3.1.2 Snap Sampler

The Snap Sampler is a type of no-purge passive grab sampler. It is a patented (US Pat. 7,178,415) groundwater sampling system with custom sample bottles that have tight-fitting caps that are spring loaded on each end of the bottle. The bottles are latched into a mechanical assembly on a suspension cable that holds the caps in an open position until sample collection. The assembly is deployed down the well and left in place in the saturated screen for an equilibration period to allow diffusion of molecules from the groundwater into the bottles. The assembly includes a trigger wire or pneumatic tube running from the bottle holder to the surface that allows the user to release the latches so that the caps “Snap” into place on both ends of the bottles after a suitable equilibration period.

The Snap Sampler apparatus and bottles should be allowed to equilibrate for a documented period of time before sample collection. A two-week minimum equilibration period is recommended between deployment of a Snap Sampler system and retrieval of sample(s). Shortening this equilibration period would require justification including quantification of aquifer conditions (i.e., groundwater flow velocity) and equilibrium data per analyte (available from US Army Corps of Engineers testing) that would justify a shorter equilibration period.

Available bottles and modules include 40 mL VOA vials (deployed in pairs), 125 mL poly bottles, and 350 mL bottles. The expendable bottles are shipped/delivered to a laboratory for analysis. New bottles can be replaced at the time of sampling, or if samples are decanted into lab-supplied bottles, snap sampler bottles can be reused (if there is no observation of fouling or degradation).

Advantages:

- Can be used to sample for most analytes (assuming bottle and volume requirements are met)
- No purge water is produced from the sample – all water that is removed from well is sent to lab
- Fixed system - always same sample depth

Limitations

- Modules must be dedicated to one well
- Would have to deploy an extra bottle to collect water quality parameters
- Preservative would have to be added to bottles
- Requires minimum well diameter of 2”
- Samples may have to be decanted into sample bottles to comply with required bottle type
- Would need multiple setups (trigger system and modules) to conduct vertical profiling

5.3.1.3.1.3 Syringe Sampler

Syringe samplers (Figure 5.14) 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 monitoring well sampling, does have application when attempting to collect a discrete, non-purged sample. Examples may include collecting an undisturbed liquid of dense non-aqueous phase liquid from the very bottom of a well, or targeting a zone for field analytical measurement. Syringe sampler can also be used to collect pore water samples from water within the sediment/root zone in a water body.

Measurement of water quality indicator parameters made in discrete or non-pumped 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/search.php?page=1&q=syringe+sampler), 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 thorough cleaning when sampling between monitoring 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

Limitations:

- Small sample volume renders comparison of duplicate and quality assurance samples inconclusive
- Not recommended for analysis of volatile organics from samples collected in monitoring wells due to potential volatile loss

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

5.3.1.3.2 Diffusion Sampling Techniques

"Diffusion samplers (also called equilibrium samplers) are devices that rely on the analytes to reach equilibrium between the sampler and the groundwater via diffusion. Samples are time-weighted toward conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates."[4]

5.3.1.3.2.1 Passive Diffusion Bag Sampler (PDB)

Deployed in Monitoring Wells

Passive Diffusion Bag Samplers, known by the acronyms PDBS or PDBs, are a type of passive equilibrium sampler that operate on the principle of diffusion. Samplers are filled with deionized water, sealed, and lowered into the saturated well screen where they intercept groundwater flow. When contaminants are in the surrounding groundwater a concentration gradient exists between the groundwater and the water in the sampler and, if the membrane is permeable to the specific contaminant type, the gradient drives the contaminant molecules from the groundwater into the sampler until equilibration is reached. Low density polyethylene (LDPE) membranes that make up the standard PDB are permeable to a range of non-polar VOCs and not effective for other analytes. They consist of polyethylene bags filled with water, and when lowered in a well, certain compounds can diffuse through the bag and come to equilibrium concentration with the groundwater concentration over time (Figure 5.15).

[4] https://clu-in.org/characterization/technologies/default.focus/sec/Passive_(no_purge)_Samplers/cat/Diffusion_Samplers/

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

When confronted with sampling a monitoring 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 not be justified. More appropriately, there may be instances where long term monitoring during the operation and maintenance phase of remediation justifies their use. 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 6.9.6.5.3.1, *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 I or II) deionized water and sealed at both ends. 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.

Use of dedicated or disposable deployment lines is recommended for each well.

Polypropylene or polyester braided rope, or stainless-steel cable may be used as the deployment line for passive samplers. Polyester and polypropylene ropes are chemically resistant to a wide range of solvents and the principal components do not leach into groundwater. Stainless steel may be considered when sampling for low-level phthalates (Figure 5.16).

Figure 5.16 PDB with weight.

When using polypropylene or polyester rope the tensile strength should be more than 4 times the weight of the sampler(s) and attached accessories when suspended in air, to prevent permanent stretching. As an example, a 3/16-in hollow braid polypropylene has a tensile strength of about 475 lbs and could support about 100 pounds of weight without a noticeable permanent length increase. Once samplers and accessories are submerged in the water, the weight on the line decreases due to buoyancy.

Nylon cord should be avoided because it has a high stretch factor, absorbs water, and loses strength when wet. Uncoated stainless steel, PTFE (Teflon®)-coated stainless steel, or nylon coated stainless steel, braided wire cable may be used as an alternative to rope however it is more costly, can be difficult to use in the field, and stainless steel is susceptible to corrosion in low pH or high dissolved solids content.

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 (Figure 5.17). Many VOCs equilibrate within 1 to 4 days, however, the minimum recommended equilibration period for PDBs is 2 weeks. However, the equilibration time is compound dependent, and the diffusion times for compounds such as vinyl chloride and 1,1-dichloroethene are much longer (1 to 6 days). The estimate of a one to four-day average of contaminant concentrations is merely an estimate and indication of the dynamic nature of the sampling.

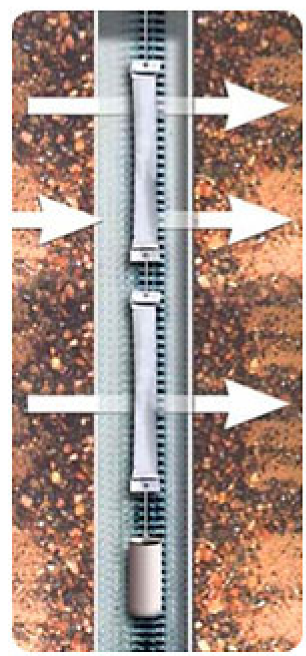

Figure 5.17 PDB suspended in well.

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 or semi-annual sampling is being conducted, it is acceptable to leave PDB samplers in the well for up to one year so that samplers can be retrieved and deployed for the next monitoring round during the same mobilization. Samples collected from PDBs represent the concentrations in the groundwater during the last approximately 1 to 4 days of residence time. **Note:** if heavy biofouling or breakdown occurs the sample should not be collected, this observation should be documented.

PDBs are available from manufacturers prefilled with deionized water or unfilled so the user can obtain deionized water to fill the PDBs from a lab or other source. It is recommended that a water travel blank accompany the samplers to the field from the point of origin and that the blank be sampled at the site prior to PDB deployment and sent to the lab. Diffusible VOCs can be in the blank from the source or from contact with air during transit and are NOT a problem because these compounds will equilibrate to the concentrations in the groundwater during sampler residence. Some compounds, such as acetone and butanone do not diffuse well through the LDPE membrane when in water but may get into the deionized water from the air or other source and end up in the sampler before deployment. These compounds will not diffuse back out to equilibrium in the groundwater, resulting in a false-positive. The use of results from a blank can alert the user that these compounds were in the deionized fill-water and not necessarily the groundwater.

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 Teflon® coated wire (if used) and stainless steel weights are the only pieces of equipment needing decontamination
- Quick deployment and recovery are benefits 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
- Fewer field personnel needed to sample sites

Limitations:

- 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.
- PDB samplers provide a time-weighted VOC concentration that is based on the equilibration time of the particular compounds; usually that period is 1 to 4 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.

Deployed in Lake, Stream, River or Estuarine Sediment

While the primary application of passive diffusion bag sampling is for use in monitoring wells, deployment of the device can be modified for application in stream bottoms, lake bottoms, and associated wetlands for the collection of pore water or groundwater. The same limitations regarding contaminant diffusion across the polyethylene membrane apply to sediment settings. In addition, the lithology of the streambed (highly permeable sands and gravels or low permeability silts, clays and organics), the "gaining" or "losing" hydrologic relationship between the stream and investigation area, pose further considerations that should be assessed in the development of the sampling plan. 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 slotted PVC well screen material offers a means to deploy without damage to the bag (Figure 5.18). **Note:** Air in bag is an artifact of long-time storage.

The slotted well screen serves as a protective barrier for the PDBs while allowing ground water to come into contact with the sampler. A 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, or equivalent) to assure that the cap will stay in place. A set of smaller diameter holes 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.

Figure 5.18 PDB for Sediments using bag provided by Columbia. (Photograph by J. Schoenleber)

In stream and pond applications where the excavation to install the PDB will take place under standing water the NJDEP recommends that the PDBs be installed in a vertical orientation using the procedure outlined below. The recommendation for vertical placement of the PDB is due to the difficulty in excavating the hole and placing backfill around the PDB below standing water.

Using a length (measurement based on need) of 4-inch diameter steel or Schedule 80 PVC pipe, drive 18 to 24-inches into the sediment with a sledgehammer. This will form a barrier (cofferdam) from any standing or moving water. Use a 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 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 be 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 should 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 4-inch casing as the PDB device may want to come up with the casing's removal. An exact record of the location of the sample device should be obtained using a global positioning satellite unit or measured triangulation.

While the NJDEP prefers PDBs be installed vertically, the NJDEP will support horizontal application of the PDBs in the following situations: 1) lowlands and wetlands where the depth to water is at or within (below) one foot of the ground surface; and 2) streams and ponds where the depth of the water is 6 inches or less, and the water is clear enough that the bottom (i.e., ground surface) can be clearly observed. The protection of the PDB, backfilling of the hole, and marking of the location, as described above, also applies in this situation.

When the diffusion devise is buried horizontally in lowlands and wetlands it should be buried deeper than 6 inches below the water-table to ensure that the diffusion device remains below the water table during the period of deployment.

When the diffusion device is buried horizontally in the bottom of streams and ponds it should be buried deeper than 6 inches (preferably 1 foot). The deeper burial will allow room for the coarse sand to be placed around the device and still allow adequate depth coverage of the native material to be placed above.

5.3.1.3.2.1.1 Nylon Screen Passive Diffusion Sampler (NSPDS)

NSPDS are a type of passive equilibrium sampler constructed using polypropylene wide-mouth bottles, a ring style cap, and an appropriate size square of nylon mesh screen. The bottles are immersed in deionized water (or organic-free deionized water if organics are target compounds), a sheet of nylon is placed over the mouth, and the cap is screwed on. They can be deployed singly or stacked in a polyethylene mesh bag.

"Vroblesky et al. (2002) found that nylon screen samplers (mesh 125 and 250µ) reached equilibrium with cations and anions in water within 20.5 hours. Mesh size might affect the equilibration of some cations and anions in the samplers (Vroblesky et al. 2002 and 2003). While much of the published work on nylon mesh screen samplers has examined cations, anions, and general groundwater parameters (e.g., dissolved oxygen), it should be suitable for most contaminants of concern. As cited in ITRC (2006), equilibration studies conducted in 2003 of nylon screen samplers collecting VOCs (benzene; tetrachloroethene, trichloroethene, and 1,4-dioxane) and inorganic constituents (perchlorate, chloride, arsenic, and iron) indicated excellent diffusion from the test jars into the sampler water, with equilibration generally achieved in 24 hours. Note that a literature search did not find any citations that reference a nylon screen sampler being used for SVOC collection."[5]

NSPDS are not commercially available.

5.3.1.3.2.1.2 Regenerated Cellulose Dialysis Membrane (RCDM) Sampler

The regenerated cellulose dialysis membrane sampler is a type of passive equilibrium sampler. "The dialysis sampler consists of a deionized water-filled tube of high-grade regenerated-

[5] https://clu-in.org/characterization/technologies/default.focus/sec/Passive_(no_purge)_Samplers/cat/Diffusion_Samplers/#1

cellulose dialysis membrane inside an outer protective layer of low density polyethylene (LDPE) mesh."[6]

"An assembled regenerated-cellulose dialysis membrane sampler is deployed by lowering it down a well to its target screen depth. The amount of time that the sampler should be left in the well prior to recovery depends on the time required by the sampler to equilibrate with ambient water and conditions in the well to recover from any disturbance caused by sampler deployment. Laboratory tests have shown that this usually occurs within two weeks (Imbrigiotta 2007). Unlike PDB samplers, dialysis samplers should not be left in a well for an extended period and generally should be retrieved within three to four weeks, at most. Samplers left longer than this can be compromised by biological activity."[7]

RCDM samplers are not commercially available. Because regenerated cellulose readily biodegrades, membrane materials are immersed and packaged in chemical preservatives by membrane manufactures, and these preservatives must be removed from the membranes before construction of samplers by a multi-step cleaning process to avoid introduction of the preservatives to the sample. Membrane pore size must be carefully selected to accommodate analytes of interest while retaining water molecules in the sampler.

5.3.1.3.2.1.3 Dual Membrane Passive Diffusion Bag Sampler

The Dual Membrane Passive Diffusion Bag Sampler is a type of passive equilibrium sampler. Dual membrane passive diffusion bag samplers (DMPDBS or DM samplers) have been developed based on existing diffusion-based passive sampling technologies as a way to expand the number/variety of compounds that can be analyzed. These samplers can be used for non-polar VOCs, SVOCs, metals, ions, cations, inorganics, 1,4 Dioxane, and PFAS. The DMPDBS combine a polyethylene PDB with an additional membrane of nylon screen, regenerated cellulose or other membrane selected for its specific diffusive properties.

The two membranes are connected in series, with the polyethylene at the bottom and either the nylon screen or cellulose at the top. Similar to PDBS, the DMPDBS are filled with deionized water prior to deployment in a monitoring well. Once installed in the saturated screen both membranes facilitate diffusion of VOCs. The upper membrane also facilitates diffusion of larger molecules, polar molecules, ions and cations, metals, and most other dissolved compounds. Once in the sampler, molecules continue to diffuse throughout the chamber maintaining dynamic equilibrium within the chamber and with the surrounding groundwater. When the sampler is retrieved, water in the top membrane may leave the sampler through the large pores, while the lower chamber serves as a reservoir from which sample bottles are filled.

The deployment of DMPDBS is similar to the PDB deployment procedure with the same tether setup, vertical profiling requirements, etc. The main difference is that a longer residence time of 21 days is recommended for compounds other than VOCs. **In addition, care must be taken to deploy the DMPDBS with the larger mesh membrane at the top and to always maintain the upright position when handling and sampling the DMPDBS to prevent loss of sample.**

[6] https://clu-in.org/characterization/technologies/default.focus/sec/Passive_(no_purge)_Samplers/cat/Diffusion_Samplers/#5
[7] https://clu-in.org/characterization/technologies/default.focus/sec/Passive_(no_purge)_Samplers/cat/Diffusion_Samplers/#5

Advantages:

- Similar advantages to PDBS including deployment, retrieval, vertical profiling, and purge water elimination
- Sample for VOCs, Semi-Volatiles, Metals, Ions, 1,4 Dioxane & PFAS
- Low turbidity samples

Limitations:

- Limited sample volume
- Must be filled in the field or be stored in deionized water
- Contact manufacturer for lab and field data of specific analytes of interest

5.3.1.3.2.2 Rigid Porous Polyethylene Sampler (RPPS)

The Rigid Porous Polyethylene Sampler is a type of passive equilibrium sampler. The RPP sampler is constructed of thin sheets of hard-foam-like porous polyethylene or short lengths of pipe made of porous polyethylene with a pore size of 6 to 15 microns. Samplers are about 1.25 inches diameter x 8 inches long and hold about 125ml of water. The thickness of the materials is significantly greater than that of a film membrane, creating significant air spaces and tortuous pathway for molecules within the wall. For diffusion to occur effectively, the air in the pores must be replaced with deionized water by adding water under pressure, to the chamber, forcing water out of the chamber through the sidewall pores, saturating the pores with water. When oriented vertically, the samplers "weep" out the bottom as the hydraulic head overcomes the surface tension of the water in the pores, so the samplers need to be packaged in deionized water and deployed immediately after unpacking or air will become entrained in the upper pores as water leaves the bottom of the sampler. "They are filled with deionized, analyte-free water, capped at one end and a Delrin plug inserted into the other end."[8] RPP samplers work by diffusion, as water soluble analytes pass through the pores until equilibrium is reached with the aquifer immediately adjacent to the well screen.

Advantages:

- RPP samplers are effectively used for water soluble analytes, such as Perchlorate, 1,4-dioxane, Inorganic anions and cations, metals, MEE parameters, MTBE, Hexavalent chromium, explosives, and dissolved gases
- Can be successfully used for long-term groundwater monitoring situations, especially thereby reducing the collection of purge water and the problems associated with disposal
- Effective in porous/permeable formations with good groundwater recovery, as well as deep wells where submersible pumps may be hindered or impeded

Limitations:

- The membrane should be shipped and stored in a saturated state (submerged in water filled packaging)
- Limited sample volume about 125ml of sample volume per RPP device. Several samplers may be needed for adequate sample volume.

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[8] https://clu-in.org/studio/passsamp_042407/day1/prez/34/34bw.pdf

- Relatively greater per sampler cost compared to other passive methods
- Not recommended for VOCs

5.3.1.3.2.3 Peeper Sampler

Peeper samplers are largely used to study pore waters from groundwater/surface water interfaces such as rivers, streams, wetlands, etc. Peeper samplers are capable of monitoring most inorganic and organic compounds present in dissolved phases (ITRC, March 2006).

Peeper samplers are multi-chambered equilibrium samplers in which each chamber is filled with deoxygenated, deionized water and covered with a fixed membrane. The sampling technique relies on diffusion of analytes to reach equilibrium between the membrane and deionized water.

Peeper samplers can be constructed of lexan, acrylic, Teflon, stainless steel or most other millable material. The length of the peeper sampler is largely determined by the depth of the sediment and the height of the water overlying the sample area.

Peepers should be deployed with minimum disturbance to the sediment layer of interest. The peeper sampler is installed vertically into the sediment, leaving several wells above the sediment–water interface to sample both the pore and overlying water. The samplers are usually hand deployed, but a diver can deploy the samplers in deeper waters.

The sampler should be left in place for days to weeks until chemical equilibrium is reached. A week to 14 days is a common period to allow for equilibration with peeper samplers.

The peeper sampler must be deoxygenated under a nitrogen atmosphere before deployment or else the oxygen held within the plastic of the frame can diffuse into the sampling cells located below the redox boundary and alter the chemistry of the collected porewater.

Advantages:

- No purge option to sample porewater
- Can be deployed by hand in most circumstances
- Can be left in place for an extended period of time
- Ease of use
- Low concerns of cross-contamination
- Can be installed at targeted/discrete depths

Limitations:

- Some compounds may require longer equilibration times
- May require divers for deeper sediment porewater sampling
- Concerns regarding redox
- Low sample volume
- Installation of peeper in-situ disrupts sediment layers

5.3.1.3.3 Accumulation/Sorption Sampling Technologies

5.3.1.3.3.1 AGI Universal Sampler

AGI Universal Samplers (formerly known as Gore™ Sorber Modules) are made by Amplified Geochemical Imaging, LLC. The sampler is constructed of two main components, a hydrophobic sorbent to collect a wide range of compounds, and a protective porous sheath made of a Gore-Tex membrane. The sampler accumulates the mass of target compounds over time and does not directly provide a measure of concentration. Samplers are installed to the sampling location and left in place for the recommended time. Samplers are removed and sent to a lab where the analytes are desorbed by a proprietary process, and the mass determined. Residence time and temperature must be recorded carefully and are used in a lab calculation to convert the accumulated mass to an estimated concentration. According to AGI, the membrane allows for unimpeded compound migration to the adsorbent while protecting the sample, regardless of media; the membrane is inert and does not off-gas into the sample. The USEPA Environmental Technology Verification program has verified the performance claims for the sampling groundwater. https://archive.epa.gov/nrmrl/archive-etv/web/pdf/01_vr_gore.pdf

Advantages:

- Used to collect VOCs and SVOCs in air, unsaturated and saturated soils, and water
- The narrow diameter of the sampler allows for use in piezometers and monitoring wells down to a ½ inch diameter
- Can be used for vertical profiling within water column
- Short exposure time, 15 minutes to 4 hours
- Can transport to lab without cooling
- Can be deployed in a short water column (as low as 6 inches)
- Can be deployed in the headspace above the water table
    - To detect compound partitioning to vapor from water
    - To detect compounds entering through screen exposed to the vadose zone

Limitations:

- Limited application, field screening only
- Currently has a single source supplier and laboratory
- Does not measure field parameters or inorganics
- Limited by vapor pressure for compound detection

5.3.1.3.3.2 Direct Push Technologies for Groundwater Sampling

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, the NJDEP recommends, apply, at a minimum, the Decontamination Procedures using Heat discussed in section 5.2.3 above.

One of the special applications of direct push technology relative to monitor well sampling is the ability to obtain vertical profile information (i.e., multiple depth discreet samples) from the same borehole. When conducting vertical water quality sampling in the same borehole, the need to eliminate all possible sources of extraneous or cross contamination is important, 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 recommended means to decontaminate sampling equipment and maintain confidence that data are not influenced by unwanted variables. In addition, equipment should be maintained in good working order to insure its performance. This means (but is not limited to) all rods used for boring advancement should have unworn O-rings at each connection, and undamaged threads to ensure that each connection can be easily tightened. All downhole equipment should be decontaminated between each use and sample collection tubing should 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 ensure that communication between various water bearing zones within the same boring does not take place. While borings less than 25 feet in depth may be backfilled with cuttings per N.J.A.C. 7:9D, in areas of groundwater or soil contamination sealing the hole with grout is recommended. Since driven boreholes generate no soil cuttings, material should be brought to the site to fill in the boreholes. Where the borehole extends to a depth greater than 25 feet, the borehole must be properly sealed. Finally, no boring work can begin without first contacting New Jersey One Call service (800-272-1000), https://www.nj1-call.org/, 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:

https://www.epa.gov/sites/production/files/2014-12/documents/wellstdy.pdf; and

https://www.ams-samplers.com/catalogsearch/result/?q=direct+push.

5.3.2 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.

5.3.2.1 Manual Sampling

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

Limitations:

- 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

5.3.2.2 Automatic Sampling

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 5.18 and 5.19 illustrate two versions of the ISCO® sampler for sequential and composite 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 insoluble components. Adequate flow rates must be maintained throughout the sampling train to effectively transport suspended solids.

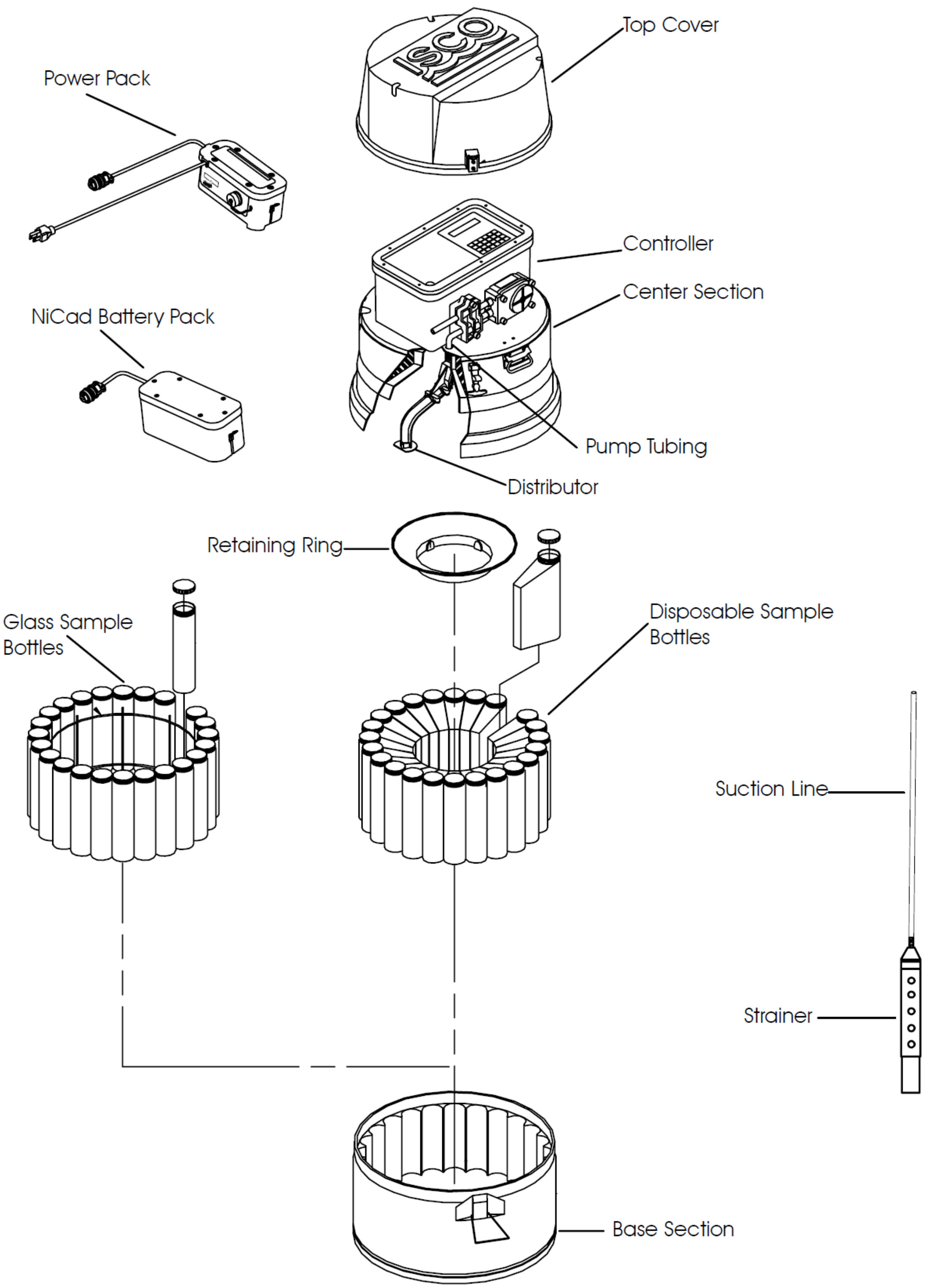

Figure 5.18 3700 Series Sampler for sequential collection. Illustration published with permission of Teledyne ISCO.

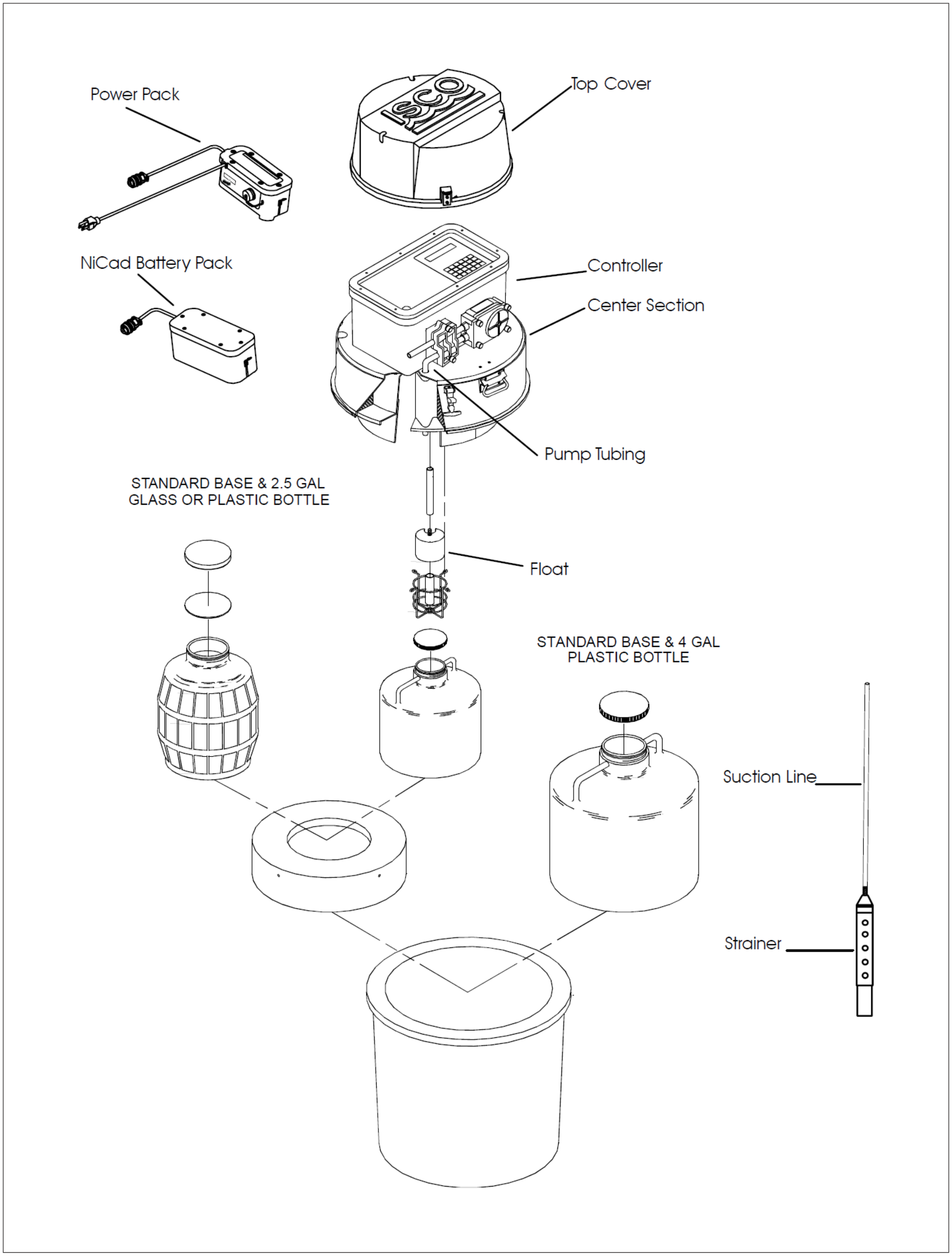

Figure 5.19 ISCO® 3700 Series Sampler for composite collection. Illustration published with permission of Teledyne ISCO.

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 desirable 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:

- capacity for either AC or DC operation; battery life for 2 to 3 days of reliable hourly sampling without recharging;
- battery weight of less than 20 pounds and sealed so no leakage occurs;
- solid-state logic and printed circuit boards;
- timing and control systems contained in a water-proof compartment and protected from humidity;
- 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;
- capability of multiplexing, (i.e., drawing more than one sample into a discrete sample bottle to allow a small composite over a short interval);
- capability for filling more than one bottle with the same aliquot for addition of different preservatives; and
- 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 Section 5.2.1 above. 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 in the manhole (e.g., to a rung above the high water line).

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 a 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

Limitations:

- 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

5.3.3 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 5.4, *Non-Aqueous Sampling Equipment*, Subsection 5.4.2, *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 Equipment* at http://water.usgs.gov/owq/FieldManual/.

5.3.3.1 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).

Advantages:

- Easy hand operation
- No field decontamination necessary
- No other equipment needed
- Eliminates need for a field blank

Limitations:

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

5.3.3.2 Pond Sampler

The commercially available pond sampler (a.k.a. Dipper) (Figure 5.20) is used to collect liquid waste samples from disposal ponds, pits, lagoons, and similar reservoirs.

Figure 5.20 Pond Sampler (Photograph by J. Schoenleber)

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 5.21.

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

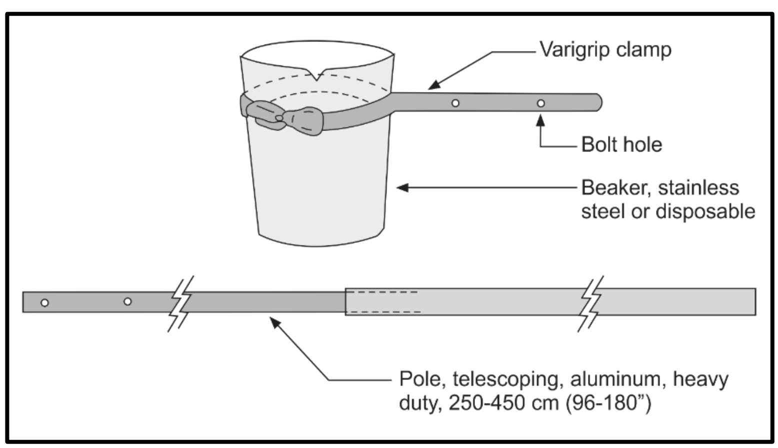

Figure 5.21 Fabricated Pond Sampler

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, *Quality Assurance s*).
- **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

Limitations:

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

5.3.3.3 Weighted Bottle Sampler

The weighted bottle sampler (Figure 5.22) 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/.

Figure 5.22 Weighted Bottle Sampler.

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

Limitations:

- 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

5.3.3.4 Wheaton Dip Sampler

The Wheaton Dip Sampler (Figure 5.23) 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.

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*).

Figure 5.23 Wheaton Dip Sampler (Photograph by J. Schoenleber)

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

Limitations:

- 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)

5.3.3.5 Kemmerer Depth Sampler/Van Dorn Sampler

Aside from depth sampling in open bodies of water for macrophytes, the Kemmerer depth sampler (Figure 5.24) 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 5.24 Kemmerer Depth Sampler

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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Ability to sample at discrete depths
- Ability to sample great depths

Limitations:

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

5.3.3.6 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.

5.3.3.7 VOC Sampler

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. This unit is deliberately made heavy to provide stability in fast-flowing streams. During periods of high flow, 10 lb. weights can be added to keep the sampler vertical when suspended from a bridge or cableway.

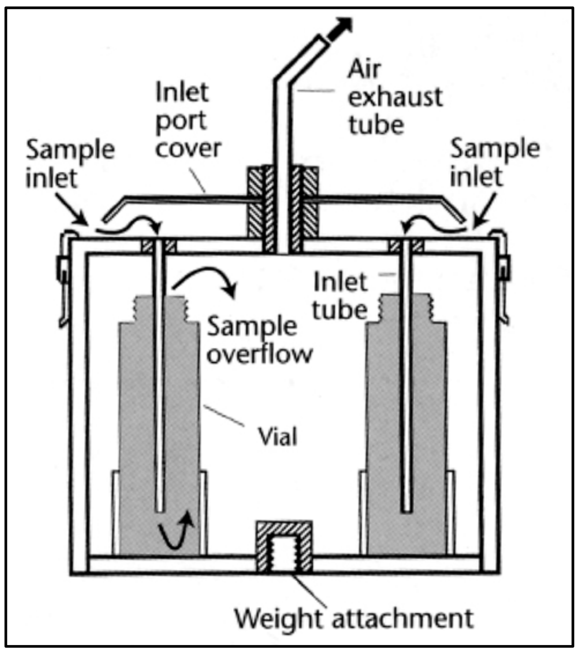

Figure 5.25 VOC Sampler.

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 into the sampler body, displacing the air in the vials and in the sampler through the exhaust tube. The total volume is eight times larger than 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 https://pubs.usgs.gov/of/1997/0401/report.pdf .

This device is not designed for, nor can it be applied to, monitoring well investigations.

5.3.3.8 Bacon Bomb Sampler

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.

Figure 5.26 Bacon Bomb Sampler

The Bacon bomb sampler (Figure 5.26) 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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Sampler remains unopened until at sampling depth
- Stainless steel construction facilitates proper decontamination

Limitations:

- Difficult to decontaminate
- Difficulties in transferring sample to container
- Tends to aerate sample
- Brass construction may not be appropriate in certain analysis

5.3.3.9 Polar Organic Chemical Integrative Sampler (POCIS)

Integrative passive samplers are an effective way to monitor the concentration of organic contaminants in aquatic systems over time. The POCIS sampler consists of multiple, stacked sampling disks mounted on a support rod. POCIS samplers have been used extensively to determine contaminant levels in surface waters, however, according to the USEPA's Contaminated Site Clean-Up Information (CLU-IN) website, a literature search failed to find an example where they had been used for groundwater sampling. The standard commercially available sampler disc is 4 inches in diameter and the protective canister is about 6.3 inches in diameter and about 6 inches in length. The POCIS was developed by the Columbia Environmental Research Center of the USGS and according to information provided by the USGS, each disk consists of a solid sorbent sandwiched between two polyethersoulfone (PES) microporous membranes which are then compressed between two stainless steel rings which expose a sampling area. The PES membrane acts as a semipermeable barrier between the sorbent and surrounding aquatic environment. It allows dissolved contaminants to pass through the sorbent while selectively excluding any particles larger than 100 nm. The membrane resists biofouling because the polyethersulphone used in the design is less prone than other materials. The POCIS is versatile in that the sorbents can be changed to target different classes of contaminants. However, only two sorbent classes are considered as standards of all POCIS deployments to date.

Any compound with a log Kow (the octanol/water partition coefficient) of less than or equal to 3 can concentrate in a POCIS sampler. Applicable classes of contaminants measured by POCIS are pharmaceuticals, household and industrial products, hormones, herbicides, and polar pesticides. Currently, there are two POCIS configurations that are targeted for different classes of contaminants. A general POCIS design contains a sorbent that is used to collect pesticides, natural as well as synthetic hormones, and wastewater related chemicals. The pharmaceutical POCIS configuration contains a sorbent that is designed to specifically target classes of pharmaceuticals.

Not to be considered a complete list.

Table 5.2 Applicable Contaminants that Concentrate in a POCIS Device

Chemical Class	Examples
Pharmaceuticals	acetaminophen, azithromycin, carbamazepine, ibuprofen, propranolol, sulfa drugs, tetracycline antibiotics
Household and industrial products	alkyl phenols, benzophenone, caffeine, DEET, fire retardants, indole, triclosan
Hormones	17β-estradiol, 17α-ethynlestradiol, estrone, estriol
Herbicides	atrazine, cyanazine, hydroxyatrazine, tertbutylazine
Polar pesticides	alachlor, chlorppyrifos, diainon, dichlorvos, diuron, isoproturon, metolachlor
Other	Urobilin

Advantages:

- Can achieve very low detection limits
- Does not have sample volume issues
- Ideally suited for emerging contaminants (e.g., endocrine disruptors)
- Does not require electricity or other support

Limitations:

- One licensed vendor
- Limited application, field screening only for groundwater sampling and surface water sampling
- Sampling rate for target contaminants must be determined
- Water flux is needed to make environmental adjustments to laboratory-determined sampling rates (improve accuracy)
- Does not provide water quality parameters and inorganic data
- Commercially available equipment is not designed for 2-inch monitoring wells
- Requires two trips-one for deployment, one for retrieval

5.3.3.10 Continuous Water-Quality Monitors

A continuous water-quality monitor (Figure 5.27) 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.

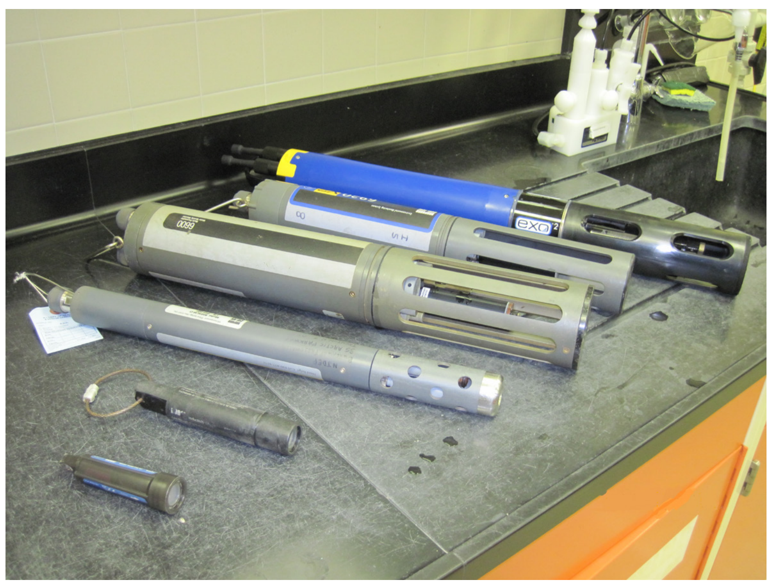

Figure 5.27 Continuous Monitoring meters

For more information regarding flow-through cells see Chapter 6, *Sample Collection*, Section 6.9, *Ground Water Sampling Procedures*, Subsection 6.9.6.5.2.3, *Specific LFPS Considerations.*

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/.

5.3.3.11 Continuous Low-Level Aquatic Monitoring (CLAM)

The CLAM is a solid phase extraction (SPE) sampler that can be used in various aquatic environments such as drinking water systems, lakes, agricultural runoff, urban water systems, monitoring wells, rivers, marine environments, and stormwater.

The CLAM weighs under two pounds, comes with a rechargeable battery, and can be left unattended to actively sample water for up to 36 hours. The CLAM Media is sheathed in a micro glass fiber matrix and kept in place within an encasing shell that can be deployed easily. A larger sample volume is allowed to be extracted due to lofted prefiltration filter. The deployable unit uses a syringe extraction filter that is identical to the solid phase extraction filters used in the laboratory for semivolatile analysis. Filters are also available that contain stationary phases that are specifically designed to isolate compounds of emerging concern (e.g., PFAS and 1,4 Dioxane). The CLAM pump delivers a calibrated flow rate through the solid phase extraction filter continuously for a time period selected by the sampling crew. This allows the detection of a time weighted, flow proportional composite sample that does not miss variability in contaminant concentrations with time.

Advantages:

- There is no need to transport heavy or fragile laboratory equipment, power sources, and solvents to remote areas as the CLAM is a self-contained submersible extraction device
- Ability to isolate and enrich pollutants up to 100 liters of water quantitatively, allowing ultra-low detection levels
- Will run unattended submerged for up to 36 hours using battery power
- Convenient for remote sampling areas

Limitations:

- May dilute contaminants to below detection levels is discharges are periodic in nature over the sampling interval
- Earlier models of this device did not include a flow totalizer, which required the sampler to document deployment times and flow rates during each deployment
- May clog if aqueous samples have high suspended solids

5.3.3.12 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 https://pubs.usgs.gov/wri/1995/4141/report.pdf for proper application. For proper cleaning when trace metal analysis is required see http://water.usgs.gov/admin/memo/QW/qw97.03.html.

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.

5.3.3.13 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 to create a clean environment 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). 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/.

5.3.4 Containerized Liquid Sampling Equipment

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 5.3.3 of this chapter.

5.3.4.1 COLIWASA

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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Inexpensive
- Simplicity of operation
- Versatile

Limitations:

- Problems encountered with fluids of very high viscosity
- Difficulty in cleaning

5.3.4.2 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.

Figure 5.29 Open Tube Thief Sampler

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.

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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Inexpensive
- Simplicity of operation
- Versatile, e.g., may be used to sample water from sump areas in homeowner basements disposable

Limitations:

- Sample leakage
- Small sample volume

5.3.4.3 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.

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, Section 2.4.8 *Sample Preservation Requirements*.).

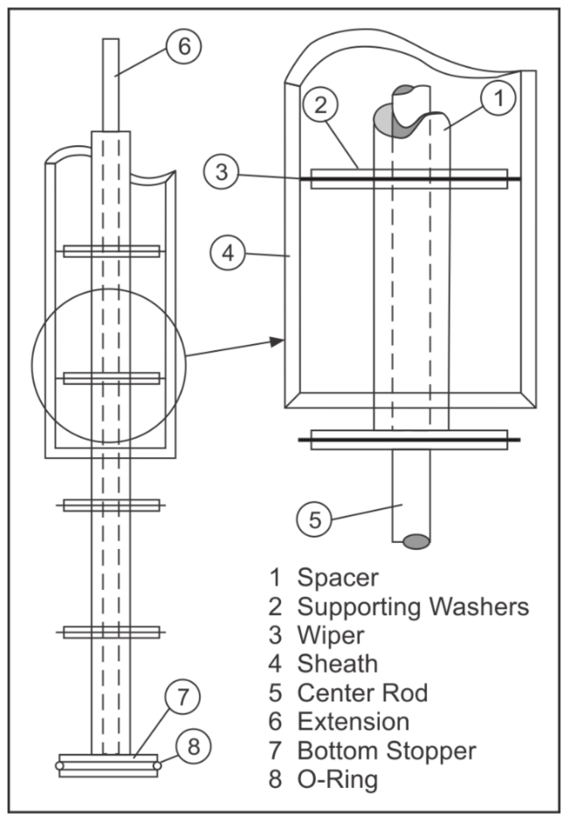

Figure 5.30 Stratified Thief Sampler

Advantages:

- Simplicity of operation
- Representative sample obtained in viscous, stratified liquids

Limitations:

- Plastic is not compatible with certain substances
- Some difficulty in transferring sample to sample container

5.4 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, *Introduction*, 6.2, *Soil Sampling*, and 6.2.7, *VOC Sample Collection for Soils* for more information on the process of collecting soil samples.

5.4.1 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.

5.4.1.1 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.

(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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Easy to use and clean

Limitations:

- Cannot be used to collect samples for volatile organic analysis

5.4.1.2 Bucket Auger

The bucket auger (Figure 5.32) 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, choose 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 organic contaminants (VOC) 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 than 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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Relatively speedy operation for subsurface samples

Limitations:

- Destroys soil horizons as it samples
- Not approved for sampling soils for volatile organic analysis
- May be difficult in certain lithologies

5.4.1.3 Soil Coring Device

The soil coring device (Figure 5.33) 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 analyses of depth profiles need to be performed.

Once opened and screened with a Photoionization 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, *Introduction*, 6.2, *Soil Sampling*, and 6.2.7, *VOC Sample Collection for Soils* for more information on collection of soil samples.

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

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.

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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Can be used in various substances
- Core sample remains relatively intact
- Bit is replaceable

Limitations:

- 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

5.4.1.4 Split Spoon Sampler

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 pipe split longitudinally and 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.

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

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, Section 2.4.8 *Sample Preservation Requirements*.).

viii. When split tube sampling is performed to gain geologic information, all work should be performed in accordance with ASTM # D 1586\D 1586 M-18.

Advantages:

- Easily available
- Strong
- Ideal for split sample collection
- Preferred sampling device for volatile organic sample collection

Limitations:

- Requires drilling or tripod for deeper samples

5.4.1.5 Shelby Tube Sampler

A Shelby tube (Figure 5.35) is used mainly for obtaining geological information but may be used in obtaining samples for chemical analysis.

Figure 5.35 Shelby tube Sampler

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 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

Limitations:

- Sometimes difficult to extract sample
- Not durable encountering rocky soils

5.4.1.6 En Core® Sampler

The En Core® sampler (Figure 5.36) is a 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. Other small-diameter core samplers can be used for sampling and placement into the appropriate sample containers; however, only the En Core® sampler can be used for sampling, storage **and** transportation of the sample to the lab. See Chapter 6, *Sample Collection*, Section 6.2.7, *VOC Sample Collection for Soils* for more specific information on collection procedures and alternative devices for collecting volatile organics in soil.

Figure 5.36 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. If a full 5-gram sample cannot be collected in one plunge, be sure to collect the remainder of the sample within the target interval.

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/deliver 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:

- Only NJDEP 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

Limitations:

- 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 cannot be effectively sampled

5.4.1.7 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

Limitations:

- 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)

5.4.1.8 Direct Push Technology for Soil Sampling

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 Eight Step decontamination procedure discussed in section 5.2.1 above.

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 is 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. Proceed 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 6.4, *Direct Push Technology Considerations*, Section 6.9.6.6, *Temporary Well Points and Direct Push Technology*, and Appendix 6.1, *Monitor Well Construction and Installation*, subsection A.6.1.3.3, or go to the following USEPA web site: https://www.epa.gov/ust/monitoring-well-comparison-study-evaluation-direct-push-versus-conventional-monitoring-wells.

5.4.2 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 Eight Step or Three Step decontamination procedures described in Sections 5.2.1, and 5.2.2, 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 Table 5.3 General Characteristics of Selected Grab and Core Samplers.

5.4.2.1 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.

5.4.2.1.1 Ponar Dredge

The Ponar dredge (Figure 5.37) 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.

Figure 5.37 Ponar Dredge. Illustration published with permission of Wildco®

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, Section 2.4.8 *Sample Preservation Requirements*.).

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

Limitations:

- 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
- Debris may prevent the jaw from closing properly
- Possible incomplete closure of jaws can result in sample loss

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

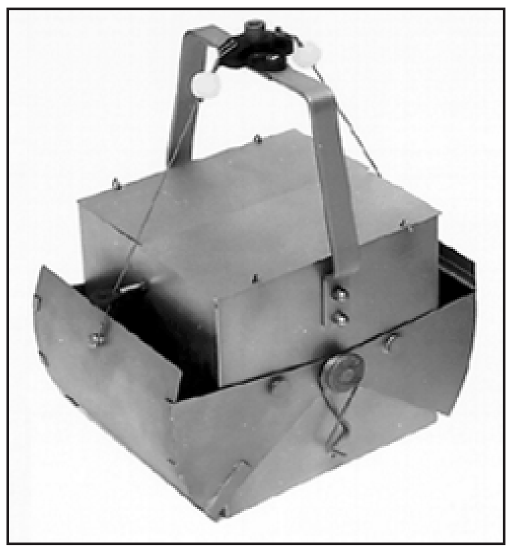

Figure 5.38 Ekman Grab Sampler. Illustration published with permission of Wildco®

5.4.2.1.2 Ekman Grab Sampler

The Ekman Grab sampler (Figure 5.38) 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.

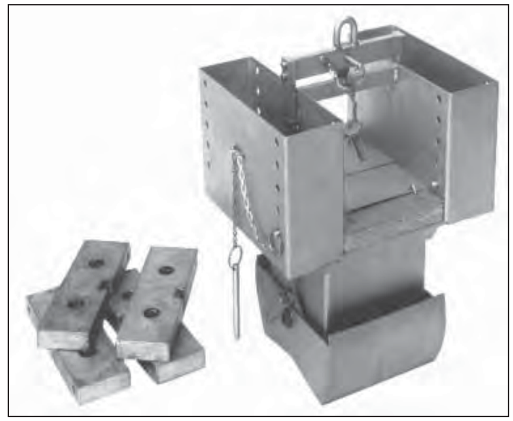

Figure 5.39 Box Corer. Illustration published with permission of Wildco®

5.4.2.1.3 Box Corer

The Box Corer (Figure 5.39), 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 5.40 Shipek® Grab Sampler. Illustration published with permission of Wildco®

5.4.2.1.4 Shipek

The Shipek® (Figure 5.40) 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.

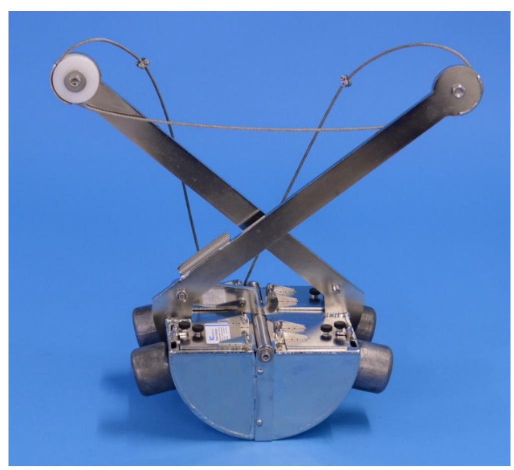

Figure 5.41 Van Veen Grab

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.

5.4.2.1.5 Van Veen Grab

An example of a clamshell pivot, the Van Veen grab (Figure 5.41) 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 5.42 Petersen Grab. Illustration published with permission of Wildco®

5.4.2.1.6 Petersen Grab

The Petersen grab (Figure 5.42), 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.

5.4.2.2 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 Eight-Step or Three Step decontamination procedures described in section 5.2 above.

Figure 5.43 Hand Corer

5.4.2.2.1 Hand Corer

The Hand Corer (Figure 5.43), 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.

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 (Figure 5.44) 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.

Figure 5.44 Ogeechee™ Sand Corer

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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Easy to use
- Minimal risk of contamination

Limitations:

- Can disrupt water/sediment interface
- Does not work well in sandy sediments

5.4.2.2.2 Russian Peat Borer

The Russian Peat Borer (Figure 5.45), 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 supports 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.

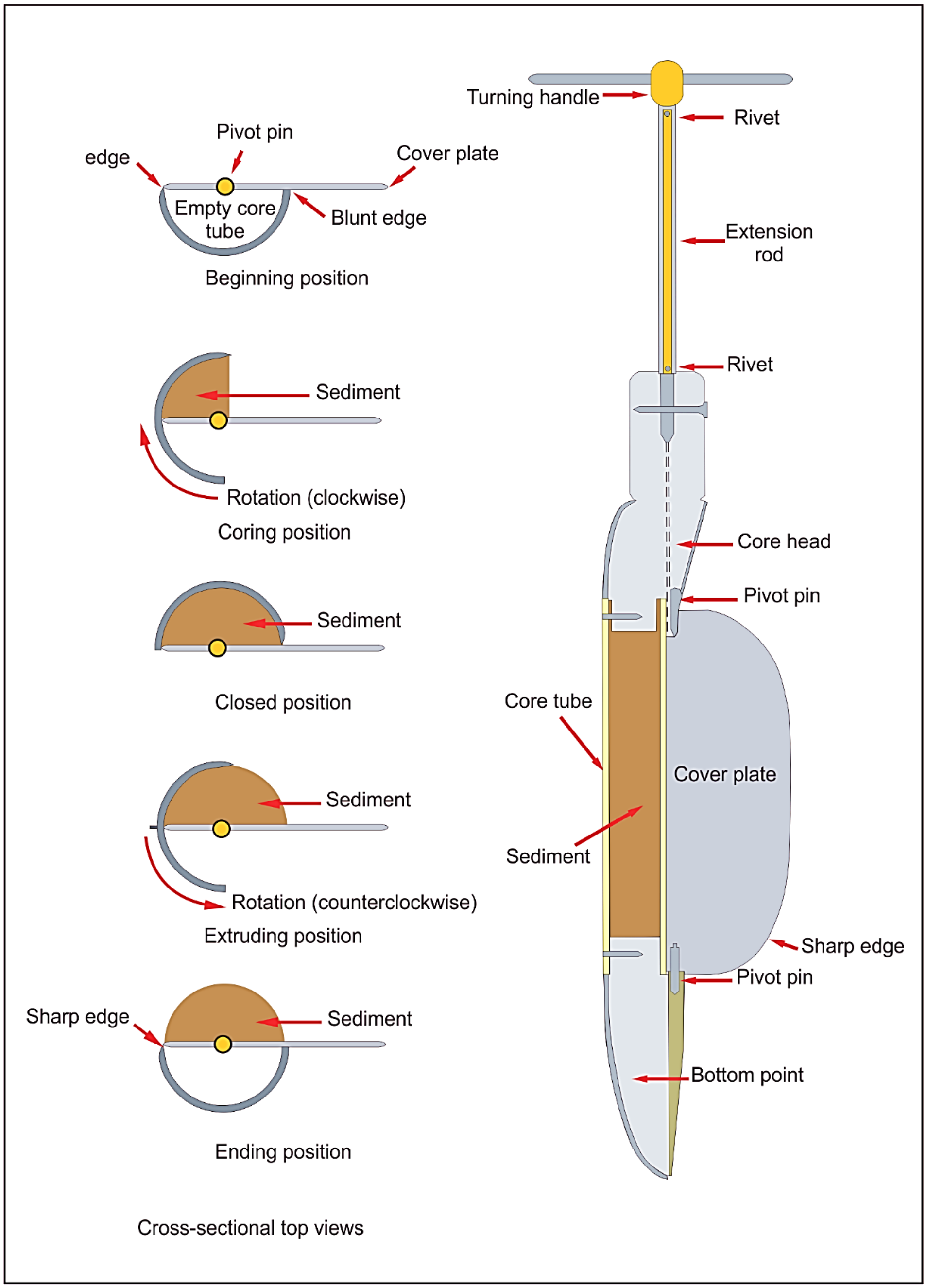

Figure 5.45 Russian Peat Borer. Illustration published with permission of Aquatic Research Instruments

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 https://archive.epa.gov/nrmrl/archive-etv/web/pdf/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. 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."

5.4.2.2.3 Split Core Sampler

The Split Core Sampler (Figure 5.46), 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.

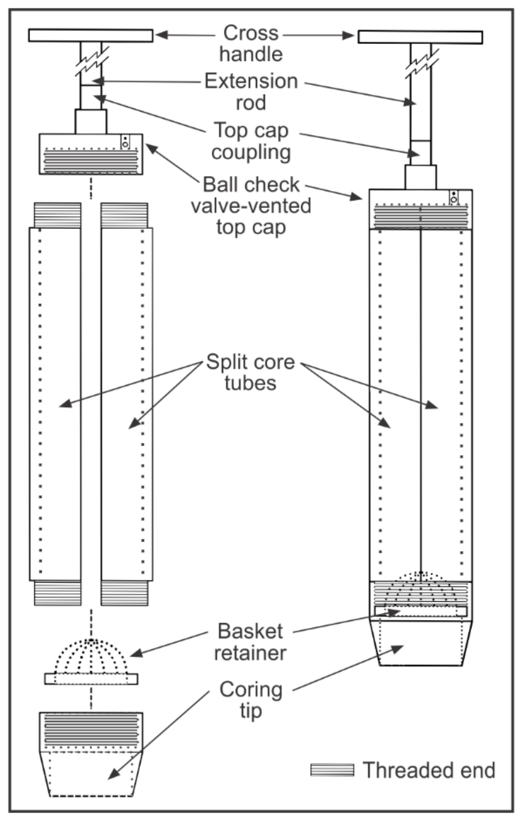

Figure 5.46 Split Core Sampler. Illustration published with permission by Art's Manufacturing & Supply by Art's Manufacturing & Supply Aquatic Research Instruments

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 https://archive.epa.gov/nrmrl/archive-etv/web/pdf/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*.".

5.4.2.2.4 Gravity Corer

A gravity corer (Figure 5.47) 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.

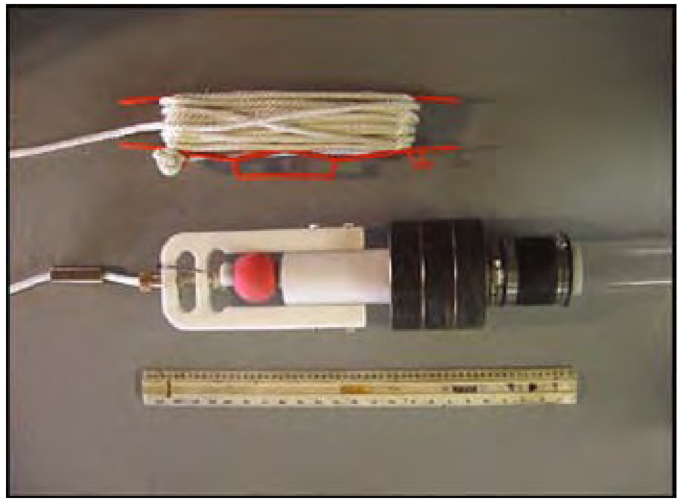

Figure 5.47 Gravity Corers. Illustration published with permission from Aquatic Research Instruments

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, Section 2.4.8 *Sample Preservation Requirements*.).
- **viii.** Decontaminate before use at next location.

Advantages:

- Collects undisturbed samples

Limitations:

- May damage membrane liners in vessels or lagoons

5.4.2.2.5 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.

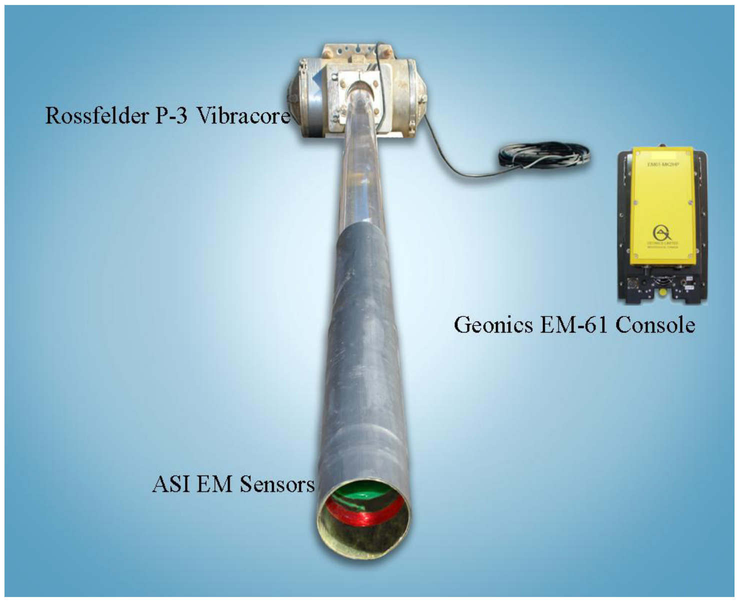

Figure 5.48 Vibracorer (Source USEPA, ETV Program Report)

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 5.48), 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.

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/category/sediment_sampling/.

5.4.2.2.6 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 5.3 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 than 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 version available, sample must be equipped with safety yoke.
Ponar* (2 sizes)	SS body, zinc-plated steel weights and neoprene flaps	6 x 6 or 9 x 9	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 than 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 than 16 mm; susceptible to loss of fines.
Birge-Ekman* (4 sizes)	SS or brass	6 x 6 x 6 or 6 x 6 x 9 or 9 x 9 x 9 or 12 x 12 x 12	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 5.3 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
Grab Samplers							
Shipek*	Cast alloy steel	4 x 6 x 6 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	2.1 D. 20-96 L	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 5.3 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. 20 L	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 .0 6 3 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 .06 3 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 .06 3 mm; core liners available in plastic; inconsistent vertical penetration.
box	SS with optional acrylic box liner	6 x 6 x 9	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 1 6 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 A8, *Bottom Material Samples*, (*http://water.usgs.gov/owq/FieldManual/*)

5.4.2.3 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.

5.4.2.3.1 Lidded Sludge/Water Sampler

A lidded sludge/water sampler (Figure 5.49) can be used to collect viscous sludge or waste fluids from tanks, tank trucks or ponds at a specific depth. It can sample liquids, multi-layer liquid wastes and mixed-phase solid/liquid wastes. Sample volume can be up to 1 liter. It consists of a removable glass sample bottle situated inside a holder that is suspended gimbal-like within a stainless steel framework, which is attached to a rod and handle.

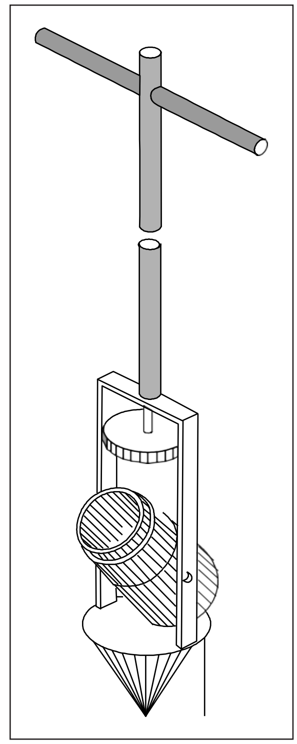

Figure 5.49 Lidded Sludge/Water Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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.

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, Section 2.4.8 *Sample Preservation Requirements*.).

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

Limitations:

- Heavy

5.4.2.3.2 Liquid Grab Sampler

A liquid grab sampler (Figure 5.50) 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.

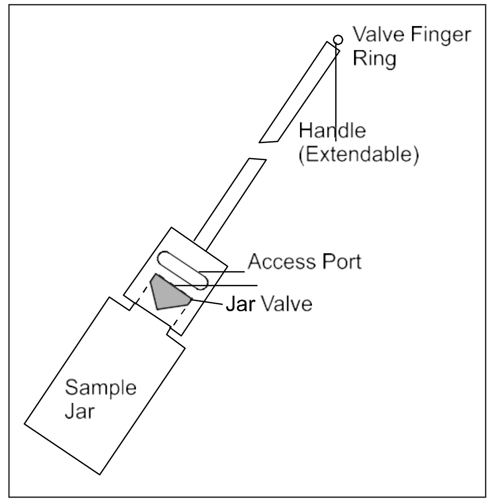

Figure 5.50 Liquid Grab Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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 the sampler closes the valve.
- **vi.** Transfer sample into laboratory cleaned sample bottles and follow procedures for preservation and transport (see Chapter 2, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Allows discrete samples to be taken at depth

Limitations:

- Depth of sampling is limited by length of pole
- Not useful in very viscous sludges
- Hard to decontaminate

5.4.2.3.3 Swing Jar Sampler

The swing jar sampler (Figure 5.51) is a surface sampler that may be used to collect surface water, liquids, sludge, powders, or fine 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 aluminum handle with a pivot at the juncture of the handle and jar holder. The jar is held in the holder with

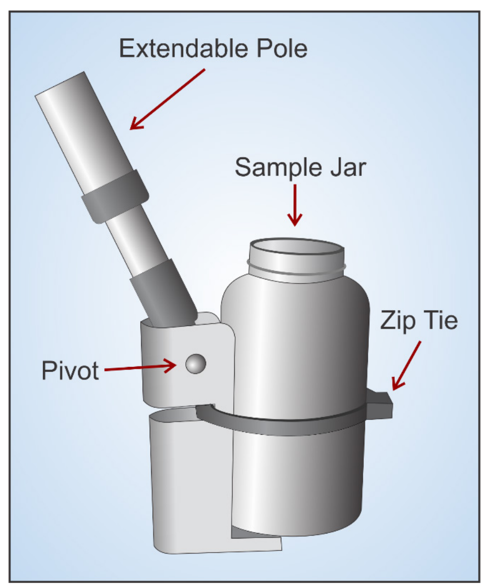

Figure 5.51 Swing Jar Sampler

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

Limitations:

- Cannot collect discrete depth samples

5.4.2.3.4 Sludge Judge

A sludge judge (Figure 5.52) 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.

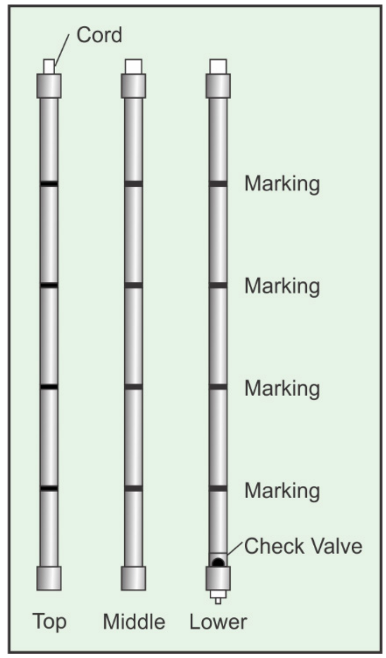

Figure 5.52 Sludge Judge (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Easy to use
- Delineates amount of settled sludge or physical state of medium

Limitations:

- Use is limited due to PVC construction
- Hard to decontaminate
- Not useful in thick sludges

5.4.3 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 5.4 at the end of this chapter lists NJDEP recommended waste material samplers and their application.

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

5.4.3.1 Grain Sampler

The grain sampler (Figure 5.53) 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 5.53 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, Section 2.4.8 *Sample Preservation Requirements*.),

Advantages:

- Ease of operation

Limitations:

- Not desirable for moist or sticky samples
- Provides a low volume

5.4.3.2 Waste Pile Sampler

The waste pile sampler (Figure 5.54) 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.

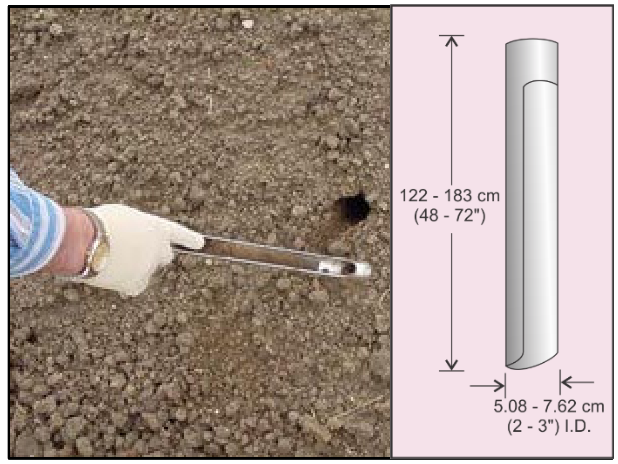

Figure 5.54 Waste Pile Sampler (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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.

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 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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Easily fabricated
- Disposable
- Inexpensive

- Can be fabricated to site-specific needs

Limitations:

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

5.4.3.3 Sampling Trier

A sampling trier (Figure 5.55) 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.

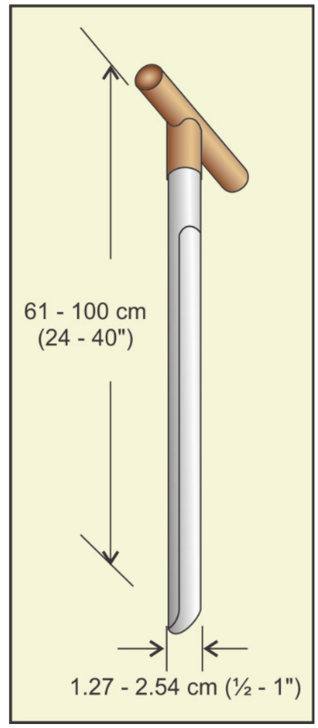

Figure 5.55 Sampling Trier (Source: USEPA RCRA Waste Sampling Draft Technical Guidance, August 2002)

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, Section 2.4.8 *Sample Preservation Requirements*.).

Advantages:

- Preferred for moist or sticky samples

Limitations:

- 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 5.4 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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