

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DIVISION OF SPILL PREVENTION AND RESPONSE CONTAMINATED SITES PROGRAM



**Field Sampling Guidance
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1.0 Introduction

The purpose of the Contaminated Sites Program *Field Sampling Guidance* is to provide fundamental guidelines and present methods and equipment options for sample collection at contaminated sites and leaking underground storage tank sites. This guidance document expands the sampling procedures currently found in the Underground Storage Tank (UST) Procedures Manual, which is adopted by reference in the 18 AAC 78 regulations. Alternatives to the procedures and equipment described in this guidance may be proposed in project work plans on a site-specific basis.

The *Field Sampling Guidance* is also intended for use in developing site characterization work plans under 18 AAC 75.335; cleanup work plans (including sampling and analysis per 18 AAC 75.355) under 18 AAC 75.360; and corrective action plans (including sampling and analysis per 18 AAC 75.355) under 18 AAC 78.250. All three plans, if applicable, must be reviewed and approved by The Alaska Department of Environmental Conservation (ADEC) Contaminated Sites Program (CSP).

The *Field Sampling Guidance* may also be used to develop work plans for sites regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These sites may be on the Environmental Protection Agency National Priorities List or may fall under executive order 12580 and thus, may have other federal guidance that must be followed.

The *Field Sampling Guidance* is not designed to be a stand-alone manual. In addition to the information herein, the *Field Sampling Guidance* provides web links to a number of relevant internal and external resources, thereby creating a comprehensive system of tools to guide the environmental professional.

Additional CSP guidance documents integral to work plan development and sampling design and procedures are located at http://dec.alaska.gov/spar/csp/guidance_forms/csguidance.htm and include the following:

- *Conceptual Site Model Policy Guidance* (2010)
- *Underground Storage Tank Procedures Manual* (2014)
- *Biogenic Interference and Silica Gel Cleanup Technical Memorandum* (2006)
- *Cumulative Risk Guidance* (2008)
- *Total Organic Carbon Technical Memorandum* (2008)
- *Arsenic Technical Memorandum* (2009)
- *Interstate Technology and Regulatory Council (ITRC) Incremental Sampling Methodology (2012) Vapor Intrusion Guidance* (2013)
- *Ecoscoping Guidance* (2014)
- *Monitoring Well Guidance* (2013)
- *Risk Assessment Procedures Manual* (2015)
- *Site Characterization Work Plan and Reporting Guidance for Investigation of Contaminated Sites* (2009)
- *Technical Memorandum, Environmental Laboratory Data and Quality Assurance Requirements* (2009)

Other applicable sources of technical regulatory guidance include:

- ITRC: <http://www.itrcweb.org/>
- Environmental Protection Agency (EPA): http://www.epa.gov/quality/qa_docs.html#g-4/
- ASTM International: <http://www.astm.org/>

Suggestions on how CSP can improve the *Field Sampling Guidance* may be sent to Todd Blessing at Todd.Blessing@alaska.gov.

The use of trade names is for descriptive purposes only and does not constitute endorsement of these products by the State of Alaska, the Alaska Department of Environmental Conservation (ADEC), or the Division of Spill Prevention and Response.

1.1 Qualifications for Environmental Sampling

CSP has established a set of qualification standards for environmental samplers to ensure sampling, interpretation, and reporting is performed or supervised by experienced and knowledgeable persons. Both 18 AAC 75 and 18 AAC 78 state regulations require "qualified environmental professional" status for those who have direct responsibility in investigation and cleanup at a contaminated site, including leaks from a regulated underground storage tanks. A qualified environmental professional is defined in 18 AAC 78 and 18 AAC 75:

A qualified environmental professional means a person who is an impartial third party and who is qualified to perform site characterization and cleanup activities including fate and transport analysis, remediation design and other activities associated with contaminated sites; actively practices in the field of environmental science or another related scientific field including engineering, geology, physical science, hydrology, biology, chemistry, or a related field; has not been found to have falsified environmental data or committed other acts of fraud directly related to environmental work; and meets one or more of the following minimum educational qualifications and experience requirements:

- A. has an undergraduate or graduate degree from a nationally or internationally accredited postsecondary institution in environmental science or engineering, geology, hydrology, physical science, biology, chemistry, or a related field and at least one year of professional experience in contaminated site characterization and cleanup activities under the direct supervision of a qualified environmental professional completed after the degree described in this paragraph was obtained;
- B. has a four year degree in any field or a two year associates degree in environmental science, geology, hydrology, physical science, biology, chemistry, or a related field from a nationally or internationally accredited postsecondary institution, and at least three years of professional experience in contaminated site characterization and cleanup activities under the direct supervision of a qualified environmental professional;
- C. is certified as an environmental technician under an apprenticeship program that conforms to the requirements of the U.S. Department of Labor, Employment and

Training Administration, 29 CFR Part 29, Labor Standards for the Registration of Apprenticeship Programs, Amendment of Regulations, Final Rule, October 29, 2008, and has at least three additional years of professional experience in contaminated site characterization and cleanup activities under the direct supervision of a qualified environmental professional.

A qualified environmental professional must prepare site assessment, release investigation, and corrective action work plans and reports required under 18 AAC 78 and site characterization and cleanup work plans and reports required under 18 AAC 75.

In some cases, a “qualified sampler” may conduct the field sampling in accordance with 18 AAC 75 and 18 AAC 78. A qualified sampler is defined in 18 AAC 75 and 18 AAC 78 and refers to an impartial third party with experience and/or a degree that has the following minimum training:

- A. applied field work involving environmental sample collection of soil, groundwater or surface water associated with coursework for a completed degree in environmental science, engineering, geology, hydrology, physical science, or a related field, at a nationally or internationally accredited postsecondary institution; or
- B. an environmental sampling training program recognized by the department; and
- C. at least three months of experience in environmental sampling under the direct supervision of a qualified environmental professional.

2.0 Sampling Work Plan

It is important to have a defined sampling strategy in the work plan prior to conducting field work. Before field work begins, identify the sampling objectives and intended data use to support the pertinent site-specific decisions. Site-specific information must be gathered to ensure that the sampling design is logical and that it meets the required objectives that are stated in the work plan. The person(s) designing the work plan must be familiar with the site-specific conditions and be familiar with the necessary elements of a work plan. Those implementing the work plan must adhere to it unless the field deviation is approved by CSP on a site-specific basis and documented in the field notes and the report.

The 2002 EPA document *Guidance on Choosing a Sampling Design for Environmental Data Collection* at <http://www2.epa.gov/sites/production/files/2015-06/documents/g5s-final.pdf> provides detailed information on the number of basic and innovative sampling designs that may be applied to a particular site or support the data use objectives. Different approaches may be applicable to sites with multiple source areas or to account for contaminant type, fate and transport considerations, or other factors.

The work plan must describe sampling procedures in detail so the project objectives can be met and the work plan adequately evaluated by CSP. The work plan must discuss the methods and procedures proposed, and the number of samples collected per location, taking into account level of effort, potential logistical limitations, weather conditions, and other issues that may affect sample integrity. The sampling strategy may have flexibility to be adjusted based on conditions in the field. Deviations from the Field Sampling Guidance may be approved by CSP on a site-specific basis but must be clearly identified and described in the work plan and report. CSP will review and approve the work plan based on 18 AAC 75 and 18 AAC 78 regulatory criteria, the intended data use, and site decisions that are expected as a result of the investigation. EPA guidance documents will also be used for work under CERCLA, the Resource Conservation and Recovery Act (RCRA), or the Toxic Substances Control Act (TSCA).

Work Plan Requirements: CSP will not accept work plans that reference this guidance in lieu of providing detailed sampling and analysis procedures.

Refer to CSP's *Site Characterization Work Plan and Reporting Guidance* at http://dec.alaska.gov/spar/csp/guidance_forms/csguidance.htm and the specific requirements outlined in Alaska Administrative Code, Chapter 75, Section 335 (18 AAC 75.335) for further guidance on general and required work plan elements. These may vary on a site-specific basis. Work plan approval is required prior to conducting any sampling.

The environmental professional should notify the CSP project manager prior to mobilizing for field activities and obtain approval prior to implementing any field modifications. Site-specific field modifications not approved by CSP on a site-specific basis and may result in the rejection of site data, use of the site data as estimated, and/or a requirement that additional supplemental data be collected. Document all work plan modifications and decision rationale in the field notebook and the final report. While in the field, environmental samplers are required to retain a reference copy of the approved work plan and should have a copy of a CSP approval letter.

3.0 Soil Sampling

Under Alaska regulation 18 AAC 75.990(127) surface soil is defined as soil that extends to two feet below the ground surface. Subsurface soil is defined at 18 AAC 75.990(123) as soil that is more than two feet below the surface.

Deviations from this section may be approved by CSP on a site-specific basis but must be clearly identified and discussed in the work plan and report.

3.1 General Guidelines

The soil sampling methodology must be clearly described in the work plan and, support data quality objectives use and intended site decisions. Unless approved by the CSP project manager on a site-specific basis, all laboratory soil samples must be discrete samples and may not be composited before analysis, except when approved as part of an incremental sampling plan, or when required by federal regulations, e.g. TSCA for Polychlorinated Biphenyls (PCBs) or RCRA waste disposal characterization. A collection of federal guidance documents and fact

sheets is provided for convenience here:

http://dec.alaska.gov/spar/csp/guidance_forms/csguidance.htm, however environmental professionals are encouraged to check with the appropriate EPA office for the most recent federal guidance on compliance with applicable federal regulations.

Judgmental sampling involving the collection of discrete analytical samples based on field screening results is the most common sampling approach used at contaminated sites in Alaska. Therefore, field sampling guidelines and procedures relevant to judgmental sampling are emphasized in this guidance.

Alternatives to discrete sampling, such as incremental sampling methodology (ISM), may be approved by CSP on a site-specific basis. Alternative sampling approaches can also be designed to perform a statistical analysis of the results. CSP recommends the use of a systematic random sampling design when statistical analysis of results is proposed for cleanup complete decisions. A general guideline for a systematic random sampling design is to collect a minimum of 20-30 samples from each source area in order to adequately perform statistical analysis, such as a derivation of a 95% upper confidence limit (UCL). The collection of incremental samples shall be collected in accordance with the 2012 Interstate Technology & Regulatory Council (ITRC) *Incremental Sampling Methodology Guidance*.

For a regulated underground storage tank system site assessment, the sampling must meet or exceed the minimum requirements in 18 AAC 78.090.

Soil samples should be collected and analyzed for all applicable contaminants of potential concern using the method specifications listed in Appendix D or in accordance with a CSP site-specific approved work plan.

Seasonal groundwater fluctuations must be assessed and included in the conceptual site model used to develop the work plan. If soil contamination has the potential to extend to seasonal high groundwater, in accordance with a site specific CSP approved work plan, install short-term or long-term monitoring wells to assess potential groundwater contamination (see groundwater section). For light non-aqueous phase liquid (LNAPL) contaminants collect soil samples above, within, and below the zone of seasonal fluctuation. For dense non-aqueous phase liquid (DNAPL) or other contaminants, additional sampling of other intervals may be required.

The creation of a preferential pathway during site work may impact groundwater. As necessary, implement precautionary measures to assure the groundwater will be protected (i.e. grouting boreholes and compacting soil). If groundwater is encountered, grout soil borings in accordance with CSP's *Monitoring Well Guidance*.

Soil sampling waste must be managed in a manner that does not contribute to further environmental degradation or pose a threat to public health or safety. On-site disposal may be approved by CSP if:

- soils are deemed to be non-hazardous waste under the RCRA hazardous waste definition,
- there is no potential for off-site contaminant migration, and

- the potential to create a human health or ecological hazard through all exposure pathways is not suspected.

3.2 Field Screening

Field screening supports and is used in conjunction with a judgmental sampling approach. Field screening is useful to determine where to collect samples for laboratory analysis, segregate excavated soils, identify release points, and estimate the extent of contamination. A field screening method must be chosen that can differentiate degrees of contamination at the site.

The proposed field screening method(s) and frequency must be stated in the work plan and support the data use objectives. If instruments or other field observations indicate contamination, soil that is excavated must be separated into stockpiles based on apparent degrees of contamination.

If applicable, include minimum field screening device detection/quantitation levels and possible interferences in the work plan.

The CSP recommends that a correlation study between on-site field screening and site-specific analytical laboratory results be evaluated and reported where variable field screening results are common or expected such as aged fuel releases or compounds with very low cleanup levels. A discussion of how the correlation study will be applied and used at the site should be included for approval in the proposed work plan.

It is important to remember that the tables below are provided as a general guide to some of the available field screening methods and for each field screening method cited in Table 1 and in Appendices B and C, there may be other sources of field screening equipment, methods, or test kits available. For example, there are numerous companies that manufacture and sell petroleum hydrocarbon immunoassay test kits. Each manufacturer currently uses similar methods but different techniques to detect and measure petroleum hydrocarbons. These differences may be important to you when selecting a field screening technology for your site. A discussion of field screening method detection limits and accuracy, including the expected quantification tolerances for any proposed detection levels that will be used for decision making, should be included for approval in the proposed work plan.

Additional guidance on the methods available may be found in Solid Waste (SW) 846 or through ASTM.

Note: The guidelines in Section 3.2 are appropriate for most petroleum contaminated sites, but may not be appropriate for non-petroleum contaminated sites. Field screening at sites contaminated with metals, PCB, solvents, or other contaminants may be subject to additional requirements and should be proposed following appropriate guidance for those contaminants. Prior to developing a sampling plan for non-petroleum contaminated sites environmental professionals should consult the appropriate guidance and consult with CSP to determine an appropriate sampling approach.

Table 1. Field Screening Methods Guide ^{1,2}

Type	Use	Contaminants of Concern
Direct Reading Devices (photoionization detector (PID) , flame ionization detector (FID)	Soil	VOCs, GRO, DRO
Qualitative Physical Screening Methods (warm water sheen test, shovel sheen test)	Soil/sediment	Hydrocarbons
Field test kits (Hach®,etc)	Soil /Water	Metals, PCB, TPH, Organics
Ultra Violet Fluorescence (siteLAB®, etc.)	Soil/Water/ Sediment	PAH, DRO, GRO, TPH, PCB
Hanby® Diesel Dog®	Soil/Water	Hydrocarbons, Aromatics
Dexsil®-Petroflag®	Soil	Hydrocarbons
Immunoassay (EnSys, EnviroGard™, RaPID Assay, etc.)	Soil/water	PCB, PAH, BTEX, TPH, Pesticides, Pentachlorophenol (PCP)
Colorimetric Wet/Gas Chemistry	Soil/Water/ Air	Target specific including petroleum hydrocarbons
UV/ROST technology	Soil	TPH, PAH
X-Ray Fluorescence	Soil/Sediment	Metals
Field gas chromatography	Soil/Water	Hydrocarbons, VOCs, SVOCs
Infrared Spectrophotometry Field Analyzer (Wilks)	Soil/Water	TPH
<p>¹ The CSP does not endorse or recommend any specific brand test kit for use. While Table 1 provides methods available at the time this document was written, it's important to note that new and/or improved methods may become available and should be considered in the work plan design phase of the project.</p> <p>² Some field screening procedures have an associated EPA approved method.</p>		

3.2.1 Primary Petroleum Hydrocarbon Field Screening Methods

3.2.1.1 PID and FID

Two commonly used field instruments for detecting volatile organic vapors at petroleum sites are photoionization detectors (PIDs) and flame ionization detectors (FIDs). Because PIDs and FIDs are limited to compounds that readily volatilize, they must not be used as the sole method of field screening for weathered fuels, used oil, or other compounds with low or no volatile components.

Heated headspace organic vapor monitoring involves the measurement of volatile organics emitted from soil samples in a sealed container. The container is typically warmed and then

tested for volatile organic vapors using photo- or flame-ionization techniques. The results generated by this method are qualitative to semi-quantitative and are limited to compounds that readily volatilize.

Conduct headspace analysis in glass jars or re-sealable polyethylene bags. If using re-sealable polyethylene bags, a blank sample must be tested prior to field screening to account for potential interferences caused by the bags themselves. In addition, the presence of moisture may interfere with instrument readings. Results must be presented in the report and documented in the field notes.

The following heated headspace field screening procedure must be used:

- Calibrate PID and FID field instruments according to the manufacturer's specifications and requirements and document in the field notes.
- Partially fill (one-third to one-half) a glass jar or re-sealable polyethylene bag with the sample to be analyzed. Total capacity of the jar or bag may not be less than eight ounces (approximately 250 mL), but the container must not be so large as to allow vapor diffusion and stratification effects to significantly affect the sample.
- If the sample is collected from a split spoon, after collecting analytical sample, transfer it to the jar or re-sealable polyethylene bag for headspace analysis immediately after opening the split spoon.
- Collect the sample from freshly uncovered soil if it's collected from an excavation or soil stockpile.
- If a jar is used, quickly cover the top with clean aluminum foil or a jar lid. Use screw tops, strong rubber bands, or other methods that will tightly seal the jar. If a re-sealable polyethylene bag is used it must be quickly sealed shut.
- From the time of collection, allow headspace vapors to develop in the container for at least 10 minutes but no longer than one hour.
- Shake or agitate containers for 15 seconds at the beginning and end of the headspace development period to assist volatilization. Temperatures of the headspace must be warmed to at least 40°F (approximately 5°C).
- After headspace development, insert the instrument sampling probe to a point about one-half the headspace depth. The container opening must be minimized and care must be taken to avoid uptake of water droplets and soil particulates.
- After probe insertion, record the highest meter reading. This normally will occur between two and five seconds after probe insertion.
- Complete headspace field screening within one hour from the time of sample collection.
- Document all field screening results in the field record or log book.
- Do NOT reuse soil from the head space sample in subsequent laboratory samples or analyses; separate samples from undisturbed, freshly exposed soil are to be collected and used for laboratory analyses.

3.2.1.2 Immunoassay

Immunoassay field screening involves the detection and the measurement of petroleum hydrocarbons using specific binding characteristics of antibodies and antigens. The antibodies

form antibody/antigen compounds with molecules of specific organic compounds present in the petroleum hydrocarbon mixtures such as gasoline, diesel fuel, and motor oils. Most immunoassay test kits use an enzyme-linked immunosorbent assay (ELISA) process. In this process, the samples being tested are combined with a labeled enzyme that then competes for binding antibody sites. The process requires incubation prior to separation of bound and unbound antibodies. The bound antibodies are then quantified using secondary processes.

The immunoassay methods generate quantitative and semi-quantitative results. Most of these methods have been designed to measure the presence and concentration of a variety of petroleum hydrocarbon mixtures. Concentration determinations are based upon a relative response to specific types of organic compounds or molecular structures present in all hydrocarbon mixtures. Therefore, it is possible to monitor for gasoline, diesel, and other hydrocarbon mixtures using immunoassay methods.

Immunoassay methods require methanol extraction of a known mass of soil containing petroleum hydrocarbons. The methanol extract is then introduced to the antibody/antigen reaction to focus the testing process on the appropriate target compounds. Once the antibody/antigen reaction has been terminated, colorimetric or turbidimetric processes are used to quantify the petroleum hydrocarbon mixture present in the soil.

3.2.1.3 Infrared Spectrophotometry

Infrared spectrophotometry (IRS) is typically used to measure the carbon-hydrogen bonds (C-H bonds) present in all petroleum hydrocarbon mixtures. IRS field screening techniques recommend the addition of silica gel to a known mass of petroleum hydrocarbon impacted soil prior to extraction using a suitable solvent. The soil extract is then analyzed directly following calibration of the infrared spectrophotometer adjusted to the appropriate wavelength to measure the C-H bond emissions. The quantitative results are prepared using the extraction solvent and appropriate petroleum hydrocarbon target analyte. The concentrations are determined based on project-specific data quality objectives and require an understanding of basic chemistry for proper preparation.

3.2.1.4 Colorimetric Wet Chemistry

Colorimetric test methods employ visible monitoring techniques to identify and quantify the presence of petroleum hydrocarbons. The methods require visual observation and quantification using visual comparison or spectrophotometric equipment. These methods usually employ organic wet chemistry techniques for determination of petroleum hydrocarbons on a qualitative, semi-quantitative, or quantitative basis.

Colorimetric wet chemistry methods require mixing soil containing petroleum hydrocarbons with coloring reagents. The presence of petroleum hydrocarbon mixtures are then determined through visible wavelength spectrophotometry or by visual observance of color in the reaction vessel.

3.2.1.5 Qualitative Physical Screening Methods

Physical screening methods, such as visual and olfactory screening, are qualitative and can provide only basic information related to the presence or absence of petroleum hydrocarbons. However, these must be reported and documented in the field notes if observed. Physical screening methods require little or no preparation prior to a direct visual observation to evaluate the presence of petroleum hydrocarbons.

3.2.1.6 Selection Criteria

Petroleum hydrocarbon field screening methods use different technologies to measure or respond to the presence of petroleum hydrocarbons. These methods can react differently under similar conditions. To select a field screening method that will provide the user with the desired results, several criteria must be considered and evaluated during the selection process. These criteria include:

- Determination of the target analytes (volatile, semi-volatile, or relatively non-volatile petroleum hydrocarbons);
- Estimation of the target analyte concentration ranges (generally comparable to applicable cleanup standards);
- Determination of the data quality objectives, such as the need for quantitative, semi-quantitative or qualitative data;
- Required expertise to perform the screening analysis; and
- An understanding of the capabilities and limitations of the screening methods. These criteria are discussed in greater detail in the following sections.

3.2.1.7 Target Analytes

Each field screening method has been designed to respond to various petroleum hydrocarbon mixtures or classes of organic compounds. Some screening methods are capable of testing only for volatile organics, while others are capable of measuring higher molecular weight petroleum hydrocarbons. To select an appropriate field screening method, the user should first try to identify the petroleum hydrocarbon mixture in the soil being tested. This is typically established using fixed laboratory analyses and/or prior knowledge of the source of contamination.

3.2.1.8 Multiple Petroleum Hydrocarbon Mixtures

The presence of multiple petroleum hydrocarbon mixtures complicates the use of field screening methods. The field screening methods are based on the detection of a variety of hydrocarbon mixtures or a combination of the petroleum fractions - Gasoline Range Organics (GRO), Diesel Range Organics (DRO), and Residual Range Organics (RRO). Without knowing which petroleum hydrocarbon mixture(s) are present, a range of field screening methods may need to be used to adequately estimate concentrations.

Field screening methods have limitations concerning the applicable ranges of concentrations they can detect. The concentration ranges are different for each field screening method. The screening method user must identify project-specific data quality objectives and identify the field

screening method that can meet those objectives. Field screening methods alone are not capable of generating results that correspond directly to the analytical methods required for GRO, DRO and RRO (AK 101, 102 and 103). Instead, the field screening methods are capable of detecting multiple ranges or varying portions of these hydrocarbon mixtures. The user should be familiar with information provided by various equipment and test kit manufacturers to ensure the selected screening method will evaluate the desired petroleum hydrocarbon ranges or mixtures.

3.2.2 Training and Expertise

Operation of the various field screening methods requires different levels of personnel training and expertise. Some of the simpler field screening methods can easily be completed after reviewing general procedures and becoming familiar with the operation of instrumentation and equipment. Other field screening methods require various levels of training and/or support from experienced personnel, test kit manufacturers, or trained chemists. It is important that the operator responsible for the direct reading of instrumentation, test kits, and field-adapted laboratory equipment fully understand the principles used to measure and quantify target analytes. This knowledge allows the operator to maximize the reliability and usability of the data being generated.

3.2.3 Capabilities and Limitations

It is important to know the specific capabilities and limitations of the various methods when selecting an appropriate field screening method. It is also important to consult with the equipment/method manufacturers to further investigate the capabilities and limitations for application to particular projects. Various factors affecting the applicability of each field screening method are listed below, along with an example of the limitation.

Moisture in soil may interfere with the operation of direct reading instruments, which may result in erroneous data.

Natural organic matter in the soil may bias screening results due to the contribution of organic compounds similar to those present in refined petroleum hydrocarbons of concern.

Soil types may interfere with testing procedures and results. Examples are: moist, dense, plastic clay that is not easily broken apart may limit the generation of headspace hydrocarbon vapors for monitoring using a direct reading instrument; organic peat lithologies can introduce significant quantities of natural organics causing high bias in immunoassay screening results; gravel and rock lithologies may decrease the accuracy of all screening methods due to limited sample surface areas, increased sample mass, and the limited sample size required by most screening methods.

Low temperature and high altitudes may limit or preclude the operation of some direct reading instrument.

Temperature fluctuations may alter the response from field screening instrumentation and equipment requiring frequent calibration.

Electrical power source stability is required for operation of some field screening method equipment. Continuous power with limited voltage and current fluctuations is typically required when using electrical equipment requiring an alternating current (AC) power supply.

3.2.3.1 Other Technology Selection Criteria

Logistical concerns require attention when shipping United States Department of Transportation (USDOT) hazardous substances such as methanol, hexane, isobutylene, or other chemicals or compressed gases to project sites. Some immunoassay methods require low temperature preservation during shipment and storage prior to use.

Timeframe for testing must be considered. Some of the field screening methods will allow the user to test hundreds of samples per day, while others will be limited to fewer than 40.

Cost will play an important role. The number of samples to be tested and the usability of the data will have a direct bearing on cost feasibility. It is suggested that the user perform a cost-benefit analysis prior to selecting field screening methods.

3.2.4 Selecting Appropriate Petroleum Hydrocarbon Field Screening Methods

Appendix B provides general information for each field screening method category described in this guide. It should be used as a preliminary or initial guide to select the field screening technologies or categories that meet your site-specific target analytes, data quality objectives, and approximate concentration ranges you wish to evaluate.

Once the selection criteria in Appendix B are understood, Appendix C can be used to identify the field screening method category or categories most appropriate for your site. Appendix C further elaborates on the technical and logistical criteria important to selecting a field screening method. Factors affecting accuracy and precision are noted for each category. A relative comparison of the training and desirable expertise for the field operator is noted. General causes of interference and the associated effects on the screening results are described for each category. Finally, other logistical considerations such as, waste byproducts, transportation, storage, and shelf life are briefly compared.

The task of selecting “the best fit” field screening method can be difficult and is dependent upon site-specific technical data.

3.3 Characterizing Excavated Petroleum Contaminated Soil

To assist in characterizing excavated soil, use Table 2A to determine the minimum number of screening and laboratory analytical samples to collect from any excavated soils (including overburden soils and soils placed into stockpiles, drums, and other containers) at contaminated sites. Excavated overburden soils must be sampled as any other excavated soil unless it has been demonstrated to CSP’s satisfaction that the overburden soils meet CSP site cleanup levels. Table 2A was originally developed for petroleum contaminated sites; however, it may also be appropriate for sites with other types of contaminants if there is a known release source.

For non-petroleum contaminants, or sites without a known source, CSP may require a different frequency of screening and analytical samples depending on data use, contaminant type, site management decisions, remediation goals, and other site-specific factors to determine the proper management of the excavated soil. Sample collection procedures, including frequency must be

clearly outlined in a site-specific work plan for all contaminated sites, and must be submitted to the department for review and approval.

Table 2A. Excavated Soil Sample Collection Guide¹

By Volume (cubic yards)	Number of Screening Samples	Associated Number of Laboratory Samples
0-10	5	1
11-50	5	2
51-100	1 per 10 cy	3
More than 100	1 per 10 cy, or as the CSP determines necessary	3 samples, plus one (1) sample for each additional 200 cubic yards, or portion thereof or as the CSP determines necessary

¹The Table is appropriate for characterizing the levels of petroleum contamination in soil suitable for management onsite subject to 18 AAC 75.325(i) or for transport to a treatment or disposal facility. Consult with CSP for determining the appropriate numbers of field screening and laboratory soil samples for characterizing maximum petroleum concentrations in soil for on-site treatment.

Excavated soils that are clearly contaminated, known to be impacted only by petroleum, not in need of characterization, and will be taken directly to a CSP approved facility for the treatment of petroleum contaminated soils may be excluded from the field screening and laboratory sampling frequency in Table 2A. Pre-treatment laboratory sampling may be required by the treatment facility to establish that the contaminants are acceptable and suitable for treatment. There may be other sampling and analysis requirements for landfarming or other types of contaminants and disposal facilities (RCRA, TSCA, or Class III landfills).

Class I landfills are typically permitted to accept soil that is contaminated below a certain level. If you anticipate disposing of contaminated soil at a Class I landfill, you should contact that landfill during work plan development to insure the facility-specific sampling requirements are met.

3.4 Field Screening Excavations at Petroleum Contaminated Sites

Surface and sub-surface field screening samples must be collected directly from an excavation area, the center of the excavation equipment bucket, or by using direct push or split spoon methods. Field screening samples must be collected in a manner that minimizes the loss of volatile organic compounds (VOCs).

Use Table 2B to determine the minimum number of screening and laboratory analytical samples to collect from a petroleum contaminated excavation. The analytical samples must be selected from the highest screening sample result.

For non-petroleum contaminants, CSP may require a different frequency of screening and analytical samples depending on data use, contaminant type, site management decisions, remediation goals, and other site-specific factors. Sample frequency and collection procedures for all contaminated sites must be proposed in the site-specific work plan submitted to the CSP

for review and approval. In order to receive a cleanup complete determination, sample results should demonstrate that the cleanup levels have been achieved on all sides and at the base of the excavation.

Table 2B. Surface/ Excavation Base and Excavation Sidewall Soil Sample Collection Guide¹

By Surface Area (square feet)	Number of Screening Samples	Associated Number of Laboratory Samples
0-50	5	1
51-124	5	2
125-250	1 per 25 sq ft	2
More than 250	10 plus 1 per additional 100 sq ft, or as the CSP determines necessary	2 samples, plus one sample for each additional 250 square feet, or portion thereof; or as the CSP determines necessary
Excavation sidewalls	For each excavation sidewall, 1 per 10 square feet (depth and length), or portion thereof, with field screening sample collection focused on soil horizon(s) demonstrated as most likely to be contaminated.**	Minimum 1 per each sidewall plus one additional sample for each sidewall areas over 250 total square feet (depth and length), or portion thereof at the highest field screening reading in all soil horizons; or as the CSP determines necessary. For example, a 12' x 30' sidewall [360 square feet total] would require 2 laboratory sidewall samples.**

¹This Table may not be appropriate for identifying the number of field screening or laboratory soil samples of a landspread, landfarm, or other soil treatment facility. For guidance on landfarming, please refer to CSP's Technical Memorandum *Landfarming at Sites in Alaska*

** Field screening samples and laboratory samples are to be collected within a soil horizon at the area most likely to be contaminated, such as on top of confining layers, at the base of more porous layers, at the groundwater interface, or along any other preferential pathways identified in the field. Sidewalls of 2 feet or less in depth must have field screening and laboratory samples collected in accordance with Table 2B.

For a regulated underground storage tank system site assessment, the field screening and sampling must meet or exceed the minimum requirements in 18 AAC 78.090. For example, at least one dispenser analytical soil sample and at least one piping analytical soil sample must be collected along the areas most likely to be impacted based on field observations and field screening results.

Conduct field screening and confirmation sampling at aboveground and underground storage tank locations for the tank area as follows:

- Below the tank, as per Table 2B.
- Adjacent to and below all fill and vent pipes.
- Excavation sidewalls, as per Table 2B.
- For an in-place assessment, no more than five (5) feet from the tank.
- Other areas of suspected contamination.

For the piping run (including vent piping) and dispensers conduct field screening and confirmation sampling as follows:

- Within two (2) feet below piping joints, elbows, connections, damaged piping components, and every ten (10) foot length of piping; if these locations are unknown then screening must occur within two (2) feet below original level of piping at a minimum frequency of one field screening sample for every ten (10) foot length of piping.
- Adjacent to and within two (2) feet below all dispensers.
- Other areas of suspected contamination.

The required laboratory analytical samples shall be collected regardless of absence of positive field screening results, or those field screening results below an arbitrary threshold.

3.5 Soil Laboratory Analytical Sample Collection

3.5.1 General Guidelines

Sample holding times must conform to the specifications in the required analytical method (see Appendix D). Special considerations should be given to sampling frozen soils, as the equipment and techniques described in the following sections may or may not apply. Please refer to Appendix F for a list of recommended sampling materials.

For regulated underground storage tank investigations, analytical samples must be collected in accordance with 18 AAC 78.090. For example, one analytical soil sample per dispenser area and one analytical soil sample along areas of piping most likely to be impacted.

3.5.2 Excavated Soil

Field screening samples and laboratory analytical samples must be collected from all excavated soils, including those soils suspected of being free of contamination.

Segregate all excavated soils into different stockpiles based on field screening results and site observations. If instruments or other field observations indicate contamination, soil must be separated into stockpiles based on apparent degrees of contamination. At a minimum, soil suspected of contamination must be segregated from soil suspected to be free of contamination.

For each stockpile, use Table 2A to determine the appropriate number of field screening and laboratory analytical samples.

Field screening and associated laboratory analytical samples must be collected at different depths and locations to adequately represent soil contaminant heterogeneity and be of sufficient quantity to ensure representativeness.

Field screening samples for volatiles must be collected at least 18 inches beneath the exposed surface of the stockpile unless additional field screening samples are needed to represent soil contaminant heterogeneity. Petroleum contamination can be persistent near the bottom of long-term stockpiles, so it is important that some field screening samples be collected near the base.

Excavated soils that are clearly contaminated with petroleum only and are slated to be taken directly to a CSP approved facility for treatment may be excluded from the field screening and laboratory sampling frequency in Table 2A. Pre-treatment laboratory sampling may be required to establish that the contaminants are acceptable and suitable for treatment at the selected facility. There may be other sampling and analysis requirements for other types of contaminated soil disposal, such as RCRA, TSCA or a Class III Landfill.

3.5.3 Excavations

For volatile samples, remove 2-6 inches of soil immediately before sample collection. Furthermore, if the excavation has been open for longer than one hour, remove 6-12 inches of soil immediately before collection. Do not collect samples from disturbed soil that has fallen into the bottom of the excavation pit.

For non-volatile samples (metals, PCBs, DRO, RRO and Polycyclic Aromatic Hydrocarbons (PAHs) it may not be necessary to expose fresh soil by removing any overburden, prior to collection.

If excavation depth precludes safely collecting samples from the bottom of the excavation, samples may be collected from the center of an excavation bucket by first removing 4-6 inches of soil immediately, prior to collection.

3.5.4 In-Situ Soils Characterization Sampling

The frequency and location of field screening and laboratory analytical samples must be proposed in the work plan submitted to CSP for approval.

Typically, two or more laboratory samples should be collected from each boring. Samples should be collected above, within, and below the zone of seasonal groundwater fluctuation commonly called “smear zone” if LNAPL are contaminants of concern. Sample intervals within each zone should be selected based on field screening of the soil cores. For DNAPL or other contaminants, additional sampling of other intervals may be required.

3.5.5 Above and Belowground Tank Sites

For a regulated underground storage tank system site assessment, the field screening and sampling must meet or exceed the minimum requirements in 18 AAC 78.090. For example, at least one dispenser analytical soil sample and at least one piping analytical soil sample along areas most likely to be impacted. Conduct field screening and confirmation sampling at aboveground and underground storage tank locations as follows:

Tank Area:

- Below the tank, as per Table 2B.
- Adjacent to and below all fill and vent pipes.
- Excavation sidewalls, as per Table 2B.

- For an in-place assessment, no more than 5 feet from the tank.
- Other areas of suspected contamination.

Piping Run (including vent piping) and Dispensers:

- Within two feet below piping joints, elbows, connections, damaged piping components, and every 10 foot length of piping; if these locations are unknown then screening must occur within 2 feet below original level of piping at a minimum frequency of one field screening sample for every 10 foot length of piping.
- Adjacent to and within 2 feet below all dispensers.
- Other areas of suspected contamination.

Absence of positive field screening results or those field screening results below an arbitrary threshold cannot be used as justification for not taking the required number of laboratory analytical samples.

3.5.6 Volatile Soil Sampling Procedure

Do not use a soil collection device for VOC sample collection that causes mixing or unnecessary disturbance of the soil in an effort to minimize volatilization. Do not use an air rotary rig for VOC sample collection or use a vacuum truck or air knife within four feet of where a VOC sample is to be collected.

Core type samples are preferred to reduce the loss of volatiles during sampling. Core samplers used for VOC sample collection must be constructed of non-reactive materials that will minimize loss of VOCs in the sample and should be of adequate size to obtain the minimum required soil mass. A large coring device or multiple core samples may be required to obtain the necessary soil mass, e.g. 25-50 grams. Certain soil types and/or site conditions are not amenable to core type devices and sampling procedures. In such cases, a spoon or scoop type sampling method may result in less soil disturbance, more immediate soil field preservation and therefore, less volatile loss.

While soil core samplers are the preferred method for collecting VOC soil samples, other sampling tools may also be acceptable with CSP approval on a site-specific basis. Therefore, detailed sampling procedures must be included in the site work plan submitted to the CSP for review and approval.

Collect and preserve AK101 and VOC soil samples immediately upon exposing the soils as follows:

- Collect a minimum of 25 grams of soil with minimum disturbance directly into tared 4-oz or larger jar with a Teflon®-lined septum fused to the lid. Interim storage/containers (e.g. re-sealable polyethylene bags) are not allowed.
- Immediately after collection, carefully add 25-mL aliquot of methanol (methanol must include a surrogate for method AK101) until the sample is submerged and then seal the lid on the jar. This step must be completed as quickly as possible, within approximately 10 seconds of placing the soil in the sample jar. If an extended time period between soil collection and preservation is necessary due to site conditions or safety concerns, this must be specified in CSP site-specific approved work plan, recorded in the field notes and documented in the final report.
- For low level VOC analysis, place a five gram soil sample into a 40 mL vial with 10 mL of deionized water. Quickly brush any soil off the vial threads and immediately seal the vial and freeze the sample to less than 0°C. The sample vial should be placed on its side while being frozen and transported to the laboratory. Consult with CSP regarding approval of low level preservation using sodium bisulfate.
- Do not place tape, including evidence tape, on the sample container directly.
- Cool and retain samples at less than 6°C except for frozen low level VOC samples.
- Collect a sample of the same material from the same location in an unpreserved jar for percent moisture determination.
- Collect appropriate field and laboratory quality control samples (see Table 3).
- Collect sample parameters in the following order:
 1. Volatile Organic Compounds (VOCs, AK101 GRO, BTEX),
 2. Semi-volatile organic compounds (SVOCs); including pesticides, herbicides, DRO, RRO, and PCBs,
 3. Total Organic Carbon (TOC), and
 4. Metals.
- Soils that are frozen in-situ (< -7°C) may not be required to be preserved immediately for VOC analysis as specified above. In these cases, the soil must be maintained frozen (< -7°C) in appropriate containers and sub-sampled and preserved as soon as practical. The soil must not be thawed prior to sub-sampling and preservation. Sub-sampling and preservation must follow the procedure specified above. The collection, maintenance of frozen soil at temperature, and sub-sampling/preservation procedures must be detailed in a site-specific work plan submitted to the CSP for review and approval.
- The EPA Contract Laboratory Program Sample Collection Guidelines for Volatile Organic Aromatics (VOAs) in Soil may also be required for VOCs at some sites. (Appendix B of EPA 540-R-09-03.)
- If volatile samples are not being collected, alternate sampling procedures may be approved on a site-specific basis.

Note: VOCs must be preserved in the field with methanol.

Alternative preservation methods (freezing or sodium bisulfate) for low level analysis of VOCs is acceptable only when performed in conjunction with methanol preserved samples unless otherwise approved by CSP on a site-specific basis.

3.5.7 Incremental Sampling Methodology

An incremental sampling approach must adhere to *ITRC's Incremental Sampling Methodology Guidance* at: <http://www.itrcweb.org/ism-1>.

3.5.8 Total Organic Carbon

Refer to CSP's *Guidelines for Total Organic Carbon (TOC) Sample Collection and Data Reduction for Method Three and Method Four* for requirements.

3.5.9 Sampling Requirements for Naturally Occurring Compounds

Naturally occurring inorganic compounds may be found in concentrations above the regulatory cleanup level in 18 AAC 75.341 Table B1. The presence of inorganic compounds may be considered naturally occurring if no known or suspected anthropogenic inorganic contaminant sources are present. See CSP's technical memorandum, *Arsenic in Soil* (March 2009), for additional information. Although the focus is on naturally occurring arsenic, the principles apply to all naturally occurring inorganic compounds.

CSP recommends the use of EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA 540-R-01-003, September 2002)*, for sampling and proposing site-specific background concentrations.

Naturally occurring organic material is present in many Alaskan soils. Biogenic interference is the term that is used to describe the naturally occurring organic material that is quantified and reported as DRO and/or RRO in accordance with the AK 102 and AK 103 methods. For more information see CSP's technical memorandum, *Biogenic Interference and Silica Gel Cleanup*.

3.5.10 Sampling Requirements for Environmental Molecular Diagnostics

Environmental Molecular Diagnostics (EMDs) is a term that describes a variety of advanced and emerging techniques to analyze biological and chemical features of environmental processes in soils, sediments, water, and air. These techniques focus on the analysis of stable chemical isotopes and biological molecules such as nucleic acids (e.g., DNA or RNA) or enzymes. Most environmental media (soil, sediments, groundwater, etc.) can be sampled for EMD analyses, and sampling typically requires the same equipment and collection containers as traditional soil or groundwater sampling. However, additional sampling requirements (e.g., maintenance of sterility or use of specialized passive samplers) may also need to be considered. For more information, see ITRC's Technology Overview, at: <http://www.itrcweb.org/GuidanceDocuments/EMD1.pdf>, as well as the ITRC technical guidance, *Environmental Molecular Diagnostics: New Tools for Better Decisions*, at: <http://www.itrcweb.org/emd-2/>.

3.6 Soil Sampling Equipment

3.6.1 Scoop/Trowel/Stainless Steel Spoon

A trowel, scoop (Figure 1), or stainless steel spoon may be used to collect soil samples. They can also be used for homogenizing soil or for collecting a variety of other waste samples. 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).

Samples can be put directly into sample containers or be processed through sieves to acquire the desired grain size. Stainless steel trowels and scoops can be purchased from scientific or environmental equipment supply houses.



Figure 1. Stainless Steel Scoop. (Photograph by D.Dibblee)

Procedures for Use:

- At specified intervals, take small, equal portions of sample from the surface and immediately below the surface.
- Transfer samples into laboratory cleaned sample bottles and follow procedures for preservation and transport.

Advantages:

- Easy to use and clean.

Disadvantages:

- Not preferred for volatile organic sample collection due to loss of volatiles.

3.6.2 Bucket Auger

The bucket auger (Figure 2) 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's 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 2. Bucket Augers.
(Photographs publish with permission by Art's Manufacturing and Supply)

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. Due to lost volatiles, the bucket auger should not be used when sampling for volatile organic compounds unless specifically approved in a CSP site-specific work plan. Bucket augers are acceptable for inorganic analysis.

Additional auger flights can be used to increase the depth obtainable by the unit. The bucket auger is used to bore just above the desired sampling depth. A coring device, smaller in diameter than the auger flight, is then used to obtain the sample from undisturbed soil at the base of the augered hole.

Procedures for Use:

- Remove unnecessary rocks, twigs, and other non-soil materials from selected sampling point.
- Attach the bucket and handle to an extension rod.
- Begin turning the auger with a clockwise motion and continue until the desired sampling depth is obtained.
- Transfer the sample into laboratory cleaned sample containers using a decontaminated stainless steel spoon or trowel.
- When collecting samples at depths greater than 12 inches, it's advisable to discard one-half inch of material in the top portion of the auger due to cave-in.
- Follow procedures for transport.

Advantages:

- Relatively speedy operation for subsurface samples.

Disadvantages:

- Don't use for volatile organic sample collection, unless approved by CSP in a site-specific work plan.

3.6.3 Soil Coring Device

The soil-coring device (Figure 3) 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.



Figure 3. Soil Coring Device (Photograph by J. Schoenleber)

Once the desired depth is reached, the slide hammer can be used to assist in pulling back the device. Caution should be used when back-hammering so as not to loosen soil captured within the barrel if a liner/retaining basket is not used. This device may be used in conjunction with a soil auger if core analysis of depth profiles need to be performed.

Once opened, collect a soil sample for volatile organic analysis using a soil core device or other appropriate sampler. Subsequently, field screen the remaining core with a PID or FID as needed.

Procedures for Use:

- Assemble the split barrel and screw on cutting shoe and end caps. Liner and basket retainers are optional.
- Place the sampler in position with the bit touching the ground.
- Drive with slide hammer until unit is completely advanced. Avoid sample compression.
- After reaching the required depth, use the slide hammer to back out device using caution so as not to lose sample.
- Remove both ends and tap barrel to break open split sections.
- Use a utility hook knife to open plastic liner.
- For volatile organic analysis, use a soil core device or other appropriate sampler to collect the sample prior to preservation.
- Record visual observations and field screening data in boring log.
- Follow procedures for transport.

Soil coring devices must be of stainless steel construction.

Advantages:

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

Disadvantages:

- Depth restrictions.
- Not useful in rocky or tightly packed soils.

3.6.4 Split Spoon Sampler

A split spoon sampler (Figure 4) is used to collect representative soil samples at depth. The sampler itself is carbon or stainless steel tubing 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 hammer dropped from a drill rig mast. The weight and throw of the hammer varies by drill rig.



Figure 4. Split Spoon Sampler (Photograph by D. Dibblee)

Procedures for Use:

- 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.
- 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.
- Record the length of the tube that penetrated the material being sampled, the weight of the hammer and distance dropped and the number of blows required to obtain this depth.
- Once soil core is acquired, if collecting samples for analyses of volatile compounds, collect and preserve samples in accordance with Appendix D. Conduct field screening readings with PID/FID of the exposed soil core. Field screening must be conducted in accordance with Section 3.2 of this document.
- Volatile samples must be collected within two minutes of core retrieval.
- Collect additional samples for non-volatile analyses as necessary.

When split tube sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D1586.

Advantages:

- Easily available.
- Strong.
- Ideal for split sample collection.

Disadvantages:

- Requires drilling or tripod for deeper samples.
- Requires split spoon decontamination after each sample.

3.6.5 Shelby Tube Sampler

A Shelby tube is used mainly for obtaining geological information but may be used in obtaining samples for chemical analysis. The Shelby tube consists of a thin walled tube with a tapered cutting head. This allows the sampler to penetrate the soil and aids in retaining the sample in the tube after the tube is advanced (without excessive force) to the desired depth.



Figure 5. Shelby Tube Sampler (photo taken from Diedrich Drill, Inc.)

Procedures for Use:

- Place the sampler in a perpendicular position on the material to be sampled.
- 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.
- Let sit for a few minutes to allow soils to expand in the tube.
- Before pulling out the tube, rotate the tube at least two revolutions to shear off the sample at the bottom. If the sample is to be shipped for further geologic analysis, the tube must be appropriately prepared for shipment. Generally, this is accomplished by sealing the ends of the tube with wax in order to preserve the moisture content. In such instances, the procedures and preparation for shipment must be in accordance with ASTM D1586.

Advantages:

- Inexpensive.
- Tube may be used to ship the sample without disturbing the sample.
- Provides core sample.
- Easily cleaned.

Disadvantages:

- Sometimes difficult to extract sample.
- Not durable when rocky soils are encountered.

3.6.6 Soil Core Samplers (VOCs)

While soil core samplers are the preferred method for collecting VOC samples, other sampling tools may also be acceptable, with CSP approval on a site-specific basis.

There are a number of soil core sampling devices available for VOC sample collection which are approved for EPA method 5035A. The En Core® sampler, or equivalent brand of soil core sampler, is acceptable to collect soil samples for VOC analysis as described in ASTM D6418-09. These devices are used to collect a specific soil sample mass for volatile organic analysis in a manner that minimizes loss of contaminants due to volatilization, biodegradation, or both. In performing the ASTM collection procedure, the integrity of the soil sample structure is maintained during sample collection, preservation, storage, and transfer in the laboratory for analysis. The sample is expelled directly from the coring body/storage chamber into the appropriate container for preservation without disrupting the integrity of the sample and as a result has limited exposure to the atmosphere during the collection, storage, and transfer process. Methanol field preservation is required for all volatiles soil analysis. Alternate low level volatile collection and analysis techniques per EPA SW846 Method 5035A must be approved by the CSP on a site-specific basis.

Below are examples of coring devices for collecting soil to be tested for volatile contaminants. Soil is extruded from sampler after collection and placed in a container and preserved with methanol.



Figure 6. Examples of Soil Coring Devices: Core N' One™ tool Soil Moisture Equipment Corp. 0200 Soil Core Sampler

Procedures for Use (En Core provided as an example only):

- Open foil package containing 5-gram En Core.
- Insert 5-gram Teflon® sampler into En Core.
- DO NOT pull plunger back prior to use.
- Set device aside on a clean surface.

T-handle:

- In a controlled setting, open coring device and expose core for field screening with direct reading instrument.
- Once the sample increment is identified, carefully prepare soil core surface for sub-core sampling by scraping away a small portion of soil with a stainless steel spatula.
- 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.
- Extrude core into sample jar with methanol preservative and **repeat as necessary to obtain the required sample mass.**

Advantages:

- Engineered to maintain integrity of soil sample without loss of volatile organics.

Disadvantages:

- Plunger is designed to open as it is pressed into the soil core. Depending on the cohesive nature of the material being sampled, obtaining a full sample in one movement may be difficult.
- Cores consisting of small rocks, shale, cobble, tight clays, peat/tundra or similar material cannot be effectively sampled. If soil matrix is not amenable, other sampling methods may be proposed in the work plan for CSP review and approval on a site-specific basis.
- Depending on the size of the core sampling device and the required sample mass, multiple cores may be required, resulting in additional sample handling and possible VOC loss.

3.6.7 Power Auger

The power auger is not a tool for sample collection, in and of itself. 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 equipment 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 coring device, smaller in diameter than the auger flight, is then used to obtain the sample from undisturbed soil at the base of the augered hole.

Advantages:

- Reduces sampling time.
- Inexpensive.

Disadvantages:

- 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).

3.6.8 Direct Push Technology

Use of Direct Push (DP) 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 an attractive system. While various manufacturers make and distribute their own equipment and accessories, the same general principles still apply when collecting soil samples.

Direct push systems use hollow steel rods to advance a probe or sampling tool. The rods are typically 3-5 feet long and have treaded ends. As the DP rods are pushed, hammered and/or vibrated into the ground, new sections are added to reach target depths. There are two types of rod systems, single rod and dual rod/cased systems. Both systems allow for the collection of soil, soil gas and groundwater samples. Single rod systems use only one string of rods to connect to the probe or sample tool and the rods are removed from the hole each time a sample is collected. Cased systems or dual rod systems advance an outer tube (casing) and a separate inner sampling rod (sometimes referred to as piston samplers) simultaneously. When sample depths are reached the inner sample rod and sample core are removed, and the outer drive casing remains in the ground and keeps the hole open. The inner rod can then be refitted with a new sample sleeve, then re-inserted to collect the next sample interval. For more information related to direct push technology, go to the following web site: <http://geoprobe.com/>

Procedures for Use:

- Hammer sampling barrel to desired sampling interval and remove.
- Open the sampling barrel, remove the plastic sleeve containing the core and cut open the sleeve.
- Conduct field screening readings with PID/FID of the exposed soil core. Field screening must be conducted in accordance with Section IIB of this document.
- If collecting samples for analyses of volatile compounds, use appropriate DP rod system and methods to reduce error as described below. Collect and preserve samples in accordance with Appendix D and below.
- Collect additional samples for non-volatile analyses as necessary.

Sample Collection by Direct Push:

The potential for loss of volatiles resulting in non-representative samples will depend on both the type of soil sampler and the type of DP rod system. A major concern is for non-sealed samplers that have an open bottom which may, when used with single-rod systems, allow them to collect soil that has sloughed from an upper section of the probe hole; therefore, they may collect samples that are not representative of the sampling zone. If the sloughed soil contains contaminants, an incorrect conclusion could be made regarding the presence of contaminants at the target interval. Alternatively, if the overlying soil is less contaminated than the soil in the targeted interval, erroneously low concentrations could be indicated. As a result, non-sealed samplers must not be used with single-rod DP systems where contaminated soils are present. In such cases, piston samplers (Macro Core) are the only appropriate soil samplers.

Care must be taken to keep drilling rates/rod removal rates slow enough that water has a chance to drain through weep holes in the sheath drive head. Ensure that water does not wash back through the core and preferentially remove fines from the sample.

Care must be taken to coordinate drilling and sampling rates so that core sections are not left waiting to be sampled while exposed to air. Use sleeve caps to seal ends of core section sleeves to reduce loss of volatiles while awaiting sample collection. Volatile samples must be collected within two minutes of core retrieval.

Ensure that core recoveries are appropriate. Sample core recovery may be lower in cores from greater depth. Loss of core and incomplete core sections showing slough and/or loss of fines are cause for recollecting the sample interval.

Advantages:

- Allows for continuous sampling.
- Profiling and collection of soils over large areas can be accomplished in less time. Efficient access to remote locations due to equipment size and mobility.
- Direct push techniques produce a minimal amount of investigation-derived waste material compared to most other drilling methods.

Disadvantages:

- Direct push sampling is limited to soils and unconsolidated materials that can be penetrated with available equipment.
- Decontamination of reusable equipment is required between boreholes.

General guidance on the construction of temporary wells installed via direct push technology can be referenced through ASTM D6001-96, *Direct Push Water Sampling for Geoenvironmental Investigations*, and via the following Internet links:

<http://www2.epa.gov/superfund>

<http://www2.epa.gov/ust>

<http://geoprobe.com/>

Additional Considerations:

When collecting soil samples for EMD analyses of the microbial community, sterility of sampling tools and containers needs to be maintained using aseptic techniques; if impractical, contamination from other locations or sampling tools must be minimized. Sampling equipment may need to be decontaminated with disinfectant prior to sampling a new location. Use of sample blanks can provide information on the presence of contaminating microorganisms introduced during sampling.

4.0 Groundwater Sampling

The importance of proper groundwater sampling cannot be overemphasized. Care must be taken to ensure that the sample is not altered or contaminated by the sampling equipment, sampling process, or the sample handling procedure. Sampling must be targeted at the interval(s) within the water column based on the physical characteristics of the contaminant. It is important to have representative samples collected from the same depth interval to evaluate trends between sampling events. Deviations from this section may be approved by CSP on a site-specific basis but must be clearly identified and discussed in the work plan and report.

4.1 General Guidelines

For monitoring well design, construction, development, maintenance, and decommissioning information, refer to CSP's *Monitoring Well Guidance*.

During monitoring well installation, the grout needs be allowed to set for a minimum of 24 hours before the surface pad and protective casing are installed unless approved by CSP on a site-specific basis. The surface pad must be allowed to cure for a minimum of 24 hours before the monitoring well is developed unless approved by CSP on a site-specific basis. CSP recognizes that remote site work may make these installation times impractical.

Except when compressed air is being used for well development, monitoring well sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, water quality parameters have stabilized (see below), or 24 hours have passed following development. In the case of using compressed air to develop a monitoring well, wait at least 7 days before sampling. If sampling is conducted prior to the prescribed waiting period, the data for that sampling event may be considered screening level only and subsequent sampling event(s) may be required. Well screen intervals and length of screens must be approved by CSP on a site-specific basis and need to be designed so that samples are representative of the overall groundwater contaminant plume.

The groundwater sampling methodology must be described in the work plan, must support the intended data use to make site decisions, and be approved by CSP. Groundwater samples needs to be collected and analyzed for all appropriate contaminants of concern using the method specifications listed in Appendix E and the approved work plan unless approved by CSP on a site-specific basis. Well screen intervals and length of screens must be approved and need to be designed so that samples are representative of the impacted area of groundwater.

In general, groundwater samples should be collected from wells screened through the smear zone and into the permanently saturated zone. However, site conditions (e.g., diving plumes, confined aquifers, etc.) and contaminant types may dictate that representative groundwater samples also be collected from other depth intervals. If further vertical delineation of contaminant concentration(s) is necessary, the interval(s) within the water column where samples are collected must be based on the physical characteristics of the contaminants and the site specific hydrogeology. This is a consideration at sites with chlorinated solvents or other DNAPLs and possibly other sites. The field notes and the report must document the depth that the groundwater samples were collected (e.g. pump intake depth) relative to the ground surface and the static water level in the well.

Groundwater sampling devices must compliment the intended data use and site decisions. Select groundwater purging and sampling equipment to minimize increases in sample temperature, water column agitation, and sample agitation. Materials comprising sampling devices and tubing must not adsorb, desorb, or leach contaminants of concern and must be resistant to chemical and biological degradation.

Due to the loss of volatiles with using these methods, peristaltic pumps (section 4.4.5 of Groundwater Sample Equipment), inertia pumps (section 4.4.4), and bailers (section 4.4.10) should not be used for the collection of volatiles or other air sensitive parameters unless approved by the CSP project manager in a site-specific work plan. Volatile or other air sensitive samples collected by these methods may be considered biased low.

Rather, the use of bladder pumps (section 4.4.1), positive pressure submersible pumps (section 4.4.2), gear pumps (section 4.4.3), passive diffusion bag samplers (section 4.4.6), or samplers like HydraSleeve (section 4.4.8) or Snap Samplers (section 4.4.9) should be used to reduce the loss of volatiles during sampling. For more information on HydraSleeve and Snap Samplers, see the *ITRC's March 2006 Technology Overview of Passive Sampler Technologies* (http://www.itrcweb.org/Documents/DSP_4.pdf).

The application of EMDs to groundwater may involve collecting groundwater for (off-site) laboratory analysis, or the use of sterile, in-line field filtration devices to facilitate the field collection of biomass. Field filtration increases the likelihood of collecting suspended particles and attached microorganisms, decreases shipping costs, and significantly reduces costly laboratory extraction procedures. Shipping filtration devices to the laboratory, in lieu of groundwater samples, may also require maintenance of the samples at 4°C during handling and transport.

The creation of a preferential pathway during site work may impact groundwater. As necessary, implement precautionary measures to assure the groundwater will be protected (i.e. grouting boreholes and compacting soil). If groundwater is encountered, grout soil borings and decommission well points/monitoring wells in accordance with CSP's *Monitoring Well Guidance*, see section IV, subsection A, of this document.

Monitoring well development and purge water:

All monitoring well development and purge water must be treated or disposed of using methods described in an approved CSP site-specific work plan.

Proper waste characterization is important to determine whether any RCRA hazardous waste is generated during well development, purging, or sampling, and if so, it must be treated or disposed of in accordance with RCRA and the approved CSP site-specific work plan.

If free product or sheen are present in development or purge water, it needs to be treated or disposed of off-site.

If contamination is not visible (i.e. no free product or heavy sheen), the monitoring well purge water may be filtered using a type of water filter system appropriate for the contaminants in the purge water. This filtered purge water may be reapplied to the ground surface within site boundaries and a minimum of 100 feet away from any drinking water wells and/or surface waters, with site-specific CSP approval.

4.2 Drinking Water

Reference the Drinking Water Program's web page at: <http://dec.alaska.gov/eh/dw/index.htm> for additional information on how to collect drinking water samples.

4.3 Groundwater Laboratory Analytical Sample Collection

Groundwater samples must be collected as close as possible (within the top foot of water column) at the time of sampling unless approved by CSP on a site-specific basis. The use of Teflon® sampling equipment (e.g. tubing) is the preferred approach. The use of HDPE equipment must be minimized to the extent practicable. Please refer to Appendix F for a list of recommended sampling materials.

Sample holding times must conform to the specifications in the required laboratory method (see Appendix E). In some cases, sterility may need to be maintained (e.g., practice aseptic technique) and dedicated, disposable sampling equipment may be required when collecting biological samples (e.g., microorganisms).

Prior to sampling, determine depth to groundwater to within 0.01 feet. Check the monitoring well for the presence of NAPL that might be floating on top of the water or in a separate layer at the bottom of the casing. If wells contain NAPL then alternate wells that are representative of the affected groundwater should be sampled, if available. Alternatively, water samples should be collected using methods that minimize the potential for NAPL inclusion in samples that will be analyzed to measure dissolved phase concentrations; the field notes and report must describe the fact that NAPL was present and the observed thickness of the NAPL.

Identify NAPL by an electronic device designed to detect non-aqueous liquids and to measure the thickness of the non-aqueous layer. Because of the lower density of the NAPL, bailers will measure a smaller NAPL thickness than is actually in the monitoring well, or measure no NAPL at all.

When samples are collected for laboratory analysis, any devices used to collect additional information, such as a flow-through cell, must be removed from the sample train before sampling.

During laboratory analytical sample collection, do not use a constricting device on the sample tubing to reduce the flow rate because the constrictor will cause a pressure difference in the water column and a loss of VOCs and dissolved gasses.

Water samples typically should not be filtered prior to analysis. If filtering is approved by CSP in a site-specific work plan, both filtered and non-filtered samples will need to be collected and analyzed so the effects (bias) of the filtering process on the contaminant concentrations can be evaluated.

Sample the wells least likely to be contaminated first. Collect water quality parameters and samples in the following order:

- In-field water quality measurements,
- Volatile Organic Compounds (VOCs, AK101 GRO, BTEX),
- Semi-volatile organic compounds (SVOCs); including pesticides, herbicides, DRO/RRO, PCBs,
- TOC, and
- Total metals; and Dissolved metals (filtered), refer to 18 AAC 75.380(c)(2).

4.4 Groundwater Sampling Equipment

4.4.1 Bladder Pump

An example of positive-displacement, the bladder pump (Figure 6) consists of a Teflon® or stainless steel housing that encloses a flexible Teflon® or HDPE membrane. Below the bladder, a screen may be attached to filter any material that may clog check valves located above and below the bladder. The pumping action begins with water entering the membrane through the lower check valve and, once filled, compressed gas is injected into the cavity between the housing and bladder. Utilizing positive-displacement, water is forced (squeezed) through the upper check valve and into the sample discharge line. The upper-check valve prevents back flow into the bladder. All movement of gas and sample is managed through a series of regulators housed in a control mechanism at the surface.

The source of gas for the bladder is either bottled (typically nitrogen, carbon dioxide, or ultra-zero air) or via an on-site oil-less air compressor. Flow rates can be reduced to levels much like the variable speed centrifugal submersible pump without fear of motor stall.



Figure 7. Example of a Teflon® constructed bladder pump, complete (top) and exploded version illustrating internal Teflon® bladder (Photograph by J. Schoenleber)

Field cleaning of bladder pumps is acceptable if the bladder pump housing is constructed of stainless steel or Teflon® with an internal disposable bladder.

Procedures for Use:

- Check all fittings for tightness.
- Lower decontaminated pump and dedicated tubing into the well below the smear zone.
- Connect compressor to power source ensuring the power source is downwind to prevent fumes from entering sampling area. If compressor is not used, connect to external air source.
- Engage air source (compressor or external) via control box. Full water flow will begin after five to fifteen pumping cycles. After stabilization of well water has been observed and recorded, sampling may begin.
- Adjust the refill and discharge cycles in accordance with manufacturer's instructions to optimize pumping efficiency. Reduce the flow rate, by adjusting the throttle control, to 100-150 milliliter (mL)/minute or less while sampling volatile and semi-volatile organics.
- Collect sample directly from discharge line into laboratory-cleaned sample bottles after well has stabilized and follow procedures for transport.

Advantages:

- Positive-displacement.
- Acceptable for well evacuation and sample collection for all parameters.
- Operational variables are easily controlled.
- Minimal disturbance of sample.
- In-line filtration possible.
- Available in a variety of diameters.
- No variances from the Technical Requirements for Site Remediation necessary.
- Sample depth up to 1,000 feet.

Disadvantages:

- Large gas volumes may be needed, especially for deep installations.
- Only pumps with disposable bladders may be field cleaned for portable use when

approved decontamination methods are employed.

- Sample flow rate of a typical bladder pump is not sufficient for purging some larger diameter wells.
- The check ball design of bladder pumps may make it an unacceptable method for sampling wells that contain excessive amounts of sediment (check balls may not seal properly if dirty).
- At high pumping rates, use of the bladder pump may cause disturbance of the water column.

4.4.2 Variable Speed Submersible Centrifugal Pump

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. Some examples include:

- Proactive Environmental Products®
- QED®
- Grundfos®

The variable speed feature is one of the key design items, which allows for application of low-flow purging and sample collection. When using variable speed submersible pumps to collect the equipment blank, one must follow the same general rules for all groundwater sampling equipment. This includes the requirement that all sampling equipment that comes in contact with the sample must also come into contact with the equipment blank water.



Figure 8. Proactive SS Monsoon® Pump. Example with disassembled pump (right)



Figure 9. Disassembled Grundfos® Pump being prepared for decontamination (Photograph by J. Schoenleber)

Procedures for Use (depending on pump manufacturer and/or model):

- Decontaminate pump, electrical leader and all associated fittings.
- For low-flow purging and sampling, attach precut tubing whose length has been predetermined based upon well-specific pump intake depth.
- For volume-average sampling, set the pump either within three feet of the top of water column, or, immediately above the well screen depending on chosen method.
- Install pump slowly through water column wiping down tubing with deionized saturated paper towel.
- If a portable gasoline generator is used, it should be placed downwind. Initiate purge based on procedure selected.
- After purging, collect sample as specified in CP approved site-specific work plan.

Advantages:

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

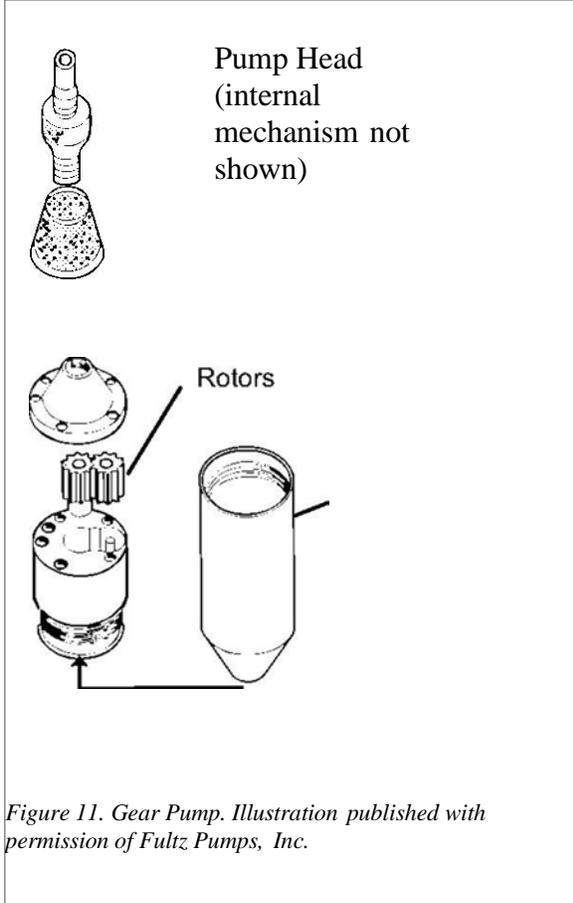
Disadvantages (depending on pump manufacturer and/or model):

- During low-flow purging and sampling, temperature increases may be observed.
- At extremely low-flow rates, motor stall is possible. To re-establish 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.
- Low yielding wells can also test the limits of variable speed design.
- Decontamination issues.

4.4.3 Gear Pump

Positive-displacement pumps, e.g. Fultz Pumps, Inc., also have the capacity for variable speed control (Figure 9). 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 10). Internal parts (gears) may not be readily accessible on-site, therefore careful attention must be made when cleaning. This must be considered when choosing to use this pump for a portable application. Pumps may be 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, pumps whose power supply and pump discharge lines are separate are also available. This pump may be best applied when used in a dedicated system.



Procedures for Use:

- Decontaminate pump, electrical leader and all associated fittings.
- For low-flow purging and sampling, attach precut tubing whose length has been predetermined based upon well-specific targeted zone of influence information. For volume average sampling, set the pump either within three feet of the top of water column, or, immediately above the well screen depending on chosen method.
- Install pump slowly through water column, wiping down tubing with DI saturated paper towel.
- Initiate purge based on procedure selected.
- At end of purge, collect sample as specified in approved CSP site-specific work plan.

Advantages:

- Positive-displacement.
- Light weight.
- Good variable speed control, especially at low rates.
- Acceptable for low-flow purging and sampling.

Disadvantages:

- For portable sampling, many are designed with power supply molded into tubing, which is difficult to decontaminate.
- Turbid purge water wears on fluorocarbon gears and may clog the pump.
- New rotors require wear-in time before the pump can be put back into service.
- Submersible motor lead connection exists with portable pump applications that may be susceptible to degradation and loss of power connection to pump.

4.4.4 Inertia Pump

An inertia pump (Figure 12) consists of a riser tube fitted with a one-way foot valve. It is typically operated by hand, but mechanical actuators can also be employed. Inertia pumps are



Figure 12. Inertia pumps offered by Solinst

best used with smaller-diameter wells (e.g., recommended for 2-inch or less). Inertia pumps must not be used for volatile analysis or dissolved gases due to the loss of volatiles in the intake line that draws the sample to the land surface. Any volatile organic groundwater data collected using inertia pumps must be considered biased low and generally will not be used for demonstrating the extent of the contamination, decreasing trends, or site

closure decisions.

Procedures for Use:

- Install the inertia pump in the well. The one-way valve will open and let water into the tubing. The water level within the tube will be the same as the water level (pressure head) in the well.
- Operate the inertia pump by pulling up the tubing with one upstroke. The upstroke action should be rapid enough to cause water to rise, but slow enough and methodical to avoid in-well disturbance. The weight of the water will keep the valve closed during the upstroke. Water will rise above the head level in the well by the length of the pump stroke. Water will momentarily continue to rise after the upstroke stops because of its momentum. On the down stroke, the valve will open to allow more water to be drawn into the tubing. The valve will close at the end of the down stroke. The momentum on the upstroke and the depth to which the tubing is submerged controls the rate at which water is drawn into the tubing.
- As this cycle is repeated, water will rise in pulses corresponding with each pumping stroke.

Advantages:

- Very simple to use and is (typically) hand-operated.
- May be used in small diameter wells.

- No pumps are involved (although electronic actuators may be used).
- No decontamination of pump necessary (however, all tubing must be changed between wells if dedicated tubing is not used).
- Can be used for sampling inorganic contaminants.
- Purge and sample with same tubing.
- Less potential for loss of volatile fraction from negative pressure gradient than for sampling methods using pumps that create a vacuum.

Disadvantages:

- Depth limitations are anticipated ≥ 25 feet.
- A large annular gap between the inertia pump tubing and the ID of the well casing may facilitate inefficient pumping.
- Unless using an in-line flow through cell for field readings, may not provide reliable or reproducible data for air sensitive parameters e.g. dissolved oxygen, pH, carbon dioxide or iron and its associated forms.
- Assistance from a second person may be required to hold in-line flow through cell when operating the inertia pump.
- Potential for VOC loss during pumping.

4.4.5 Peristaltic Pump

A peristaltic pump (Figure 13) is a self-priming suction lift (negative air pressure) pump utilized at the ground surface, consisting of a rotor with ball bearing rollers. One end of dedicated tubing is inserted into the well and the other end is attached to a short length of flexible tubing, which



Figure 13. Geopump™ Peristaltic Pump. Photograph reproduced with permission from Geotech Environmental Equipment, Inc.

has been threaded around the rotor, out of the pump, and connected to a discharge tube. The liquid moves totally within the tubing, thus no part of the pump contacts the liquid. Tubing used for well evacuation may also be used for sample collection. Teflon® or Teflon®-lined polyethylene tubing is recommended for sampling. Silicone tubing is recommended for tubing in contact with the rotors.

The grade of silicone tubing must be appropriate for its intended application. Based upon the required analysis and sampling objectives other materials are acceptable, but must first be approved by CSP in a site-specific work plan. Peristaltic pumps

must not be used for volatile analysis or dissolved gases due to the loss of volatiles from the creation of a vacuum in the intake line that draws the sample to the land surface. Any volatile organic groundwater data collected using peristaltic pumps must be considered biased low and generally will not be used for demonstrating the extent of the contamination, decreasing trends,

or site closure decisions.

During sampling, the peristaltic pump tubing must remain filled with water to avoid aeration of the sample.

Procedures for Use:

- Check tubing at rotor for cracks or leaks, replace if necessary.
- Thread flexible length of tubing through rotor/pump.
- Insert dedicated length of tubing in well and attach to flexible tubing at rotor.
- Tubing depth introduced into the water column must not exceed 12 inches.
- If necessary, add a small stainless steel weight to tubing to aid introduction of tubing into well casing (especially helpful in two-inch diameter wells).
- Attach evacuation line to outlet of flexible pump tubing such that the discharge is directed away from pump and well.
- Engage pump and commence evacuation. Pump speed must be maintained at a rate that will not cause significant drawdown (> 0.3 ft.). After well has been properly purged, begin sampling.
- Collect sample into laboratory cleaned sample bottles.

Advantages:

- May be used in small diameter wells.
- Sample does not contact the pump or other sampling equipment other than tubing prior to collection.
- Ease of operation.
- Speed of operation is variably controlled.
- No decontamination of pump necessary (however, all tubing must be changed between wells if dedicated tubing is not used).
- Can be used for sampling inorganic contaminants.
- Purge and sample with same pump and tubing.

Disadvantages:

- Depth limitation of ~25 feet.
- Potential for loss of volatile fraction due to negative pressure gradient.
- Unless using an in-line flow through cell flow-through-cell for field readings, may not provide reliable or reproducible data for air sensitive parameters e.g. dissolved oxygen, pH, carbon dioxide or iron and its associated forms.

4.4.6 Passive Diffusion Bag Samplers (PDBs)

When confronted with sampling a monitoring well that displays little or virtually no recharge capability during well evacuation (where historic data indicate drawdown exceeds three tenths of a foot while purging at flow rates that are equal to or below 100 milliliter per minute), the option

to use this no-purge sampling technique may be justified. More appropriately, there may be instances where long-term monitoring during the operation and maintenance phase of remediation justifies their use. Other reasons for using PDBs can also be approved by CSP on a site specific basis.

PDB samplers cannot be used for all contaminants. They are applicable to a select list of VOCs. For a list of applicable VOC compounds, refer to the following website:

<http://www.itrcweb.org/Guidance/ListDocuments?topicID=17&subTopicID=27>.

Metals and other organics will not diffuse through the membrane. Additionally, PDBs must not be used for semi-volatile contaminants and petroleum hydrocarbons (GRO, DRO, and RRO). Due to the limited number of contaminants PDB samplers are capable of detecting, these devices must not be used for initial investigations where a more complete understanding of the contaminants of concern remains to be determined. PDB samplers may be applicable to sites where adequate characterization has determined that applicable VOCs are the only groundwater contaminants of concern.

In addition, samplers must be cautious when using PDB samplers in wells where the vertical distribution of contaminants has not been determined. Multiple PDB samplers are recommended in wells when the well screen or saturated portion of the borehole is greater than 5 feet, following the general recommendation that a single PDB should not represent more than 5 feet of the water column. In an uncontaminated sentinel well, contaminants might enter the well in a stratified manner that could elude a single PDB. Therefore, the conservative approach for a sentinel well would be to deploy multiple bags as appropriate (ITRC 2004).

PDB samplers are made of low-density polyethylene plastic tubing (typically 4 mL), filled with laboratory grade (ASTM Type II) deionized water and sealed at both ends (Figure 13). The samplers are typically about 18 to 24 inches in length and can hold from 220 mL to 350 mL of water. Vendors can usually modify the length and diameter of a sampler to meet specific sampling requirements.

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

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

yielding formations additional time may be required for the well to re-stabilize.

If quarterly sampling is being conducted, it is acceptable to leave PDB samplers in the well for up to three months so that samplers can be retrieved and deployed for the next monitoring round during the same mobilization. Unfortunately, data are currently unavailable to support longer deployment periods (i.e., semi-annual or annual). Leaving samplers in a well for longer than three months is not allowed unless data is provided to CSP's satisfaction that longer deployment provides representative data. Additionally, PDBs are susceptible to damage by freezing and therefore, are not recommended if freezing conditions are anticipated to be present in the well. If future data become available which demonstrate longer deployment timeframes are appropriate, this condition will be modified.



Figure 14. Eon PDB Sampler with accessories (Photograph by J. Schoenleber)

Advantages:

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

Disadvantages:

- PDB samplers provide a time-weighted VOC concentration that is based on the equilibration time of the particular compounds; usually that period is two to three 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 are limited to specific VOC contaminants.
- PDB samplers work best when there is unrestricted horizontal movement of groundwater through the well-screen or open hole. If filter packs or screens are less permeable than the surrounding formation, groundwater 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 specific depth interval within the water column.
- Contamination migrating above or below the targeted depth interval will not be detected.
- Difficult to measure water quality parameters.
- In some cases, heavy iron or biofouling of the bag may inhibit sampler performance.
- PDBs may burst in freezing conditions.

4.4.7 Direct Push Technology

Use of direct push (DP) technology to obtain ground water samples via temporary well points has gained wide acceptance. While various manufacturers make and distribute their own ground water equipment and accessories, the same general principles still apply when collecting ground water samples. Direct push wells installed without proper filter packs and annular seals must not be used for long-term monitoring (e.g. more than one sampling event). However, they may be appropriate for collecting grab samples during site characterization, as long as the well is properly developed prior to sampling. It is important to note that the resulting data may be restricted in use. Direct push wells installed with proper filter packs and annular seals may be approved by CSP for long-term monitoring. As with any monitoring well, all DP monitoring wells and well points will need to be decommissioned in accordance with the CSP *Monitoring Well Guidance*.

Direct push technology can also be used for high resolution site characterization or used to collect hydrogeologic data. Several specialized tools have been designed to collect data that can be used in modeling groundwater aquifers for contaminant fate and transport studies used to develop site-specific remediation systems. Some useful tools and associated applications are listed below.

4.4.7.1 Plume Delineation

Light-induced fluorescence (LIF) and ultraviolet optical screening tool (UVOST) uses laser-induced fluorescence to measure NAPL petroleum contamination in-situ. A probe emits ultraviolet light through optical fibers in a direct push steel rod. Light causes polycyclic aromatic hydrocarbons associated with petroleum to excite and fluoresce, emitting different wavelengths depending on the type of fuel. The wavelength signal response is transmitted through a fiber line

on the probe and analyzed in real time at the surface in a fluorescence versus depth log. Fluorescence is quantified by percentage of relative emittance (%RE), which is compared to a known standard. By quantifying the %RE, the data can be compared to laboratory analytical correlation samples measured in parts per million (ppm). These tools are typically used for site characterization of source area soils. However, the data can be used to show concentration representations in three dimensions where transport of contaminants occurs with groundwater flow.

Membrane Interface Probes (MIPs) can be used in saturated and unsaturated zones for the detection and measurement of volatile organic compounds (VOCs) in the subsurface. The MIP is an interface between contaminants in the subsurface and detectors at the ground surface. A heated probe fitted with a permeable membrane is pushed to depth through the soil. Volatile organic compounds in the subsurface diffuse across the membrane and enter into a carrier gas stream. The VOCs are transported through the carrier gas stream to gas phase detectors at the ground surface for measurement. The MIP is also fitted with an electrical conductivity measurement tip to provide data to indicate probable lithology. A simultaneous log of soil conductivity and VOC results is produced.

The CSP will consider approval of LIF/UVOST and MIP on a site-specific basis. Laboratory analytical correlation samples are required.

4.4.7.2 Electrical Conductivity

Electrical conductivity probes (ECP) measure electrical conductance of unconsolidated soil formations and any contaminated fluids. High electrical conductivity is associated with the finer grain sizes (clays) while lower conductivity is generally indicative of coarser grained sediments such as sands.

4.4.7.3 Hydraulic Conductivity

Hydraulic conductivity probes (HPTs) – these tools may be used to help define subsurface lithology, assess formation permeability and hydro stratigraphy at high resolution (down to the centimeter scale). QA testing of the sensors is required to verify performance prior to field use and a QA log should be submitted with all data reports.

4.4.7.4 Cone Penetrometer Test

A Cone Penetration Test (CPT) is commonly used to determine the subsurface stratigraphy in-situ and to estimate geotechnical parameters of the materials present. Cone penetrometer tests are a quasi-static penetration test, meaning that the cone is pushed at a slow rate rather than driven with a hammer or rotary drilling. The CPT is designed to evaluate subsurface conditions based primarily on the resistance to penetration encountered by the cone tip. Resistance measurements are also recorded for the cone sleeve, or shaft. The use of CPT tools in combination with DP technology allows for continuous data at high resolution, repeatable penetration results, and cost savings over more traditional boring and sampling methods.

4.4.7.5 High-Resolution Piezocone

The High-Resolution Piezocone is a sensor probe that converts pore pressure to water level or hydraulic head. Piezocone penetrometer tests are highly effective for identifying sand, silt, and clay layers, as well as determining pore pressure. The Piezocone can simultaneously collect soil type and hydraulic conductivity data. Piezocone penetrometer tests are also moderately effective for determining other geotechnical engineering properties including friction angle, undrained shear strength, density index, permeability, and horizontal stress.

Advantages:

- Relative ease of collecting minimally disturbed groundwater samples at depth.
- Ability to collect hydrogeological data while installing monitoring well.

Disadvantages:

- Decontamination of reusable equipment is required between boreholes.
- For decommissioning, grouting starting from the bottom of the boring and completed at the surface is recommended.
- Depending on casing diameter, some groundwater sampling equipment may not be applicable.

General guidance on the construction of temporary wells installed via direct push technology can be referenced through ASTM D6001-96, *Direct Push Water Sampling for Geoenvironmental Investigations*, and via the following Internet links:

<http://www2.epa.gov/superfund>

<http://www2.epa.gov/ust>

<http://geoprobe.com/>

<http://www.ams-samplers.com/>

<http://www.itrcweb.org/Guidance/GetDocument?documentID=91>

4.4.8 HydraSleeve™

The HydraSleeve™ groundwater sampler consists of three basic components: the sampling sleeve, a stainless steel weight, and a self-sealing valve. The sleeve comes in various volumes and sizes to account for different well diameters and sampling needs. The HydraSleeve™ is typically used for no-purge sampling, but can be used for purged wells also.



Figure 15. 1.5-inch Hydra Sleeve™ and stainless steel weight (1 liter capacity)

Procedures for use:

- Attach the weight to the bottom of the flattened sleeve and attach a cord to the top.
- Lower the sleeve to the desired sampling interval.

- Pull sharply on the cord to initiate sample collection.
- Retrieve sampler, insert discharge straw and fill sample containers as needed.

Advantages:

- Disposable, simple to use and inexpensive.
- Effective in sampling low yield wells.
- Can sample discrete intervals.
- Sleeves can be deployed in-line to create a vertical contaminant profile.

Disadvantages:

- Larger sample volumes are difficult to retrieve.

4.4.9 Snap Sampler™



Figure 16. Snap Sampler™ VOA Vial

The Snap Sampler™ is designed to collect representative groundwater samples in-situ without purging. The sampler utilizes a double ended cap to close the bottle while it is submerged in the well, eliminating the need to transfer the sample to another container. Samplers are typically leased from the manufacturer or purchased and dedicated to a particular well.

Procedures for use:

- Snap Sampler™ container is placed within the Snap Sampler™ and the Snap Caps™ are attached in the open position.
- Sampler is lowered into a well to the desired interval using the trigger tubing which contains the trigger line and is attached to a docking station at the wellhead.
- Pull trigger line to close sampler and retrieve.
- If necessary, preservative is added to a specialized cavity in one of the Snap Caps™.

Advantages:

- Capable of sampling discrete intervals.
- Minimal disturbance if allowed to equilibrate prior to sample collection.
- Can be deployed in-line to create a vertical contaminant profile.

Disadvantages:

- Limited sample volume depending on type and well diameter.
- Can only be used in wells that are two inches in diameter or greater.

- Fixed trigger length generally means each trigger line is dedicated to a specific well.
- Not all analytical laboratories are equipped to analyze Snap Sampler™ bottles.

4.4.10 Bottom Fill Bailer

Bailer design is simple and versatile, consisting of a cylindrical length of Teflon®, HDPE or stainless steel with a check valve at the bottom. Bailers (Figures 17 and 18) are available in numerous dimensions to accommodate a wide variety of well diameters. Their low relative cost allow them to be utilized for a one-time use per well per sampling episode.

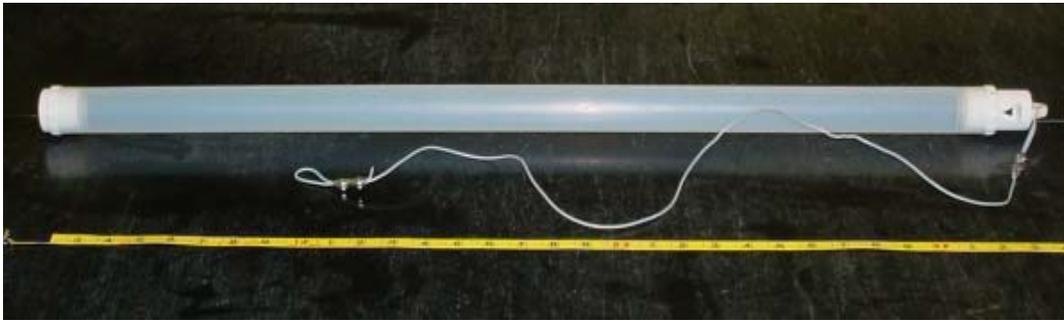


Figure 17. Bottom fill bailer with Teflon® coated stainless steel leader (Photograph by J. Schoenleber)

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

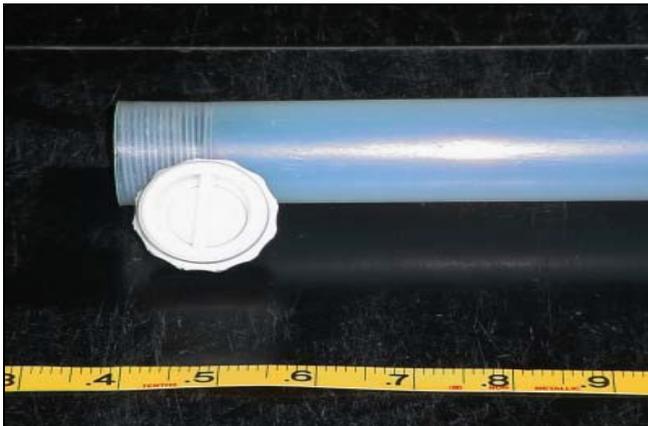


Figure 18. Teflon® constructed bailer with Teflon® ball check valve (Photograph by J. Schoenleber)

Disposable bailers are typically decontaminated by the manufacturer and must be provided in a sealed polyethylene bag. The manufacturer must be prepared to provide certification that the bailers are clean and state in writing the methods used to achieve decontamination. These bailers may then be acceptable for use depending on site-specific objectives and conditions.

Bailers, even when carefully handled, result in some disturbance of the groundwater in the well, therefore, bailers should not be used as the only method for measuring

petroleum product thickness in wells. Samples collected with bailers must be recovered with a minimal amount of aeration. This can be accomplished if care is taken to gradually lower the

bailer *until* it contacts the water surface and is then allowed to fill as it slowly sinks in a controlled manner. However, despite the care taken to control aeration during the fill process, filling and emptying the bailer *will* alter dissolved oxygen concentrations. Due to these reasons (operator induced turbulence and air exposure) this device 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).

When a bailer is used for sample collection, VOC analytical results may be biased low (due to aeration) and metal analytical results may be biased high (due to turbidity). For this reason, bailers are not recommended for VOC or metals sample collection.

Procedures for Use:

- Allow sufficient time after purging for the well to equilibrate and fines to settle. If full recovery exceeds one hour, collect samples as soon as the well has recharged to 80% its pre-purged volume, when practical.
- Fit reusable bailers with a new bailer line for each well sampled; the bailer and line may be handled only by personnel wearing clean disposable gloves.
- Lower the bailer slowly to minimize disturbance of the well and water column.
- The leader or bailer line that comes in contact with the water must be new or decontaminated.
- Prevent the bailing line from contacting the outside of the well, equipment, and clothing.
- Obtain samples as close as possible to the water level/air interface, unless analysis indicates that contamination is at a different depth.
- Lift the bailer slowly and transfer the contents to a sample container with a minimum of disturbance and agitation to prevent loss of volatile compounds.
- Dedicating a bailer and leaving it in a well for long-term monitoring is not allowed due to the potential risk of accumulated contamination.

Advantages:

- No external power source required.
- Economical enough that a separate laboratory-cleaned bailer may be used for each well, therefore eliminating cross contamination.
- Available in Teflon®, HDPE, or stainless steel construction.
- Disposable bailers acceptable when material of construction is appropriate for contaminant.
- Simple to use, lightweight, portable.

Disadvantages:

- Limited volume of sample collected.
- Not appropriate as the sole means for measuring petroleum fuel product thickness in monitoring well.
- Unable to collect discrete samples from a depth below the water surface (vertical delineation).

- Field cleaning not acceptable.
- Reusable polyethylene bailers are not acceptable sampling devices for chemical analysis.
- Ball check valve function susceptible to wear, dimension distortion and silt buildup resulting in leakage in reusable bailers. This leakage may aerate succeeding sample and may gather unwanted material by rinsing unwanted material from well casing.
- Cannot provide reliable or reproducible data for air sensitive parameters, e.g., dissolved oxygen, pH, carbon dioxide or iron and its associated forms.
- Volatile organic analytical results may be biased low (due to aeration) and metals results may be biased high (due to turbidity).

4.4.11 Sterivex™ filters

A Sterivex™ filter is a sterile in-line filtration apparatus (typically with a 0.22 µm pore size to capture microbial cells) that is connected to tubing and a submersible or low-flow pump. This approach must only be used for the evaluation of environmental molecular diagnostics in groundwater samples.

Groundwater is pumped through the filter which captures microbial biomass for identification, enumeration, or activity assessments, typically via extraction of genetic material (e.g., nucleic acids) and molecular biological analyses in the laboratory. An alternative to using Sterivex™ filters is to collect sufficient groundwater (typically 1 liter or more) for microbial analyses. Care must be given to ensure that groundwater samples are processed and transported under the appropriate sample preservation conditions for the biomolecule being analyzed (e.g., DNA, RNA, or whole cells).

Procedures for use:

- Connect the Sterivex™ filter inlet to a Luer lock fitting and to the end of the Teflon tubing with a clamp.
- Filter groundwater into a graduated cylinder to record the volume of groundwater filtered.
- If less than the desired volume (typically one liter) is filtered prior to clogging then a second filtration unit may be used.
- When done sampling groundwater, push the remaining water through the Sterivex™ filter using a sterile 10-mL syringe.
- Add preservative/stabilizing agent to the Sterivex™ filter if sampling for mRNA.
- Cap both ends of the filter (one with the Luer lock, the other with a rubber cap provided by the laboratory).
- Place the Sterivex™ filter into a sterile container (e.g. 100-mL Falcon plastic centrifuge tube) and transport to laboratory (typically at 4° Celsius) for analyses.

Advantages:

- Can be integrated with the same submersible/low-flow groundwater sampling methods for VOCs.

- Shipping filters in lieu of groundwater samples decreases shipping costs and decreases laboratory extraction costs.
- Increases the likelihood of collecting suspended particles and attached microorganisms in groundwater.

Disadvantages:

- Sterivex™ filter may clog before the desired volume of groundwater is filtered. (Be sure to record the volume of groundwater filtered through each filter.)

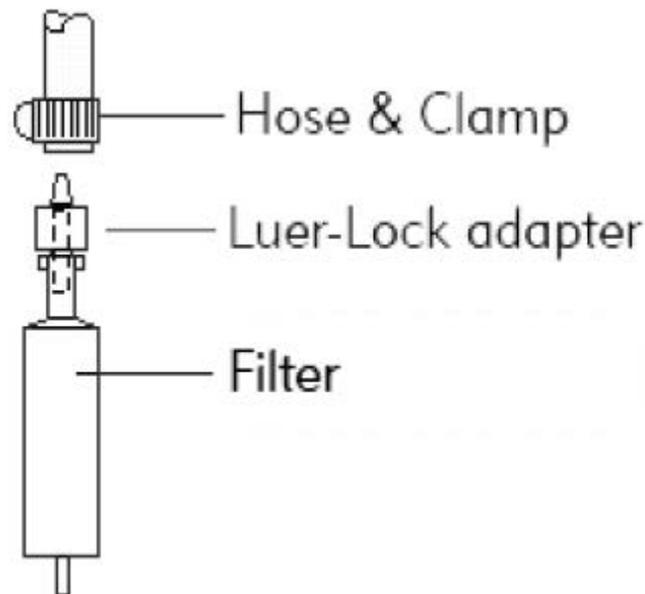


Figure 19. Sterivex™ filter and filter fittings used to collect microbial biomass from groundwater (Figure courtesy Microbial Insights, Inc., Knoxville TN)

4.4.12 BioTraps™

A Bio-Trap™ is a passive microbial sampling device used to assess in-situ microbial activity. It contains a solid composite matrix of powdered activated carbon and Nomex® material called Bio-Sep® beads. This matrix can be amended with ¹³C-labeled compounds or electron donors or acceptors, prior to deployment and incubation in groundwater. Bio-Traps™ are typically deployed for several weeks, retrieved and transported to a laboratory (typically at 4° Celsius), and analyzed using a variety of EMD methods. Bio-Traps™ configurations may also be customized to individual contaminated sites conditions; for example, Bio-Traps™ may be amended with contaminants having stable isotopes to demonstrate that biodegradation is occurring at a site. Bio Traps™ may also be deployed within bailers that effectively seal the sampling devices from the external ambient groundwater environment, once deployed. This configuration may be useful where the capturing and analyzing metabolic by-products (such as methane or carbon dioxide) may be of interest.

Procedures for use:

- Discuss sampling goals for using Bio-Trap™ samplers with the laboratory provider prior to use.
- Deploy the sampling devices into monitoring wells at the desired depth.
- Retrieve samplers after sufficient deployment duration to allow microbial biofilm formation (typically 30 to 90 days).
- Transport to laboratory (typically at 4° Celsius) for analyses.

Advantages:

- Simple to deploy and retrieve.
- Can be configured to answer unique site-specific questions.
- Bio-Traps™ can be amended with electron donors or inorganic amendments to bio-stimulate the microbial community and answer site-specific questions or screen remedial alternatives.
- Bio-Traps™ can be amended with ¹³C-labeled contaminants to confirm biodegradation is occurring at a site.
- Can potentially provide more accurate temporal and spatial representation of the subsurface microbial community than from groundwater grab samples.

Disadvantages:

- Require additional field visits for deployment and retrieval.
- Some ¹³C-labeled contaminants may be expensive to synthesize.

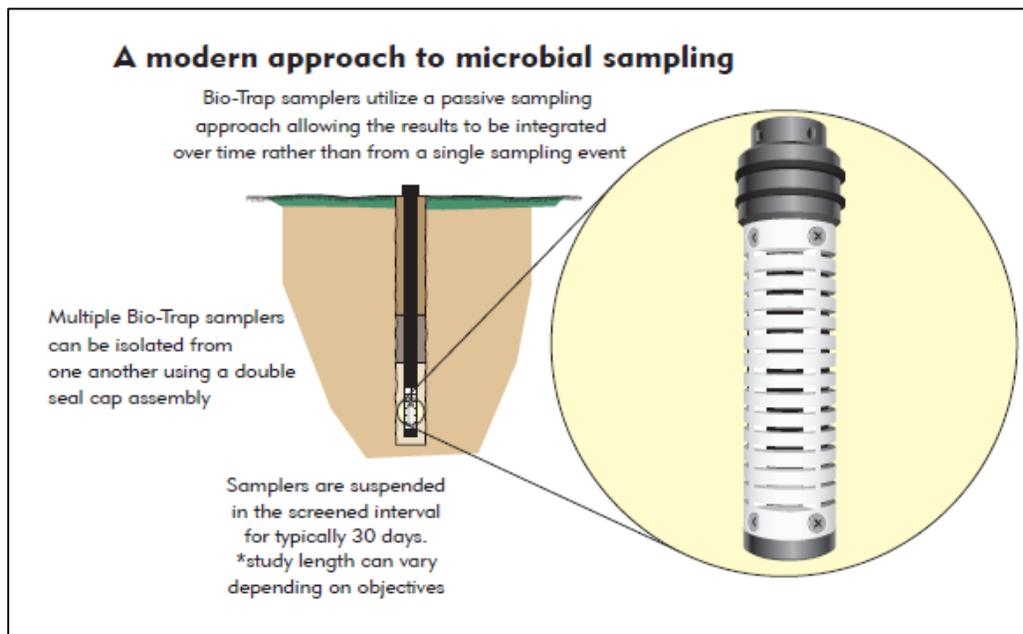


Figure 20. Bio-Trap™ passive microbial sampling device (Figure courtesy Microbial Insights, Inc., Knoxville TN)

4.4.13 Purge Techniques

Purging is the process of removing stagnant water from a monitoring well prior to sampling, causing it to be replaced by groundwater from the adjacent formation. Prior to purging, three measurements need to be recorded: the inside diameter of the well, the depth to water in the well, and the depth to the bottom of the well. With that information, the volume of the water in the well casing needs to be calculated and recorded. The Table below can be used to help calculate the volume of water in the well casing:

Table 3. Volume of water in well casing

Casing Inside Diameter in Inches	Gallons per Foot of Water
½ (0.5)	0.01
1	0.04
2	0.16
3	0.37
4	0.65
5	1.02
6	1.47
7	2.00
8	2.61
9	3.31
10	4.08
11	4.93
12	5.88

When purging monitoring wells prior to sampling:

- remove at least three casing volumes, **or**
- monitor water quality parameters until a minimum of three (minimum of four if using temperature as an indicator) of the parameters listed below stabilize, **or**
- for low yield wells, the entire well casing is evacuated.

All water quality parameters, except turbidity, must be obtained using a flow-through-cell and turbidity measurements must be obtained before the water enters the flow-through-cell. Additionally, water quality parameters shall be measured and recorded in a field notebook while purging monitoring wells.

In order to collect representative groundwater samples, CSP recommends that groundwater be purged and sampled using low-flow techniques. For low-flow sampling, the goal is minimum drawdown (<0.3 feet) during purging. The water level must be measured at each interval that the water quality parameters are measured and recorded on the field log. Flow rate must be between 50 and 500 mL/min. Temperature and pH, while commonly used as purging indicators, are insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and must also be measured and recorded (EPA 540/S-95/504, April 1996).

Water quality parameters are considered stable when three successive readings, collected 3-5 minutes apart, are within:

- $\pm 3\%$ for temperature (minimum of $\pm 0.2^\circ\text{C}$),
- ± 0.1 for pH,
- $\pm 3\%$ for conductivity,
- ± 10 mv for redox potential,
- $\pm 10\%$ for dissolved oxygen (DO), and
- $\pm 10\%$ for turbidity.

A minimum of three (minimum of four if using temperature as an indicator) of these parameters must be monitored and recorded. Low flow purging and sampling are particularly useful for wells that purge dry or take one hour or longer to recover. If a well is low yield and purged dry, do not collect a sample until it has recharged to approximately 80% of its pre-purge volume, when practical.

Collection of groundwater samples for EMD analyses must occur after geochemical stabilization.

4.4.14 No Purge Techniques

No purge groundwater sampling is a method for obtaining groundwater samples without purging the well beforehand. Under certain site conditions no purge sampling may not provide representative groundwater data, so it is necessary to demonstrate, in accordance with a CSP approved site-specific work plan, that purge sampling will provide similar results to purge sampling at the site. This would include collecting and analyzing both no purge and purge samples from each monitoring well during the same sampling event.

No purge sampling may not be used for the initial groundwater monitoring event at a site unless it is done in conjunction with purge sampling during that sampling event.

Additional information on no purge sampling can be found at the website: <http://www.epa.gov/environment-health-and-safety/clean-water/ground-water/bulletins> or <https://clu-in.org/characterization/>.

4.5 Passive Groundwater Sampling

Passive groundwater sampling allows a sample to be collected from a discrete location without active media transport induced by pumping or purge techniques. Passive technologies rely on the sampling device being exposed to media in ambient equilibrium during the sampler deployment period. For example, well water is expected to be in natural exchange with the formation water.

4.5.1 Passive Groundwater Sampling for Microorganisms

Passive samplers for groundwater microorganisms (and EMD analyses) are typically deployed in-situ within an aquifer environment for several weeks, and rely on formation of microbial biofilms that develop on or within a solid matrix of the sampler. Passive samplers can also be amended with substrates (e.g., electron donors or acceptors, stable isotopes, or microbial cultures) prior to deployment as part of biostimulation or bioaugmentation strategies.

The Interstate Technology and Regulatory Council's website describes various tools and techniques for passive groundwater sampling and use of passive samplers as part of EMD analyses. Refer to the ITRC website at:

<http://www.itrcweb.org/Guidance/ListDocuments?topicID=17&subTopicID=27> and <http://www.itrcweb.org/emd-2/> for current guidance.

5.0 Air Sampling

5.1 Vapor Intrusion

Vapor intrusion is the migration of volatile chemicals from a subsurface vapor source into overlying buildings. See CSP's *Vapor Intrusion Guidance* for more specific guidance for evaluating and responding to a vapor intrusion exposure pathway at contaminated sites. Procedures for air and soil gas sample collection and analysis are provided in this guidance. Evaluation of soil gas or air by methods not described in the *Vapor Intrusion Guidance* can be approved by CSP on a site-specific basis.

6.0 Surface Water Sampling

Surface water sampling methods can be defined in many ways. In general, water can be collected by two methods: by hand collection, or by use of sampling equipment designed for obtaining water samples from specific depths of the water column. (Alternative classification can include isokinetic and non-isokinetic, depth-integrated or non-depth-integrated sampling methods, as defined by U.S. Geological Service, depending on the environment sampled and type of sample collected.) Hand collection is obviously limited to surface waters or just under the water's surface, whereas specialized sampling equipment may obtain individual water samples from depths of many meters. Examples of water sample collection equipment include those common to limnological and oceanographic applications, such as: a Van Dorn sampler, a Kemmerer Bottle, a Nansen or Niskin bottle, or other samplers capable of sampling at specific depths (often with messengers or manipulating a trigger line and mechanism). Deviations from this section may be approved by CSP on a site-specific basis but must be clearly identified and discussed in the work plan and report.

Other surface water sampling devices may include a dip sampler to obtain samples from an outfall pipe or areas difficult to access; bailers, hand-held bottles or even buckets; and automatic samplers deployed to collect either grab or composite samples at specific depths, flow rates, or points in time. Additional samplers may also be available for specialized applications (e.g., Biological Oxygen Demand, or B.O.D. sampler). USGS has also developed a specialized

sampler specific to collecting VOCs in stream water (manufactured by WILDCO, Inc.; see image below).

CSP recommends surface water samples be collected unfiltered. If filtering is approved by CSP in a site-specific work plan, both filtered and non-filtered surface water samples will need to be collected and analyzed so the effects (bias) of the filtering process on the contaminant concentrations can be evaluated.

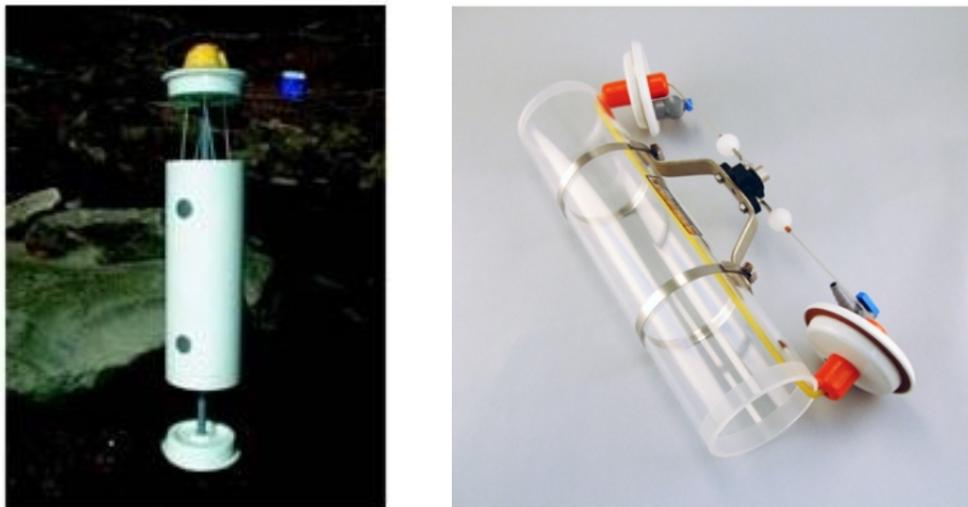


Figure 21. Van Dorn water sampler on left, Kemmerer bottle sampler on right (photos courtesy of Wildco, Inc.).

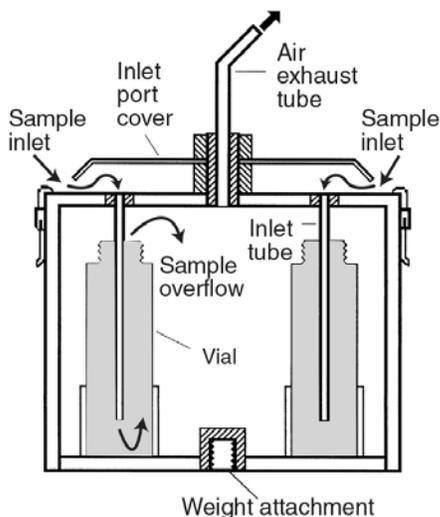


Figure 22. VOC sampler that holds four VOA vials from *Field Guide for Collecting Samples for Analysis of Volatile Organic Compounds in Stream Water for the National Water-Quality Assessment Program* by Larry R. Shelton, U.S. Geological Survey, Open-File Report 97-401. Image from http://water.usgs.gov/owq/FieldManual/Chapter2/Chapter2_V3-1.pdf.

The CSP recommends sampling surface waters following procedures and guidelines established by USGS and NOAA, and documented in the *National Field Manual for the Collection of Water- Quality Data* (USGS, various dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chapters. A1-A9, available online at: <http://water.usgs.gov/owq/FieldManual/>), and (relevant to

Alaska) *Guidelines for Collecting High Priority Ephemeral Data for Oil Spills in the Arctic in Support of Natural Resource Damage Assessments* (NOAA, 2014, available online at: http://response.restoration.noaa.gov/sites/default/files/NOAA-guidelines-ephemeral-data-collection_Arctic_December2014.pdf).

Use of additional guidance documents may include standards of procedures from various EPA regional offices (e.g., USEPA Region 4, 2013 SESD Operating Procedure, Surface Water Sampling, SESDPROC-201-R3, available online at: <http://www2.epa.gov/sites/production/files/2015-06/documents/Surfacewater-Sampling.pdf>).

As with groundwater sampling, field measurements (e.g., temperature, dissolved oxygen, pH, water hardness, etc.) should also be collected at the time of surface water sample collection, following the guidelines in Section IV of this document. Many of these can be collected with the use of multi-parameter probes or instrumentation. Other parameters or information (e.g., stream discharge, light penetration to determine euphotic zone, etc.) may also be necessary when collecting water samples for biological indicators, or analyte-specific analyses. Consult the guidance listed above for more sampling-specific information.

Procedures for Use:

Consult the guidance documents above to select sampling equipment based on project objectives, sampling strategy and type of surface water body anticipated. In particular:

- Determine what depth samples are to be collected.
- Determine how samples are to be collected; e.g., by hand, specialized sampling equipment, or through ice.
- Determine what kind of (and how often) ancillary data should be collected.
- Include the appropriate number of sample blanks and other quality control samples to be collected.
- If using in-situ samplers and sensors, be sure instrumentation is properly calibrated before deployment or use.
- Follow Appendix E for use of appropriate sampling containers, depending on the analyses of interest.
- All sample containers must be pre-cleaned by the laboratory prior to filling with sample.
- The sampler and supporting equipment must be rinsed thoroughly with water at the sampling location between samples, and rinsed with water from the next sampling location before collecting a sample from the new location. More rigorous equipment decontamination may be necessary if highly contaminated sites are sampled or if low level contaminants are a concern. To reduce the probability of cross-contamination of samples, sample relatively clean sites first and then subsequently sample more contaminated locations.
- Consider employing “Clean Hands/Dirty Hands” sampling techniques (USGS, referenced above) (e.g., dedicated sampler and dedicated logistical support).
- If anaerobic conditions need to be maintained, then the water in sampler and/or sample bottle should not be exposed to air after collection, and shall be collected and capped at depth.

- When collecting surface water into sample bottles that contain preservative (e.g., pre-loaded), it may be most practical to sub-sample from a sampling device (which could be another sample bottle used as a ladle) and fill the sample container containing preservative until no headspace is apparent, instead of attempting to sample and cap at depth, and potentially losing preservative.
- Follow guidelines in Appendix E for surface water sample storage and preservation, depending on analyses to be performed.
- For toxicity testing, store unpreserved at 4°C for not longer than 24 hours, unless the test method dictates otherwise.
- For compliance with or to demonstrate impairment of Alaska Water Quality Standards, Water Hardness, and Water Quality Criteria for Toxics and Other Deleterious Substances (Alaska Administrative Code, 18 AAC 70), sufficient numbers of samples may need to be collected to adequately describe the frequency and duration of a criterion or standard compliance or exceedance. Sufficient sampling may also need to occur to demonstrate impairment representative of chronic or acute exposure (e.g., sampling to determine 1-hour, 24-hour, or 4-day average concentration).
- Sufficient sample volumes may need to be collected to determine both total and dissolved analytes.
- In some cases, surface waters samples may be composited prior to analysis. ***In all cases, samples collected for volatile organic analysis must be sub-sampled and collected directly from the water sampler before mixing the sample, to minimize volatilization of contaminants.***

Advantages:

- Many surface water collection procedures are very simple to perform.

Disadvantages:

- Identifying where, and in some cases when, to collect surface water samples may be a larger challenge than specific methodology used. Attention should be given to determining the best location (and time) to collect samples that are truly representative of site or field conditions.
- Discrete water samples are a snap-shot of conditions at the time of sampling; not time-integrated.
- Collection of surface water at some sites may require use of boats or vessels, or (in the case of ice-covered water bodies) ice auger equipment.

7.0 Sediment Sampling

7.1 Sediment grab sampling and core sampling

Depending on project objectives, sediment sampling can range from collecting sediments with simple hand tools (such as a shovel) to the use of mechanical equipment common to oceanographic and limnological investigations. Sediment samples can be collected from different environments including streams, marine inter-tidal areas, or sub-tidal areas. The types of

sampling conducted is dependent on the data quality objectives. Two common forms of sediment sampling will be discussed in this guidance: grab sampling and core sampling. For more information on sediment sampling techniques, equipment and procedures, consult *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses* (available online at: <http://water.epa.gov/polwaste/sediments/cs/collection.cfm>). Deviations from this section may be approved by CSP on a site-specific basis but must be clearly identified and discussed in the work plan and report.

Sediment grab samplers commonly employ the use of simple mechanical jaws with a trigger mechanism that remain open during descent through the water column, but closes the sampler upon pulling up during ascent. Common examples include the Ponar and Van Veen grab samplers, pictured in Figure 23a and 23b. Grab samplers exist in a variety of configurations, and are recommended for collecting surficial sediments where depth profiling is not required. In contrast, dredge samplers (Figure 23c) are commonly used to collect benthos (i.e., macroinvertebrates or other aquatic organisms living in sediment). Because dredge sampling typically disrupts the sediment profile and potentially alters pore water integrity, and a loss of fine grain sediment may occur, dredge sampling is not typically used to characterize sediments and must be approved by CSP on a site-specific basis. Many grab samplers are also marketed as dredge samplers, as they may also be appropriate for benthos collection.

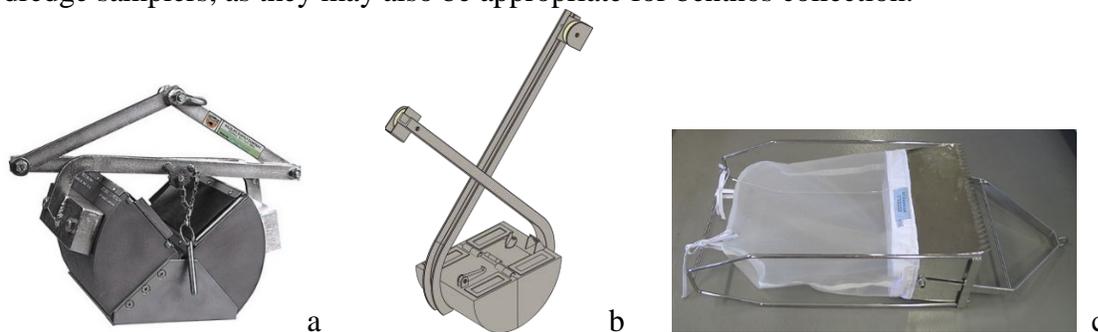


Figure 23: a) Ponar grab sampler; b) Van Veen grab sampler; c) rectangular dredge sampler (image sources: a) Wildco Supply; b) Wikipedia; c) KC-Denmark A/S Research Equipment)

Sediment core samplers typically consist of a hollow metal or plastic pipe that serves as the core barrel, in which a removable plastic liner or core tube fits and retains the sediment sample. Core samples are recommended when vertical sediment profiles, historical depositional analyses, or maintenance of oxygen-free environments in sediments is required. Core samplers can be simply hand-operated by pushing into sediments, or weighted or mechanical attachments (often deployed from a vessel) can be used to facilitate sediment penetration and collection (e.g., vibracorer, box corer, etc.). Additional configurations may include a valve and core catcher to retain the sediment sample; driving tips and core cutter for penetration of the sediment; piston-driven impact or vibration mechanisms to increase penetration of the corer into the sediment; and stabilizing fins to ensure vertical descent of the corer. Most core samplers do not work well in sandy sediments or in extremely soft (high water content) sediments. In these situations, use of grab samplers may be more appropriate. In cases where metals are contaminants of concern, plastic liners should be used to avoid contact of the sediments with stainless steel.

Sediment collection techniques (most commonly core sampling) can also be used to collect sediment pore water samples, via post-sampling processing by centrifugation or various sediment

“squeezing” techniques. These additional sample processing steps increase the potential to alter sediment pore water chemistry by causing increases in ammonia, sulfide, and dissolved organic carbon (DOC) concentrations, as compared to those collected via passive sampling methods (e.g., peepers). Other constituents, such as salinity, dissolved inorganic carbon, sulfide, and sulfate may also change if oxidation is not prevented. If sediments are anoxic (which is common), it may be necessary to maintain anoxia during sediment sampling and processing, depending on project objectives. When anoxic sediments are exposed to air, volatile sulfides will be lost, which may increase the availability of sulfide-bound metals. In addition, iron and manganese oxyhydroxides can quickly form and readily complex with trace metals, and alter metal-related toxicity. Generally, if total metal concentrations are of interest for regulatory adherence, maintaining anoxic conditions may be unnecessary. However, if project objectives call for determining various metal species, or if sediment pore water is to be extracted for bioavailability determinations, then anoxic conditions need to be maintained, and all steps involved in sediment sample processing must be conducted in inert atmospheres (e.g., glove box with argon or nitrogen gas), or by limited contact with the atmosphere to prevent oxidation (and subsequent sorption/precipitation) of reduced metals or organic contaminants. Light (photochemistry) and temperature may also impact sediment chemistry by causing changes in metal speciation or DOC concentrations. Sediment samples must be immediately placed and kept in the dark, at less than 6°C for transport. Follow Appendices D and E below for proper preservation and storage/hold time requirements.



Figure 24. a) Sediment hand core sampler; b) box corer (image sources: a) Forestry Suppliers, Inc.; b) Wildco)

The optimal sediment collection method will depend upon the purpose of the sample (i.e., intended analysis), characteristics of the sediment, and the contaminants of concern. Table 4 provides guidance on sediment sample volumes required for common environmental analyses. CSP requests that any sediment sampling strategy, equipment, and procedures, as well as handling and processing steps, be adequately described in a work plan for contaminated site assessment or remedial evaluation.

Table 4. Typical Sample Volumes for Various Sediment Analyses

Sediment Analysis	Minimum Sample Volume
Inorganic chemicals	100 mL
Non-petroleum organic chemicals	1 L
Other chemical parameters (e.g., total organic carbon, moisture content)	300 mL
Particle size	230 mL
Petroleum hydrocarbons ¹	250-1000 mL
Acute and chronic whole sediment toxicity tests ²	1-2 L
Bioaccumulation tests ³	15 L
Benthic macroinvertebrate assessments	8-16 L
Pore water extraction	2 L
Elutriate (aqueous extraction of suspended sediments) preparation	1 L

¹ The maximum volume (1,000 mL) is required only for oil and grease analysis; otherwise, 250 mL is sufficient for AK 101, 102, and 103 analyses. BTEX and VOCs analysis will require additional sediment volumes; see Appendix D.

² Amount needed per whole sediment test (i.e., one species) assuming 8 replicates per sample and test volumes specified in USEPA 2000.

³ Based on an average of 3 L of sediment per test chamber and 5 replicates (USEPA 2000).

Procedures for Use:

Consult EPA 2001 for selecting sampling equipment based on project objectives, sampling strategy and type of sediment material anticipated (i.e., coarse or fine-grained). The depth of sediment sampling is dependent on the project objectives (e.g., whether vertical profiling is necessary). Issues that determine the appropriate depth of sampling include: regulatory objectives (e.g., depth of dredging for sediment remediation), need to characterize sediments at depth (e.g., materials to be dredged versus shallow depositional areas in some superfund sites), historical comparisons, sediment deposition rates, and/or time period of contamination.

Generally, grab samples should be collected if large sediment volumes, large sediment sizes, or greater surficial surface area is to be sampled, and vertical depth profiles or maintenance of anoxic sediment conditions are not required. Winching systems for sampling from vessels and maintaining appropriate sampler control during descent and ascent may be necessary in some situations.

Using Table 4 as guidance, collect sufficient sediment volume necessary for project objectives and analyses. Collect a minimum volume of sediment and store in glass bottles or high density polyethylene (HDPE) or polytetrafluoroethylene (PTFE) containers with appropriate preservatives, depending on the chemical analysis, as outlined in Appendix D. Following collection methods outlined in EPA 2001, samples must be visually inspected to ensure that:

- The sampler is not overfilled so that the sediment surface is touching the top of the

sampler;

- Overlying water is present (indicates minimal leakage). This overlying water must be removed prior to processing and storage by siphoning, not decanting;
- The overlying water is clear or not excessively turbid;
- The sediment-water interface is intact and relatively flat, with no sign of channeling or sample washout;
- The desired depth of penetration has been achieved; and
- There is no evidence of sediment loss (e.g., incomplete closure of the sampler, penetration at an angle, or tilting upon retrieval).

All containers must be pre-cleaned prior to filling with sample. Purge containers with inert gas (e.g., nitrogen) prior to and after filling if anoxic conditions must be maintained.

Sediment samples collected in the field must be stored in containers without headspace at less than 6°C and in the dark to minimize changes in contaminant bioavailability.

The sampler and equipment must be rinsed thoroughly with deionized water at the sampling location between samples, and rinsed with deionized water from the next sampling location before collecting a sample from the new location. More rigorous equipment decontamination might be necessary if highly contaminated sites are sampled or if low level contaminants are a concern. To reduce the probability of cross-contamination of samples, sample relatively clean sites first and then subsequently sample more contaminated locations.

If a project involves evaluation of metal contamination, or if anaerobic conditions need to be maintained for other reasons, it might be necessary to homogenize, sub-sample, and composite samples in an oxygen-free glovebox or other suitable apparatus.

Be sure to record the following in the field notes:

- latitude and longitude coordinates of sample location, if possible;
- date and time of sampling;
- water depth and the sampling penetration depth;
- possible sample contamination, equipment failure, unusual appearance of sediment integrity, inability to control vertical descent of the sampler;
- estimate of quantity of sediment recovered by a grab sampler, or length and appearance of recovered cores;
- description of the sediment including texture and consistency, color, presence of biota or debris, presence of oily sheen, changes in sediment characteristics with depth, and presence/location/thickness of the redox potential discontinuity (RPD) layer (a visual indication of black is often adequate for documenting anoxia); and
- a photograph of the sample is desirable, especially longitudinally-sectioned cores, to document stratification.

Core samples must be collected if depth profiling, historical analysis, or reduced oxygen exposure is required. Following collection methods outlined in EPA 2001, core sampling procedures ensure:

- The core sampler was not inserted at an angle or tilted upon retrieval.
- The core collected the required depth to meet the study objectives, with no loss of sediment.
- The volume of overlying water in sediment samples must be minimized to reduce the potential for re-suspension of surface sediments during transport.
- Care must be taken to retain the surficial floc overlying a core sample.
- Core samples may be best shipped as intact core samples, using the core sampler tube liner as a shipping container. Prior to transport, headspace in the core liner must be filled with site water and both ends of the liner must be completely sealed. Cores must be secured in an upright position during transport to minimize disturbance of the sediment.

Processing sediment samples in the field or laboratory may also involve homogenization, sieving, and other manipulations prior to chemical analyses. ***In all cases, samples collected for volatile organic analysis must be sub-sampled and collected directly from the core sampler or grab sampler, before mixing the sample, to minimize volatilization of contaminants.***

Advantages:

- Sediment grab and core sampling is typically simple to collect (particularly if bathymetric information is available prior to sampling).
- Sediment pore water can be extracted from core samples.
- Bioavailable concentrations of contaminants may be determined from pore water.

Disadvantages:

- Samples are snap-shot of conditions at the time of sampling; not time-integrated.
- Some sites may require use of boats or vessels to sample sediment locations.
- Core samplers typically have a small surface area and may require multiple samples to represent site conditions.
- Ex-situ sediment pore water extraction is known to change pore water chemistry to some degree (although such changes may be minimized or controlled with proper handling and processing).

7.2 Sediment pore water sampling

Sediment pore water sampling can be conducted to characterize groundwater transport and discharge to surface water bodies, identify sediment contamination and exposure pathways, and evaluate ecological risk. Pore water can be collected from sediment samples, or via active sampling methods, or by the use of passive sampling methods. Pore water sampling also commonly involves sampling from the groundwater-surface water interface (GSI), so CSP groundwater cleanup levels and surface water criteria and standards may apply when reporting the data. Refer to the CSP's April, 2011 guidance document: *Regulatory Approach to Managing*

7.2.1 Extracting sediment pore water from sediment samples

7.2.1.1 Extraction via centrifugation

Sediment pore water can be extracted *ex-situ* from sediment samples collected as either grab samples or core samples; the latter can be collected in a manner to preserve anoxic sediment conditions. Centrifugation is generally the preferred laboratory method for the extraction of interstitial water. The following guidelines are applicable for centrifugation:

- Extract sediment pore water as soon as possible.
- Interstitial water that has accumulated on the surface of the homogenized sediment sample must be mixed into the sediment before the sample is partitioned among centrifuge bottles.
- Sediments must be centrifuged at high speed (e.g., 8,000-10,000 x g) for 30 minutes.
- Centrifuging must be conducted at 2-6°C to minimize temperature-mediated biological and chemical processes.
- Extracted sediment pore water must be preserved immediately for chemical analyses or analyzed as soon as possible after extraction, unpreserved. For toxicity testing, store at 2-6°C for not longer than 24 hours, unless the test method dictates otherwise.
- Filtration must be avoided unless required by a test method because it might reduce interstitial water toxicity. Double (serial) centrifugation (low speed followed by high speed) must be used instead.
- If filtering is required by a test method, pre-treated filters must be used to reduce potential contamination.

7.2.1.2 Extraction via other methods

Additional methods of obtaining sediment pore water include sediment squeezing, vacuum filtration, gas pressurization and displacement. Generally, these methods are known to alter sediment pore water chemistry and characteristics by causing changes in equilibrium from pressure, temperature, and gradient changes. These methods must not be used for obtaining sediment pore water.

Active sampling methods for pore water

The CSP defines active pore water sampling as that which involves the use of pumps and PushPoint™ samplers, temporary well points, soil vapor implants (commonly installed with a slide hammer or fence post driver), or small-diameter pre-packed wells to provide discrete, single-point-in-time (i.e. snap-shot) samples. Installation is commonly performed using hand tools, although larger mechanical equipment may be used for deeper installations. Although many variations of push points, well points and sampling apparatus exists, CSP recommends the use of one-inch inner-diameter (I.D.) well points to facilitate the use of submersible or inertia pumps to minimize the loss of VOCs during sampling. However, CSP also recognizes that EPA guidance is available (USEPA, 2013. *Operating Procedure: Pore Water Sampling*, Region 4 Science and Ecosystem Support Division, Athens, Georgia) that describes the use of low-flow peristaltic

pumps to collect pore water samples. In this particular methodology, the low-flow pump is stopped after drawing pore water into the tubing, and the portion of tubing connected to the well point is removed (without losing the water in the tubing), and the samples are collected from this lower portion of tubing, again to minimize loss of VOCs from the sample. This approach allows the use of smaller diameter points and tubing. Once collected, samples of pore water collected by active methods can be handled, processed and analyzed with methods established for groundwater and/or drinking water samples.



Figure 25. Photo showing vapor implant (top) and Henry Sampler (bottom) push points; courtesy of Chris Eckley, USEPA, Region 10

This sampling method is likely to capture colloidal material, onto which contaminants of concern may adhere (e.g., PAHs, metals, etc.). Colloids may or may not be removed during laboratory extraction and analysis, depending on project objectives and laboratory procedures used. It may be important to consider colloids when interpreting pore water data or comparing to other sampling methods (e.g., passive sampling). Consult the CSP Project Manager for more project-specific guidance.

Procedures for Use:

- Assemble the drive rod (and guard rod if using one), drive point, tubing and slide hammer (if using a PushPoint™, no assembly may be necessary).
- Insert the assembly at the sampling location and advance to the desired depth (often the groundwater-surface water interface). It may be necessary to use a flange if deploying through a surface water column to prevent intrusion of surface into the pore water sample. See USEPA, 2013 for further instructions.
- Remove the drive or guard rod.
- Purge and sample by using a pump inserted into the rod assembly or with a low-flow peristaltic pump.
- Remove the drive rod and pull tubing from buried well point or implant, or remove entire PushPoint™.
- An alternative is to install one-inch (I.D.) pre-packed screened monitoring wells (with direct push equipment or via trenches dug to just above the groundsmear zone), and develop and sample as for drive points.

Advantages:

- Inexpensive and easy to use.
- Multiple equipment choices and configurations are available for sample collection.

Disadvantages:

- Push point or implant is expendable.
- Frozen soils or gravely sediments or subsurface refusal may limit desired depth to collect pore water.

- Well point or implant screen may clog with sediment during sampling.
- Samples are snap-shot of conditions at the time of sampling; not time-integrated.

7.3 Passive sampling methods for pore water

7.3.1 Equilibrium-based samplers

One form of passive sampling methods involves the use of equilibrium-based polymer sampling devices, which are typically deployed in-situ for extended lengths of time (e.g., 30 days or more). Under equilibrium, the contaminant composition of the sampler water will match that of the surrounding pore water. Common polymer passive sampling materials include polyethylene (PE), polyoxymethylene (POM), and fiber optic cable coated with polydimethylsiloxane; also known as a Solid Phase Micro Extraction (SPME) sampler. These passive samplers are commonly used to evaluate hydrophobic chemicals in the dissolved phase, and to determine bioavailability of contaminants. EPA’s recent guidance further describes the theory and practical applications of polymer-based passive samplers for sediment pore water; see USEPA 2012 *Guidelines for Using Passive Samplers to Monitor Organic Contaminants at Superfund Sediment Sites*.



Additional equilibrium-based sampling devices include Peepers (also called in-situ dialysis samplers), which are commonly a rigid material sampler with openings (with many configurations) that exposes a permeable membrane that separates a volume of water (commonly deionized and deoxygenated water) from the pore water environment it is sampling. Passive Diffusion Bag samplers (mentioned in groundwater sampling equipment) can also be deployed in protective screened housings for deployment in sediments. Peepers are similar to PDB samplers, but may be constructed of different membrane materials (e.g., polysulfone or cellulose), and were originally designed to sample the groundwater-surface water interface.

Figure 26. Polymer passive sampling materials; source: USEPA 2012

When equilibrium-based passive samplers are used, CSP requires an approach to ensure samplers have achieved equilibrium with their environment during deployment. This may include a sufficiently long duration of deployment (e.g., 45 days, or duration based on empirical evaluation) or use of Performance Reference Compounds (PRCs), which can be used to determine if the sampling device has achieved equilibrium with its environment. For example, known quantities of a PRC can be pre-loaded into samplers prior to deployment, and their loss can be quantified after retrieval and used to demonstrate the sampling device has achieved equilibrium, or to

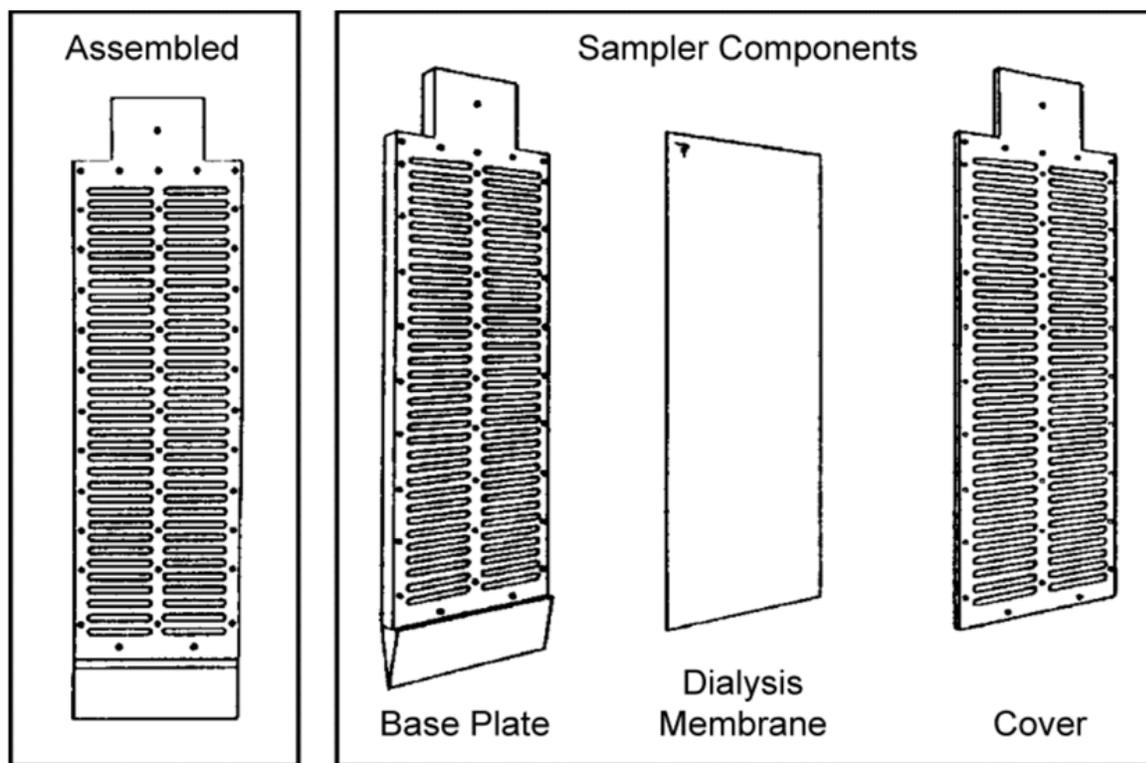


Figure 27. Peeper sampling device; source: USEPA 2001

estimate concentrations of contaminants under modeled equilibrium conditions. Because of the uncertainty of equilibrium conditions in the environment and how well the PRCs mimic behavior of contaminants of concern, CSP may require the inclusion of PRCs during the use of passive sampling on a case-by-case basis.

Determining dissolved phase concentrations of contaminants requires use of dissolved phase partition coefficients (k_d) for each sampling device (material) and contaminant being sampled, that can be calculated from the contaminants K_{ow} , determined empirically by the laboratory, or may be reported in the scientific literature.

7.3.2 Sorbent-based Samplers

Additional passive samplers that are sorbent-based diffusion samplers are available for sampling VOCs in sediment pore water. These include the GORE Module (also known as the GORESORBER™ Module), devices containing activated carbon (such as the Bio-Trap™), the Polar Organic Chemical Integrative Sampler (POCIS™), and Semi-permeable Membrane Devices

(SPMDs). Semi-permeable Membrane Devices are similar to the PDB samplers, but are filled with triolein (a fatty acid compound used to simulate the bio-concentration of contaminants into lipid tissues of aquatic organisms). Semi-permeable Membrane Devices may be used to sample sediment pore water in some situations, but they are more commonly used to sample the overlying water column. The range of contaminants the various sorbent-based sampling devices can sample may also include more than VOCs. Sorbent-based passive samplers accumulate contaminants over the duration of the deployment time. As with polymer samplers used for hydrophobic contaminants, PRCs may be incorporated into sorbent-based passive samplers use to evaluate sampling rates during deployment.



Figure 28. SPMD wound on sampling apparatus; source EST Labs, Inc.

Use of some passive samplers may require patent rights to be observed and may be only available for purchase and/or analysis from sole source vendors and laboratories. Non-ADEC approved laboratories for contaminated sites analysis may offer analysis of passive samplers and may be approved by the CSP project Manager on a case-by-case basis.

Procedures for Use:

- Use of passive samplers requires solvent cleaning prior to deployment (and possibly loading with a PRC), so coordination with the analytical laboratory is necessary beforehand.
- In addition to samplers, hardware for deployment must be clean and free of petroleum hydrocarbons.
- Deployment in the field can utilize many different configurations for protection and securing passive samplers for later retrieval. Consult USEPA 2012 for additional guidance on deployment variations.
- Utilize blanks; including fabrication, field (exposed to surrounding air during sampler deployment and retrieval), trip (remaining in sealed container; must include sampler and solvent blanks), and laboratory blanks. If PRCs are used with the passive samplers, the trip blanks also must be spiked with the PRCs.
- Remove colloids, biofilms, and debris from the surface of passive samplers by rinsing with clean (distilled or deionized) water or site water. If using tweezers to handle sampler materials, be sure to clean them of colloids or biofilm material before handling new samplers.
- After rinsing, place the samplers back into vials or wrap in aluminum foil and seal in ZipLock™ bags without delay. If using vials preloaded with solvents in the field, be aware of shipping and handling restrictions with various freight and air carriers.
- **Important note:** many passive samplers can sample the air as well as the sediment pore water you may be targeting; it is important to handle them carefully by keeping them away from common field gear, such as outboard motors and gas cans, and vehicle exhaust, etc.

Advantages:

- Polymer samplers are typically inexpensive, easy to use, and very durable.
- May eliminate the costs associated with purge water/IDW disposal.
- Time-integrated (e.g., time-weighted average) samples may be obtained.
- Very low detection limits (ng/mL) are possible with many passive samplers.
- Partition coefficients may be readily available to determine dissolved phase concentrations of contaminants.
- Bioavailable concentrations of contaminants may be determined.

Disadvantages:

- Non-polymer based passive samplers may be more costly than polymer samplers, and limited laboratory analysis may be available.
- A minimum of two field visits is required. A third field trip may be required if samplers cannot be retrieved during the first retrieval attempt.
- Extended deployments (e.g., 30 to 45 days), or samplers readily visible for retrieval may increase the risk of vandalism or theft.

7.3.3 Passive sampling sediment pore water for metal contaminants:

As with hydrophobic organic compounds (HOCs), pore water concentrations of metals may be useful to predict the bioavailability of metals to aquatic organisms or provide a more relevant exposure metric than bulk sediment metal concentrations. Metals dissolved in pore water are also often the partitioned component of sediments that are chemically available for reactions (e.g., mercury methylation). Sampling pore water for metals can occur by active or passive sampling methods. Active methods include using sediment core sampling or grab sampling (e.g., ponar dredge). Active sampling is typically followed by pore water extraction via centrifugation or sediment squeezing. Passive sampling for metals is less established than for HOCs, and there is a lack of clear guidance on sampling protocols, calibration methods, and data interpretation for many metals. Peepers are probably the most common equilibrium-based sampling approach for metals, but other equilibrium sampling devices (e.g., Gellyfish) are also available; see Table 5. Metals that have been sampled with passive samplers include Ag, Cd, Cr, Cu, Ni, Pb, Zn, as well as Fe and Mn. When using passive samplers for dissolved metals in sediment pore water, it is recommended that additional sediments and pore water characteristics and parameters also be determined; these include: acid volatile sulfide (AVS), sediment organic carbon (TOC), oxidation-reduction potential (ORP), pH, dissolved organic carbon (DOC), dissolved oxygen, temperature, and grain size. This information will be useful in identifying vertical transition zones from oxic to anoxic conditions in sediments and sediment pore water, and the extent of chemical interactions and potential metal complexes that may form in pore water (e.g., reactions with sulfate, carbonate, DOC, etc.). When using passive samplers (such as Peepers) for dissolved metals in sediment pore water, sampling devices must be de-oxygenated prior to deployment (e.g., water within the sampling device must be purged with Argon, or other inert gas).

When using active sampling methods and extracting pore water from sediments (e.g., centrifugation), pore water is filtered through 0.45 μm filters to remove colloidal materials.

However, colloids may also be important to consider for bioavailability determinations, depending on project objectives. A decision may be made to eliminate filtering as a sample processing step, or to utilize filters with larger-diameter pore spaces to allow colloids to pass through. Consult with the CSP Project Manager for further guidance. Use of PRCs is also not common practice when using passive sampling methods for dissolved metals in sediment pore water. Use of PRCs is not common practice when using passive sampling methods for dissolved metals in sediment pore water.

Table 5. Summary of passive sampling media and configurations for organic and metal analytes

Passive Sampling Media	Configuration	Target Analytes
Polydimethylsiloxane (PDMS)	Coated fiber, vial	HOCs
Polyethylene (PE)	Film/sheet, tube	HOCs
Polyoxymethylene (POM)	Film/sheet	HOCs
Ethylvinylacetate (EVA)	Coated vial	HOCs
Silicone rubber (SR)	Sheet, ring	HOCs
Gels	Diffusive gradient thin film (DGT)	Metals
Resin impregnated polyacrylamide gel	“Gellyfish”	Metals
Metal-chelating media	Disk/membrane	Metals
Water-filled equilibration cell	“Peeper”	Metals

Note: HOCs = Hydrophobic organic compounds.

Adapted from: Parkerton *et al.* 2013. Guidance on passive sampling methods to improve management of contaminated sediments: Summary of a SEATAC Technical Workshop: Pensacola, Florida. Society of Environmental Toxicology and Chemistry (SEATAC).

8.0 Other Environmental Media

Consult with CSP Project Manager for specific guidance when sampling other media (e.g. blueberries, aquatic life, etc.) as part of bio-monitoring or risk assessments.

9.0 Quality Control (QC) Measures

It is expected that all sampling and field screening activities discussed in this document are performed using standard industry methods and practices. In addition, all sampling and field screening methods are performed using tools and instruments that are either single use (disposable) or are free of contamination and will not contribute to false readings in the field or in the laboratory. Field instruments must be calibrated on a periodic basis and documented in a field record or log book. Deviations from this section may be approved by CSP on a site-specific basis but must be clearly identified and discussed in the work plan and report.

9.1 Field Documentation

Document all field readings, sample locations, and field observations in a field record or log book. Logbooks or field records must be bound books that are permanently assigned to a specific project. Field forms and camera may also be used for field documentation in a variety of activities. Field forms include borehole logs, well construction, well sampling, site safety and

health plan forms, etc. It is not necessary to duplicate information recorded on a field form into the logbook. All logbooks and field form entries must be printed legibly using a waterproof pen. All field forms must be completed in full on a daily basis. Entries to the field notebooks must include the following items if applicable:

- Project name/Site ID/Client/Page Number
- Date
- Weather, site conditions, and other salient observations
- Full name of on-site personnel, affiliations and project title e.g., team leader (including all visitors)
- Daily objectives
- Time and location of activities
- Field observations and comments
- Deviations from the CSP site-specific approved work plan
- Photographic log (photographic name, roll or frame number, description of photograph, date, and time)
- Site sketches with reference to north direction, sample and field screening locations and depths, and on-site groundwater flow direction
- Survey and location (latitude and longitude coordinates when possible)
- All field measurements (e.g. leak check results, geochemical parameters, field screening results)
- Daily equipment calibrations and maintenance
- Sample record (sample identification, date, time, media, number of samples, and location)
- Cleanup or remediation activities (system performance, system calibration or maintenance record, excavation activities and volume of material removed)
- Waste tracking (when, how much, destination)
- Soil boring logs will include: blow counts, visual or olfactory observations, field screening readings, soil type, soil moisture, groundwater depth if encountered

Correct erroneous field record or log book entries with a single line through the error. Do not erase incorrect information. Date and initial revised entries. Logbooks and field forms will be kept in the project file when complete or when not in use. Include complete copies of all field notes and field records in reports submitted to the CSP.

9.2 Instrument Calibration

All field instruments must be calibrated prior to each project according to manufacturer's specifications and instrument calibration must be checked and documented on-site on a daily basis. Certain field screening parameters may require more frequent calibrations depending on site conditions, such as temperature, barometric pressure, etc. Retain a reference copy of manufacturer's operating instructions in the field. All instrument users must be trained in routine maintenance and operation. Calibration standard(s), dates, times and all calibration results must be recorded in the field record or log book.

9.3 Sample Containers and General Sample Collection QC

Obtain containers from the lab with the appropriate preservative. Sample containers must conform to the specifications in the required laboratory procedure. In cases where EMDs may be used, sample containers may be sterile and field personnel may need to practice aseptic technique.

Sample container and preservative shipments must comply with Department of Transportation (DOT) and/or International Air Transport Association (IATA) regulations.

Inspect sample containers before transit to the site to ensure that they are undamaged and are tightly sealed. Sample containers must be packaged so that they are secured to prevent damage or tampering in transit to the site. Re-inspect sample containers and lids at the job site. Sample containers that have lost lids or that have been damaged may not be used for sample containment.

Use indelible, waterproof ink to label containers. Document information entered onto the label or container in the field record or log book.

Ensure that sample container threads and rims are clean before tightening lids. Do not tape lids to jars when collecting samples. Change disposable gloves after each sampling location.

Include the following information on the containers or labels:

- Project name,
- Unique identifying alphanumeric assigned to the sample for laboratory analysis,
- Date and time of collection,
- Sampler's name or initials,
- Requested laboratory analysis, and
- Preservative, as applicable.

All sample numbers need to be unique and the number convention must be discussed in the work plan. Use packing material, such as bubble wrap around glass jars to prevent breakage during transport. Unless specified in a CSP site-specific approved work plan, samples must be placed in a cooler that is kept under 6°C and held in the dark. Samples must be verified that they are properly labeled and that field sample forms including a Chain of Custody are properly filled out. During transport and storage of samples, maintain strict chain of custody and place chain of custody seals on coolers and boxes during transport.

9.4 Sample Preservation for Biological EMD Analyses

Preservation of samples to be analyzed via biological EMD methods depends upon the biomolecule of interest (i.e., whether it is DNA, RNA, or whole cells). Nucleic acids are susceptible to degradation from high temperatures, acid or alkaline conditions, or enzymes that specifically degrade them (e.g., DNases or RNases). Use of preservatives may be appropriate to maintain the integrity of DNA; preservatives are required to stabilize RNA. Preservatives used to stabilize groundwater cations or anions are typically not used. Alternatively, freezing soil cores

or groundwater samples at -80° Celsius may preserve nucleic acids for subsequent analysis. Exceptions to freezing samples include EMDs that analyze whole cells (e.g., Fluorescence In-situ Hybridization) or use of Bio-Trap™ passive sampling devices. Generally, samples collected for whole cell analysis or via Bio-Trap™ sampling devices will be chilled to 2-6°C and transported via overnight delivery. Consult the laboratory prior to sampling and transport to ensure holding time problems can be avoided or minimized, or if freezing or use of stabilizing agents is appropriate. See ITRC’s guidance, *Environmental Molecular Diagnostics: New tools for Better Decisions* for more information on sampling and preservations considerations: <http://www.itrcweb.org/emd-2/>.

9.5 Quality Control Field Sample Collection

A sampling approach that is properly designed and implemented will allow the sampling objectives to be met, avoid confusion in the field, and contribute to the generation of high quality data necessary to support defensible decision-making. Measures of quality include the appropriateness and accuracy of the sample collection; adherence to sample handling protocols; the quality and appropriateness of the laboratory analysis; and the representativeness of the data with respect to the study objectives. Quality control activities must be documented in field record or log book. Collect Quality Control samples per the requirements in Table 6. For guidance on laboratory data see CSP’s Guidance on *Environmental Laboratory Data and Quality Assurance Requirements*.

Table 6. Minimum Quality Control Requirements

Minimum Field QC Samples	Applicability	Allowable Tolerance
Field Duplicate (Minimum of one per every 10 field samples for each matrix sampled, for each day in field, for each target analyte, minimum of one)	All soil and water samples collected on the same day	Relative percent differences (RPD) less than: 30% water, 50% soil
Decontamination or Equipment Blank (One per set of 20 similar samples, minimum of one)	Per project specifications	Less than the practical quantitation limit
Trip Blank – Water (One trip blank per analysis and cooler)	All water samples being analyzed for GRO, BTEX, or VOCs	Less than the practical quantitation limit
VOC Trip Blank – Soil (One trip blank per preservation method per set of 20; a minimum of one per analysis and cooler)	All soil samples being analyzed for GRO, BTEX or VOCs	Less than the practical quantitation limit
Field Blank (One per set of 20, minimum of one)	Per project specifications. Used for highly contaminated sites with volatile organic contaminants	Less than the practical quantitation limit

9.6 Field Duplicate Requirements

A minimum of one field duplicate must be collected for every 10 field samples for each matrix

sampled and for each target analyte. Field duplicates must be collected from locations of known or suspected contamination, and duplicate soil and water samples must be collected in the same manner and at the same time and location as the primary sample. For a sampling occurring over multiple days, all field duplicates must not be collected in one day and the goal should be to collect a minimum of one field duplicate per day.

Field duplicates must be:

- submitted as blind samples to the approved laboratory for analysis,
- given unique sample numbers (or names) and sample collection time, and
- adequately documented in the field record or log book.

Field duplicate results must be used to calculate and report a precision value for field sampling quality control according to the following equation:

$$RPD (\%) = \left| \frac{R_1 - R_2}{\frac{(R_1 + R_2)}{2}} \right| \times 100$$

Where:

R_1 = Sample Concentration

R_2 = Field Duplicate Concentration

An exceedance of the allowable tolerance limits suggests that the precision of the sampling effort is insufficient. Inadequate precision could be due to various issues including poor sampling methodology.

9.6.1 Trip, Field, and Equipment Blank Requirements

The primary purpose of quality control blanks (i.e. trip, field and equipment blanks) is to trace sources of artificially introduced contamination. Field blanks are a sample of preservative or deionized water poured into the container in the field, and shipped to the laboratory with field samples. Per project specifications, a minimum of one field blank will be collected per 20 samples per matrix. Equipment blanks are samples of analyte-free water poured over or through decontaminated field sampling equipment prior to the collection of environmental samples. Per project specification, a minimum of one equipment blank will be collected per 20 samples per matrix. Exceeding allowable tolerance limits for equipment or field blanks suggests that field contamination may have affected associated sample results.

Trip blanks are a clean sample of a matrix that is taken from the laboratory to the site and then transported back to the laboratory without having been exposed to sampling procedures. One trip blank is required per cooler. Exceeding allowable tolerance limits for trip blanks suggests that contamination was introduced during shipping and field handling procedures.

9.7 Equipment Decontamination

Depending on the contaminant, wash water and rinsate solutions may need to be collected in appropriate containers and disposed of properly in accordance with federal, state, and local regulations. Proposed decontamination water management needs to be described in work plans.

Decontaminate all reusable equipment such as steel tapes, well sounders, transducers, and water quality probes after each sampling point using a stiff brush and a solution of water and laboratory-grade detergent. An appropriate solvent may be used to remove heavy contaminant residues from the sampling tools. If necessary, sampling equipment can be sterilized in the field with chemical disinfectants, (e.g., detergents, hydrogen peroxide, sodium hypochlorite, ethanol, etc.) or heat (flame) sterilization. Rinse tools twice in clean water and again with distilled or deionized water.

Properly collect, store, and dispose of solvent waste and wash water in accordance with hazardous waste regulations, if applicable, and the CSP site-specific approved work plan. Clean drill auger sections, split spoons, and drive hammers that come in contact with bore holes before use and between borings. Scrub tools with a stiff brush in a solution of water and laboratory-grade detergent. High pressure water or steam may also be used.

Visibly contaminated decontamination water for sites with petroleum hydrocarbons may be containerized for off-site shipment, or with CSP site-specific approval, filtered on-site and re-applied directly to the ground surface within site boundaries a minimum of 100 feet away from any drinking water wells and/or surface water bodies. If not visibly contaminated, decontamination water may be re-applied directly to the ground surface within site boundaries a minimum of 100 feet away from any drinking water wells and/or surface water bodies, if approved in a CSP site-specific work plan.

Refer to ASTM D5088 - Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites.

9.8 Chain-of-Custody and Sample Handling and Shipment

The purpose of the chain-of-custody is to demonstrate accountability and document sample integrity from the time of sample collection until sample analysis.

CSP requires the following elements of chain-of-custody for sample collection:

- Sample labeling,
- Laboratory receipt forms,
- Field custody form (chain-of-custody form),
- Custody seals on all coolers, and
- Inter-laboratory transfer documentation, if applicable.

Maintain samples according to the holding times and temperatures in Appendix C, Appendix D and the approved CSP site-specific work plan. The chain-of-custody form must include

information on analyses specifying the methods to be performed. Do not place samples into the shipping container unless they are recorded on the chain-of-custody form. Obtain a copy of the shipping manifest if using a lab courier or commercial carrier for sample shipment. Sample coolers/containers must arrive at the lab with an intact and correctly applied custody seal unless the coolers are hand-delivered. If the seal was broken at some point during transport, the reason for breaking the seal, condition of the container contents, the cooler temperature, and anything added to or removed from the container must be documented on the chain-of-custody form. The container must then be sealed with a new custody seal. Sample shipments must comply with DOT and/or IATA regulations. Refer to ASTM D4840 - *Guide for Sample Chain-of-Custody Procedures* for additional information. Refer to ASTM D6911 - *Standard Guide for Packaging and Shipping Environmental Samples for Laboratory Analysis* for additional information.

10.0 Reporting

Following the completion of field work, a report must be submitted to CSP for review. The report needs to include a detailed description of every phase of the sampling effort and methodology and include a discussion of the analytical results. Descriptions of the sampling effort must match the CSP site-specific approved work plan or any deviations that occurred in the field must be explained and documented in the report. The sampling results must be well organized in tabular format. Sample and field screening locations must be depicted on figures with a scale and an arrow pointing north so sample results can be cross-referenced against data tables and other site figures or pictures. The report narrative must define the extent of contamination vertically and horizontally determined by the sampling effort and identify any data gaps that remain. Soil boring logs, complete copies of field notes, laboratory data packages, and CSP laboratory review checklists must be included in the report. CSP checklists can be found at: http://dec.alaska.gov/spar/csp/guidance_forms/csguidance.htm

Refer to CSP's *Site Characterization Work Plan and Reporting Guidance* at: http://dec.alaska.gov/spar/csp/guidance_forms/csguidance.htm for further guidance on reporting elements. These may vary on a site-specific basis.

Appendix A – References

ADEC, 2002, Underground Storage Tank Manual ADEC, 2005, Conceptual Site Model Policy Guidance

ADEC, 2006, Biogenic Interference and Silica Gel Cleanup Technical Memorandum ADEC, 2008, Cumulative Risk Guidance

ADEC, 2008, Guidelines for Total Organic Carbon (TOC) Sample Collection and Data Reduction for Method Three and Method Four

ADEC, 2013, Monitoring Well Guidance

ADEC, 2009, Draft Guidance on Multi Increment Soil Sampling ADEC, 2012 Vapor Intrusion Guidance

ADEC, 2009, Arsenic in Soil

ADEC, 2009, Ecoscoping Guidance

ADEC, 2009, Risk Assessment Procedures Manual

ADEC, 2009, Site Characterization Work Plan and Reporting Guidance for Investigation of Contaminated Sites (2009)

ADEC Amended April 2009, Drinking Water Regulations, 18 AAC 80. Alaska State Regulation 18 AAC 75

Alaska State Regulation 18 ACC 78

ASTM D1586-08, ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

ASTM D4840-99 Standard Guide for Sample Chain-of-Custody Procedures

ASTM D5088-02(2008) Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites.

ASTM D6001-96, Direct Push Water Sampling for Geoenvironmental Investigations

ASTM D6418 – 09 Standard Practice for Using the Disposable En Core Sampler for Sampling and Storing Soil for Volatile Organic Analysis

ASTM D6911-03 Standard Guide for Packaging and Shipping Environmental Samples for Laboratory Analysis

Alabama Department of Environmental Management, Land Division

General Guidance for Selecting Petroleum Hydrocarbon Field Screening Methods, IT Corporation and U.S. Army Cold Regions Research and Engineering Laboratory, June 1999.

Indiana Department of Environmental Management, Risk Integrated System of Closure, User's Guide, Technical Guide: <http://www.in.gov/idem/4153.htm>

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Ritalahti, K. M., J. K. Hatt, E. Petrovskis, and F. E. Löffler. 2010a. "Groundwater sampling for nucleic acid biomarker analysis." In K. N. Timmis (ed.), *Handbook of Hydrocarbon and Lipid Microbiology*. Springer Berlin Heidelberg, Part 31, 10.1007/978-3-540-77587-4_265, pp. 3407-3418.

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USEPA, 1994, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)

USEPA, 1996, Low Stress (low flow) Purging and Sampling Procedures for the Collection of Ground Water Samples from Monitoring Wells

USEPA. 2000. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates. Second Edition. EPA/600/R-99/064, Duluth, MN.

International Atomic Energy Agency, 2003. *Collection and preparation of bottom sediment samples for analysis of radionuclides and trace elements*.

USEPA, 2001. *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual*. Office of Water; EPA-823-B-01-002.

USEPA, 2002, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers

USEPA, 2002, Guidance on Choosing a Sampling Design for Environmental Data Collection

USEPA, 2002, Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites

USGS. 1995. Guidelines for collecting and processing samples of stream bed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program, by Larry R. Shelton and Paul D. Capel. U.S. Geological Survey Open-File Report 94-458, revised 1995.

USGS East-Coast sediment analysis: Procedures, database, and georeferenced displays, Chapter 1: Grain-size analysis of marine sediments: methodology and data processing. Open-file Report 00-358 <http://pubs.usgs.gov/of/2000/of00-358/text/chapter1.htm>

Appendix B – Initial Comparison for Selecting the Appropriate Field Screening Method for Petroleum Hydrocarbons

Field Screening Method Categories	Principle Used To Detect & Measure Petroleum Hydrocarbons	Detectable Target Analytes	Effects Caused by Weathered Petroleum Hydrocarbons	Data Quality Objectives	Applicable Concentration Ranges
<i>Colorimetric Wet Chemistry</i>	Colorimetric reagents mix with petroleum hydrocarbons providing a visual response	Petroleum hydrocarbons	Bias is minimal	Qualitative	Yes (petroleum hydrocarbon present) No (petroleum hydrocarbon not present) at a concentration >300 ppm
<i>Headspace Organic Vapor Monitoring</i>	Vapor phase volatile hydrocarbons are ionized or passed through colorimetric reagents for detection	Volatile organic compounds	Low bias due to loss of volatile organic compounds	Semi-quantitative	1.0 to >10,000 ppm
<i>Immunoassay</i>	Some kits are selective for BTEX and aromatic compounds, while other kits are selective for aliphatic compounds	Gasoline, Diesel Fuel, and Heavier Fuels OR Oils	Low bias using test Methods that quantify using BTEX and other aromatic compounds	Quantitative or Semi-quantitative	100 to >25,000 ppm; Semi-quantitative methods provide a greater than/less than to two calibration point concentrations
<i>Infrared Spectrophotometry</i>	Method measures infrared adsorption of C-H bonds present in all organic compounds	Gasoline, Diesel Fuel, and Heavier Fuels or Oils	No bias	Quantitative	100 to >25,000 ppm
<i>Qualitative Physical Screening Methods</i>	Physical properties are used to determine if petroleum hydrocarbons are present	Petroleum hydrocarbons	Bias is minimal	Qualitative	Yes (petroleum hydrocarbon present) No (petroleum hydrocarbon not present)

Appendix C – Technical and Logistical Screening Method Comparison

Field Screening Method Categories	Factors Affecting Accuracy	Factors Affecting Precision	Training and Required Expertise	Interferences		Waste Byproducts	Logistic Considerations	Comments
				Cause	Effect			
<i>Colorimetric Wet Chemistry</i>	Weathered petroleum mixtures	Soil heterogeneity	Qualified Environmental Professional is necessary	Moisture	Low bias from dilution	Petroleum Hydrocarbons Colorimetric reagent mixture	No significant considerations	Test kit literature should be reviewed during the selection process
<i>Headspace Organic Vapor Monitoring</i>	Moisture, weathered petroleum mixtures, operator error	Soil heterogeneity and operator error	Qualified Environmental Professional is necessary	Moisture and non-target analytes that respond to ionization detector instruments	Erroneous readings	Empty gas cylinders used to store calibration gases	Shipping of USDOT hazardous substances (isobutylene, hydrogen, and methane)	Most ionization detectors are limited by altitudes greater than 4,000 feet and temperatures less than 40°F
<i>Immunoassay</i>	Moisture, weathered petroleum mixtures, multiple petroleum mixtures, operator error	Soil heterogeneity and operator error	Training of Qualified Environmental Professional is recommended by test kit manufacturers	Moisture and biological organic matter	Low bias High bias	Methanol and Enzymatic reagent wastes	Shipping of USDOT hazardous substances (methanol). Some methods require low temperature preservation	Manufacturer literature should be consulted during the field screening method selection process
<i>Infrared Spectrophotometry</i>	Operator error	Soil heterogeneity and operator error	Trained chemist support necessary	Moisture and biological organic matter	No bias Limited bias with high concentrations	Methanol; hexane; possibly chlorinated solvent wastes	Shipping of USDOT hazardous substances (methanol, hexane, or other chlorinated solvents)	Biological organics and moisture removed during sample extraction process. Excessive quantities of the biological organics may overwhelm the silica gel
<i>Qualitative Physical Screening Methods</i>	Soil adsorption and weathering of petroleum product	Soil heterogeneity	Qualified Environmental Professional is necessary	Natural organic materials	Limits visibility	Petroleum; soil and water mixture	No significant considerations	Warm water sheen test and direct visual observation

Appendix D – Sample Collection Reference Guide – Soil, Sediment, Sludge, Fill Material

Parameter	Analytical Method ¹	Container Description (Minimum) [Clear glass may be substituted for amber if samples are protected from exposure to light]	Preservation/ Holding Time
Gasoline Range Organics**	AK101*	4 oz. amber glass, TLS	Methanol preservative, 0° to 6°C / 28 days
Diesel Range Organics	AK102*	4 oz. amber glass, TLC	0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Residual Range Organics	AK103*	4 oz. amber glass, TLC	0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)** ⁴	8021B or 8260B or 8260C	4 oz. amber glass, TLS	Methanol preservative, 0° to 6°C / 14 days
Volatile Organic Compounds (VOCs) ⁴	8260C or 8260B or 8021	4 oz. amber glass, TLS	Methanol preservative, 0° to 6°C / 14 days
1,4-Dioxane ⁶	8260C or 8260B	4 oz. amber glass, TLS	Methanol preservative, 0° to 6°C / 14 days
Semi-volatile Organic Compounds (SVOC)	8270D	4 oz. amber glass, TLC	0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Polynuclear Aromatic Hydrocarbons (PAH) ²	8270D or 8310	4 oz. amber glass, TLC	0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Pesticides	8081B or 8270D	4 oz. amber glass, TLC	0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Herbicides	8151A	4 oz. amber glass, TLC	0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Polychlorinated Biphenyls (PCBs) ⁵	8082A	4 oz. amber glass, TLC	0° to 6°C / None, 40 days to analysis of extract (recommended)
Perfluorinated Alkyl Acids	Consult with CS Program for Method, Container, and Holding Times		
Metals † except Mercury	6010C or 6020A	100mL Wide mouth HDPE or amber glass	None / 6 ⁷ months
Mercury	7471B or 6020A	100mL Wide mouth HDPE or amber glass	0° to 6°C / 28 days

Notes:

Several of the 7000 series methods have been deleted from SW846 but these methods may still be approved in a CSP site-specific work plan. Check the laboratory's approval status.

¹ Unless otherwise noted, all preparation and analytical methods refer to the most current of EPA's Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, adopted by reference in 18 AAC 78.090(i).

² Naphthalene can be analyzed by 8021B or 8260C, if naphthalene is the only PAH contaminant of concern; however methods 8270D or 8310 are preferred.

³ HDPE, High Density Polyethylene or amber glass sample collection bottles, certified clean for trace metals analysis.

⁴ May be analyzed out of AK101 methanol preserved sample, if not, then sample must be preserved with methanol in the field. Alternate volatile preservation methods for low concentration analysis per SW-846 method 5035A must be approved on a site-specific basis by the CS program prior to sample collection.

⁵ PCBs must be prepared using extraction method 3540C or 3550C.

⁶ High temperature sample preparation techniques by EPA Method SW-846 may be required to improve the recovery and achieve lower detection limits.

⁷ If bioassays or toxicity testing is to be conducted with metals, then anoxia may need to be maintained, and analyses should occur within 24 hours after sample collection, unless the test method dictates otherwise. Consult the CSP Project Manager for more project-specific guidance.

† Analytical method 6010C may be used for high contaminant level screening. These results can be used for closure only if laboratory reporting limits meet the site-specific cleanup levels. Analytical method 6020A is acceptable for closure.

* ADEC Analytical Methods AK101, AK102, and AK103 are included in Appendix D of the UST Procedures Manual.

** The AK101 method can be extended for specific determination of volatile aromatics (BTEX) as specified in EPA Method 8021B or 8260B for solids utilizing methanol preservation option only. All AK101 and volatile aromatic samples must be preserved with methanol.

Appendix E – Sample Collection Reference Guide – Groundwater, Surface Water, Marine Water, Drinking Water⁷, Wastewater

Parameter	Analytical Method ^{1,3,7}	Container Description	Preservation/ Holding Time
Gasoline Range Organics	AK101*	Duplicate or Triplicate 40 mL VOA, TLS	HCL to pH less than 2 / 0° to 6°C / 14 days
Diesel Range Organics	AK102*	min. 100 mL ² - 1 L amber glass, TLC	HCL to pH less than 2 / 0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Residual Range Organics	AK103*	min. 100 mL ² - 1 L amber glass, TLC	HCL to pH less than 2 / 0° to 6°C / 14 days to extraction, 40 days to analysis of extract
Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)	8021B or 8260B or 8260C	Duplicate or Triplicate 40 mL VOA, TLS	HCL to pH less than 2 / 0° to 6°C / 14 days
Volatile Organic Compounds (VOCs)	8021B or 8260B or 8260C	Duplicate or Triplicate 40 mL VOA, TLS	HCL to pH less than 2 / 0° to 6°C / 14 days
1,4-Dioxane ⁸	8260B or 8260C	Duplicate or Triplicate 40 mL VOA, TLS	HCL to pH less than 2 / 0° to 6°C / 14 days
Semi Volatile Compounds (SVOC)	8270D	1 L amber glass, TLC	0° to 6°C / 7 days to extraction, 40 days to analysis of extract
Polynuclear Aromatic Hydrocarbons (PAH) ⁵	8270D or 8310	1 L amber glass, TLS	0° to 6°C / 7 days to extraction, 40 days to analysis of extract
Pesticides	8081B or 8270D	1 L amber glass, TLC	0° to 6°C / 7 days to extraction, 40 days to analysis of extract
Herbicides	8151A	1 L amber glass, TLC	0° to 6°C / 7 days to extraction, 40 days to analysis of extract
Polychlorinated Biphenyls (PCBs) ⁶	8082A	1 L amber glass, TLC	0° to 6°C / None, 40 days to analysis of extract (recommended)
Perfluorinated Compounds	537	1 L HDPE with unlined no Teflon lid	0° to 6°C / 7 days to extraction, 30 days to analysis of extract
Metals † except Mercury	6010C or 6020A	min. 100 mL HDPE ⁴	HNO ₃ to pH less than 2 ⁹ / 6 months max. total holding time
Mercury	7470B, or 6020A	min. 100 mL HDPE ⁴	HNO ₃ to pH less than 2 / 28 days max. total holding time

Notes:

Several of the 7000 series methods have been deleted from SW846 but these methods may still be approved in a CSP site-specific work plan. Check the laboratory's approval status.

¹Unless otherwise noted, all preparation and analytical methods refer to the most current of EPA's Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, adopted by reference in 18 AAC 78.090(i).

²Minimum (100 mL) is listed for the modified "small volume" method. This requires a separate lab approval and is designated AK102-SV or AK103-SV. Verify the laboratory approval status for this method.

³Sample collection and laboratory analyses for water collected from drinking water sources must be done in accordance with 18 AAC 80 and appropriate drinking water methods.

⁴HDPE, High Density Polyethylene sample collection bottles, certified clean for trace metals analysis.

⁵Naphthalene can be analyzed by 8021B or 8260C, if naphthalene is the only PAH contaminant of concern; however, methods 8270D or 8310 are preferred.

⁶PCBs must be prepared using method 3510C, 3535A, or 3520C.

⁷Drinking water samples must be analyzed by the appropriate drinking water analytical methods as follows:

Volatile Organic Compounds (including BTEX, 1,2-DCA, MTBE): EPA 524.2

Ethylene Dibromide (EDB): EPA 504.1

Semi-volatile Organic Compounds (including PAHs): EPA 525.2

Polychlorinated Biphenyls (PCBs), Pesticides: EPA 508.1

Metals: EPA 200.8

⁸ High temperature sample preparation techniques by EPA Method SW-846 may be required to improve the recovery and achieve lower detection limits.

⁹ If total metals are analyzed, then acidification is acceptable. However, if metals are to be speciated, or if bioassays or toxicity testing is to be conducted with metals, then samples should not be acidified. Instead, store at 4°C in the dark and maintain anoxia. Conduct toxicity analyses within 24 hours of sample collection, unless the test method dictates otherwise. Consult the CSP Project Manager for more project-specific guidance.

* ADEC Analytical Methods AK101, AK102, and AK103 are included in Appendix D of the UST Procedures Manual.

† Analytical method 6010C may be used for high contaminant level screening. These results can be used for closure only if laboratory reporting limits meet the site-specific cleanup levels. Analytical method 6020A is acceptable for closure.

Legend:

Appendix D and E:

PAH = acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene

VOA = Volatile Organic Analysis

TLC = Teflon® lined screw caps

TLS = Teflon® lined septa sonically bonded to screw caps

Appendix F – Determination of Sampling and Lab Analysis for Petroleum in Soil and Groundwater, and Recommended Sampling Materials

Product Type	GRO ¹	DRO	RRO	BTEX ^{1,2}	PAHs ^{3,4,5}	Other VOCs ^{1,2,3}	EDB ⁷ 1,2 DCA	MTBE	Metals ⁸	PCBs	PFOS & PFOA ¹⁰
Test Methods ⁹	AK101	AK102	AK103	EPA 8021B EPA 8260C	EPA 8260C ³ EPA 8270D EPA 8310	EPA 8021B EPA 8260C	EPA 8260C ^{1,6} EPA 8011 ⁶ EPA 504.1 ⁶	EPA 8260C	EPA 6010C EPA 6020A, or 7000 series	EPA 8082A	
Recommended Sampling Materials ¹¹	Glass, Teflon, HDPE, or Stainless Steel	Glass, Teflon, HDPE, or Stainless Steel	Glass, Teflon, HDPE, or Stainless Steel	Glass, Teflon, HDPE, or Stainless Steel	Glass, Teflon, or HDPE	Glass, Teflon, HDPE, or Stainless Steel	HDPE or Stainless Steel				
Site COPCs											
Leaded Gasoline	required			required	naphthalene only required	may be required by PM	required	may be required by PM	Total lead only		
Aviation Gasoline	required			required	naphthalene only required	may be required by PM	required	may be required by PM	Total lead only		
Unleaded Gasoline	required			required	naphthalene only required	may be required by PM		may be required by PM			
JP-4, Kerosene, Jet B	required	required		required	required	may be required by PM					
Diesel #1 or Arctic Diesel	required	required		required	required	may be required by PM					
#2 Diesel	required	required		required	required	may be required by PM					
JP-5, JP-8, or Jet A	required	required		required	required	may be required by PM					
#3-#6 Fuel Oils or Bunker C	may be required by PM	required	required	required	required	may be required by PM					
Crude Oil	required	required	required	required	required	may be required by PM					
Waste oil, used oil, or unknowns	required	required	required	required	required	required to test for solvents	required	may be required by PM	required	required	
Fire Training Facilities	required	required	required	required	required	may be required by PM					required

Notes:

¹ AK101 (GRO), BTEX, and VOC soil samples must be preserved in methanol.

² EPA 8260C may be required to evaluate non-BTEX volatile petroleum hydrocarbons, such as 1,2,4- and 1,3,5-trimethylbenzene, butylbenzene(s), etc. for vapor intrusion or other applicable pathways to protect human health and the environment.

³ Naphthalene can be analyzed by 8021B or 8260C, if naphthalene is the only PAH contaminant of concern; however, methods 8270D or 8310 are preferred.

⁴ PAHs must include acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, flourene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene.

⁵ For each source area, PAH analysis must be performed on a sufficient percentage of the samples of the most likely contaminated locations based on field readings/site observations/previous sampling data to determine if PAHs are contaminants of concern. For each source area this would include the most likely contaminated location in the excavated soil and the most likely contaminated excavation location of what is left in the excavation. In general, analyzing 10% of the samples for each source area is a sufficient number for site characterization. If PAH concentrations are less than applicable cleanup levels, further PAH analysis is generally not required. PAHs must be sampled in groundwater if soil sample concentrations are above applicable cleanup levels and groundwater sampling is required.

⁶ EPA 8260C is required for the analysis of 1,2-Dichloroethane (1,2-DCA). EPA 8011 or EPA 504.1 must be used when evaluating ethylene dibromide (EDB). EDB soil samples must be collected with zero headspace and cooled to less than 6°C. EPA 8260 will quantify EDB in ground water; however, the detection limits do not meet the Table C cleanup level of 0.00005 mg/L.

⁷ For each source area, EDB analysis must be performed on a sufficient percentage of the samples of the most likely contaminated locations based on field readings/site observations/previous sampling data to determine if EDB is a contaminant of concern. For each source area this would include the most likely contaminated location in the excavated soil and the most likely contaminated excavation location of what is left in the excavation. In general, analyzing 10% of the samples for each source area is a sufficient number for site characterization. If EDB concentrations are less than applicable cleanup levels, further EDB analysis is generally not required. EDB must be sampled in groundwater if soil sample concentrations are above applicable cleanup levels and groundwater sampling is required.

⁸ Metals must include arsenic, cadmium, chromium, mercury, and lead, unless otherwise noted. For CERCLA sites include silver and selenium along with arsenic, barium, cadmium, chromium, mercury, and lead.

⁹ Drinking water samples must be analyzed by the appropriate drinking water analytical methods as follows:

Volatile Organic Compounds (including BTEX, 1,2-DCA, MTBE): EPA 524.2

Ethylene Dibromide (EDB): EPA 504.1

Semi-volatile Organic Compounds (including PAHs): EPA 525.2

Polychlorinated Biphenyls (PCBs): EPA 508.1

Metals: EPA 200.8

TAH and TAqH may also be required for groundwater that is in contact with surface water.

¹⁰ To prevent interference and adsorption, Teflon and glass must not be used during sampling or storage for samples destined for analysis of perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), or other perfluorinated compounds (PFCs).

¹¹ Samples should be collected using the specified materials above (i.e. tubing, bladders, containers, etc.) to prevent any sampling bias.