This ITRC Passive Sampling document details different passive sampling techniques across multiple media. Different types of media require specific considerations and have their own unique complications. The previous ITRC Passive Sampling documents identified passive sampling techniques that were mostly applicable to groundwater. The types of media discussed in this document are groundwater, surface water, pore water, sediment, soil gas, indoor/outdoor air, soil, and NAPL.

Table 2-1 includes a comprehensive list of passive sampling devices presented in this document, the type of sampling technology, and the applicable media. Although the technologies included below can produce quantitative results, qualitative data may also be acquired.

Table 2-1. Passive samplers by media type

Sampling Device	**Technology Type**	**Groundwater**	**Surface Water**	**Pore-Water**	**Sediment**	**Soil Gas**	**Indoor Air***	**Outdoor Air***	**Soil**	**NAPL**
Thin Walled Soil Sampler	Grab								●	●
Snap Sampler	Grab	●	◐							
HydraSleeve	Grab	●	●							
Rigid Porous Polyethylene Sampler (RPPS)	Equilibration	●	●	●						
Regenerated Cellulose Dialysis Membrane Sampler (RCDM)	Equilibration	●	●	●						
Polymeric Sampling Devices	Equilibration	●	●	●		●	●	●		
Peeper Sampler	Equilibration	●	●	●						
Passive Diffusion Bag (PDB)	Equilibration	●	●	●						
Nylon Screen Passive Diffusion Sampler (NSPDS)	Equilibration	●	●	●						
Dual Membrane Passive Diffusion Bag Sampler (DMPDB)	Equilibration	●	●	●						
Ceramic Diffusion Sampler / Ceramic Dosimeter	Equilibration	●	●	●						
Waterloo Membrane Sampler	Accumulation					●	●	●		

Sampling Device	Technology Type	Groundwater	Surface Water	Pore-Water	Sediment	Soil Gas	Indoor Air*	Outdoor Air*	Soil	NAPL
Sentinel	Accumulation	●	●	●						
Semipermeable Membrane Devices (SPMDs)	Accumulation	●	●	●		●	●	●		
Radiello Sampler	Accumulation						●	●		
Polar Organic Chemical Integrated Sampler (POCIS)	Accumulation	●	●	●						
Mineral Samplers (Min-Traps)	Accumulation	●								
Fossil Fuel Traps	Accumulation					●				●
Diffusion Gradient in Thin Films (DGT) Sampler	Accumulation	●	●	●						
Dart Sampler	Accumulation				●				●	●
Bio-Trap Sampler	Accumulation	●	◐							
Beacon Sampler	Accumulation					●	●	●		
AGI Universal Sampler (formerly the Gore Sorber)	Accumulation	●	●	●		●	●	●		
Passive In Situ Concentration Extraction Sampler (PISCES)	Accumulation		●							

2.1 Terminology

For the purposes of this document each medium is described as follows:

- **Groundwater** is water that can be found in the subsurface in the pore spaces within soil, sand, and rock and is accessed by monitoring wells. Although groundwater does exhibit a flow direction, its velocities are typically much slower than surface water.
- **Surface water** is permanent or recurring water open to the atmosphere under either high-flow (for example, rivers or streams) or low-flow (for example, ponds, oceans, wetlands, or lakes) conditions. Surface water features are fed from a collection of sources, such as groundwater exfiltration, upstream tributaries, precipitation, storm water runoff, wastewater, or snowmelt. Surface water features can persist all year long, or in shorter durations, such as seasonally or tidally. Surface water is primarily differentiated from temporary stormwater features because it is not a direct result of a single or short-term precipitation event. Although most surface water flows

toward oceans, it may also undergo infiltration into groundwater aquifers where the ground surface is higher than the prevailing water table.

- **Pore water** in this document refers to *sediment* pore water rather than *soil* pore water. In the context of this document, pore water is described as water located within the pore spaces between sediment particles that may represent the mobile water interacting between groundwater and surface water within permanent surface water features or intermittently flooded features (such as seasonal streams, intertidal zones, or stormwater swales/basins).
- **Soil** is a solid medium consisting primarily of inorganic particles (but may contain organic matter, water, and air). Soil development involves time and a stable ground surface (bedrock or unconsolidated material), differentiating it from sediment.
- **Sediment** is a medium consisting of primarily solid minerals and/or organic particles that are deposited by water or wind transportation. Sediments may be deposited at the bottom of permanent surface water features (such as rivers or streams) or located along the surface of intermittently flooded features (such as seasonal streams, intertidal zones, or stormwater swales/basins). Sediments may be moved and deposited in new locations over short-term events, differentiating it from soil that remains in one location.
- **Soil gas (soil vapor)** is gaseous elements and chemicals in the spaces between soil particles within the vadose zone. The soil gas may contain chemicals in a gaseous phase that are targeted for environmental investigation.
- **Indoor air** is the air present within buildings and structures that may be closed or sealed from exterior air.
- **Outdoor air** in this document refers to the air present outside of buildings and structures or from within structures that cannot be sealed from external sources.
- **NAPL** is the acronym for “nonaqueous phase liquid” and refers to typically organic liquids that are immiscible or not soluble in water. There are two types of NAPL: light nonaqueous phase liquids (LNAPL), which are less dense than water, and dense nonaqueous phase liquids (DNAPL), which are denser than water.

2.2 Media Conditions Affecting Sampling Approach

Each medium is described by a specific set of physical conditions that affect the fate and transport of chemicals within the medium. These physical conditions must be considered when trying to extract a sample that represents the temporal-spatial extent and concentrations of the chemicals of interest. Some of these considerations affect decisions about the method of acquiring a sample. The considerations below serve as examples to encourage thoughtfulness about factors that can affect sample integrity on specific sites.

2.2.1 Groundwater Considerations

Technical Considerations

Groundwater flows directionally, at a slow rate, through a variable granular medium or through cracks and fissures within a solid medium, at some depth below the ground surface, frequently in defined geological strata. Because there is no direct access, a conduit-like structure (that is, a groundwater well) is typically required to provide access to groundwater.

This combination of hydraulic, geologic, and well construction conditions influences the transport of chemicals present in the soil and groundwater and whether a water sample taken from a specific monitoring well represents the water quality in the target aquifer (groundwater) or not. The location of the well casing and screen in relation to the groundwater level, target aquifer, and aquifer flow conditions are factors for consideration. Additionally, water in the blank casing is isolated from aquifer flow, interacts with air in the casing, may further interact with well construction materials over time, and may be subject to leakage from surface runoff (Puls and Barcelona 1996 [LBCSV95N] Puls, Robert W., and Michael J. Barcelona. 1996. Ground Water Issue: LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES. EPA/540/S-95/504. USEPA. https://www.epa.gov/sites/default/files/2015-06/documents/lwflw2a.pdf.). Therefore, to optimize the conditions needed to collect a sample representing the aquifer, the sampling device should be placed within the saturated portion of the screen of a cased well or in the water-bearing interval of an open-borehole well in fractured bedrock aquifers.

Allowing a sampling device to remain in the well until the well has returned to natural flow conditions is called the minimum residence time. This accounts for things such as displacement and mixing, and is dependent on the rate of groundwater flow through the well.

Vertical Interval Sampling Considerations

Hydrogeologic conditions may cause variations in flow rates and/or geochemistry at different vertical intervals when groundwater sampling. When hydrogeologic conditions vary vertically within an aquifer, it is possible that concentrations of targeted chemicals may also vary with depth.

When active sampling methods are used, the concentration of chemicals in the sample collected represents a flow-weighted average across the length of the saturated open interval ( ). Although this is also generally true of passive samples due to a typical condition of natural mixing within the saturated screen interval, passive samples also can be said to represent the groundwater at the depth of placement in the well (mixed or otherwise). In the case of horizontal flow through the screen at that (passive sample) interval, then the sample may represent the groundwater at that same depth in the adjacent aquifer.

When sampling long-screen wells, known conditions may suggest the use of a vertical flow meter and other geophysical logging tools to evaluate vertical flow and mixing in the open interval and whether passive samples may represent specific depths of the adjacent aquifer. In this case, the well may be suitable for vertical profiling to determine optimum sampler placement and to monitor discrete intervals. To determine the geochemical variation over the open or screened interval of a well with longer screens, it is suggested the initial use of multiple passive samplers over the length of the saturated screen to vertically and chemically profile the well. These chemical results, combined with the borehole flow meter and geophysical logging results, can give a better idea of the depth to deploy passive samplers during sampling events. Passive and active samples from wells with shorter screen intervals (for example, 10 feet or less) are generally expected to provide similar results without the need for vertical profiling.

Site-specific Considerations
Site conditions vary widely and are important to consider prior to, and during, groundwater sampling events because the conditions may affect the ability to acquire a representative sample, maintain personnel safety, and minimize the generation of waste for disposal. Although there are many additional considerations when setting up any groundwater sampling program, the following are several examples of site-specific conditions that may help determine whether or how to use passive sampling methods.

Site Access: If there are seasonal conditions (for example snow, ice, swampy, or tidal conditions) or environmental or biological concerns (for example, tick season, bird nesting season, etc.) that render the wells difficult to access, or limit the equipment that can be delivered to the wells during certain times of the year, passive sampling may be desirable because there can be less equipment involved and the equipment tends to be less bulky or heavy than pumping equipment, making it easier to reach the site. High-traffic sites can cause logistics problems, delays, and safety issues for personnel, so limiting the time and equipment needed at the site by using passive sampling devices is often desirable.

Water Level Changes: If water levels fall or rise, the installed depth of passive samplers may need to be adjusted so that the zone sampled by the passive device remains within the saturated screen as conditions change. The length of saturated screen should be reviewed to be sure the method can still obtain adequate sample volume. Consideration should also be given to how the vertical change affects the source and flow of water through the well because these may affect sample results. Active sampling methods may produce samples that result in greater blend from a longer screen interval or a more concentrated blend of water from a shorter interval. At sites with nearby pumping wells or major surface water affecting groundwater, localized changes in groundwater flow direction can result. Because passive samplers sample the water flowing through the well, they can provide insights into chemical movement affected by the surrounding conditions. Active sampling methods, such as pumping, add another variable to where the sample originates because they induce flow toward the well.

Well Construction: It is important to first determine whether the type of sampling equipment will fit within the constraints of the well casing diameter, the depth from which the sample must be recovered, and the required sample volume. There are not many options for pumps that will fit wells smaller than 2 inches in diameter, but there are several passive samplers that can be used in wells as small as 1-inch diameter. As well sampling depths increase, it becomes increasingly difficult for pumps to lift water to the surface and may add to the type and cost of sampling equipment required; most passive sampling methods simply require a longer suspension tether and reel to hold the tether. Because passive samplers are limited to the volume of water in the well and should be used only to sample within the screen interval, the length of saturated screen or water-producing fractured-bedrock interval in open-hole wells should be determined before selecting the sampling method to be sure there is adequate sample volume for the laboratory method. To facilitate the use of passive samplers, sampler selection should include coordination with laboratories to determine the minimum sample volume required to meet data quality objectives (DQOs). In the case where new wells are being designed, screen placement should intersect the zones of suspected contaminant contribution.

Investigation-Derived Waste (IDW) Disposal: Local regulations and site capabilities dictate how purge water from active sampling methods is disposed (ITRC 2023 [55DMC29X] ITRC. 2023. "PFAS Technical and Regulatory Guidance Document and Fact Sheets." Interstate Technology & Regulatory Council, PFAS Team. https://pfas-1.itrcweb.org/.). Passive sampling methods produce little to no purge water (IDW) for disposal.

2.2.2 Surface Water Considerations

Careful judgment must be used to balance safety precautions with sampling objectives when developing and implementing surface water sampling strategies. Surface water samples are typically collected by either (1) inserting or placing the sample bottle/jar directly into the water body or (2) decanting water from a clean (that is, contaminant-free) container such as a ladle, scoop, bottle, or bowl. The physical actions needed to collect the sample may seem simple. However, accessing ideal/preferred sampling locations and depth intervals needed to satisfy data objectives can often be dangerous or impractical because of difficult and/or remote site conditions. This is because streams, rivers, and lakes are often secluded and surrounded by uneven surfaces, steep/slippery slopes, steep drop-off points, eroded banks, jagged rock piles, deep soft/muddy areas, sinkhole-like conditions, and other dangerous or unnavigable terrain. Water current can be a safety hazard for medium to large rivers and streams. Other hazards may include watercraft traffic, fencing, sharp surfaces or jagged edges from debris or structures, insects, snakes or other wildlife, or property line/trespassing issues. For example, it can be difficult to collect a surface water sample from the middle of a large wastewater settling pond/impoundment that is hundreds of feet long and wide, has steep slippery walls covered with an expensive liner fabric that must be safeguarded to maintain liner integrity, and the surface of the wastewater is more than 30 feet below ground surface/walkways around the pond. In this example, there is no easy or safe way to deploy a boat to collect a sample further out than points along the sides of the impoundment. Even collecting a sample from the water's edge would be a challenge because of the slippery 30-foot drop with no proper footing that would allow samplers to reach the surface of the pond without harnesses and/or attaching the sampling devices to long poles that would increase the difficulty of the sampling task.

Limitations of sampling approaches vary when sampling fast-moving water, slow-moving water, or stagnant water. The sampling strategy must be carefully orchestrated to collect samples that are representative of conditions that address the project objectives. Logistics need to be planned and executed so that the sampling team can obtain quality samples from various depth intervals and/or representative of upstream/background water quality conditions. When the surface waters being sampled are shallow enough to allow samplers to wade into the water, especially when there is significant flow velocity, sampling should be performed carefully and methodically to reduce disturbance of bottom sediments. If multiple samples are to be collected in a river or stream, it is important to collect downstream locations first and move progressively upstream to collect additional samples so that downstream locations are not affected by suspended/disturbed upstream sediment material. If a river or stream is too deep to wade and/or conditions are deemed unsafe, samples can be collected from an elevated platform (bridge, retaining wall, etc.) or boat using supplemental sampling equipment such as a plastic bucket attached to a rope.

The logistics required to collect surface water samples for a particular project and whether the samples collected are used for screening purposes or to obtain quantitative data for site characterization will generally determine the most appropriate sampling devices needed to satisfy the DQOs. A strong and dynamic project work plan should identify strategic sampling locations that account for the site-specific conditions and provide enough flexibility to allow field personnel to make changes that account for unanticipated adverse conditions, including variations in flow patterns, areas of pooling/stagnant water, point-source discharges from adjacent/upstream locations, and other unforeseen conditions that may influence or impact concentrations within background and downstream locations. It is possible to select a sampling approach that will help simplify the sample collection process and determine how intermediate steps such as adding sample preservatives should be accomplished, thereby saving time and reducing hazards. There are many sampling devices available, including glass and plastic bottles/containers, various ladles/scoops, long-handled and/or measuring cup–type devices, peristaltic pumps with tubing of various materials, and other specialty devices such as Van Dorn samplers. There are numerous equilibrium and accumulation type passive sampling technologies that may be used to accomplish various surface water sampling objectives, each with advantages and limitations that need to be examined.

2.2.3 Porewater Considerations

Pore water sample collection may be completed to understand the interaction between surface water and groundwater, to understand the bioavailable fraction of contaminants, and to support ecological evaluations. Groundwater is generally low in dissolved oxygen and enriched in inorganic solutes compared to surface water, so collection of physical and chemical parameters is recommended to compare each aqueous media. On-site collection of sediment pore water is completed by wading into surface water bodies, deployment by a diver, or from a platform or boat. Water currents and traversing soft sediment surfaces are often primary concerns when wading into shallow water bodies, and consideration should be taken when accessing sampling locations. Additional health and safety considerations related to working in and around water bodies include those described in the **Section 2.2.2** above, such as accessing water bodies, boat deployment considerations, biological hazards, and complying with local regulations. In deeper waters, divers may be required for sample collection, but this adds concerns for logistics as well as health and safety that are not discussed here. When wading into surface water bodies or collecting sediment samples, it is important to limit disruption of bottom sediments, which may bias results. Enter the sampling area from a downstream location and proceed upstream during sample deployment and/or collection.

In the case of having to revisit a location, whether it be to collect confirmatory samples or retrieve samplers, additional concerns may need to be addressed. Samplers may be affected by boat traffic or human disturbance in the time between access events. If there is a need to revisit a sampling location, careful consideration should be given to appropriate ways to mark the sampling location and protect it from external hazards. It is recommended that an accurate GPS unit be used to record location area in conjunction with flagging or marking of a sample location. Appropriate signage may be used to warn potential visitors to the sampling location and provide contact information.

A primary consideration during pore water sample collection is surface water intrusion into the sample. This is more of a concern for point samplers, as passive samplers have time to integrate ambient conditions, but it should be considered in all situations. Surface water may infiltrate the sample if a preferential pathway is provided by the sampling device. Mitigation strategies may be implemented, such as use of a sampling flange, especially if the target sampling interval is near the sediment surface. However, investigators should confirm that sampler and flange construction material will not cross-contaminate the sample. Aside from sampler or flange insertion, care should be taken to avoid disturbing the sampling area.

Quality assurance/quality control samples and background samples are another component of an investigation. Identifying locations for background and duplicate samples is a critical part of determining the performance and validity of samplers during investigation or remedial monitoring.

Pore water sampling data can be a tool used during an ecological evaluation to understand the bioavailable fraction of contaminants. Typically, this bioavailable fraction provides a stronger relationship (compared to bulk sediment) for predicting contaminant concentrations in benthic receptors. This subsequently can influence cleanup decisions and long-term monitoring at sediment sites. Freely dissolved concentrations (C_{free}) of hydrophobic organic compounds (HOCs) in pore water represent the actual bioavailable fraction of those compounds and provide useful information for risk assessment rather than bulk sediment/soil concentrations (Imbrigiotta and Harte 2020 [9LSVPE48] Imbrigiotta, Thomas, and Philip Harte. 2020. “Passive Sampling of Groundwater Wells for Determination of Water Chemistry.” In U.S. Geological Survey Techniques and Methods. https://doi.org/10.3133/tm1d8.; Burgess 2012 [DQ5ELCGU] Burgess, Robert. 2012. Guidelines for Using Passive Samplers to Monitor Organic Contaminants at Superfund Sediment Sites. OSWER Directive 9200.1-110 FS. USEPA. https://semspub.epa.gov/work/HQ/175405.pdf.)

). Polymeric sampling devices such as low-density polyethylene (LDPE) and solid phase microextraction (SPME) fibers coated with polydimethylsiloxane (PDMS), and polyoxymethylene (POM) have been used to determine C_{free} of HOCs in pore water.

Ex Situ vs. In Situ Pore Water Sampling

Most of the passive samplers discussed in this document are deployed in environmental media in the field, which is called in situ deployment. For pore water sampling, in situ deployment is preferred when it is critical to understand the influence of the field conditions, such as groundwater intrusion, currents, bioturbation, depth-varying chemical concentration profiles, and sediment-water column gradients and fluxes (Ghosh et al. 2014 [T8GHY3EM] Ghosh, Upal, Susan Kane Driscoll, Robert M. Burgess, et al. 2014. “Passive Sampling Methods for Contaminated Sediments: Practical Guidance for Selection, Calibration, and Implementation.” Integrated Environmental Assessment and Management 10 (2): 210–23. https://doi.org/10.1002/ieam.1507.). However, achieving equilibrium between polymeric sampling devices and pore water by the in situ approach is often difficult or practically impossible within a reasonable timeframe for strongly HOCs such as dioxin/furans because the uptake kinetics of strongly HOCs to polymeric sampling devices are particularly slow.

Placement of passive samplers is often difficult in deep waters or in water where divers are not easily deployed. In such cases, conventional sediment grab or coring can be used to collect sediment samples, and passive samplers are placed in the collected sediments under controlled laboratory settings, which is called ex situ deployment. Polymeric sampling devices, diffusive gradient in thin films (DGT), or other passive samplers can also be deployed under controlled laboratory settings to determine dissolved-phase pore water concentrations of target chemicals (Burgess et al. 2017 [97JRK4GH] Burgess, R. M., S. B. Kane Driscoll, A. Burton, et al. 2017. Laboratory, Field, and Analytical Procedures for Using Passive Sampling in the Evaluation of Contaminated Sediments: User's Manual. User's Manual EPA/600/R-16/357. USEPA and SERDP-ESTCP. https://semspub.epa.gov/work/HQ/100000146.pdf.). For example, in the ex situ deployment approach of polymeric sampling devices, field-collected sediments or soils are brought to a laboratory and polymeric sampling devices are deployed under static or well-mixed conditions to attain equilibrium partially or fully between the polymeric sampling devices and pore water.

Ex situ sampling with well-mixed sediment slurry samples can achieve equilibrium more quickly than in situ sampling, and it has been accepted for partitioning investigations, treatability testing, and sediment toxicity assessment (Ghosh et al. 2014 [T8GHY3EM] Ghosh, Upal, Susan Kane Driscoll, Robert M. Burgess, et al. 2014. "Passive Sampling Methods for Contaminated Sediments: Practical Guidance for Selection, Calibration, and Implementation." Integrated Environmental Assessment and Management 10 (2): 210–23. https://doi.org/10.1002/ieam.1507.; Michalsen et al. 2018 [IEVQDPQE] Michalsen, Mandy, Danny Reible, Adesewa Aribidara, et al. 2018. Standardizing Polymeric Sampling for Measuring Freely-Dissolved Organic Contaminants in Sediment Porewater. Standardized Method Memo ER-201735. ESTCP. https://apps.dtic.mil/sti/pdfs/AD1084245.pdf.). Pore water concentrations of HOCs based on in situ and ex situ sampling generally agreed within a factor of two to three (Apell and Gschwend 2016 [CA63XU9R] Apell, J. N., and P. M. Gschwend. 2016. "In Situ Passive Sampling of Sediments in the Lower Duwamish Waterway Superfund Site: Replicability, Comparison with Ex Situ Measurements, and Use of Data." Environmental Pollution 218: 95–101.; Reininghaus et al. 2020 [VJYVK4C3] Reininghaus, M., T. F. Parkerton, and G. Witt. 2020. "Comparison of In Situ and Ex Situ Equilibrium Passive Sampling for Measuring Freely Dissolved Concentrations of Parent and Alkylated Polycyclic Aromatic Hydrocarbons in Sediments." Environmental Toxicology and Chemistry 39: 2169–79.). The ex situ deployment approach is simpler to perform but should be carefully planned and designed. Key steps involved in performing ex situ deployment of polymeric sampling devices are described in detail elsewhere (Ghosh et al. 2014 [T8GHY3EM] Ghosh, Upal, Susan Kane Driscoll, Robert M. Burgess, et al. 2014. "Passive Sampling Methods for Contaminated Sediments: Practical Guidance for Selection, Calibration, and Implementation." Integrated Environmental Assessment and Management 10 (2): 210–23. https://doi.org/10.1002/ieam.1507.; Burgess et al. 2017 [97JRK4GH] Burgess, R. M., S. B. Kane Driscoll, A. Burton, et al. 2017. Laboratory, Field, and Analytical Procedures for Using Passive Sampling in the Evaluation of Contaminated Sediments: User's Manual. User's Manual EPA/600/R-16/357. USEPA and SERDP-ESTCP. https://semspub.epa.gov/work/HQ/100000146.pdf.; Michalsen et al. 2018 [IEVQDPQE] Michalsen, Mandy, Danny Reible, Adesewa Aribidara, et al. 2018. Standardizing Polymeric Sampling for Measuring Freely-Dissolved Organic Contaminants in Sediment Porewater. Standardized Method Memo ER-201735. ESTCP. https://apps.dtic.mil/sti/pdfs/AD1084245.pdf.; Jonker et al. 2020 [J4PNQM7R] Jonker, Michiel T. O., Robert M. Burgess, Upal Ghosh, et al. 2020. Ex Situ Determination of Freely Dissolved Concentrations of Hydrophobic Organic Chemicals in Sediments and Soils: Basis for Interpreting Toxicity and Assessing Bioavailability, Risks and Remediation Necessity. 15: 1800–1828. https://www.nature.com/articles/s41596-020-0311-y.).

Passive samplers described in this document for sediment pore water collection include a variety of equilibration and accumulation samplers.

2.2.4 Sediment Considerations

As described in the above sampling considerations sections for surface water and pore water sampling, similar health and safety concerns are applicable when collecting sediment samples to support environmental investigation or remediation activities. Accessing preferred sampling locations often poses logistic challenges, including but not limited to traversing across uneven or unnavigable surfaces, biological hazards, transportation of materials required for sampling, and complying with applicable regulations in and around water bodies. Prior to completion of sediment collection, a formalized health and safety plan and a field sampling plan should be prepared to address these considerations.

Sediment is often heterogeneous, so a variety of factors should be considered when determining appropriate sample depths and locations, such as surface water flow rates, tidal influence, physical and chemical properties of the sediments, and co-location of other sampling media, such as surface water or pore water. Investigators should also consider project goals when collecting sediments: are targeted discharges or discrete sample depths the focus of investigation versus understanding the greater ecological system?

Tidal influences may provide areas of higher contamination due to the presence of depositional or erosional environments, areas of sediment resuspension, and/or changes in chemical solubility resulting from varying salinity in surface water. Coarser media may not be representative of contaminant levels due to the physical properties of the sediments. It is important to confirm with the regulatory agency if there are sediment sample collection requirements such as grain size or total organic carbon analysis.

When collecting surface water and sediment concurrently, surface water samples should be collected first to avoid cross contamination from disturbed sediments during sampling activities. In addition, samples should be collected from the most downstream location first and continue sampling upstream. Care should be taken to minimize sediment disturbance during discrete sample collection to avoid cross contamination between depths, and appropriate techniques should be chosen to reduce loss of finer grained sampling media during collection. In addition, sampling personnel should be sure that any aqueous media entering the sample jar or bottle is representative of sediment conditions and has not been "washed" during sample extraction by overlying water.

If sediment samples are composited from multiple depths or homogenized as part of collection activities, considerations should include changes in chemical properties during mixing, thorough homogenization of the sample, and appropriate decontamination procedures.

The only passive sediment sampler that is described in this guidance document is the Dart sampler (**Section 5.3.10**).

2.2.5 Soil Gas Considerations

It is common to complete soil gas investigations for a wide range of uses, including vapor intrusion assessments, groundwater investigations, and subsurface source area delineations. Whether using passive sampling devices or collecting subsurface vapor in canisters, drilling is required to install a soil vapor point (temporary or extended use) and/or monitoring well. As such, health and safety concerns should be addressed ahead of time to ensure workers' safety and that subsurface utilities are not encountered during the drilling and probe/well installation.

The overall costs and length of soil gas investigations are also important considerations. Active soil gas methods can require well construction at a greater depth below ground surface (bgs) than with a passive soil gas sampler to ensure enough packing material can be installed. Ambient air is not sampled through short circuiting and the screen interval is not within the groundwater-saturated zone (Abreu and Schuver 2012 [43UDNI2M] Abreu, Lilian, and Henry Schuver. 2012. Conceptual Model Scenarios for the Vapor Intrusion Pathway. EPA 530-R-10-003. USEPA, Office of Solid Waste and Emergency Response. https://www.epa.gov/sites/default/files/2015-09/documents/vi-cms-v11final-2-24-2012.pdf.). The active methods for sampling soil gas rely on pumps or vacuum pressure from evacuated canisters, tubing, and fittings, which are susceptible to leakage. Both the construction methods and required sampling equipment can have high costs and take several mobilizations to complete characterization. Shallow passive soil gas sampling has the potential to complete the lateral delineation of a contaminant plume at a reduced cost and in less time. However, you must also consider vertical delineation of a contaminant plume, for which active soil vapor sampling methods may be more appropriate.

The chemicals sampled as part of a site investigation need to be considered when selecting a sampling method for soil gas. Passive samplers often have a much narrower chemical list compared to canister samples. Analytical results obtained from passive samplers require known sampling rates to back-calculate soil vapor concentrations. Careful consideration is needed to determine whether the passive sampler has known uptake rates for given chemicals at a site. Additionally, environmental factors such as temperature, humidity, wind speed, and barometric pressure can positively or negatively influence the accuracy of the resulting data. Thus, it may be necessary to measure these factors in the field.

It is always important to consider the DQOs for a site when deciding whether to use passive or active sampling for soil gas. Many states are not accepting passive soil gas data for risk assessments but will for screening purposes. It is best to check your state's guidance and contact the regulatory program when considering passive soil gas sampling for a specific remedial phase.

Compared to canisters, passive samplers are smaller and much easier to store, transport to the field, and ship to a lab for analysis. Additionally, passive samplers are often easier to deploy because they do not require power sources while sampling or field technician oversight during collection.

2.2.6 Indoor Air Considerations

There are some considerations specific to indoor air sampling, including variability of contaminant concentrations, flow and ventilation within a structure, background sources, and the added complication of human tampering. The same passive samplers can be used for soil gas and indoor air investigations. Sampler-specific considerations (for example, chemical selection, cost savings, etc.) identified in **Section 2.2.5** also apply to indoor air.

When assessing indoor air, many factors may influence contaminant concentrations within a structure and create significant temporal variability. Temporal variability may exist due to the structure's use by occupants, outside weather conditions, and/or heating ventilation, and air conditioning (HVAC) systems. Passive sampler deployment periods can range from days to weeks, which may help to overcome this variability compared to active/grab sampling methods. However, average concentrations representative of days to weeks may not adequately reflect short-term concentration spikes that could have toxicological significance for chemicals that represent short-term or acute exposure concerns.

Similar to soil gas considerations discussed in **Section 2.2.5**, contaminant uptake into passive samplers in an indoor environment is also influenced by temperature, humidity, and air flow. These factors are often influenced by how the building is used by occupants throughout a given day and even an entire season. Changes in the operational use of an HVAC system, frequency of doors and windows being opened, and changes in weather conditions can all influence seasonal variation. Differences can also be observed during varying shifts (that is, day versus night shifts) if processes change or even cease between shifts. It is important to understand how these influencing factors may affect the sampling accuracy for the passive sampler throughout the deployment period.

Indoor sources of chemicals being targeted may also provide an additional challenge when performing an indoor air survey. Field personnel should always consider the current building uses and perform building surveys that inventory all chemicals that are currently in use at the facility. Field personnel shall remove any products that may interfere with sampling results associated with the vapor intrusion assessment at least 24 hours before collecting a sample (USEPA 2015 [ZH2YKUR7] USEPA. 2015. "OSWER Technical Guide For Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air." USEPA, Office of Solid Waste and Emergency Response, June. https://www.epa.gov/sites/default/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf.; Guillot 2016 [JUGE4LGB] Guillot, Richard. 2016. "Ambient Air Sampling." USEPA, Science and Ecosystem Support Division, March 30. https://www.epa.gov/system/files/documents/2022-06/Ambient%20Air%20Sampling%28SESDPROC-303-R5%29_0.pdf.). This can help identify indoor sources prior to sampling.

Passive sampling devices are discrete and inconspicuous compared to canisters, which can reduce risk perception and tampering from building occupants. Small devices may go unnoticed by occupants and therefore not cause workplace distractions or elevated risk concerns. Passive samplers are cheaper than canisters, so missing equipment is less of a cost burden.

2.2.7 Outdoor Air Considerations

Compared to most others, outdoor air is one of the most accessible media to sample. There is no need to enter a structure (that is, residential, commercial, and/or industrial building), drill into the subsurface, or install a conduit-like structure, such as a soil vapor probe or a groundwater monitoring well. In many cases, whether using active or passive sampling methods, all that is required is a sample collection device (that is, a passivated canister and flow controller for active collection or a sorbent tube for passive collection). However, there are several considerations to keep in mind when both planning and collecting outdoor air samples.

The primary considerations for outdoor air sampling pertain to the environmental variables for where and when to collect. The three most common are wind direction, season, and weather. Consider the wind direction to ensure that outdoor air samples are collected from upwind, downwind, and in some cases, crosswind locations. The season should be considered to assess variability between the warmer and colder months. Weather conditions may dictate if the sampling device(s) needs to be protected from the elements (that is, precipitation and direct sunlight), while conditions such as barometric pressure may also affect some physical samplers and/or the resulting data.

When planning and implementing an outdoor air survey, the types of industries at or around the sampling area must also be considered, as they may bias the analytical data. For example, collecting an outdoor air sample in a highly industrial area where there is constant trucking traffic may yield analytical data with higher concentrations of benzene. This consideration should be evaluated in tandem with wind direction to ensure that samples are not being collected downwind of a facility that may release chemicals into the air that could affect the data.

Health and safety conditions are another set of considerations that should be evaluated when planning and/or implementing outdoor air sampling. If possible, you should have a clear understanding of the potential hazardous chemicals that may be in the immediate atmosphere at and around the sampling locations and ensure that workers have the appropriate personal protective equipment (PPE). Many outdoor air samples are collected on the roofs of buildings, possibly necessitating additional PPE. Additionally, whether using an active or passive sampler, field personnel must consider public perception and ease any safety concerns. These sampling devices are not common in the everyday lives of most people and may lead to fear and/or curiosity.

Another set of considerations you must evaluate when planning and/or implementing an outdoor air survey is the equipment to be used. As mentioned above, in some cases, only an active or passive sampling device is required to collect outdoor air samples. However, many projects require field personnel to collect field screening levels using various monitoring devices (that is, a photoionization detector or multi-gas meter). When monitoring outdoor air for dust, field meters are typically the primary sampling method. Workers must ensure that they have the proper monitoring device(s) for the task at hand and that the devices are properly calibrated and charged. Additionally, security equipment may be needed to prevent tampering. These may include a chain and lock, a protective container, and caution tape. In the case of inclement weather, field personnel must consider what equipment will be needed to protect the sampling devices from sun, precipitation, or even winds that bring a higher than normal particulate level.

Outdoor air samples are often collected in tandem with indoor air samples to collect data that may prove integral in evaluating vapor intrusion versus outdoor air infiltration/background. It is important to consider the placement of outdoor air samplers in relation to the target building. Again, the wind direction becomes important for these projects, as it is common protocol to collect outdoor air samples upwind, downwind, and crosswind from the targeted building.

As discussed above, passive sampling devices are discrete and inconspicuous compared to canisters, which can reduce risk perception and tampering from the public. Passive samplers are cheaper than canisters, so missing equipment is less of a cost burden.

2.2.8 Soil Considerations

Commonly, there are three types of soil samples: samples collected on the surface (0-6 inches below grade), shallow (up to 2 feet below grade), and at depth (> 2 feet below grade). Surface soil samples are generally quick to prepare for sample collection, not as destructive to the site, and less costly. Collecting the at-depth soil sample can be very expensive given the equipment required, and time consuming to prepare for. When planning a soil sampling event, consideration must be given to soil lithology, weather, site constraints, and equipment needed.

Soil can be grouped into three main categories: coarse-grained (sands and gravels), fine-grained (silts and clays), and highly organic soils (peat) (Kelechava 2018 [D397EAY7] Kelechava, Brad. 2018. "ASTM D2487 Unified Soil Classification System." The ANSI Blog, March 15. https://blog.ansi.org/2018/03/unified-soil-classification-astm-d2487-17/.; ASTM 2020 [BWLIENR8] ASTM. 2020. "D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)." ASTM, April. https://www.astm.org/standards/d2487.). Each group of soil has its own limitations and advantages when collecting surface and at depth soil samples. For example, collecting a deep sample from a fine-grained soil can be difficult because the soil might easily slide away/heave from the soil auger or soil collection sleeve/liner, making collection at the desired depth time-consuming and sometimes unlikely.

To collect soil at depth, certain equipment is needed and site constraints might make this difficult to maneuver. For example, certain locations may be inaccessible to a drill rig.

2.2.9 NAPL Considerations

Although passive samplers can be used for NAPL collection, they do not provide a general advantage over nonpassive or active methods, such as bailers. One exception would be collection of NAPL-impacted soil for NAPL characterization testing that requires the preservation of the physical or geochemical properties of the media.

For NAPL in soil, it is important to retrieve an undisturbed section of the soil column to complete characterization of NAPL mobility or transmissivity within the unconsolidated material. Although standard soil collection methods can produce NAPL samples, it is important to collect soil that has not been disturbed by mechanical forces to retain the precise properties observed in situ.

There are also passive means of detecting NAPL in boreholes. The Ribbon NAPL sampler can be deployed to boreholes to assist in detecting NAPL. The FLUTe Profiler can also be used in open boreholes to detect NAPL. However, these technologies are not quantitative and are generally restricted for use in direct sensing during site characterization activities. See ITRC's document on advanced site characterization tools (ASCTs) for more information on these types of direct sensing tools.

When NAPL or sheen is present in association with groundwater or surface water, caution should be taken in the use of passive samplers, as is the case with nonpassive samplers, due to potential interference/contamination of the sampler or media being tested. Nonpassive methods used in the collection of a NAPL sample from a monitoring well or surface water are discussed in **Section 6**.

2.3 Contaminant Sampling Considerations

As with any sampling method, it is important to keep in mind the compatibility between the chemical and the sampling equipment. It is not uncommon for investigators to have to adapt sampling techniques and materials based on the contaminant of concern. For example, polytetrafluoroethylene (PTFE)-containing materials should not be used when sampling for per- and polyfluoroalkyl substances (PFAS). In situations where certain chemicals may adsorb to the sampler, it is possible that the sample may be biased low. In cases where certain chemicals adsorbing to the sampler could cause cross contamination, incorporating single-use materials may be a mitigation strategy to reduce that risk.