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Operating Procedure	
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Purpose

The purpose of this procedure is to document both general and specific procedures, methods, and considerations to be used and observed when performing groundwater sampling for field screening and laboratory analysis. This Standard Operating Procedure (SOP) is specific to the Field Services Branch (FSB) to maintain conformance to technical and quality system requirements. While this SOP may be informative for other businesses, it is not intended for and may not be directly applicable to operations in other organizations. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

Scope/Application

This document describes specific methods to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion that Laboratory Services and Applied Science Division (LSASD) field personnel determine that any of the procedures described in this SOP are inappropriate, inadequate, or impractical and that another procedure may be used to obtain a groundwater sample, the variant procedure will be documented in the field logbook, in accordance with the LSASD Operating Procedure for Logbooks (LSASDPROC-1002), along with a description of the circumstances requiring its use.

Note: LSASD is currently migrating to a paperless organization. As a result, this SOP will allow for the use of electronic logbooks, checklists, signatures, SOPs, and forms as they are developed, which will also be housed on the Local Area Network (LAN) and traceable to each project.

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1.0 General Information

1.1 Documentation/Verification

This procedure was prepared by persons deemed technically competent by LSASD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.2 General Precautions

1.2.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the LSASD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.2.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location, if possible. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous

materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

- Documentation of field sampling is done legibly, completely, and neatly in a bound logbook.

2.0 Groundwater Purging and Sampling

2.1 Overview of Purging and Sampling Methods

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of aquifer conditions. Sampling is the process of obtaining, containerizing, and preserving (when required) a ground water sample after the purging process is complete. There are several approaches to well purging and sampling that may be appropriate in various circumstances or for various combinations of available equipment. They are briefly summarized below and in *Table 1, Purge and Sample Strategies with Equipment Considerations*.

The static water level should always be measured first, prior to inserting any tubing or pumping equipment into the well casing and after the well has been uncapped long enough for the water level to adjust to atmospheric pressure. The water level should also be monitored and documented during pumping, especially for the low-flow method. A clean, decontaminated water level probe should always be used and should be cleaned and dried off in the field after use in a well, prior to being inserted in a different well.

The **Multiple-Volume Purge** method involves removing a minimum of three well volumes of water from the top of the water column and then sampling when the well has achieved stability of water quality parameters and adequately low turbidity. This is a traditional method and consistent results are generally obtained with samplers of varying skill. A drawback is that large volumes of contaminated purge water may be produced for large diameter or deep wells.

The **Low-Flow** method involves purging the well at a relatively low flow rate that minimizes drawdown, with the pump or tubing inlet located within the screened interval of the well. The well is sampled when water quality parameters are stable, adequately low turbidity is achieved, and the water level has achieved a stable drawdown (an unchanging water level). This method is often faster than Multiple-Volume Purge and generates less purge water. The method requires more skill and judgment on the part of the samplers.

The **Multiple-Volume Purge** method and the **Low-Flow** method can be considered equivalent for conventionally screened and filter-packed wells in that they both sample a flow-weighted average of water entering the well during pumping. However, other variables can result in differences between results with the two methods. In repeat sampling events, the sampling design should not change from one method to the other without appropriate cause. The transition should be noted in the report.

Minimum-Purge and **No-Purge** methods are based on the assumption that water within the screened interval of the well is at equilibrium with the water in the surrounding aquifer.

This assumption should be carefully considered in the use of these methods and various cautions are discussed in the sections below. The **Minimal-Purge** and **No-purge** methods are most useful for long-term monitoring and are generally inappropriate for the early stages of investigation. In some cases, the methods might be used to gather screening-level data from wells that are too large to practically purge or have other sampling complications.

Table 1 Purge and Sample Strategies with Equipment Considerations

Purging Strategy	Purge Equipment	Sample Equipment	Comments
Multi-Volume Purge	-----	-----	Overall Method Comments- Advantages: Consistent results can be achieved with minimal skill level required. Common, simple equipment can be used. Disadvantages: Can result in large volumes of purge water/ more IDW. Can take extended periods of time with large diameter wells or long water columns.
In this traditional method, 3-5 well volumes of water are removed from the top of the water column while verifying the stability of water quality parameters. Following the well purge, the well is sampled from the top of the water column.	Bailer	Bailer	Bailers are rarely used for purging due to the effort required, the difficulty of lowering turbidity adequately, and the possibility of aerating the upper water column.
	Electric Submersible Pump	Bailer	Common multiple-volume setup when depth to water exceeds 25 feet. Abbreviated pump decontamination procedure can be used between wells.
	Electric Submersible Pump	Electric Submersible Pump	Requires full pump decontamination and new tubing at each well. In most cases the pump would be deployed to the screened interval instead to perform Low-Flow sampling.
	Peristaltic Pump	Peristaltic Pump	Common, multi-volume setup when depth to water is less than 25 feet. Special sampling techniques are required for the collection of SVOCs and VOCs.
Low-Flow methods	-----	-----	Overall Method Comments- Advantages: Lower volumes of purge water. May be faster, especially with longer water columns. Disadvantages: Requires greater skill for consistent results. Higher tubing costs than multi-volume method.
The pump or tubing inlet is placed within the screened interval and the well is purged to stable water quality parameters while maintaining stable drawdown of the water level.	Electric Submersible Pump	Electric Submersible Pump	Commonly used when depth to water exceeds 25 feet. Pump is cleaned to sample equipment standards prior to sampling each well and new or dedicated tubing used for each well. Concerns have been raised concerning VOC loss from agitation in the turbine section or from sample heating.
	Peristaltic Pump	Peristaltic Pump	Commonly used where depth to water is less than 25 feet. Special sampling techniques required for the collection of SVOCs and VOCs. Concerns have been raised concerning VOC loss from vacuum created in sample tubing.
	Bladder Pump	Bladder Pump	Least danger of VOC loss as entire sample train is under positive pressure and little sample heating occurs. Difficult to remove large volumes of water in reasonable time. Mild surging effect may keep turbidity elevated in sensitive wells.
Minimum-Purge, No-Purge Methods	-----	-----	Overall Method Comments- Advantages: Very little or no waste water. Well suited to repeat sampling events. Likely faster with lower costs. Disadvantages: Not directly equivalent to other methods. Vertical stratification or vertical flow conditions in the screened interval can result in deceptive or non-intuitive analytical results.
Predicated on the assumption that aquifer flow through the well maintains the water in the screened interval in a state equivalent to that in the aquifer. This assumption should be proven or the data qualified. Sampling is conducted with little or no purge, or by equilibrating a sampler in screened interval.	Pumps, various	Pumps, various	In the minimum-purge method, the internal volume of the sample tubing and pump is calculated. One volume of the pump and tubing is purged to flush the equipment and the well is then sampled.
	na	Passive Diffusion Bags	In most common form, a sealed water-filled polyethylene bag is allowed to equilibrate in the water column. Suitable primarily for VOCs. Generally require 2 week minimum in-situ residence time.
	na	Hydrasleeves	Collect a fixed volume of water from a specific interval. Requires duplicate samplers or redeployment for larger volumes. Sorbtion issues may bias results.
	na	Snap sampler	Deploys a sample container in the sampling interval where it is allowed to equilibrate (commonly for two weeks) before being sealed insitu by the sampler mechanism and retrieved. Limited to specific containers.

The **Minimum-Purge** and **No-Purge** methods collect water in the vicinity of the sampling device under near-static conditions and are not equivalent to the **Multiple- Volume Purge** and **Low-Flow** methods. Stratification of horizontal flow or vertical flow conditions within the well can result in non-intuitive and deceptive results. A comparison study should be conducted before transitioning a sampling program to the minimal-purge or no-purge methods.

2.2 Purging

Wells are purged to eliminate stagnant water residing in the casing and/or screen that has undergone geochemical changes or loss of VOCs. At the conclusion of purging, the desired flow-weighted average of water entering the well under pumping conditions will be available for sampling. Turbidity is often elevated during purging by the disturbance of formation materials at the borehole walls. As many contaminants (metals and many organics) will sorb to the formation particles, a sample including these particles will not represent the dissolved concentrations of the contaminants. Thus, a secondary goal of purging is to reduce the turbidity to the point that the sample will be representative of the dissolved contaminant concentration.

In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed and the volume of water removed during purging. The measurements should be recorded in a purge table in the field logbook that includes the start time of purging, the parameter measurements at intervals during purging, estimated pumped volumes, depths to water (especially for **Low-Flow** sampling), and any notes of unusual conditions. A typical purge table used for Low-Flow sampling is reproduced below in **Figure 1**.

2.0.1 Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Secondary Drinking Water Standard of 5 NTUs).

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than 5 percent. Other parameters, such as dissolved oxygen (DO) or oxidation-reduction potential (ORP), may also be used as a purge adequacy parameter. Normal stability goals for DO are 0.2 mg/L or 10% change in saturation, whichever is greater. DO and ORP measurements must be conducted using either a flow-through cell or an over-topping cell to minimize oxygenation of the sample during measurement. A reasonable ORP stability goal is a range of 20 mV, although ORP is rarely at equilibrium in environmental media and often will not demonstrate enough stability to be used as a purge stabilization parameter. Determining the frequency of measurements has generally been left to 'Best Professional Judgement'. Measurements recorded at frequent intervals with low flow rates can falsely indicate stability of parameters. Several measurements should be made early in the well purge to establish the direction and magnitude of trends, which can then inform the stability decision. Stability

parameters should either be not trending, or approaching an asymptote, when a stability determination is made. As a matter of practice, parameter measurements are generally made at 5-10 minute intervals.

Sometimes the measurement interval may be greater if turbidity is lessening very slowly.

Because the measured groundwater temperature during purging is subject to changes related to surface ambient conditions, pumping rates and pump temperature, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from LSASD's list of parameters used for stability determination. Even though temperature is not used to determine stability, it is still advisable to record the temperature of purge water as it is often used in the interpretation of other parameters.

Information on conducting the stability parameter measurements is available in the LSASD Operating Procedures for Field pH Measurement (LSASDPROC-100), Field Specific Conductance Measurement (LSASDPROC-101), Field Temperature Measurement (LSASDPROC-102), Field Turbidity Measurement (LSASDPROC-103), Field Measurement of Dissolved Oxygen (LSASDPROC-106) and Field Measurement of Oxidation-Reduction Potential (LSASDPROC-113).

Figure 1 Purge Table Showing Field Measurements

Continuation of sample GW 65-0713

INITIAL
23.33ft

TIME	pH (S.U.s)	Spec. Cond. (us/cm)	Temp. (Deg. C)	D.O. (mg/L)	D.O. (% sat.)	ORP (mV)	Turbidity (NTUs)	Water Level (Ft.)	Purge Vol. (gallons)
0930									Pump On
0935	5.71	1065	19.6	0.77	8.7	43.9	2.10	24.83	1/4
1004	5.64	988	20.0	0.36	3.9	222.5	17.8	25.24	2
1026	5.63	959	20.5	0.25	2.7	98	9.95	25.18	3 1/2
1038	5.62	950	20.5	0.21	2.4	75	9.85	25.18	4
1046	5.61	946	20.8	0.21	2.4	73	6.07	25.18	4 1/2
1047									Sample Collection Time

2.3 Multiple-Volume Purge

In the traditional Multiple-Volume Purge method, water is removed from the top of the water column, causing water to enter the screen and flush stagnant casing water upward to be subsequently removed. In recognition of the mixing of fresh and stagnant water in the casing section, a minimum of three well volumes is removed, at which time purging can be terminated upon parameter stabilization. Wells can be assumed to be adequately purged when five well volumes have been removed, although further purging may be conducted to meet specific goals, such as further reduction of turbidity.

2.3.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be calculated. The diameter of the well is determined and the water level, followed by total depth of the well, are measured and recorded prior to inserting anything into the well. The water level is subtracted from the total depth, providing the length of the water column. Specific methodology for obtaining these measurements is found in LSASD Operating Procedure for Groundwater Level and Well Depth Measurement (LSASDPROC-105).

Once this information is obtained, the volume of water to be purged can be determined using one of several methods. The well volume can be calculated using the equation:

$V = \pi r^2 h \times 7.4805$ gal / cu foot Where:

h = length of water column in feet, r = radius of well casing in feet V =
one well volume in gallons

Or, more conveniently:

$$V = 0.041 d^2 h$$

Where:

h = length of water column in feet d =
diameter of well in inches
V = one well volume in gallons

Multiplying the casing volume, V, by 3 provides the usual 3-volume purge in gallons. Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, such as listed in **Table 2, Well Casing Diameter Volume Factors**. The water column length is multiplied by the appropriate factor from **Table 2** to determine the single well volume, three well volumes, or five well volumes for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

An adequate purge is normally achieved when three to five well volumes have been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate multiplication of that volume, i.e., a minimum three well volumes, clearly identified as an initial purge volume goal.

TABLE 2 WELL CASING DIAMETER VOLUME FACTORS

		Reference	Minimum purge	Maximum purge*
		1 Well Volume (gallons/ft)	3 Well Volumes (gallons/ft)	5 Well Volumes (gallons/ft)
Well Casing Diameter (in)	0.5	0.01	0.03	0.05
	0.75	0.02	0.07	0.11
	1	0.04	0.12	0.20
	2	0.16	0.49	0.82
	3	0.37	1.1	1.8
	4	0.65	2.0	3.3
	5	1.0	3.1	5.1
	6	1.5	4.4	7.3
	7	2.0	6.0	10.0
	8	2.6	7.8	13.1
	9	3.3	9.9	16.5
	10	4.1	12.2	20.4
	11	4.9	14.8	24.7
	12	5.9	17.6	29.4
	13	6.9	20.7	34.5
	14	8.0	24.0	40.0
	15	9.2	27.5	45.9
	16	10.4	31.3	52.2
	18	13.2	39.7	66.1
24	23.5	70.5	118	
36	52.9	159	264	
48	94.0	282	470	

* See text for discussion on terminating purge at five well volumes

2.3.2 Pumping Conditions

The pump or tubing inlet should be located at the top of the water column. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is as close as possible to the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump or tubing will have to be lowered to accommodate the drawdown.

2.3.3 Stability of Chemical Parameters

In the **Multiple-Volume Purge** method, a stability determination may be made after three well volumes have been removed. If the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to a total of five well volumes) should be removed. If the parameters have not stabilized after the removal of five well volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible.

2.3.4 Sample Collection

There are several means by which sampling can proceed after adequate volume has been purged and water quality parameters have stabilized. If a submersible pump and tubing are of suitable material and cleanliness for sample collection, sampling can proceed immediately by directly filling bottles from the tubing outlet. Commonly with the multiple-volume purge method, the pump is set up and cleaned in a manner suitable only for purging. In these cases, the pump is stopped and removed from the well and sampling proceeds with a bailer per the procedure described in **Section 2.6.5**. The pump should have a check valve to prevent water in the pump tubing from discharging back into the well when the pump is stopped. If a peristaltic pump is used, sampling can proceed as described in **Section 2.6.1**.

2.4 Low-Flow Method

The **Low-Flow** method involves placing the pump or tubing inlet within the screened interval of the well (generally mid-screen, discussed in **Section 2.4.2**) and purging at a low enough rate to achieve stable drawdown and minimal depression of the water level (a total drawdown of one foot or less is generally preferred, if possible). The well is sampled with as little interruption in pumping and flow rate as is possible after field parameters are stable and low turbidity is achieved. In general, only water in the screened interval of the well is pumped and the stagnant water in the well casing above the screen is not removed. Wells can generally be sampled in less time with less purge volume than with the multi-volume purge method. More attention is required in the assessment of stability criteria than the multi-volume method.

2.4.1 Nomenclature

A variety of terminology has been used to describe this method by LSASD and others, including: 'low flow', 'low-flow/low-volume', 'tubing-in-screen method', 'low flow/minimal drawdown', and 'micropurge'. The current preferred LSASD terminology for this method is 'Low-Flow'. As the term 'micropurge' is sometimes used to refer to minimal-purge methods and has been trademarked by a vendor, the use of 'micropurge' to describe the **Low-Flow** method generally introduces ambiguity and confusion and thus the use of the term is discouraged.

2.4.2 Placement of Pump Tubing or Intake

The inlet of the pump tubing or intake of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. In cases where the water column does not cover the entire screen length, the midpoint of submerged screen should be determined for intake placement. The pump or tubing can be placed by carefully lowering them to the bottom of the well and then withdrawing half of the screen length, plus the length of any sump sections at the bottom of the well. A measuring tape should be used at the top of casing to accurately determine the length the pump is raised from the bottom. The pump should then be tied off so that it stays at the desired depth. A drawback of this approach is that it may stir up sediment at the well bottom. An alternate approach is to lower the pump or tubing a measured distance to place it at mid-screen without touching the bottom of the well. Special care should be used in lowering pumps slowly, especially in the screened interval, to prevent elevating turbidity needlessly by the surging action of the pump. While it is often thought that particular aquifer zones can be targeted by specific pump or intake placement, for conventionally constructed screened and filter-packed monitoring wells the zone monitored is only weakly dependent on the intake placement (Varljen, Barcelona, Obereiner & Kaminski, 2006).

2.4.2.1.1 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well to measure the water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. In some cases, because of low recharge rates, it may be necessary for the well to drawdown a considerable distance (10 ft or more in extreme cases) to maintain a minimal usable pumping rate for sampling (100-200 ml/min). Excessive pump rates and drawdown can result in increased turbidity, aeration of the sample if the screen is exposed, or pulling in of stagnant water from the column. Stable drawdown is an essential condition of the Low-Flow method. If the stable drawdown condition cannot be met, then one of the other methods should be employed.

2.4.2.1.2 Stability of Chemical Parameters

As with the **Multiple-Volume Purging** method described, it is important that all chemical parameters be stable prior to sampling. It is common for wells to require the removal of one or more screened-interval volumes (~2 gal for a 10 ft screen in a 2" dia. well) to achieve stability. Although it is possible for wells to achieve stability with lower purge volumes, the sampler should exercise caution in making an early stability determination.

2.4.2.1.3 Sample Collection

Low-Flow sampling is implemented using a pump and tubing suitable for sampling. After making the determination of parameter stability with stable drawdown, sampling can proceed immediately. Where submersible or bladder pumps are used, sampling can proceed by directly filling bottles from the tubing outlet. Where peristaltic pumps are used, sampling can proceed per the procedure described in Section 2.6.1.

2.5 Minimum-Purge and No-Purge Sampling

The **Minimum-Purge** and **No-Purge** sampling methods are employed when it is necessary to keep purge volumes to an absolute minimum, where it is desirable to reduce long-term monitoring costs, or where large wells or other limitations prevent well purging. The underlying assumption when employing these methods is that the water within the well screen is equilibrated with the groundwater in the associated formation. This assumption should be demonstrated prior to use of these methods or the results suitably qualified. These methods are generally impractical for LSASD to implement because of the common lack of hydrogeological information in early investigative phases and the necessity with some methods that the samplers be pre-deployed to allow equilibration.

Vertical flow conditions and stratification of the water column have also been known to result in deceptive and non-intuitive analytical results. The use of these methods in the early phases of investigation can easily result in misinterpretation of site conditions and plume boundaries.

Particular caution is in order in the use of these methods when any of the following conditions exist:

- Low hydraulic conductivity ($K < 10^{-5}$ cm/sec)
- Low groundwater surface gradients
- Fractured bedrock
- Wells with long screened intervals
- Wells screened in materials of varying hydraulic conductivities

If it is desired to transition a long-term monitoring program to **Minimum-Purge** or **No-Purge** sampling, a pilot study should be conducted where the **Minimum-Purge** or **No-Purge** sample results are compared to the conventional methods in use. Multiple samplers may be deployed in the screened interval to help establish appropriate monitoring intervals.

These methods are in common use and for the purposes of the LSASD quality system they can be considered standard, but unaccredited, procedures. Several **Minimum-Purge** or **No-Purge** procedures that might be employed are shown below. It is not the intention to recommend particular equipment or vendors, and other equipment that can accomplish the same goals may be suitable.

2.5.1 Minimum Purge Sampling

The pump or tubing inlet is deployed in the screened interval. A volume of water equal to the internal pump and tubing volume is pumped to flush the equipment. Sampling then proceeds immediately. While superficially similar to Low-Flow sampling, the results obtained in this method will be sensitive to the vertical pump or tubing inlet placement and are subject to the limitations described above.

2.5.2 Passive Diffusion Bags

The no-purge Passive Diffusion Bag (PDB) typically consists of a sealed low-density polyethylene (LDPE) bag containing deionized water. They are deployed in the screened interval of a well and allowed to equilibrate, commonly for two weeks, prior to retrieval and decanting of the water into sample containers. Many volatile organic compounds will reach equilibrium across the LDPE material, including BTEX compounds and many chlorinated solvents. Compounds showing poor equilibration across LDPE include acetone, MTBE, MIBK, and styrene. PDBs have been constructed of other materials for sampling other analytes, but the vast majority of PDB samplers are of the LDPE material. Various vendors and the Interstate Technology and Regulatory Council (ITRC) can provide additional information on these devices.

2.5.3 *HydraSleeves*TM

*HydraSleeves*TM are no-purge grab sampling devices consisting of a closed-bottom sleeve of low-density polyethylene with a reed valve at the top. They are deployed in a collapsed state to the desired interval and fill themselves through the reed valve when pulled upward through the sampling interval. The following is a summary of their operation:

Sampler placement – A reusable weight is attached to the bottom of the sampler or the sampler is clipped to a weighted line. The *HydraSleeve*TM is lowered on the weighted line and placed with the top of the sampler at the bottom of the desired sampling interval. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. The well is allowed to return to equilibrium.

Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level and only minimal agitation during collection.

Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field parameter measurements.

Because the *HydraSleeve*TM is retrieved before equilibration can occur and they are constructed of non-Teflon® materials, there may be issues with sorption of contaminants in the use of this sampler.

2.5.4 Snap Samplers

The Snap Sampler is a patented no-purge groundwater sampling device that employs a double-end-opening bottle with “Snap” sealing end caps. The dedicated, device is deployed at the desired position in the screened interval with up to six Snap Samplers and six individual sampling bottles. The device is allowed to equilibrate in the screened interval and retrieved between 3 and 14 days after deployment. Longer deployments are possible to accommodate sampling schedules.

To operate, Snap Samplers are loaded with Snap Sampler bottles and the "Snap" caps are set into an open position. Samplers are deployed downhole with an attachment/trigger line and left to equilibrate downhole. To collect samples, the Snap Sampler bottles seal under the water surface by pulling a mechanical trigger line, or using an electric or pneumatic trigger system. The trigger releases Teflon® "Snap Caps" that seal the double-ended bottles. The end caps are designed to seal the water sample within the bottles with no headspace vapor. After the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal.

The manufacturer of the Snap Sampler provides considerable additional information on the validation and use of the device.

2.6 Equipment Considerations and Use

Equipment choices are dictated by the purging and sampling method used, the depth to water, the quantity of water to be pumped, and quality considerations. The advantages and disadvantages of various commonly used pumps are discussed in the sections below and summarized in *Table 1, Purge and Sample Strategies with Equipment Considerations*. Additional information on the use of individual pumps is available in LSASD Operating Procedure for Pump Operation, SESDPROC-203.

2.6.1 Peristaltic Pumps

Peristaltic pumps are simple, inexpensive, and reliable equipment for purging and sampling where the limit of suction is not exceeded (approximately 25-28 vertical feet from the groundwater surface to the pump). When used for sampling, they should be equipped with new Teflon® tubing for each well. The flexible peristaltic pump-head tubing should also be changed between wells.

Samples for organic analyses cannot be exposed to the flexible peristaltic pump-head tubing, both due to the risk that the tubing would sorb contaminants and the propensity of this tubing to contribute organic compounds to the sample. Samples can be collected without contact with the pump-head tubing by the use of vacuum transfer caps for analyses requiring 1 liter glass containers and the use of the 'soda-straw' method for the filling of VOC vials.

The sample containers for the more turbidity-sensitive analyses are filled first, as removing tubing to fill the VOC vials (and to a lesser extent the glass bottles) may disturb the well and increase turbidity. The most appropriate order of sampling with a peristaltic pump is generally to fill poly containers for metals and classical analyses, followed by glass bottles for SVOCs and associated analyses, and finally to fill 40 ml VOC vials.

The following step-by-step procedure assumes that the pump has been set up per LSASD Operating Procedure for Pump Operation (LSASDPROC-203) and that containers for a typical full suite of analyses will be filled. The procedure is suitable for use with either **Multi-Volume Purge** or **Low-Flow** methods with minor differences in the collection of VOCs:

- 2.6.1.1 Deploy the lower end of the tubing to the desired point in the well. This would be the top-of-water for the multi-volume purge method or to the mid-screen for the **Low-Flow** method. Connect the well tubing to the flexible pump-head tubing and connect a short piece of tubing from the pump-head tubing to an over-topping cell (where probes can be inserted to measure parameters) in a measuring bucket for purge water collection.
- 2.6.1.2 Turn on the pump and establish a suitable pumping rate. For the multi-volume purge method, the rate will generally be a relatively fast rate that the well will sustain without elevating turbidity. For the **Low-Flow** method the pump rate is established at a slower rate to maintain a minimal and stable drawdown level.
- 2.6.1.3 Proceed with the measurement of water quality parameters and adjust the pump rate as needed to achieve low turbidity and stable drawdown.
- 2.6.1.4 When the well purge has been determined to be sufficient, fill containers for metals and classical analyses directly from the pump outlet. There is no need to interrupt pumping. The tubing should be held at the opening of the container and should not touch the container during filling. Protect caps from dust and debris during filling.
- 2.6.1.5 After filling the containers for metals and classical analyses stop the pump. Make sure that the tubing leading into the well is secured against movement during the following operations.
- 2.6.1.6 Create a crimp in the well tubing approximately one foot from the pump and grasp the crimped tubing in one hand. It is generally most effective to create a double 'Z' crimp.
- 2.6.1.7 Cut the sample tubing between the crimp and the pump. The tightly-held crimped tubing should keep water from running back into the well. In lieu of cutting the tubing, the well tubing can be disconnected from the pump and a short piece of tubing connected in its place.
- 2.6.1.8 Insert both free ends of the tubing into the ferrule-nut fittings of a pre-cleaned Teflon® transfer cap assembly and tighten the nuts. Attach the transfer cap assembly to the first glass container for semi-volatile analysis and securely tighten the threaded ring.
- 2.6.1.9 Turn the pump on. Very slowly release the 'Z' crimp in the sample tubing. As vacuum builds up in the sample container, water should begin to move up the sample tubing instead of back into the well. If after several minutes water has not begun moving up the tubing, check the tightness of fittings and the attachment of the cap to the bottle. Allowing water to rush back down the tubing from the 'Z' crimp can surge the well and elevate turbidity.

- 2.6.1.10 Fill the container to about halfway between the shoulder and the neck. Crimp the well tubing. Move the transfer cap to any additional bottles and repeat the filling process.
- 2.6.1.11 When finished filling bottles with the transfer cap, again crimp the tubing. Remove the well tubing from the transfer cap and reattach it to the pump. Slowly run the pump and release the crimp until water is approaching the flexible peristaltic tubing.
- 2.6.1.12 Make a kink or otherwise mark the tubing at the top of the casing in case the tubing needs to be reinserted (to the same depth) for additional sample volume. Slowly remove the tubing from the well and coil it in one hand in loose coils. With the top end of the tubing blocked, water is retained in the tubing as it is withdrawn, much as in a capped soda straw, hence the name for this method.
- 2.6.1.13 Remove the top from a 40 ml VOC vial and position the end of the sample tubing near the top of the vial. Reverse the pump direction and turn the speed knob to its slowest position. Turn on the pump and slowly increase speed until water slowly fills the vial. Fill the vial with a slow laminar flow that does not agitate the water in the vial or entrain bubbles. Continue to fill the vial until a convex meniscus forms on the top of the vial and turn off the pump.
- 2.6.1.14 Carefully screw the septum-lid to the vial and fasten firmly. Invert the vial and gently tap it on your knuckles or a hard surface to check for bubbles. Carefully add additional volume to the vial if necessary. Small bubbles are undesirable but may be unavoidable with some media, especially when using pre-preserved vials.
- 2.6.1.15 Repeat the filling process for additional vials. Avoid partially filling vials as the available water in the tubing is used. If more volume is required than that contained in the tubing, purge the remaining water from the tubing and reinsert the tubing in the well to the level marked previously. Run the pump to refill the tubing. If performing **Low-Flow** sampling, run additional volume through the pump to purge any water that may have been collected from the stagnant water column, and, preferably, to reestablish drawdown.

Note: During the filling of vials and re-insertion of tubing into the well to collect additional sample volume, the water level will begin to recover or completely recover, and pumping equilibrium will be lost while the pump is temporarily turned off. Therefore, to re-establish equilibrium and to clear out any water collected in the tube while re-inserting it, it may be desirable to let the pump run a few minutes at the established equilibrium purge speed before stopping it and removing the tubing to continue the soda straw method to fill more vials. Re-establishing equilibrium is preferable, if time permits. After re-establishing drawdown, if the pump is slowed slightly, allowing the water level to be rising in the casing, fresh formation water should be coming in from the screen, which should be acceptable for pulling water into the tubing for sample collection.

2.6.1.16 Fill additional vials as needed. Be sure that any water that has contacted the flexible peristaltic tubing is not pumped into a vial.

2.6.2 Submersible Centrifugal Pumps

Submersible centrifugal pumps are used in wells of 2” diameter and larger. They are especially useful where large volumes of water are to be removed or when the groundwater surface is too far below ground surface for peristaltic pumps to function. Commonly used pumps are the Grundfos® Redi-Flo2, the Geotech GeoSub, and the various ‘Monsoon’ style pumps. Other pumps are acceptable if constructed of suitable materials.

When used with the Multiple-Volume Purge method, the pump is generally used only to purge, with sampling performed with a bailer. In this use, the pump can be used with polyethylene or other tubing or hose that will not contribute contaminants to the well. The pump and tubing are decontaminated between wells per the relevant provisions of LSASD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205). When used in this application the pump should be equipped with a check valve to prevent water in the discharge tubing or hose from running back down into the well.

When used for Low-Flow purging and sampling (for contaminants other than PFAS compounds) the pump must be constructed of stainless steel and Teflon®. Pump cleaning at each well follows the more stringent procedures described in LSASD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) for this application. The sample tubing should be either new Teflon® tubing, or tubing dedicated to each well. Dedicated tubing would ideally be cleaned between uses, but tubing stored in the well casing between uses is acceptable, although caution should be exercised where very high concentrations of contaminants have been sampled in a well. --- Note: See Section 3.4 for PFAS sampling requirements.

2.6.3 Bladder Pumps

Bladder pumps use a source of compressed gas to compress and release a bladder straddled by check valves within the pump body. As the bladder is compressed, water is expelled out the upper check valve to the surface. When gas pressure is released, the bladder refills as well water enters the lower pump inlet. A control unit is used to control the pressure and timing of the bladder inflation gas flow.

Bladder pumps are capable of pumping from moderate depths to water, but are not capable of high flow rates. As they operate cyclically, the well is surged slightly on each cycle and it may be difficult to lower turbidity in sensitive or poorly developed wells. As the entire sample train is under positive pressure and the pumps develop little heat, they are ideal for sampling VOCs.

Prior to sampling and between each well the pumps are cleaned internally and externally per the provisions of LSASD Operating Procedure for Field Decontamination

(SESDPROC-205) and a new Teflon® bladder installed. New (or dedicated) Teflon® sample tubing is used at each well, although polyethylene tubing can be used for the compressed gas drive line and cleaned between each well.

2.6.4 Inertial Pumps

Inertial pumps consist of a check valve which is affixed to the lower end of semi-rigid tubing. The tubing and valve are cycled up and down, allowing water to alternately be drawn into the check valve inlet and then pulled up towards the surface. Two commonly used inertial pumps are the Waterra® pump for wells larger than 1" and the Geoprobe® Tubing Check Valve for small diameter wells. The primary use of these pumps is in well development where their near-immunity to silt is an advantage. Inertial pumps should not be used for the final well purge or for sampling as there is a low likelihood of reducing turbidity to appropriate levels and they have the potential to strip volatiles from the water column through agitation.

To set up the pump, the check valve is screwed onto the discharge tubing where it will cut its own threads. In the case of the Waterra® pump, a surge block can also be pressed onto the check valve. The pump is lowered into the well to the screened interval and rapidly cycled up and down a distance of 3" -12". The stroke length and speed are adjusted for pumping effect. Electric actuators can be used to reduce the effort involved. The pump should be moved to different levels in the screen to surge the entire screen.

The pump can occasionally be lowered to the bottom of the well to vacuum out fine sand and silt. Any sediment that clogs the valve is usually quickly rinsed out by the pump cycling and if the clog remains the pump is easily retrieved and redeployed.

The surging activity is usually continued until turbidity is lowered to a measurable range and is not easily lowered further. Further development or purging is then conducted with other pumps. --- Note: Also see Sections 2.8.2 and 3.15 for more on well development.

2.6.5 Bailers

Bailers are a common means of sampling when the Multiple-Volume Purge method is used. They are occasionally used for purging wells with low purge volumes when other equipment is not available or has failed. As bailers surge the well on each withdrawal, it is very difficult to lower turbidity adequately during a well purge, and when used for sampling they can elevate turbidity in a well before all sample volume is collected. If not lowered carefully into the top of the water column, the agitation may strip volatile compounds. Due to the difficulties and limitations inherent in their use, other sampling or purging means should generally be given preference.

Bailers should be closed-top Teflon® bailers with Teflon® coated stainless steel leaders used with new nylon haul rope. They are lowered gently into the top of the water column, allowed to fill, and removed slowly. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging and during sampling, to minimize turbidity and loss of volatile organic constituents.

If the well has previously been purged with a pump, there is likely stagnant water at the top of the well that was above the pump or tubing inlet. Several bailers of water should be retrieved and discarded to assure the upper stagnant water has been removed unless the pump was slowly pulled all the way through the top of the water column at the conclusion of pumping to remove any potentially stagnant water.

When sampling, containers are filled directly by pouring from the outlet at the top of the bailer. Containers for metals analysis should be filled first in case the bailing process increases well turbidity. VOC vials should be filled carefully and slowly with a laminar flow to reduce agitation and the stripping of VOCs.

2.7 Wells with In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, and in other applications. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps.

A permanent monitoring well with an in-place pump may be treated as other monitoring wells without pumps. Since the in-place pump is generally “hard” mounted at a pre-selected depth, it cannot be moved up or down during purging and sampling. If the pump inlet is above the screened interval, the well should be sampled using the Multiple- Volume Purge method. If the pump intake is located within the screened interval, the well can be sampled using Low-Flow procedures. Known details of pump type and construction, tubing types, pump setting depths, and any other available information about the system should be recorded in the field logbook.

In the case of the other types of wells, e.g., municipal, industrial, residential supply wells and irrigation wells, there is often not enough known about the construction aspects of the wells to apply the same criteria as used for monitoring wells. The volume to be purged in these situations therefore depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following subsections describe considerations and procedures to be followed when purging wells with in-place plumbing under the conditions described. Procedures for sampling residential wells are described in the LSASD Applied Science Branch Operating Procedure for Potable Water Supply Sampling ASBPROC-305 R4. Most residential supply wells fall under the intermittently running category.

2.7.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be found located between the pump and the storage tank. If no valve is present, locate and use the valve closest to the tank. Measurements of field parameters are recorded immediately prior to the time of sampling.

2.7.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Often under these conditions, 15 to 30 minutes of purging will be adequate. If samples must be collected from a tap that is past the collection tank, then it is preferable to determine that the pump is cycling and bringing up fresh formation water to the supply tank (usually the switching on and off of the pump or relay can be heard). Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purge and the final measurements made at the time of sampling should be considered the measurements of record for the event.

2.8 Temporary Monitoring Wells

2.8.1 General Considerations

As temporary wells are installed for immediate sample acquisition, the procedures used to purge temporary ground water monitoring wells may differ from those for permanent wells. Temporary wells include standard well screen and riser placed in boreholes created by hand augering or drilling, or they may consist of a drive rod and screen such as a direct-push Geoprobe® Screen Point that is driven into place at the desired sampling interval. As aquifer water enters the sampler immediately upon deployment, the requirement to remove several volumes of water to replace stagnant water does not necessarily apply. In practice, developing and purging the well to usable turbidity levels will usually remove many times the water that would be removed in a Multiple-Volume Purge with calculated well volumes. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply standard permanent monitoring well purging criteria to achieve representative aquifer conditions in the sample.

2.8.2 Development of Temporary Wells

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, causing extreme turbidity. The goal of development and purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure.

As an option, a small diameter inertial pump can be used to agitate and help loosen particles in the screen with the back-and-forth action used to actuate the device. The intake can be used at varying depths within the screen. The inertial pump use should be followed by purging with a peristaltic pump, if the water level is sufficiently high enough.

The following procedure has been found to be effective in developing and sampling small

diameter temporary wells where a peristaltic pump can be used. Turbidity can generally be lowered to 50 NTU at the time of sampling and turbidity less than 10 NTU is often achieved.

1. Cut peristaltic tubing to reach to the bottom of the well. Connect to a peristaltic pump and begin pumping at a high rate.
2. Use the tubing to vacuum out sediment at the bottom of the well.
3. Aggressively surge the end of the tubing in the screened interval by cycling the tubing rapidly up and down and moving the intake to different levels within the screen. Periodically repeat vacuuming of the well bottom.
4. When a visible 'break' to a lower turbidity is observed, cease surging the well and begin lowering the pumping rate.
5. When the water clears (turbidity < 100-200 NTU) begin raising the end of the tubing to the top of the water column.
6. Continue purging from the top of the water column, lowering the pump speed as required to lower turbidity. When adequately low turbidity and stable water quality parameters have been achieved, sampling can proceed.

Where the water level is below the limit of suction in a small diameter temporary well, a Geoprobe® mechanical bladder pump can be used for purging and sampling. The well should first be developed with an inertial pump to remove the bulk of silt and suspended particles that could clog the check valves of the bladder pump. The inertial pump is used to vacuum out the bottom of the well and surged in the screened interval until a 'break' to lower turbidity is observed prior to deployment of the bladder pump. Since the mechanical bladder pump requires cumbersome redeployment to change its pumping level, it should be deployed low enough in the water column that the water level will not be lowered below the pump during purging and sampling. The mechanical bladder pump is generally deployed above the screened interval to facilitate the settling of particles, but below the top of the water column to alleviate the need to reset the pump. Detailed instructions on the deployment of the pump can be found in SESDPROC203, Pump Operation.

If practical, temporary wells should be allowed to sit undisturbed after installation and development for approximately 24 hours before purging and collecting samples.

2.8.3 Decommissioning of Temporary Wells

After temporary wells have fulfilled their purpose, they should be properly decommissioned similar to permanent wells. In general, the casings and screens can be easily removed and the borehole should then be pressure grouted from the bottom of the original borehole to prevent surface contamination of the aquifer, cross-connection of aquifers, and to remove a potential vapor pathway.

Direct-push screen-point wells may be decommissioned by one of two methods:

1. A disposable screen is used. The sampling sheath is pulled off of the screen and a 30% solids bentonite grout is pumped down the tool string as the rods are withdrawn. Grout volumes are measured during pumping to assure that the hole is completely filled. The disposable screen is left behind at the bottom of the borehole.
2. The screen is removed with the sampler sheath and tool string. The hole is immediately re-entered with an empty sample sheath with disposable point. Upon reaching the original total depth of the temporary well, 30% solids bentonite grout is pumped down the tool string with the pumped volume monitored during tool string withdrawal to assure that the hole is completely filled.

A system is available to insert a small diameter grouting tube down through the screen- point screen. Grout is pumped through the grouting tube while the tools are withdrawn. LSASD does not use this system as grout denser than 20% solids cannot reliably be installed with this system.

Additional guidance on decommissioning may be found in SESDGUID-101, Design and Installation of Monitoring Wells.

2.8.4 Other Considerations for Direct-Push Groundwater Sampling

With certain direct push sampling techniques, such as the Hydropunch™ and other discrete samplers used with cone-penetrometer rigs, purging is either not practical or not possible. The sampling device may be simply pushed or driven to the desired depth and opened, whereupon the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the sampler may collect a turbid sample inappropriate for metals analyses or the sample may have inadequate volume to achieve desired reporting levels.

2.9 Wells Purged to Dryness

In some situations, a well may be screened in a low transmissivity zone and slow recovery allows it to be purged dry (extreme drawdown with water level near the bottom of the casing) even if using slow purge rates. That could occur during the Multiple- Volume Purge method or the Low-Flow method. In these cases, the well should be purged to dryness (evacuated) and sampled upon recovery of adequate volume for sampling. Sampling should occur as soon as adequate volume has recovered, if practical (if the well recovers fully during the night then a sample can be collected the next morning). The field parameters should be measured and recorded at the time of sample collection as the measurements of record for the sampling event.

Sampling under these conditions is not ideal and suitable qualifications of the data should be included in the report. Water cascading down the screen into the well may strip volatile compounds and elevate turbidity. Although suffering from other limitations, No- Purge methods may prove useful for these wells.

3.0 Special Purging and Sampling Procedures and Considerations

3.1 Volatile Organic Compounds (VOC) Analysis

Groundwater samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either pre-preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time prior to being extracted by the laboratory, whereas unpreserved samples have only a seven-day holding time prior to extraction. In the majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high amount of dissolved limestone, i.e., is highly calcareous, there will likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles and rendering the sample unacceptable. In this case, unpreserved vials should be used and arrangements confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm or knuckle to check if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. While the 8260 method allows for bubbles up to 6 mm at the time of analysis, dissolved or entrained gases can coalesce during shipment. Collecting VOC vials absent of bubbles is generally feasible and is a reasonable precaution.

3.2 Special Precautions for Trace Contaminant Sampling

- Sampling equipment must be constructed of Teflon® or stainless steel materials. Bailers and pumps should be of Teflon® and stainless steel construction throughout.
- New Teflon® tubing should be used at each well, although tubing dedicated to a particular well may be reused, either after decontamination or storage in the well between sampling events. Caution is appropriate in reusing tubing where early sampling events report high concentrations of contaminants.
- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.
- Sample collection activities shall proceed progressively from the least suspected

contaminated area to the most suspected contaminated area if purging and sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same cooler as environmental (i.e., containing low contaminant levels) or background samples.

- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, verified certified-clean disposable or non-disposable equipment cleaned according to procedures contained in LSASD Operating Procedure for Field Equipment Cleaning and Decontamination (LSASDPROC-205) or LSASD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

3.3 Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which contacts the water in the well must be cleaned in accordance with the cleaning procedures described in the LSASD Operating Procedure for Field Equipment Cleaning and Decontamination (LSASDPROC-205) or LSASD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (LSASDPROC-206). Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Rinse blank samples should be collected to verify the adequacy of cleaning when using a sampling pump other than a peristaltic pump.

3.4 Sampling for Per- and Polyfluoroalkyl Substances (PFAS) Analysis

Sources of Per- and Polyfluoroalkyl Substances (PFAS) contamination in groundwater can be from discharges or releases, applications of some PFAS products such as aqueous film-forming foams (AFFF), air deposition from manufacturing stack emissions, landfill leachate, and land applications of biosolids or effluents. The distribution of PFAS in groundwater is multifaceted and will be dependent on site-specific conditions as well as the individual properties of the PFAS such as chain length and functional group. Heavy PFAS contamination of subsurface soils can serve as long-term sources for both groundwater and surface water contamination. For more information about conducting site investigations for PFAS, please see the Interstate Technology and Regulatory Council's (ITRC's) August 2020 Fact Sheets: *Site Characterization Considerations, Sampling Precautions, and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS)*, and *Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances*.

3.4.1 Sampling Equipment

Special considerations are required for groundwater sampling equipment for PFAS analyses due to considerations related to PFAS behavior. It is important to consider the composition of the sampling equipment related to its ability to leach PFAS into the sample, or to adsorb PFAS from the sample media. Guidance documents recommend direct contact sampling equipment be inert and made of stainless-steel, high-density polyethylene (HDPE) and/or silicone. Disposable, one-time use equipment should be used when feasible. When equipment that will be in contact with sample media such as surge blocks, bailers, bailing rope, downhole pumps, tubing, electronic water level gauges, etc. cannot be verified as being PFAS-free, equipment blanks should be collected and analyzed to measure any PFAS contribution the equipment may have on the groundwater sample data. Reusable direct contact sampling equipment that will be used to collect samples for PFAS analyses should be decontaminated following the procedures in the *Field Equipment Cleaning and Decontamination at the FEC*, LSASDPROC-206.

Peristaltic pumps with HDPE and silicone tubing have been successfully used by LSASD personnel to collect groundwater samples from shallow monitoring wells and temporary wells for PFAS analyses. For sampling monitoring wells where the water table is deeper than the range of peristaltic pumps, stainless-steel single stage electric pumps can be used with HDPE tubing to both purge and sample the well. The pump's specifications should be reviewed to ensure that Teflon® or PTFE components are replaced when possible. It is advisable to collect the appropriate amount of equipment blanks based on the amount of sampling and field decontamination that is being performed (i.e. daily, 5%, 10%, etc.). Equipment blanks can be collected from the stainless-steel single stage pumps and HDPE tubing using PFAS-free water and clean, 4-Liter plastic graduated cylinders.

Depending on a project's data quality objectives (DQOs), it may be necessary to remove dedicated equipment in a monitoring well. It is advisable for sites with long-term monitoring for PFAS to remove dedicated equipment and replace with PFAS-free sampling equipment and components. When components in dedicated sampling equipment may contain Teflon™/polytetrafluoroethylene (PTFE) or other per-fluorinated compounds, efforts should be made to differentiate PFAS detected in the samples that can be attribute to the formation groundwater and the PFAS that may be the result of contamination from the dedicated sampling equipment.

3.4.2 Trace Level Sampling Technique for PFAS

To prevent PFAS contamination, **extreme care** is required when handling containers, samples and equipment that will be used to collect samples for PFAS analyses. **New gloves** must be worn when decontaminating and handling sample containers and equipment. When worn gloves become compromised by writing in a logbook, touching clothing, wiping away sweat, etc. by potential PFAS containing materials, they need to be changed for new gloves. Nitrile gloves are recommended for PFAS sampling investigations. Also, sample containers should be kept covered in original packaging or in Whirl-Paks® until ready for use. The sample container should be kept closed until it is filled with the appropriate volume of groundwater sample. The container's cap should only be kept in the sampler's gloved hand and replaced as soon as the sampling is done.

A trace level sampling technique can be used to minimize PFAS contamination of the samples. This process will require two field personnel for PFAS sample collection. When the field investigators are prepared to fill the sample container(s), a designated sampler will don new gloves while a second designee, with new gloves, will assist by opening sample container packaging/Whirl-Pak®. The designated sampler removes the sample container(s) from the packaging but keeps them closed. Only after the second designee, is ready to fill the sample container does the designated sampler remove the cap and hold it in their hand until the appropriate sample volume is obtained. After capping the sample container(s), return them to their Whirl-Pak®. The designated sampler who holds the sample container(s) should not touch anything else during the sample collection process. This is important because of the wide use of PFAS in commercial products such as clothing and personal hygiene products. Additionally, the designated sampler should avoid touching the sample media and the inside of the sample container. The second designee will operate sampling equipment and assist with sample container packaging and labeling. Sampling equipment known or suspected to contain PFASs should be avoided during sampling activities.

Sampling for groundwater during heavy precipitation shall be avoided due to the potential of rain mixing with the groundwater media during the sampling process. If a light rain begins to fall during the purging process of a well, samplers may erect a pop-up tent to minimize the impact of the precipitation on the groundwater PFAS sampling results. Gore-Tex® and other waterproof, breathable fabrics that contain PFAS should be avoided during PFAS sampling but rubberize rain suits are permissible.

Teflon should not be used for PFOS sample collection.

3.4.3 Quality Control Samples and Standard Operating Procedures

For groundwater samples undergoing PFAS analyses, it extremely important that quality control samples be collected as part of the investigation to demonstrate the PFAS contribution of the sample containers, decontamination solutions, gloves, decontaminated equipment and plastic used to store equipment. It is also important to take field quality control samples such as additional equipment rinse blanks, material blanks, field blanks, duplicates, and trip blanks to evaluate the groundwater sampling and sample handling activities of the investigation. Field blanks are very useful in assessing if the sampler's clothing, safety equipment and/or personal hygiene products had an impact on the sampling results.

Along with a good quality assurance program, standard operating procedures (SOPs) and detailed SAPs are required for PFAS investigations to provide consistency between samplers and investigations.

3.4.4 PFAS Groundwater Sample Handling Considerations and High PFAS Concentration Samples

Since PFAS sampling and analyses is non-routine for many field investigators and some laboratories, it is extremely important to coordinate the sample handling and documentation. The Region 4 LSASD laboratory requires that the samples be double

bagged with the inner bag being labeled with sample information. Sample labels **must not** be fixed to the sample container's exterior. Depending on the PFAS analytical method, two tared sample tubes with serial numbers may be used for the sample containers per sample station. These serial numbers need to be written on the sample's label. Samples are shipped cooled on ice at ≤ 10 °C. It is also helpful to double bag the ice which reduces the amount the ice melts during transport.

When collecting samples for multiple analyses, it is recommended to segregate the sample containers for the PFAS analyses into separate coolers from the containers for the other analyses.

When collecting samples of potentially high concentrations of PFAS groundwater, it is recommended that single-use sampling equipment be utilized if possible. High concentration groundwater samples should be segregated from suspected low-level samples during shipping to the laboratory. Samples that may contain high concentrations of PFAS should be clearly identified on the sample Chain of Custody that accompanies the samples to the laboratory.

3.5 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, sufficiently low turbidity is difficult to achieve and maintain. Removal and insertion of equipment after the purge or during sampling may elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to fill sample containers for metals analysis first. The preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds, and finally volatile organic compounds.

3.6 Filtering

As many contaminants are known to sorb to soil particles, the normal goal of sampling is to reduce the presence of these particles (measured by turbidity) in order that the dissolved concentration of contaminants can be obtained. However, transport of sorbed contamination on colloidal particles can be a means of contaminant transport on some sites. For this reason, the LSASD approach is to reduce turbidity through the careful purging of wells, rather than through filtering of samples, in order that the colloidal particles would be included in the sample.

As a standard practice, ground water samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter and used for flow system analysis and for the purpose of geochemical speciation modeling. Filtration is not acceptable to correct for improperly designed or constructed monitoring wells, inadequate well development, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis

should not be filtered. Prior to filtration of the ground water sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis:

1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the LSASD Guidance Document, Design and Installation of Monitoring Wells (SESDGUID-001).
2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with USEPA approved methods.
3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the redevelopment or re-installation of permanent ground water monitoring wells or the implementation of carefully conducted low flow rate sampling techniques.

If filtration is necessary for purposes of geochemical modeling or other **pre- approved** cases, the following procedures are suggested:

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.
2. When using pumps for sampling, the filter can generally be attached directly to the pump outlet. When sampling with a bailer or when otherwise required, an initial unfiltered sample with extra volume will be collected, and a peristaltic pump with filter used to decant and filter the sample to the final sample container.
3. Use a 0.45 µm pore-size filter to remove most non-dissolved particles. A 5 µm or 10 µm pore-size filter should be used for the purpose of determining colloidal constituent concentrations.
4. Fill the filter and rinse with approximately one additional filter volume prior to filling sample bottles.

Potential differences can result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from the following: 1) Metals in Ground Water: Sampling Artifacts and Reproducibility; 2) Filtration of Ground Water Samples for Metals Analysis; and 3) Ground Water Sampling - A Workshop Summary. See Section 4.0, References, for complete citation for these

documents.

3.7 Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in the following: 1) Sampling for Organic Chemicals and Microorganisms in the Subsurface; 2) Handbook for Evaluating Water Bacteriological Laboratories; and 3) Microbiological Methods for Monitoring the Environment, Water and Wastes. See Section 4.0, References, for complete citation for these documents.

3.8 Sample Handling and Preservation Requirements

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.
2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.
3. Place the sample into appropriate, labeled containers. Samples collected for VOC, and alkalinity analysis must be collected without headspace. All other sample containers must be filled with an allowance for ullage.
4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If pre-preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by Analytical Services Branch (ASB) personnel prior to departure for the field investigation. For all other chemical preservatives, LSASD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the LSASD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), most recent version. Consult the Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM) for the correct preservative for the particular analytes of interest.
All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample.
5. Sample containers should be placed in an ice-filled cooler as soon as possible after filling. Ice in coolers should be in bags with minimal pooled water and the cooler should be periodically checked and replenished to maintain sample storage

temperature.

3.9 Field Care of Purging Equipment

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible centrifugal or bladder pumps to purge wells which are excessively contaminated with oily compounds as it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative equipment, such as bailers or peristaltic pumps, should be considered.

3.10 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in the LSASD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDFROC-205) or LSASD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDFROC-206). Malfunctioning equipment should be labeled in the field and repaired, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

3.11 Quality Control

Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers, tubing, or other sampling equipment.

Where appropriate, a background sample upgradient of all known influences or a control sample upgradient of site influences may be indicated. Background and control samples should be collected as close to the sampled area as possible and from the same water-bearing formation as the site samples.

3.12 Investigation Derived Waste

Purging, well development and field cleaning of equipment generate liquid investigation derived waste (IDW), the disposition of which must be considered. See LSASD Operating Procedure for Management of Investigation Derived Waste (SESDFROC-202) for guidance on management or disposal of this waste.

3.13 Records

Information generated or obtained by LSASD personnel will be organized and accounted for in accordance with LSASD records management procedures found in LSASD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with LSASD Operating Procedure for Logbooks, SESDPROC-010 and LSASD Procedure for Sample and Evidence Management, SESDPROC-005.

3.14 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water levels measured according to the LSASD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations, pumping rates during purging, driller or boring logs, and number of drums left on site if IDW is temporarily stored there. This information should be documented in the field records.

3.15 Well Development

Wells may be encountered that are difficult to sample effectively due to inadequate initial development or the need for redevelopment due to scaling, sedimentation, corrosion, or biofouling. Some wells were not properly developed when installed. Those wells may have borehole walls smeared with clays, sandpicks and screens that have not been cleared of smaller particles, and sediments accumulated in the bottom of the casing. These wells may produce water at much lower flow rates than the formations are capable of, and often produce water with chronically elevated turbidity. Transmissivity calculations for poorly developed wells may not be inaccurate. Redevelopment of these wells should be considered as the process can improve sample quality and speed stabilization for purging and sampling events. General well development procedures are described in Design and Installation of Monitoring Wells (SESDGUID-101). Additional well development explanation and description of techniques are included in the book *Groundwater and Wells* (referenced below) and other publications.

Techniques commonly used for conditioning and re-development of monitoring wells include using snug-fitting swabs on sections of tremie pipe to clean screens and create positive and negative pressure surges through the screen, surging, removing sediments in the bottom of the well with inertial pumps, aggressive pumping and surging throughout the screen with submersible pumps, and use of automated inertial pump systems such as the Waterra system. Drillers may be able to use compressed air to assist in development. Techniques used and amount of time and effort for development will depend on the condition of the well and the construction of the well (borehole diameter, depth, screen length).

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LSASD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

LSASD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

LSASD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

LSASD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

LSASD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

LSASD Operating Procedure for Groundwater Level and Well Depth Measurement, LSASDPROC-105, Most Recent Version

LSASD Operating Procedure for Management of Investigation Derived Waste, SESDROC-202, Most Recent Version

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Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the LSASD Document Control Coordinator on the LSASD local area network (LAN).

History	Effective Date
Replaced Chief with Supervisor; General formatting revisions.	April 22, 2023
<p>LSASDPROC-301-R5, Groundwater Sampling, replaces SESDPROC-301-R4.</p> <p>General: Corrected any typographical, grammatical, and/or editorial errors.</p> <p>General: Reorganization of sections, including moving references section to end of document. Elimination of redundancy. Clarifications of certain aspects of low-flow methods.</p> <p>Specific: Addition of PFAS sampling section.</p>	November 23, 2021
<p>SESDPROC-301-R4, Groundwater Sampling, replaces SESDPROC-301-R3.</p> <p>General: Corrected any typographical, grammatical, and/or editorial errors.</p> <p>General: An extensive rewrite and reorganization of material. Stronger support of low-flow methods while maintaining cautious view of minimal/no purge methods.</p>	April 26, 2017
SESDPROC-301-R3, Groundwater Sampling, replaces SESDPROC-301-R2.	March 6, 2013
SESDPROC-301-R2, Groundwater Sampling, replaces SESDPROC-301-R1.	October 28, 2011
SESDPROC-301-R1, Groundwater Sampling, replaces SESDPROC-301-R0.	November 1, 2007
SESDPROC-301-R0, Groundwater Sampling, Original Issue	February 05, 2007