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Standard Practice for Low-Flow Purging and Sampling ~~for Wells and Devices~~ Used for ~~Ground-Water Quality Investigations~~Groundwater Monitoring[1]

This standard is issued under the fixed designation D6771; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice describes the method of low-flow purging and sampling used to collect groundwater samples from wells to assess groundwater quality.

1.2 The purpose of this procedure is to collect groundwater samples that represent a flow-weighted average of solute and colloid concentrations transported through the formation near the well screen under ambient conditions. Samples collected using this method can be analyzed for groundwater contaminants and/or naturally occurring analytes.

1.3 This practice is generally not suitable for use in wells with very low-yields and cannot be conducted using grab sampling or inertial lift devices. This practice is not suitable for use in wells with non-aqueous phase liquids.

1.4 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses are approximate mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.5 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "standard" in the title means only that the document has been approved through the ASTM consensus process.*

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] ~~This practice is~~ These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and ~~is~~are the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

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*A Summary of Changes section appears at the end of this standard

2. Referenced Documents

2.1 *ASTM Standards:*[2]
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
~~D5092~~D5092/D5092M Practice for Design and Installation of Groundwater Monitoring Wells
~~D5521~~D5521/D5521M Guide for Development of Groundwater Monitoring Wells in Granular Aquifers
D5608 Practices for Decontamination of Sampling and Non Sample Contacting Equipment Used at Low Level Radioactive Waste Sites
D5903 Guide for Planning and Preparing for a Groundwater Sampling Event
~~D5978~~D5978/D5978M Guide for Maintenance and Rehabilitation of Groundwater Monitoring Wells
D6089 Guide for Documenting a Groundwater Sampling Event
D6452 Guide for Purging Methods for Wells Used for Ground Water Quality Investigations
D6517 Guide for Field Preservation of Ground Water Samples
~~D6564~~D6564/D6564M Guide for Field Filtration of Groundwater Samples
~~D6634~~D6634/D6634M Guide for Selection of Purging and Sampling Devices for Groundwater Monitoring Wells
~~D6725~~D6725/D6725M Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
D6911 Guide for Packaging and Shipping Environmental Samples for Laboratory Analysis
D7069 Guide for Field Quality Assurance in a Groundwater Sampling Event
D7929 Guide for Selection of Passive Techniques for Sampling Groundwater Monitoring Wells

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms about soil and rock and the fluids contained in them, refer to Terminology in D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *artifactual turbidity*—particulate matter that is not naturally mobile in the groundwater system and can be introduced to the subsurface during drilling or well construction, sheared from the target monitoring zone during purging of the well, or produced by exposure of groundwater to atmospheric conditions (abbreviated definition from D653).

3.2.2 *~~blank-casing~~ blank-riser pipe water*—water in the ~~casing~~ riser pipe interval of a monitoring well above or below the well screen that is assumed to not represent formation quality water because it is less susceptible to ambient well flushing and is potentially stagnant.

3.2.3 *drawdown [L]*—vertical distance the ambient (non-pumping) water level is lowered due to continuous removal of water from the well.

3.2.4 *flow-through cell*—vessel through which purge water is transported in order to contact sensors for continuous measurement of indicator and operational parameters.

3.2.5 *flow-weighted average concentration*—single analyte value that reflects a mixture proportional to the flow rate and respective concentrations of groundwater entering the screen interval.

3.2.6 *indicator parameters*—chemical properties (oxygen, oxidation-reduction potential, specific conductance, and pH) measured to determine when the discharge water is considered to represent a flow-weighted average concentration of the formation water.

3.2.7 *operational parameters*—physical properties (water level, turbidity, and temperature) measured to determine whether pumping operations have introduced potential sampling biases.

3.2.8 *optimum pumping rate* $[L^3/T]$—well-specific pump rate used to minimize the purge time required before sampling while also minimizing changes to the ambient groundwater flow conditions and operational parameters.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.9 *pumping water level [L]*—free or unconfined water elevation during purging and sampling.

3.2.10 *screen volume [L^3]*—quantity of water contained in the screened interval of a monitoring well.

3.2.11 *stabilization*—condition that occurs when changes in indicator and operational parameter values are maintained within a specified range over a selected number of consecutive readings and it appears the readings will continue to remain within that specified range during subsequent readings.

4. Summary of Practice

4.1 *General Objective*—Under ambient conditions, the amount of groundwater flow through a monitoring well screen is dependent on the local hydrogeological conditions and well design (for example, well diameter, screen length, sand pack). If a well is constructed, developed, and maintained properly, hydraulic communication normally exists between the formation and well under ambient conditions (**1**).[3] With adequate hydraulic communication and ambient aquifer flow, the composition of the formation water and pre-pumping well water may be very similar (Guide D7929). However, purging methods are commonly applied to assure the collection of formation-quality water. Indicator parameters (for example, dissolved oxygen and specific conductance) can be monitored to assess changes in the composition of the discharge water as formation water is drawn into the well, mixes with existing well water, and displaces the pre-existing water in the screened interval during purging. If the well is purged at a rate that results in substantial changes (that is, stress) to the ambient flow conditions, as can be shown by increases in operational parameters (drawdown and turbidity), the quality of formation water entering the well screen can be altered. The low-flow purging and sampling method was developed to collect reproducible samples that are considered to represent a flow-weighted average of the formation water while minimizing changes to the ambient flow conditions (**2**).

4.2 *Minimizing Hydraulic Stress*—Pumping that induces excessive drawdown and/or groundwater inflow velocities through the well screen can result in sampling biases associated with screen dewatering, water column aeration, artifactual turbidity, and/or mixing of ~~blank-casing~~ blank-riser pipe water into the screened interval. The magnitude of these effects at a given pumping rate are dependent on the well design and near-well hydrogeological conditions (for example, gradient and hydraulic conductivity). Since the amount of hydraulic stress and related sampling biases that can occur at a given pumping rate varies for each well, the overall goal of low-flow purging and sampling is to minimize hydraulic stress by reducing the pumping rate to the extent practical. Typically pumping rates on the order of 0.1 to 1.0 L/min can be used to minimize changes to ambient flow conditions while preserving the quality of formation water entering the well (**2**), although higher rates can be used if appropriate.

4.3 *Sample Composition*—Groundwater samples collected by this method are considered to represent a flow-weighted average of the formation water entering the screened interval based on the stabilization of indicator parameters (**3-7**). The vertical distribution of the inflow rate through the well screen varies according to the vertical distribution of permeable materials in the surrounding formation and the presence of vertical head gradients (if any). Some degree of vertical mixing often occurs within the well under ambient flow conditions (**4, 8**). During pumping, the mixed pre-pumping well water is incorporated with groundwater that enters the well screen and advances toward the pump intake. The purge time needed to achieve stabilization of indicator parameters is dependent on the well design, the degree of in-well mixing, vertical heterogeneity of surrounding formation materials, and stratification of the formation water quality (if any) entering the well screen. These factors control the volume of water to be purged. Where the composition of formation water entering the well screen interval is relatively homogenous and/or is similar to the pre-pumping well water (as signaled by the stabilization of indicator parameters), a sample collected by low-flow purging and sampling reflects an acceptable mixture of the formation and pre-pumping well water (**3, 4**).

5. Significance and Use

5.1 *Method Considerations*—The objective of most groundwater sampling programs is to obtain samples that are similar in composition to that of the formation water near the well screen. The low-flow purging and sampling method uses the stabilization of indicator parameters to determine when the pump discharge is considered to represent a flow-weighted average of the formation water. Measurements of operational parameters are used to determine potential sampling bias (for example, artifactual turbidity and increased temperature) that may have been introduced by pumping operations and to ensure that the sample is representative of formation water. The low-flow purge rate minimizes lowering of the ambient groundwater level and thereby minimizes potential entrainment of ~~blank-casing~~ blank-riser pipe (and potentially stagnant) water above or below the screen into the screened-zone of

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.

the well. This sampling method assumes that the well has been properly designed and constructed as described in Practices ~~D5092~~D5092/D5092M and ~~D6725~~D6725/D6725M, adequately developed as described in Guide ~~D5521~~D5521/D5521M, and has received proper well maintenance and rehabilitation as described in Guide ~~D5978~~D5978/D5978M (see Note 1).

NOTE 1—This Standard is not intended to replace or supersede any regulatory requirements, standard operating procedure (SOP), quality assurance project plan (QAPP), ground water sampling and analysis plan (GWSAP) or site-specific regulatory permit requirements. The procedures described in this Standard may be used in conjunction with regulatory requirements, SOPs, QAPPs, GWSAPs or permits where allowed by the authority with jurisdiction.

5.2 *Applicability*—Low-flow purging and sampling may be used in a monitoring well that can be pumped at a constant low-flow rate without continuously increasing drawdown in the well (**2**). If a well cannot be purged without continuously increasing drawdown even at very low pumping rates (for example, 50 – 100 mL/min), the well should not be sampled using this sampling method as described in this standard; a passive sampling method, as described in Guide D7929, may be considered as an alternative.

5.3 *Target Analytes*—Low-flow purging and sampling can be used to collect samples for all categories of aqueous-phase contaminants and naturally-occurring analytes. It is particularly well suited for use where it is desirable to sample aqueous-phase constituents that may sorb or partition to particulate matter, because the method minimizes the potential for artifactual turbidity compared with high flow/high volume purging using a pump, bailer, or inertial-lift device (**9-12**).

6. Benefits and Limitations of Low-Flow Purging and Sampling

6.1 *Benefits:*

6.1.1 Purging and sampling at a low-flow rate provides more accurate and reproducible samples of the formation-quality water than high flow/high volume purging and sampling methods by minimizing hydraulic stresses on the ambient flow conditions that may introduce one or more of the following biases to the sample (**12, 13**):

6.1.1.1 *Artifactual Turbidity*—Artificially elevated turbidity levels induced by pumping rates that entrain colloidal sized particles that are immobile under ambient flow conditions can result in increased concentrations of contaminants that are sorbed or partitioned on those colloids (for example, metals and some organics);

6.1.1.2 Artificial aeration, or oxygenation, of the water column from percolation and/or cascading of water down the sand pack and well screen, respectively, when the well is rapidly dewatered. Water column aeration can also result from agitation by the sampling device. These processes can result in the loss of volatile organic compounds and dissolved gases, as well as chemical changes associated with oxygenation; and

6.1.1.3 Entrainment of ~~blank-casing~~ blank-riser pipe (and potentially stagnant) water from drawdown or excessive agitation of the water column.

6.1.2 Purging and sampling at a low-flow rate can provide more cost and well-maintenance benefits than other purge and sampling methods by:

6.1.2.1 Reducing purge-water volume, resulting in reduced exposure of field personnel to potentially contaminated purge water;

6.1.2.2 Reducing well maintenance (for example, redevelopment) through reduced pumping stress on the well and formation, resulting in greatly reduced movement of fine sediment into the filter pack and well screen;

6.1.2.3 Reducing purge-water volume, resulting in savings of costs related to purge water handling and disposal or treatment; and

6.1.2.4 Potentially reducing purge time, particularly when using dedicated pumps (**14**), resulting in labor cost savings.

6.2 *Limitations:*

6.2.1 Low-flow purging and sampling is generally not suitable for use in very low-yield wells (those that will not yield sufficient water without continuously increasing drawdown while pumping at very low rates (for example, 50 – 100 mL/min) over time).

6.2.2 As with any sampling method, low-flow purging and sampling is not suitable for sampling in wells known to contain light or dense non-aqueous-phase liquids (NAPL), because it may misrepresent the risk to human health and may complicate data interpretation.

6.2.3 Low-flow purging and sampling cannot be performed using grab sampling devices (for example, bailers) or inertial-lift devices, because these devices can severely agitate the water column in the well, and this typically results in aeration, excessive mixing of the water column, and artifactual turbidity (see Guide ~~D6634~~D6634/D6634M).

6.2.4 Low flow purging and sampling could result in longer purge times than other purge methods described in Guide D6452, such as fixed volume purging and well evacuation purging.

7. Equipment Requirements for Low-Flow Purging and Sampling

7.1 A variety of adjustable-rate submersible pumps (for example, bladder, centrifugal, peristaltic) capable of pumping at low flow rates can be used for low-flow purging and sampling. Because the purging and sampling processes are joined together into one continuous operation, the pump selected (see Guide ~~D6634~~D6634/D6634M) should be appropriate for use both in purging and sampling the analytes of interest. Equipment accompanying the pump selected should include a power source (for example, generator, compressor, compressed gas, or battery) and a controller capable of varying the pump discharge within the range of desired flow rates for purging and sampling (generally 0.1 to 1.0 L/min).

7.2 Dedicated tubing or dedicated pumps with tubing (those that are permanently installed in the well) are strongly recommended over portable pumps because they eliminate disturbance to the water column in the well caused by deployment of the pump and/or tubing prior to each purging event, and result in lower turbidity values, shorter purge times, and lower purge volumes to achieve stabilized indicator parameter measurements. However, portable pumps and disposable tubing can be used if care is taken to minimize disturbance to the water column during pump and tubing installation (see Guide D6634D6634/D6634M). In instances where the pump is at the surface, the tubing should be dedicated to the well and preferably stored in the well. Using dedicated pumps and tubing reduces the possibility of cross contamination from the previous well sampled (due to desorption of sorbed analytes), the need to decontaminate the equipment between sampling events, and the loss of analytes due to sorption especially by new materials.

7.3 The length of tubing fitted to the pump system for purging and sampling should be minimized to reduce the amount of time required to bring purge water to the surface. A 6.4- to 9.5-mm (¼- to ⅜-in.) outside tubing diameter is typically used. The selection of tubing materials should be appropriate for the target analytes.

7.4 A means of determining the pumping flow rate is necessary. This can be accomplished using a volume measuring device (for example, graduated cylinder) and a timepiece capable of measuring seconds, a flow meter, or any other device that will allow an accurate flow rate determination.

7.5 Low-flow purging and sampling requires periodic water-level measurements. Any water-level measurement equipment that does not disturb the water column in the well may be used (for example, transducer or electronic water level meter), as long as it provides the accuracy required by the sampling program (generally ±3 mm (0.01 ft)).

7.6 The purging phase of this sampling protocol requires periodic measurements of indicator and operational parameters to determine when purging is complete and sampling can commence. Indicator parameters and operational parameters of turbidity and temperature should be measured using a multi-parameter instrument coupled with an in-line flow-through cell. Transparent flow-through cells are preferred to observe for potential sediment accumulation and/or gas bubbles. Where initial turbidity levels are high, it may be preferable to measure turbidity ahead of the flow-through cell to prevent the accumulation of solids in the cell from affecting turbidity readings. A flow diverter located upstream of the cell can be used to collect a sample for measurement using a portable turbidity meter. The multi-parameter instrument and turbidity meter should be properly calibrated and maintained in accordance with manufacturer instructions.

7.7 Other equipment and supplies used in low-flow purging and sampling typically include decontamination supplies, sample bottles, calibration standards for field water quality instruments, and field documentation materials.

8. Description of the Procedure

8.1 *Preparation for Low-Flow Purging and Sampling*—Prior to conducting a sampling event, the sampling team should prepare themselves and any equipment and materials to be used during the event in accordance with Practice D5903. It is particularly important to review and bring to the site a copy of the site-specific sampling and analysis plan, well construction data for the wells to be sampled, and the field data from previous sampling events. Any equipment used in the sampling program that could contact the water in the well, the water collected during field parameter measurement, or the water collected as a sample should be properly cleaned before (and after) each use (see Practices D5088 and D5608). The clean equipment should not be allowed to contact the ground or other surfaces that could impart contaminants. An effort should be made to closely match the length of the tubing used for the pump with the sampling depth so that there is no excess tubing. Using excess tubing and/or leaving the tubing and flow-through cell in direct sunlight on hot days can elevate water temperature and could affect sample chemistry (see Guide D6634D6634/D6634M). Dedicated sampling equipment eliminates concerns about cross-contamination and reduces the need for decontamination and equipment cleaning blank samples.

8.2 *Pump Placement:*

8.2.1 The intake of the pump or tubing generally should be positioned at or near the mid-point of the submerged portion of the well screen. The position for the intake should be below the water level in the well at all times. Since the sample composition from low-flow purging and sampling is designed to represent a flow-weighted average of formation water entering across the entire screened interval, the location of the pump or tubing intake should not affect the quality of the sample. However, locating the pump or tubing intake near the distant ends of the screen interval may increase the overall purging time due to the later arrival of groundwater from the opposite end of the screen interval (**3-5**). The same pump or tubing intake position should be used for subsequent groundwater monitoring events.

8.2.2 Dedicated sampling equipment is strongly recommended to avoid issues resulting from insertion of the pump (or sample tubing in the case of a peristaltic pump) through the water column for consistent placement of the pump (or tubing) inlet for each sampling event. Portable pumps or sample tubing should be installed carefully and lowered slowly into the screened zone to minimize mixing ~~blank-casing~~ blank-riser pipe water into the screened interval. The disturbance of the water column caused by the deployment of portable equipment usually results in an increased purge time to achieve stabilization of turbidity and indicator parameters.

8.3 *Optimum Pumping Rate:*

8.3.1 The optimum pumping rate used for low-flow purging and sampling should be determined in the field on a well-specific basis because each well screen is located in a hydraulically unique position and hydraulic performance can vary according to the well design and effects of drilling and well development on the borehole and adjacent formation. In general, the optimum pumping rate is selected to minimize the purge time required before sampling, as well as changes to the ambient groundwater flow conditions (for example, artifactual turbidity, aeration of the water column, and/or mixing of ~~blank-casing~~ blank-riser pipe water) that could potentially result in sampling bias. The optimum pumping rate established for a given well can be used for subsequent monitoring events, provided the well performance does not vary seasonally or during its lifetime.

8.3.2 If an optimum purging rate has not been previously established, the following procedure is recommended. After the pump intake is set in the well, the pump should be started at a low initial pumping rate (for example, 100 - 200 mL/min). From the time the pump is started, the pumping water level in the well should be measured (see 8.4.1) to determine the amount of drawdown caused by pumping. If drawdown continues to increase over several water level measurements, the pumping rate should be reduced until the pumping water level stabilizes (see Table 1). If the pumping water level cannot be stabilized, then low-flow purging and sampling may not be feasible and an alternative method, such as passive sampling (see Guide D7929), should be considered. If there is minimal change in the ambient water level after starting the pump, the pumping rate may be increased until a relatively small amount of drawdown is observed and then adjusted (if necessary) to stabilize the pumping water level. Once optimized, the purging flow rate should be recorded and can be used at subsequent sampling events as the initial purge rate, making adjustments as needed for temporal or seasonal changes in well yield.

8.4 *Measurements of Operational Parameters:*

8.4.1 Pumping water level is a required operational parameter measured to assess and minimize changes to the ambient groundwater level and potential sampling biases associated with well dewatering, such as water column aeration and/or mixing of ~~blank-casing~~ blank-riser pipe water into the screen interval. Prior to installing a portable pump in the well or prior to the commencement of pumping in wells in which dedicated pumps are installed, an initial measurement of the ambient water level should be obtained. During initial purging, the pumping water level should be measured on either a continuous or periodic basis (every few minutes) to minimize the amount of drawdown and confirm that water levels stabilize at the optimum pumping rate as described in 8.3.2. After stabilization, pumping water level measurements should be collected periodically to confirm the level remains stable throughout the purging and sampling process.

8.4.2 Measurement of turbidity is a recommended operational parameter that can be used to assess and minimize potential sampling biases associated with artifactual turbidity (Note 2). Laboratory analysis of groundwater samples with artifactual turbidity can potentially result in concentrations of some organic and inorganic analytes (for example, metals and highly hydrophobic organics such as polynuclear aromatic hydrocarbons, PCBs, and some pesticides) that are higher than the concentration in the ambient formation water (**15**). After the pumping water level stabilizes (see Table 1), turbidity should either be measured using a multi-parameter instrument coupled with an in-line flow-through cell or with a portable meter from purge water samples collected prior to entering the flow-through cell. The frequency of measurements should be similar to the rate determined for measurements of indicator parameters (see 8.5.1). If turbidity values are persistently high, the pumping rate should be lowered until turbidity decreases. If this fails to solve the problem, well maintenance or redevelopment may be necessary. Difficulties with high turbidity should be identified during pilot tests prior to implementing low-flow purging or during the initial low-flow sampling event, and contingencies should be established to minimize the problem of elevated turbidity (for example, redeveloping the well).

NOTE 2—Sources of naturally occurring and artifactual turbidity in monitoring wells can include: (*1*) naturally occurring colloid-sized or smaller solids that may be in transit through the formation; (*2*) naturally occurring solids or artifactual solids from well drilling and installation (for example, drilling fluids, filter pack, grout) that have not been effectively removed by well development and are mobilized by agitation of the water column (for example,