Well Purging Procedures for Obtaining Valid Water Samples from Domestic and Monitoring Wells

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Background: Wells are purged (pumped or bailed) prior to sampling because a fresh water sample is needed to accurately assess groundwater quality. Water standing in a well for a period of time undergoes changes that can affect and alter the water quality; it stagnates. Examples of these changes include:

- temperature
- gases (e.g., oxygen, carbon dioxide, methane, or hydrogen sulfide) can go into or escape from solution
- oxidation
- biological activity
- precipitation of metals
- reactions with the well casing and/or grout

These changes can impact several parameters including but not limited to: pH, Eh, alkalinity/acidity, hardness, and the concentration of metals, sulfate, dissolved solids, and dissolved oxygen.

Knowledge of the well's yield rate prior to purging and sampling is preferable to prevent dewatering which can cause sampling problems. However, in many cases you will not have any idea of the well yield. This guidance sheet discusses purging and sampling of both low- and high-yielding wells.

The procedures discussed herein are primarily designed for wells located in undisturbed sedimentary strata of the Appalachian Plateau region and for mining-related issues. Ground-water movement through undisturbed strata in this region is mainly via the secondary permeability and porosity of fractures in the rock (non-Darcian). The sedimentary rocks throughout much of the Appalachian Plateau are highly cemented and well indurated; thus primary porosity and permeability (intergranular storage and flow) are very low and their influence to the ground-water regime is negligible.

Purging: Typically, purging a monitoring well of three (3) well volumes is considered sufficient to obtain a valid sample. The well volume is the amount of water contained initially inside the well bore. If you have reason to believe that three well volumes are inadequate, continue to purge the well. Reasons to indicate the well is insufficiently purged include but are not limited to: 1) the water became and has remained cloudy or discolored during purging, 2) the field parameters (discussed below) have not yet stabilized, or 3) you can hear material falling from the sides or surface of the borehole into the water. Ultimately, the decision to sample or not after purging three well volumes is to the discretion of the best professional judgment of the individual conducting the sampling. If you purge five or more well volumes, proceed with the sampling. Just be sure to maintain a detailed record of the purging procedure and any problems that may have occurred. How to determine the water quantity to be purged is discussed below.

Determination that a well has been adequately purged can also be achieved by monitoring one or more field parameters (e.g., pH, temperature, specific conductance, Eh, and/or turbidity). Dissolved oxygen (DO) can also be used as a field parameter at wells with a submersible pump. However, DO is not recommended to be used at a well with a jet pump and cannot be used when the well is purged with a bailer. Those two methods can artificially entrain oxygen into the water. You do not have to monitor for all field parameters. You should monitor for at least two of them; although, one may be acceptable if you have no other means. Readings should be taken every three to five minutes while pumping.

Once all of the field parameters that you are monitoring have stabilized for at least 15 minutes, you can take the water sample. Stabilization is reached when the readings for:

- pH is within 0.1or 0.2 of a standard unit
- temperature is within 0.2 degrees C or 3%
- specific conductance is within 5% for values equal to or less than 100 microsiemens and 3% for values greater than 100 microsiemens
- DO is within 10%
- Eh/ORP (oxidation reduction potential) is within 10 millivolts
- Turbidity is within 10% for values greater than 1 NTU but less than 100 NTUs

With this purging method, you are not governed by the amount of water purged. However, if purging is continued until five well volumes or more are removed, sampling can proceed, even if the field parameters have not stabilized. Just be sure to record any problems that occurred at any time during the purging and sampling process. Ideally, a sealed flow-through-cell should be used when measuring the field parameters to preclude any atmospheric impacts on the water sample.

For domestic wells that are consistently used (i.e., daily), extensive purging prior to sampling may not be needed. If the well has been used for normal domestic purposes within the previous 24 hours, this will perform most of the required purging. However, you will need to run water at 1-2 gpm for approximately 10-15 minutes prior to taking a sample. This will clear the plumbing system and allow for a fresh water sample to be taken.

When sampling a domestic well, collect the water from the cold water line as close as possible to the well. If possible, samples should be taken from a spigot prior to the holding (pressure) tank. Do not sample the hot water line. Do not sample after an in-line filter or after a treatment system, unless you want to determine how well the filter or treatment system is working.

Flowing artesian wells do not need to be purged. Sample them at the overflow or as close as possible to the well head.

Domestic wells in this region are frequently inaccessible because they have been buried or the well cap cannot be removed. In these cases, it is recommended that you use the field parameter method to determine when to sample. However, if you cannot use the field parameter method, you can estimate the well dimensions and the purge volumes. As stated before, be sure to record how the purging amount was determined and method was performed.

Low-Flow Purging and Sampling: There are times when a very low yielding well will be completely dewatered during purging. Precautions should be taken to prevent this situation, but it does happen. In these cases, allow the well to sufficiently recover (preferably 75% or more of the pre-purging water level) so a complete sample can be taken. Sample even if the field parameters had not stabilized. If the recovery is insufficient to obtain a sample without disturbing the sediment at the bottom of the well, it is best to wait until you can. In most cases, the well should be sampled within 24 hours of the dewatering. Significant water quality changes, as discussed above, may occur if the water is allowed to sit for several days. One additional caveat is that flow-flow sampling is based on the assumption of horizontal flow through a porous (Darcian) aquifer adjacent to the pump intake; seldom the case in the fractured rock of the Appalachian Plateau.

Ideally, you will know ahead of time that this is a low-yielding well and a low-flow purging technique should be utilized. The low-flow purging pump rate is generally less than 0.25 gpm (1 lpm) which is designed to minimize drawdown and alteration to the water chemistry. Adjustable rate submersible pumps are ideal for low-flow purging. Suction pumps are not recommended because they can cause degassing, changes in pH, and loss of volatiles. The pump intake should be located in the center of the yielding zone (e.g., well screen or water column of an open borehole). Take care when putting the pump in the well to minimize any disturbance that could disturb sediment from the bottom of the well or dislodge material from the borehole sides.

Measure the water level prior to starting the pump. Turn the pump on to its lowest setting until water begins to discharge. Check the water level and adjust the pump rate to keep the drawdown to less than 0.3 feet, if possible. Continue pumping until the chemical parameters stabilize as discussed above. Monitor the water level every three to five minutes while purging. The pumping rate should also be checked every three to five minutes. The total amount of water pumped can be used in lieu of the pumping rate. Record the start time and the time samples were collected, so the average pumping rate can be calculated using the total water pumped over that time period.

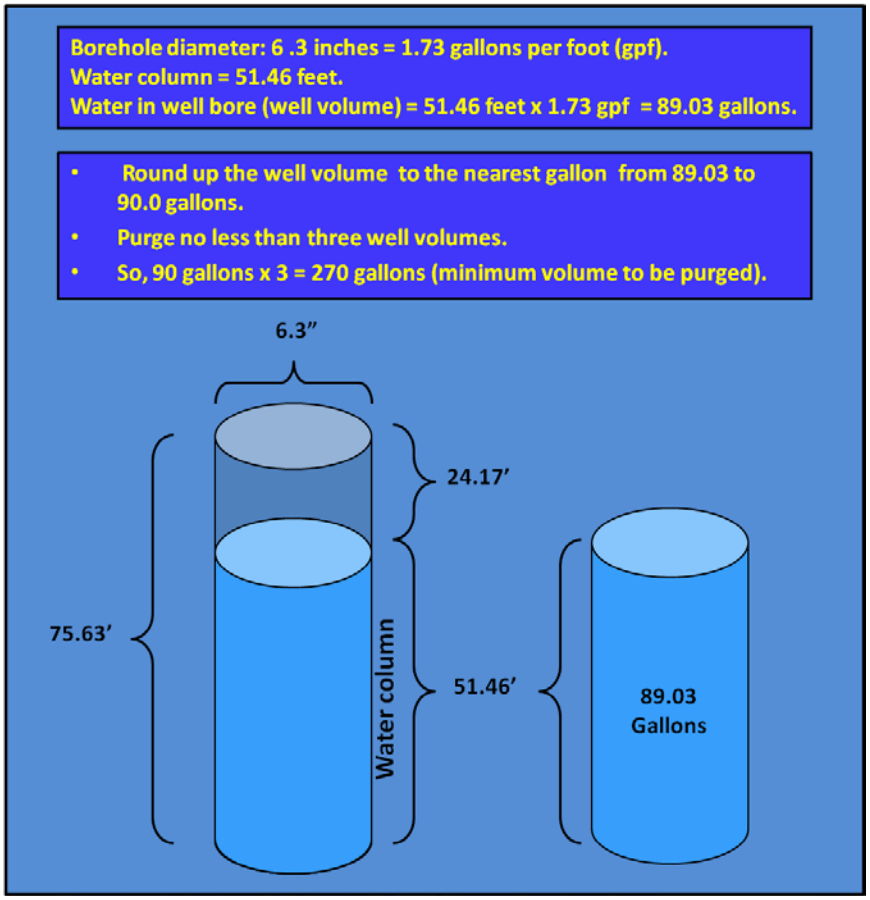
How to determine well purging volumes:

1. Measure depth to water and total depth of well from the same reference point. Total depth can also be taken from the drillers or well log, if available. If total depth is from the drillers log and you measure the depth to water from the top of casing, then you must subtract the height of the casing above the ground from the depth to water measurement. If the measurements are in feet and inches, divide the inches by 12 to convert to feet (Example: total depth = 22' 5" = 22.42'). Subtract the depth to water from the total depth to determine the water column height.
2. Use Table 1 to determine the well volume in gallons per linear foot for the well you intend to sample. If the table does not have the exact diameter of your well, go to the next highest one.
3. Multiply the height of the water column times gallons per linear foot to determine the total well bore volume in gallons.
4. Multiply the result of step 3 by 3 to determine the total amount of gallons to properly purge the well by 3 volumes. Always round up to the nearest gallon!

Example Calculation:
The well casing diameter = 6.3"
Measured well depth = 75' 7.5"
Measured depth to water = 24' 2"
Measured well depth in feet = 75' + 7.5"/12" = 75' + 0.625' = 75.63'
Measured depth to water in feet = 24' + 2"/12" = 24' + 0.167' = 24.17'
Then 75.63 - 24.17 = 51.46' = height of standing water column in the well.
Based on Table 1, use a well inside diameter of 6.5" which is 1.73 gallons per linear foot.
So, 51.46' x 1.73 gallons per linear foot = 89.03 gallons in one well volume.
Three well volumes = 90.0 gallons x 3 well volumes = 270 gallons. Round up to nearest gallon, when necessary.

Flow measurements can be taken by directly measuring all of the water pumped from the well. However, an easier and acceptable alternate method for pumped wells is to measure the discharge rate and then run the water for the length of time required to remove the predetermined quantity of water. For example, if you need to purge 40 gallons and your discharge rate is 3 gallons per minute, you have to purge for at least 14 minutes. With this alternate method, you will need to periodically recheck the discharge rate for changes. As a well is pumped, the water level is frequently drawn down causing the efficiency of the pump to decrease. Pump efficiency is decreased because the water has to be lifted higher above the decreasing water level in the well. This causes the flow rate to decrease. Therefore, you will need to adjust the flow rate or the purging time to compensate.

If the well is only partially cased (i.e., open-borehole completion), as many wells in the Appalachian Plateau Region are, you will need to use the borehole diameter rather than the casing diameter for the volumetric calculations. Open borehole completions will commonly have one to two lengths (10-20 feet) of casing in the hole with the remainder of the hole open in the rock. Information on the borehole diameter may not always be available. Therefore, you will need to estimate the diameter from the size of the casing sticking up. In these situations, the casing diameter is frequently about an inch smaller than the borehole. Use your best professional judgment here. There also are a few cases where the cased section of the well will be larger diameter than the lower uncased portion of the well. In these situations, you may over estimate the purged volume required, which should not cause any sampling problems. You probably will not know if a well was constructed this way, unless the drillers log is available.



The purged water should be discharged away from the well to prevent the water from immediately re-entering the well from the surface. Domestic and monitoring wells in this region are frequently not grouted at the surface or in the annulus between the casing and the borehole. This leaves an easy pathway for surface water to enter the well. The presence or absence of surface grouting should be noted in the field sampling notes. Proper well completion techniques dictate that wells should be properly grouted to seal off the surface. However, well drillers in this region seldom do it.

It is very important to take complete notes on the purging procedure used and any problems incurred. This type of information may be important for subsequent interpretation of the water quality or verifying the validity of the water sample. Examples of things to note include: color changes, odors, gases exsolving (bubbling) from the water, pumping problems, where in the plumbing system the sample was drawn, purge volumes and calculations, general well condition (heavily rusted casing, type of casing, no grouting, no well cap, buried well head, no vent, etc.), and other information that could impact the water quality.

If additional information regarding well purging is required, contact any of the hydrologists at the Appalachian Regional Office or you can consult any of the following references:

E.E. Johnson, 1987, Ground Water and Wells. Second Ed., Johnson, St. Paul, Minn.

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data, U.S. Geological Survey, Open-File Report 95-399, 113 p.
Radtke, D.B. and Wilde, F.D., eds., in press, National Field Manual for Collection of Water-Quality Data--Field Measurement: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.

U.S. Environmental Protection Agency, 1996, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, U.S. EPA, Region I, Standard Operating Procedure: GW 0001, 13 p.

Table 1. Well Volumes.

Volume of Casing			
Inside Diameter in Inches	Volume in Gallons per Linear Foot	Inside Diameter in Inches	Volume in Gallons per Linear Foot
1	0.04	6.5	1.73
1.25	0.08	7	2.00
1.5	0.10	7.5	2.30
2	0.17	8	2.60
2.5	0.29	8.5	2.95
3	0.38	9	3.31
3.5	0.50	9.5	3.69
4	0.66	10	4.09
4.5	0.83	10.5	4.50
5	1.02	11	4.94
5.5	1.24	11.5	5.40
6	1.50	12	5.81