The final steps that must be completed involve documentating the procedures used and the measurements made. Field forms should be completed before leaving the sampling site. Report the median of the recorded field-measurement readings as the final well voume is purged.

- ▶ Record anomalies, difficulties, and adjustments on the field form.
- ▶ Record the purge volume, rate of pumping, initial and final intake locations, and time and respective reading of sequential field measurements (fig. 6.0–3).

6.0.3.A WELL PURGING

Well purging removes standing water from a well. Purging reduces chemical and biochemical artifacts caused by well installation, inadequate well development, well-construction materials, or infrequent pumping (American Society for Testing and Materials, 2005). Purging also serves to rinse and condition sampling equipment with well water.

When selecting purging equipment for monitoring wells, a portable, submersible nonaerating pump that also will be used for sampling is recommended.

- ▶ When the water table is deeper than 250 ft and (or) a large volume of water must be purged, a dual-pump system often is used: position a submersible pump downhole and a centrifugal pump at the surface. Water from the slow-pumping submersible pump is used for field measurements and to collect the sample, while the centrifugal pump operates at a higher rate to evacuate the required purge volume.
- ▶ When the water table is less than 25 to 30 ft from land surface, a peristaltic pump sometimes is used to purge small-diameter wells; a peristaltic pump or other suction-lift device should not be used if dissolved-oxygen concentrations or Eh are being monitored during purging.

- To reduce the volume and time required for purging, especially in deep wells or in wells for which purge water must be contained, an inflatable packer sometimes is set above the pump and above the screened or open interval. Packers can fail to form a complete seal between aquifer intervals, and should be used with pressure transducers to indicate water leakage.
- **A bailer is not recommended for purging.** The plunging action of the bailer can release or stir up particulates that are not ambient in ground-water flow, resulting in biased measurements and analyses. (Refer to "Subsample measurement" in 6.0.3.B for information about using a bailer.)

Steel tapes, electric tapes, or acoustic sensors are used to measure water level. An electric tape or other water-level sensor is recommended for continuous monitoring of drawdown during purging—repeated lowering of a weighted steel tape can release or stir up particulate materials and affect turbidity readings.

Standard procedure

The standard USGS procedure is to purge a minimum of three well volumes while monitoring temperature, pH, conductivity, dissolved-oxygen concentration, and turbidity.

- Sequential measurements of these parameters are used as criteria to help determine when water withdrawn from the well is representative of water flowing through the aquifer and when purging should end and sampling begin (table 6.0–1).
- The criteria normally are met within three well volumes, but well characteristics and study objectives could require removal of additional well volumes.
- The same pump should be used for purging and sampling, if possible, without stopping or removing the pump (see Koterba and others, 1995), unless the dual-pump system is used.

Exceptions to the standard purging procedure

The number of well volumes removed and the parameters used as purge criteria can be subject to data-collection objectives, well characteristics, and equipment.

- ▶ Study objectives could require a different purge volume or require sequential sampling of additional chemical constituents.
- ▶ A lesser purge volume and modified procedures are needed, for example, for wells
  - – that are being pumped continuously or regularly every few hours (such as in-service public-supply wells).
  - – that are pumped dry or that have a water column of less than 4 ft plus the length of the submersible pump.
  - – in which sampling zones are isolated by packers.
  - – in which the pump intake is installed permanently within the screened or open interval.

Before purging begins:

1. Check the well-identification number. Check the well's record of water levels, drawdown, and field-measurement variability (if available).
2. Prepare the necessary field forms, such as the well-purge record, national or study field form, and chain-of-custody record. Record the type of equipment being used.
3. Lay plastic sheeting around the well to prevent contaminating the equipment. Unlock the well housing or top of the protective casing and remove the well cap.

To purge the well:

1. Measure and record the depth to static water level (fig. 6.0–3).
2. Calculate and record the well volume as shown on fig. 6.0–3. Note that the depth to the screened or open interval and the inside casing diameter must be known to calculate well volume.
3. In a monitoring well, lower a submersible pump followed by a water-level sensor to the desired location of the pump intake. **The final pump intake position always is located at the point of sample collection.** Note that the pump position is fixed in supply wells and in monitoring wells with a permanently installed sampling system. **Lower the equipment slowly and smoothly to avoid stirring up particulates.**
   - Position the pump intake between 3 ft (~0.9 m) below static water surface and a minimum distance above the top of the open/screened interval of 10 times the well diameter (20 in. for a 2-in. well diameter), if the sample is to be integrated over the entire screened or open area of the aquifer. The location of the intake may be different when the study objective requires collecting the sample from a point within the open/screened interval or from wells in which packers are installed.
   - The water-level sensor should be a maximum of 1 ft (~0.3 m) below water surface.
4. Start the pump. Gradually increase and (or) adjust the pumping rate to limit drawdown to between 0.5 and 1.0 ft (~0.15 to ~0.3 m). Measure the water level as purging progresses.
   - If the final intake position is above the screened or open interval, the final pumping rate should be about 500 to 1,000 milliliters per minute. Do not exceed 1 ft of drawdown.
   - If the final intake position is within the screened or open interval, the final pumping rate should be about 200 to 500 milliliters per minute. Do not exceed 0.5 ft of drawdown.
   - If the pump and intake position are fixed, as in a supply well, control the rate of flow for field measurements through flow-splitting valve(s).
5. **Do not move the pump during purging or sample collection after the intake has been set at the final location.**

6. Purge a minimum of three well volumes or the purge volume dictated by study objectives (note "Exceptions to the standard three-well-volume purging procedure"). Throughout purging, monitor and record field-measurement readings (fig. 6.0–3).

    - Check for special instructions regarding field-measurement or field-analysis requirements dictated by the study objectives.
    - Contain purge water as required by Federal, State, or local regulations.

7. **As the third or last well volume is purged, when the final field measurements are recorded, adjust the purge rate to the pumping rate to be used during sampling.**

    - Record field measurements at regular time intervals—about 3 to 5 minutes apart. For deep wells, the time intervals could be 15 minutes or longer. The time intervals selected will depend on the well characteristics and hydraulic properties of the aquifer, but the intervals must be sufficiently spaced to yield results representative of aquifer properties.
    - Consult criteria for field-measurement stabilization (table 6.0–1). Field experience, understanding of the effects of hydrologic and geochemical conditions, and knowledge of data-collection and data-quality requirements often are necessary to determine the most accurate field value.

        If criteria are being met—record at least five sequential measurements and report the median value.

        If criteria are not being met—consult the study requirements and objectives. Extend the purge time if readings still do not stabilize; report the median value of the last five or more sequential measurements.

RECORD OF WELL PURGING

Date:__________________ By: __________________

SITE ID __________________ STATION NAME __________________ OTHER ID __________________

WELL PURGING METHOD AND PUMP TYPE (describe):____________________________________

TIME	WATER LEVEL below: MP or LS	DRAW-DOWN	WELL YIELD	TEMPER-ATURE	CON-DUC-TIVITY	pH	DIS-SOLVED OXYGEN	TURBID-ITY	APPROX. PUMPING RATE
HR:MIN	ft or m	ft or m	gpm or cfs	°C	µS/cm	units	mg/L	input correct units	gal/min or L/min

Well volume = V = 0.0408 HD^2 = ____ gallons **Purge volume** = (n)(V) = ____ gallons

V = volume of water in well, in gallons; D = inside well diameter, in inches; H = height of water column, in feet; n = number of well volumes to purge. If casing diameter = 2 in., well volume is 0.16 gallons per foot of casing.

FIELD MEASUREMENTS NTU, Nephelometric Turbidity Units; FTU, Formazin Turbidity Units	STABILITY CRITERIA Allowable difference in sequential parameter values
pH	± 0.1 standard units
Temperature, in degrees Celsius (°C)	± 0.2°C (thermistor)
Specific electrical conductance (SC), in microsiemens per centimeter at 25°C (µS/cm)	± 5%, for SC ≤ 100 µS/cm ± 3%, for SC > 100 µS/cm
Dissolved-oxygen concentration, in milligrams per liter (mg/L)	± 0.3 mg/L
Turbidity (TBY)[1]	± 10%, for TBY < 100 turbidity units

[1] Select appropriate unit from http://water.usgs.gov/owq/turbidity/turbidity.pcodes_mcodes.update.xls.

Figure 6.0–3. Example of a field form to record well purging.

Containment and disposal of purge water must conform to Federal, State, or local regulations.

6.0.3.B DOWNHOLE, FLOWTHROUGH-CHAMBER, AND SUBSAMPLE MEASUREMENT PROCEDURES

A flowthrough-chamber system is recommended for direct field measurements (fig. 6.0–4), if samples also will be collected for chemical analysis. A downhole system is recommended if field measurements will be monitored without sampling. If samples must be bailed from the well, measure only pH and conductivity in subsamples of the bailed volume (fig. 6.0–5).

- ▶ **Downhole or flowthrough-chamber systems are required for reported values of temperature, dissolved oxygen (DO), and Eh**—Do not make these measurements in a bailed subsample or other discrete sample.
- ▶ Downhole or flowthrough-chamber systems are preferred for reported values of pH, conductivity, and turbidity.

A positive-displacement submersible pump is recommended for downhole and flowthrough-chamber systems. Lower a length of pipe to check that the well is free from obstructions before lowering a pump or downhole instrument in a well—this practice will prevent loss of costly equipment.

Downhole system

A downhole system is used for in situ field measurements. Ground water should flow upward past downhole sensors in order to obtain values representative of the depth interval being sampled; therefore, a submersible pump follows the downhole instrument. Because of this constraint, the downhole method may not be practical at wells with dedicated pumps or when using multiple equipment in small-diameter wells. Figure 6.0–4 shows the steps for downhole measurement of field parameters.

- The depth at which sensors are located depends on study objectives. If a sample is to represent ground water that is integrated over the screened interval, locate sensors approximately 1 ft above the screened interval in a 2-in. diameter well and just below the pump intake.
- Remove downhole sensors from the well before collecting samples for chemical analysis in order to prevent these instruments from affecting sample chemistry. Note that the process of removing these instruments and putting the pump back in the well causes disturbances that can affect the quality of samples subsequently collected for chemical analyses (Puls and others, 1991; Kearl and others, 1992; Puls and Powell, 1992).

Flowthrough-chamber system

A flowthrough chamber is an airtight, transparent vessel with a pressure-relief valve and either (1) grommeted ports to accommodate individual sensors or (2) a multiparameter instrument. Several types of flowthrough-chamber systems are available and can be designed for a specific measurement (for example, see NFM 6.2.2 for the description of a flowthrough cell for the spectrophotometric determination of dissolved-oxygen concentration).

When setting up a flowthrough chamber:

1. Install the chamber in-line from the pump and as close to the wellhead as possible.
   - Keep the chamber, field-measurement instruments, and tubing off the ground, shaded from direct sunlight, and shielded from wind. Spread a clean plastic sheet underneath, where tubing might be in contact with the ground.
   - Keep the tubing as short as possible.
2. Install the dissolved-oxygen sensor immediately downstream from the chamber inflow, and install the pH sensor downstream from the conductivity sensor.
3. Turn on the pump; direct initial flow to waste to avoid introducing sediment into the chamber.
   - Adjust the flow into the chamber so that a constant stream of water is maintained at the rate required for dissolved-oxygen measurements (see NFM 6.2).
   - Correct any backpressure conditions; tilt the chamber to expel trapped air.

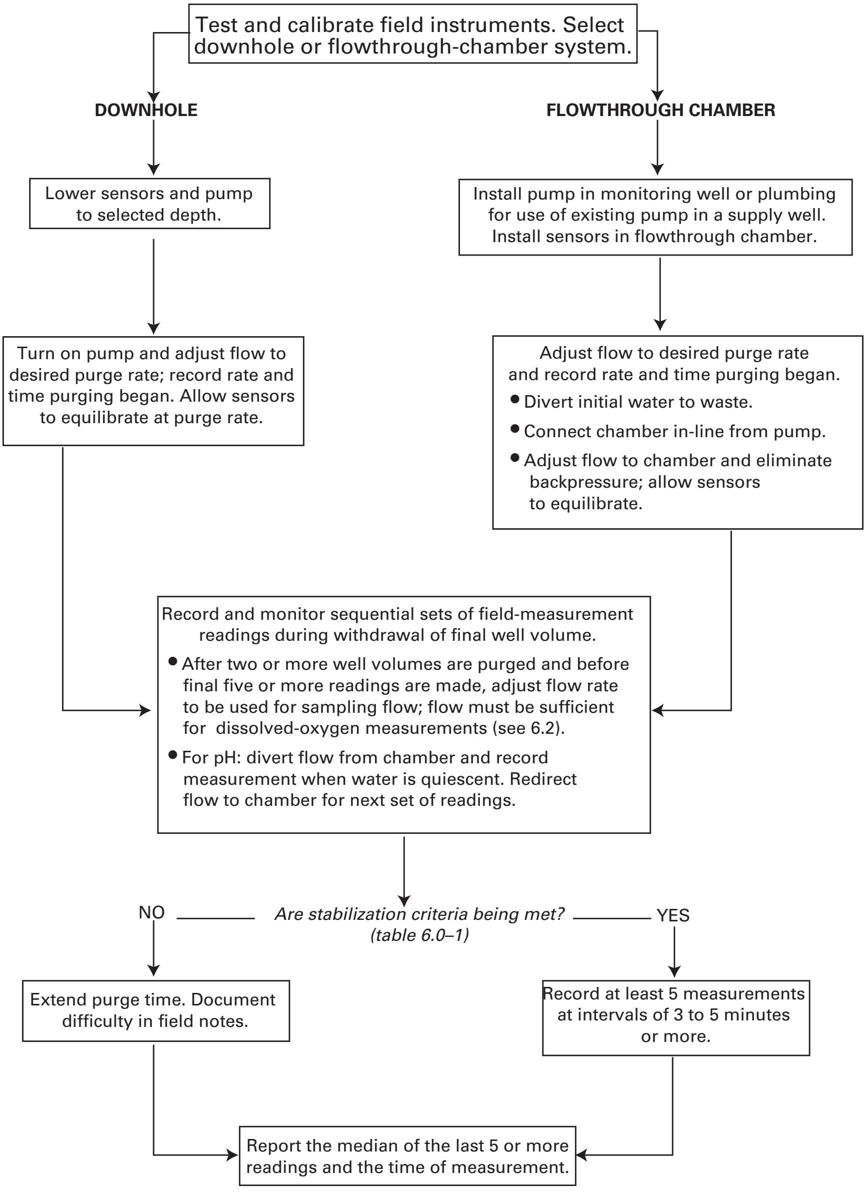

Figure 6.0–4. Field-measurement procedures using downhole and flowthrough-chamber systems for ground water.

Subsample measurement

Subsamples or discrete samples are aliquots of sample collected from a **nonpumping sampling device** such as a bailer, a thief sampler, or a syringe sampler. Measurements of field parameters made in discrete or nonpumped samples are more vulnerable to bias from changes in temperature, pressure, turbidity, and concentrations of dissolved gases than measurements using a downhole or flowthrough-chamber system.

- Subsamples can be used for conductivity, pH, and alkalinity.
- Subsamples must not be used for reported measurements of temperature, dissolved oxygen, Eh, or turbidity.
- Subsample procedures must not be used in reducing (anoxic) waters.

Figure 6.0-5 shows the steps for measurement of field parameters on a bailed sample. If collecting a sample with a bailer, use one with a double check valve. Field rinse the sampler with sample water before using. To shield the sample from atmospheric contamination, make measurements in a collection chamber or in a glove box filled with inert gas. Indicate on field forms the sampling and measurement procedures used.

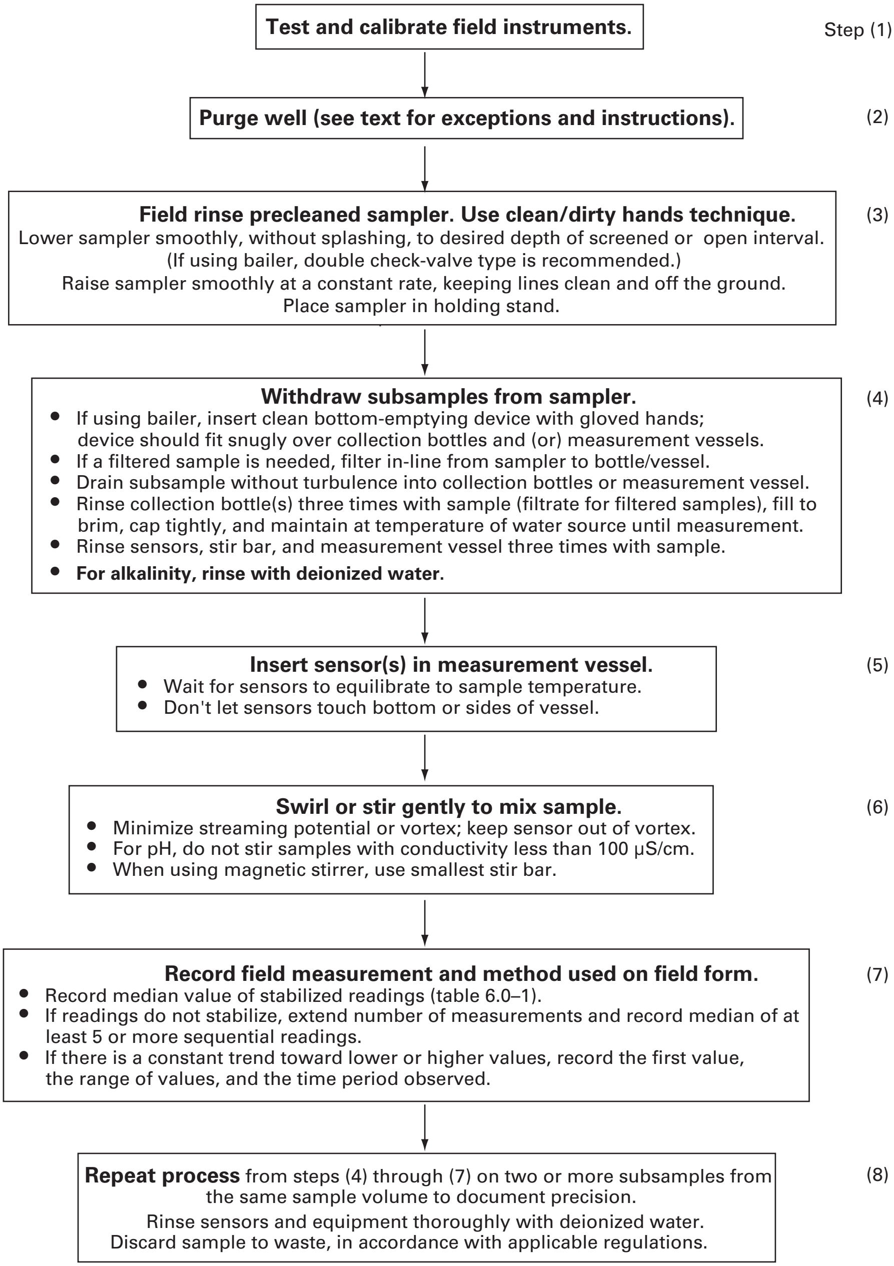

Figure 6.0–5. Subsample field-measurement procedures for conductivity, pH, and alkalinity of ground water.

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