Designation: D8006 – 16

Standard Guide for Sampling and Analysis of Residential and Commercial Water Supply Wells in Areas of Exploration and Production (E&P) Operations[1]

This standard is issued under the fixed designation D8006; 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 guide presents a methodology for obtaining representative groundwater samples from domestic or commercial water wells that are in proximity to oil and gas exploration and production (E&P) operations. E&P operations include, but are not necessarily limited to, site preparation, drilling, completion, and well stimulation (including hydraulic fracturing), and production activities. The goal is to obtain representative groundwater samples from domestic or commercial water wells that can be used to identify the baseline groundwater quality and any subsequent changes that may be identified. While this guide focuses on baseline sampling in conjunction with oil and gas E&P activities, the principles and practices recommended are based on well-established methods that have been in use for many years in other industrial situations. This guide recommends sampling and analytical testing procedures that can identify various chemical species present including metals, dissolved gases (such as methane), hydrocarbons (and other organic compounds), as well as overall water quality.

1.2 This guide provides information on typical residential and commercial water supply well systems and guidance on developing and implementing a sampling program, including determining sampling locations, suggested purging techniques, selection of potential analyses and laboratory certifications, data management, and integrity. It also includes guidance on personal safety. The information included pertains to baseline sampling before beginning any activities that could present potential risks to local aquifers, periodic sampling during and after such work, and ongoing monitoring relating to known or potential groundwater constituents in the area. This guide does not address policy issues related to frequency or timing of sampling or sampling distances from the wellhead. In addition, it does not address reporting limits, sample preservation, holding times, laboratory quality control, regulatory action levels, or interpretation of analytical results.

1.3 These guidelines are not intended to replace or supersede regulatory requirements and technical methodology or guidance nor are these guidelines intended for inclusion by reference in regulations. Instances where this guide is in conflict with statutory or regulatory requirements, practitioners shall defer to the latter. These guidelines are intended to assist in developing sampling programs to meet project goals and objectives. However, site-specific conditions, regulatory requirements, site-specific health and safety issues, technical manuals and directives, and program data quality objectives should be evaluated and consulted along with the information contained in this guide for each individual site and sampling program.

1.4 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide 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 of this document means only that the document has been approved through the ASTM consensus process.

1.5 Users are responsible for investigating and identifying all the legal and regulatory requirements that are applicable for the location where the sampling is being performed.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.26 on Hydraulic Fracturing.

Current edition approved March 1, 2016. Published March 2016. DOI: 10.1520/D8006–16.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D511 Test Methods for Calcium and Magnesium In Water
D512 Test Methods for Chloride Ion In Water
D516 Test Method for Sulfate Ion in Water
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D858 Test Methods for Manganese in Water
D888 Test Methods for Dissolved Oxygen in Water
D1067 Test Methods for Acidity or Alkalinity of Water
D1068 Test Methods for Iron in Water
D1125 Test Methods for Electrical Conductivity and Resistivity of Water
D1246 Test Method for Bromide Ion in Water
D1293 Test Methods for pH of Water
D1687 Test Methods for Chromium in Water
D1976 Test Method for Elements in Water by Inductively-Coupled Argon Plasma Atomic Emission Spectroscopy
D2330 Test Method for Methylene Blue Active Substances (Withdrawn 2011)[3]
D2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection Gas Chromatography
D2972 Test Methods for Arsenic in Water
D3082 Test Method for Boron in Water
D3223 Test Method for Total Mercury in Water
D3557 Test Methods for Cadmium in Water
D3559 Test Methods for Lead in Water
D3648 Practices for the Measurement of Radioactivity
D3859 Test Methods for Selenium in Water
D3920 Test Method for Strontium in Water
D4191 Test Method for Sodium in Water by Atomic Absorption Spectrophotometry
D4192 Test Method for Potassium in Water by Atomic Absorption Spectrophotometry
D4327 Test Method for Anions in Water by Suppressed Ion Chromatography
D4382 Test Method for Barium in Water, Atomic Absorption Spectrophotometry, Graphite Furnace
D4658 Test Method for Sulfide Ion in Water
D5673 Test Method for Elements in Water by Inductively Coupled Plasma—Mass Spectrometry
D5907 Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water
D5980 Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring
D7315 Test Method for Determination of Turbidity Above 1 Turbidity Unit (TU) in Static Mode
D7678 Test Method for Total Petroleum Hydrocarbons (TPH) in Water and Wastewater with Solvent Extraction using Mid-IR Laser Spectroscopy

2.2 *EPA Standards:*[4]

EPA 160.1 Total Dissolved Solids (TDS)
EPA 300.0 Determination of Inorganic Anions by Ion Chromatography
EPA 300.1 Determination of Inorganic Anions in Drinking Water by Ion Chromatography
EPA 310.1 Ortho-Phosphorus, Dissolved Automated, Ascorbic Acid
EPA 310.2 Alkalinity (Colorimetric, Automated, Methyl Orange)
EPA 325.1 Chloride (Colorimetric, Automated Ferricyanide AAI)
EPA 425.1 Methylene Blue Active Substances (MBAS)
EPA 900.0 Gross Alpha and Beta Activity in Water, Official Name: Gross Alpha and Gross Beta Radioactivity in Drinking Water
EPA 903.1 Radium-226 in Drinking Water, Official Name: Radium-226 in Drinking Water (Radon Emanation Technique)
EPA 906.0 Tritium in Drinking Water EPA 908.0 Uranium in Drinking Water-Radiochemical Method
EPA 9030B Acid-Soluble and Acid-Insoluble Sulfides: Distillation
EPA 9034 Titrimetric Procedure for Acid-Soluble and Acid-Insoluble Sulfides
EPA 9056A Determination of Inorganic Anions by Ion Chromatography
RSKSOP-175 Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique (Advisory)
SW846 8015D Nonhalogenated Organics Using GC/FID
SW846 8260C Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
SW846 8270D Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
SW846 6010D Inductively Coupled Plasma-Atomic Emission Spectrometry
SW846 6020B Inductively Coupled Plasma-Mass Spectrometry
SW846 7470A Mercury in Liquid Waste (Manual Cold-Vapor Technique)

2.3 *Federal Standard:*[5]

40 CFR Part 136 Guidelines Establishing Test Procedures for the Analysis of Pollutants

2.4 *Other:*

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories[6]
PA DEP 3686 REV 1 Light Hydrocarbons in Aqueous Samples via Headspace and Gas Chromatography with Flame Ionization Detection (GC/FID)

[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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, http://www.epa.gov.

[5] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cistern, n*—receptacle for the collection or storage of groundwater or rainwater.

3.2.2 *groundwater spring, n*—place where groundwater flows naturally from underground onto the land surface or into a body of surface water.

3.2.2.1 *Discussion*—The occurrence of a groundwater spring depends on the nature of geologic formations, especially permeable and impermeable strata, on the position of the water table, and on topography.

3.2.3 *pitless adaptor, n*—device located below the ground surface used to connect the submersible pump in a water supply well to a pressure tank or other form of water storage.

3.2.3.1 *Discussion*—This device serves to protect the well-head from freezing conditions and may center the submersible pump in the well.

3.2.4 *point-of-entry treatment (POET) system, n*—or whole house or building treatment systems, treats all water entering the building.

3.2.4.1 *Discussion*—These systems are typically situated in the basement of a home or building or in a vault within proximity to the home or building.

3.2.5 *point-of-use (POU) system, n*—treats water at the point where it is used.

3.2.5.1 *Discussion*—These systems are typically situated under kitchen or bathroom sinks or both or in closets/cabinets in proximity to kitchens or bathrooms.

3.2.6 *pressure tank, n*—closed vessel used to store water from a supply well or spring under pressure for use within a home or building.

3.2.6.1 *Discussion*—Typically "bladder" pressure tanks are used in association with supply wells and springs; these tanks contain a rubber bladder filled with air that is used in association with a pressure switch to regulate the pressure of the water in the tank.

3.2.7 *water softener, n*—water treatment system that substitutes sodium ions for ions that cause water to be "hard," in most cases, calcium and magnesium ions and having a cation resin in the sodium form that removes cations such as calcium and magnesium from water and releases another ion such as sodium.

3.2.7.1 *Discussion*—Water softeners are also used to remove iron, manganese, some radiological materials, nitrate, arsenic, chromium, selenium, and sulfate.

4. Significance and Use

4.1 A supply well provides groundwater for household, domestic, commercial, agricultural, or industrial uses.

4.2 Using a standardized protocol based on an existing industry standard or approved regulatory methods and procedures to collect water samples from a supply well is essential to obtain representative water quality data. These data can be critical to efforts to protect water uses, and human health, and identify changes when they occur. Use of this guide will help the project team to design and execute an effective water supply sampling program.

4.3 It is important to understand the objectives of the sampling program before designing it. Water supplies may be sampled for various reasons including any or all of the following:

(1) baseline sampling before an operation of concern,

(2) periodic sampling during such an operation,

(3) investigative responses to perceived changes in water quality, or

(4) ongoing monitoring related to known or potential groundwater constituents of concern in the area.

Sampling programs should be based on these objectives and be developed in coordination with the prospective laboratory(ies) to ensure its procedures, capabilities, and limitations meet the needs of the program, protect human health and fulfill regulatory requirements.

5. Well Purging and Sampling Requirements

5.1 *Sampling Equipment:*

5.1.1 Gas or multiple meters to provide, at a minimum, information on lower explosive limits for combustible gases and oxygen levels to be used for atmospheric screening;

5.1.2 Sample containers, made of compatible materials, preservatives appropriate for the sampling to be performed, labels, and chain-of-custody forms (COCs).

5.1.3 Field notebook, preferably with waterproof, numbered pages or electronic equivalent such as a tablet.

5.1.4 Schedule and contact information for the properties (locations) to be sampled and contact information for laboratory and carrier/shipping company (if used).

5.1.5 Area maps, including GPS coordinates of well(s).

5.1.6 Large cooler and bagged ice for storing all samples and a mini cooler that can be brought inside the home/building to put samples directly on ice after collection and gallon and quart size zip-lock bags in which to put sample containers, ice, and COC, and trash bags for site-derived waste.

5.1.7 Intrinsically safe flashlight or headlamp (sample ports are commonly located in low light areas).

5.1.8 Pan or other secondary containment system to catch any water that may have dripped during sampling. Make sure cleanup is performed after sampling is complete.

5.1.9 Safety equipment including: gloves (work and latex or nitrile), safety glasses, shoes with slip resistant soles, clean rags or towels, pails and buckets, basic tool kit, first aid kit, and fire extinguisher.

5.1.10 Specific health and safety plan.

5.1.11 Watch or wristwatch with second hand, or a digital timer, and graduated container to calculate flow rate and volume.

5.1.12 Supplies need to include apparatus used to measure field parameters such as pH, turbidity, specific conductance, and dissolved oxygen.

5.1.13 Digital Camera.

5.2 *Field Visit and Sample Collection*—After arrangements with the property owner or responsible party have been made, the following steps should be taken:

5.2.1 Confirm location and note time of arrival, weather conditions, including barometric pressure, and all onsite personnel.

5.2.2 Provide the property owner/occupant an explanation of the work to be undertaken, how long it is expected to take, and what the owner/occupant can expect. Provide identification (for example, personal identification badge (with photograph) and a card or letter that can be provided to the property owner/occupant with the appropriate contact information).

5.2.3 Document information from property owner including comments on water quality and water usage the day of the sampling.

5.2.4 Record the well permit number if one has been issued (check with local authorities), and refer to D5980 for further information on pulling monitoring well permits that show the depth of the well and the location of the screened interval.

5.2.5 Sketch the area including the location of the supply well(s) and photo-document with a digital camera, and sketch location in logbook. Be aware that a property may have more than one supply well or other water sources. It is important to understand and document the uses of these supply sources (for example, drinking and agricultural) and understand and document if they are connected to the system being sampled (into one pressure tank or separate pressure tanks); this will allow the sampling team to choose the correct sample location(s) and the source of the sample.

5.2.6 As appropriate, photograph features on the property (buildings, septic systems, wells, surface water, chemical storage areas, fuel tanks, vehicle and equipment storage/parking areas, visual surface staining, signs of stressed vegetation, and cracks in foundation) and the water delivery system (pressure tank, water treatment equipment, wellhead and pump, sampling port, and floor drain if present). All photographs should have a date/time stamp and be annotated to where the photograph was taken.

5.2.7 Locate the water shutoff valve. It is critical this step is undertaken before starting any purging or sampling to reduce any potential damage if a leak or break does occur.

5.3 *Determining Sample Locations*—Samples should be collected as close to the water well as possible; however, the actual water supply well should only be accessed by a licensed plumber or similarly qualified individual as contaminants can be introduced if this work is undertaken by untrained personnel. The sampling team should not remove well caps, plugs, or ports from water supply wells, unless permissible by applicable statue or regulations.

5.3.1 The sampling team should review the water system configuration to determine the closest water tap to the water source; this is commonly, but not always, a drain port on the front near the base of the bladder/pressure tank. Care should be taken to ensure the valve is operational. Do not force valves open. Treatment systems and exact sample locations should be documented. Samples should be collected before the water reaches any treatment systems. Collecting treated water should be avoided since it will not be representative of actual inflow conditions. Usually, water treatment systems are designed to allow temporary bypass flow without alteration to the system itself. If the sample is collected after treatment, it should be noted in the field notebook.

5.3.2 Water lines should be traced to determine exactly what is being sampled (for example, water from pressure tank, water treated through a treatment system). The sampling team should not alter the piping or water delivery system in any way, including turning treatment systems off or removing tubing or both; however, if the sampling team needs to take a sample through existing tubing, this should be noted.

5.4 *Purging and Sampling of Supply Wells*—Stagnant, non-representative water should be purged from the water supply system before samples are collected to ensure that the sample is representative of actual well conditions. The convention of purging monitoring wells of three well volumes before sampling is not necessarily applicable to nor practical for supply wells. Supply wells may contain hundreds of gallons of water, the purging of which would be time-consuming, potentially detrimental to the well pump, may result in short-term depletion of the property owner's water supply, could overfill septic systems if discharged to a sink, and increase electric utility cost to the property owner. Additionally, while monitoring wells tend to remain stagnant for long durations, supply wells are commonly pumped more frequently. Thus, it is important to purge the plumbing system but not necessarily the supply well. An unused or infrequently used supply well may require a greater purge volume. The water supply system should be purged until two times the holding tank volume is removed or field parameter measurements stabilize. This ensures water is coming from the well and not just residual water in the plumbing system.

5.4.1 Holding tank volumes are commonly listed on the side of the pressure tank, or can be determined based on the dimensions of the tank or both. A good rule of thumb is to listen for the bladder/pressure tank switch to click, which indicates that the bladder/pressure tank is filling with water from the well.

5.4.2 Field parameters, including temperature, pH, specific conductance, dissolved oxygen, color/appearance, and flow rate should be recorded at established sample time intervals (every 3 to 5 min) during purging with instruments calibrated in accordance with manufacturer specifications. This is most accurately and efficiently accomplished with flow-through cells equipped with probes for temperature, pH, and specific conductance. When the field parameters vary less than ±10 % in replicate measurements for dissolved oxygen and specific conductance, ±0.2 pH units, and ±10 NTUs for turbidity, the well is adequately stabilized. Purging may be terminated 30 minutes following removal of two holding tank volumes should parameter stabilization not be achieved. In this case at least one casing volume should be removed. This sample may not reflect groundwater conditions, because it may consist only of water from the well casing, which has been in the well casing for an unknown period of time. Barometric pressure and field temperature should also be recorded.

5.4.3 The sampling team should establish whether the well has deliverability problems and if a drawdown would be objectionable to the well user. In such a case, it may be acceptable to obtain a sample before purging, prior to removal

of two holding tank volumes, or prior to parameter stabilization and note the exceptionable circumstances.

5.4.4 In the event a treatment system must be bypassed, the sampling team should also take into account the presence of unwanted residual treated water that will be present in the line that is to be purged. The treatment system shall be returned to its original working status immediately after the sample is collected. Treatment systems designed for bacteriological decontamination (such as UV lights or chlorinators) should not be switched off or bypassed.

5.4.5 Typically, purging occurs at a sink connected to the water delivery system and water runs down the drain; however, the property owner/occupant should be consulted about this in case they would like this water collected for another use. Flow rate shall be estimated and recorded during purging.

5.4.6 Once purging is complete, the flow rate should be reduced to a steady, non-turbulent stream before collecting the samples (if possible) to minimize suspended solids and the potential for loss of dissolved gas or other volatile constituents, if present.

5.4.7 The sample should be collected directly from the water delivery system as close to the well as possible into laboratory supplied sample containers; intermediate collection containers should not be used. There may be times when samples will need to be collected from taps located in other areas. Taps in residential homes are often equipped with screens that may aerate samples before collection. In those sampling scenarios, and where feasible, screens should be removed before sampling. If samples cannot be collected without removing screens, it should be documented in the field sampling logbook and included in the notes for the analytical laboratory. The sampling team should include sampling location, collection date and time, and method and purge details (for example, field parameters) in the field notebook. Sampling methodology should be documented in such detail that a third party could duplicate it in the future. Preservatives and mitigation of interferences may be necessary depending on the laboratory analysis to be performed.

5.4.8 The sampling team should also record a physical description of the water including color, odor, and sediment. Note that samples that require analysis for dissolved constituents, or that are excessively turbid, may need to be field filtered to obtain representative analytical results for dissolved constituents. Resulting solids should be retained for separate analyses. If analysis for total and dissolved constituents is desired, a filtered sample for dissolved analysis and a separate unfiltered sample for total analysis may be needed for digestion, prior to analysis.

5.4.9 Following sampling, the sampling team must ensure the sample point is completely closed and not leaking and the area is clean. If the leak cannot be stopped, the sampling team must notify the owner or the property who should call a plumber to fix the leak at the expense of the responsible party. The sampling team must document the time of completion and inform the owner/occupant of task completion. It is recommended that the sampling team complete a pre- and post-sampling checklist to document the condition for the water delivery system before and after sampling.

6. Sampling Team Qualifications

6.1 It is strongly recommended that the sampling be performed by a third-party sampling company or agency independent of the firm requesting the services. The sampling team should consist of experienced individuals who have received training in the areas shown below and work under the direction/supervision of an appropriately credentialed professional (for example, registered or licensed professional) or an independent laboratory approved in the jurisdiction where the water supply well is located. In addition, a qualified sampling team shall have the following knowledge and experience:

6.1.1 Collection, interference mitigation, preservation, storage, and handling procedures of representative water samples for chemical analysis.

6.1.2 Appropriate quality control and quality assurance procedures to meet data quality objectives.

6.1.3 Practices regarding cross-contamination prevention.

6.1.4 Use pre-cleaned sampling containers of proper material and size, mitigate interferences and use preservatives as specified by each analytical procedure.

6.1.5 Appropriate sample collection procedures and protocols.

6.1.6 Configuration and operation of residential water supply systems.

6.1.7 Interface with property owners/occupants.

6.1.8 Proficient with the use and operation of field parameter meters including calibration, functioning, and evaluation.

6.1.9 General knowledge of laboratory methods.

6.1.10 Knowledge of gaseous sampling methods and procedures.

6.1.11 In addition, the sampling team should be familiar with sampling containers and labeling, chain of custody, sample preservation and shipping procedures, equipment decontamination, insertion of blind field standards, sample splits, duplicates, blanks and documentation, sample preparation and handling, holding times, storage, and transport.

7. Evaluation of Well Condition/Construction

7.1 Conduct an owner/occupant interview to get information on the well and water system operation history, boring logs and construction details, service experience and concerns and any previous analyses. If possible, obtain copies of prior testing reports. Before the collection of supply well samples, the condition and construction of the supply well should be evaluated and documented in accordance with this section, and the total depth of the well and depth to water determined where possible from existing documentation. This evaluation will help with the interpretation of analytical data and should include the following considerations:

7.1.1 Condition of sanitary cap/seal of well head.

7.1.2 Evidence of the presence of biota, refuse, compost, chemicals, animal husbandry, septic systems, and/or waste that may represent a potential contaminant source in immediate surrounding areas.

7.1.3 Topography and proximity to potential contaminant sources/utilities (for example, septic system, treatment system discharge streams, sewage lines, natural gas lines, heating and fuel oil tanks, vehicles, equipment, or chemical storage).

7.1.4 Construction information including whether the well head is aboveground or underground (stickup or vault); well construction details based on landowner records or anecdotal data or both if available; well design and depth; casing materials (if cased); and submersible pump type, age, and depth. Research local, county, or state well permit records, if necessary.

7.1.5 Evaluation of treatment system maintenance records, system operation history, and pump/well servicing records.

7.2 Information gathered during this evaluation should be thoroughly documented in field logbooks or tablets and photographs with date and time stamp should be taken.

7.3 A map indicating the location of the water well, or source and other pertinent features (for example, oil and gas wells, pipelines, tanks, pits, and so forth) in the vicinity of the well should be documented. In addition, global positioning system (GPS) coordinates and elevations of the well and other pertinent features should also be collected.

7.4 There is the potential for other water supply sources to exist on a property. These sources should be documented and, depending on the sampling program or regulatory requirements, in some cases, sampled. The sampling team should determine if these water supply sources are from groundwater, surface water, municipal sources, or rainwater. Samples should not be collected from rainwater or municipal water sources unless specifically required by the program or the applicable regulatory authority.

8. Assessment of Water Supply System

8.1 Water supply systems may also include water treatment systems. It is important to be aware of the various types of treatment systems as they can be indicative of preexisting groundwater quality issues and concerns.

8.2 Treatment systems can generally be separated into two types:

8.2.1 Point-of-entry treatment, or whole house or building treatment system, which treats all water entering the building. These systems are typically situated in the basement of a home or building, or in a vault within proximity to the home or building.

8.2.2 Point-of-use systems treat water at the point where it is used. These systems are typically situated under kitchen or bathroom sinks or both or in closets/cabinets in proximity to the end use.

8.3 Where possible, photographs should be taken of the water delivery and treatment systems. When collecting a sample, the sampling team should attempt to collect a sample upstream to the treatment system; however, the treatment system should not be altered. The sampling location should be noted in the field book and photographed.

9. Supply Well and System Damage Prevention

9.1 This section addresses considerations for typical water supply wells but it should be adapted as appropriate to prevent damage to the site-specific water supply well and delivery systems. Note that taps or valves associated with supply well delivery systems are typically not used and may become rusted, brittle, or corroded. The condition of taps and valves should be assessed before use and only used if deemed in operable condition. Taps or valves in questionable condition should be replaced before sampling upon receipt of written consent from the occupant, property, or well owner. Note that, in some areas, this work may be required to be done by a licensed plumber.

9.2 Water systems should not be altered in any way by the sampling team unless the owner provides written approval and the sampling team secures the services of a licensed plumber, well driller, or pump contractor, as necessary.

9.3 Purge water discharge options should be fully evaluated before purging. If discharging to the ground, the location of the discharge should be at a location so as to not impact the well.

9.3.1 If discharging down a drain, ensure the floor or sinks drain properly before using it as a purging outlet.

9.3.2 If using an outdoor spigot, ensure purge water will be directed away from the building and any other nearby features.

9.4 Before starting work, it is critical that the sampling team locates the water shutoff valve. This step is undertaken before starting any purging or sampling or both to reduce any potential damage if a leak or break does occur.

9.5 Secondary containment (for example, a pan) should be used to catch any dripping. If not possible, use absorbent materials (towels).

9.6 Sampling methodology should be documented in such detail that a third party would be able to duplicate it in the future.

9.6.1 Water samples collected from a cistern or other water collection system should be sampled with a new, clean, disposable bailer and monofilament line lowered to mid depth to minimize stagnant water issues; where possible, samples should be collected from the center of the water collection system.

10. Personal Safety

10.1 In the initial phases of planning, personal safety should be evaluated since it may influence the field plan, including the number of personnel needed, the work hours, and/or contact methods. The sampling team will be coming into direct contact with the public and likely entering the houses of unknown persons. Before sampling, the owner/occupant should be contacted to set up an appointment for the work and obtain an access agreement. The access agreement should contain the property's legal address, owner of record, reason for sampling, jurisdiction requiring the sampling (if any), names of the individual's doing the sampling, who will be responsible for mitigation of damage resulting from the sampling (if any), and their company's contact information. A copy of the signed access agreement should be carried by the sampling team. While the vast majority of homeowners or owners of commercial buildings are friendly and cooperative with people performing sampling, the following safety considerations should be considered:

10.1.1 All sampling should be performed by teams of at least two people when feasible and permitted by the property owners. This substantially reduces the risk of one individual

sustaining a debilitating injury under conditions in which there is no timely help available. The sampling team members need to be able to be in contact with each other at all times electronically (cell phone, walkie talkie) or remain in voice or visual contact with each other.

10.1.2 Determine if it is safe for a sampling team to be working after dark in an emergency situation. Work should only be performed during daylight hours whenever possible.

10.1.3 The sampling team should consider whether cell phones may work in basements or remote areas. If remote communications are not possible then alternate means should be considered. The sampling team should be equipped with portable lighting to assure a visually safe work environment. The portable lighting should be intrinsically safe.

10.1.4 Have a communication plan for the site (such as frequency of check-ins). Have a plan of action to be taken if a check-in is missed.

10.1.5 In addition to the potential for produced gases (such as methane and hydrogen sulfide), confined spaces such as underground vaults can develop low oxygen content. Confined spaces should only be accessed by qualified personnel who follow applicable safety and work permitting procedures (that is, OSHA Confined Space Training. Oxygen sensors should be used to warn against this risk.

10.2 The sampling team should continue to evaluate their personal safety and make changes to the plan as needed. Any changes to the plan should be communicated immediately to other team members on location.

10.3 The sampling team shall use proper personal protective equipment when handling any chemical reagents such as sample preservatives.

10.4 A site-specific health and safety plan (HASP) shall be developed by the sampling company, reviewed and signed by the sampling team, and be in their possession during sampling activities.

11. Parameters/Analytical Categories

11.1 The analytical suite selected will depend on the objectives of the sampling program, protection of human health and applicable federal, state, and local government regulations and site-specific monitoring agreements. The recommended minimum sampling and analyses program for wells potentially affected by oil and gas operations is shown in Table 1. Site-specific parameters (for example, potential contaminants known to be associated with the geological formation, key chemicals used in drilling muds and large volume or mobile chemicals or both found in the planned fracturing fluid system) may also be required based on knowledge of potential contaminants not listed in Table 1. If it is well documented that analyses of a specific parameter is not necessary, it can be deleted after demonstration that it is not applicable. The accompanying notes to Table 1 are an essential component of the program. Recommended analytical methods are provided in Table 2. Select the methods that provide the sensitivity that meets the data quality objectives of the sampling program. Additional acceptable methods can be found in 40 CFR Part 136 and State and local regulations.

11.2 The laboratory should be contacted before preparing the sampling and analysis plan to ensure that the sampling plan is prepared in accordance with the laboratory approved sample collection, mitigation of interferences preservation, quality control and assurance, handling procedure, chain of custody,

TABLE 1 Potential Analysis for Residential and Commercial Water Supply Well Sampling and Analysis Program Related to E&P Operations

NOTE 1—All analyses shall be conducted using methods approved by the local regulations authority that has certified the laboratory. Table 2 lists ASTM and US EPA published methods that may be used. The user of this guide is strongly encouraged to search and obtain the latest edition of the standards and guidance's that are used for this work.

NOTE 2—It is recognized that there will be naturally occurring variability in constituent concentrations between the baseline analyses and subsequent analyses. Extreme caution shall be exercised in drawing conclusions on the significance of the results. The same (or equivalent) analytical methods used in the baseline analyses shall be used in all subsequent analyses.

NOTE 3—Reporting limits for post baseline sampling shall be the same as baseline reporting limits, which shall meet the data quality objectives of the sampling analysis program. The reporting limits for the baseline samples shall be the standard reporting limit for the certified laboratory performing the analyses. The laboratory shall be certified for the analyses they are reporting. For instance, a laboratory with certification for metals cannot perform organic analyses unless they also have certification for organics. Results less than the reporting limit shall be reported with a "J" flag to show the result is an estimated value. If a regulatory authority allows another form of certification than NELAP, this laboratory may be used, but the other requirements still apply.

NOTE 4—Sample preservatives, containers, mitigation of interferences and holding times shall meet requirements of the referenced standard analytical methods used in the standard operating procedures (SOP).

Classification	Notes
Organics (for example, VOCs, PAHs)	Minimum analyses include benzene, ethylbenzene, toluene, and xylenes (BETX), TPH.
Dissolved Gases	Minimum analyses include methane and ethane.
Water Quality	Minimum analyses include pH, specific conductance, total alkalinity, total dissolved solids, chloride, sulfate, temperature, and turbidity. Acidity, bromide and sulfide (and others) may be required on a site-specific basis.
Metals	Minimum analyses include arsenic, barium, iron, magnesium, sodium, calcium, manganese, and lead. Boron, potassium, chromium, selenium, cadmium, mercury, and strontium may be required on a sitespecific basis.
Radioactivity	Optional analyses based on professional judgment and regulatory requirements.
MBAS/Surfactants	Optional analyses based on professional judgment and regulatory requirements.

TABLE 2 Recommended Analytical Methods

	ASTM Methods	EPA Methods
Organics		
Benzene, ethylbenzene, toluene, xylenes (BTEX)	D2908	SW846 8260C or 8021C[A]
TPH	D7678	SW846 8015D[B]
Dissolved Gases		
Methane	See[C]	See[C]
Ethane	See[C]	See[C]
Water Quality		
pH	FIELD D1293	FIELD
Specific conductance	FIELD D1125	FIELD
Temperature	FIELD	FIELD
Turbidity	FIELD D7315	FIELD
Dissolved oxygen	FIELD D888	FIELD
Total alkalinity	D1067	EPA 310.1 and 310.2
Total dissolved solids	D5907	EPA 160.1
Chloride	D512; D4327	EPA 300.0, 300.1, 325.1; 9056A
Sulfate	D516; D4327	EPA 300.0; 300.1; 9056A
Bromide	D1246; D4327	EPA 300.0; 300.1; 9056A
Sulfide	D4658	EPA 9030 and 9034
Metals and Trace Elements		
Arsenic	D5673; D1976; D2972	SW846 6020B or 6010D
Barium	D5673; D4382	SW846 6020B or 6010D
Iron	D1976; D1068	SW846 6020B or 6010D
Magnesium	D1976; D511	SW846 6020B or 6010D
Sodium	D4191	SW846 6020B or 6010D
Calcium	D511	SW846 6020B or 6010D
Manganese	D5673; D1976; D858	SW846 6020B or 6010D
Lead	D5673; D1976; D3559	SW846 6020B or 6010D
Boron	D1976; D3082	SW846 6020B or 6010D
Potassium	D4192	SW846 6020B or 6010D
Chromium	D1976; D1687; D5673	SW846 6020B or 6010D
Selenium	D1976; D3859; D5673	SW846 6020B or 6010D
Cadmium	D1976; D3557; D5673	SW846 6020B or 6010D
Mercury	D3223	SW846 7470A
Strontium	D3920	SW846 6020B or 6010D
Radioactivity	D3648	Gross Alpha/Beta EPA 900.0 Tritium EPA 906.0 Uranium EPA 908.0 Radium EPA 903.1
MBAS/Surfactants	D2330	EPA 425.1

ASTM—ASTM International
EPA—U.S. Environmental Protection Agency
SM—Standard methods for the examination of water and wastewater
PA-DEP—Pennsylvania Department of Environmental Protection

[A]Method 8260C is performed using GC/MS that has greater specificity for compounds such as chlorinated solvents.
[B]DRO and GRO measured separately.
[C]RSK 175 is not an official method, but is currently recommended. ASTM is developing a revised procedure (WK43267). WK43267 is based largely on PA-DEP 3686 Rev 1.

and applicable data quality objectives so that the data quality objectives can be met.

12. Laboratory Certifications

12.1 The selected laboratory shall be accredited by the National Environmental Laboratory Accreditation Program (NELAP),[7] the International Laboratory Accreditation Cooperation, International Standardization Organization/International Electrotechnical Commission (ISO/IEC) 17025 accrediting body, or another similar body such as a state-certified laboratory.

13. Sample Shipment/Chain of Custody Documentation

13.1 Each sample collected should be assigned a unique sample tracking number and labeled with the street address of the building (if a building exists), sample location, sample date, collection time, and parameter/test name. Samples should be

[7] National Environmental Laboratory Accreditation Program (NELAP), http://www.nelac-institute.org/newnelap.php.

contained, interferences mitigated if necessary, preserved, and stored as required by the specific analytical procedure immediately following sampling, and procedures used and documented in the field. Where possible, the sample location should be photographed and GPS coordinates of the well documented.

13.2 The number of each of the quality assurance and quality control (QA/QC) samples including duplicates, trip blanks, temperature blanks, field blanks and blind field standards inserted, should be prepared as part of the sampling program and collected and identified as appropriate.

13.3 Before the laboratory begins analyzing the samples, the project manager or designated person responsible for this task should check the COCs against the sampling plan. Following receipt of analytical results, the project manager or designated person responsible for this task should review the results compared to the field notes, past results, and regulatory criteria.

13.4 Anomalous results should be evaluated based on field notes, historical data, and data from the surrounding area.

13.5 The entire data collection process from sample collection through to delivery of the results to the regulatory agency, owner/occupant, and/or additional party as appropriate should be documented and tracked.

14. Report

14.1 A report providing the results of the sampling should be provided to the customer and the property owner. Reporting should include the following:

14.1.1 Methodology for sample collection and analysis, in sufficient detail to permit replication by a third party.

14.1.2 Sample results and relevant federal, state, and local standards/criteria.

14.1.3 Map, street address, and GPS coordinates (if available) for supply well locations.

14.1.4 Photographs of supply well location and associated water delivery equipment (if available), clearly annotated to indicate where the photograph was taken.

14.1.5 QA/QC results.

14.1.6 Individuals involved in the work.

14.2 All correspondence relating to the sampling program should also be tracked.

15. Keywords

15.1 baseline sampling; hydraulic fracturing; natural gas wells; oil and gas operations; production; water quality

BIBLIOGRAPHY

(1) United States Environmental Protection Agency Groundwater and Drinking Water webpage: http://water.epa.gov/drink/

(2) United States Environmental Protection Agency Region 4 Potable Water Supply Sampling, May 30, 2013.

(3) *USGS National Field Manual for the Collection of Water-Quality Data (TWRI Book 9)*, Chap. A4, Collection of Water Samples, Version 2.0, 9/2006.