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Ground Water Sampling Guidance

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The following document has been adapted from Groundwater Sampling Field Manual PUBL-DG-038 96 Produced by the Wisconsin Department of Natural Resources Bureau of Drinking Water and Groundwater September 1996 by Steve Karklins with Editor Jordana Lenon. Changes have been made to adapt the document to Utah rules and statutes. A copy of the original document is in two parts and can be obtained at http://dnr.wi.gov/org/water/dwg/gw/pubs/desk_a.pdf and http://dnr.wi.gov/org/water/dwg/gw/pubs/desk_b.pdf.

DISCLAIMER

The mention of trade names or commercial products in this document does not constitute an endorsement or recommendation. Also, while this document and the accompanying *Ground Water Monitoring Plan Guidance* include brief mention of health and safety issues, neither document adequately addresses all health and safety issues and requirements. Both documents should be supplemented with other appropriate references, requirements and training on health and safety.

This guidance is not a rule. It has been prepared to give the reader information, in plain language, about how the Division of Waste Management and Radiation Control expects to interpret Rule R315-308. In the event questions arise regarding the matters discussed in this guidance, the text of the rule will govern.

GROUND WATER SAMPLING GUIDANCE TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE AND USE OF THIS FIELD MANUAL

This field manual provides easy-to-use, procedures for consistently collecting quality, representative groundwater samples and measurements.

Before going out in the field, you should develop a sampling plan and a QA/QC plan. All sampling personnel should read these plans. The *Groundwater Sampling Guidance,* contains detailed information on creating such plans. Consistently follow the procedures and protocols specified in these plans throughout a project's life. Clearly document any deviations from them, including reasons for the deviations.

Most sections of this guidance contain an "Alternative Methods" subsection to help you consider alternative procedures and equipment not covered. This guidance contains commonly used equipment and procedures and is not intended to limit your choice of procedures and equipment to use for a specific site or project.

This guidance uses the Λ iconic symbol to highlight key points to follow for all procedural options. This guidance also uses "***Note***", "***Important note***", "***Caution***", and "***Tip***" to highlight important points that apply to a specific subsection or procedural option (e.g., coated tapes).

2.0 SAMPLING PROCEDURES FOR MONITORING WELLS

2.1 PRE-FIELD CHECKLISTS AND DOCUMENTATION

Pre-field Checklists (Included in Appendix A)

Go through the following two checklists before heading out to the field. These lists can be modified to meet specific project needs.

1. Pre-field Work Procedures Checklist.
2. Equipment Checklist.

Documentation of the Sampling Event

1. **Sampling Plan.** The sampling plan documents the equipment and procedures you use during a sampling event. ***Document any deviations*** from the sampling plan; use the "Field Procedures Documentation" sheet included in Appendix A. Or, create your own form to record deviations.

2. **Well-Specific Field Sheet (Appendix A)**. Document well purging and sampling information, measurements, etc., on this sheet. Or, customize your own data sheet.

3. **Field Procedures Documentation (Appendix A).** If a sampling plan is not available, you may wish to use the "Field Procedures Documentation" sheet included in Appendix A. Customize this sheet as necessary.

4. **Chain of Custody Form (Appendix A).** When strict tracking of of samples is required for legal proceedings, document the possession of groundwater samples collected by filling out a chain of custody form. Use this form to document each time the samples change possession.

Refer to the "Chain of Custody for Samples Requiring Strict Custody" instruction included in Appendix B when collecting samples for any legal action.

5. **Sample Tracking Form (Appendix A)**. For sampling events that do not require chain of custody documentation a sample tracking document may be used.

2.2 MEASURING STATIC WATER LEVEL

- Measure the static water level for a well ***before*** purging, sampling or inserting any other instrument or device into a well's water column.

- Collect water level measurements from all site wells within a reasonably short time, preferably the same day.

- Collect measurements in the order of least contaminated to most contaminated wells (if known). Decontaminate the measuring device between each well.

- Read water level measurements to the nearest 0.01 foot from a permanently-marked spot on the well (e.g., top of casing or reference elevation).

- When possible, use one measuring device for all site wells. If using more than one measuring instrument, check the calibration of both instruments against the same well to ensure that they provide the same water level measurements.

- After removing a ***water/air tight well cap*** (e.g., flush mounted well), allow the water level in the well to stabilize. This may be especially important for wells screened in silt and clay (low permeability) formations. Take several measurements to ensure that the water level has stabilized.

- Bring along records of previous water level measurements taken on the well.

Electronic Water Level Indicator

1. Lower the decontaminated probe or electrode into the well until the instrument indicates that you've reached the water column.
2. Slowly raise and lower the probe or electrode in and out of the water column until you are satisfied that the instrument is providing a reliable water level reading. If necessary, adjust the instrument's sensitivity according to the manufacturer's instructions.

3. Read the measurement on the cable or tape to the nearest 0.01 foot against the top of casing or reference elevation on the well. Record this measurement as "depth to water."

Popper

1. Lower the decontaminated popper and tape into the well until you hear a "pop," indicating that you've reached the water column.

2. Raise and lower the popper, listening for a repeating "pop" sound. Continue doing this until you are satisfied that you have a reliable reading.

3. Read the measurement on the tape to the nearest 0.01 foot against the top of casing or reference elevation on the well. Record this measurement as "depth to water."

4. You can also use the popper to measure the ***well depth*** by lowering the popper and tape through the water column until the tape becomes slack. Slowly pull the tape up until it just becomes taut again. Read the tape against the top of casing or reference elevation on the well and record this measurement as "depth to well bottom."

> ***Caution!*** Deep wells, water table wells, high noise areas and floating products in wells may make it difficult to hear the "pop" and collect a reliable "depth to water" reading. Some individuals can "feel" the water surface without hearing a pop; however, if you are not confident you are collecting a reliable reading, use another measuring method.

Indicator Substance

> ***Important Note:*** If you use a tape coated with an indicator substance, you ***must ensure*** that the indicator substance will not contaminate the well or subsequent samples collected from that well. If you have any doubt, choose another water level measurement method.

1. Coat at least 2 feet of the end of the tape.

2. Lower the coated tape into the well until you hear or feel the tape reach the water column. Lower the tape a few inches into the water and wait at least five seconds.

3. Without moving the tape, read and record the tape measurement to the nearest 0.01 foot against the top of casing or reference elevation on the well.

4. Withdraw the tape from the well and record the measurement where the wetted and dry portions of the tape intersect.

5. Subtract the measurements (Step 3 minus Step 4). Record this measurement as "depth to water."

Alternative Methods

Alternative water level measuring devices or methods are acceptable if they (1) are consistently accurate to ±0.01 foot; (2) do not affect the integrity and chemistry of groundwater samples; (3) do not affect the groundwater geochemistry or well materials; and (4) can be thoroughly decontaminated between wells. Document the type of alternative device or alternative method used. Include this information in the sampling plan and groundwater data reports generated for the site. Follow the manufacturer's instructions for the instrument's use and its limitations.

Calculating Groundwater Elevation

After obtaining depth to water measurements, subtract the "depth to water" from the "top of casing or reference elevation" and record this data as "groundwater elevation."

2.3 PURGING AND SAMPLING PROCEDURES

The ***goal of purging*** is either to remove stagnant water from the well or prevent stagnant water from entering samples as you are collecting them. Stagnant water does not represent groundwater.

The ***goal of sampling*** is to collect unaltered samples that represent the physical and chemical composition of groundwater.

- Purge and sample wells in order of least-to-most contaminated. (This is not necessary if you use dedicated or disposable equipment.) If you do not know this order, sample the upgradient wells first, then the furthest down-gradient or side-gradient wells, and finally the wells closest to, but down-gradient of the most contaminated area.

- Wait at least one week before sampling a newly-constructed and developed well; waiting a month or more may be appropriate for wells constructed in silt or clay.

- When using a bailer, purge and sample ***SLOWLY AND CAREFULLY***. Use a bottom-emptying device to decant samples from the bailer.

- Do ***not*** use cotton or cloth rope or line; use stainless steel cord, Teflon®-coated cord, nylon, or equivalent cord that can be decontaminated between each well. Or, use disposable rope or line.

- Decontaminate all equipment and accessories between use in each well. Store and transport all equipment in clean containers.

- Place a clean plastic sheet or other protective covering around the base of the well to prevent the equipment from contacting the ground. If you do not use a protective covering, ensure that your equipment does not touch the ground or a contaminated surface.

Wells that do NOT Purge Dry

This section applies to wells that take less than – 1 hour for their water levels to recover, or nearly so, after they have been purged.

The following purging and sampling procedures are recommended for wells that do not purge dry. The first procedure (A) consistently yields the ***highest level of data quality*****.** The last procedure (C) may yield a ***lower level of data quality***:

A. <u>Low-flow Purging < 1 L/min (0.26 gpm), Low-flow Sampling < 300 ml/min (0.3 L/min or 0.1 gpm) and Monitoring Indicator Parameters for Stability in a Closed Flow-through Cell</u>

1. SLOWLY lower the pump to the ***middle*** of the well's screened area. (A dedicated system is recommended.) Securely fasten the power cable and sample tubing at the top of the well. Connect the power source, controller box, gas source, etc., to the pumping equipment.

2. Connect the sample tubing to the water entry point of the closed flow-through cell.

   <u>Closed Flow-Through Cell</u>

   Air pockets may exist in the upper neck of each port hole that has a probe inserted into it – this is not a problem. Just make sure the probe's sensors are completely submerged in water during use.

   Avoid exposing the flow-through cell to extreme heat and sun in the summer and freezing temperatures in the winter.

3. Set up and calibrate all indicator parameter instruments and place each probe into its respective port of the closed flow-through cell.

4. Set the pump controller to the desired purging rate (i.e., < 1 L/min). Do ***not*** use a valve to reduce the flow from a pump; valves can cause an "orifice" effect that can cause sample agitation and alteration.

5. Record the "purging time start," and start purging the well at a rate of 1 L/min or less. During purging, the water level in the well should not decrease significantly and should stabilize after purging for a few minutes. If the water level continues to decline while purging, decrease the purging rate if possible. Record the "purging flow rate" as an average. Use a graduated beaker, cylinder, calibrated bucket or other device to measure the flow rate while purging and sampling.

6a. Purge the well until you have taken at least three consecutive readings, spaced – 2 minutes or – 0.5 well volumes or more apart, that are within the following ranges for the following indicator parameters:

Dissolved Oxygen	± 0.2 mg/L
Specific Conductance	± 5.0 Φmhos/cm for values < 1000 Φmhos/cm ± 10.0 Φmhos/cm for values > 1000 Φmhos/cm
pH	± 0.1 pH units
Temperature	± 0.1 ^{o}C
Turbidity	< 5 NTUs (***Required*** if metals samples will not be filtered. ***Recommended*** if sorptive compounds or elements are collected. ***Optional***, but recommended, if other compounds or elements are collected).
Eh **(*optional*)**	± 30 mv

Stable dissolved oxygen, specific conductance and turbidity readings are considered the most reliable parameters for indicating that stagnant water has been replaced by formation water. You may adjust the ± ranges and which indicator parameters you use to indicate that stagnant water has been replaced by formation water to reflect site-specific data, geochemistry, and hydrogeologic conditions.

Turbidity stabilization and NTU readings below 5 are required if you will not be filtering metals samples. In addition, monitor turbidity stabilization when collecting sorptive, hydrophobic, or high octanol-water partition coefficient (Kow) compounds or elements.

OR

6b. Purge the well until the readings for indicator parameters listed above (or well-specific indicator parameters) vary within ±10% over three or more consecutive readings, spaced –2 minutes or – 0.5 well volumes or more apart.

7. Record the final three stable readings for each indicator parameter on the "Well Specific Field Sheet" (Appendix A). Or, use your own customized data sheet. Record indicator parameter data measured before stabilization on graph paper. Or, customize your own data sheet.

8. Record the "volume purged," "purging time stop," "purged dry (Y/N)," and any problems purging.

9. Collect samples as described under Section 2.5. Record "sample flow rate" as an average, "time sample collected," and any other pertinent information related to the sampling event.

B. Purging Specific Number of Well Volumes with a Standard pump and Sampling with a Pump or Grab Sampler

1. SLOWLY lower the pump to the ***middle*** of the screened area of the well. Securely fasten the power cable and sample tubing. Connect the power source, controller box, gas source, etc., to the pumping equipment.

2. Use **Equation 1** or **Table 1** (see following this section) to calculate the number of gallons to remove a ***Specific number of required*** well volumes from the well. Record this data as "___ well volumes."

3a. Using a **pump** to *purge **and** sample* the well: Record the "purging time start" and start purging the well. Minimize well drawdown; it should stabilize before sampling. If the water level continues to decline during purging, try using a lower purging rate. Use a graduated beaker, cylinder, calibrated bucket or other device to calculate the flow rate while purging and sampling.

3b. Using a **pump** to *purge* the well and then using a **grab sampler** to *sample* the well: Record the "purging time start" and start purging the well with the pump's inlet at the ***top*** of the water column. As you are purging, ***slowly lower the pump*** so that, after the specific number or required well volumes are purged, the pump's inlet is near the bottom of the well (within ~ 1 foot). ***Important note*:** Before collecting samples with a grab sampler, you must lower the pump while purging the well, thus removing any stagnant water before collecting samples.

4. Record "purging flow rate" as an average, "volume purged," "purging time stop," "purged dry (Y/N)," and any problems purging.

5a. If you use a **pump** to collect samples, the sampling flow rate should be as low as possible, and preferably less than the purging flow rate.

5b. If you use a **grab sampler**, try not to disturb the samples. If you use a bailer, use a bottom-emptying device to decant your samples.

6. Collect samples as described under Section 2.5. Record "sample flow rate" as an average, "time sample collected," and any other pertinent information related to the sampling event.

C. Purging Specific Number of Well Volumes with a Bailer and then Sampling with a Bailer or Other Grab Sampler

1. Use **Equation 1** or **Table 1** (see the following section) to calculate the number of gallons needed for removing a ***Specific number of required*** well volumes. Record this data as "___ well volumes."

2. Record the "purging time start." Lower and raise a decontaminated bailer in and out of the water column ***very slowly*** and purge four well volumes.

Tip! To hasten purging and sampling with a bailer, tie an overhand knot, string or other easily-removable marker to the rope or cable just short of the well's depth to water. You can then rapidly lower the bailer into the well to just above the water column, then ***gently and slowly*** lower it into, then ***gently and slowly*** pull it out of the water column.

3. Use a calibrated bucket or other device to keep track of the volume of water you remove. Purge specific number of required well volumes.
4. Record "volume purged," "purging time stop," "purged dry (Y/N)," and any problems purging.

5. Sample the well by ***slowly and gently*** lowering the bailer until it is submerged and in the middle of the well screen. Do not allow the bailer to contact the bottom of the well. ***Very slowly and carefully*** raise the bailer out of the water column and to the surface. Do not bang it against the side of the well (typical of the "helicoptering" technique).
6. Collect samples as described under Section 2.5. Use of a bottom-emptying device to decant samples from a bailer. Record "time sample collected" and any other pertinent information related to the sampling event.

EQUATION 1
Volume to be Purged from a Monitoring Well

$$V = B \times (D/2)^2 \times H \times 4 \times 7.48 \text{ gallons/ft}^3$$

Where:
V = Total purge volumes (i.e., four well volumes in gallons)
B = Pi (3.1416)
D = Inside diameter of well casing (feet)
H = Feet of water in well (depth to well bottom minus depth to water)

TABLE 1
Four Well Volumes of Water (in gallons) per One-Foot Section of Well Casing

Nominal casing or pipe size (inch)	Well casing or pipe schedule	Actual inside diameter of well casing (inch)	Four well volumes per one foot of water in well
1	40	1.05	0.18
1	80	0.96	0.15
1.25	40	1.38	0.31
1.25	80	1.28	0.27
1.5	40	1.61	0.42
1.5	80	1.50	0.37
2	5	2.25	0.82
2	40	2.07	0.70
2	80	1.94	0.61
3	40	3.07	1.54
3	80	2.90	1.37
4	5	4.33	3.07
4	40	4.03	2.65
4	80	3.83	2.39

How to calculate four well volumes using Table 1

Step 1: Measure the actual inside diameter of the well casing - find on column three of chart. You may also use the nominal pipe size and schedule in lieu of a measurement.

Step 2: Calculate feet of water in the well casing (depth to well bottom minus depth to water).

Step 3: Multiply step 2 by the applicable value in column four. For example, you have a 2-inch, schedule 40 casing that measures 2.07 inside diameter and you have 20 feet of water (step 2) in the well. Multiply 20 feet by 0.70 (column 4) = 14 gallons; therefore, you must purge 14 gallons from the well before collecting samples.

To Convert:
Gallons to liters, multiply gallons by 3.785
Liters to gallons, multiply liters by 0.2642
Milliliters to gallons, multiply milliliters by 0.0002642
Feet to meters, multiply feet by 0.3048
Centimeters to feet, multiply centimeters by 0.03281

Wells that Purge Dry

This section applies to wells that take – 1 or more hours to recover, or nearly so, after they have been purged dry, or nearly so.

A. Low-flow Purging and Sampling in a WATER TABLE WELL (water level intersects the well screen)

1. Slowly lower the pump to the ***lower portion*** of the screened area of the well but without setting it at the very bottom of the well. Secure the power cable and sample tubing. A dedicated system is recommended over a portable system.

2. Record the "purging time start" and start purging the well at < 300 ml/min or <0.1 gpm. Purge until drawdown reaches the top of the pump or until the pump runs dry, then shut the pump off immediately! (***Caution!*** Some pumps can be damaged by running them dry - follow the manufacturer's instructions.) Record the "purging flow rate" as an average.

   Note: A pressure transducer or electric water level indicator can assist in determining when drawdown reaches the top of the pump. If you use an electric water level indicator, lower the probe tip to the well pump and turn the instrument on before pumping. Start pumping, then shut off the pump when the water level indicator shuts off.

3. Allow the well to recover, or nearly so. If time permits, purge the well a second time and allow the water to recover again before sampling. To save time, purge a well the first time, move on to the next well and purge it, then come back to the first well to purge it again before sampling. (With portable equipment - decontaminate first.) Record "volume purged," "purging time stop," "purged dry (Y)," and any problems purging.

4. Collect samples as described under Section 2.5. (Collect samples within 24 hours of purging, if possible.) Record "sampling flow rate" as an average, "time sample collected," and any other pertinent information related to the sampling event.

B. <u>Low-flow Purging and Sampling in a PIEZOMETER (water level is above the top of well screen)</u>

1. SLOWLY lower the pump to the ***lower portion*** of the screened area of the well but do not set the pump on the very bottom of the well. Secure the power cable and sample tubing at the top of the well. A dedicated system is recommended over a portable system.

2. Record the "purging time start" and start purging the well at <300 ml/min or <0.1 gpm. Purge the well until the water level is just below the top of the well screen. (Use a pressure transducer, water level indicator, or similar method.) Shut off the pump and record the "purging flow rate" as an average, "volume purged," "purging time (stop)," "purged dry (Y)," and any problems purging.

3. Allow the well to recover, or nearly so, then begin collecting samples as described under Section 2.5. (Collect samples within 24 hours of purging, if possible.) If the water level in the well reaches the top of the screen before all samples are collected, shut off the pump, allow the well to recover again, then resume collecting the rest of the samples. Record "sample flow rate" as an average, "time samples collected," and any other pertinent information related to the sampling event.

C. <u>Purging and Sampling with a BAILER, or other grab sampler, in a Water Table Well or Piezometer</u>

1. Record "purging time start" and bail the well dry, or nearly so. Take extra care to purge the well very slowly and very gently. Do not allow the bailer to contact the bottom of the well.

2. Allow the well to recover, or nearly so. If time permits, purge the well dry, or nearly so, a second time. Record "volume purged," "purging time stop," "well purged dry (Y)," and any problems purging.

3. Collect samples as described under Section 2.5, within 24 hours of well recovery, if possible. Use a bottom-emptying device to decant samples from the bailer. Record "time sample collected" and any other pertinent information related to the sampling event.

Alternative Methods

Alternative purging and sampling methods and equipment are acceptable if they provide representative groundwater samples. Your purging and sampling method and your equipment must not adversely affect sample integrity, chemistry, temperature and turbidity. In addition, alternative equipment must have minimal or no effect on groundwater geochemistry, aquifer permeability and well materials. Equipment and materials must minimize sorption and leaching. Use the equipment in a manner that minimally alters the groundwater samples. The sampling method is approved as part of the ground water monitoring plan.

Document and describe any alternative equipment and procedures you use to purge a well and collect samples. Include this information in the sampling plan and groundwater data reports you generate for a site.

2.5 SAMPLE COLLECTION

Sample Collection and Filling Procedures

Λ Take in-field water quality measurements before sample collection. (See Section 2.6.)

Λ Open only one sample container or one set of sample containers immediately before filling. Preserve samples within 15 minutes of collection and immediately place on ice.

Λ Minimize the contact of extraneous contamination with sample containers and equipment. Common extraneous contaminants include perfumes, cosmetics, bug spray, sun tan lotion, Sharpie®, spray lubricants (e.g., WD-40®) and engine fumes. Sample up wind or remove extraneous contaminants before opening containers and collecting samples.

Λ Use waterproof labels. Write on them with a permanent, waterproof marking device (e.g., grease pencil). Labels should include:

- T A unique sample number.
- T Site/project name or other identifier.
- T Date and time sample collected.
- T Sample collectors initials.
- T Type of preservation added and analysis required.

Λ Appendix C includes a table that indicates a substance's potential to volatilize from a water sample during sample collection. Use extra caution when collecting samples that have a "medium" or "high" potential to volatilize from water.

Λ Remember to keep complete and accurate records. Record all field information before proceeding to the next well.

Order of Filling Sample Containers

Collect sample parameters in the following order:

1. Unfiltered samples for in-field water quality measurements. (This is not necessary if you take down-well or closed flow-through cell measurements.)
2. Volatile organic compounds (VOCs).
3. Non-filtered, non-preserved (e.g., sulfate, total chromium VI, mercury, semi- and non-volatiles, pesticides, PCBs).
4. Non-filtered, preserved (e.g., nitrogen series [ammonia, nitrates, nitrites, etc.], phenolics, total phosphorous, total metals, cyanide, total organic carbon).
5. Filtered, non-preserved (e.g., dissolved chromium VI).
6. Filtered, preserved (e.g., dissolved metals)
7. Miscellaneous parameters.

Note: Collect sulfate samples before sulfuric acid preserved samples (e.g., nitrogen series). Collect nitrogen series samples before nitric acid preserved samples (e.g., boron, dissolved metals).

Procedures for Filling Sample Containers

Note: If a sample container already has preservative in it before you fill it (common for VOC vials), do not rinse the container before filling and take care to minimize sample overflow that may dilute the preservative.

1. Tip the sample container at a slight angle and allow a slow steady stream of water to run down its inner wall. Hold the sampling discharge tube close to the sample container but do not touch it.

2. Immediately after filling a sample container, if not already done, add any required preservative (filter first, if required), replace the cap, add the label, and place the sample in a plastic bag (optional) on ice in a cooler.

3. Record the "time sample collected." To avoid confusion, you may wish to record sample collection time in military time (e.g., 1300 instead of 1:00 pm, 1845 instead of 6:45 pm, etc.,).

Volatile Organic Compounds (VOCs)

Note: Do ***not*** filter VOC or other organic samples. Turn off any nearby gasoline engines or sample up wind of any engine exhaust. Remember to store one trip blank per cooler when collecting volatile (VOCs, GRO, and PVOCs) samples. Store empty VOC containers on ice to help you reduce VOC volatilization when you fill them.

1. If a laboratory hasn't already done so, add sufficient preservation to the container.

2. Tip the container at a slight angle and allow a slow, steady stream of water to run down its inner wall.

3. Fill the sample container until the water forms a positive meniscus at the brim, then immediately replace the cap.

4. Invert the sample container and tap it lightly to check for bubbles. If bubbles are present, fill a new sample container (containing preservative) and check for bubbles the same way. If bubbles are unavoidable, collect numerous samples and save those with the least amount of bubbles. Do not try to reopen and add more water to samples that have bubbles.

   Refill a ***used*** container only if you again add sufficient preservative ***and*** refill it with water from the same well, to avoid cross-contamination between samples.

5. Label the sample, place it in a plastic bag (optional), then immediately place it on ice in a cooler. Record the "time sample collected."

Semi-volatiles and Pesticides

When collecting semi-volatiles and pesticides, unless project objectives or regulations require otherwise, use similar, but less rigorous, procedures as those described for collecting VOC samples. Use the same equipment decontamination and storage procedures you use for collecting VOC samples.

When collecting semi-volatiles and pesticides, the type of sample container, volume and preservative may be quite different than that required for VOC samples. In addition, leave approximately ½ inch of air space when filling sample bottles to allow for expansion. Otherwise, the bottles may break.

> ***Note:*** The number of sample bottles required depends on the number of different extraction, clean-up, analytical methods and quality control (QC) needed for the project. Remember that laboratories are required to duplicate and spike samples at a set frequency. Collecting insufficient sample volumes may result in higher detection limits, because sample volume must be reduced to accommodate QC requirements.

Inorganics

Inorganic samples (e.g., dissolved metals) are quite susceptible to aeration, oxidation, precipitation, coprecipitation, extraneous contamination and cross-contamination during sampling, filtering and handling. Therefore, take extra care to avoid sample aeration before filtering (if required) and preserving.

Other Sample Parameters

Other sample parameters subject to rapid change (by aeration and subsequent changes in redox state, or addition or loss of dissolved gasses) once groundwater is removed from a well include: chromium VI, pH, Eh, oxygen, inorganic carbon, alkalinity, TOC, ammonium, nitrate/nitrite, sulfide, cyanide, molybdenum, mercury, selenium, dissolved iron (ferrous iron - FE^{+2}), manganese, zinc, cadmium, lead, vanadium, arsenic and phosphate. Take precautions to avoid altering these parameters during sampling. Add preservative, if required, ***immediately*** and place on ice in a cooler.

Contact a qualified laboratory for specific directions on collecting, preserving and handling samples not discussed in this manual.

2.6 FIELD WATER QUALITY MEASUREMENTS

- Use a closed flow-through cell. Or, you can use a down well measuring probe; however, well water must be flowing past the probe during measurements (i.e., the probe is near the pump's inlet during purging or is lowered and raised in the screened portion of the well).

- If you do not use a closed flow-through cell or a down-well probe, take in-field measurements immediately, or less preferably, within 30 minutes of collection.

- Avoid exposing instruments and samples to extreme heat or cold.

- Specific conductance, pH, dissolved oxygen and Eh can change rapidly due to aeration, oxidation and the loss or gain of dissolved gasses as you remove groundwater from a well. Minimize atmospheric contact with the sample.

Following are procedures for "***out of the well***" (i.e., closed flow-through cell or sample bottle) water quality measurements. Your equipment's operation manual may deviate from guidelines provided here. Follow the manufacturer's instructions for your instrument and familiarize yourself with the methodology in the most recent version of *Standard Methods for the Examination of Water and Wastewater*.

Temperature

1. Place the thermometer or probe into a closed flow-through cell or sample bottle and allow the purge water to continuously flow past the thermometer or probe. If you use a sample bottle, allow the water to overflow while measuring temperature.

2. Allow the thermometer or probe to equilibrate (± .1° C) with the water for a minute or more, then record the temperature. Do not remove the thermometer or probe from the water when taking the reading.

3. Decontaminate the thermometer or probe and store properly.

Specific Conductance (conductivity and electric conductance)

Note: Measure specific conductance ***before*** pH (unless using a flow-through cell). In addition, as specific conductance is a temperature sensitive measurement, adjust readings to 25^{o}C.

1. Calibrate the conductivity instrument and probe against a standard potassium chloride (KCl) solution. Do this in the field, or less preferably, in the laboratory. Calibrate the instrument according to the manufacturer's instructions. Recalibrate at least daily; more often is recommended and prudent. Record calibration data.

2. If required, set the instrument to the anticipated range for measurement (e.g., *x*100 Φmhos/cm).

3. Place instrument in purge water flow and allow measurement to stabilize (± 5Φmhos/cm for values <1000, ± 10 Φmhos/cm for values >1000 in consecutive readings).

4a. If your instrument ***automatically compensates for temperature***, record the measurement as "field specific conductance at 25^{o}C." Don't forget to multiply the measurement by the range at which the instrument is set.

4b. If your instrument ***does not automatically compensate for temperature***, measure the temperature of the sample and set the instrument's temperature dial to the sample temperature. Record the measurement as the "field specific conductance at 25°C." Don't forget to multiply the measurement by the range at which the instrument is set.

4c. If your instrument cannot compensate for temperature, apply a correction factor as specified in the manufacturer's instructions or by using the following formula:

$$\textbf{specific conductance @ } 25^{\circ}\textbf{C} = \frac{\textbf{sample conductivity (}\Phi\textbf{mhos/cm)}}{\textbf{1 + 0.0191 } x \textbf{ (sample temp. in } ^{\circ}\textbf{C - 25)}}$$

Note: Conductivity meters that do not automatically correct readings to 25°C usually include a conversion table or chart for correcting data to 25°C.

5. Decontaminate the electrode and store properly.

Note: Most problems related to collecting poor conductivity data include: weak batteries; fouling of the electrode (chemical cleaning may be necessary); insufficient submersion of the probe into the sample; allowing the probe to touch the container walls; improper or no instrument calibration; not allowing the probe to equalize with the sample temperature; and improperly or not converting readings to 25°C.

pH

1. Calibrate the pH instrument with pH buffer solutions that span the range of expected groundwater pH values. Two fresh pH buffer solutions (7.00 and 4.00 ***or*** 7.00 and 10.00) having temperatures within 5°C of the groundwater samples are required for instrument calibration. Properly fill the probe with a salt solution, if required. Follow the manufacturer's instructions for the procedures and frequency of instrument calibration. Calibrate the instrument at least daily; more often is recommended and prudent. Record calibration data.

2a. Place the calibrated pH probe into a closed flow-through cell and allow the purge water to continuously flow past the probe.

2b. If you measure pH from a sample container, fill a container for this measurement ***only.*** Do not insert a pH probe into a sample that will later be analyzed for other parameters.

3. Allow the pH probe to equilibrate (± .1 pH units) with the water for a minute or more, then record pH. Do not remove the pH probe from the water while taking the reading. Read pH measurements to the nearest 0.1 pH units.

4. Rinse the pH probe with reagent grade water and store in the buffer solution or as recommended by the equipment's manufacturer.

Turbidity

Measure the turbidity of a sample the same day you collect it, preferably in the field immediately after collection.

If you cannot measure sample turbidity soon after collection, you may store samples in the dark for up to 24 hours before measuring turbidity. Shake the sample vigorously before measuring. *Standard Methods for the Examination of Water and Wastewater* discusses interferences and procedures for measuring turbidity.

1a. Use a turbidity meter according to the manufacturer's instructions. Read turbidity to the nearest 0.1 Nephelometric Turbidity Unit (NTU) and record your measurement. In addition, provide this measurement to the laboratory if any well samples will be analyzed for metals.

1b. When you do not use a turbidity meter, describe the turbidity (e.g., slight, moderate) and record your observations or have a laboratory determine sample turbidity within 24 hours of sample collection.

Dissolved Oxygen

You can measure dissolved oxygen (DO) with an electrometric method (dissolved oxygen meter), colorimetric method, the Winkler method, or with the iodometric method. (See most recent version of *Standard Methods for the Examination of Water and Wastewater*.) Dissolved oxygen meters usually require calibration before use and a visual check of the probe to verify that the membrane is not damaged.

To function properly, most DO probes require that water continuously flow past the membrane while measurements are being taken. Therefore, for down-well measurements of DO after purging a well, use either a DO probe equipped with a stirring rod or, less preferably, slowly raise and lower the probe in the water column while taking readings. If you use a DO probe on a water sample removed from the well, either use a probe equipped with a stirring rod or, while purging the well, allow the purge water to overflow from the sample container while taking DO readings.

If your DO meter is not responding as expected or is very sluggish, you may need to change the probe's membrane; follow the manufacturer's instructions for doing this. Lowering a probe into a deep well may also result in sluggish performance because signal strength weakens with cable distance.

Eh (Oxidation-reduction potential)

Eh is usually measured with a noble metal (e.g., platinum) and a reference electrode system using a pH meter that reads millivolts. Take field measurements of Eh in an air-tight flow-through cell or similar air-tight device. Read Eh measurements to the nearest 10 millivolts (mV).

Follow the equipment manufacturer's instructions and refer to the most recent version of *Standard Methods for the Examination of Water and Wastewater*.

Other Water Quality Measurements

Other water quality measurements that may change physically and chemically soon after collection include dissolved carbon dioxide and alkalinity. These parameters are best measured in-field and immediately after collection. Follow the equipment manufacturer's instructions and the most recent version of *Standard Methods for the Examination of Water and Wastewater* for measuring these parameters.

2.7 SAMPLE FILTRATION

Λ If filtering is to be done the Division ***strongly recommends*** direct, in-line filtering of samples. It is fast, simple and greatly reduces sample alteration. Direct, in-line filtering means that you attach the filter ***directly*** to a pump's discharge line or to the discharge tube of a grab sampler (e.g., bailer). If you place a sample into any type of container or transfer vessel before filtering, any filtering that follows is not direct, in-line filtering.

- If you do not use direct, in-line filtration, filter samples ***immediately*** after collection, document when you filtered the samples.

- Use a 0.45 micron pore size filter membrane for filtering. If possible, rinse or flush the filter membrane and filtering device with a minimum of 0.5 liters (500 mls) of reagent grade water before use.

- Avoid applying high pressure (>50 psi) when filtering samples. For silt-laden or turbid samples, try using a pre-filter (e.g., glass microfiber), a filter membrane of larger diameter or larger surface area, or a slower pumping rate or bailing technique. If high turbidity is a recurring problem, the well may need to be redeveloped or rehabilitated.

- If possible, allow 150 mls or so of sample to pass through the filtering device before filling sample containers. If possible, rinse sample containers once with filtrate.

2.8 SAMPLE PRESERVATION AND HANDLING

Sample Preservation

Appendix C includes sample preservation for a variety of compounds and parameters. You may add preservative to sample bottles before or immediately after sample collection. (Filter the sample, if required, before adding preservative.) If you add preservative to a container before adding the sample, take care to minimize sample overflow that may dilute the preservative.

Checking and Adjusting the pH of a Preserved Sample

Note: Do ***not*** check the pH of VOC samples.

When using a pH meter to check the pH of a preserved sample, follow these procedures:

1. If applicable, check and fill the reference electrode with solution as recommended by the instrument's manufacturer.
2. Calibrate the instrument according to the manufacturer's instruction. Two fresh pH buffer solutions (7.00 and 4.00 ***or*** 7.00 and 10.00) having temperatures within 5^{o}C of the groundwater samples are typically required for instrument calibration.

3. Pour a small portion of the preserved sample into a separate container. Immerse the electrode into the separate container and wait for the reading to stabilize. Do not swirl or stir the electrode while taking the reading unless recommended by the manufacturer.

4a. If sample pH needs adjustment, add additional preservative to the original sample and repeat Step 3.

4b. If sample pH is acceptable, dispose of the separate sample (do ***not*** pour it back into the original sample container), replace the lid on the original sample and place it on ice in a cooler.

5. Rinse the electrode with reagent grade water and store the electrode in the buffer solution or as recommended by the manufacturer.

When using pH paper to check the pH of a preserved sample, follow these procedures:

1. Gently tip the sample container on its side to wet the inside of the lid and remove the lid.

2. Touch the pH paper to the droplets inside the lid and read the pH. Do ***not*** put the pH paper directly into the sample container. Compare the color of the pH paper to color-pH provided by the manufacturer.

3a. If sample pH needs adjustment, add additional preservative to the sample, rinse the container lid with reagent grade water, replace the container lid and repeat Steps 1 and 2.

3b. If sample pH is acceptable, rinse the container lid with reagent grade water, shake the lid to remove any excess water and replace the lid.

Sample Handling and Storage

After samples are collected, filtered (if required), labeled, and preserved (if required), they must be placed ***immediately*** on ice. Keep samples at or below 4^{o}C, but above freezing throughout storage, handling and shipping. Make sure there is enough ice for the duration of sample storage and transport. The Division ***discourages*** using frozen cold packs (e.g., "blue ice"). If you do use them, place a temperature blank in the cooler so the laboratory can document the temperature of the samples when they arrive.

Breakable sample containers (e.g., glass VOC vials) should be separated by bubble wrap, foam, ice, etc. At least a portion of each container must contact the ice, otherwise the protective layer (e.g., bubble wrap) may insulate the sample from the cooling effects of the ice. Placing samples in a plastic bag can help minimize the chance of cross-contamination among samples should a container break.

2.9 QUALITY ASSURANCE/QUALITY CONTROL

- Λ Field QA/QC efforts must match the data quality objectives established or required for the project and sampling event.
- Λ Remember that QA/QC procedures and samples are not optional.
- Λ All QA/QC samples must be collected, handled and processed in the ***same exact manner*** as the other analytical samples being collected. Make sure the laboratory receives sufficient sample volumes or additional containers to perform required QC procedures.
- Λ All purging, sampling and decontamination wastewaters, and materials must be stored, handled and disposed of properly.

Quality Control Samples

Trip Blank

Include one trip blank per cooler if collecting volatiles (i.e., VOCs, GRO, or PVOCs). Prepare trip blanks with laboratory ***reagent grade water***. ***Do not*** prepare them with water (even if distilled or deionized) purchased at a store; there is no guarantee that store-bought water is free of contamination. Trip blanks must be analyzed by the same laboratory that is analyzing the volatile samples. The trip blanks should not be opened until they are analyzed.

Typically one trip blank per vehicle and one trip blank per cooler is used. Store, transport and ship all volatile samples in one cooler to minimize the number of trip blanks.

Note: If holding times permit, trip blanks do not need to be analyzed if VOC, GRO and PVOC compounds are not detected in ***any*** of the groundwater samples. The holding time for a trip blank begins when groundwater samples are being collected.

Field Blank (field rinsate blank, decontamination blank, equipment blank)

Collect one field blank for every 10 samples or less collected. Decontaminate the sampling equipment for the field blank the same way you do when collecting other samples. After decontaminating the sampling device (e.g., bailer or pump), fill it with laboratory ***reagent grade water***, then collect a sample of the reagent grade water - this is your field blank. Collect the field blank from equipment used in a site's most contaminated well, if possible. The field blank should be analyzed for the same parameters as the samples. Field blanks are ***not*** required if you use dedicated sampling equipment ("permanently" left in the well) or disposable sampling equipment.

Field Duplicate

Collect one field duplicate for every 10 samples or less collected. Collect the field duplicate from the most contaminated well, if possible. The field duplicate should be analyzed for the same parameters as the samples. When using a grab sampler (e.g., bailer), collect the duplicate from the same bailer of water as the original sample is collected, bailer volume permitting.

Field Split Samples

Typically not required. The Division may request that split samples be taken during a sampling event. If a split sample is collected by the Division it will be analyzed using laboratory resources of the Division and will be used to compare results of permittee sampling. Where possible samples should be collected using a sample splitter or other method to assure that the split samples are identical. Collect the sample from the well, filter if required, and dispense into two or more containers. Preserve the samples if required. The samples must be analyzed by identical laboratory analytical methods to be comparable. The permittee may want to collect split samples to provide a comparison of results from different analytical laboratories.

Sequential Samples

Typically not required. Sequential samples are taken from the same well during the same sampling event but are collected with different equipment or procedures. These samples can be used to detect variability in analytical results caused by different sampling equipment or procedures.

Equipment Decontamination

Check with your laboratory for recommended equipment cleaning solutions and procedures for each analyte you are sampling. Collection of inorganic compounds may necessitate a dilute acid equipment rinse first. Collection of organic compounds may require a pesticide grade isopropanol, acetone, methanol or hexane equipment rinse. If you use pesticide grade hexane, take extra safety precautions because hexane is quite flammable. Use your professional judgment to decide which of the following procedures to use:

Minimum Decontamination Procedures

1. Disassemble the equipment if possible. Use a weak non-phosphate detergent (e.g., Alquinox®, Liquinox®) and water solution, and scrub the equipment inside and out. Visually inspect the equipment to ensure no visible contamination is present.

2. Thoroughly rinse the equipment with organic-free tap water. Reassemble the equipment, if applicable.

3. Store and transport the equipment in clean plastic, aluminum foil, or a container that will protect the equipment from extraneous contamination.

More Rigorous Decontamination Procedures

1. Wash equipment with a non-phosphate detergent solution and scrub with an inert brush. For internal mechanisms and tubing, circulate the detergent solution through the equipment.

2. Thoroughly rinse the equipment with organic-free tap water.

3a. For ***organic*** (e.g., VOCs) sample collection, rinse equipment with an organic desorbing agent (e.g., pesticide grade isopropanol, acetone, methanol or hexane).

3b. For ***inorganic*** sample collection, rinse equipment with inorganic desorbing agent (e.g., dilute [0.1 Normal] reagent grade hydrochloric acid or nitric acid solution). For stainless steel and low-carbon steel, a more dilute hydrochloric acid solution (1 percent) is recommended.

Note: If you use organic or inorganic desorbing agents, check with your laboratory regarding potential analytical interferences caused by desorbing agents and their proper use and disposal.

4. Rinse the equipment with organic-free tap water only if you are using an ***inorganic*** desorbing agent.

5. Rinse with laboratory reagent grade water. If practical, allow the equipment to air dry before its next use or storage.

6. Store and transport the equipment in clean plastic, aluminum foil or a container that will protect it from extraneous contamination.

Other decontamination methods such as high pressure steam cleaning, hot-water power wash, ultrasonic cleaning and other methods decontaminate most equipment satisfactorily. Refer to the manufacturer's instructions for use.

Note: Dedicated sampling equipment ("permanently" left in the well) significantly reduces the need for equipment decontamination. Sampling equipment used in wells containing free product should be dedicated (suspended above the water column) or disposable.

Sample Tracking, Security and Chain of Custody Procedures

Sample tracking, security and chain of custody procedures provide a legal record of sample transport, possession and handling.

Sample Identification

Use waterproof labels or a similar method to identify each sample container. Use a permanent waterproof marker. Avoid placing labels on container lids; however, if you do place a label on a lid, make sure it's attached to the container as well. Labels should include the following information:

T a unique sample number
T site/project name
T date and time sample collected
T sample collectors initials
T preservation and analysis required

Sample Seals

Some sampling protocols require sample seals. Affix the seal to the sample container so that it has to be broken to open the container. Write your initials, the date and time on the seal.

Shipping Custody Seal

Use tape or a lock to seal the container for shipping. If you use tape, write your signature, the date and time on the tape.

Chain of Custody Record

Complete a chain of custody (COC) record for each sampling event where COC is required. Each time the samples change possession, whoever relinquishes and whoever receives the samples must sign, date and time the chain of custody form.

Note: If you place the chain of custody record in a sealed shipper, you do not need to have the commercial courier (e.g., UPS) sign, date and time the record; however, the courier should have a record of when he or she picked up the samples and where they were sent.

Appendix A includes an example chain of custody form. Check with laboratory for more specific chain of custody procedures or forms required. Appendix C contains "Chain of Custody for Samples Requiring Strict Custody" when collecting enforcement samples.

Sample Tracking

When the rigorous documentation of COC is not required, a sample tracking form should be used

Appendix A includes an example of a sample tracking form. Check with laboratory for a form and procedures for the specific laboratory used.

3.0 REFERENCES

American Public Health Association. 1995. Standard methods for examination of water and wastewater. 19th Ed. American Public Health Association, Washington, D.C.

APPENDIX A

Checklists

- Pre-field Work Procedures Checklist
- Equipment Checklist

Documentation Sheets and Forms

- Well Specific Field Sheet (WSFS)
- Groundwater Sampling Field Procedures Documentation
- Chain of Custody Form
- Tracking Record

PRE-FIELD WORK PROCEDURES CHECKLISTS

All the following procedures may not be necessary for each sampling event. Use those procedures applicable to your sampling plan or customize this list.

LOGISTICS

___ Arrange for site access with the land/home/facility owner and tenants.
___ Locate the nearest post office, UPS office, Fedex drop off spot, etc., if you will need to ship the samples from the field. (UPS has a 70 lb. restriction per container.)

LABORATORY ARRANGEMENTS

___ Select a qualified laboratory to perform the sample analysis. Check that the laboratory (and subcontracted lab) is certified to perform the required analysis.
___ Make sure you have sufficient numbers, types, and volumes of sample containers – **get extras!** Remember QA/QC sample containers and trip blanks.
___ Discuss sample preservation, holding time, shipping requirements, and QA/QC expectations with the laboratory.
___ Inform the laboratory of the date and number of samples you will send.
___ Familiarize yourself with chain of custody or other sample tracking procedures.

SITE HISTORY

___ Review past water quality data or sampling and analysis plan (SAP) to determine the well sampling order.

EQUIPMENT AND FIELD PREPARATION

___ Review the (SAP) and QA/QC plan.
___ Organize equipment (Equipment Checklist).
___ Check that equipment is in good working condition:

T Test and recharge/replace batteries as necessary.
T Test the equipment with tap water or calibration standards.
T Inspect the equipment for defects, loose bolts, frayed wiring, etc.
T Check the instruments' ability to calibrate and function properly.

___ Check that all equipment is properly decontaminated and stored for transport.
___ Fill out the Well Specific Field Sheet (WSFS) as much as possible before heading out to the field.

HEALTH AND SAFETY EQUIPMENT AND PREPARATION

___ If required, prepare and follow a health and safety plan (HSP).
___ Inform sub-contractors and other site personnel of contaminants and site hazards.

EQUIPMENT CHECKLIST

All the following items may not be necessary for each sampling event. Check those items applicable to your sampling plan or customize this list.

GENERAL AND LOGISTICS

___ Permission/notification to land/home owner/tenant
___ Directions to the site and site access roads/site access keys
___ Contact names, addresses and phone numbers
___ Site map showing well locations, keys for well locks
___ Calculator and/or purge volume conversion tables
___ _____

DOCUMENTATION AND REFERENCE MATERIAL S

___ A copy of this ground water sampling guide
___ Sampling and analysis plan (SAP), QA/QC plan, and health and safety plan (HSP)
___ Well Specific Field Sheet (WSFS) and Field Procedures Documentation sheet
___ Well and boring logs
___ Field note book and waterproof pens
___ Clipboard with waterproof cover
___ Chain of custody forms or other sample tracking forms
___ Camera and film
___ _____

PURGING AND SAMPLING EQUIPMENT

___ Plastic sheet or equivalent ground cover
___ Purging pump or bailer and accessories (inert material)
___ Sampling pump or bailer and accessories (inert material)
___ Pump or bailer rope/cable (no cotton or cloth) and tripod
___ Pump sample tubing (inert material)
___ Pump power supply, air compressor, inert gas, etc.
___ Calibrated buckets or similar device for purge water
___ Waterproof grease markers or pens (Sharpies™ are a potential source of VOCs)
___ Sample containers (provided by lab) - **bring extra,** and water proof labels/tags
___ QA/QC sample bottles (VOC trip blanks filled by lab)
___ Sample transfer containers and wide mouth funnel
___ Filtering apparatus and all accessories
___ Filter membranes (0.45 micron) and pre-filters, or
___ Disposable in-line filters
___ 55 gallon drums for wastewater and drum labels
___ _____

FIELD MEASUREMENTS AND EQUIPMENT

___ Water level measuring instrument (0.01 foot increments) and backup device
___ Thermometer or temperature instrument
___ Conductivity meter and calibration standards (KCl)
___ pH meter, buffer solutions (pH 4, 7 and 10) and beakers
___ Dissolved oxygen meter and membrane replacement kit and/or Eh meter
___ Turbidity meter
___ All meters fully charged and operational; spare batteries
___ Closed flow through cell
___ Squirt bottles filled with reagent grade water
___ _____

DECONTAMINATION EQUIPMENT

___ Non-phosphate cleaner and scrub brushes
___ Wash and rinse tubs or buckets and wastewater containers
___ Laboratory reagent grade water (two gallons/well usually sufficient)
___ Clean containers to transport equipment
___ _____

SAMPLE PRESERVATION AND SHIPPING

___ Sample preservatives, transfer pipettes and pH paper
___ Coolers sufficiently large to hold all samples, including QA/QC samples
___ Crushed or cubed ice (frozen cold packs discouraged, need temp. blank)
___ Bubble wrap, Ziplock™ bags or equivalent to protect sample containers
___ Strapping tape, postage, Fedex or UPS shipping labels, COC forms, etc.,
___ _____

TOOLS AND MISCELLANEOUS

___ Extra locks, keys for wells, flashlight, rain gear, etc.
___ Propane torch for frozen locks and bolt cutters for corroded locks
___ Adjustable wrench, screw drivers, hammer, scissors, knife, duct tape, etc.
___ Plastic garbage bags for contaminated waste
___ Bailer retrieval device (e.g., weighted hook)
___ Drum bung wrench and racket socket set (typ. 15/16" socket for 55 gallon drums)
___ _____

PERSONAL PROTECTIVE EQUIPMENT

___ Respirators and cartridges (compatible for contaminants)
___ Safety glasses and/or splash shield
___ Inner and outer gloves (compatible for contaminants)
___ Hard hat and steel toed boots
___ Air monitoring equipment
___ First aid kit and eye wash kit
___ _____

WELL SPECIFIC FIELD SHEET (Sheet ___ of ___)

Facility/Project Name: _____ Date: _____
Section/Grid or Address: ___
Permit #: __
Weather today and past weeks (precipitation): _____
Persons Sampling: ___

Well Name					
Well ID No.					
Other Unique Well No.					
Damage to Well? (Y/N)					
Top of Casing or Reference Elevation (MSL)					
Depth to Water (to 0.01 ft)					
Groundwater Elevation (MSL)					
Depth to Well Bottom (ft)					
4 Well Volumes (gal. or liters)					
Purging Device; dedicated (D) or portable (PT)					
Purge Device Intake Depth (ft)					
Purging Time (start - stop)					
Average Purging Flow Rate (gpm or L/min)					
Volume Purged (gal. or liters)					
Purged Dry? (Y/N)					
Problems Purging? (Y/N)					
Sampling Device (D or PT)					
Sampler Intake Depth (ft)					
Average Sampling Flow Rate (gpm or L/min)					
Time Sample Collected					
Preservative (e.g., HCL)					
Field Temperature (EC)					
Field Specific Conductance					
Time Measured					
Well Name					
Field pH (standard units)					

Time Measured					
Turbidity (NTUs or describe)					
Time Measured					
Dissolved Oxygen (mg/l)					
Time Measured					
Eh - redox potential (mv)					
Time Measured					
Sample Field Filtered? (Y/N)					
Time Samples Filtered					
Well Capped & Locked? (Y/N)					

Comments (Discuss well damage, purging or sampling problems, deviations from sampling plan, etc.):

Sheet Completed by _____ Date _____

GROUNDWATER SAMPLING FIELD PROCEDURES DOCUMENTATION

Facility/Project Name: _____ Date: ____
Section/Grid Location or Address: _
Facility Type: _____ Permit #: _
Weather (temp., cloudiness, bar. pres., wind): _____

_____

Persons Sampling and Title: _____

_____

_____

Water Level Equipment (type, model): _____
Purging Equipment (type, model, material): _____

Purging Method (4 well vol. or stabilization): _____
How Purge Volume Measured? (eg., calibrated bucket): _____
Sample Collection Equipment (type, model, material): _____

_____

Method of Sample Withdrawal (bottom emptying device, low flow): _____
Type of Transfer Containers: _____
Filtering Equipment (type, material): _____
Filter Membrane (type, pore size): _____
When Were Samples Sent to Lab? _____
Was Chain of Custody or Sample Tracking used? _____
Were Enforcement Samples Sent? _____
How Were Samples Kept Cool (ice, other)? _____
Equipment Decontamination Procedures? _____

_____

Decontamination Water Disposal? _____

_____

pH Meter (type, model): _____
Person calibrating: _____
Frequency calibrated: _____
Calibration procedures (buffers used): _____
Problems with meter: _____
Conductivity Meter (type, model): _____
Person calibrating: _____
Frequency calibrated: _____
Calibration procedures: _____
Problems with meter: _____

Turbidity Equipment (type, model): _____
Person calibrating/set-up: _____
Frequency calibrated: _____
Calibration procedures: _____

Problems with meter: _____

Dissolved Oxygen Meter (type, model): _____

Person calibrating/set-up: _____

Frequency calibrated: _____

Calibration procedures: _____

Problems with meter: _____

When Were In-field Measurements Taken (immediately after collection or XX minutes after collection)?: _____

Comments (difficulties, questionable data, deviations from sampling plan, etc): _____

CHAIN OF CUSTODY FORM

The following page contains an example of a Chain of Custody form used by the Utah Department of Health Division of Laboratory Services. This form, or a similar form suppled by a laboratory, can be used when samples require strict chain of custody. However, use of chain of custody can increase the cost of sampling and may not be necessary in all cases.

SAMPLE TRACKING FORM

The following page contains a sample tracking form used by the Utah Department of Health, Division of Laboratory Services. This form or a similar form supplied by the laboratory conducting your analyses may be used to track samples. Use of this form will not validate samples for use in legal proceedings.

Use black ink only

TRACKING RECORD

State of Utah
Department of Health
Division of Laboratory Services
46 North Medical Drive
Salt Lake City, Utah 84113-1105 (801) 584-8400

Project Name	Cost Code
Sampler Name (please print)	
Person to Address Report / Questions To:	
Agency:	
Street:	
Cty,St,Zip:	Phone: FAX:

Field ID#	Date	Time	Matrix	Sample Description	PERCHLORATE (CLO_4)	CHLORIDE (CLIC)	SULFATE (SO_4C)	NITRATE (NO_3C)	BROMIDE (BRIC)	IODINE (I-IC)	TDS (TDS)			pH (To be taken in the field) Please record your results in this column	DLS Sample Number

Relinquished to DLS By:	Date	Time	Received for DLS By:	Date	Time

Revised May 19, 1998

APPENDIX B

REFERENCE MATERIALS

- Sample Containers, Preservation and Holding Time Requirements
- Chain of Custody Procedures for Enforcement Samples
- Potential of a Substance for Volatilizing from a Water Sample
- Equivalency and Conversion Tables

Sample Containers, Preservation and Holding Time Requirements

Parameter	Volume[3] (ml)	Container[1]	Preservation[2]	Holding Time
Alkalinity ($CaCO_3$)	200	G,P	Cool 4°C	14 days
BOD - 5 Day	500 - 1000	G,P	Cool 4°C	48 hrs
BOD - Long Term	500	G,P	Cool 4°C	24 hrs
Boron	50 - 100	P	HNO_3 pH<2 Cool 4°C	28 days
Chemical Oxygen Demand (COD)	50 - 250	G,P	H_2SO_4 pH<2 Cool 4°C	28 days
Chloride	100 - 200	G,P	Cool 4°C	28 days
Chloride - I.C.[4]	25	G,P	Cool 4°C	28 days
Color	50 - 500	G,P	Cool 4°C	48 hrs
Corrosivity	1000		Cool 4°C	
Cyanide - Total[6]	1000	G,P	NaOH pH>12 Cool 4°C	14 days
Cyanide - Amendable to chlorination[6]	1000	G,P	NaOH pH>12[6] Cool 4°C	14 days
Fluoride	250 - 300	G,P	Cool 4°C	28 days
Metals - dissolved (except mercury & Cr^{+6})	250 - 1000[5]	P	Filter immed. HNO_3 pH<2 Cool 4°C	180 days
Hexavalent Chromium (Cr^{+6})	50 - 100	P	Cool 4°C	24 hrs
	Volume[3]			Holding

Parameter	(ml)	Container[1]	Preservation[2]	Time
Mercury - dissolved	500[5]	P or Teflon®	Filter immed. HNO_3 pH<2 Cool 4°C	28 days
NITROGEN				
Ammonia	500	G,P	H_2SO_4 pH<2 Cool 4°C	28 days
Nitrate + Nitrite	100 - 200	G,P	H_2SO_4 pH<2 Cool 4°C	28 days
Nitrate/Nitrite (Drinking water only)	100	G,P	Cool 4°C	48 hrs
Nitrate - I.C.[4]	60	G,P	Cool 4°C	48 hrs
Nitrite - I.C.[4]	60	G,P	Cool 4°C	48 hrs
Total Kjeldahl	500	G,P	H_2SO_4 pH<2 Cool 4°C	28 days
Oil & Grease	2000	G only widemouth	H_2SO_4 pH<2 Cool 4°C	28 days
Pesticides & PCBs	Consult Laboratory	G amber/TLS	Cool 4°C	7 days to extraction
pH	25	G,P	None	immed. & on-site
Phenolics	1000[5]	G only/TLS	H_2SO_4 pH<2 Cool 4°C	28 days
PHOSPHOROUS				
Dissolved (soluble)	50 - 250	G,P	Filter, H_2SO_4 Cool 4°C	28 days
Total	50 - 250	G,P	H_2SO_4 pH<2 Cool 4°C	28 days
RESIDUE				
Dissolved Filterable	100	G,P	Cool 4°C	48 hrs
Total & Total Volatile	100	G,P	Cool 4°C	7 days
Parameter	(ml)	Container[1]	Preservation[2]	Time

	Volume[3]			Holding
Semi-volatiles	2 liters	G amber/TLS	Cool 4°C	7 days to extract
Silica - dissolved	50 - 100	P only	Cool 4°C	28 days
Specific Conductance	100	G,P	Cool 4°C	28 days
Sulfate	50 - 100	G,P	Cool 4°C	28 days
Sulfide	100 - 625[5]	G,P	2 ml 2 N zinc acetate and NaOH ph>9 Cool 4°C	7 days
Sulfite	100 - 625[5]	G,P	Add EDTA Cool 4°C	immed.
Surfactants (MBAS)	250	G,P	Cool 4°C	48 hrs
Turbidity	100 - 250	G,P	Cool 4°C store in dark	48 hrs
Volatile Organics (VOCs)	2 to 4 40 ml vials	G vials/TLS	HCL pH<2 No headspace Cool 4°C	14 days

Abbreviations and Endnotes :

G Glass bottle (typically borosilicate)
P Plastic bottle (typically polypropylene, polyethylene or PVC)
TLS Teflon® lined septa

[1] In many cases, Teflon® and stainless steel containers (except for metals) are acceptable. For metals, polyethylene with a polypropylene cap (no liner) is preferred - a dilute nitric acid rinse may be recommended by some laboratories.

[2] Preserve samples immediately after collection. Consult the laboratory for volumes of preservative required per sample. Verify the pH of the sample (except VOCs).

[3] Volume listed may not include quality control (QC) volume required by laboratory (except those volumes that include a number 5 superscript). Check with the laboratory if unsure of the laboratories QC volume requirements.

[4] Ion chromatography (IC) analysis only. Ion chromatography is not universally available at certified laboratories and may require special arrangements.

[5] Volume includes quality control (QC) effort required by laboratories.

[6] Cyanide samples containing residual chlorine should be treated with 0.6 grams ascorbic acid/L of sample at the time of collection. Sulfide will interfere with the cyanide test and must be removed before the pH is adjusted. Contact the laboratory for special instructions for collecting samples containing sulfide.

Chain of Custody for Samples Requiring Strict Custody

To be admissible as evidence, sample results must be traceable back through their collection, storage, handling, shipment and analysis so that the court is satisfied how the sample results submitted as evidence were collected, transferred and claimed. This is accomplished by a written record documenting the sample identity from collection to introduction as evidence.

Field records identifying sampling personnel, equipment, collection, storage and transfer techniques, and field conditions are required. The sample collector is responsible for maintaining sample custody and integrity until the samples are transferred via a dated and signed chain of custody form to a carrier or are personally delivered and transferred directly to the laboratory.

A sample is in custody if it is:

1. In physical possession, or
2. In view, after being in physical possession, or
3. Secured so that no one can tamper with it.

The courts have accepted two degrees of chain of custody. The first, described below, involves physical possession of the sample from collection to laboratory possession. With this chain of custody method, the sample collector or other person to which sample possession was transferred to delivers the samples to the laboratory. The second chain of custody method is by shipping the samples through a mail carrier. Mail carriers may not assume any liability or responsibility for compromised sample integrity during shipping (e.g., broken samples and/or containers, ice melting in cooler, etc.).

In both cases, a written record must be transferred with the samples. However, when using the second method described above, the sample collector fills out a chain of custody record, seals it in a shipping container, and mails it by a carrier to the laboratory. Upon arrival, a pre-determined laboratory custodian receives the samples, notes the shippers condition (whether sealed or unsealed), each sample container's condition (broken samples, ice present in cooler, etc.), and assumes custody of the samples by signing and dating the chain of custody record. The laboratory maintains possession of the chain of custody record until the sample analysis is complete and then sends the analytical results, along with the chain of custody record, to the sample collector or other pre-designated receiver of the analytical results and chain of custody records.

For routing surveillance samples, the second chain of custody method should suffice. If enforcement action may occur based on the type of samples and/or regulatory programs or agencies involved, the first chain of custody method involving the sample collector physically delivering and transferring possession of the samples to the laboratory is recommended.

Field Chain of Custody Procedures

1. Limit sample collection and handling to as few people as possible. If sample transfers are necessary, use signed receipts of possession. The chain of custody record must accompany the samples. Keep a copy of the chain of custody record for your own records.

2. If the samples are known or suspected of being hazardous, give a receipt for each sample collected to the property or facility owner (s. 144.69, Wis. stats.). The property or facility owner may request split samples.

3. If the samples are known or suspected of being hazardous (e.g., explosion or corrosion hazard), special shipping procedures may be required by the mail carrier. Check with the mail carrier for restrictions and procedures.

4. Follow the Quality Assurance/Quality Control procedures discussed in Section 2.9 of this manual and in the *Groundwater Sampling Plan Guidance*.

5. Record field measurements and other important data in a bound field note book, on field measurement data sheets provided by this guidance, or on modified data sheets that meet site-specific needs. For legal purposes, indelible ink should be used for recording all data and errors in field records should be crossed out with one line and initialed.

6. Complete appropriate laboratory tracking forms and attach them to the chain of custody record. Complete these forms in indelible ink.

7. When required or applicable, document with photographs sample locations, pollution sources, violations, etc. If possible, use cameras that print the date the photos were taken.

8. Maintain physical possession and sample integrity of the collected samples until they are properly transferred to the laboratory custodian or the mail carrier.

9. Obtain a sample possession transfer receipt (a copy of the dated and signed chain of custody record) after transferring possession of the samples to the laboratory custodian or the mail carrier.

Sample Security When Strict Custody Procedures are Necessary

Use the following procedures when securing and transferring possession of strict custody samples:

1. Use sample seals. Tape the sample container so that the tape must be cut or ripped to open the container. Use nylon-reinforced tape or other tape that cannot be tampered with without being noticed upon receipt. Sign and date the tape across the top.

2. Using an indelible permanent marker or ink, write the following information on the security tape, writing across the overlapping ends:

    a. Name of the sample collector(s), date, time, well number, facility name, etc., where the samples were collected.

b. Write the words "**Strict Custody Requirements**," or similar language indicating that sample security is critical.

c. Write "To be opened by _____ personnel only." In the blank, specify water chemistry unit, pesticide and organic chemistry unit, water microbiological unit, or other appropriate personnel.

d. If all the samples are organic, specify "organic." If they are all inorganic, specify "inorganic." If the samples are a combination of both or others, specify accordingly.

By overlapping and writing over the edges of the security tape, it will be possible to detect if someone has tampered with the sample container. If someone were to remove the tape and then reseal it, it would be difficult to seamlessly realign the writing.

Do not use sealing wax to seal the tape. Sealing wax is brittle and will chip and break during normal use. This gives the appearance of tampering even when none has occurred.

Sample containers labeled "Strict Custody Requirements," or with similar language, must be locked up by the laboratory upon receipt and not removed from the locked refrigerator until ready to be analyzed. The laboratory will hold all strict custody samples until notified otherwise. When the case is resolved, either by trial or stipulation, the enforcement specialist should notify the laboratory that the samples associated with the case may be discarded or destroyed.

Potential of a Substance for Volatilizing from a Water Sample

Substance	CAS Number	Henry's Law Constant (atm-m^3/mole)	Potential for Volatilizing from Water
Acenaphthylene	208-96-8	1.1×10^{-5}	Low
Acetone	67-64-1	3.9×10^{-5}	Low
Aldicarb	116-06-3	1.4×10^{-9}	Low
Ammonia	7664-41-7	3.2×10^{-4}	Moderate
Anthracene	120-12-7	6.5×10^{-5}	Low
Atrazine	1912-24-9	2.6×10^{-13}	Low
Benzene	71-43-2	5.6×10^{-3}	High
Benzo(a)pyrene	50-32-8	1.1×10^{-4}	Moderate
Benzo(b)fluoranthene	205-99-2	1.1×10^{-4}	Moderate
Bromodichloromethane	75-27-4	1.6×10^{-3}	High
Bromoform	75-25-2	5.5×10^{-4}	Moderate
Bromomethane	74-83-9	6.2×10^{-3}	High
Carbaryl	63-25-2	4.4×10^{-9}	Low
Carbofuran	1563-66-2	9.2×10^{-5}	Low
Carbon tetrachloride	56-23-5	3.0×10^{-2}	High
Carbon disulfide	75-15-0	3.0×10^{-2}	High
Chlordane	57-74-9	4.9×10^{-5}	Low
Chloroethane	75-00-3	6.2×10^{-4}	Moderate
Chloroform	67-66-3	2.7×10^{-3}	High
Chloromethane	74-87-3	8.8×10^{-3}	High
Chrysene	218-01-9	9.5×10^{-5}	Low
1,2-Dibromoethane (EDB)	106-93-4	6.7×10^{-4}	Moderate
Dibromochloromethane	124-48-1	8.7×10^{-4}	Moderate
1,2-Dibromo-3-chloropropane	96-12-8	1.5×10^{-4}	Moderate
Dibutyl phthalate	84-74-2	1.8×10^{-6}	Low
Dicamba	1918-00-9	7.9×10^{-9}	Low
1,2-Dichlorobenzene	95-50-1	1.9×10^{-3}	High
1,3-Dichlorobenzene	541-73-1	3.3×10^{-3}	High
1,4-Dichlorobenzene	106-46-7	2.4×10^{-3}	High
Dichlorodifluoromethane	75-71-8	3.4×10^{-1}	High
1,1-Dichloroethane	75-34-3	5.6×10^{-3}	High

Substance	CAS Number	Henry's Law Constant (atm-m^3/mole)	Potential for Volatilizing from Water
1,2-Dichloroethane	107-06-2	9.8×10^{-4}	Moderate
1,2-Dichloroethylene (cis)	156-59-2	4.1×10^{-3}	High
1,2-Dichloroethylene (trans)	156-60-5	9.4×10^{-3}	High
1,1-Dichloroethylene	75-35-4	2.6×10^{-2}	High
2,4-Dichlorophenoxyacetic acid	94-75-7	1.0×10^{-8}	Low
1,2-Dichloropropane	78-87-5	2.8×10^{-3}	High
1,3-Dichloropropene (cis/trans)	542-75-6	1.8×10^{-2}	High
Di (2-ethylhexyl) phthalate	117-81-7	3.6×10^{-7}	Low
Dimethoate	60-51-5	6.2×10^{-11}	Low
2,4-Dinitrotoluene	121-14-2	1.3×10^{-7}	Low
2,6-Dinitrotoluene	606-20-2	7.5×10^{-7}	Low
Dinoseb	88-85-7	4.6×10^{-7}	Low
Dioxins	1746-01-6	5.6×10^{-3}	High
Endrin	72-20-8	7.5×10^{-6}	Low
Ethylbenzene	100-41-4	8.4×10^{-3}	High
Fluoranthene	206-44-0	6.5×10^{-6}	Low
Fluorene	86-73-7	1.0×10^{-4}	Moderate
Fluoride	16984-48-8	6.0×10^{-8}	Low
Fluorotrichloromethane (freon 11)	75-69-4	9.7×10^{-2}	High
Formaldehyde	50-00-0	1.7×10^{-7}	Low
Heptachlor	76-44-8	1.1×10^{-3}	High
Heptachlor epoxide	1024-57-3	3.2×10^{-5}	Low
Hexachlorobenzene	118-74-1	1.3×10^{-3}	High
Lindane	58-89-9	1.4×10^{-5}	Low
Mercury	7439-97-6	1.1×10^{-2}	High
Methanol	67-56-1	4.5×10^{-6}	Low
Methoxychlor	72-43-5	1.6×10^{-5}	Low
Methyl isobutyl ketone	108-10-1	1.4×10^{-4}	Moderate
Methyl ethyl ketone (MEK)	78-93-3	2.7×10^{-5}	Low
Methylene chloride	75-09-2	2.0×10^{-3}	High
Monochlorobenzene	108-90-7	3.8×10^{-3}	High
n-Hexane	110-54-3	1.4×10^{-2}	High
Naphthalene	91-20-3	4.8×10^{-4}	Moderate

Substance	CAS Number	Henry's Law Constant ($atm\text{-}m^3/mole$)	Potential for Volatilizing from Water
Pentachlorophenol	87-86-5	2.4×10^{-6}	Low
Phenol	108-95-2	3.3×10^{-7}	Low
Polychlorinated biphenyls	1336-36-3	1.1×10^{-3}	High
Pyrene	129-00-0	1.1×10^{-5}	Low
Pyridine	110-86-1	8.9×10^{-6}	Low
Simazine	122-34-9	2.7×10^{-9}	Low
Styrene	100-42-5	2.8×10^{-3}	High
1,1,1,2-Tetrachloroethane	630-20-6	2.4×10^{-3}	High
1,1,2,2-Tetrachloroethane	79-34-5	4.6×10^{-4}	Moderate
Tetrachloroethylene	127-18-4	1.8×10^{-2}	High
Toluene	108-88-3	6.6×10^{-3}	High
Toxaphene	8001-35-2	6.6×10^{-6}	Low
1,2,4-Trichlorobenzene	120-82-1	1.4×10^{-3}	High
1,1,1-Trichloroethane	71-55-6	1.7×10^{-2}	High
1,1,2-Trichloroethane	79-00-5	9.1×10^{-4}	Moderate
1,2,3-Trichloropropane	96-18-4	3.4×10^{-4}	Moderate
Trichloroethylene	79-01-6	1.0×10^{-2}	High
2,4,5-Trichlorophenoxy-propionic acid (2,4,5-TP)	93-72-1	8.7×10^{-9}	Low
Trifluralin	1582-09-8	2.6×10^{-5}	Low
1,2,4-Trimethylbenzene	95-63-6	5.6×10^{-3}	High
Vinyl chloride	75-01-4	2.7×10^{-2}	High
Xylene (mixed o-, m-, and p-)	1330-20-7	7.0×10^{-3}	High

CAS Number: Chemical Abstract Service (CAS) registry numbers are unique numbers assigned to a chemical substance and are widely used in scientific publications.

Note: Most metals (exception - mercury) and inorganics are not susceptible to volatilizing from a groundwater sample under normal sampling conditions and temperatures.

(Sources: USEPA Superfund Chemical Data Matrix [SCDM] March 1993 data tables. U.S. Environmental Protection Agency (EPA). 1990. *Basics of Pump-and-Treat Ground-Water Remediation Technology*. U.S. Environmental Protection Agency, Washington, D.C. EPA/600/8-90/003.)

Equivalency and Conversion Table s

Volume Equivalents

unit	cc	in^3	liters	Quarts	Gals	ft^3
cc	1	.06102	.001	.00106	.00026	.00004
in^3	16.387	1	.01639	.01732	.00433	.00058
Pints	473.18	28.875	.47318	.5	.125	.01671
liters	1000	61.023	1	1.0567	.26417	.03531
Quarts	946.36	57.75	.94636	1	.25	.03342
Gallons	3785.4	231	3.7854	4	1	.13368
ft^3	28317.0	1728	28.317	29.922	7.4805	1
$meter^3$	100000	61023.4	1000	908.08	227.02	35.314

Equivalent Pumping Rate Table

Milliliters per Minute (ml/min)	Liters per Minute (L/min)	Gallons per Minute (gpm)
100	0.1	0.026
200	0.2	0.05
300	0.3	0.08
400	0.4	0.11
500	0.5	0.13
600	0.6	0.16
700	0.7	0.18
800	0.8	0.21
900	0.9	0.24
1000	1	0.26
2000	2	0.53
3000	3	0.79
4000	4	1.06
5000	5	1.32

Conversion formulas for rates not included in this table:
Liters per minute X 0.26417 = gallons per minute
Gallons per minute X 3.7854 = liters per minute

Length

To Convert From	To	Multiply By
inches	centimeters	2.540
inches	feet	0.0833
feet	meters	0.3048
feet	miles	0.0001894
meters	miles	6.214×10^{-4}
meters	yards	1.094

1 meter = 10 decimeters = 100 centimeters = 1000 millimeters

Volume

To Convert From	To	Multiply By
cubic centimeters	cubic inches	0.06102
cubic inches	cubic feet	0.00058
cubic inches	liters	0.01639
cubic inches	gallons	0.00433
liters	gallons	0.14546
gallons	cubic feet	0.13368

1 liter = 1 cubic decimeter = 10 deciliters = 100 centiliters = 1000 milliliters = 1000 cubic centimeters

Water attributes

Cubic foot
7.48 gallons
28,317 milliliters
28.317 liters
62.428 lbs

Gallon
231 cubic inches
3,785 milliliters
3.785 liters
8.345 lbs

Liter
0.2642 gallons
61 cubic inches
2.205 lbs

Cubic meter
1,000 liters
264.2 gallons
22.045 lbs