Field Guidance Manual

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1. PREFACE

The purpose of this guidance manual is to ensure that all field personnel for the Ground Water Monitoring and Assessment Program (GWMAP) are conducting field work in a safe and consistent manner and that the data collected are representative of the conditions at the point of collection. This document is to be used as a tool for training and as a reference for all field personnel. The instructions for equipment operations are consistent with the manufacturer's recommendations. For trouble-shooting instructions, please refer to the equipment's operation manuals available at the Field Operation Center and the Field Coordinators office area.

These procedures assume that there are at least two people in the field to collect data: the Recorder and the Operator. The Recorder's primary responsibilities are the operation of the data logger, completion of the field form, ensuring that the well is stabilized prior to sample collection, and that all samples are collected in properly labeled and preserved bottles. The Operator's primary responsibilities are to set up and calibrate the equipment, ensure that the equipment is functioning properly, observe all measurements, collect samples and pack up the equipment. Sampling is a team effort. It is important to be as efficient as possible without compromising accuracy.

2. SAFETY GUIDELINES

Your safety is of paramount importance. Field work will always be done in pairs. If you ever feel that your safety is seriously compromised by being on a particular site, leave and call the office immediately. A cellular phone will accompany each field team. Field personnel are responsible for understanding the phone's operating policies and procedures. These policies and procedures will be addressed during employee training. Please use the guidelines below and common sense to reschedule sampling times or to stop sampling.

1. Minnesota Department of Transportation; classifies roads in POOR condition.
2. Weather advisory; tornado, freezing rain, etc.
3. If threatening weather is developing while in the field, return to a shelter.
4. Please DO NOT take any unnecessary risks.

The guidelines in this section must be followed to help insure the safety of GWMAP and other MPCA employees. Report all accidents to your supervisor; Steve Moore, Manager; Field Operations Center (FOC) and Dan Bryant, Safety Officer.

2.1 Training

2.1.1 GWMAP Field Operations Personnel Training

GWMAP new employee training will be conducted for each new employee within one week of that employee's start date. The Field Coordinator, currently Jim Stockinger, will schedule and conduct this training.

2.1.2 Defensive Driving

All field personnel should complete a Defensive Driving Course and are reminded to be alert and obey all traffic laws when on the road.

2.1.3 Employee-Right-to-Know

Annual Employee-Right-To-Know training is provided to all staff that work with chemicals. Dan Bryant will schedule and conduct this training. Material Data Safety Sheets (MSDS) are available for review and are located where chemicals are present. Hands on training for the proper handling of these chemicals will be provided with the new employee training.

2.2 Work Area Safety

2.2.1 Field Operations Center

Before beginning any activity, prepare a work area. The work area should be large enough to accommodate personnel, equipment and materials needed for the activity. Know where the nearest emergency equipment is located and if chemicals are involve in the activity, the work area should be as close to a wash station as possible.

1. Clear walking and standing paths to and from the area. This will allow a clear getaway from any dangerous situation that may occur and help prevent trips and falls. Make sure paths are wide enough to accommodate all potential travel. One path must be cleared to the nearest wash station.
2. Clean the area; wash and dry the work surface to prevent any potential cross-contamination or injury from unknown and/or unseen chemicals that may have been spilled or left by someone else.

3. Lay out all the equipment needed for the activity. This will help size up the work area to insure there is plenty of space. Also, this will minimize the amount of movement during the activity.
4. If working with chemicals, place an eye wash bottle within arms reach of the work area for immediate treatment of any chemical contact with the skin, eyes, etc.
5. Always work with the smallest amount of chemical as possible. This will prevent the waste of chemicals and lessen the potential harm if a chemical spill was to occur.

2.2.2 Field

When in the field, the work area is dictated by the surroundings. However, it is your responsibility to make the site as safe as possible. If you are at a site where your safety is in question, leave the site.

Assess the site; look for any potential hazards. Prepare the sampling vehicle. Park the vehicle on as level ground as possible. This will make objects in the vehicle more stable, help prevent bottles from spilling and increase the vehicle's accessibility. Prepare the sampling area by laying out the equipment needed. Give yourself enough room to move around to perform your job.

For operations using drilling equipment, keep observers at a distance (approximately 50 feet) while performing these operations. Know the safety features the equipment has and the dangers that the equipment presents. Keep the work area tidy to prevent injuries as a result of trips and falls. This will also allow for escape paths from the equipment if something were to happen. Wear the appropriate safety equipment including: hard hat, safety glasses, hearing protection, gloves, and durable clothing such as blue jeans. When possible, drilling operations should be done with three (3) people; driller, driller's assistant and field geologist.

2.3 Chemical Safety

GWMAP utilizes many chemicals for its operations. Concentrated acids may be used to preserve samples in order to maintain the water's chemical characteristics. Also, the chemicals used in cleaning and calibrating the sampling equipment can pose potential safety problems. In addition to the chemicals GWMAP utilizes, many other chemicals are stored at the FOC and used by other MPCA personnel.

A list of the chemicals utilized by GWMAP along with their MSDS are located at the FOC. It is the responsibility of the Field Coordinator to maintain this list. The following are the chemicals primarily utilized by GWMAP:

- Sulfuric Acid (H_2SO_4) - preservative for anions and pesticides and alkalinity titration
- Nitric Acid (HNO_3) - preservative for cations
- Phosphoric Acid (H_3PO_4) - preservative for TOC
- Hydrochloric Acid (HCl) - preservative for VOC
- Mercuric Chloride (HgCl) - preservative for N^{15}
- Zobell Solution (potassium chloride, potassium ferrocyanide trihydrate, potassium ferricyanide) - ORP calibration
- Potassium Chloride (KCl) - conductivity calibration standard, DO and pH/ORP probe storage
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In general, treat any unknown substances as potentially harmful and handle them as such. If you have any questions about chemical handling, storage or disposal, contact Steve Moore (297-4150), Dan Bryant (297-1365) or the Employee Hazardous Materials Information Hotline (1-800-673-7466). MSDS's are available.

2.3.1 Bottle Labeling

Each bottle containing chemicals must be labeled with its contents (name, chemical formula concentration and nature of hazard). In addition, bottles containing preservation acids are to be color coded (see the section 4.1 P*reserving Bottles* for color codes). When transferring chemicals from one bottle to another, the bottle the chemical is being transferred into must be labeled before transferring the chemical. Preserved bottles are to be labeled with the preserving acid and its concentration. Store preserved bottles in boxes labeled as preserved and place the boxes on the shelves marked for preserved bottles.

2.3.2 Field Operations Center Procedures

Field Operations Center procedures that involve the use of chemicals include sample bottle preservation and equipment calibration. Follow the procedures outlined in Sections 3 (*YSI 600 Operations)* and 4 (*Pre-Sampling Procedures)* for the proper steps in performing these operations.

Accidents can and do happen, therefore FOC operations are never to be performed alone. Know where the wash stations, eye wash bottles and other emergency equipment are before starting any potentially dangerous activities. Know the proper operation of the emergency equipment that is available at the FOC. Training on the proper use of this equipment will be given by Steve Moore.
When working with chemicals protective clothing must be worn. Gloves, apron and eye/face protection is provided.

2.3.3 Protective Gloves

The warehouse maintains a supply of several varieties and sizes of gloves. Latex, rubber, and cloth gloves are available for different applications. Select a pair that is appropriate for the activity. If you are working with dry chemicals the cloth gloves may be adequate, if you are working with liquids, the latex or rubber gloves will work best. Select a pair that you feel comfortable with. Make sure the gloves are the appropriate size for your hands. A little tight is better than a little loose. Properly fitted gloves will help reduce the chances of accidents.

When wearing gloves, always consider them to be contaminated with the substance you are working with. The purpose of the gloves is to prevent chemical contact with the skin. Therefore, do not touch yourself, others or objects you do not want to come in contact with the chemical. Remove your gloves so that they are turned inside out. This insures you will to not come into contact with the contaminated side of the gloves. Dispose of the gloves as soon as you are finished using them. Contact Steve Moore if the warehouse becomes low on the glove supply.

2.3.4 Apron

The apron's primary purpose is to protect the user's clothing from chemical spills, drops or splashes. Without an apron, a chemical could be splashed onto clothing. Your skin may then come into contact with the chemical. Depending on the chemical, the clothing may be ruined. The aprons are reusable and should be washed and dried after each use. Steve Moore can replace the aprons when they wear out.

2.3.5 Eye / Face Protection

Our eyes and face are the most sensitive area of our body and deserve the greatest amount of safety consideration when using chemicals. A variety of eye wear is available for your protection. Safety glasses are designed to protect against projectiles, therefore they do not offer an acceptable amount of protect against chemical vapors or splashes. Safety goggles provide better protection against chemical contact with the eyes, however they leave most of one's face

exposed. Face shields offer the greatest level of protection for one's face and eyes. Whenever the potential for splashes or sprays are apparent, a face shield must be worn.

2.4 Field Operations

Field operations that involve the use of chemicals include sample collection and field kits. Follow the procedures outlined in Section 5 (*Protocols)* of this manual for the proper steps in performing these operations.

Field operations are never to be performed alone; teams of at least two people are always assigned. Place the eye wash bottles, first aid kit and other emergency equipment within reach before starting any potentially dangerous activities.

2.4.1 In General

When in the field, wear clothing appropriate for field work. T-shirts, jeans and tennis shoes are the standard. Shorts or cut-offs, tank tops and sandals (topless shoes) are not acceptable field attire. They are not professional nor do they offer an adequate amount of protection against the hazards of field work. Steel toed boots are an option but not required (except for drilling operations).

2.4.2 Sampling and Alkalinity Titration

During sampling, protocol dictates that latex gloves must be worn to prevent contamination. These gloves also provide protection from chemical contact during sampling.

Protective eye wear must be worn during sampling and titration. When in the field, always carry an extra set of eye protection. If someone is observing our sampling procedures, they must have the appropriate safety equipment available. Since bottles are preserved, the acid preservatives could splash while filling the bottles. In addition, VOC samples must be preserved at the time of sampling (see Section 6 *Sample Collection* for the procedures for filling bottles). Concentrated HCl is used as the preservative. The HCl comes in an eye dropper type bottle and if squeezed, will shoot a stream of acid. Caution must be observed when preserving and sampling VOCs.

The digital titrators utilize a cartridge similar to a syringe. When pressure is applied to the plunger (either with the wheel distributor or release button), acid is forced out the distributor. If caution is not observed, a stream of acid could shoot out. Always point the distributor away from yourself, observers and the vehicle.

3. YSI 600 OPERATION

The purpose of this section is to ensure that the Ground Water Monitoring and Assessment Program's (GWMAP) personnel are familiar with the proper maintenance, operation and procedures associated with the use of the YSI 600 series of equipment. This section is intended as a reference manual for all samplers. Instructions for equipment operation and maintenance are consistent with the manufacturer's recommendations and guidelines. For further information about the YSI 600 series and for trouble-shooting, please refer to the operator's manual or call YSI at 1-800-765-4974. For further information concerning GWMAP's sampling protocols, please refer to Section 5 (*Protocols)* in this manual.

3.1 General Information

The YSI 600 series is a multi-parameter meters for monitoring water quality. It is designed for remote, long term, down-hole deployment in monitoring wells and for spot checking of water quality parameters. The YSI 600 series has been adapted for monitoring ground water using a flow cell.

The YSI 600 series has the capability to measure six parameters: temperature, conductivity, dissolved oxygen, pH, oxidation-reduction potential (ORP) and water level. Calculated values include: specific conductance, salinity, total dissolved solids (TDS), and resistivity.

This system is made up of three basic components; a monitor, the sonde, and the field cable. The monitor is needed to setup, log and display the data being collected. On the older models, this component also supplies the power to the sonde. The sonde is the component that houses the probes. It is the portion that is inserted into the water column. On the YSI 600LM, the sonde also has data logging capabilities and houses a battery supply, while the YSI 600XL data logging capabilities and power supply are all through the monitor. The monitor is still needed to setup and program the sonde's datalogger. The field cable is the component that connects the monitor to the sonde. This cable houses the vent tube needed for the water level measuring feature of the system.

3.2 Installing and Removing Probes

The YSI 600 series is equipped with three detachable probes: conductivity/temperature, pH/ORP and rapid-pulse DO. Whenever the probes are not installed in the sonde, the protective plug must be placed in the probe port. When installing or removing probes from the sonde, extra care must be taken to ensure the sonde and the probes are completely dry. Water near these connections can cause the meter to short out.

1. To remove a protective plug or probe, insert the tool, provided in the maintenance kit, into one of the holes in the slip nut or plug head and turn counter-clockwise.
1. To install a protective plug, insert the tool and turn plug clockwise to tighten.
1. To install a probe, locate the port with the connector corresponding to the probe you wish to install:
1. Rapid-Pulse DO = three pin connector
1. Conductivity/Temperature = six pin connector
1. pH/ORP = four pin connector
1. Apply a thin coat of O-ring lubricant to the O-rings on the connector side of the probe. Insert the probe into the port and gently rotate the probe until the two

connectors align. Using the tool, turn the slip nut clockwise to tighten, being careful not to cross thread the nut or over-tighten.

** Note: Before installing probe to the sonde, be sure the probe and the port are free of moisture.*

3.3 Calibration, Maintenance and Storage

3.3.1 General Tips for Calibrating the YSI 600

Before beginning the calibration procedures outlined below, remove the stainless steel weight on the bottom of the sonde guard. This allows the calibration solutions access to the probes with minimal displacement of the fluids in the calibration cup and reduces the amount of carry-over from one solution to the next. However, DO NOT remove the protective guard itself. Fill a large bucket with ambient temperature water to rinse the sonde between solutions. Also, have several clean, absorbent paper or cotton towels available to dry the sonde after rinsing. This will help to limit the dilution of the calibration solutions.

A calibration cup is supplied with the YSI 600. This cup is designed to fit over the outside of the sonde sensor guard; it is not recommended nor is it necessary to remove the guard to calibrate the sensors.

Calibration procedures need to be conducted only periodically to assure high performance. Daily calibration needs to be performed on the DO probe, while weekly calibration needs to be performed on the conductivity and pH probes. The ORP sensor can be calibrated less frequently and temperature does not need to be calibrated.

Once the instrument has been calibrated, the cable connecting the sonde to the monitor cannot be disconnected. The sonde receives its power from the monitor, if the power supply is removed (i.e. disconnecting the cable) the calibration values are lost. Anytime the cables are switched, the instrument must be recalibrated.

Note: On the YSI 600LM (sonde contains a battery source and datalogger), the field cable can be disconnected from the sonde or the monitor without the probes losing their calibration value.

3.3.2 Short Term Storage

Short term (weekly or biweekly) storage of the meter is fairly simple. The most important thing to remember with short term storage is to make sure the probes stay moist **without** immersing them in liquid. The sonde will be stored (short term) with all the probes and the protective cover installed. Pour approximately 1/2 inch of water into the flow cell and insert the sonde. Make sure that the probes are not immersed in the water during storage. A water soaked sponge may be used on the bottom of the flow cell in place of the 1/2 inch of water. Seal the flow cell to reduce evaporation. Check the meter periodically to make sure that water is still present.

For long term storage (monthly or yearly) follow the guidelines below. Each probe has its own storage guidelines.

3.3.3 Conductivity

Calibration of the conductivity probe must be performed weekly.

3.3.3.1 Calibration

1. Fill a clean dry calibration cup with approximately 300 mL of conductivity standard.
1. Rinse the conductivity probe with a small amount of conductivity standard.
1. Immerse the probe end of the sonde into the solution. Gently rotate and/or move the sonde to dislodge any trapped air bubbles. The probe must be completely immersed in the solution past the vent hole.
1. Allow at least one minute for the temperature to equilibrate.
1. From the *Calibration Mode* menu, select *Conductivity* and then *SpCond.*
1. Enter the calibration value for the standard being used in mS/cm at 25^{o}C and press enter.
1. Observe the readings under the Specific Conductivity (SpC), Conductivity (CND), and Temperature (TMP). When they show no significant change for approximately 30 seconds press <Y>. If the calibration value is accepted, press any key to return to the *Calibration Mode* menu.
1. Rinse the sonde in tap water and dry with a paper or cotton towel.

Note: The calibration standard values on the bottles are listed in uS/cm and must be converted to mS/cm. To convert uS/cm to mS/cm, divide the uS/cm value by 1000. As a rule, GWMAP uses conductivity standard of 1000 uS/cm, therefore the conversion to mS/cm is 1.000.

Warning: Calibration reagents may be hazardous to your health. Refer to Appendix A of the YSI 600 Manual for health and safety information.

3.3.3.2 Maintenance

The opening to the conductivity electrodes must be cleaned weekly. The small brush included with the maintenance kit is ideal for this purpose. Dip the brush in clean water and insert into the opening 15 to 20 times. If deposits are still noticeable in the opening, a mild detergent may be used with the brush to remove. After cleaning, calibrate the sensor using the method described above.

3.3.3.3 Storage

No special precautions are needed. The probe may be stored wet or dry; however do not store the probe in a corrosive solution. Also, the probe should be thoroughly cleaned prior to long term storage. The probe may be stored while installed to the sonde.

3.3.4 Dissolved Oxygen

Calibration on the DO probe should be conducted weekly.

3.3.4.1 Calibration

Inspect the probe's membrane for tears, wrinkles or air bubbles. If any are present replace the membrane and KCl solution before calibration.

1. Place approximately 1/8" of water or a wet sponge in the bottom of the flow cell.
1. Place the sonde into the flow cell. Make sure the DO and the temperature probes are not immersed in the water
1. Wait approximately 10 minutes for the air in the flow cell to become water saturated and for the temperature and DO probes to equilibrate.
1. From the *Calibration Mode* menu, select *Dissolved Oxy* and then *DO%* to access the calibration procedure.
2. Enter in the current barometric pressure in mm of Hg (to convert inches of Hg to mm of Hg, multiply the inches of Hg value by 25.4). The Air Quality Division has a barometer in the lab in the basement that has both inches and mm of Hg scales.

3. Observe the readings for percent dissolved oxygen (DO%) and Temperature (TMP). When they stabilize, press <Y> and press any key to return to the *Calibration Mode* menu.
4. Rinse the sonde in water and dry it using paper or cotton towels.

3.3.4.2 Maintenance

Inspect the membrane for visible air bubbles, wrinkle or tears. Replace the membrane and KCl solution prior to calibration and use. Inspect the electrodes for build up of dried electrolytes and/or other tarnishing. If observed, recondition the electrode using the sanding disks provided in the maintenance kit following the procedures below:

1. Dry the probe tip completely with lens cleaning tissue.
2. Hold the probe in a vertical position, place one of the sanding disks under your thumb and stroke the probe face in a direction parallel to the gold electrode (stroking in a direction NOT parallel to the electrode may severely damage the probe). 10 to 15 strokes should be enough to clean the probe.
3. After sanding, repeatedly rinse the probe's face with clean water and wipe with lens cleaning tissue to remove any grit left behind.
4. After cleaning, thoroughly rinse the entire tip of the probe with distilled or deionized water and install a new membrane.

3.3.4.3 Storage

The rapid pulse DO sensor should always be stored with a membrane and electrolyte in place. For long term storage, the probe should be immersed in water. Remove the pH/ORP probe from the sonde(see below for pH/ORP storage) and place a plug in the sonde port. Do not remove the DO probe from the sonde. Fill the flow cell with water and insert the sonde into the flow cell. The conductivity/temperature probe may be left installed on the sonde. Make sure the water level is high enough to completely cover the DO sensor. Make sure the flow cell is sealed to prevent evaporation and check the water level periodically. At the end of storage and before use, replace the membrane and electrolyte.

3.3.5 pH

Calibration of the pH probe should be conducted weekly.

3.3.5.1 Calibration

1. Place approximately 200 mL of pH 7 buffer in a clean dry calibration cup and immerse the sonde into the solution. (Be sure there is enough calibration solution to completely cover the pH and temperature probes).
2. Allow at least 1 minute for the temperature to equilibrate
3. From the *Calibration Mode* menu select *ISE1 pH.* Select *3 point* to perform a three point calibration. Enter in the pH value for the buffer of the first point of the calibration process (pH 7).
4. Observe the temperature (TMP) and pH readings; when they stabilize, press <Y> and then any key to view the calibration value and press enter to proceed.
5. Rinse the sonde in water and dry before proceeding to the second point of the calibration procedure.
6. Place approximately 200 mL of pH 10 buffer in a clean dry calibration cup and immerse the sonde into the solution. (Be sure there is enough calibration solution to completely cover the pH and temperature probes).
7. Allow at least 1 minute for the temperature to equilibrate
8. Enter in the pH value for the buffer of the second point of the calibration process (pH 10).

9. Observe the temperature (TMP) and pH readings, when they stabilize press <Y> and then any key to view the calibration value and enter to proceed.
10. Rinse the sonde in water and dry before proceeding to the third point of the calibration procedure.
11. Place approximately 200 mL of pH 4 buffer in a clean dry calibration cup and immerse the sonde into the solution. (Be sure there is enough calibration solution to completely cover the pH and temperature probes).
12. Allow at least 1 minute for the temperature to equilibrate
13. Enter in the pH value for the buffer of the third point of the calibration process (pH 4).
14. Observe the temperature (TMP) and pH readings; when they stabilize, press <Y> and then any key to view the calibration value, then press <Esc> twice to return to the *Main* menu.
15. Rinse the sonde in water and dry before proceeding to the second point of the calibration procedure.

** Warning: Calibration reagents may be hazardous to your health. Refer to Appendix A of the YSI 600 Manual for health and safety information.*

3.3.5.2 Maintenance

Inspect the probe for any foreign material. Pay particular attention to the glass bulb on the end of the probe. Cleaning is required whenever deposits or contaminants appear on the glass probe. Follow the guidelines below for cleaning.

1. Remove probe from the sonde.
2. Using clean water and a clean cloth, remove all foreign material.
3. Carefully remove any material which may be blocking the circular reference electrode junction of the sensor.
4. Dry the probe port and probe connection with compressed air and apply a very thin coat of O-ring lubricant before re-installing.

3.3.5.3 Storage

Remove the pH/ORP probe from the sonde and place a plug into the vacant port. Place the probe into the storage vessel filled with 2 molar KCl solution. Make sure the vessel is sealed to prevent evaporation and check the solution level periodically.

Make sure the reference electrode does not dry out. If the electrode does happen to dry out, it can be rehydrated by soaking it in 2 molar KCl solution for 12 to 24 hours.

** Warning: DO NOT store the pH/ORP probe in distilled or deionized water.*

3.3.6 ORP

The ORP sensor does not need to be calibrated weekly. A periodic (monthly) check is all that is needed. A weekly check can be performed if needed. However the calibration solution for ORP (Zobells Solution) is extremely toxic and the less we need to use, the better.

3.3.6.1 Calibration

1. Place approximately 200 mL of Zobells Solution buffer in a clean dry calibration cup and immerse the sonde into the solution. (Be sure there is enough calibration solution to completely cover the pH and temperature probes).
2. Allow at least 1 minute for the temperature to equilibrate
3. From the *Calibration Mode* menu select *ISE2 ORP*. Enter in the ORP value for the solution and press enter.

4. Observe the temperature (TMP) and pH readings; when they stabilize, press <Y> and then enter to view the calibration value and press enter to proceed.
5. Rinse the sonde in water and dry.

** Warning: Calibration reagents may be hazardous to your health. Refer to Appendix A of the YSI 600 Manual for health and safety information.*

3.3.6.2 Maintenance and Storage

Follow the guidelines for cleaning and storage detailed above in the section 3.3.5.2 *pH Maintenance* and section 3.3.5.3 *pH Storage*.

3.3.7 Pressure Transducer

The YSI 600XL is equipped with a pressure transducer for measuring water level. The transducer is vented to the atmosphere, therefore changes in atmosphere pressure do not effect the readings. The transducer must be calibrated before each deployment to ensure it's accuracy.

When using the vented level option of the YSI 600, it is important that the vent tube (which run through the middle of the field cable) is open to the atmosphere and free of obstructions. At the open end of the vent tube, a desiccant system must be installed. This system is designed to keep moisture from entering the vent tube and causing an obstruct.

3.3.7.1 Calibration

The transducer is calibrated in the factory, but needs to be zeroed. This procedure, while called calibration, is actually used only to zero the instrument. Before performing this procedure, make sure the sonde is not submerged. The instrument is zeroed to the atmospheric pressure. Dissolved oxygen readings are also temperature dependent. The DO readings are automatically temperature compensated during the calibration procedures and during operation.

1. Select the *Pressure-abs* option under the Calibrate menu.
2. Enter "0.00" at the prompt. Press *Enter* and monitor the stabilization of the readings.
3. After no changes occur for approximately 30 seconds, press *Enter* to confirm the calibration.
4. Press Enter again to return to the Calibrate menu.

3.3.7.2 Storage and Maintenance

When storing the sonde and field cables for long periods of time the sonde and the cable must be disconnected. It is important that the vent tube, on the sonde and the cable remains capped. This will prevent moisture from entering the system. Yellow, plastic caps are included with the YSI for this purpose.

For short periods of storage, the cable and the sonde may stay connected. However, the vent tube still must be capped or a desiccant system must be installed. During storage of the field cables, be careful not to bend them too sharply. Overly bending the cable may cause the vent tube to kink.

No additional maintenance is required for the pressure transducer.

3.4 Flow Cell Maintenance

The following procedure should be used for cleaning of the flow cell.

1. Remove the sonde from the flow cell.
2. Disassemble the cell and clean all parts with a mild detergent. DO NOT use harsh solvents to clean the flow cell.

3. Inspect the O-rings and the O-ring seats for damage that may prevent sealing. Replace them as needed. Reassemble the flow cell.

3.5 Power Supply

3.5.1 Batteries

3.5.1.1 Internal Battery (In the Monitor)

An internal Nickel Metal Hydride (NiMH) battery pack powers the monitor and the sonde. When fully charged, this supply is sufficient to run the meter and sonde for 6 to 8 continuous hours. The following are a few facts particular to the NiMH batteries:

- The NiMH batteries do not have a memory effect. This means that the batteries can be recharged without being fully discharged.
- NiMH batteries do not hold their full charge when stored. They need to be charged fully within a day before use.
- Special care needs to be taken to avoid overcharging the batteries. They should never be hooked up to the charger for more than 48 hours.

3.5.1.2 Internal Battery (In the Sonde)

In the YSI 600LM, the sonde contains its own internal battery source. This battery is source is in the form of four AA alkaline batteries. These batteries are field replaceable and can provide weeks of operation during deployment.

> *Note: The life of the 4 alkaline batteries is dependent upon the configuration and programming of the YSI during the deployment.*

3.5.1.3 Auxiliary Battery Pack

This pack contains eight D-cell disposable alkaline batteries. This should provide an additional 8 continuous hours of operation.

3.5.1.4 Power Pack

An additional power pack is available for remote deployment. This is a rechargeable lead acid battery. This should be able to power the monitor and sonde for 6 to 9 months.

3.5.2 Charging Power Supplies

Basic 110 volt adapters are available to recharge both the NiMH internal battery and the Power Packs. In addition, a vehicle cigarette lighter adapter is available to run the meter and recharge the internal batteries.

The NiMH internal battery will discharge during storage. It is important to recharge this battery within one day before use. Twenty-four (24) hours is needed to fully charge the battery. Never have the charger hooked up to the battery for more than 48 hours. Always remember to take the auxiliary battery pack, charger and cigarette lighter adapter when traveling and sampling overnight.

The Power Packs for remote deployment will discharge during long term storage. They need to be recharged every 2 to 3 months for 24 hours whether or not they have been used. Charge the batteries before and after each use. Always store the battery with a full charge. Never charge the batteries for more than 48 hours.

Always store batteries in a cool, dry place. Disconnect the battery from the equipment needing the power.

3.6 Applications

3.6.1 Surface Measurements with Flow Cell

Follow the procedures outlined in Section 5.5.4 *(Equipment Setup)* for domestic wells of this manual.

3.6.2 Down-Hole Measurements

The following guidelines are to be used with monitoring wells where access to down-hole readings are available.

1. Remove the sonde from the flow cell and lower it into the well. DO NOT remove the protective guard or the stainless steel weight. Lower the meter to the bottom of the well.
2. Wait a few minutes for the sensors to equilibrate. Once readings begin to stabilize, begin recording measurements in one to three minute intervals. Record a minimum of three measurements.
3. Remove the sonde from the well and place back into the flow cell.

3.6.3 Surface Water

Field parameters for surface water can be recorded using the YSI 600. Remove the sonde from the flow cell. DO NOT remove the protective guard or the stainless steel weight on the end of the sonde. Allow the sonde to be suspended in the water. Measurement at different depths can be attained by lowering or raising the sonde throughout the water column. Record readings in approximately three minute intervals. Record as many readings as needed to satisfied the objectives of the monitoring. Monitoring can be done from an overpass or bridge if you have a long enough cable to reach the water.

3.6.4 Remote Deployment

For remote deployment, the YSI 600 needs to be programmed. This program is specific to the objectives of the deployment. Each time the meter is deployed a new program will have to be discussed and written. For this reason, procedures regarding deployment will not be discussed in this manual. Refer to the YSI 600 operators manual for further information regarding programming.

4. PRE-SAMPLING PROCEDURES

4.1 Preserving Bottles

The cation, anion and TOC/DOC bottles are preserved before leaving for a sampling trip, generally in sets of 24 (depending on number needed). VOC sample bottles ***CANNOT*** be preserved at this time. They must be preserved at the time of sampling. To preserve the sample bottles, use the disposable pipettes and drop the proper amount of acid into the appropriate labeled bottle. Use a separate disposable pipette for each type of acid.

1. Estimate the amount of acid needed for the number of bottles to be preserved and pour it into a new pre-marked, color coded, 125 mL preserving bottle (this is to reduce the amount of acid wasted and prevent contamination of the acid supply).
1. Apply the bar coded labels to the appropriate bottles. The labels must be applied to the bottles in the vertical direction, on the opposite side of the bottle from the bottle batch label (the data logger scanner cannot read the bar code around the curved surfaces of the bottles).
1. Using a new disposable pipette, drop the appropriate amount of acid into each bottle (2 pipettes of HNO_3 for cations, 2 pipettes of H_2SO_4 for anions, and 8 drops H_2PO_4 for TOC). Use a different pipette for each acid (this prevents cross contamination of the acids). Replace the caps on the bottles immediately after adding the acid.
1. After the bottles are preserved, place the cation and anion bottles back into their boxes and the TOCs into the TOC tray. Mark the boxes as preserved and place on the designated shelf.
1. Preserve the acid blank with the appropriate amount of cation acid (2 pipettes of HNO_3). See procedure below for preparing the acid blank.
1. Discard preserving supplies (125 mL preserving bottles and excess acid and the pipettes) after completing the acid blank. Rinse the 125 mL preserving bottles with water to dilute the acids and pour down the drain.
1. Apply the appropriate bar coded labels to the general chemistry and tritium bottles. VOCs bottles need to be labeled in the field.

Note: Only transfer acids into bottles that have been labeled with the correct color code and / or labels. Cation preserving acid (HNO_3) is color coded red and anion preserving acid (H_2SO_4) is color coded blue. Cross contamination of preserving acids results in the loss of data!

Bottle preservation needs to be done in conjunction with an acid blank (see Section 8.2.1 *Acid Blank* for this procedure).

4.2 Equipment Check Out

Vehicles and all equipment must be checked out before leaving. Mileage and general maintenance must be logged on a daily basis. Check all equipment to ensure it is in proper working condition. Keep equipment grouped in assigned sets. If there is a problem with one set and a substitute is needed, write it down in the equipment maintenance log. Verify that the sample bottles are preserved and take enough bottles to complete the sampling trip. Take extra bottles along in case some become contaminated. Make sure the VOC set has a trip blank with it and always carry all

the VOCs in a set together. Double check the equipment lists to ensure no equipment is left behind.

At the start of each new sampling day, the first time you turn on the data logger it will ask you to enter in the identification number for the equipment you will be using on that day. To enter the numbers, use the scanner to read the bar codes for the YSI 600XL monitor and the GPS. Also, enter the names of the people who will be sampling that day. The data logger will also request you to enter in the project identification. If you are using a new set of VOCs, label the trip blank with a VOC bar coded label and scan it into the data logger. This function is in the Utilities command under VOC Trip Blank. When scanning in a new set of VOC trip blanks, make sure the start date for the set is the same as that on the trip blank labels.

4.3 Alkalinity Standard Preparation

The alkalinity standards that are used as comparisons for the alkalinity titration deteriorate with time and exposure to light. Therefore, they need to be replaced at least weekly. To prepare the standards follow the instructions below:

1. Pour out the old standards and wash. Triple rinse with DI water and shake out excess.
2. Add one BG-MR pillow to the Erlenmeyer flask.
3. Triple rinse the volumetric flask with DI water and measure out exactly 100 mL of DI water.
4. Pour the DI water into the Erlenmeyer flask, rinsing the sides of the flask.
5. Take one pillow of pre-measured acid (either pH 4.5 or 4.8) and pour into the Erlenmeyer flask (the solution will turn a pink color).
6. Repeat the process with the other pre-measured pH standard pillow (either pH 4.5 or 4.8, whichever one that was not used in the first time).

When titrating, titrate to a point where the sample water is a shade of pink which is between the shades of the two color standards.

5. PROTOCOLS

These procedures outline below assume that there are at least two people in the field: the Recorder and the Operator. The Recorder's primary responsibilities include; the operation of the data logger, completion of any necessary field forms and entries into the field book, ensuring that the well is stabilized prior to sample collection, and that all samples are collected in properly labeled and preserved bottles. The Operator's primary responsibilities are to set up the equipment, ensure that the equipment is functioning properly, observe all measurements, collect samples and pack up the equipment. Field work is a team effort. It is important to be as efficient as possible without compromising accuracy.

5.1 Field Notes

The field notes are to be used as a supplement to the data logger. The data logger is limited in its ability to enter and store descriptive data. Completion of the field notes is important. The information contained on the field notes is valuable for data interpretation and with identifying locations for re-sampling. For example, if a sample comes back from the lab with a high nitrate concentration, we can go back to the field notes and see if a feedlot or septic system was near the well head which could explain the high nitrate reading.

5.1.1 Field Forms

Field forms are used for one-time samples taken for a project like the baseline (see Appendix I for a copy of Calling Checklist and Field Form). Take notes on the field form about any information concerning the well and the sampling procedure. Make a simple sketch of the site in the box provided showing access road, major buildings, well head (**X**), and sampling point (●). Indicate where the sampling point is and its distance from the well. Make any additional notes about the plumbing materials and sampling area that can be obtained. Also, note any information about the water quality that can be obtained from observation or from the well owner (examples: owner might refer to some previous testing, or state that they had an iron bacteria problem, or the water may look or smell unusual).

While on-site, be observant. Learn to recognize chlorinators, filters, or softeners. Look for and ask about possible contamination sources, i.e., fuel tanks, septic systems or feedlots that are close to the well. Make detailed notes on the field form, if possible indicates the location of contamination sources on a site map.

5.1.2 Field Books

Field books are similar to the field forms, except the field book is used for a project with repeat sampling of the same well or group of wells. This book documents the data collection events for the entire project. Deviations from the standard protocols, detailed weather conditions, changes in site conditions, and geologic investigations must be included in the field book.

Below is a suggested format. This represents the minimum amount of information that should be recorded within the field book.

Date: 2/19/98 **Event**: *Sampling* **Time**: 1:45
Identification Number: *987541* **Samplers:** JS, EE **Name**: *Odonnel*
Weather Condition: *warm and sunny*
Water Level: *13ft*
Site Information/Land Use: unsewered area with corn field 500 ft to north

Sampling Procedure: *bailed, appx. 5 gals of water and sampled*

Sample Bottles Collected:	**Bottle ID:**	**Dup ID:**
bacteria	*3589*	*3658*
cation (filtered)	*3569*	*6587*
anion	*6987*	*5844*

Field Kit Readings:

NO_3	*5*	**Cl**	*10*
Mn	*24*	**NH_4**	*12*
Fe^{+2}	*NA*	**CO_2**	*10*
H_2S	*NA*	**SO_4**	*55*
Alkalinity	*357 / 360 / 358*		

Comments:

bottle top filter used to filter cation
field readings collected down hole after sampling
water was extremely turbid but cleared up during purge

Note: Field books will be used for drilling/probing operations and a similar format is used as the one above. The only difference is that soil samples may be collected in addition to water samples and more well information will be documented.

5.2 Global Positioning System (GPS) Operation

GWMAP takes a GPS reading from every point in which a sample is collected. When taking the GPS reading, it is important to set the receiver directly over the monitoring point. If this is not possible, stay as close to the monitoring point as possible and make a note on the field form and in the field book indicating where you took the reading and the approximate distance from the exact location.

1. Turn dial to STS and scroll to "record / rover" screen. Click on "start". Verify that the number of points is increasing. This may take some time depending on the location.
2. While the GPS is recording points, go back and take the discharge reading (see previous section "Well Purging").
3. Record the file number from the upper right hand corner of the screen into the data logger under the field "file name".
4. Allow the points to reach at least one hundred (100), then click stop.
5. Turn dial to POS and enter the latitude, longitude and mean sea level into the data logger.
6. Turn dial to OFF.

Note: The file name on the GPS will appear in the upper right hand corner of the GPS screen. When the GPS is turned on, the file name will begin with a letter followed by a series of six numbers followed by the letter "A". Once the GPS is stopped, the file name will change; the first letter and the series of numbers will remain the same but the last letter will change from an "A" to a "B".

5.3 Data Logger Operation

In order to expedite sample collection, tracking and shipping, GWMAP has incorporated a data logger into its protocol. The data logger is designed to quickly guide the user through the protocols while minimizing the potential for errors. The design allows entering of the necessary

field data, while in the field. When returning to office, this data can be down-loaded to a PC eliminating the need for data entry.

The data logger is programmed with the protocol for each of the operations GWMAP performs: domestic well sampling, monitoring wells sampling, surface water sampling and drilling (soil and temporary well sampling). At the start of a day of field work, the appropriate protocol is selected along with the project a team is working on..

5.4 Well Purging

Wells must be purged prior to sampling to remove stagnant water that may accumulate. A total of three well volumes must be purged and stabilization readings taken to ensure fresh aquifer water is collected (see below to calculate well volumes and stabilization criteria).

5.4.1 Well Volume Calculation

Calculating the volume of water in well is important in determining the purge time. Three things must be known about the well in order to make this calculation: water level, well depth, and well diameter. The length of the water column must be multiplied by the area of the well. Since most wells are circular, the area of a circle must be calculated using (Pi) r^2. This gives the volume of water contained within the well casing or one well volume. Appendix III (*Well Casing Volume Conversions)* contains a chart with this calculation complete for common well diameters. This calculation has been automated with the data logger. The sampler must enter the water level, well diameter and well depth and the data logger will calculate the well volume.

5.4.2 Stability Readings

Stability is determined after the removal of three well volumes and by a minimum of three measurements taken at regular intervals that meet the following criteria.

Temperature	+/- 0.1 degree C
pH	+/- 0.1 STD unit
Specific Conductance	+/- 5%

Although DO and Redox are not criteria for stabilization they can be useful indicators of stability. If it appears that the DO reading is not yet stable, take a few more minutes to allow the DO meter to produce a more accurate reading. Also, if the redox measurement is fluctuating by more than 5 mV the well should be continued to be purged. If these measurements will not stabilize, examine, clean and/or recalibrate the probes (see Section 3 *YSI 600 Operations* for these procedures).

> *Note: The DO probe requires a 40 second warm-up period after being turned on. During this 40 second period the DO reading will continue to change.*

5.4.3 No Purge Situations

Listed below are some situations where deviation from the standard protocol is acceptable. These are considered no purge situations. They are based on information obtained on the installation and operation of pressure tanks, and an article by Robin and Gillham, *Field Evaluation of Well Purging Procedures* (Ground Water Monitoring Review, Fall 1987).

At production wells that are continually pumping and where the sampling point is before the pressure tank, such as at an outside hydrant. Example: livestock wells on sizable farms where animals are continuously being watered from the well being sampled.

Wells with a pump in the open interval of an unscreened well (see well log) and sampling point is before pressure tank. According to code, the pump should not be placed below casing, but this practice is common, especially on ridges in hilly areas (e.g., southeast Minnesota).

If the well is screened across the water table (see the well log) no stagnant water should be present.

If you are at a site that meets the above criteria for not purging, please let all probes be in contact with the water in an active flow-cell for at least five minutes before taking any readings. The well needs to be stabilized before samples are collected from the well. Also, it is still necessary to take a discharge rate at these sites.

> *Note: If the well is a low yielding aquifer, be careful not to dewater the well. Watch the dissolved oxygen reading; if it increases rapidly the well may be beginning to dewater.*

5.5 Domestic Wells

5.5.1 Well Owner Introduction

Upon arrival at a site, introduce yourselves to the resident or well owner. Verify that you are at the correct site. Provide them with a business card, State Identification Card, and brochure and answer any questions they might have. Let them know that you are going to be on-site long enough to purge the well (estimate an approximate time, 30 to 60 minutes, usually). Verify that the sampling point selected is the closest, untreated source to the well head.

Gather any information about the well. Ask if they have had any problem with the well, has the well been tested before and if so, what where the results. Much of this information can and should be gathered during the phone conversation prior to arriving on site.

5.5.2 Sample Point Selection

Ideally the sampling point should be an outside faucet, as close to the well head as possible. This point must not be treated in any way by filters, chlorinators or water softeners (most outside faucets by-pass these systems). If these systems are in place, see if they can be by-passed or turned off for 72 hours prior to sampling. If they can not, we will need to select a new sampling point or not collect the sample from this residence. Again, much of this information should be gathered during the phone conversation prior to arriving on site.

5.5.3 Water Level

For several of GWMAP's studies, water levels need to be obtained from domestic wells. This process tends to be more problematic with the pitless adapters, pumps, plumbing and electrical wiring installed in these wells.

1. Before taking the water level make sure the pump in not running. A steel tape works best for this application. Most electronic water level indicator's probes are too large to get by the pitless adapters. It is also helpful to review the driller well log to get an approximate depth to water prior to taking the actual water level.
2. Remove the well cap and begin to lower the end of the tape into the well.
3. Using chalk, mark the tape as you lower it into the well. Mark approximately the first 10 feet of the tape with the chalk.
4. Continue to lower the tape into the well until the tip of the tape is approximately 5 feet below the suspected water level.

5. Note the total depth that you lowered the tape. Pull the tape back up the well and look at the chalk mark. The chalk should be washed off to the level of the water.
6. Subtract the number that the chalked washed off from the total depth the tape was lowered. This is the depth to water measurement. For instance, the tape was lowered to 30 feet, the chalk was washed of the tape to a level of 6 feet. Therefore the water level is 24 feet below the top of the casing. To get the measurement from ground surface, subtract off the casing stickup from the water level.
7. Decontaminate the water level tape. See Section 8.1 *(Field Decontamination) Procedures* for the process. Use bleach as the cleaning solution.

Note: The pitless adapter is usually located 4 to 8 feet below the surface. The tape may get stopped at this point. If this happens, bounce the tape up and down looking for a slot for the tape to fall through. If one cannot be found do not attempt to force it, water levels cannot be obtained from some domestic wells.

5.5.4 Equipment Setup

1. After selecting the sampling point, the equipment is ready to be setup. Remove any hoses and/or attachments from the faucet (these attachments may cause aeration or contamination that may interfere with the sample).
2. Take the extension hose and connect it the faucet.
3. Attach the discharge hose to the quick connect at the Y-connector, and make sure the valve to that side of the Y is fully open.
4. Attach the YSI flow cell to the other side of the Y-connection using the 3/8 inch nalgene tubing. The valve on this side of the Y should be fully closed at this point (the discharge should be taken at this point).
5. After the discharge is taken, the valve on the Y-connector leading to the YSI flow cell can be open. Approximately 1 gallon per minute of water should be flowing through the flow cell.
6. Allow the probes to equilibrate prior to taking stabilization readings.

5.6 Monitoring Wells

5.6.1 Water Level

Water levels are taken before sampling to calculate well volume and to determine purge time and/or volume. Water levels on monitoring wells are taken using a electronic water level indicator. Water level readings are recorded to the nearest tenth of a foot.

1. Upon arrival on site, open the well protective casing and the well itself. If the well has a continuous water recorder installed, remove it from the well and allow the well to recover to its static water level (approximately five minutes).
2. Test the water level indicator to ensure the instrument is functioning properly. Lower the probe down the well until the water column is reached (a “beep” will be heard and the light will be lit).
3. Take a water level measurement. (If a piece of equipment was removed from the well, take water level readings in 30 second intervals until three consecutive readings show no change in water level). Readings are always taken from the top of the highest stickup. It may be necessary to lay something across the protective casing to get an accurate reading.

5.6.2 Sampling with a Bailer

Some monitoring wells do not recover rapidly enough to allow them to be sampled with a pump. In these situations, bailers are used to conduct sampling operations. Bailers can be a very effective sampling tool with the proper technique. The largest alteration of sensitive parameters occurs due to lack of proper technique. The sampler must be very cautious to minimize turbulence and aeration and to keep the bailer and bailer line clean. Both the bailer and the bailer line should never be touched without a gloved hand and they should never be allowed to touch the ground. Also, when lowering and raising the bailer in and out of the water column, do it slowly to minimize the amount of turbulence.

5.6.3 Sampling with a Pump

GWMAP utilizes several styles of pumps during its operations. Each pump has advantages and limitations for GWMAP's given applications. For more information regarding the advantages and limitations of a given pump see Section 4.2 *(Advance Preparation for Sampling)* in the "Minnesota Pollution Control Agency Ground Water Sampling Guidance" (MPCA 1995). GWMAP uses two styles of pumps: peristaltic suction lift (Masterflex) and helical rotor electric (Keck and Whales).

5.6.3.1 Peristaltic

Peristaltic pumps create a suction that draws the water up through a tube. GWMAP utilizes this type of pump primarily with geoprobe sampling. Peristaltic pumps can only lift water from approximately 25ft deep. This limits it's ability to sample many deeper monitoring wells. Peristaltic pumps have variable flow rates to control flow. Depending on the model these pumps can be powered by an interval or external 12 volt battery. Special adapters allow the pump to be plugged into vehicle cigarette lighter. The major disadvantage of the peristaltic pump is that the suction causes pressure differentially that tends to cause gases to come out of solution. This is primarily a concern with VOC samples.

The following process is used to minimize the loss of VOC's by preventing the VOC's sample water from coming into contact with the pumping mechanism that causes the pressure differentially.

When sampling for VOC's with a peristaltic pump:

1. Turn the pump on to pull water up through the tubing.
2. When the tubing is full up to the pump head, stop the pump.
3. Pull the tubing from the well (be careful to not let the tubing come into contact with the ground).
4. Reverse the flow of the pump to discharge the water out the down-hole end of the tubing. Fill the VOC vials at this point.

Since no part of the pump comes into contact with the sample water, decontamination of the pump is not necessary. However, all the tubing utilized is replaceable and is replaced at each sampling location.

5.6.3.2 Keck

The Keck is GWMAP's primary purging and sampling pump. It is used for most monitoring well sampling applications. It features a 1.5 inch pump head for insertion down two inch monitoring wells, a variable flow rate and an internal 12 volt battery. The pump can also be powered by an external 12 volt battery source. The internal battery is rechargeable and has the capacity of approximately six hours of continuous operation on a single charge. Flow rate can be controlled anywhere from 4 to 0.1 L per minute.

The Kecks tend be cumbersome and do not pump extremely turbid water very well. They also can be a little harder to decontaminate than some other pumps. They also have a tendency to start hard at the beginning of the day. In order to overcome this problem, cooling the pump head with ice will loosen the pumping mechanism and allow it to start easier.

5.6.3.3 Whales

The whales pump is most commonly used for developing wells. The flow rate cannot be controlled, therefore GWMAP does not use this pump for sampling. The whales is relatively inexpensive and extremely durable. It will pump extremely turbid water and requires very little maintenance. The pump is powered by a external 12 volt battery. It is extremely portable and easy to use. The pump is inserted down a well and connected to the battery. Rigid tubing is used as the discharge line which allows the pump be to surged through the water column for well developing.

5.6.4 Down Hole Readings

Water quality measurements are collected during each sampling event. If a well is pumped, field readings are collected during the purge to determine stability. The purge water is directed through a flow cell for measurement of these readings. The YSI 600 series of equipment allows GWMAP to collect additional water quality information in-situ. After samples are collected from a monitoring well, a YSI 600 is lowered into the well and readings are recorded. A minimum of three readings at one to three minute intervals are collected. These readings are collected at all monitoring wells which allow access. Down hole readings are not collected from wells with pumps permanently installed in them (i.e. domestic wells)

Note: The YSI must be thoroughly decontaminated between monitoring wells to prevent cross contamination from well to well.

5.7 Surface Water

For several of GWMAP's studies, surface water samples are collected. Whenever possible, surface water is collected from a bridge overpass. This method involves using a surface water *Kemmerer* bailer.

1. The YSI 600 and bailer are lowered over the side bridge to a point where they are approximately one third of the way through the water column (i.e. if water depth is a total of six feet, samples should be collected from approximately two feet below the surface). Field readings and samples are collected simultaneously.
2. To close the bailer, send the messenger down the retrieval line and it closes the bailer.
3. The bailer is retrieved and emptied into the sample bottles using the discharge valve equipped on the bailer.
4. If additional bottles need to be filled, repeat steps 1-3. The YSI should remain lowered into the water body during the bottle filling process and removed when the collection process is ended.

Note: The YSI must be thoroughly decontaminated, using 10% bleach solution, before it is lowered into a monitoring well. The bleach will kill any bacteria and/or algae that may have been picked up from the surface water.

Note: A minimum of three field readings should be collected.

If the sampling point can not be accessed from a bridge overpass, the sampler has two other options depending on the situation. The first option is to wade into the water and the second is to use a boat. On small / shallow rivers wading is suggested.

1. Put on a pair of waders and an approved life vest.
2. Take the YSI 600 and bottles and wade into the water until you reach the sampling location.
3. Suspend the YSI sonde in the water at the depth the samples are to be collected. Have your partner record the information from the shore. Collect a minimum of three readings at approximately one minute intervals.
4. After readings are collected, bottles can be filled. With the cap on the bottle, lower the bottle into the water column to the level the samples are to be collected. Open the bottle, underwater, and allow the bottle to fill itself. Once the bottle is filled, cap the bottle, underwater, and return to the surface.

Note: This method is not recommended for bottles that are preserved (i.e. cation and anions, TOC, and DOC). To fill these bottles use a clean one liter bottle and collect the water using the steps above. Then transfer the water for the one liter bottle to the sample bottles.

Note: VOCs may be sampled following the steps above. However, do not preserve the samples and have them analyzed within seven days. If the samples cannot be analyzed within the seven days, use the transfer method and preserve the samples prior to filling. Document the method used in the field notes.

If the surface water to be sampled is a larger or deeper river or lake, a boat is recommended. Follow the same basic steps as outlined in the bridge overpass procedures. Remember to obey all Minnesota boating laws and regulations.

5.8 Well and "Geoprobe" Procedures

5.8.1 Well Installation

All monitoring points installed will meet the requirements of the current Minnesota Department of Health (MDH) Well Code. All sites will be returned to their pre-existing state after drilling procedures. Landscaping efforts may be offered to property owner for well concealment after construction. These landscaping efforts shall not exceed a cost of $50 (unless extensive damage is caused during well installation).

5.8.1.1 Soil Sampling

During drilling and probing operations, soil samples may be collected for either textural (sieve) or chemical analysis.

5.8.1.1.1 Textural Analysis

Soils for textural analysis can be placed into a plastic baggy, labeled with the site name, date, and depth of sample. The baggy should contain a representative cross-section from the entire sample. If a distinct difference is noticed within the sample, the sample should be split into two separate samples.

GWMAP's primary interest in soil texture is the amount of sand in the sample. We perform all textural analysis in house using sieve analysis. Five sieves are utilized; 2 mm, 1 mm, 0.5 mm, 0.25 mm and 0.1 mm.

1. Dry the soil using a microwave. Put the microwave on the highest setting for approximately 10 minutes. Place a cup of water in the microwave with the soil.
2. Stack the sieves one on top of another, the largest size on top.
3. After the soil is dry, break up the soil peds and weigh out exactly 100 grams.
4. Place the 100 grams of soil in the top sieve and shake vigorously for 10 minutes.
5. After shaking, take each sieve, one by one, empty the contents onto a scale and weigh the amount. This number is the percent by weight for each of the five textual categories.

5.8.1.1.2 Chemical Analysis

There are two collection methods GWMAP uses for soils: the first is collection with a split spoon sampler (drilling) and the second is with a PVC liner (geoprobing). If the split spoon is being utilized, open the split spoon and place the contents into the sample container. If the entire sample is not to be collected, homogenize the soil over the entire sample depth. This provide a representative sample across the sample interval. The container must be labeled with the site name, date, bar coded label and depth. The soils are placed in a separate cooler with ice. A temperature of 4^{o}C should be maintained.

If the PVC liners is used, the method mentioned above may be used or the PVC can be capped and the liner acts as the sample container. The liner should be labeled the same as any other sample container.

5.8.2 Well Development

Well developing procedures will be performed upon completion of installation and as needed when wells show signs of turbid water. Developing procedures must be completed a minimum of two weeks before a sampling event.

5.8.3 Well Beautification

Well beautification procedures involve landscaping, painting and/or other things meant to conceal a well into its surroundings. These will be done with consultation and approval of the property owner. These procedures must be completed a minimum of two weeks before a sampling event. It is best if these procedures can be completed at the time of well installation.

5.8.4 Well Abandonment

For monitoring wells installed on private property, abandonment will occur upon the property owner's request. Well and geoprobe sealing will be conducted in accordance with the MDH Well Code.

Upon completion of the study, responsibility of monitoring wells will be offered to other monitoring programs (both local and state) for continuation of data collection. If no other program wishes to take complete responsibility for a well, that well will be properly abandoned according to the existing MDH Well Abandonment Code.

6. SAMPLE COLLECTION

6.1 Bottle Preparation

The first step in sample collection is bottle preparation. The general chemistry, cation, anion, DOC and TOC bottles are preserved and labeled before leaving on a sampling trip. All other sample bottles need to be prepared and labeled on site. Prior to sampling, label any additional bottles that need to be collected. Make sure all three VOC vials have the same numbered bar coded labels and the labels are placed on the bottle in the vertical direction. VOC BOTTLES DO NOT GET PRESERVED UNTIL THEY ARE READY TO BE FILLED. Gather all of the bottles and place them in the bottle tray with a set of sampling gloves and the VOC preservative (HCl). Take the tray to the sampling point for the Operator.

6.2 Filling the Bottles

After the well has been purged and stabilized, samples are ready to be collected. If the well is being pumped, remove the inlet hose from the YSI flow cell.. DO NOT turn off the water flow. Samples are collected from the inlet hose of the flow cell. If the well is being bailed, the samples are collected from the sampling nipple that comes with the bailer. Sampling gloves must be worn for sample collection.

Samples are collected in the following order:

- unfiltered; field kits, bacteria, general chemistry, anion, cation, TOC, any other unfiltered samples,
- filtered; field kits, cation, DOC any other filtered samples.

Note: Not all sample bottles listed above are collected at every well or for every project.

Bottles that are reused (field kit bottles), are triple rinsed with sample water prior to filling the bottles. Samples are collected with a slow, steady controlled flow, taking caution to not overfill the sample bottles that have preservatives, as this may overly dilute the preservative.

VOCs are the most sensitive of the parameters collected, therefore special techniques need to be applied to ensure the sample quality.

1. Remove the cap and add 2 drops of HCl preservative.
2. Tilt the vial and fill with water as if you were filling a beer mug (any aeration of the water at this point can cause the loss of volatiles).
3. Attain a positive meniscus and cap with no air bubbles. Invert the vial, tap gently on bottom of the vial and check for the appearance of air bubbles; if any appear, repeat sample collection until all three vials are filled without visible air bubbles (If air bubbles still appear after the second attempt, the bottle should be discarded and a new bottle filled).

Note: Preservative may also be added after filling the bottle. If preserving before, do not excessively overfill bottle, this will dilute the preservative.

Note: Never touch the inside of the any of the bottle caps, even with gloved fingers. If the cap is touched or dropped, do NOT use it. Replace it with a clean cap or use a new bottle. If you have filled the vehicle with gas, do not take VOC samples until you have

thoroughly washed your hands. Also, samplers cannot wear insect repellent, perfumes or colognes.

6.3 Duplicate Samples

A duplicate sample is collected every tenth sample The purpose of the duplicate is to test the ability of the lab to reproduce its analytical procedures. The duplicate is completely masked to the lab.

In order for a duplicate sample to be statistically valid, a homogeneous mixture of sample water is needed between the sample bottles and the duplicate bottles. In order to attain this homogeneous mixture, take both bottles (for example; the sample general chemistry bottle and the duplicate general chemistry bottle) fill one bottle half full, then the other bottle half full, then fill the first bottle three quarters full and then the second, then top both bottles off. Repeat this process for all the bottles that are to be duplicated. Due to their sensitive nature, VOC samples are duplicated in a slightly different way. Simply fill each bottle the same way as you would under normal circumstances, except you will fill the first sample vial and then the first duplicate vial and then the second sample vial and so on.

6.4 Sample Identification

After the samples are collected, the bottle identifications need to be entered into the data logger. Using the scanner, scan the bar code of the bottle into the appropriate field (the numbers can also be entered manually by typing in the numbers to verify the numbers). After entering in the code for each sample bottle, the data logger will require you to verify the numbers you entered. Here you must re-enter the bar code. This function was designed into the system to help eliminate the potential for transposing numbers.

After scanning the bottle codes, place the samples in a cooler with plenty of ice. The cooler's interior temperature should be at 4^{o}C. Check the temperature regularly. Make sure the bottles are secure and the caps are on tightly. Place the glass bottles in their trays and/or buffer with ice and plastic bottles to prevent breakage.

7. FIELD ANALYSIS

Hach field kits are utilized to assess chemical concentration in the field. They help delineate plumes, assess redox conditions and assist with placement of monitoring wells without the need to wait for results from the lab. The numbers from the field kits are always replicated with a laboratory sample. They are primarily used as a screening tool and not as the analytical data.

Some chemicals in these kits may be harmful to the user if inappropriately handled or accidentally misused. Please read all warnings on reagent labels and observe all precautionary instructions. Refer to the Material Safety Data Sheets (MSDS) supplied with your reagent for additional chemical information. Always wear eye protection when handling chemicals.

For emergency information, contact your physician or call the Rocky Mountain Poison and Drug center at 303-623-5716.

7.1 GeoChemical Indicators

7.1.1 Alkalinity

At the pH values typically encountered in Minnesota ground water, alkalinity is a measurement of the amount of bicarbonate in the water. It is used to classify the water type and as a geochemical indicator. An alkalinity titration is performed at every sample location (turbid water will interfere with the color change during the test, therefore some wells cannot be done). A Hach alkalinity kit with digital titrator is used to perform this field measurement. Three titrations must be done with the results having a maximum difference of no more than ten units.

1. Assemble titrator by placing a candy cane delivery tube on the end of the acid cartridge and inserting the acid cartridge into the titrator. Remove the air from acid delivery tube and test to see that the acid is being delivered at an appropriate and constant level. Zero the titrator.
2. Triple rinse both the Erlenmeyer and volumetric flasks with sample water. Shake out any excess water.
3. Add one BG-MR pillow to the Erlenmeyer flask.
4. Measure exactly 100 mL of sample water with the volumetric flask and pour it into an Erlenmeyer flask, rinsing down any BG-MR crystals that may be caught on the sides of the flask.
5. Titrate until color changes to pink. Titrate until the shade of the sample water is between the two color standards. Record the raw reading on titrator. Pour out the water and repeat the process two more times or until three readings are achieved with a maximum difference of 10 units.

Note: Use caution because acid can squirt out of the titrator and can burn skin and damage clothing. Safety goggles or glasses must be worn during titrations. Use the same flask for all titrations.

7.1.2 Chloride

Chloride is a good indicator of contamination and is used to track plumes and for the placement of monitoring wells. It is also useful at assess the geochemical condition of the water.

low range <160 mg/L Cl

1. Use low range cartridge.
2. Take a 25 mL sample and dilute it to 100 mL with deionized water.
3. Pour the sample into 125 mL Erlenmeyer flask and add the powder pillow.
4. Titrate to endpoint which is where yellow color just starts to turn pink.
5. The digital readout is in mg/L directly.

For high range cartridge:

expect Cl > 160 mg/L

multiple the digital readout by 10 = mg/L Cl

7.2 Reduction-Oxidation (Redox) Indicators

The redox condition of an aquifer is useful tool to assist with determining the fate of many chemicals within the aquifer. The following is a list of the redox parameters GWMAP uses and the methods for conducting each of the test. The parameters are in order with regard to the redox scale (from most to least oxidized).

When conducting the analysis, do the kits in the order listed below. Starting with nitrate, if high concentrations of nitrate are found, chance of finding the rest of the parameter is unlikely. If very low concentrations of nitrate are found, continue on with the manganese and iron tests. If no manganese or iron are detected, chances are that you will not detect the remainder of the redox chemicals. If manganese is detected continue on down the list in the same manner.

7.2.1 Dissolved Oxygen

The following method described is commonly known as the Azide Modification of the Winkler method. GWMAP rarely performs this titration due to our use of electronic DO probes. The titration is performed at times when the probes are not available. DO readings are used to assess the redox state of the water being sampled.

1-5 mg/L O_2

1. Collect the water sample in a clean 300mL BOD bottle
2. Add the contents of one Manganous Sulfate powder pillow and one Alkaline Iodide-Azide reagent powder pillow. Cap the bottle immediately with a stopper so that no air is trapped in the bottle and invert the bottle to mix.
3. An orange-brown floc precipitate will form if oxygen is present. Allow the floc in the solution to settle, then again invert several times and wait for the floc to settle (this ensures a complete reaction of the sample and reagents).
4. Remove the stopper and add the contents of one Sulfamic Acid powder pillow. Insert the stopper without trapping air and invert bottle several times to mix. (The floc will dissolve and leave a yellow color if oxygen is present).
5. Use a graduated cylinder to measure 200 mL of sample and transfer it to a 250 mL erlenmeyer flask.
6. Add 2 drops of Starch Indicator solution and swirl to mix.
7. Using the Hach digital titrator and 0.200 N $Na_2S_2O_3$ cartridge, titrate the sample to a colorless endpoint. Record the number of digits required.
8. Multiple the number of digits required by the digit multiplier of 0.01 to determine the amount of DO in mg/L.

Note: If the range of DO is expected to be greater than 5 mg/l, a different sample volume and chemicals may need to be used. Refer to the Hach Water Analysis Handbook for more information.

7.2.2 Nitrate

Nitrate is used as an indicator of contamination associated with a human imposed impact. It is also the primary chemical of concern in much of Minnesota's ground water supply. GWMAP primarily uses the field nitrate kit as a screening tool in plume tracking, and placement of monitoring wells. It is also used to assist in understanding the redox conditions of the aquifer of interest.

Pocket Colorimeter 0-30 mg/L NO_3-N

1. Fill a 10-mL cell to the 10-mL line with sample.
2. Add the contents of one NitraVER® 5 Reagent Powder Pillow to the cell (the prepared sample). Cap the cell.
3. Repeatedly invert the sample cell for one minute.
4. Set the cell down and wait 5 minutes.
5. Fill a 10-mL cell to the 10-mL line with sample (the blank).
6. Place the blank in the cell holder with the diamond mark facing the keypad.
7. Cover the sample cell with the instrument cap (flat side should face the back of the instrument). Be sure the cap fits tightly against the instrument.
8. Press: ZERO. The instrument will turn on and the display will show --- followed by 0.0.
9. Place the prepared sample in the cell holder with the diamond mark facing the keypad.
10. Cover the sample cell with the instrument cap (flat side should face the back of the instrument). Be sure the cap fits tightly against the instrument case.
11. Press: READ. The instrument will show "---" followed by the results in mg/L nitrate as nitrogen.

7.2.3 Manganese

Manganese is used to assist with assessing the redox state of the water.

0-0.7 mg/L Mn

1. Fill a clean 25 mL mixing bottle to the 25 mL mark with demineralized water. This is the reagent blank.
2. Fill the second 25 mL mixing bottle to the 25 mL mark with sample. This is the prepared sample.
3. Add the contents of one Ascorbic Acid Reagent Powder Pillow to each bottle. Swirl to dissolve. For samples containing high hardness (greater than 300 mg/L as $CaCO_3$), add 10 drops of Rochelle Salt solution (not included in kit).
4. Add 1.0 mL of Alkaline-Cyanide Reagent to each bottle. Swirl to mix (a turbidity may form, but will dissipate after step 5).
5. Using the 1 mL calibrated plastic dropper, dispense 1.0 mL of P.A.N. Indicator Solution, 0.1% to each bottle. Swirl to mix. An orange color will develop if manganese is present.
6. Allow the color to develop for a minimum period of 2 minutes (if the sample contains more that 5 mg/L of iron, allow 10 minutes).
7. Pour at least 5 mL of the prepared solutions into two clean viewing tubes.
8. Insert the tube of prepared sample into the right top opening of the color comparator.

9. Insert the glass sample tube containing the reagent blank into the left top opening of the comparator.
10. Hold the comparator up to a light source such as the sky, a window or lamp and view through the two openings in the front. Rotate the disc to obtain a color match.
11. Read the mg/L manganese (Mn) through the scale window.

P.A.N. Method

1. Fill a clean 25 mL graduated cylinder to the 25 mL mark with demineralized water. Transfer all of the water to a 25 mL mixing bottle.
2. Fill the 25 mL graduated cylinder to the 25 mL mark with sample. Transfer the sample to a second 25 mL mixing bottle.
3. Add the contents of one Ascorbic Acid Reagent Powder Pillow to each bottle. Swirl to dissolve.
4. Add 1.0 mL of Alkaline-Cyanide Reagent to each bottle. Swirl to mix.
5. Using the 1 mL calibrated plastic dropper, dispense 1.0 mL of P.A.N. Indicator Solution, 0.1 %, to each bottle. Swirl to mix. An orange color will develop if manganese is present.
6. Allow the color to develop for a minimum period of 2 minutes.
7. Pour at least 10 mL of the prepared solutions into two clean 2.5 cm sample cells.
8. Open the light shield and turn the Right Set Control fully clockwise.
9. Place the 1.0 cm cell holder into the sample well in the Left Set position. Press down firmly to seat it in place. Close the light shield.
10. While holding the On button down, adjust the Left Set control to align the meter needle with the arrow at the far left of the scale arc. Remove the 1.0 cm cell holder.
11. Place the prepared reagent blank in to sample well. Press down firmly to seat it in place. Close the light shield. While holding the On button down, adjust the Right Set control for a meter reading of zero mg/L.
12. Place the sample cell containing the prepared sample into the sample well. Press down firmly to seat it in place. Close the light shield. While holding the on button down, allow the meter reading to stabilize. Read and record the mg/L Manganese (Mn).

7.2.4 Iron, Ferrous

Ferrous iron is the reduced form of iron. It is useful in determining the redox state of the water.

0-10.0 mg/L Fe^{+2}

1. Fill a viewing tube to the first (5-mL) line with sample water. This is the blank.
2. Place this tube in the top left opening of the color comparator.
3. Fill the measuring vial to the 25-mL mark with sample water.
4. Add the contents of one Ferrous Iron Reagent Powder Pillow to the measuring vial.
5. Swirl to mix. An orange color will develop if ferrous iron is present. Allow three minutes for full color development.
6. Fill another viewing tube to the first (5-mL) mark with the prepared sample.
7. Place the second tube in the top right opening of the color comparator.
8. Hold comparator up to a light source such as the sky, a window or a lamp. Look through the openings in front.
9. Rotate the color disc until the color matches in the two openings.
10. Read the mg/L ferrous iron in the scale window.

7.2.5 Sulfate

Sulfate is a major anion and also useful for assessing the redox state of the aquifer. Hydrogen sulfide is the reduced form of sulfur.

0-80 mg/L SO_4

1. Fill a clean 2.5 cm sample cell to the 10-mL mark with the water to be tested.
2. Add the contents of one SulfaVER® 4 Sulfate Reagent Powder Pillow. Cap and swirl to mix. A white turbidity will develop if sulfate is present. Allow at least five minutes for the turbidity to develop fully, but do not wait more than 10 minutes before completing steps 5 and 6.
3. Open the light shield and turn the Right Set control fully clockwise. Place the 1 cm cell holder into the Left Set position of the sample well. Press down firmly to seat it into place. Close the light shield.
4. While holding the On button down, adjust the Left Set control to align the meter needle with the arrow at the far left of the scale arc. Remove the cell holder.
5. Fill a clean 2.5 cm sample cell to the 10-mL mark with original sample water. Cap and place it into the sample well. Press down firmly to seat it into place. Close the light shield. While holding the On button down, adjust the Right Set control for a meter reading of zero mg/L.
6. Place the prepared sample (from Step 2) into the sample well. Press down firmly to seat it into place. Close the light shield. While holding the ON button down, allow the meter reading to stabilize; then read and record the mg/L sulfate (SO_4^{-2}).

7.2.6 Hydrogen Sulfide

Hydrogen sulfide is used to assess the redox state of the water. It is present in water under highly reduced conditions.

low range 0-.55 mg/L H_2SO_4

1. Rinse one of the square mixing bottles with demineralized water or the pretreated water sample. Fill to the 25 mL mark. This is the blank solution.
2. Rinse the second square mixing bottle with the sample to be tested. Fill to the 25 mL mark. Avoid aeration of the sample during the test procedure.
3. Fill the dropper to the 1 mL mark with Sulfide 1 Reagent. Add 1 mL of Sulfide 1 Reagent to each mixing bottle. Swirl to mix.
4. Fill the second dropper to the 1 mL mark with Sulfide 2 Reagent. Add 1 mL of Sulfide 2 Reagent to each mixing bottle. Swirl to mix. The prepared sample immediately will turn pink and then blue if sulfide is present. Allow the sample to stand for five minutes for full color development.
5. Insert the lengthwise adapter into the comparator.
6. Fill one sample tube exactly to the line below the number 46600 with the prepared sample.
7. Fill the second sample tube with the prepared blank to the line below the number 46600.
8. Place the prepared sample from step 6 into the right top opening of the comparator.
9. Place the prepared blank from step 7 into the left top opening of the comparator.
10. Hold the comparator with the tubes tops pointing to window or light source. View through the openings in the from of the comparator. When viewing use care to not spill samples from unstoppered tubes.

11. Rotate the disc to obtain a color match. Read the total sulfide as mg/L S^{2-} from the lower scale through the scale window. To obtain results as mg/L H_2S, multiply the mg/L S^{2-} by 1.06.

8. QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES

8.1 Field Decontamination Procedures

Decontamination procedures are performed on all equipment that goes down hole on multiple wells (i.e. pumps, water level indicators, YSI, etc.). Depending upon the study and the potential cross contaminate, either a bleach solution or an alconox solution are utilized for decontamination procedures.

1. Pour approximately one to two gallons of cleaning solution into a five gallon pail. For alconox solution, mix approximately one tablespoon of alconox for each gallon of water to be used. For bleach solution, mix one gallon of bleach to 10 gallons of water (10% solution).
2. Drain the tubing from the pumps and shake of excess water from other equipment. Place equipment into the pail with cleaning solution.
3. Using a coarse bristle brush, scrub equipment with the cleaning solution. All portions of the equipment that come into contact with the water column must be scrubbed (tubing, cords, etc.).
4. Pour the cleaning solution into the "*decon tube"*. Place the pump into the "*decon tube"* and start the pump. Run pump until all the cleaning solution has been run through the pump. Drain this water from the pump.
5. Repeat steps 1-4 using DI water instead of cleaning solution.

This procedure is the bare minimum decontamination that should be performed. The more water that can be run through the pump and tubing, the better. The above procedure is for field decontamination only. Decontamination of equipment back in the Field Operation Center is very similar except it is more extensive and is performed every time the equipment returns from a sampling event. A larger quantity of water should be flushed through the pump and tubing. The carrier and control units should be cleaned.

An equipment blank should be taken before and after each sampling event to determine the effectiveness of the decontamination procedures.

8.2 Sample Blanks

8.2.1 Acid Blanks

The purpose of an acid blank is to detect any metal contamination from the acid and to see if any contamination from the ambient air has occurred during the preserving process. The acid blank is taken at the time the sample bottles are being preserved.

1. Fill a cation bottle with DI water from the U of M Lab and label with a generic GWMAP bar coded label and a blank label indicating the acid blank and the date. Remove the cap and place near the area where you will be preserving the bottles.
2. Preserve sample bottles as described in previous section "Preserving Bottles". After completing the preservation process, add two pipettes of HNO_3 (cation preserving acid) to the acid blank and cap the bottle (preserve the bottle as if it was a cation bottle).

3. Using the data logger, access the function called “Acid Blanks” under the Utilities command. Enter your name and scan the acid blank bar coded label. Then scan all the cation bottles preserved during that session (this ties the samples to the acid used for preserving, which is needed for data interpretation if contamination is discovered in the acid blank).
4. Place the acid blank in the refrigerator. From this point, the acid blank is treated like a cation sample.

Note: Always preserve the acid blank after all the sample bottles have been preserved.

8.2.2 Trip Blanks

Trip blanks are used in association with VOC samples. Due to the sensitive nature of VOCs, cross contamination and/or outside interference can impact the results of a sample. The trip blank is designed to detect potential contamination and/or interference. The trip blank comes sealed and labeled from the lab. An additional GWMAP VOC label must be placed on the bottle to be entered into the data logger.

Each set of VOCs must have an associated set of trip blanks for each sampling trip. The trip blanks and the associated samples must always stay together from the time the bottles leave the lab, to the time the samples are returned to the lab. A new set of VOC and trip blanks are used for each sampling trip. If a sampling event is multiple days in length without returning to the Field Operation Center, one trip blank is needed for the entire sampling event. However, if a sampling event is multiple days in length with returning daily to the Field Operation Center, a new trip blank is needed for each day (trip) of that event.

8.2.3 Temperature Blanks

A temperature blank is required for all bacteria samples. The purpose of the temperature blank is to ensure the samples have been kept at the appropriate temperature during storage and transportation. The bacteria sample bottle is used for the blank. Fill the bottle with DI water (as one would if it were a bacteria sample) and place in the refrigerator or cooler with the samples. Label the bottle “temperature blank”.

8.2.4 Equipment Blanks

With the use of equipment at multiple sites, the issue of cross contamination becomes a concern. This blank should be taken before and after a sample event where VOCs are being collected. The equipment blank is meant to detect any cross contamination that may occur through the equipment. This blank is collected from the pump (used with a monitoring well). DI water is pumped through this equipment and a VOC sample is collected.

8.3 Lab Checks

8.3.1 Duplicate Samples

A duplicate sample is collected at least every tenth sample. The purpose of the duplicate is to test the ability of the lab to reproduce its analytical procedures. The duplicate is completely masked to the lab. The data logger prompts the sampler to collect the duplicate. Cation, anion, general chemistry, TOC, DOC and VOC samples are duplicated (occasionally a pesticide sample is duplicated). See Section 6.3 *(Duplicate Samples* under *Sample Collection)* for the proper procedure to collect a duplicate sample.

8.3.2 Spikes

A yearly "spiked" sample is prepared and sent to the lab. The purpose of the spike is test the lab's ability to accurately detect the concentration of a known sample. An anion, cation and pesticide blank are spiked to a known concentration for several parameters.

8.4 Field Reading Checks

8.4.1 ORP vs DO

If ORP < 50, DO should be < 0.50 mg/L
If these measurements do not agree, check the DO membrane, the flow cell for lodged air bubbles and look at the flow system for excess air. If there is not any apparent problem with the equipment, adjust the flow rate and observe the well behavior for pump surges and pressure tanks. Also check the ORP probe. The probe does get fouled and may need a cleaning (see Section 3 *YSI 600 Operation*). If in the field, try the backup probe.

8.4.2 pH Range

pH < 6.3 or > 8.0
Recalibrate and zero the meter, as they do have a tendency to "drift". Look at the probe; check for cracks and fouling. If needed, clean the probe. Replace the probe with a backup.

A pH > 8.0 may occur in some buried carbonate aquifers, in sodium dominated systems, or in silica-rich aquifers. Sodium-dominated systems are rare in Minnesota but there is the potential to see some in the Red River Valley. An additional sign of a sodium-dominated system would be a conductivity reading > 2.50

A pH < 6.3 can occur in aquifers rich in orgaincs. Peaty or sandy forested areas consisting of primarily oak and evergreen trees have a tendency to increase the acidity of the soil, therefore lowering the pH of shallow ground water

8.4.3 DO vs Temperature

DO > [14.3 - (0.30 * Temp)] - temperature in degrees C
Check the DO membrane, the flow cell for lodged air bubbles and look at the flow system for excess air. If there is no apparent problem with the equipment, adjust the flow rate and observe the well behavior for pump surges and pressure tanks.

8.4.4 Alkalinity vs Conductivity

[Alkalinity / (Conductivity * 1000)] > 0.80 or < 0.20
Check the flow rate and flow consistency. The conductivity probe is flow dependent. A flow rate that is either too fast or too slow will impose error into the measurement. Also, a non-continuous flow will cause the reading to fluctuate dramatically.

A ratio of < 0.20 would normally only occur in a Cretaceous aquifer. A ratio > 0.80 would normally only occur in a shallow fresh water system where conductivity < 0.150, ORP > 100 and DO > 4.00 (QWTA, shallow North Shore Precambrian, or shallow carbonate aquifers).

8.4.5 DO Low Range

DO < -0.50 mg/L
If this occurs, recalibrate the meter using the correct barometric pressure. Also check the probe for possible fouling or degradation of the membrane or electrodes.

Note: Any and all potentials for error on the field form and/or in the field book. This information is extremely valuable during data interpretation.

9. POST SAMPLING PROCEDURES

The following procedures are completed after returning from a sampling event. Samples are store using the procedures outlined below from the time they are collected to the time they are analyzed. Following these procedures are essential to data quality, efficiency of field work and to ensure the equipment operating at its peak performance.

9.1 Sample Storage

While in the field, samples are stored in standard coolers, packed with ice to maintain a temperature of 4^{o}C. The cooler temperatures are monitored using thermometers every two to three hours. Upon returning to the Field Operation Center, the samples are transferred from the coolers to a refrigerator. The refrigerator is kept running continuously to maintain the 4^{o}C temperature required for sample storage. While samples are in the refrigerator, the temperature is monitored daily.

If samples are to be shipped to lab, they are shipped by over-night delivery. Samples are shipped in standard coolers, packed with ice that has been double bagged and wrapped in bubble wrap to prevent bottles from shifting and breaking.

9.2 Holding Times

A sample's holding time is the length of time between sample collection and analysis. Each sample bottle collected, is logged into the database where its holding time is monitored to insure sample times are not exceeded. The following is a list of the lab, samples and their associated holding time.

Minnesota Department of Health	
VOC (preserved)	14 days
VOC (unpreserved)	7 days
Bacteria	48 hours
University of Minnesota Soils Research	
TOC (preserved)	28 days
DOC (preserved)	28 days
Anions(preserved)	28 days
Cations (filtered and unfiltered)	6 months
General Chemistry	28 days
Soil (chemistry)	None
University of Canada, Waterloo	
N15 (preserved)	2 weeks
N15 (not preserved)	48 hours
Tritium	6 months
Minnesota Valley Technical Laboratories (MVTL)	
List 1 Pesticide (not filtered)	14 days
List 2 Pesticide (not filtered)	7 days
USGS Kansas Lab	
List 1 Pesticide (filtered)	14 days

9.3 Sample Inventory

Sample inventory must be completed 48 hours prior to sample drops. This allows time for the chain of custody reports to be completed. Inventory involves using the data logger to scan all the sample bottles that are to be delivered to the lab. Using a series of links and queries within the database, each bottle is associated with it's monitoring location, sampling date and time and all the other sample bottles and data collected for that location.

9.4 Equipment Cleaning and Stocking

Upon returning from a sampling event, all equipment must be cleaned and decontaminated. The pumps must go through a thorough decontamination procedure similar to the one detailed in Section 8.1 *(Field Decontamination Procedure).* The face and control panels of the Keck and peristaltic pumps must be washed to remove dirt. After cleaning the pumps, a equipment blank must be taken (see Section 8.2.4 *Equipment Blanks* for the procedure). The internal battery of the Keck and the 12 volt portable batteries must be recharged.

The YSI equipment must be washed and decontaminated. Check all the probes for any fouling. Replace the DO membrane. Clean and calibrate all probes. Following the procedure outlined in Section 3 *(YSI 600 Operations)*. The internal batteries of the monitors and data loggers must to recharged.

All other equipment must be cleaned and/or decontaminated (i.e. water level equipment, slugs, field boxes and kits, etc.). Give the data logger and GPS to the database manager for down-loading and charging of the battery packs of the units.

Field boxes and field kits must be cleaned restocked with the appropriate supplies. Appendix IV (*Equipment Lists)* is a listing of all the equipment and supplies needed for a sampling trip. A quick inventory should be performed to ensure that supplies are adequate for several sampling events. An inventory sheet is posted at the Field Operation Center. If supplies are low, inform the field coordinator of the situation and they will order more supplies.

Final, wash and vacuum the sampling vehicles. This can be done at Travel Management. Also complete the maintenance records for the vehicles and check the mileage between oil changes. Maintenance records are turned into the division management each month. The engine oil must be changed every 3000 to 5000 miles or every six months.

APPENDIX I. GUIDELINES FOR CONTACTING WELL OWNERS

Hello, is this the _____ residence?

Yes

My names is _____, and I am calling from the _____ office. We are conducting a statewide ground water study and we are going to be in _____ township/county/area next week and we would like to collect a sample from your well for our study.

Pause, let them think about what you have said.
If yes or maybe it seems to be the reaction, let them know more details. We only need an outside faucet, we do not need to go in your house. We hook up a hose to the outside faucet, let the water run, calibrate our equipment, and then collect the samples. We will probably be on-site for about one hour (some are less, some are more). We are collecting information on over 100 constituents in ground water, and the lab results from the sample we collect from your well will be sent to you.

Use these points if your audience needs to be persuaded to let us sample their wells. If you were to have these tests done yourself, they would cost approximately $400. It may also help to remind them that we have **no** enforcement authority. We are not looking for specific contaminants. Our interests are in the chemical constituents that are naturally in ground water and how that changes within different aquifers or within different areas of the state.

Note: Use only as many of these arguments as you need to in order to get a YES.

If they say "I really don't think so" try to answer their fears. An offer to sent them an official letter may "legitimize" our project, and need for being on their property. However, for those that say NO, or are not interested, say "thank you" and let them go.

If they say yes, then proceed. "Great! We appreciate your cooperation. I am going to ask you a few quick questions." Then proceed down the checklist.

Using the Phone Checklist

Unique number, aquifer, and grid number should just be copied from the well log. Do not ask the well owner for that information - they won't know it.

Age and well depth are asked just to verify that the same well is being referenced by both parties. Answers should be close to what the well log says, but don't rule it out if they are off by a few years or feet, but if it's decades, then reconsider.

Other wells on property are asked about because if there are two wells, we need to know which faucet/hydrant is the one to sample.

Chlorinators are a problem for sampling. We can't sample unless 1) they willingly turn the chlorinator off for 72 hours before we get there; and 2) we can take a sample before the chlorinator.

The closest *untreated* (**not** filtered, softened, chlorinated) sampling point to the well is sometimes a good way to get the owner to tell us where the faucets on the house are (i.e., north side under the window, etc.) and if there is anything unusual about them (i.e., happened to run softened water or don't work or whatever...).

Unless the exact day of sampling is known, I think the best thing to say is "we will be there next week, probably on Tuesday or Wednesday." That is better than "in the next two weeks..." If the well owner really wants to be home when we are sampling, we can call the night before we are planning to sample their well to say "we are going to be there tomorrow." If they don't sound like this is imperative, don't offer - calling ahead can be a hassle for the sampling team.

Ask if there are livestock at the site that are using the water constantly, which may save us time when sampling. Most of the time it is obvious if there are livestock, but sometimes it isn't - so we ask. (Applicable in agricultural areas only.)

Mailing address is very important. Confirm the owners address. We cannot send them the results of the tests on their well water without it.

Directions are not crucial in rural area, because the Plat books are helpful. In town or in subdivisions some basic directions are helpful.

Name on box/house color are just helpful hints to help us identify that we are at the right place if no one is home.

Notes/observations - write down anything you notice. For example, if the well owner was grumpy on the phone, or if we should only come on a particular day or time, or if the owner needs to be called prior to sampling, or if they have a mean dog, etc. Use this space to write any observations that the field team might find helpful or should know about.

Thank them very much for their time and for cooperating in the ground water study.

APPENDIX II. WELL OWNER CALLING CHECKLIST

Please complete the following information for each call to the best of your and the well owner's ability.

OFFICE USE ONLY

GENERAL INFORMATION:

Unique Number: _____ *Grid Number:* _____ *County:* _____

GWMAP Station ID Number : _____

Phone Number(s) Called: _____ , _____

Spoke to: _____ *Permission:* _____

WELL INFORMATION:

Aquifer: _____ *Well Depth:* _____ *Diameter:* _____

Year Installed: _____ *Chlorinator / Softener:* _____

If so, can it be bypassed?: _____

Other wells on property(if any): _____

Closest sampling point to well (or owners preferred sampling source):

_____

Location of well head: _____

Production farm/barns, etc. use this well?: _____

SITE INFORMATION:

Mailing Address: _____

_____

Directions: _____

_____

_____

When we will be there: _____ *Name on mailbox:* _____

House color: _____ *Fire Number:* _____

OTHER:

Notes/Observations: _____

_____

Date Called: _____ *Caller Initials:* _____

APPENDIX III. GWMAP WELL SAMPLING FIELD FORM

(To be used in conjunction with the Data Logger)

Sample Date: ____/____/____ *County:* _____

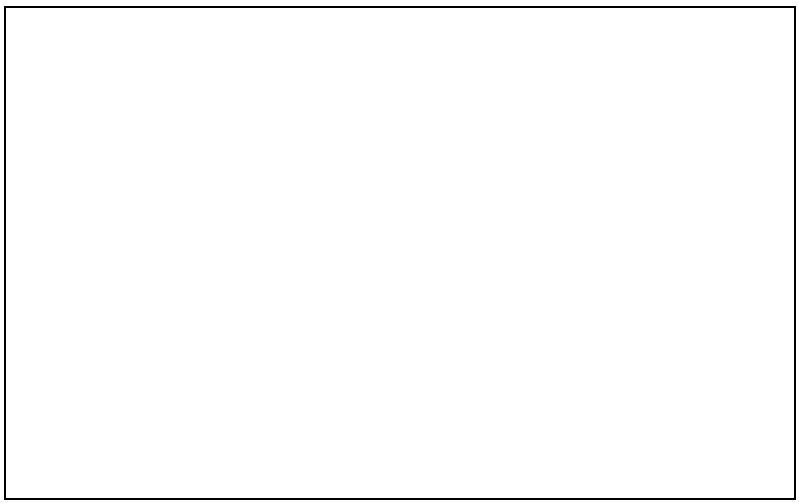
Sampler(s): _____ , _____

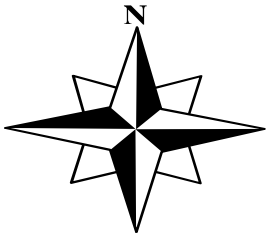
ON-SITE FIELD INFORMATION:

Weather conditions: _____ *Temperature:* _____

Others on site: _____

Site Map:





Description of sampling point: _____

Distance between sample point and well head: _____

Potential Contamination Sources (include approximate distance from well head): _____

_____

Well Problems: _____

Equipment Problems: _____

WELL HISTORY:

Has water been tested before?: _____ *If so, when?:* _____

By GWMAP?: _____ *If not, by whom?:* _____

Qualitative Results: _____

_____

ADDITIONAL COMMENTS: _____

_____

_____

_____

APPENDIX IV. WELL CASING CONVERSION FACTORS

Diameter of Casing	Gallons per Foot Depth	Diameter of Casing	Gallons per Foot Depth
1	.041	10	4.080
1 1/2	.092	11	4.937
2	.163	12	5.875
2 1/2	.255	14	8.000
3	.367	16	10.44
3 1/2	.500	18	13.22
4	.633	20	16.32
4 1/2	.826	22	19.75
5	1.020	24	23.50
5 1/2	1.234	26	27.58
6	1.469	28	32.00
7	2.000	30	36.72
8	2.611	32	41.78
9	3.305	34	47.16

1 Gallon = 3.785 Liters
1 Meter = 3.281 Feet
1 Gallon of Water Weights 8.33 lb. = 3.785 Kilograms
1 Gallon per Foot of Depth = 12.419 Liters per Foot Depth
1 Gallon per Meter of Depth = 12.419×10^{-3} Cubic Meters per Meter Depth

APPENDIX V. CONVERTING QUARTERS

When converting quarters to the A,B,C,D method the order of listing is reversed. They are listed in the order of largest unit to smallest unit.

Eample: At point X the legal description would read;

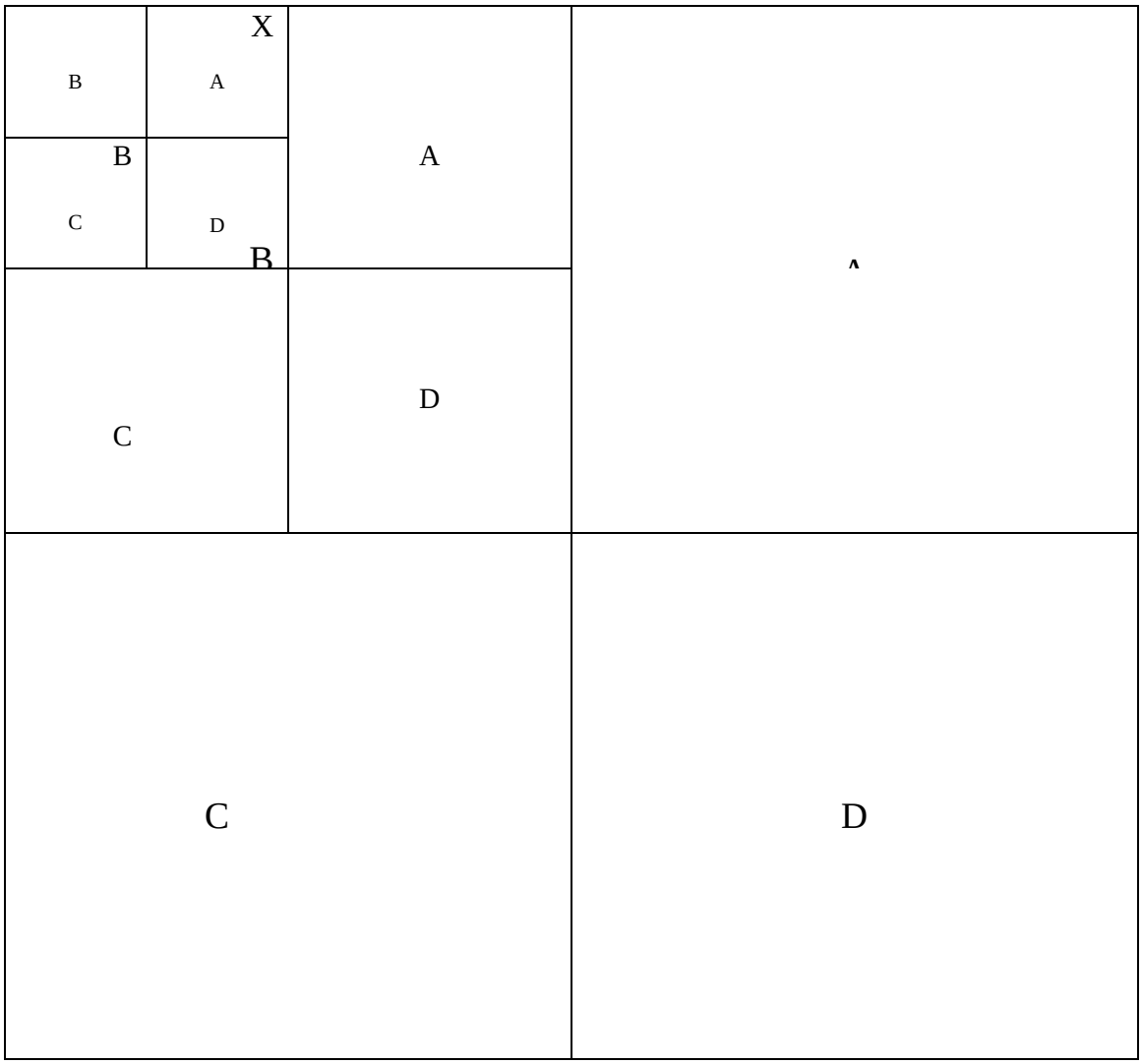
NE1/4 NW1/4 NW1/4 of Section # Range# Township #

Using the A,B,C,D method the legal description would read in the reverse order

Township # Range # Section # B B A

When using this method at least two and not more than six quarters should be identified

NE 1/4 = A, NW 1/4 = B, SW 1/4 = C, SE 1/4 = D



APPENDIX VI: MINNESOTA COUNTIES AND NUMBERS

01.....Aitkin
02.....Anoka
03.....Becker
04.....Beltrami
05.....Benton
06.....Big Stone
07.....Blue Earth
08.....Brown
09.....Carlton
10.....Carver
11.....Cass
12.....Chippewa
13.....Chisago
14.....Clay
15.....Clearwater
16.....Cook
17.....Cottonwood
18.....Crow Wing
19.....Dakota
20.....Dodge
21.....Douglas
22.....Faribault
23.....Fillmore
24.....Freeborn
25.....Goodhue
26.....Grant
27.....Hennepin
28.....Houston
29.....Hubbard
30.....Isanti
31.....Itasca
32.....Jackson
33.....Kanabec
34.....Kandiyohi
35.....Kittson
36.....Koochiching
37.....Lac Qui Parle
38.....Lake
39.....Lake of the Woods
40.....Le Sueur
41.....Lincoln
42.....Lyon
43.....McLeod
44.....Mahnomen
45.....Marshall
46.....Martin
47.....Meeker
48.....Mille Lacs
49.....Morrison
50.....Mower
51.....Murray
52.....Nicollet
53.....Nobles
54.....Norman
55.....Olmsted
56.....Ottertail
57.....Pennington
58.....Pine
59.....Pipestone
60.....Polk
61.....Pope
62.....Ramsey
63.....Red Lake
64.....Redwood
65.....Renville
66.....Rice
67.....Rock
68.....Roseau
69.....St. Louis
70.....Scott
71.....Sherburne
72.....Sibley
73.....Stearns
74.....Steele
75.....Stevens
76.....Swift
77.....Todd
78.....Traverse
79.....Wabasha
80.....Wadena
81.....Waseca
82.....Washington
83.....Watonwan
84.....Wilkin
85.....Winona
86.....Wright
87.....Yellow Medicine