

Other equipment that may be necessary depending on the site, include an organic vapour analyser or similar device to measure organic vapours in the well, and devices for measuring and/or sampling light non-aqueous phase layers (NAPL – eg petroleum hydrocarbons) or dense non-aqueous phase layers DNAPL (DNAPL – eg Trichloroethylene (TCE)).

There are numerous sampling devices available. Each has certain advantages, disadvantages and limitations based on the type of suspected contaminants, monitoring well construction, and hydrogeology. *Selection of the proper sampling device is probably the most crucial element, which influences whether or not groundwater samples are representative.* Some questions to consider when selecting the sampling device are listed below:

- ☐ Will the device fit inside the monitoring well(s) to be sample?
- ☐ Will contaminants either be leached into or absorbed from the sample by the construction materials of the device?
- ☐ Will the pH or redox potential (Eh) of the groundwater sample be altered by the device?
- ☐ Will volatile organic constituents be stripped from the sample due to sample aeration or degassing as a result of the device operation?
- ☐ Will the device also be suitable for purging?
- ☐ Can the rate of delivery be controlled and is it sufficiently low?
- ☐ Will it operate under the various hydrogeologic conditions of the site?

Other considerations include cost, ease of maintenance, operation and cleaning; the portability of the device and required accessory equipment; and the reliability and durability of the device. In general, bailers constructed of Teflon or stainless steel, or gas operated bladder pumps with a Teflon bladder and tubing and a Teflon or stainless steel body is the preferred purging and sampling tools (US EPA, 1986b; Barcelona et al, 1984; 1985). Nielsen and Yeates (1985) present a fairly comprehensive discussion of these and other sampling devices, and a suction side sampling device is described by Armstrong and McLaren (1984).

Most parameter measuring devices typically used during groundwater sampling (ie, pH meter, water level meter, etc.) are portable field operated devices that are readily available from numerous manufacturers. Some manufacturers (In-situ, YSI, Martek) have recently developed down hole devices for measuring several groundwater parameters in-situ. In line flow through cells have also been developed to allow parameter measurements within the discharge line at the sampling point (Barcelona, et al. 1985). The type of meter selected should be durable and easily calibrated.

Whenever possible, dedicated equipment should be used at a site. Use of dedicated equipment will significantly decrease the potential for cross contamination and increase sample reliability. While initial costs of dedicated equipment may be relatively high, these may be offset by the savings in the labour costs that are associated with non-dedicated equipment, and re-sampling and analysis if suspect analytical data are obtained. Use of dedicated equipment is not limited to sampling devices or bailer analytical ropes/cables. Cross contamination can also occur by use of a contaminated water level measuring device. Water level devices with lead weights (ie, power sounders) should not be used at sites where there is potential for metals contaminations or acidic water. Hydrocarbon measuring devices (ie, interface probes) should not be used to measure water levels unless hydrocarbons are suspected. At sites where pH, conductivity, Eh or other field parameters are considered indicator parameters of contamination (eg, landfills), dedicated meters and/or probes should be used to minimise potential effects of field instrumentation variability. Use of dedicated probes is relatively inexpensive and is essential for wells with highly conductive, low or high pH, or highly contaminated groundwater. These conditions could affect the ability of probes to detect lower concentrations

accurately during subsequent use. Clean disposable beakers from a laboratory supply house should also be used if accuracy of field parameters is a critical component of the sampling objectives.

Instruction manuals for the specific types of brands of equipment to be used should be reviewed, and calibration and operation procedures incorporated into the sampling plan to ensure proper field operation of the equipment.

## **4. Procedures**

### **4.1 Pre-Field Procedures**

Prior to conducting a sampling event, a great deal of pre-planning must be done to ensure a flawless sampling event. These pre-sampling procedures include the procurement and calibration of equipment, obtaining and checking sample bottles and review of the sampling plan and field forms. It is suggested that preparation for a sampling event begin at least one to two weeks before the sampling is to take place. Pre-field Procedure checklists should be modified as necessary for each site. All items should be checked as they are completed. If more than one person is involved in the pre-field preparation, they should initial the item when checking it off the list.

#### **4.1.1 Review Sampling Plan**

The field personnel should thoroughly review the site Sampling Plan, well locations, and site characteristics prior to ordering sample bottles and organising the equipment. Particular attention should be made to the sampling order, protocol, and parameters to be analysed. Any questions or uncertainties should be immediately rectified with the Project Manager. Any sample labels or forms to be used should have pertinent information such as job number, client, etc.

#### **4.1.2 Equipment and Materials**

All equipment necessary for a sampling event should be cleaned, checked and calibrated to ensure that it is working properly prior to going to the site. As much preparation as possible should be done ahead of time since neither the facilities (ie, water, electricity, etc.) nor the material required for equipment cleaning and calibration may be available at the site. In addition, if too much is required to set up at the site, it could affect your ability to collect samples and ship or deliver them to the laboratory on the same day. A typical equipment checklist is presented in Appendix 8A. This checklist can be modified for each site checklist or N/A should be placed opposite items that are not applicable. All other items should be checked as each piece of equipment is loaded in the field vehicle.

If dedicated equipment such as bailers, pH meters, pumps, etc. are to be used, they should be ordered from the manufacturer several weeks in advanced, to allow for replacement if wrong or malfunctioning equipment is sent. This is especially important if the sampling event has a specified regulatory time frame (ie 30 days) and a delay could cause serious problems for the client. The equipment should be closely inspected for defects, cleaned and calibrated (if necessary). All non-reusable equipment and supplies should be obtained and packs of frozen ice (if required) should be frozen. One option is to purchase dry ice and use it to keep the packs of ice frozen in the field until the samples are obtained.

The necessary sample bottles should be ordered from the lab one to two weeks prior to the sampling event. Verify the type of bottles (ie VOA vial, amber jar, plastic bottle) needed for each parameter to be analysed and whether the sample bottle will include or require preservative. Make sure you specify the number and types of blanks and duplicates needed. If possible, have the bottle labelled with the parameter (VOC, metals, etc.). Verify what samples should be filtered. When the bottles arrive

inventory them immediately to make sure the correct number and type of bottles were sent, they are intact (check to see if the caps are tight), and have preservative. Contact the laboratory immediately to obtain additional replacement bottles if needed.

All meters should be cleaned and calibrated against fresh, known standards in accordance with the manufacturer procedures prior to arriving at the site. The calibration for pH is temperature correlated and the pH of the buffers at the temperature of calibration (usually in a chart provided with the buffer) should be noted. If possible, calibrate the conductivity meter using a standard similar to the expected at the site. The electrical conductivity should be measured at 25 degrees Celsius or converted to specific conductivity (Table 1). Some meters are temperature corrected and measure specific conductivity directly. If specific conductivity is a crucial parameter, then an additional calibration using a cooled standard with the same conductivity as the initial standard or a standard with a different conductivity can be used. Measurement of a cooled standard should be within 1% of the expected value (either temperature compensated or calculated) and measurement of a standard with different conductivity should be within 5% of the expected value.

Decontamination of meter probes consists of triple rinse in distilled water. Non-dedicated bailers, pumps and discharge lines should be cleaned with a dilute non-phosphate detergent/soap and clean (tap) water mixture, rinsed with tap water and triple rinsed in distilled water. The US EPA (1986b) recommends an initial rinse of dilute (0.1 N) hydrochloric or nitric acid and a final rinse of the type II reagent grade water if inorganic are principal constituents; and final rinse of acetone followed by pesticide-quality hexane for organics.

The sample bottles and clean, calibrated equipment should be stored in a secure clean area prior to loading in the field vehicle or shipment to the site.

## **4.2 Field Procedures**

This section provides guidelines for field procedures and is divided into five sub-sections: Pre-purging Procedures; Well Purging; Well Sampling; Shipment; and Post Sampling Procedure.

### **4.2.1 Pre-Purging Procedures**

It is very important that prior to purging and sampling that various observations concerning the condition of the well are made. Also required are specific measurements during a sampling event such as purge volume, water and depth of well. These observations and measurements are all documented on a Field Parameter Form, which should be completed for each well.

During a sampling event, wells should not be sampled if:

- ☐ The well has been damaged or destroyed
- ☐ The well is dry or an insufficient volume of water is obtained after purging
- ☐ The well has obviously been tampered with or contaminated at the well head

The Project Manager should be notified if any of these conditions occur.

#### **4.2.1.1 Well Inspection and Fluid Level Measurements**

The conditions of the well and surrounding area should be observed and recorded on the Field Parameter Form upon arrival at the well location. Information that should be noted includes, but is not limited to:

- ☐ Presence and condition of the well's identification sign
- ☐ Is the well locked and does the key work
- ☐ Physical surroundings (high weeds, standing water, cleanliness, activities nearby, all of which can impact on the well)
- ☐ Conditions of the protective casing/monument
- ☐ Condition of the well head
- ☐ Obstructions or kinks in well casing
- ☐ Condition of cement footing (cracked, raised)
- ☐ Water is annular space
- ☐ Grease around top of well on threaded caps
- ☐ Does cap fit securely so contaminants can not penetrate
- ☐ Is reference point clearly marked
- ☐ Weather conditions: include wind direction for volatiles and note if sampling was performed downwind
- ☐ Evidence of contamination (eg, animal or insect parts in well, etc.)

If organic contaminants are known or suspected, then an Organic Vapour Analyser (eg, PID) or similar device should be used to measure vapour emissions from the well. This is useful for both evaluating changes in groundwater within the well and health and safety of the sampling personnel. The equipment used should be calibrated in accordance with the manufacturer specifications.

The depth of groundwater at each monitoring well is measured to the nearest 0.01m prior to purging and samples withdrawal. The elevation of the groundwater is then determined by the following equation:

$$\text{Groundwater Elevation} = \text{Elevation of reference point} - \text{Depth to water}$$

Note: all well measurements must be made from the reference point at which the elevation was measured. The reference point could commonly be the top of the monitoring well casing or the top of the protective casing/monument. This point must be noted on the Field Parameter Form. If water-measuring device is used, which requires a correction because of previous repairs, the actual reading, correction factor, and resulting calculated value should be recorded.

If floating or immiscible liquids are present in the well, the depths to the water-immiscible liquid interface should be measured and recorded on the Field Parameter Form.

All measurements should be checked twice to verify the accuracy of the measurement. The measurements obtained should be compared against previous measurements for the well as a check against mis-measured or anomalous data. The water level measuring device and/or interface probe should be thoroughly rinsed in deionised water and dried prior to use in each well. If the water is oily, immiscible fluids are present, or previous analysis indicate significant contamination, then a dilute trisodium phosphate/water solution followed by a thorough rinse with deionised water should be used to clean the device.



#### 4.2.1.2 Well Purging

Subsequent to measurement of the depth to water in the monitoring well, the volume of standing water in the well (casing volume) should be calculated as follows:

$$1 \text{ casing volume (litres)} = \pi r^2 h \times 1000$$

where,

$$\pi = 3.14$$

r = radius of well casing in metres

h = height of water column in well in metres

#### OR

For 25mm diameter well casing, casing volume (litres per m depth)  $\approx 0.5$  h

For 50mm diameter well casing, casing volume (litres per m depth)  $\approx 1.95$  h

For 75mm diameter well casing, casing volume (litres per m depth)  $\approx 4.4$  h

For 100mm diameter well casing, casing volume (litres per m depth)  $\approx 7.85$  h

For 150mm diameter well casing, casing volume (litres per m depth)  $\approx 17.7$  h

For 300mm diameter well casing, casing volume (litres per m depth)  $\approx 70.7$  h

This value is then used to calculate the volume of water purged from the well prior to sampling. The calculation of well volume, the duration of purging, and purge volume should be included on the Field Parameter Form.

The purpose of purging a monitoring well is to ensure that a water sample representative of the groundwater in the water-bearing strata is collected. The amount of water purged prior to sampling is somewhat controversial and debated topic (Giddings, 1983). Depending on the hydrogeologic conditions, the necessary volumes could range from one to as many as tens of well volumes. However, regulatory requirements may specify a set amount (eg US EPA 1986b). The regulatory requirements that apply to the groundwater monitoring being conducted should be verified when developing the site-sampling plan.

The optimum volume to be purged is the minimum amount needed to obtain representative water. Over purging in wells completed in highly transmissive strata may induce migration of water from areas within the water-bearing strata, which are relatively remote from the well. Under purging will result in a non-representative sample.

The optimum method for determining the purging volume is to conduct a test in each well in which samples are collected after several different volumes have been purged and analysed for parameters of interest. Comparison of the results will indicate the volume at which the concentrations become relatively stable (Gibb, Schuller and Griffin, 1981). However, this is both costly and time consuming. ***As a general rule, purge a minimum volume of three to five times the volume of water in the well for wells completed in moderate to highly transmissive strata; and at least one well volume for wells in strata with a low transmissivity (wells that do not yield three well volumes)(US EPA, 1986b).*** In order to evaluate whether representative water is obtained, periodically measure the pH, conductivity, and temperature during purging until relatively stable measurements are obtained. The amount purged and temperature during purging until relatively stable measurements are obtained. The amount purged and visual and olfactory observations of the purged water should be recorded with these measurements on the Field Parameter Form.

Prior to taking pH, conductivity, and temperature measurements on the first monitoring well to be sampled, recheck the calibration of the field meters. The pH reading must be within 0.1 pH unit of the expected value (ie pH 4 buffer, calibrated to within pH 3.90 – 4.10). The specific conductivity value must be within 5% of the expected value (ie, 1413 umhos/cm standard, calibrated to within 1342 – 1484). If the recheck of the calibration of the instrument does not fall within these limits the instrument must be re-calibrated. The calibration of the field instruments must be checked at the end of the day, or as required. If the calibration check is not within the limits listed above, the meter must be re-calibrated.

***The single most important objective while purging a well is minimising the contamination.***

Equipment should never touch the ground or any other possible contamination sources. For example, a drum or garbage bin lined with a new plastic bag can be used to collect the rope when using a bailer. Purged water should be discarded away from the well footing. This will prevent the possibility of contamination due to the formation of mud. A calibrated 20L drum or bucket can be used to collect and measure the volume of water purged.

The well can be purged with the sample equipment used to sample the well or a separate piece of equipment (ie, pump or bailer). When using a bailer for purging, the largest available bailer that will fit into the well should be used in order to minimise purge time. Nylon rope, preferably braided, or Teflon coated stainless steel cable should be used. It is imperative that a new or dedicated rope be used. In addition, the rope should be of adequate length and strength – thicker rope is easier to grip.

**Suggested precautions while purging a well:**

- 1) Lower the bailer slowly into the well;
  - ☐ So as to prevent contamination from rust or other sediment, which may accumulate around the top of the well casing
  - ☐ To minimise the upwelling of bottom sediments
  - ☐ To minimise the possibility of the bailer becoming lodged in the well due to a kink in the well casing
  - ☐ To minimise the chance of the rope becoming untied from the bailer
- 2) Never allow the bailer to come in contact with any surface other than your hands and the inside of the well.
- 3) Check the rope where it attaches to the bailer with each bail
- 4) Always wash your hands and use clean powderless PVC, latex or nitrile gloves to help prevent contamination. If a non-dedicated bailer or pump is used it should be thoroughly cleaned inside and out prior to use in each well. No dedicated pumps are most often used for purging when large volumes of water must be removed from the well prior to sampling.

In high-yielded wells, where the water level is above the screen the water should be purged from the uppermost part of the water column above the screen. This will cause the water to move upward in the well thereby effectively flushing it. In low-yield wells the water should be purged from the bottom of the water column (US EPA, 1986b). The well should be purged at a relatively constant rate, which maximises the rate of purging without inducing sufficient drawdown to cause cascading water within the well. Purge rates for a particular well should be as consistent with previous purge rates for the well.

If the purge water is significantly contaminated, it should be placed in a drum.

#### 4.2.1.3 Sampling the Well

Groundwater samples should be collected as soon as possible after purging. Low-yield wells that were purged to dryness should be sampled as soon as the water level recovers sufficiently and pH, conductivity and temperature have stabilised. If the well does not recover sufficiently within 24 hours of purging, the well should be considered dry. The equipment used to collect the groundwater sample from the well should be selected based on the parameters to be analysed and is typically the same as that used for purging. All precautions should be made to minimise physical alteration or chemical contamination during sample collection. This sample order will minimise potential for least contaminated to most contaminated well. This sampling order will minimise potential for contamination from use of non-dedicated sampling and/or filtering equipment.

Samples for each well should be collected in order of most volatile to least volatile parameters. The preferred collection order (US EPA, 1986b) for some common parameters are:

- ☐ Volatile organics (VOA)
- ☐ Purgable organic carbon (POC)
- ☐ Purgable halogens (POX)
- ☐ Total organic halogens (TOX)
- ☐ Total organic carbon (TOC)
- ☐ Extractable organics
- ☐ Total metals
- ☐ Dissolved metals
- ☐ Phenol
- ☐ Cyanide
- ☐ Sulphate and chloride
- ☐ Turbidity
- ☐ Nitrate and ammonia
- ☐ Radionuclides

Temperature, pH, and specific conductivity measurements should be made in the field before and after sample collection as a check on the stability of the water sampled over time. These measurements should be recorded on the Field Parameter Form. When collecting samples for analysis of volatile constituents or gases using a bladder pump, the rate should not exceed 100 mls/minute. If a bailer is used, it is preferable to use one with single or double check valve and a bottom-emptying device.

##### 4.2.1.3.1 Immiscible Liquid Sampling

Light phase immiscible liquids greater than 600 mm thick can be sampled with a bottom valve bailer. A top filling bailer on a stainless steel weighted rope is the desired sampling method if the layer is less than 600 mm thick. If the depth to this layer is less than about 6 m, then a peristaltic pump can be used to "vacuum" a sample. Dense non-aqueous phase liquids (DNAPL's) are best sampled using a double check valve bailer or Kemmer-style sample (US EPA 1986).

##### 4.2.1.3.2 Filtration

Regulatory guidelines may vary regarding filtration of samples in field. However, all samples (except those listed below) should be filtered through a 0.45-micron membrane pressure filter unless regulatory requirements specify otherwise.

**Parameter Not Requiring Field Filtering**

- ☐ Alkalinity
- ☐ Turbidity
- ☐ Total Suspended Solids (TSS)
- ☐ Semi-volatile Organics (base, neutral, acid organics)
- ☐ Volatile Organics (VOA)
- ☐ Total Organic Carbon (TOC)
- ☐ Total Organic Halogen (TOX)
- ☐ Total Heavy Metals
- ☐ Any other parameters listed as **total** (refers to unfiltered samples. If it does not say total, assume dissolved)
- ☐ Coliform
- ☐ pH
- ☐ Specific Conductivity
- ☐ Oil and Grease

Filtration and preservation of groundwater samples is an integral part of the monitoring program. Improper techniques during this process can destroy the integrity of the sample. Therefore, all possible precautions should be taken to ensure that no contamination sources are introduced during filtration or preservation.

Filtration equipment should be decontaminated in the same manner as purging and sampling equipment. In addition, rinse the inside of the filter and discharge tube with purge water just prior to sampling. If significant contamination is known to be present, it is good practice to replace the discharge tubing prior to sampling each well.

**NOTES:**

- Filtering should be performed **immediately** upon collection of the samples. Filtration should be done in the field. Where this is not possible, it should be completed as soon as possible after the sample has been taken (**within two hours**), and should be done under the most sanitary conditions available.
- Refer to the Sampling Plan to assist in determining the order of filtering. Any sample that is suspected or known to contain high contamination levels, are to be filtered last to prevent possible contamination of the clean samples due to use of the same filtering equipment.

When using an in-line filter cartridge, a minimum of three (3) pump cycles of water must be allowed to pass through the filter before obtaining a sample. These filters should only be used for filtering inorganic parameters, unless analytical data is available to support that no sample contamination will occur.

**4.2.1.3.3 Filling Sample Bottles**

Sample bottles for non-filtered samples should be filled directly from the bailer or pump with a minimal amount of air contact. TOC, TOX, and volatile organics bottles should be headspace free, unless requested otherwise by testing laboratory. All samples that are filtered should be collected in the sample bottle directly from the filter discharge line. When filling sample bottles, these important procedures and precautions should be followed:

- 1) Bottle caps should be removed carefully so that the inside of the cap is not touched. **Caps should never be put on the ground.** Caps for VOA vials contain a Teflon septum. The Teflon side of the septum must be facing the sample to prevent contamination of the sample through the septum.