



# TABS ON CONTAMINATED SITES

## Contaminated Sites Program - Federal Sites

This is one in a series of Technical Assistance Bulletins (TABs) prepared by Environment Canada-Ontario Region for Federal Facilities operating in Ontario.

# TAB #5



## Sampling & Analysis of Hydrocarbon Contaminated Groundwater

### DESCRIPTION:

Based on the results of geophysical and soil vapour surveys, monitoring wells and piezometers are placed in strategic positions, and representative ground-water samples are collected and analyzed. The objective of a ground-water monitoring program is to identify, interpret and track the movement of a contaminant plume so that a comprehensive remediation program can be implemented if deemed necessary.

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This TAB is intended to outline proper procedures for sampling and analysis of hydrocarbon contaminated groundwater. These procedures are also applicable to groundwater monitoring programs for contaminants other than hydrocarbons, although there may be variations in the analytical methods and parameters used for other programs. For additional parameters, we recommend that the CCME Interim Environmental Quality Criteria for Contaminated Sites document be consulted, along with other federal and provincial regulations, guidelines, and codes of practice.

**Note:** In the text, the term "monitoring wells" refers to both "wells" and "piezometer stand-pipes".

### 1. MONITORING WELL LOCATION

Monitoring well location is a function of the site's **flow conditions and the distribution of contaminant source(s)**. The best location for wells is determined by utilizing site screening methods which would identify and delineate the general extent and location of contamination (refer to **TABs #2 and #3**).

Once contamination "hot spots" have been identified, wells may then be confidently placed to obtain representative results. The wells are then used to develop a 3-Dimensional geological and hydrological model of the site.

The number of wells required for a monitoring program is entirely site dependant, but a minimum of 3 is needed, and can range up to 200 or more wells for a 20 hectare site. **At least 1 well should be installed upstream of the contamination to provide baseline water quality information for the site.**

Linear alignment of wells should be avoided unless they are along an identified bedrock fracture.

Since comprehensive groundwater remediation is dependant on removal of contamination from the **vadose zone** (the water suspended in the soils above the water table), well location should enable monitoring of this zone to determine its level of contamination.

## **2. SAMPLING QUALITY ASSURANCE AND QUALITY CONTROL**

Sample collection is often the greatest source of error in groundwater monitoring data. Therefore, a proper Quality Assurance/Quality Control (QA/QC) program should be established in order to ensure that data obtained are **accurate and representative** of actual groundwater conditions.

**Quality Control** is the set of procedures used to measure and correct data quality. **Quality Assurance** is the set of procedures used to provide documentary assurance of the proper application of the methodologies used in the sampling program and in the laboratory analysis before any field investigations commence. It is the development of a sampling protocol-a written description of the detailed sampling procedures that should be followed throughout the program. The protocol should contain the following elements, which are described later in greater detail:

- Sampling locations (use a map).
- Sample collection methods.
- Equipment used, and methods for calibration, maintenance and decontamination procedures.
- Use of quality control samples.
- Type, number, and size of sample containers to be used.
- Sample volumes to be collected.

- The sampling order (least to most contaminated).
- Preservation instructions.
- Procedures for minimizing sample aeration and air contact (oxygen may affect the sample).
- Documentation requirements for well sampling records and sample log records.
- Procedures for maintaining chain of custody records.
- Plans for storage and transportation of samples.

### **(2a) Quality Control Samples**

**I) QC Duplicates:** A second complete set of samples should be collected from each monitoring well during the same sampling trip, to provide confirmation of contamination levels. One set of duplicates should be collected for each set of samples, or for large sets, one set for every **20 samples**.

**II) Blanks:** Three types of quality control blanks are used during sampling. (Trip Blanks, Field Blanks, and Equipment Blanks; refer to **TAB #4**)

Prepare a blank of each type for each sample set, or for large sets, one each for every 20 samples.

**III) Spikes:** Spiked samples which are prepared in the field at the time of sample collection provide a quantitative measure of analyte loss by microbial degradation, volatilization, adsorption by sampling equipment, and other mechanisms. To avoid cross-contamination, spiked samples should not be transported in the same cooler as the field samples.

Samples are prepared by adding a known mass of the target compounds or elements of interest to a known volume of contaminant-free water. The concentration levels of target compounds should be about **10 times** the analytical detection limit. The concentration of target compounds in spiking solutions and their stability must be independently verified.

Both blanks and spikes should be available from the laboratory, which will perform the analyses.

**IV) Control Site Samples:** Control site samples are analyzed to determine background contamination levels of the groundwater for comparison with other contaminated wells. Control site samples are obtained from at least 1 well, which is installed upstream from the contaminated area and provides baseline water quality information for the site. The well should draw water from the same aquifer that is

contaminated. The control site samples should be taken at the same time as other samples.

#### **V) Identification of Quality Control Samples:**

Each quality control sample should be assigned a unique number in the same sequence as the field samples, with the details of each sample recorded on a **Sample Log Record**.

#### **(2b) Record Keeping and Documentation**

**I) Well Sampling Record:** The Well Sampling Record should be completed, signed, dated and kept in the site sample files. This record, documents the condition of the well at the time of sample collection and is used to corroborate sample data. Additionally, items on this record may lead to follow-up actions (e.g. the provision of a well label or the removal of accumulated silt in the well).

**II) Sample Log Record:** This record should be kept in the site sample files, and should contain the following:

1. The sampling site name.
2. The signature(s) of the sample collector(s).
3. The well identification number.
4. The unique sample number.
5. If the sample is a field sample, QC duplicate, blank, spike, or control site sample.
6. The sampling date and time.
7. The type of analysis required for the sample.
8. If the sample is a composite or grab.
9. The type of preservative added to the sample (if required).
10. The temperature at which the sample was preserved.
11. If the sample was filtered.

**III) Chain of Custody Record:** Chain of custody is a mechanism for ensuring that data from the analysis of a sample is credible and defensible. Chain of custody records provide a record of all the personnel responsible for handling the samples. This record contains all information necessary for the proper tracking of field and blank samples from the time of their collection until the time of laboratory analysis and reporting. These records **must** accompany the samples at all times.

**Note:** *Samples should change hands as few times as possible on their way to the laboratory. Chain of custody records should be available from the laboratory which performed the analysis. Refer to **TAB #4** for a recommended format.*

#### **Procedures**

1. Chain of custody begins at the time and point of sample collection.
2. After both field and blank sample bottles have been filled, preserved (if required), and sealed, affix a signed and dated chain of custody seal, if available, across the sample cap, over-lapping the joints between the cap and container. The seals should be available from the laboratory that will perform the analysis.
3. Record the sample number and other appropriate information on the **Chain of Custody Record** and always record transfer of custody with your signature, the signature of the person receiving the sample, the date, and time. Retain an original of this record with site sample files.
4. Samples must be secure during storage and transport. Affix signed and dated chain of custody labels to shipping containers over-lapping container cover joints.
5. Chain of custody must be maintained until completion of the analysis of a sample and the reporting of analytical results.
6. The chain of custody record should be kept in the site sample files.

#### **3. PLANNING A SAMPLING TRIP**

1. Ensure that you have legal authorization to enter a property and collect samples.
2. Notify the property owners and appropriate parties when samples will be collected.
3. Check with laboratory personnel to arrange for analyses within the appropriate sample holding times. Pick up all necessary sample bottles, trip blanks, and blank water for preparation of field and equipment blanks.
4. Ensure that the samples are properly and carefully preserved.
5. Plan how and when the samples will get back to the laboratory as quickly as possible. Make shipping arrangements if the samples will need to be shipped.
6. Obtain a site map identifying well locations to ensure that wells can be found under snow-banks or tall grass.
7. Know the diameter of wells being sampled to enable sampling equipment, of the proper size, to be available.
8. Choose the order of sampling to minimize potential cross-contamination. **The least-contaminated wells should be sampled first**, beginning with the baseline well. Base the order

on past sampling trips, or if unsure, use your best judgement.

9. Prepare as much of the sample documentation as possible before the sampling trip (e.g. Well sampling records, sample log records).

#### 4. PRE-TRIP EQUIPMENT DECONTAMINATION

All field equipment that will come in contact with samples must be thoroughly cleaned prior to use to prevent inadvertent sample contamination from used equipment.

##### **Procedures**

1. Disassemble equipment.
2. Submerge and clean equipment in solutions of phosphate-free laboratory detergent. It is not recommended that solvents be used for equipment cleaning since they are expensive, toxic, and the residues left on equipment can severely contaminate samples. Steam cleaning is a viable alternative.
3. Rinse equipment with tap water, followed by 3 separate rinses with distilled deionized water.
4. Seal and label clean and dried equipment in new polyethylene bags, noting the date, equipment contained, decontamination procedure, and person performing the decontamination.
5. If possible, dedicate one set of sampling equipment per well to minimize potential cross-contamination.
6. **Do not use lubricants** on the drill bits and rods that are used to excavate boreholes. Only non-petroleum vegetable oil based lubricants should be used on the external surfaces of the drilling equipment that may come into contact with the drill rods. After each borehole is extracted, the augers, bits, and rods used during the drilling should be washed with lab detergent, then rinsed thoroughly with **deionized rinse water**.

#### 5. SAMPLE CONTAINERS

Sample container and cap selection for groundwater collection depends on the parameters to be analyzed for. Refer to **TABLE 2** for the volume of sample containers required and the proper container and cap material required for specific sampling parameters. The laboratory that will perform the analysis should be able to provide proper sampling containers. It is recommended that amber glass bottles (if available) be used for sampling for organics.

## 6. SAMPLING PROCEDURES

### (6a) Water Level Measurements

Water level measurements are the basic data of any hydrogeological investigation, and are relatively easy to perform. Results from the following procedures should be recorded on the **Well Sampling Record**.

#### Procedures

##### *With Electric Water Level Gauge*

1. Turn meter on and lower the probe sensor down the well until the light or buzzer goes on.
2. Slowly reel in the probe until the light or buzzer goes off. This is the water level. Record the depth to the water level from the top of the well casing or protective casing, which ever has been or will be surveyed in to a common datum for all local wells (mark the measuring point for future use).
3. Raise the probe a little, then lower again. Check your measurement.
4. Turn the meter off.
5. Reel out the line until it goes limp. Measure this depth-it is the depth of the well. Check this depth against the well label, and determine if silting has occurred - make a note of this.
6. Reel in the line remembering to wipe off water, oil, and rust with a rag, sorbent pad, or paper towel.
7. If you have been following the correct sampling order (least to most contaminated), and you will purge the well, there is no need to decontaminate the measuring equipment until you get home. Otherwise, clean the meter thoroughly as detailed in *Field Decontamination of Equipment* section.

##### *With Weighted Steel Tape*

1. Chalk the bottom 0.5 meter or more, of the tape.
2. Reel out the tape while listening for a "plop" as the weight hits the water (little noise will be made with a pointed weight). Then drop the weight about another 0.25 meters.
3. Record the depth from the top of the well casing or protective casing, which ever has been or will be entered into a common datum for all local wells (Mark the measuring point for future use). Do not raise and re-lower.
4. Reel in the tape, note where the water has wetted the chalk dust. Subtract this level from the depth

measurement in Step 3 above. This is the depth to the water level.

5. Perform steps 5, 6, & 7 as in previous section.

### **(6b) Free Product Sampling**

If there are any oil traces or odour on the probe of the water level meter or steel tape, leave sampling of this well until last. Then return to measure the thickness of the free product layer and to collect a sample of this material. Free product is collected to determine the identity and concentration of contaminant. Free product sampling is necessary to assess the need for product recovery systems and to possibly determine the specific source of the product leak.

#### **Equipment**

- Interface probe or steel tape, chalk, and water finding paste.
- A clear plastic bailer and nylon cord.
- A 10 ml. pipet and a pipet bulb.
- Clean gloves should be worn by the person collecting the sample. Gloves should be changed for each well.

#### **Procedures**

##### **I) Determine Free Product Thickness**

###### ***Using Interface Probe***

1. Lower the probe into the well until it beeps and record the depth from the top of the well casing or protective casing, whichever has been or will be entered into a common datum for all local wells (mark the measuring point for future use).
2. Lower the probe again until it beeps continuously. Record the depth again. The difference between the two measurements is the free product layer thickness.
3. Record the free product thickness on the Well Sampling Record.

###### ***Using Tape and Water Paste***

1. On opposite sides of the bottom 0.5 meters or more of a weighted steel tape, apply chalk and water finding paste.
2. Carefully lower the tape to about 7 or 8 cm. Below the previously determined water level. Remove the tape from the well and compare the chalked and water paste sides. The difference between the 2 measurements is the free product layer thickness.

3. Record the free product thickness on the Well Sampling Record.

##### **II) Sample Collection of Free Product:**

1. Carefully lower a Teflon® or PVC lined "bottom delivery" type bailer to the product layer (determined from previous measurements), then lower an additional 15 cm.
2. Withdraw the bailer, measure and record the oil thickness.
3. Transfer (using the pipet and pipet bulb) free product to a 40 ml. Septum vial filling it half full with product (do not completely fill the vial as thermal expansion could cause it to burst). It is a good practice to collect all samples in duplicate. Immediately seal, wipe, and label the vial and store in a separate sample cooler to avoid cross-contamination. Remember to affix a chain of custody seal across the sample cap, overlapping the joints between the cap and container.
4. Assign the samples a unique sample number, with the details of each sample recorded on a **Sample Log Record**.
5. Do not store free product samples in the same container as water samples since cross contamination may occur.

##### **(6c) Purging the Well**

Wells may need to be purged prior to ground-water sampling to remove stagnant water and/or free product to ensure that samples collected are representative of aquifer conditions.

#### **Equipment**

- Pump or bailer, or point-source sampler.

#### **Procedures**

##### ***When not to purge***

This procedure is most useful for monitoring wells set in coarse-grained deposits.

1. Representative samples of groundwater can be collected without well purging if devices such as submersible bladder or inertial pumps are used. Dedicated submersible pumps allow sample collection within the screened interval and which do not disturb stagnant water at the air-water interface.
2. Obtain a sample from the screened interval of the well by inserting the pump intake to that depth, and pumping slowly to remove water from the

screened zone. This procedure is especially useful for wells equipped with dedicated pumps.

### ***When to Purge***

Purging is essential for sand-packed wells set in moderate to low permeability formations.

1. Continuously measure temperature, pH, and conductivity of the purged water. Continue to purge until those parameters stabilize.
2. If purge waters smell of petroleum product, collect and dispose of them properly. Otherwise, it is safe to discard them on the ground in an area of known contamination.

### **(6d) Grab & Composite Samples**

#### **I) Grab Samples:**

These are samples collected in a short period of time (a few seconds) and are typically less expensive than composite samples. They represent a "snapshot" of the water quality at a specific place and time. If sampling for volatile hydrocarbons, a grab sample must be obtained to avoid loss of volatile compounds during the composite process. There are 2 kinds of grab sampling:

1. **Discrete**-A sample that is taken at a selected depth and time.
2. **Depth-Integrated**-A sample that is collected over a predetermined portion or the entire depth of the water column at a selected time.

#### **II) Composite Samples:**

These are samples that combine portions of multiple grab samples. There are 2 kinds of composite sampling:

1. **Sequential**-A sample made by continuous, constant mixing of equal water volumes collected at regular time intervals.
2. **Flow Proportional**-A sample made by mixing volumes of water proportional to the volume of water flow collected during regular time intervals.

Usually composite sampling is chosen to provide a more representative sample of heterogeneous water conditions.

**Note:** *Composite sampling should not be used for volatile organics.*

### **(6e) Fundamental Sample Collection & Preservation Procedures**

The following procedures should be followed for all sampling events in order to maintain sample integrity between the time of sample collection and the time of analysis.

#### **Procedures**

1. Clean gloves should be worn by the person collecting the sample. Gloves should be changed for each well.
2. **TABLE 2** shows the volume of sample container, the type of container and the cap material to be used for sample collection. Amber glass bottles are recommended for samples for organic analysis to minimize the potential for photochemical oxidation.
3. **Minimize sample aeration and air contact** to avoid loss of volatile compounds.
4. Samples should be collected when the temperature, pH, and conductivity of the ground water, being pumped, have stabilized.
5. If preservation is required, preservatives should be added to the vial before the sample is collected except when collecting samples in polyethylene bottles for metals analysis. In this instance, nitric acid (HNO<sub>3</sub>), used for preserving samples for metals analysis, should be added after the sample is placed in the polyethylene bottle. If a glass bottle is used for collecting samples for metals analysis, then the nitric acid should be added before the sample is collected.
6. Petroleum hydrocarbons should be preserved immediately through the use of acids or toxicants to prevent microbial activity. Do not filter samples requiring analysis for metals or organics, and only use preservatives whose purity have been certified.
7. If preservatives are added to samples, then also add the preservative to the field blanks.
8. Immediately seal the container after sample collection and preservation (if necessary).
9. Assign the samples a unique sample number, with the details of each sample recorded in the **Sample Log Record**. Remember to affix a chain of custody seal across the sample cap, overlapping the joints between the cap and container.
10. Keep samples cool (4°C) and in the dark. Use ice cubes or crushed ice to chill samples as soon as they are collected, and ice packs to maintain internal temperatures in shipping containers.
11. Do not ship free product samples in the same container as water samples since cross contamination may occur.
12. Deliver samples to the laboratory as soon as possible after collection, noting the recommended

**Maximum Holding Times (MHT).** The MHT is the length of time a sample can be stored after collection and preservation, and before preparation and analysis without significantly affecting the integrity of the sample and the analytical results.

Refer to **TABLE 2** for preservation specifications and maximum holding times.

### **(6f) Volatile Hydrocarbon Sample Collection**

This method is used when the contaminant is a volatile hydrocarbon, such as gasoline or light heating oil, and when collecting samples for analysis of volatile compounds. Volatile hydrocarbon compounds include **BTEX** (Benzene, Toluene, Ethylbenzene, Xylene), and **TPH**-gasoline (Total Petroleum Hydrocarbons-gasoline). Sampling for both volatiles and semi-volatiles may be necessary when the contaminant is unknown, or there is a combination of contaminants.

#### **Collection Notes**

- Do not vacuum filter or use suction pumps while sampling for volatiles.
- Samples requiring analysis for organics should not be filtered.
- For wells with slow recovery rates that do not allow for well stabilization, water samples that are to be analyzed for volatile hydrocarbons must be collected within 2 hours after well excavation.
- All samples for volatile hydrocarbons analysis should be preserved immediately with Hydrochloric Acid (HCl) upon collection.

#### **Sample Collection**

##### ***Procedure 1:***

Use this procedure if the well is not purged, and is equipped with a dedicated submersible pump or if a submersible bladder or inertial pump can be gently lowered to screen level.

1. Pump sample directly into a vial, minimizing aeration, until it overflows. Seal immediately with a Teflon® lined cap. Fill 2 such vials (1 is a QC duplicate).
2. Invert and tap the vials to see if air bubbles have been trapped inside. If there are bubbles, discard the sample and refill the vial so that no air bubbles are trapped.
3. Assign the samples a unique sample number, with the details of each sample recorded in the

**Sample Log Record.** Remember to affix a chain of custody seal across the sample cap, overlapping the joints between the cap and container.

##### ***Procedure 2:***

Use this procedure if the well is purged and sampling is by bailer. The bailer should be a Teflon® or PVC lined "bottom delivery" type bailer, which allows vials to be filled with a minimum amount of sample aeration and air contact.

1. Purge the well and allow re-charge.
2. Attach a clean nylon cord or mono-filament to the bailer and carefully lower it to about midway between the water surface and the bottom of the well.
3. Withdraw bailer, and insert bottom-emptying device.
4. Fill 2 vials, following Steps 1, 2, and 3 for Procedure 1.
5. The nylon cord or mono-filament lines should be discarded before proceeding to the next well.

### **(6g) Semi-Volatile Hydrocarbon Sample Collection**

This method is used when the contaminant is semi-volatile hydrocarbon, such as a middle distillate fuel, fuel oil residual fuel, or a waste oil, and when collecting samples for analysis of semi-volatile compounds. Semi-volatile hydrocarbon compounds include TPH-fuel oil (Total Petroleum Hydrocarbons-fuel oil), **phenols**, and **PAHs** (Polycyclic Aromatic Hydrocarbons). Sampling for both volatiles and semi-volatiles may be necessary when the contaminant is unknown, or there is a combination of contaminants.

#### **Procedures**

1. Collect samples for semi-volatile analysis after samples for volatiles analysis have been secured.
2. Using the same groundwater collection method used for volatile hydrocarbons (i.e. Bailer or pump) fill an amber glass sample bottle to the shoulder leaving approximately 5 cm. headspace. Immediately seal with a Teflon® lined cap.
3. Assign the Samples a unique sample number, with the details of each sample recorded in the **Sample Log Record**. Remember to affix a chain of

custody seal across the sample cap, overlapping the joints between the cap and container.

### **(6h) General Water Quality Sample Collection**

This method is used when sampling for general water quality parameters, such as metals and PCBs, which do not require special handling procedures.

#### **Procedures**

1. Collect general water quality samples using the same groundwater collection method as used for volatiles and semi-volatiles (i.e. bailer or pump) but collect after samples for volatile and semi-volatile hydrocarbons have been secured.
2. It is recommended that unless absolutely necessary, samples for organics and metals should not be filtered in order to maintain consistency between sample handling for inorganics and organics, and to provide proper analytical results.
3. Assign the samples a unique sample number, with the details of each sample recorded in the **Sample Log Record**. Remember to affix a chain of custody seal across the sample cap, overlapping the joints between the cap and container.

### **(6i) Sampling Spring and Seeps**

#### **I) Springs:**

- There is no need to purge springs, and no special sampling equipment is required.
- Collect samples from the point closest to where the water comes out of the ground, using the appropriate sample bottles and vials (refer to **TABLE 2**).
- Assign the samples a unique sample number, with the details of each sample recorded in the **Sample Log Record**.

#### **II) Seeps:**

- Dig out seeps, and let them flow until the water runs clear. If necessary, install a well screen in the middle of the seep, develop it, and come back the following day when the water has cleared.
- Collect your samples with the appropriate sample bottles and vials from the point closest to where the water emerges from the ground.
- Sometimes, the flow of water in seeps may be slower than the rate of volatilization of organic contaminants, so interpret results with caution.

It may be worth returning to the seep after the occurrence of a wet spell.

- Assign the samples a unique sample number, with the details of each sample recorded in the **Sample Log Record**.

### **7. FIELD DECONTAMINATION OF EQUIPMENT**

Field decontamination of equipment is necessary so that contamination from one well does not bias succeeding samples.

#### **Equipment**

- 2 garden hand-pump sprayers
- Fill one with laboratory detergent solution (do not use solvents) in clean tap water.
- Fill the other with deionized rinse water. Spare soap and rinse water (3 litres of each per well is usually adequate).
- Buckets.

#### **Procedure for Pumps**

1. Before the water dries on the pump, thoroughly spray the outside of both the pump and lines with soap solution, then rinse with deionized rinse water.
2. Fill a bucket with 3 litres of soap solution and pump it through the lines. Follow that with the 3 litres of deionized rinse water.
3. Collect the last rinse water of your worst well as an equipment blank. It will tell you how good your decontamination practice is.

#### **Procedure for Bailers**

1. Take the bailer apart in sections.
2. Spray it inside and out with soap solution. Repeat.
3. Rinse it inside and out twice with deionized rinse water.
4. Collect the last rinse water of your worst well as an equipment blank.

#### **Keeping Equipment Clean**

After the equipment is cleaned, do not allow it to lie on the ground or on any other surface which may be contaminated. If necessary, use a clean plastic sheet to protect cleaned equipment.

### **8. ANALYTICAL PROCEDURES**

#### **(8a) What to Analyze For**

Petroleum products vary in composition, and accordingly, different petroleum products must be



analyzed for different parameters. To determine what parameters to analyze for and how many sample containers are required (excluding QC duplicates), refer to **TABLE 1**.

b) Personnel responsible.

### **(8b) Analytical Methods**

There are often several acceptable analytical methods for measuring the recommended parameters. Refer to **TABLE 2** for suggested EPA analytical methods for the recommended parameters.

### **(8c) Analytical Quality Assurance/Quality Control**

#### **QA/QC of Laboratory Work:**

The laboratory conducting the analysis should follow proper QA/QC procedures. Prior to sampling, the laboratory should provide the following information:

1. Laboratory storage and sampling procedures.
2. Turnaround times from the receipt of samples to analysis of samples, and finally to the reporting of data.
3. Maximum holding times of samples according to approved methodologies.
4. Laboratory analytical methods, including integrity of data in terms of precision, accuracy, completeness, and comparability. Identify specific parameters for each method. If other methods are proposed, provide justification.
5. Preparation of reagents and deionized water.
6. Complete itemization of laboratory equipment.
  - a) Specific name and model of equipment used.
  - b) Maintenance schedules.
  - c) Calibration procedures in terms of accuracy, precision and references, and the frequency of calibration of equipment.
7. Detection limits achievable according to methods and equipment used.
8. Preventative maintenance.
9. Corrective action.
10. Personnel.
  - a) Credentials.
  - b) Sample custodian(s).
11. Building or cooler security.
12. Routine assessment of data precision, representativeness, comparability, accuracy, and completeness of specific measurement of parameters involved.
  - a) Methodology.

**TABLE 1: ANALYTICAL PARAMETERS & CONTAINER REQUIREMENTS**

Petroleum Product	Parameters to be Analyzed	No. of Sample Containers (not including QC duplicates)
• Unleaded gasoline	A, B	2 (40 ml)
• Regular gasoline, aviation gasoline	A, B, D	2 (40 ml); 1 (1000 ml)
• Fuel oil (any grade), diesel fuel, kerosene, jet fuels, mineral oil/spirits	A, C, H	2 (40 ml); 1 (1000 ml)
• Petroleum solvents	A, C, G	2 (40 ml); 1 (1000 ml)
• Waste oil, any waste petroleum product	A, C, E, F, G, H	2 (40 ml); 4 (1000 ml)
• Unknown petroleum or hydrocarbon mixture	A, B, C, E, G, H	3 (40 ml); 3 (1000 ml)
• Crude oil, hydraulic fluids	C, H	1 (40 ml); 1 (1000 ml)
• Coal gasification	H	1 (1000 ml)

A = Benzene, Ethylbenzene, Toluene, Xylene (BETX)      E = Lead, Chromium, Cadmium  
 B = Total Petroleum Hydrocarbons (TPH) - Gasoline      F = Polychlorinated Biphenyls (PCBs)  
 C = Total Petroleum Hydrocarbons (TPH) - Fuel Oil      G = Phenols  
 D = Lead      H = Polycyclic Aromatic Hydrocarbons (PAHs)

**TABLE 2: SAMPLE COLLECTION AND ANALYTICAL PROCEDURES**

PARAMETER	BTEX	TPH-GASOLINE*	TPH-FUEL OIL*+	PHENOLS (total)	METALS (total)	PAHs	PCBs	FREE PRODUCT
Container Volume	40 ml	40 ml	40 ml	1000 ml	1000 ml	1000 ml	1000 ml	40 ml
Container/Cap Material	Amber glass bottle with teflon®-lined cap	Amber glass bottle with teflon®-lined cap	Amber glass bottle with teflon®-lined cap	Amber glass bottle with teflon®-lined cap	Polyethylene or glass bottle with polyethylene cap	Amber glass bottle with teflon®-lined cap	Amber glass bottle with teflon®-lined cap	Amber glass bottle with teflon®-lined cap
Preservation (type & temp.)	Cool 4°C & HCl to pH2	Cool 4°C & HCl to pH2	Cool 4°C & HCl to pH2	Cool 4°C	HNO <sub>3</sub> to pH ≤ 2	Cool 4°C, store in the dark	Cool 4°C	Cool 4°C & HCl to pH2
Max. Holding Time	7 days without HCl, 14 days with HCl	7 days without HCl, 14 days with HCl	7 days without HCl, 14 days with HCl	7 days until extraction, 40 days after extraction	6 months	7 days until extraction, 40 days after extraction	7 days until extraction, 40 days after extraction	7 days without HCl, 14 days with HCl
Recommended Analytical Method(s)	Purge and Trap GC/PID or GC/FID	Purge and Trap GC/PID, or GC/FID	Direct Injection GC/PID, or GC/FID	Liquid-Liquid Extraction GC/FID	Acid Digestion AA, Furnace Technique	Liquid-Liquid Extraction HPLC/Fluorescence */or UV detectors (do not use GC)	Liquid-Liquid Extraction GC/ECD	Direct Injection GC/PID, or GC/FID
Recommended EPA Method	5030, 502.2, 503.1, 8020	5030, 502.2, 503.1, 8020	502.2, 503.1	3510, 3520, 604, 8040	3020 <sup>1</sup> , 7131 <sup>2</sup> , 7191 <sup>3</sup> , 7421 <sup>4</sup>	3510, 3520, 610, 8310	3510, 3520, 608, 8080	502.2, 503.1

\* Total purgeable plus total extractable hydrocarbons.  
 + TPH Fuel Oil includes: fuel oils, diesel fuel, jet fuels, kerosene, mineral oil/spirits, motor oil, & crude oil  
<sup>1</sup> = (Acid Digestion, use for all metals)  
<sup>2</sup> = (for total cadmium)  
<sup>3</sup> = (for total chromium)  
<sup>4</sup> = (for total lead)

BTEX = Benzene, Toluene, Ethylbenzene, Xylene  
 TPH = Total Petroleum Hydrocarbons

PAH = Polycyclic Aromatic Hydrocarbons or Polynuclear Aromatic Hydrocarbons  
 PCB = Polychlorinated Biphenyls  
 HCL - Hydrochloric Acid  
 HNO<sub>3</sub> = Nitric Acid  
 GC = Gas Chromatography  
 PID = Photoionization Detector  
 FID = Flame Ionization Detector  
 AA = Atomic Absorption  
 HPLC = High Pressure Liquid Chromatography  
 ECD = Electron Capture Detector

To support the QA/QC program, sample results from the laboratory should be returned with the following documentation:

1. Unique sample number.
2. The media being sampled (in this instance, water).
3. The date and time that the analysis was begun and completed.
4. Laboratory and analyst's name.
5. Method of analysis.
6. Calibration charts and other measurement charts.
7. Method of detecting limits.
8. Confidence limits.
9. Records of calculations.
10. Actual analytical results.
11. Results of field quality control samples.
12. Auxiliary data (laboratory QA/QC data).
13. Assessment of data.

To avoid laboratory bias during analysis, the only

information that the laboratory should be provided with, is the sample number.

### (8d) Remediation Criteria for Contaminated Sites

The analytical results from the laboratory should be checked against the CCME Interim Canadian Environmental Quality Criteria for Contaminated Sites to determine if remedial action is necessary.

**TABLE 3** summarizes the recommended remediation criteria levels for contaminated groundwater.

**TABLE 3: GROUNDWATER REMEDIATION CRITERIA**

all values are µg/L (ppb) unless otherwise indicated

Parameter *	Freshwater Aquatic Life	Drinking Water
<b>METALS</b>		
Cadmium	0.2-1.8	5
Chromium	2-20	50
Lead	1-7	10
<b>PCBs</b>	1 ng/L (ppt)	---
<b>BETX</b>		
Benzene	300	5
Ethylbenzene	700	≤2.4
Toluene	300	≤24
Xylene	---	≤300
<b>PHENOLS (total)</b>	1	---

Parameter	Level I**	Level II**	Level III**
<b>TPH - Gasoline ***</b>	200	50,000	200,000
<b>TPH - Fuel Oil ***</b>	200	50,000	200,000

  

Parameter	A****	B****	C****
<b>PAHs</b>			
• Group 1 - carcinogenic PAH	0.01	0.1	1
• Group 2 - other PAH	0.2	2	20

\*CCME (1991) "Interim Canadian Environmental Quality Criteria for Contaminated Sites". For other parameters, consult this document

\*\*Alberta MUST (1990) "Subsurface Remediation Guidelines for Underground Storage Tanks - Draft" (refer to this document for the application of the "Level I, II, III" guidelines)

Level I = High Sensitivity Sites      Level II = Moderate Sensitivity Sites      Level III = Low Sensitivity Sites

\*\*\*Represents total purgeable plus total extractable hydrocarbons

\*\*\*\*CCME (1989) "Interim Guidelines for PAH Contamination at Abandoned Coal Tar Sites" (refer to this document for specific chemical parameters found in Group 1 and Group 2, and for the application of the "A, B, C" guidelines).

A = Low contamination (drinking water criteria)

B = Intermediate contamination

C = Significant contamination (ground water cannot be used for drinking)

## SOURCES

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