

## **SPECIALIZED TESTING REQUIREMENTS TO MEET THE BC CONTAMINATED SITES REGULATION**

Brent D. Mawdsley, B.Sc.

ASL Analytical Service Laboratories Ltd.  
1988 Triumph St., Vancouver, BC V5L 1K5

### **ABSTRACT**

British Columbia's *Contaminated Sites Regulation* requires the use of several specialized laboratory testing procedures that determine to what degree a site is contaminated. The results of these analyses can have a significant impact on mine decommissioning projects.

Several of these tests are the same as those required for regular environmental monitoring programs. However, the testing for hydrocarbon contamination has been recently revised and more changes are expected in the summer of 1999. Hence, hydrocarbon analysis and interpretation of data are a source of confusion to other industry sectors.

This paper outlines the testing requirements of the BC Contaminated Sites Regulation in relation to mine decommissioning with emphasis on clarifying the hydrocarbon testing procedures. It also addresses issues pertaining to analytical variability that can have a significant effect on data interpretation.

### **INTRODUCTION**

British Columbia's *Contaminated Sites Regulation* (BC Reg. 375/96 deposited December 16, 1996 and effective April 1, 1997) provides detailed rules to complement the contaminated sites provisions in the *Waste Management Act* (RSBC 1996 Chapter 482). The *Contaminated Sites Regulation* (CSR) helps determine if a site is contaminated by providing numerical standards for acceptable concentrations of substances in soil, surface water and groundwater, for specific land and water use categories. One of the land uses is industrial, which includes mines.

Several specialized laboratory testing procedures are required to determine to what degree a site is contaminated. Since the results of these analyses can have a significant impact on mine decommissioning projects, anyone dealing with these issues should have a basic understanding of these tests and what the results mean.

Several tests are the same as those required for established environmental monitoring programs and so will be familiar to the mining industry. However, the test methods and parameter definitions for hydrocarbon

contaminants have been recently revised and more changes are expected by the end of 1999. Hence, hydrocarbon analysis and interpretation of data are a source of confusion to many industry sectors.

## **ANALYSES REQUIRED BY THE *CONTAMINATED SITES REGULATION***

The *Contaminated Sites Regulation* lists parameters of concern and the associated numerical standards for various types of land and water use. Soil standards for agricultural, commercial, industrial, urban park, and residential land use are listed in Schedules 4 and 5; water standards for aquatic life, irrigation, livestock, and drinking water use are listed in Schedule 6.

Major classes of parameters listed in the *Contaminated Sites Regulation* are shown below. This is a summary of all parameters listed in the Regulation and some of these parameters apply to soils or waters only (see the *Contaminated Sites Regulation* for details).

- Inorganic Substances
  - Metals (aluminum, arsenic, antimony, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, sodium, thallium, tin, uranium, vanadium, and zinc)
  - Anions (chloride, fluoride, nitrate, nitrite, sulphate, and sulphide)
  - Cyanide (weak and strong acid dissociable)
  - Other (ammonia, chlorine and elemental sulphur)
- Organic Substances
  - Petroleum Hydrocarbons (VPH, LEPH, HEPH)
  - Monocyclic Aromatic Hydrocarbons (MAH) (benzene, toluene, ethylbenzene, xylenes and styrene)
  - Polycyclic Aromatic Hydrocarbons (PAH) (acenaphthene, acridine, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, and pyrene)
  - Phenolic Substances (chlorinated and nonchlorinated)
  - Polychlorinated Biphenyls (PCB)
  - Chlorinated Hydrocarbons
  - Pesticides

- Phthalate Esters
- Dioxins and Furans
- Miscellaneous (nonaqueous phase liquids and odorous substances)
- Radioactive Substances

Many of the inorganic parameters are similar to those used in environmental baseline and permit monitoring programs for the mining industry. For contaminated sites projects, however, a large focus has been on hydrocarbon contamination. These testing requirements have been a source of confusion to industry in general; therefore, this paper further addresses the relevant terminology and analysis methods.

## **PETROLEUM HYDROCARBON PARAMETERS**

Petroleum hydrocarbons are a broad class of organic compounds containing only carbon and hydrogen atoms. Their molecular structure may consist of straight chains of carbon atoms with only single bonds (aliphatic compounds), double and triple bonds (olefinic compounds), or ring-like structures (aromatic compounds). They are commonly defined by "products" such as crude oil, bunker oil, lubrication oils (motor oil and greases), middle distillates (heating, diesel and jet fuels), and gasoline (automotive and aviation).

Petroleum hydrocarbon parameters in the *Contaminated Sites Regulation* consist of specific, aggregate, and calculated parameters. Definitions of these parameters are summarised in Table 1.

Specific or "target" parameters are individual compounds that can be quantified against known amounts of the same individual compound. The specific petroleum hydrocarbon parameters listed in the Regulation are: benzene, toluene, ethylbenzene, xylene, styrene and individual polycyclic aromatic hydrocarbon (PAH) compounds.

Aggregate parameters consist of a number of compounds that are not individually identified or quantified. Therefore, they are defined by the method used to analyse them. The aggregate petroleum hydrocarbon parameters required by the Regulation are: Volatile Hydrocarbons (VH) and Extractable Petroleum Hydrocarbons (EPH). These parameters are not specifically listed in the Schedules to the Regulation but are defined in the relevant laboratory methods and are required to calculate some of the regulated parameters. The tests are sometimes used as "screening" methods.

TABLE 1: Petroleum Hydrocarbon Parameters Listed in the BC Contaminated Sites Regulation (CSR)			
Acronym	Parameter Name	Definition	Notes
<b>BTEX &amp; S</b>	Benzene, Toluene, Ethylbenzene, Xylenes & Styrene	Specific Monocyclic Aromatic Hydrocarbons (MAH) listed in the CSR	Toxic compounds commonly found in gasoline.
<b>VH</b>	Volatile Hydrocarbons	The collective (or aggregate) concentration of hydrocarbon compounds which elute between n-hexane (C6)* and n-decane (C10) on a specific type of GC column. This hydrocarbon range includes BTEX & S.	Includes "lighter" hydrocarbon products like gasoline, mineral spirits, and paint thinners.
<b>VPH</b>	Volatile Petroleum Hydrocarbons	Calculation: $VPH = VH_{6-10} - \sum BTEX$ (& S for soils only) The same sample extract (soils) or aliquot (waters) should be used to determine VH and BTEX & S.	BTEX & S are excluded from VPH to avoid "double counting" because they are specifically regulated under the CSR.
<b>EPH</b>	Extractable Petroleum Hydrocarbons	The collective (or aggregate) concentration of all hydrocarbon compounds which elute in the range C10 - C32 on a specific type of GC column. This result is divided into two boiling point ranges (C10 - C19) and (C19 - C32). These hydrocarbon ranges include several PAH compounds.	EPH <sub>10-19</sub> includes products like diesel, kerosene, and jet fuel. EPH <sub>19-32</sub> includes products like lubricating oils, greases, hydraulic oils, and waxes.
<b>PAH</b>	Polycyclic Aromatic Hydrocarbons	Specific Polycyclic Aromatic Hydrocarbon (PAH) compounds listed in the CSR.	Toxic compounds commonly found in coal tar distillate, charred wood, asphalt, creosote, crude oil, bunker oil, and diesel.
<b>LEPH</b>	Light Extractable Petroleum Hydrocarbons	Calculation: $LEPH = EPH_{10-19} - \sum \text{specific "light" PAHs listed in the CSR}$ $HEPH = EPH_{19-32} - \sum \text{specific "heavy" PAHs listed in the CSR}$ The same sample extract (soils) or aliquot (waters) should be used to determine EPH and PAHs.	Selected PAHs are excluded from LEPH and HEPH to avoid "double counting" because they are specifically regulated under the CSR.
<b>HEPH</b>	Heavy Extractable Petroleum Hydrocarbons		

\* "Cn" is an abbreviation for any hydrocarbon compound with "n" number of carbon atoms.  
GC = Gas Chromatograph;  $\sum$  = the sum of the individual concentrations of

Calculated parameters are derived from the results of two or more specific and aggregate parameters. Since they are based on a calculation involving aggregate parameters, they are also defined by the method used to analyse them. The calculated petroleum hydrocarbon parameters in the Regulation are: Volatile Petroleum Hydrocarbons (VPH), Light Extractable Petroleum Hydrocarbons (LEPH), and Heavy Extractable Petroleum Hydrocarbons (HEPH).

The specific and aggregate compounds are measured by selectively removing (purging or extracting) them from the sample matrix (water, soil, solid, or biota), then identifying and quantifying them (determining how much is present) by gas chromatography.

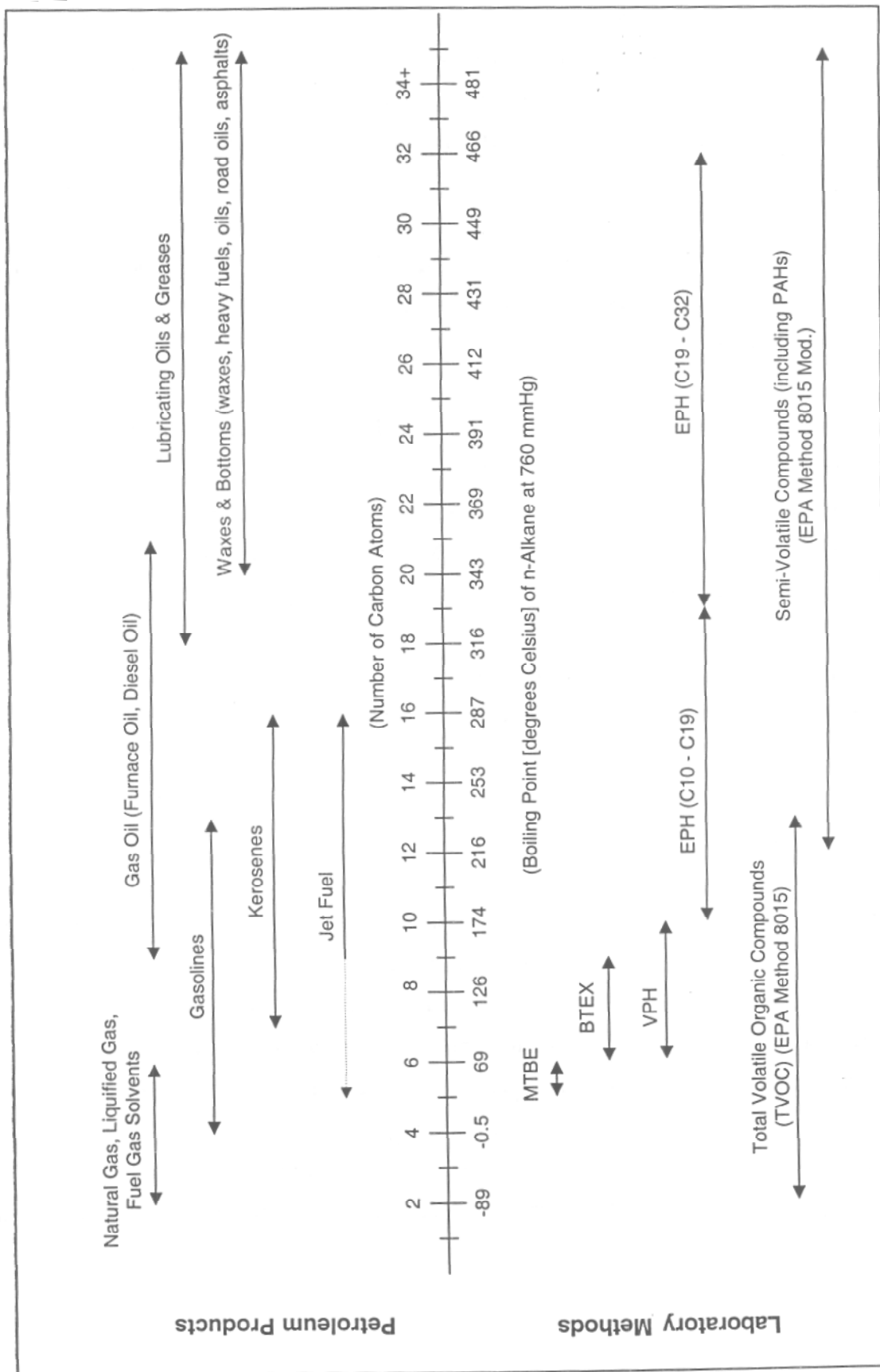
Gas chromatography is a technique that separates compounds based on their boiling point, which is a function of their molecular size (number of carbon atoms) and structure, then measures them using various selective detectors. Typically, specific petroleum hydrocarbon parameters are analysed by gas chromatography with a mass spectrometer detector (GC/MS) and aggregate parameters are analysed by gas chromatography with a flame ionization detector (GC/FID).

Some common petroleum hydrocarbon products, their approximate size ranges (number of carbon atoms), and their boiling point ranges are shown in Figure 1. This figure also shows the associated environmental laboratory testing methods.

## **ANALYTICAL VARIABILITY**

The "product" from an environmental laboratory is a report containing a series of results. Clients usually understand that each result is associated with an inherent uncertainty or "error-bar." This uncertainty or analytical variability is the variation from the "true value" due to systematic and random error. Since uncertainty can be associated with each step from sampling through analysis, and has an additive effect, the degree of total variability is usually not known and can in some cases be larger than the client expects, especially for some of the organic compounds in complex sample matrices. This means that each time you analyse a sample for the same parameter, you may get a slightly different result. This can have a significant impact on how test results are interpreted, especially if the reported result is near a particular regulatory limit or guideline.

**FIGURE 1: Petroleum Hydrocarbon Products and Their Associated Environmental Testing Methods**



Analytical variability is dependent on several factors including the analysis method and analyte concentration, but one of the largest sources is the sample matrix itself. The critical factor is sample homogeneity. The less homogeneous a sample, the more difficult it is to take representative sub-samples for analysis. Therefore, analytical variability is larger.

The consistency of samples submitted to an environmental laboratory, even within a single submission of one sample type is not uniform. Dealing with the consistency of the samples is a highly critical component of the testing process and can have a dramatic impact on the final result. For example, the *Contaminated Sites Regulation* requires groundwater to be analysed for organic contaminants such as polycyclic aromatic hydrocarbons (PAH). The intent of the regulation is to measure PAH in the water column, but in reality samples are often submitted that contain suspended matter. Even if the suspended solids is barely visible, the results can be orders of magnitude higher due to PAH adsorbed on the suspended particulate. We have seen cases where PAH concentrations reported for "water" samples are higher than their solubility in water. This obviously cannot be correct. If the laboratory does not recognise this discrepancy, corrective action such as re-sampling or solids removal may not be addressed in time. This could have costly consequences.

The underlying goal of a laboratory quality control program is the prediction and measurement of analytical variability. However, because variability is dependent on so many factors, it is not straightforward for the laboratory to routinely provide information on variability such as confidence limits on each result. Therefore, the availability of experienced laboratory personnel to assist clients with the interpretation of results is very important.

## **CONCLUSION**

The issue of petroleum hydrocarbon contamination as defined by the BC *Contaminated Sites Regulation* may have to be dealt with before or during mine decommissioning. The interpretation and use of petroleum hydrocarbon analysis data can be challenging for the following reasons:

- Definitions of the petroleum hydrocarbon parameters listed in the BC *Contaminated Sites Regulation* have gone through several changes over the past couple of years and are still evolving.
- Petroleum hydrocarbon "products" are variable and complex mixtures of compounds that are, in many cases, defined by the methods used to analyse them. This means that a slight difference in the laboratory method can make a significant difference in the analytical result.

- Most of these parameters can only approximate the type of product(s) present in soil, solid and water samples.
- Non-homogeneous samples can increase the inherent analytical variability. This can have a significant impact on how test results are interpreted, especially if they are near a regulatory limit or guideline.

Effective communication with knowledgeable laboratory personnel is extremely important, especially when critical decisions must be made based on the interpretation of analytical results generated to meet the requirements of the BC *Contaminated Sites Regulation*.