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TASC HYDROCARBON SCREENING SURVEY

AN IMPROVED FIELD METHOD FOR IN SITU DELINEATION AND ASSESSMENT OF VOC and Semi-VOC CONTAMINATION LOCATED IN DIFFICULT SUBSURFACE CONDITIONS

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1 Technology Description

C5 Engineering Ltd. has developed the TASC Hydrocarbon Screening Survey for in situ delineation and assessment of contamination located in difficult soil conditions. C5 Engineering Ltd. is a full service engineering company offering professional services in the environmental, water resources and geotechnical fields. The company has been in operation since 1994.

Mr. Ken Manly, P.Eng., is the principal of the company and has over 20 years experience in the geo-environmental field. He has been involved in a wide range of environmental assessment projects ranging from underground storage tank investigations to managing the hydrogeology and hydrology impact components for new mine developments. In addition to expertise in acid mine drainage (AMD) he has a particular interest in volatile and semi-volatile hydrocarbons in the subsurface environment.

2 Problem Definition

The objective of contaminated site investigations is to establish the chemical composition and distribution of contaminants, assess the contaminant migration pathways, evaluate the risk to human and ecological receptors and develop and implement an appropriate remediation plan. The "nature" of contaminants, in particular the toxicology and human health risks, has been the main focus of research over the last two decades. Considerable research effort in chemistry, toxicology, biology, hydrology and hydrogeology and other fields has established a reasonable understanding of the basic physics and biochemical processes involved in contaminant fate and transport.

Although considerable progress has been made in developing analysis and interpretation techniques, none of these tools can be employed until the investigator can answer the fundamental delineation question of "What are the contaminants and where are they?"

To delineate the extent of contamination, identification of both high and low contamination zones through the suspect area is required. The distribution of contamination in the subsurface is a multi-dimensional multi-media problem involving the areal extent and depth as well as variations in contaminant concentration in the soil, water and air. The concentration parameters also vary with time. Clearly, the more data points that are available, the better the delineation will be.

Drilling, sampling and analysis for the volumetric concentration of individual chemical components in the soil and groundwater is the conventional means of obtaining data. This is an effective approach since it addresses the multi-dimensional nature of the contaminant problem. However, with difficult conditions the costs quickly escalate to unacceptable levels due primarily to the high costs of drilling, sampling and laboratory

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analyses, which typically account for at least 60 percent or more of the investigation cost.

The TASC Hydrocarbon Screening Survey was designed by geotechnical and environmental engineers specifically to reduce the drilling and laboratory analysis costs in difficult subsurface conditions. Our experience in geotechnical and hydrogeological drilling, sampling and instrument installation and recovery of soil samples has allowed us to design a robust, durable, easy to install sampler for use in the subsurface environment under difficult conditions.

The US EPA identifies the most common difficult conditions as:

- Site Size
- Site access restrictions - infrastructure such as buildings, power lines, pipelines, social concerns such as damage to parks, remote sites
- Difficult penetration conditions
- Great depth
- Difficult chemical physical properties e.g. DNAPL

It is noteworthy that only one of these is related to the nature of the contaminant. All the others are related to the spatial distribution.

The TASC Hydrocarbon Screening Survey provides an effective means to delineate volatile and semi-volatile hydrocarbon contamination in the subsurface by reducing the drilling, sampling and analysis costs.

2.1 Basic Principals

The TASC Hydrocarbon Screening Survey operates on the principle of diffusion mass transport of contaminants through the soil mass. Volatile contaminants in the subsurface diffuse through the soil and groundwater from the high concentration source to the surface. This principal is well established and is widely used in industry and government. For example, the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings is widely used by the US EPA and the American Society for Testing Materials (ASTM) to assess the environmental risk to indoor air quality based on the nature of the chemical and soil conditions. The Michigan Department of Environmental Quality has developed groundwater and soil volatilization to indoor air inhalation criteria for their Part 201 Generic Cleanup Criteria Tables based on the diffusion principal.

The volumetric concentration (mg/L or mg/kg) of individual compounds at the source is of fundamental importance to the risk based assessment and remediation. However, the investigator interested primarily in plume delineation can make effective use of total mass measurements rather than volumetric concentration. In this case, the detectable mass of the contaminant, rather than the volumetric concentration at the source becomes the measurement of interest. Using this focus, both the field sampling and laboratory analyses are simplified and the costs reduced dramatically.

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The diffusion coefficient of a soil mass can be assumed to be constant and the mass accumulated over a specific sampling time at any location will be proportional to the concentration in the underlying source. The areas of low and high concentration of various compounds or groups of compounds may be mapped using this principal. Since the soil gas flux is small, (The Johnson and Ettinger model suggests the effective diffusion coefficient on the order of $5x10^{-4}$ cm^2/s) the volumetric concentration at any instant in time is also small and may be below normal detection limits. (This property results in false negative using active soil gas sampling techniques.) Therefore, in order to be effective, a sampling device in the shallow subsurface must be capable of collecting sufficient mass over a realistic period of time to allow the compounds to be detected.

The TASC (Time Accumulating Subsurface Collector) Hydrocarbon Screening Survey was designed specifically to meet this requirement. Figure 1 through 4 at the end of the text show the areal distribution and relative concentration of specific contaminants at Turner Valley Gas Plant in Alberta prepared from the results of a TASC Hydrocarbon Screening Survey. Conventional drilling and sampling later confirmed the distribution and the relative concentrations. A complete case history for this and other sites is available.

Individual TASC samplers are installed in the shallow subsurface or, if buildings or other infrastructure is present, below the building floor slab, pavement or other structures.

Volatile compounds that diffuse through the soil mass are collected on the sampler over a predetermined sampling period. The sampling period is estimated from the expected site conditions including soil conditions and contaminants. The collected compounds are then desorbed and analysed using gas chromatography with flame ionization detection. This analysis method is well established (eg NIOSH Method 1003, Issue 2). The time required for the samplers to be in place depends on the nature of the contaminants, their expected or known depth and the subsoil conditions.

The mass accumulated on the sampler depends on the source concentration, effective diffusion rate of the soil and the length of the flow path. If the diffusion rate is high and the pathway short, the accumulation could be conducted in minutes.

For most brown fields surveys the samplers are analized for a full range of compounds to about C_{30} boiling point. The analysis employs internal control standards and specific testing for the thirty six (36) standard compounds listed in table 1. These compounds are constituents of a range of fuels or are common solvents.

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Table 1 TASC Hydrocarbon Screening Survey Standards

Alkanes	BTEX	Chlorobenzenes	Other Chlorinated	Keytones
C6	benzene	o-dichlorobenzene	Dichloromethane	acetone
C7	toluene	p-dichlorobenzene	1,1-dichloroethane	MEK
C8	ethyl benzene	1,2,4-trichlorobenzene	Chloroform	MIBK
C9	o, m-xylenes	1,2,3,4-tetrachlorobenzene	1,2-dichloroethane	
C10	p-xylenes	Pentachlorobenzene	1,1,1-trichloroethane	
C11		Hexachlorobenzene	carbon tetrachloride	
C12		1,2,3,5-tetrachlorobenzene	1,2-dichloropropane	
C13			Trichloroethylene	
C15			1,3-dichloropropene	
C20			1,1,2-trichloroethane	
			Tetrachloroethylene	

2.2 Installation Details

The samplers are normally installed to a depth of about 200mm below surface using hand operated tools such as a shovel, hand auger or hammer drill if conditions allow power tools. Installation typically requires five to six minutes per sampler. Recovery times are similar.

Each TASC sampler is 25 mm in diameter and 90 mm long. They are made of nylon and are tough and durable for easy shipping and handling in the field.

They may be installed anywhere there is access by foot, including lawns, gardens, roadways, fields and other areas. They may be installed through pavements in public areas if necessary and do not require closing the area to public access.

The samplers have been installed under water up to 1.8 m in depth and depths up to about 9 m are possible with the current technology. However, if underwater installation is expected we should be advised in advance so that the appropriate sampler can be provided.

Since the sampler operates on passive diffusion, no special equipment is required for operation. Due to the usually shallow

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installation, no secondary waste streams are usually generated in the field and normal laboratory protocols are required.

3 Performance

The TASC Hydrocarbon Screening Survey has been used at several sites in Alberta, Canada including Calgary International Airport (Client: Transport Canada) and the Turner Valley Gas Plant (Client:: Alberta Culture). The TASC survey has also been used in permafrost in the Canadian Arctic (Government of Canada, Industrial Research Application Program). Case histories for these projects are available.

The survey is usually used to target subsequent conventional drilling and sampling locations. The TASC Hydrocarbon Screening Survey has also been used to provide additional information on the spatial delineation of plumes of known contaminants working from previously installed monitoring wells. This approach is particularly cost effective at sites with difficult ground conditions.
The TASC Hydrocarbon Screening Survey has proven effective in delineating volatile hydrocarbons in a variety of soils ranging from coarse alluvial gravels to low permeability clay till, and frozen ground.

4 Cost Benefit Analysis

The TASC Hydrocarbon Screening Survey cost is $CDN 240 per sampler FOB Calgary exclusive of provincial, state and federal taxes. A minimum of 10 sampling locations is required per sampling event. This cost includes the installation and recovery of the samplers assuming a standard installation as discussed above and preparation of contamination contour maps. Travel to the site, accommodation and vehicle rentals are charged at cost. All third party disbursements, including surveyors and any speciality equipment required would be charged at cost plus 10%.

There are no other costs associated with the TASC Hydrocarbon Screening Survey.

4.1 Cost Effectiveness

In the local market, drilling and sampling for contaminants using a conventional auger rig to a depth of about 6 m, installation and development of a monitoring well, sampling and analysis of one soil sample and one groundwater sample costs about $CDN 1,300 to $CDN 1,800 per location. In cases where difficult conditions are encountered costs can be expected to at least double.

Based on these values, the TASC Hydrocarbon Screening Survey is a minimum of 80 percent cheaper than conventional drilling and sampling. At difficult sites, the cost savings for plume delineation applications are even more substantial with a cost reduction of 10 to 20 times in comparison to conventional drilling and sampling.

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5 Regulatory and Policy Issues

The soil gas survey technique is recognized by the US EPA and the Canadian Council of Ministers of the Environment (CCME). The TASC Hydrocarbon Screening Survey is a non-intrusive, robust and durable sampling system that can be installed with minimal technical training. There are no secondary waste streams generated from the system under normal conditions.

Occupational Health and Safety risks associated with TASC are the normal operation of hand operated power tools as well as any relevant contaminated site investigation protocols established for the site.

The TASC Hydrocarbon Screening Survey does not directly measure the contaminant concentration at the source. However, as a screening tool, it provides an effective means of delineating the chemical composition and areal distribution of volatile contaminants in the subsurface. In cases where there has been no volumetric analyses conducted prior to the TASC survey, the survey is useful to establish the locations and parameters for the far more expensive quantitative sampling and analyses.

The survey is particularly effective at locations where the subsurface stratigraphy and contaminant characterization is partially known. In these cases, the screening survey results can be used to back calculate the source concentration based on known soil and groundwater conditions. In this way data gaps may be filled in a cost effective manner.

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Figure 1 Total Organic Compounds Detected

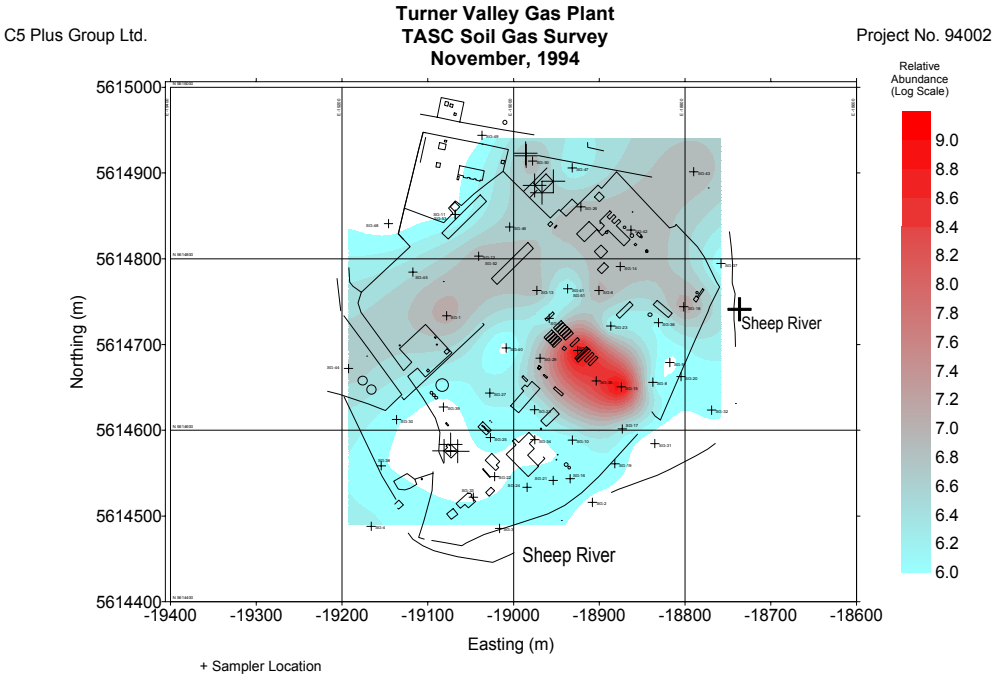

Figure 2 BTEX

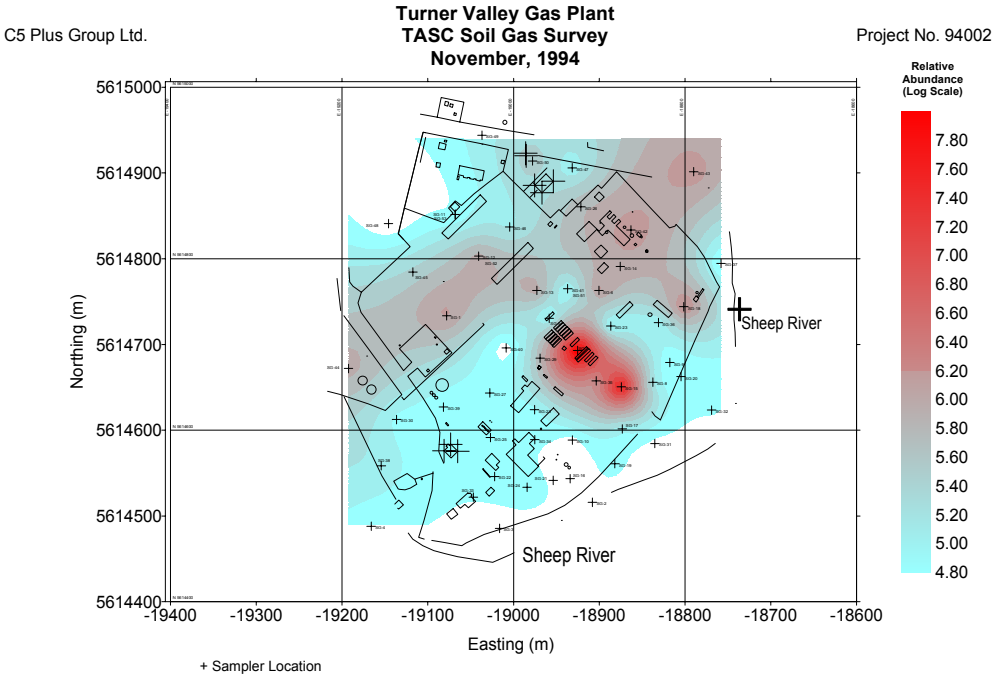

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Figure 3 Chlorinated Compounds

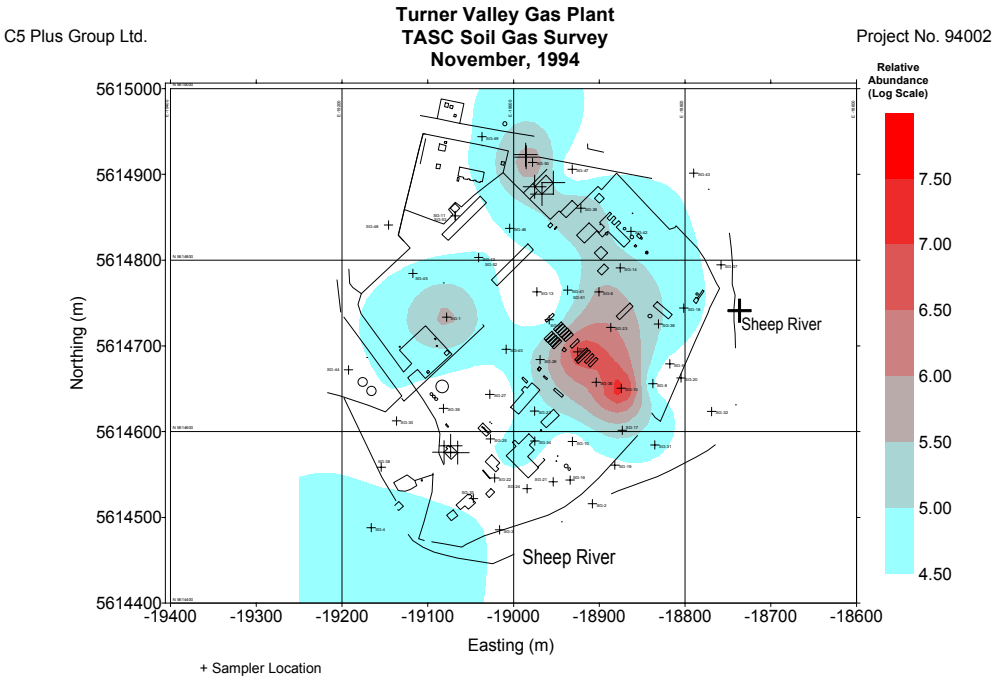

Figure 4 Acetone