

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 # 29



Expedited Site Characterization : Tools And Technologies

DESCRIPTION:

The process of Expedited Site Characterization (ESC) described in TAB # 27, is made possible by the tool and technology selection criteria/philosophy, of the ESC methodology, reviewed in TAB # 28. The development and acceptance of the array of new tools and technologies allow the rapid collection and analysis of data. Selected tools and technologies that are currently being accepted and used for ESC are presented. These fall into five broad categories: Non-Intrusive Tools, Subsurface Access Technologies, Analytical Chemistry Technologies and Data Management and Visualization Technologies.

INTRODUCTION

The tools that are currently being accepted and used for ESC fall into five broad categories:

- Aerial Images.
- Non-Intrusive Tools.
- Subsurface Access Technologies.
- Analytical Chemistry Technologies.
- Data Management and Visualization Technologies.

Aerial images are either photographs, or output from a variety of remote sensing techniques. They are often the primary source of information for the initial stage of an ESC. Non-intrusive tools rely on Geophysics, and are discussed in the following Section. They constitute a “second line” of tools for the collection of information towards the development of the conceptual model. Subsurface Access Technologies are the tools that imply or relate to the intrusion of the

subsurface. Only recent technologies aimed at accelerating investigations will be presented. The field of analytical chemistry has also experienced a recent surge in new developments aimed at expediting the generation of results, and these are emphasized in this document. Finally, since the process of ESC requires the rapid processing of information and communication of results, and interpretations among team members and the other stakeholders, new developments in data management and visualization are mentioned.

NON-INTRUSIVE TOOLS

General information on their use:

The use of non-intrusive tools, cost-effectively, increases sampling density at a site. They allow the detection and mapping of anomalies, the mapping of the presence and continuity of strata, and the mapping of the limits of buried waste, landfills or trenches. These techniques rely on the

contrast between the measured property of the target region and the background conditions. They include the following:

1. Surface Geophysical Surveying Methods

- Electromagnetics (frequency and time domain).
- Ground penetrating radar.
- Resistivity.
- Seismic (refraction and reflection).
- Micro-gravity.
- Magnetism.

2. Borehole Geophysical Surveying Methods

- Frequency Domain Electromagnetics (EM).
- Ground Penetrating Radar.
- Seismic Reflection and Refraction.

SUBSURFACE ACCESS TECHNOLOGIES

Requirements

The technologies discussed here, serve the purpose of penetrating the subsurface for the collection of samples (gas, water, and soil), and for the installation of data collection instruments. The inclusion and use of **existing wells** increases the number of locations previously accessed.

Using **direct push** for subsurface access, provides “continuous” monitoring of the subsurface, as opposed to its “discrete” counterpart.

The techniques involved in the **drilling** of new wells are readily available, and generally well understood by field personnel and regulatory authorities. In addition to conventional drilling technologies, there are emerging technologies, such as **rotasonic** drilling, which may match some of the advantages of direct push technologies.

Most of the recent Research and Development for the intrusive technologies, has been towards the direct push techniques. Direct Push technologies have been developed and used for many years by the Civil Engineering industry for the exploration of geological strata. Environmental industries

have added chemical detection capabilities to the direct push techniques.

Direct Push Technologies

Advantages:

- Rapid stratigraphic logging and contaminant detection with sensor systems.
- Rapid, depth-discrete soil, soil gas and groundwater sampling.
- No drill cutting wastes produced.
- Minimally invasive; effective grouting and sealing capabilities have been developed (prevents vertical contaminant transport down the penetration hole).

Limitations:

- Not appropriate presently for long-term monitoring measurements, or continuous sampling over days or weeks.

Two classes of direct push technologies exist for subsurface probing:

1. Percussion Probing.

- Involves a combination of pushing and driving rods with a hydraulic hammer.

2. Cone Penetration.

- Involves the penetration of a cone at a constant rate of penetration, with a hydraulic ram.

See **Table 1** for a partial comparison of the two techniques.

Percussion Probing is generally more productive and more maneuverable than cone penetration testing. The systems are both well suited to the abstraction of depth-discrete groundwater and soil gas samples. Percussion Probing is well suited for the collection of continuous (limited) or depth-discrete soil samples. CPT is particularly effective for soil stratigraphic logging and chemical screening. The stratigraphic logging sensors are well developed and proven, whereas many of the chemical sensors are still being developed and validated in the field. Fluorescence sensor systems, both laser induced and mercury bulb contact activation, are the most developed. These sensors have the ability to detect aromatic compounds in the subsurface.

Table 1: Partial Comparison of Two ESC Soil Invasive Techniques.

Technique	Advantages	Limitations
Percussion Probing	<ul style="list-style-type: none"> • Relatively inexpensive. • Well developed suite of sampling tools. • Better mobility. • Faster. • Allows collection of soil samples. 	<ul style="list-style-type: none"> • Difficult to penetrate hard/dense soils. • Stratigraphic logging capabilities with sensors limited. • Depth.
Cone Penetration Testing	<ul style="list-style-type: none"> • Well developed stratigraphic profiling capabilities currently available. • Developed to penetrate hard/dense soils. • Steam cleaning as the rods are removed. • Protective operating environment. • Extensive R & D today for enhancements. 	<ul style="list-style-type: none"> • More expensive. • Difficult to maneuver in “tight” spaces. • Slower . • Cannot collect soil samples.

CHEMICAL ANALYTICAL METHODS

Fixed-based versus field methods

The decision between using an off-site, fixed-base laboratory versus an on-site mobile laboratory will depend on:

- The environmental media to be sampled and the contaminant groups to be analyzed.
- Screening versus definitive level.
- Usability for risk assessment.
- Number of samples and analytes to be analyzed.
- Required turn-around times.
- Match sampling rate to analysis rate in the field.

When only a small number of samples will be collected, samples can be transported rapidly by air freight to a fixed laboratory service that offers a 24 hour turn-around time. This avoids the expense of bringing a laboratory to the field, while achieving the rapid analytical output, that is necessary for a successful dynamic field investigation. The laboratory analytical techniques, (listed in the following sections), and

field technologies (**Table 2**), are some of the approaches used in the context of an ESC.

Organic Contaminants

Standard Laboratory Analysis:

- Gas Chromatograph/Mass spectrometry (GC/MS).
- Ion Trap Mass Spectrometry.
- Infrared (IR, laser diode) Spectrophotometry.
- Ultraviolet (UV) and visible absorption. spectrophotometry.
- Photo-acoustic Spectrometry.
- High Resolution/Long Range Fourier. Transform Infrared (FTIR) Spectroscopy.
- Raman Spectroscopy.

Newly emerging methods - hand-held or transportable:

- Ion Trap Mass Spectrometer.
- Surface Acoustic Wave sensors (SAW devices).
- Fiber optic sensors.
- Laser induced Fluorescence (LIF).
- Laser Raman Spectroscopy.
- Immunoassay Techniques.

Table 2: A List of ESC Designated Field Investigative Technologies.

Sensors	For detection or measurement of:
Laser Induced Fluorescence Probe	Petroleum, oil, lubricants
Soil Moisture Probe	Moisture
Fiber Optic Probe	Pore pressure
Electrochemical Probe	TNT
Gamma Probe	Radionuclides
<i>in situ</i> groundwater and soil probes	VOCs
Raman Probe	DNAPLs
Laser Induced Breakdown Spectroscopy Probe	Heavy Metals
Fluorescence detector	Fuel
Electrical Resistance Tomography/Ground Penetrating Radar Probes	Tank/Barrier Integrity Monitors
X-Ray Fluorescence Probe	Metals
Position Location	More accurate position profile

Inorganic ContaminantsMetals:

- X-ray fluorescence.
- Inductively coupled Plasma Mass Spectrometry (ICP-MS).
- Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES).
- Infrared (IR, laser diode) Spectroscopy.
- Stripping Analysis.

Radionuclides:

- ICP-MS, ICP-AES.
- Alpha, beta and gamma spectroscopy.
- Scintillation techniques.
- Long Range Alpha Detector (LRAD) - (newly emerging but commercially available).

Other Inorganics (sulfates, nitrates, chlorides, etc.):

- HACH® kits.
- Ion chromatography .

DATA VISUALIZATION**Requirements**

- Ability to transmit data to remote locations (e.g., to regulators, stakeholders).
- Data analysis and interpretation, including geostatistics.
- Display and visualization, including contour maps, fence diagrams, cross sections and possible 3-D visualizations.

Applications

In many cases, maps, photographs, and other geo-referenced images (in reports and presentations) are the only visible evidence to regulators and the public that progress is being made in the environmental clean-up. In addition, visualizing site data in three dimensions can be critical in the development and testing of a site model. Thus, thematic mapping during all phases of remediation and restoration is a fundamental activity.

Geographic Information Systems (GIS) and data visualization technologies can, and should be employed early in the remedial process to create a database for recording, modeling, and mapping spatial data related to site characterization and remediation activities. The rapid pace that is set for regulatory compliance, and the legal requirements for historical records and long-term site monitoring have made GIS vital for information management, analysis, and presentation. For example, within the Department of National Defence, most facilities have developed a GIS for thematic mapping and site analyses. These systems, developed with such commercially available software as Arc/Info®, MapInfo® and Intergraph®, are excellent sources of data for site remediation activities in and around the facilities.

GLOSSARY**Rotasonic:**

This is a drilling technique where a casing penetrates the subsurface (soil and rock) through the simultaneous application of rotation and a high frequency (50-150Hz) axial vibration. It is a variation of Resonant-Sonic drilling, the name indicating that the frequency of vibration is set to achieve harmonic resonance within the casing thereby greatly facilitating the propagation of the vibration from the vibratory head to the tip of the casing.

Tomography:

A method for determining the distribution of physical properties within a given volume of subsurface, by inverting the results of a large number of measurements made in three dimensions (e.g., seismic, radar, resistivity, and EMS) between different source and receiver locations.

SOURCES OF INFORMATION ON ESC INVESTIGATIVE TOOLS

A catalogue of technologies developed through the US Department of the Environment's Characterization, Monitoring, and Sensor Technology Program can be found on the Internet at:

- http://www.cmst.org/cmst/Tech_Cat.text/toc.html

Also, the US Environmental Protection Agency (EPA) has databases for site characterization technologies at the following Internet locations:

- <http://www.clu-in.com/char1.htm>
- <http://www.epa.gov/region01/steward/ceit/vendfact.html>
- <http://www.clu-in.com/csct.htm>

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Aussi disponible en français

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