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.

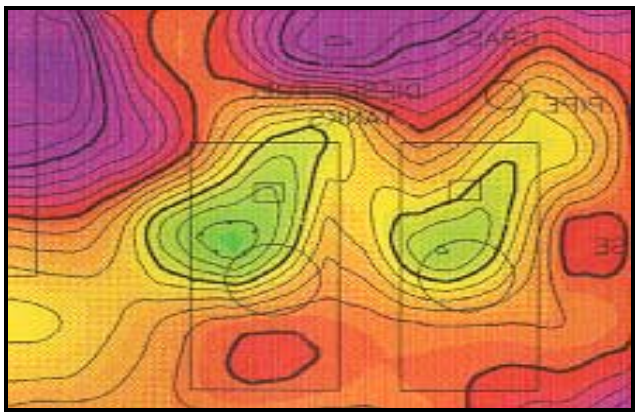
TAB #3

Electromagnetic Surveys & Ground Penetrating Radar

DESCRIPTION:
Two of the most effective and often used geophysical methods for site assessment are Electromagnetic Surveys (EMS) and Ground Penetrating Radar (GPR). They are quick screening technologies that produce a rapid characterization of a potentially contaminated site. They can readily identify geophysical conditions, buried wastes and utilities, extent of contamination, and potential migration routes. EMS and GPR should be utilized prior to more expensive traditional site assessment techniques such as drilling, since they can dictate the best location for borehole and monitoring well installation, as well as help in the remedial investigation to determine site remediation options.

HOW THEY WORK

- **EMS** measures the electrical conductivity of subsurface soil, rock, ground-water, and some types of contamination.
- **GPR** emits radio wave frequencies which respond to changes in the electrical properties of sub-surface components.



profile, a colour contour map, or a 3D map of shallow subsurface conditions.

APPLICATIONS

EMS and GPR are both used to identify the "hot spots" of a site (see diagram). However, each has its own specific applications for which it is best used (refer to **TABLE 1**). They are often used together or with other geophysical techniques in order to fully characterize a site. For a brief

TABLE 1: APPLICATIONS OF EMS & GPR

Application	EMS	GPR
Spatial Detection Ability: • Detecting Lateral Variation (Profiling)	• EXCELLENT lateral resolution. • Continuous profiling available on commonly used equipment (EM 31), potentially allowing for total site profiling.	• EXCELLENT lateral resolution. • Can profile to about 10m, but is highly dependent on specific conditions.
• Detecting Vertical Variations (Sounding)	• GOOD vertical resolution of geological conditions & contaminant plumes. • Resolution decreases with increased depth penetration. • Vertical information is provided in a relative sense (e.g. thick vs. thin, shallow vs. deep). • Can sound to a depth of 6m with continuous surveying (EM 31) or to a depth of up to 60m with stationary sounding (EM 34-3). • Some EMS instruments can reportedly sound to depths of 330m or more. • Continuous surveying potentially allows for total site coverage.	• Continuous surveying potentially allows for total site coverage. • VERY GOOD resolution of geological conditions. • Adequate resolution of aerial extent of shallow contaminant plumes. • POOR resolution of contaminant plume depths. • Can only sound to about 10m, and is highly dependent on specific site conditions. • Better sounding results obtained on dry, sandy, or rocky sites; poorer sounding results obtained on moist, clayey, or conductive soils.
Determining Natural Geologic & Hydrologic Conditions:		
• Depth, thickness, & vertical variations of soil & rock layers.	GOOD	EXCELLENT
• Mapping lateral variations in soil & rock (e.g. fractures, karst features).	EXCELLENT	EXCELLENT
• Depth of water table.	GOOD (provides relative depth)	LIMITED APPLICATION (very site specific)

A **contamination** "Hot Spot" is identified by a difference in conductivity and is *represented* by a certain colour on a contour map.

summary of various geophysical methods, refer to
TAB #2: "*Site Assessment Procedures*".

EM CONDUCTIVITY CONTOUR MAP

TABLE 1 (Continued): APPLICATIONS OF EMS & GPR

Application	EMS	GPR
Locating Buried Wastes & Utilities, & Delineating Trench Boundaries:		
• Bulk waste trenches - with metal. - without metal.	EXCELLENT EXCELLENT	EXCELLENT EXCELLENT
• Depth of trenches & landfills.	LIMITED APPLICATION	GOOD
• Detection of 45 gal. steel drums.	GOOD	GOOD
• Estimates of depth & quantity of 45 gal. steel drums.	LIMITED APPLICATION	GOOD
• Buried pipes & tanks.	EXCELLENT	EXCELLENT
• Potential and existing pathways of contaminant migration via conduits & permeable trench backfill.	GOOD	EXCELLENT
Determining Sub-Surface Contamination:		
Organic Plumes		
• Floaters (low density hydrocarbons)	GOOD	MODERATE (very site specific)
• Mixers (water soluble organic compounds associated with other conductive contaminants such as landfill leachate, industrial wastes, leaking evaporation ponds & lagoons).	GOOD	MODERATE (very site specific)
• Sinkers (high density halogenated hydrocarbons, such as trichloroethylene, tetrachloroethane, and carbon tetrachloride).	GOOD (if the contaminant plume has an electrically conductive component).	POOR
Inorganic (conductive) plumes	EXCELLENT high resolution; quick aerial mapping of shallow plumes (to 6m depth) with continuous mode of operation (EM 31).	GOOD high resolution; limited to shallow investigations in non-conductive surface soils; can map the top of shallow, plumes; quick mapping since it is a continuous survey. Use GPR if EMS is rendered ineffective due to interference (e.g. railroad tracks, buried pipes).

EQUIPMENT SPECIFICATION

Various EMS equipment can be used, depending upon the site conditions and the type of survey needed. **TABLE 2** is a comparative description of the most commonly used EMS and GPR equipment.

TABLE 2: COMMONLY USED EMS & GPR EQUIPMENT

Comparison Criteria	EMS Equipment			Ground Penetrating Radar
	EM 31	EM 34-3	EM 38**	
Surveying Depth	3 to 6 m	7.5 to 60 m	0.75 to 1.5 m	up to 10 m
Speed of Measurement	5 sec. (or up to 8km/hr)	20 sec.	5 sec. (or up to 8 km/hr)	up to 8km/hr.
Persons Required to Operate	1	2	1	1
Continuous Profiling	Yes	No	Yes	Yes
Measured quantity	Apparent Conductivity (mmho/m)	Apparent Conductivity (mmho/m)	Apparent Conductivity (mmho/m)	Dielectric Constant (MHz)
Probes Inserted in Ground	No	No	No	No
Used Over Frozen Ground/ Snow/ Asphalt	Yes	Yes	Yes	Yes
Susceptible to Interference *	yes	Yes	Yes	No

* Data obtained from EMS equipment is susceptible to interference from metal pipes, fences, vehicles, buildings, active power lines, radio transmission sources, railways and other cultural features.
** The Em 38 is used to map soil salinity (e.g. de-icing salt contamination).

SOURCES

United States environmental Protection Agency (1987). *Expanded Site Inspection Transitional Guidance for the Year 1988.*

Geological Survey of Canada (1983). *Electromagnetic Survey of Gloucester Waste Disposal Site*.

National Water Well Association (1985). *Corrective Actions for Containing and Controlling Ground-Water Contamination-A Short Course*.

For further information please contact:

Environment Canada
Ontario Region - Environmental Protection Branch
Environmental Contaminants &
Nuclear Programs Division
4905 Dufferin Street
Downsview, ON M3H 5T4
Telephone: (416) 739-4826
Fax: (416) 739-4405

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