



**Electromagnetic induction** (EM) profiling is a surface geophysical technique used to measure terrain conductivity, a term which refers to the bulk electrical conductivity of subsurface materials. EM conductivity surveying is primarily a tool for rapid lateral mapping of variations in soil conductivity. It is used for **mapping lateral transitions in soil type, contaminant plumes, sand and gravel deposits, clay aquitards, and shallow bedrock.**



FIGURE 1 - GEONICS EM31



FIGURE 2 - GEONICS EM34-3

## APPLICATIONS

“Terrain Conductivity,” the electrical conductivity of the earth, depends on several soil or geologic parameters including:

- groundwater conductivity,
- clay content,
- soil or formation porosity, and
- degree of water saturation.

EM techniques will respond to changes in any of these parameters. EM techniques are widely used for:

- mapping changes in soil type,
- mapping alluvial paleo-channels,
- delineating leachate plumes from landfills and other impoundments,
- mapping windows or discontinuities in aquitards,
- mapping zones of permafrost,
- mapping and/or detecting other geologic features, and
- detecting and mapping buried metallic objects and debris.

EM surveys can be helpful for siting boreholes, interpolating between boreholes, or directing further detailed site studies.

## INSTRUMENTATION

The most common instruments for measurement of terrain conductivity are the Geonics EM31 (Figure 1) and the EM34-3 (Figure 2). Both instruments operate on the same principle, but they differ in their respective depths of exploration. In the EM31, the transmitting and receiving coils are mounted at the ends of a 3.7-meter rigid boom, so that the instrument can be operated by one person. The EM34-3 consists of a transmitting console, a receiving console, and two separate coils which are connected by a cable. The EM34-3 operates with three transmitter-receiver coil separations: 10, 20, or 40 meters. This instrument requires two operators.

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# Electromagnetic Induction

These EM instruments do not require any ground contact or surface disturbance; therefore, they are rapid, relatively inexpensive, and can be run with little or no exposure to buried toxic materials.

## PRINCIPLE OF OPERATION

The basic principle of operation of the EM method is illustrated in Figure 3. A transmitter coil radiates an electromagnetic field which induces electrical currents (termed eddy currents,  $J_e$ ) in the earth below the coil.

These eddy currents in turn generate a secondary magnetic field ( $B_s$ ). The receiver coil detects and measures this secondary field. The instrument output, calibrated to read in units of terrain conductivity (apparent conductivity), is obtained by comparing the strength of the quadrature phase component of the secondary field to the strength of the primary field. The apparent conductivity measurement represents a weighted average

of subsurface conductivity from the ground surface to the effective depth of exploration of the instrument.

The depth of exploration depends on the separation between the transmitter coil and the receiver coil, as well as on the coil orientation (coil axis/dipole horizontal or vertical). The eight configurations of coil separation and orientation which are possible for the EM31 and EM34-3 are summarized in the table below, together with their "nominal" depths of exploration. In practice, depths of exploration tend to be less than the "nominal" or ideal depths. Nevertheless, the table presents a general overview of the relative depths of exploration of the various coil configurations.

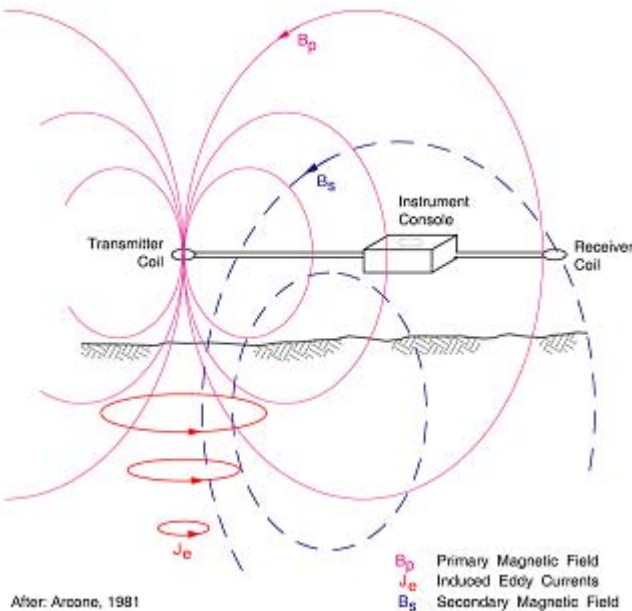


FIGURE 3 - EM PRINCIPLES OF OPERATION

Instrument	Coil Separation	Orientation	Nominal Depth
EM31	3.7 meters	HD	2.5 m (8 ft)
		VD	5.2 m (17 ft)
EM34-3	10 meters	HD	6.8 m (22 ft)
		VD	14.3 m (47 ft)
EM34-3	20 meters	HD	13.5 m (44 ft)
		VD	28.6 m (94 ft)
EM34-3	40 meters	HD	27 m (89 ft)
		VD	57 m (188 ft)

TABLE 1 - NOMINAL DEPTH OF EXPLORATION FOR GEONICS EM INSTRUMENTS

### Table Notes

1. HD - Coil Axis/Dipole Horizontal  
VD - Coil Axis/Dipole Vertical
2. "Depth of Exploration" - Depth above which 67% of the signal originates in a uniform earth

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