

1.0 Introduction

1.1 Use and Scope of Report

Subsurface exploration is fundamental to geotechnical engineering practice. Traditional exploration methods have developed along the lines of direct observation and measurement, such as borings, in-situ test probes, and open excavations. These methods provide limited, or “point”, information relative to the total volume of soil, rock, and fluids involved in the engineering question. This imbalance compounds as the project size (e.g. site) increases. In addition, physical constraints or environmental conditions can eliminate direct exploration entirely. Although commonplace and useful, direct exploration methods produce limited subsurface information.

Today, geophysical methods offer geotechnical engineers with new tools and opportunities for subsurface exploration. Geophysical methods can economically explore large subsurface volumes, supply continuous data (as opposed to “point” data), and are non-invasive (useful for contaminated sites). However, geophysical methods are indirect surveys containing inherent ambiguity and resolution limitations. Verification using direct exploration methods can minimize these issues (i.e. “ground-truthing”).

When used in combination, the advantages of each exploration method are potentially maximized. Geophysical methods can identify potential subsurface problems difficult to detect by direct (“point”) exploration methods alone (resulting in more efficient boring placement), and can economically evaluate substantially larger subsurface volumes than direct exploration methods. Similarly, direct exploration methods provide valuable verification and calibration of geophysical survey data, reducing inherent interpretation ambiguities. Geophysical methods can enhance and extend traditional subsurface exploration activities.

This primer is designed to provide geotechnical engineers with a cursory understanding of commonly available geophysical methods, and as an aid in identifying viable geophysical methods for a given geotechnical engineering question.

This primer does not contain the detail necessary to teach geotechnical engineers how to acquire, process, and interpret geophysical data. References are provided at the end of each chapter for additional information on each method. Useful sources of additional information include USACE Report EM 1110-1-1802 (USACE, 1995) and “Application of geophysical methods to highway related problems” (Wightman et al., 2003).

How to Use this Primer:

- Step 1 Define the geotechnical engineering question
- Step 2 Review the geophysics applicability matrices (Figs. 1.2 and 1.3), and identify potentially viable geophysical methods
- Step 3 Review individual chapters covering the geophysical method(s) identified in Step 2; the *Advantages* and *Limitations and Interferences* sections in each chapter will help determine whether a particular method is actually viable for the particular site or specific problem.
- Step 4 Select the geophysical method(s) and contact a geophysical contractor to further discuss feasibility and cost (see Chapter 11).

The geophysical methods covered in this primer include only those methods that have gained general acceptance in geotechnical engineering applications, and those deemed applicable by the authors, as indicated in Table 1.1:

Geophysical Methods Covered	Geophysical Methods <i>Not</i> Covered
Seismic Refraction	Time-domain electromagnetics (EM)
Seismic Reflection	Magnetics
Surface Wave	Equipotential
Resistivity	Mise-a-la-masse
Self-potential (SP)	Induced polarization
Frequency-domain electromagnetics (EM)	Very low-frequency (VLF) EM
Ground-penetrating radar (GPR)	Airborne geophysics
Micro-gravity	Satellite remote sensing
Selected borehole geophysical methods	

Table 1.1 – Geophysical methods covered, and not covered, in this report

1.2 Fundamentals of Geophysics

Several basic concepts are common to all geophysical methods and are important to understanding the technology. These basic concepts are grouped and discussed in this section.

Contrast in Physical Properties

All geophysical methods rely on, and often measure, the contrasting physical properties of subsurface deposits. Table 1.2 summarizes the physical properties that must vary in the subsurface for a particular geophysical method to obtain relevant information.