PEAT MAPPING USING RESISTIVITY

Paul Fisk, Keith Holster, Silas Nichols, and Peter Connors

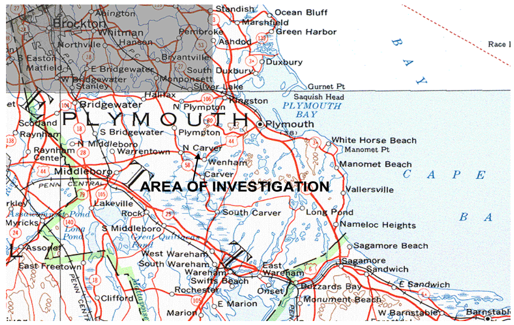
Abstract

A demonstration project was conducted to evaluate the effectiveness of Geometric's OhmMapper system to locate and define the lateral and vertical extents of peat deposits along a highway construction right of way. The test area was in Carver, Massachusetts on a section of Route 44 that is currently under construction. Peat was excavated to depths varying from 15 to 30 feet and replaced with sand. Borings indicated peat deposits below the sand fill. The Geometric's OhmMapper resistivity survey was conducted in an area where borings indicated the presence of peat. After completion of the resistivity survey the area was excavated and the peat deposits mapped for comparison with resistivity survey results. Soil, ground water, and peat samples were obtained from the site materials for laboratory resistivity tests.

The results of the Geometric's OhmMapper investigation were presented as a comparison of the color resistivity cross sections and test pit drag line results. The results indicate a correlation of the low resistivity areas and locations that peat/muck was excavated. The low resistivity values for the peat, limited penetration and the definition of the bottom of the peat layer. The method did outline the lateral and the approximate vertical extent of peat material. This contribution is significant since the most expensive part of a boring or trenching program would be to establish the lateral extent of peat.

Introduction

This project was a cooperative effort between Geometrics, Massachusetts Highway Department, Federal Highway Administration and NDT Corporation to evaluate the effectiveness of Geometric's OhmMapper system to locate and define the lateral and vertical extents of peat deposits along a highway construction right of way. The test area is in Carver, Massachusetts, and Figure 1, on a section of Route 44 between stations 153+00 and 162+00 that is currently under construction. During highway construction peat was excavated to an approximate depth of 15 feet and replaced with sand. Borings post cut and fill indicated peat deposits were still present below the sand fill.



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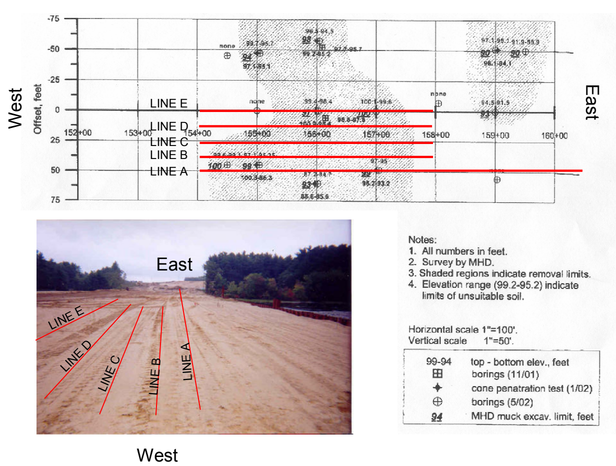
The Geometric's Ohmmapper geophysical investigation was conducted along the lines of coverage shown on Figure 2 in an area where borings indicated peat deposits. After the geophysical investigation was completed, the area was excavated and peat deposits mapped for comparison with geophysical survey results. Soil samples and water samples were obtained from the sand soil fill, peat and ground water for laboratory resistivity values.



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Geometric's OhmMapper Resistivity Measurements

The Geometric's OhmMapper is a capacitive-coupled resistivity meter. Conventional resistivity surveys use driven metal stakes for electrodes. The Geometric's OhmMapper replaces these metal stakes with cables that provide inductive coupling to the ground. The measurements are made by dragging a set of cables over the survey area. With the Geometric's OhmMapper, resistivity measurements are made much faster and more frequently than with a driven electrode system. Measurements were made at a rate of two times per second as the array is pulled along the ground. In addition, since driven metal stakes are not necessary, resistivity surveys may easily be taken over pavement, asphalt, frozen ground, or solid rock. Maximum depth of investigation for the Geometric's OhmMapper is in the range of 20 meters, actual depth penetration depends on the earth resistivity values at the survey site.

The technique is based on an AC current acting like a capacitor. The Geometric's OhmMapper transmitter generates a 16.5 kHz AC signal that is applied to the metal shield in a coaxial cable. This metal shield acts as one plate of a capacitor the ground acts as the other. The insulation around the coaxial cable serves as a dielectric between the shield and ground plates of the cable-earth capacitor. The 16.5 kHz AC signal flows into the ground through the capacitance of the shield-earth contact. At the receiver the capacitance of the cables are charged by the voltages generated by the transmitter current flowing though the ground. This (voltage) is measured with a sophisticated AC voltage meter in the receiver. Ground resistivities can be calculated from the measured voltage at the receiver, and the known current generated at the transmitter.

The Geometrics OhmMapper uses a Dipole-Dipole electrode configuration. The Dipole-Dipole configuration consists of a pair of current electrodes spaced at a distance "B" (Figure 3 for the system used) apart and a pair of potential electrodes also spaced "B" distance apart. The "B" spacing (adjustable for 5, 10, 15, 20, + meter spacing) determines the area over which the current is applied to the ground and the area over which the voltage is measured. Large separations provide better penetration but lower resolution, smaller separations provide higher resolution but may require high current input for both depth of penetration and resolution. The distance between the center of the current electrode "pair" and the center of the potential electrode "pair" is the "A" spacing. The greater the "A" spacing the greater the depth of penetration and the earth volume over which the data are averaged. To create cross-sections (depth versus resistivity value) a number of different "A" spacings were required to define the resistivity with depth.

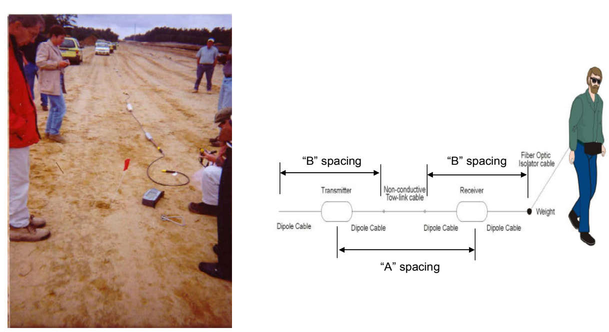

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FIGURE 3

A spacing of 5 meters for "B" was determined to be sufficient for the materials and depths to be investigated; this was kept as a constant for the survey. While data with four different "A" spacings (5, 10, 15 and 20 meters) were collected along each line. One 700 foot line, located 50 feet to the right of the centerline, between station 154+00 to 161+00 and four 400 foot line, located at 37.5, 25, 12.5 and 0 feet right of the centerline, were collected between stations 154+50 and 157+50 see Figure 2.

The resistivity measured by the Geometric's OhmMapper is an apparent resistivity which is an average resistivity of the volume of material involved in the measurement. This is plotted as a two dimensional cross section (pseudo section) through the earth. The boundary between two layers with different resistivity values results in a smooth resistivity curve which is not unique; a combination of different resistivity and-thickness values can produce the same curve, therefore the pseudo section must be modeled.

The interpretation is by inversion modeling of the data. Known individual resistivities of the earth materials involved will provide constraints to the model. Grouping of the data values for different geometries (dipole and spacings) over the same lines of coverage is input to inversion software to calculate a more realistic resistivity and depth profile. The pseudo-sections produced by modeling provide a reasonable representation of the resistivity-depth sections but because the modeling does not produce a unique cross section of the earth some caution needs to be exercised in the interpretation of the measurements. Experience along with knowledge of the local soils and, bedrock geology (if involved) is beneficial.

Results of Route 44 Investigation

For this survey there were three major layers of interest; 1) the dry fill/overburden; 2) the water table; and 3) the presences or lack of an organic peat/muck layer:

Layer	Laboratory ohm meters	Geometric's Ohm-Mapper range ohm meters
fill/overburden	700-1,000	>600
water table	205+/-	200-600
peat/muck	20-75	<200

The entire embankment was excavated from 154+00 to 160+00 with survey shots of the bottom of excavation (peat/muck) at 25 foot centers. The test pits were used to confirm the existence of organic muck/peat and determine the lateral and vertical extents. Samples were taken for the "special borrow", peat/muck and ground water and resistivity values measured in the laboratory. Identification and accurate measurement of the lateral and vertical extent of the peat/muck was questionable at some locations due to the use of a drag line excavation method.

Laboratory resistivity measurements of samples retrieved from test pits are listed below:

Special Borrow	Sample #SO1		
	As received	86,201 ohm cm	862 ohm meter
	Saturated	75,681 ohm cm	757 ohm meter
Special Borrow	Sample		
	As received	97,628ohm cm	976ohm meter
	Saturated	90,378 ohm cm	903 ohm meter
Peat			
	As received	5112ohm cm	51 ohm meter
	Saturated	7,538 ohm cm	75 ohm meter
Peat			
	As received	3,777ohm cm	37 ohm meter
	Saturated	2,759 ohm cm	27 ohm meter
Water			
	As received	20,554 ohm-cm	205 ohm meter

These results indicate that the resistivity contrast between the peat and the special borrow and ground water is large enough to be identified by the resistivity measurements.

Line E – Center Line

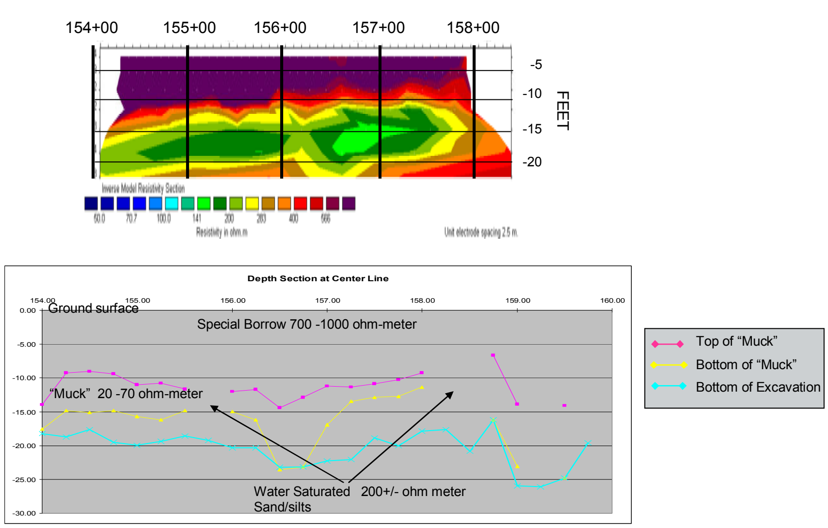

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FIGURE 4

Typical results of the Geometric's OhmMapper investigation are show on colored resistivity cross sections on Figure 4 for the lines shown on Figure 2. A comparison of inverted Geometric's OhmMapper results and test pit drag line results (Figure 4) indicate a reasonable correlation of the low resistivity areas and locations that peat/muck was excavated.

Conclusions:

The Geometric's OhmMapper provided a quick and easy method to perform an electrical survey to define the peat (compressible) material in the area of Rt. 44 construction. With the low resistivity values for the peat, penetration was limited and definition of the bottom of the peat layer is questionable. The method however will outline the lateral extent of peat material. This contribution is significant since the most expensive part of a boring –trenching program would be to establish the lateral extent of peat. The electrical survey will do this and this knowledge would serve to optimize the number of borings or backhoe excavations taken to define the bottom of peat.

Paul Fisk, President, NDT Corporation, Worcester, MA
Keith Holster, NDT Corporation, Worcester, MA
Silas Nichols, Geotechnical Engineer, Federal Highway Administration, Baltimore, MD
Pete Connors, P.E. Geotechnical Engineer, Massachusetts Highway Department, Boston, MA.