# Geophysical Survey
# Emerson Power Transmission
# Ithaca, New York

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# 1.0 Introduction

Forrest Environmental Services (FES) performed a geophysical survey at the Emerson Power Transmission Site located in Ithaca, New York on the 5th through the 7th July 2005. The survey consisted of an electric resistivity imaging (ER) survey to located saturated fractures that may indicate that the major groundwater path flows to placement of monitor/remediation wells.

Eight northeast-southwest (ER lines 1 North, 1 South, 2, 3, 4, 5 North, 5 South, and 7), one east-west (ER Line 6) and one north-south (ER Line 8) resistivity lines were conducted adjacent to the Emerson Power Transmission plant. The electrode spacing (dipole size) was 3 meters (10 feet) to 4 meters (16.4 feet) for ER lines 1 through 8. The ER lines were placed in areas of accessibility.

ER lines 1 through 8 used 35 to 84 electrodes for a total line length of 335 feet to 1100 feet. The survey covered an area approximately 5,400 linear feet and approximately 10,000 soundings were collected.

Topographically, the site slopes toward the northwest. The site consists mostly of a grassed field with wooded areas to the north. Details of the geophysical survey are described in the following sections.

## 2.0 Equipment and Procedures

The geophysical survey instrument used during this survey was an earth resistivity meter that maps the resistivity changes in the earth. ER is a fundamental parameter of the material that describes how easily the material can transmit electrical current. High values of resistivity imply that the material is very resistant to the flow of electricity, and low values of resistivity imply that the material transmits electrical current very easily.

The primary factors affecting resistivity of earth materials are porosity, water saturation, clay content, and ionic strength of the pore water. The minerals making up soil and rock generally do not readily conduct electric current. Most of the current flow takes place through the material's pore water in which ER decreases with increasing porosity and water saturation. Clay minerals are conductive because of the availability of free ions in the sheet structure of the clay particles in which ER decreases with increasing clay content. Similarly, dissolved ions in groundwater make the water more conductive to electrical current in which ER decreases with increasing ionic strength.

The ER survey was conducted by introducing a measured current into the earth through two adjacent electrodes and measuring the resultant voltage across two different electrodes at a predetermined distance apart. The voltage across two other electrodes is measured simultaneously with the applied current. At the low currents used, voltage is proportional to the current. The meter measures the voltage/current ratio or resistance in Ohms.

The ER survey was conducted using a Sting R8 earth resistivity meter (Sting), which measures the apparent resistivity of the subsurface employing an artificial source that is introduced through point electrodes. The Sting measures electrical potentials at other electrodes.

The Swift automatic electrode system (Swift) was connected to the Sting to optimize survey efficiency by gathering maximum information with a minimum of electrodes. The Swift also uses redundancies in the data set to reduce the effects of lateral heterogeneities in the earth and to calculate uncertainties in the data. The survey was conducted automatically using the Sting/Swift dipole-dipole array system.

A contact resistance test was conducted before the Sting/Swift dipole-dipole survey commenced. The contact resistance test ensures the stake has good contact with the ground. The Sting produces a current between the first two stakes and measures the voltage. The instrument measures the resistance between the first and second stakes and the ground. The contact resistance is also checked for the measurements consistent for all of the 84 electrodes.

The Swift cable resistance checks the voltage difference signal between two electrodes. Four leads of the Swift cable using two electrodes send a current through a 1 ohm resistor in the Swift box. The test is checked before the first ER survey and after the last ER line for each day.

The Swift switch relays test is performed to check the Swift box is continuous and the relays in the electrodes are working properly. A current is sent through each lead in the Swift cable to make sure the relays are functioning properly and there is no leakage between leads, and to test the relays for sticking. The test is checked before the first ER survey and after the last ER line for each day.

The depth of investigation by Sting is a function of the total distance of the electrode layout was between 335 feet for ER Line 5 South to 1,100 feet for ER Line 1 North and ER Line 5 North. The Sting has an effective analysis depth of approximately 60 to 250 feet using a 3 meter (10 feet) to 4 meters (16 feet) electrode spacing. This depth is considered sufficient to locate resistive areas that appear to be saturated zones at the Emerson Power Transmission site.

## 3.0 Interpretation Methods

The ER data were converted into a resistivity depth model using Rapid 2D resistivity inversion model and the least-squares method (RES2DINV). Soundings from each line were modeled to produce the measured apparent resistivity cross-sections. The model calculated the apparent resistivity cross-sections using finite-difference forward modeling. The least-squares optimization technique was used for the inversion routine that calculated the modeled resistivity section. The ER output consists of the inverse model resistivity cross-section. The model fits the measured data to an earth model that represents actual resistivities in the profile. The model is completed by back calculating apparent resistivities from the earth model for comparison to the measured data. The horizontal and vertical scales are in feet.

The cross-section is the inverse model resistivity pseudo-section. The ER data was converted into a resistivity depth model (RES2DINV) using a resistivity inversion model by the least-squares method and is topographically corrected. The ground surface elevations were determined by interpolating between contours on the site plan provided by Environmental Strategies Consulting LLC. RES2DINV confirms the model reliability by calculating the modeled data into empirical data or the calculated resistivity pseudo-section. The difference between the measured and calculated data is the root mean square percent error. The modeled calculated mean root square error averaged approximately 10 rms error which is considered accurate.

Resistive materials resist the flow of electrical current such as sand and gravel. Conductive materials are media that current flows relatively easy such as clay.

Low resistive materials can be caused by certain conductive soils such as clay. High resistive materials are caused generally by wood and air. Low ER values represent thick overburden. Lower ER anomalies are generally found over saturated mine shafts.

Typical resistivities of the overburden (clay) are 100 ohm meters (blue). Bedrock resistivities typically range from 200 (green) to 5,000 (red) ohm meters. The saturated zones resistivities typically measure approximately 50 ohm meters (dark blue).

## 4.0 Survey Results

The objective of the ER survey was to locate saturated fractures that may indicate the major groundwater path flows. ER cross-sections are provided in Appendix A. The horizontal scale is in meters. The vertical scale is in meters above mean sea level (msl).

ER Line 1 North indicates three conductive anomalies centered at approximately 350 feet Northeast, 660 feet Northeast, and 870 feet North approximately 100 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 1 South indicates three shallow conductive anomalies centered at approximately 120 feet Northeast, 260 feet Northeast, 330 feet Northeast, and 730 feet Northeast approximately 60 feet below ground surface. One deeper conductive anomaly is centered at approximately 320 feet Northeast approximately 150 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 2 indicates four conductive anomalies centered at approximately 240 feet Northeast, 410 feet Northeast, 510 feet Northeast, and 560 feet Northeast approximately 40 feet to 60 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 3 indicates one conductive anomaly centered at approximately 170 feet Northeast approximately 100 feet below ground surface. The conductive anomalies appear to be a saturated fracture.

ER Line 4 indicates three conductive anomalies centered at approximately 140 feet Northeast, 250 feet Northeast, and 350 feet East approximately 40 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 5 North indicates two shallow conductive anomalies centered at approximately 490 feet Northeast and 870 feet Northeast approximately 40 feet below ground surface. One deeper conductive anomaly is centered at approximately 320 feet Northeast approximately 200 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 5 South indicates two shallow conductive anomalies centered at approximately 50 feet Northeast and 170 feet Northeast approximately 30 feet below ground surface. Two deeper conductive anomalies are centered at approximately 150 feet Northeast and 220 feet Northeast approximately 50 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 6 indicates four shallow conductive anomalies centered at approximately 140 feet East, 250 feet East, 290 feet East, and 340 feet East approximately 20 feet below ground surface. One deeper conductive anomaly is centered at approximately 220 feet East approximately 50 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 7 indicates one conductive anomaly centered at approximately 340 feet Northeast approximately 80 feet below ground surface. The conductive anomaly appears to be a saturated fracture.

ER Line 8 indicates four anomalies centered at approximately 110 feet North, 180 feet North, 270 feet North, and 340 feet North approximately 50 feet below ground surface. The conductive anomalies appear to be saturated fractures.

# 1.0 Introduction

Forrest Environmental Services (FES) performed an additional geophysical survey at the Emerson Power Transmission Site located in Ithaca, New York on the 27th and 28th September 2005. The survey in July 2005 consisted of eight electric resistivity (ER) lines to located saturated fractures that may indicate that the major groundwater path flows to placement of monitor/remediation wells. The additional geophysical survey was to increase the coverage at the southwestern and northern section of the study area.

Three northeast-southwest (ER lines 10, 12, and 14), one east-west (ER Line 11), and one north-south (ER Line 9) resistivity lines were conducted adjacent to the Emerson Power Transmission plant. The electrode spacing (dipole size) was 3 meters (10 feet) to 4 meters (16.4 feet) for ER lines 9 through 14. The ER lines were placed in areas of accessibility.

ER lines 9 through 12 and 14 used 70 to 84 electrodes for a total line length of 660 feet to 1,300 feet. The survey covered an area approximately 4,200 linear feet and approximately 7,200 soundings were collected.

Topographically, the site slopes toward the northwest. The site consists mostly of a grassed areas and asphalt roads with wooded areas to the southwest. Details of the geophysical survey are described in the following sections.

## 4.0 Survey Results

The objective of the ER survey was to locate saturated fractures that may indicate the major groundwater path flows. ER cross-sections are provided in Appendix A. The horizontal scale is in meters. The vertical scale is in meters above mean sea level (msl).

ER Line 9 indicates four conductive anomalies centered at approximately 100 feet North, 280 feet North, 530 feet North, and 680 feet Northeast approximately 40 feet to 60 feet below ground surface. The conductive anomalies appear to be saturated fractures.

ER Line 10 indicates one conductive anomaly centered at approximately 460 feet Northeast approximately 100 feet below ground surface. The conductive anomaly appears to be a vertical saturated fracture.

ER Line 11 indicates two conductive anomalies centered at approximately 180 feet East and 520 feet East approximately 40 feet below ground surface. The conductive anomalies appear to be vertical saturated fractures.

ER Line 12 indicates conductive anomalies centered at approximately 180 feet Northeast and 570 feet Northeast approximately 40 feet below ground surface. The southwestern conductive anomaly appears to be a vertical saturated fracture. The northeastern conductive anomaly appears to be a saturated fracture.

ER Line 14 indicates two conductive anomalies centered at approximately 400 feet Northeast and 660 feet Northeast approximately 80 feet below ground surface. The conductive anomalies appear to be saturated fractures.