## Electrical Resistivity Imaging (also known as Electrical Resistivity Tomography)

Electrical resistivity (ER) surveys are a common and effective geophysical method for detection of subsurface voids and water saturated ground. The basic operating principle for an ER survey involves generating a direct current between two metal electrodes implanted in the ground while measuring the ground voltage between two other implanted electrodes (much like measuring the resistance of a circuit with a multimeter). Given the current flow and voltage drop between the electrodes, differences in subsurface electrical resistivity can be determined and mapped. Modern resistivity surveys employ an array of multiple electrodes connected with electrical cable. Over the course of a survey, pairs of electrodes are activated by means of a switchbox and resistivity meter. The depth of investigation for a typical ER survey is approximately one-fifth the length of the array of electrodes. The near-surface resolution is roughly half of the electrode separation. The width of a survey is typically determined by the electrode separation, e.g. a four-meter electrode separation would also give an approximately eight-meter wide "strip" centered on the survey line for a 2D survey.

Resistivity profiles illustrate vertical and lateral variations in subsurface resistivity. The presence of water or water-saturated ground will strongly affect the results of a resistivity survey by indicating a low resistivity zone. Air-filled caves or air-filled pore space provide a distinctive high resistivity signature, since air has near-infinite resistivity, in contrast with the 10 to 15 orders of magnitude more conductive surrounding bedrock.

For these studies, Southwest Geophysical Consulting uses an Advanced Geosciences Inc. (AGI) SuperSting™ Wifi R8 with a multi-electrode switchbox, a 56-electrode array to image the subsurface. Surveys typically consist of a dipole-dipole survey combined with an edge gradient survey. The dipole-dipole provides better resolution, while the edge gradient increases the current injected into the ground giving a better signal-to-noise ratio. Each survey will run independently, back-to-back using a combined command file. Each array consists of between 28 and 56 electrodes spaced from 1 to 5 meters apart. The exact dimensions of the array and number of electrodes are chosen to fit the parameters of the desired information about the subsurface including the desired depth and resolution. These parameters are determined through conversation with the client.

A Juniper Geode sub-meter GPS is used to record electrode locations and elevations, which are used during data processing to refine the image and provide location data for overlay on satellite imagery. A detailed list of each electrode number, location in latitude/longitude decimal degree format, and elevation in meters is provided as part of the data file set. EarthImager2D™ and EarthImager3D™ software are used to download and process the raw data and to provide the model used to make our interpretations.

## Workflow and Description of Work

**Field Preparation:** Field prep consists of analysis of satellite imagery to determine grid layout and expected obstacles, survey planning, command file and GPS data upload, and inventory and packing of equipment for transport. This process takes approximately 1 day.

**Day of Arrival:** Each project will be allotted a travel day before and after the field work. If enough time exists once at the field site, ground truth of the satellite photos, area ground level photographs, and grid survey and set-up will be conducted. Otherwise, these processes will take place at the beginning of the first full day of the survey.

Survey setup includes visually marking the survey boundaries and measuring out each of the survey lines perpendicular to the long edge of the survey area. The electrodes are then placed at the selected interval along the survey tape and the electrode take-out cables are placed along the survey line then attached to the electrodes. The last thing to occur before running the survey is setting up and connecting the SuperSting, switchbox, and power supplies to the take-out cables. Set-up and tear-down for each survey takes approximately 1 to 1.5 hours while the survey itself takes approximately 30 to 45 minutes. Four to five survey lines can be completed per day, depending on the amount of vegetation that has to be cleared for each line during setup, the distance each line has to be moved (based on a 2D or 3D survey), and the terrain.

Approximately three acres can be covered per day for a 3D survey. Each survey line takes approximately 1 – 1.5 hours to set up, 30-45 minutes to run the imaging program and 30 minutes to tear down and move to the next location. This tends to move a little faster as the day progresses. For a 2D survey, approximately 3 to 5 survey lines can be completed per day, or if a roll-along survey, up to six survey lines (in ideal conditions, this equates to 1 kilometer). The time for each line is heavily dependent on terrain, vegetation, and other obstacles in the survey area, numbers quoted here are for ideal situations.

**Final Day:** The last day of each project will be used to complete the survey of any remaining lines, clean and package the equipment for transport, and travel back to Albuquerque.

**Interpretation and Report:** Upon return to the office, the data is downloaded from the field computer and uploaded to the data processing program. Data interpretation can take between 3 and 5 full days depending on the complexity of the area, the number of lines, and the amount of data collected. Once data processing is complete, interpretation begins. This process can also take between 3 and 5 days. After interpretation is complete, a report of the study is written which includes an executive summary, description of the study area, description of the survey, results, photos, maps, cross-sections, and recommendations. The report generally takes 1 - 2 days and will be provided to the customer in either a .doc or .pdf format, whichever is preferred. We strive to have a report to the client within 10 working days of the completion of the field work, occasionally it will take a little longer. Example reports are available on request.

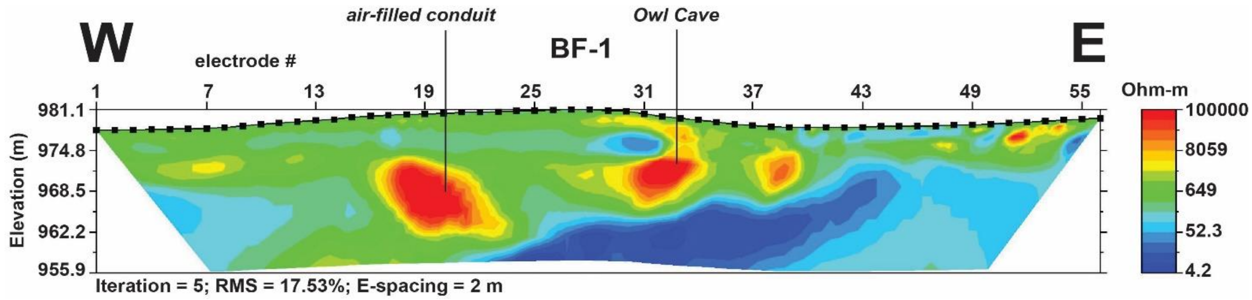


**Figure 1: 2D survey example. This image shows what a cave would look like in a 2D inverted resistivity section.**

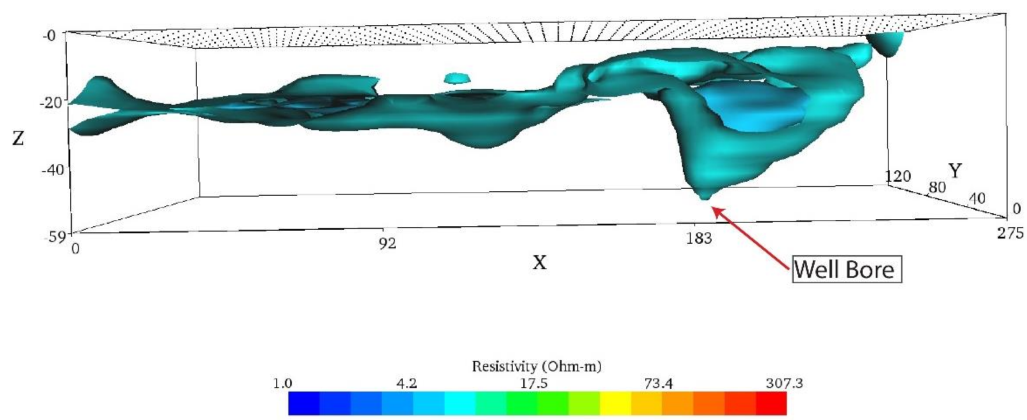


**Figure 2: 3D survey example (iso-surface). This image shows the boundary below which a very low resistivity fluid resides.**

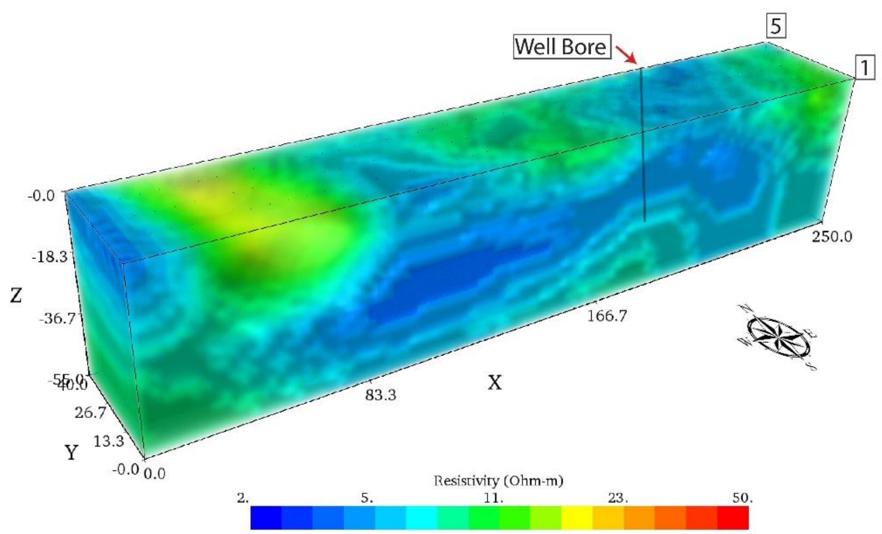


**Figure 3: 3D survey example (volume). This image is the same as in Figure 2 but includes the higher resistivity features.**