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August 29, 2006

VIA OVERNIGHT COURIER

Richard A. Gates
District Manager
U.S. Department of Labor
Mine Safety and Health Administration
135 Gemini Circle, Suite 213
Birmingham, AL 35209

Re: Sago Investigation

Dear Mr. Gates:

Enclosed for your information is the report of hydroGeophysics, Inc. on both phases of their work.

If you have any questions, please free to contact me.

Sincerely,

R. Henry Moore

RHM/dab
Enclosure
cc: Johnny Stemple
R. Nicholson, Esq
Laura E. Beverage, Esq.
Sam Kitts
Charles Dunbar
(all w/o encl.)

(C1120006)

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hydroGEOPHYSICS, Inc.
Geophysical Consulting and Services

Geophysical Survey of the Old 2 Left Section of the Sago Mine, WV

Completed for : Jackson Kelly PLLC
and International
Coal Group

Project Lead: Dale Rucker, PhD
Date: August 23, 2006
HGI Project No. : 2006-035

Geophysical Survey for the Old 2 Left Section of the Sago Mine, Buckhannon, WV

Primary Investigator:
Dale Rucker, PhD

Contributing Investigators of Significant Importance:
Marc Levitt
Shawn Calendine
John Fleming, PhD
Robert McGill

hydroGEOPHYSICS, Inc
Tucson, AZ

18 August 2006

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EXECUTIVE SUMMARY

hydroGEOPHYSICS, Inc. (HGI) was contracted with International Coal Group (ICG) and its representatives to conduct a geophysical investigation at the Old 2 Left section of the Sago Mine located near Buckhannon, West Virginia. The geophysical investigation was prompted following an explosion that occurred in a sealed area of the mine in January 2006. It is suspected that the explosion was caused by a lightning strike on the surface near the mine. However, a specific electrical path from the surface to the underground mine is unknown. The objective of the geophysical investigation was to characterize and map subsurface conditions in order to determine if a specific electrical pathway exists. The electrical path could have originated from anthropogenic or geologic features.

The anthropogenic features include metallic infrastructure from pipelines, wells, power lines, or other features that could have provided an ohmic conduction mechanism for electrical current to travel from the surface to the mine. Geologic features provide an electrolytic conduction mechanism for current travel. The electrolytic conduction relies on ionic movement within the pore space and along soil grain surfaces to transmit ions. More free ions in a pore space allows for greater current to flow, thereby reducing the electrical resistivity.

The investigation was conducted in two phases. The first phase (Phase I) included the mapping of anthropogenic features directly above the Old 2 Left section of the Sago Mine using magnetic gradiometry (MAG) and electromagnetic induction (EM). The MAG and EM mapping were carried out by either mounting the instruments on a cart, or by manually carrying the instruments in more topographically challenging areas.

Phase II consisted of completing a High Resolution Resistivity (HRR) survey to characterize the electrical properties specifically within the area of concern. The resistivity survey was completed by measuring the electric potential on a series of electrodes while injecting current on a nearby electrode. The survey was arranged such that a set of electrodes at the surface could be used in combination with electrodes on the roof of the mine. The connection of the two electrode sets was facilitated by an existing nearby borehole.

The main conclusions of the survey are:

- The total field magnetic results showed no unknown boreholes within the survey area that could have acted as a vertical conduit for current generated through a lightning strike to reach the mine elevation.
- The gradient magnetic results also showed no unknown boreholes within the surveyed areas.
- The EM conductivity results showed no vertical well casings in the surveyed areas.

- The EM in-phase results showed no unknown vertical well casings in the surveyed areas.

- The HRR results revealed no compelling vertically oriented conductive zone that could have acted as a conduit for current generated from a lightning strike to reach the mine.

1.0 Introduction

An explosion occurred in a sealed area of the Sago Mine in January 2006. It is postulated that the explosion originated from a spark generated by electrical current during a lightning strike at the surface and near the mine area where the explosion occurred. The electrical connectivity from the surface to the mine is unknown. A geophysical survey was conducted to map the subsurface electrical properties to determine an electrical path.

The electrical path could have originated from anthropogenic or naturally occurring geologic features. The anthropogenic features include metallic infrastructure such as pipelines, wells, buried power lines, or other cultural features that could have provided an ohmic conduction mechanism for electrical current to travel from the surface to the mine. A geophysical survey that relies on induced fields to map the magnetic and electrical properties of the near surface (top 20-30 feet) is capable of finding all major relevant conductors within the areas surveyed.

Geologic features provide an electrolytic conduction mechanism for current travel. The electrolytic conduction relies on ionic movement within the pore space and along soil grain surfaces to transmit ions. More free ions in a pore space allow for greater current to flow, thereby reducing the electrical resistivity. Factors affecting the resistivity include soil type (clay or shale vs. sand), moisture, and salt or metallic mineral content. Direct current resistivity is capable of mapping the subsurface to differentiate zones of low and high electrical resistivity.

1.1 Site Location

Located in north-central West Virginia, the current working mine portal (for the Sago Mine) is approximately 6 miles south of the town of Buckhannon. Plate 1, (Appendix A), shows the extent of the MAG and EM surveyed area. The area of concentrated interest for the geophysical survey was the Old 2 Left section, located at the northern end of the mine boundary.

1.2 Objective of Investigation

The objective of the geophysical investigation was to characterize and map subsurface properties to determine if an electrical path exists from the surface, above the Old 2 Left section of the Sago Mine, to the underground mine elevation.

1.3 Scope of Investigation

The investigation was conducted in two phases. The first phase (Phase I) included the mapping of anthropogenic features directly above the Old 2 Left section using MAG and EM. These instruments were cart-mounted for areas that were relatively flat with respect to the topography. Steeper topography or land that had high density vegetation required the instruments to be manually carried.

Phase II consisted of HRR data acquisition in order to map the subsurface electrical properties as related to geologic conditions. The HRR survey was completed by measuring the electric potential along a series of electrodes while a low voltage signal was injected at nearby electrodes. The survey was conducted such that a set of electrodes on the ground could be used in conjunction with roof bolts as subsurface electrodes along the mine's roof. The combination of the two electrode sets was facilitated by an access borehole.

The surface electrodes were placed at 15 foot intervals along a single transect. The roof bolts in the mine roof were used as the electrodes in the mine, and their spacing was variable depending on access and proximity to other infrastructure, such as wire meshing. A total of 112 electrodes were used on the surface and underground.

2.0 Methodology

2.1 Survey Area & Logistics

Data acquisition for this project was planned as a two-phase operation. During the Phase I portion, anthropogenic features in the area directly above the Old 2 Left section of the Sago Mine were mapped using MAG and EM instrumentation. Phase II of the project consisted of a HRR survey that was carried out in a focused area of concern within the MAG and EM areas.

Phase I mobilization commenced on June 12, 2006. Before field work was initiated, unrestricted access to all privately held areas was secured by ICG. The survey areas were located mostly in open grassy fields. Due to high traffic load, a road separating the northern portion of the survey from the southern portion was avoided.

A single-wheeled, fiberglass push cart was used to mount the MAG and EM instruments for simultaneous acquisition of both sets of data within areas of low topographic relief. Figure 1 shows the set up for the cart. Both instruments were connected to a common datalogger for time stamped, real-time data storage. A global positioning system (GPS) was used to geo-reference all the data, which was also attached to the datalogger.

Shortly after the Phase I surveys were started, technical difficulties that could not be resolved in the field necessitated HGI personnel to return to Tucson before all areas could be completely surveyed. Completion of the Phase I surveys was accomplished during the Phase II mobilization for the HRR surveys.

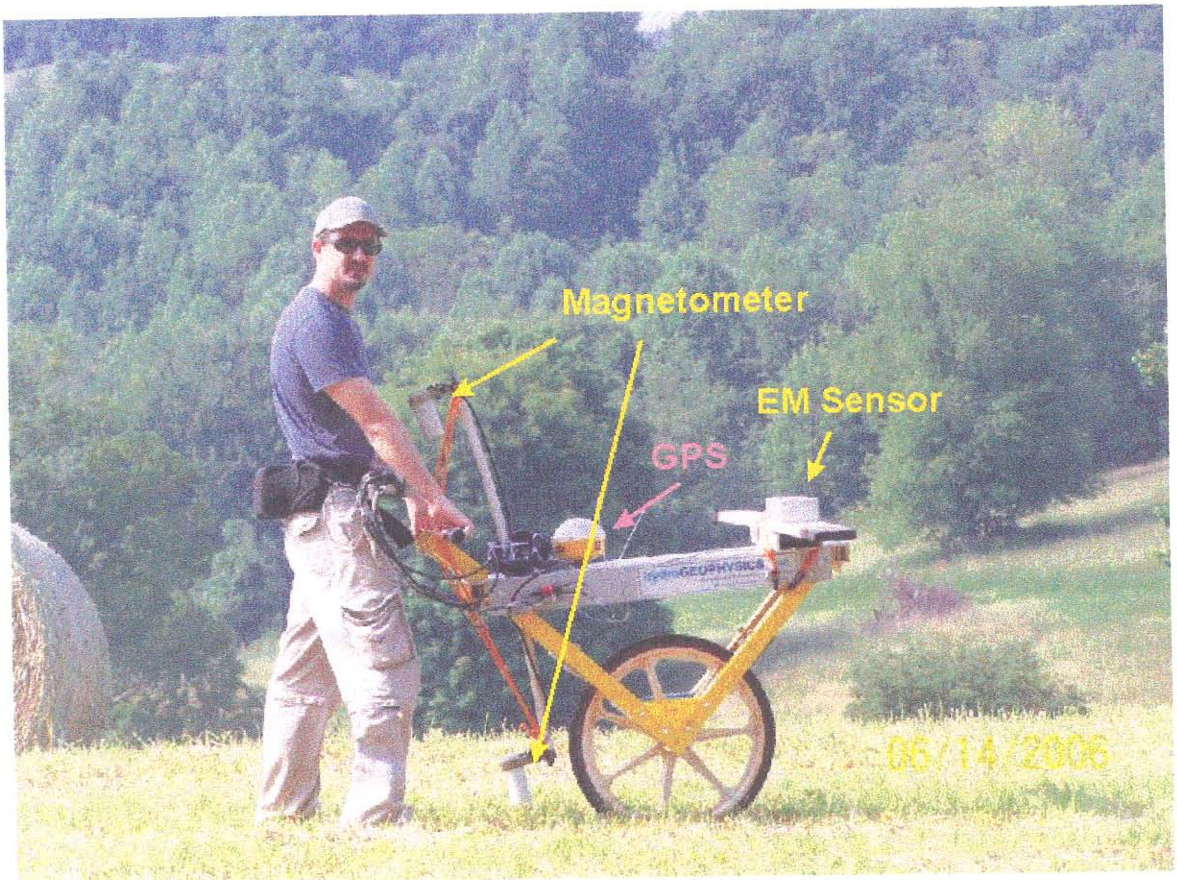


Figure 1. Push cart for simultaneous EM and MAG data acquisition. Dr. Dale Rucker

Phase II mobilization, to conduct the HRR surveys and the completion of MAG and EM data acquisition, commenced on July 17, 2006. To collect the HRR data, two sets of HRR electrodes were used: one set on the surface and one underground. The HRR survey was located in the vicinity of the suspected ignition site of the January 2006 methane explosion. The surface electrodes were installed at 15 foot intervals and the transmitter and receiver remote reference electrodes were deployed approximately 3,000 feet away. The underground HRR line used mine roof bolts for the same purpose. The spacing for the bolts varied. Figure 2 shows a schematic of the layout for the two sets of electrodes.

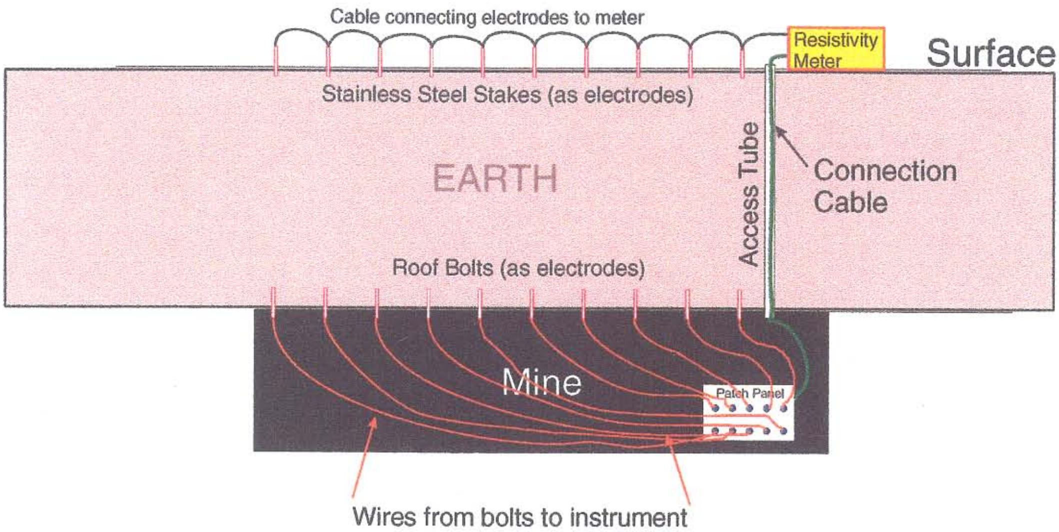


Figure 2. Schematic of the HRR line and equipment placement for the Sago resistivity survey.

Figure 3 shows the location of the surface array, overlain on an oblique photograph of the area. The surface line was approximately 825 feet long and consisted of 56 electrodes that were spaced at 15 foot intervals. The 4010 access borehole was used to connect the surface resistivity electrodes to the underground electrodes.

Figure 3. Photo of HRR survey line area. View is towards the east.

To conduct the subsurface HRR survey, entrance to the Sago Mine was required by HGI personnel to connect a multi-channel patch panel to the surface geophysical equipment, surface electrodes, and subsurface roof bolts. This necessitated HGI field engineer Shawn Calendine to complete mandatory underground coal mine hazard training. Certification of the completed ICG sponsored training was received on July 19, 2006. On the same day, the HGI field engineer was issued an ICG jumpsuit, steel toed boots, and a Self Contained Self Rescuer (SCSR) and escorted to the underground site by two MSHA officials and two ICG officials.

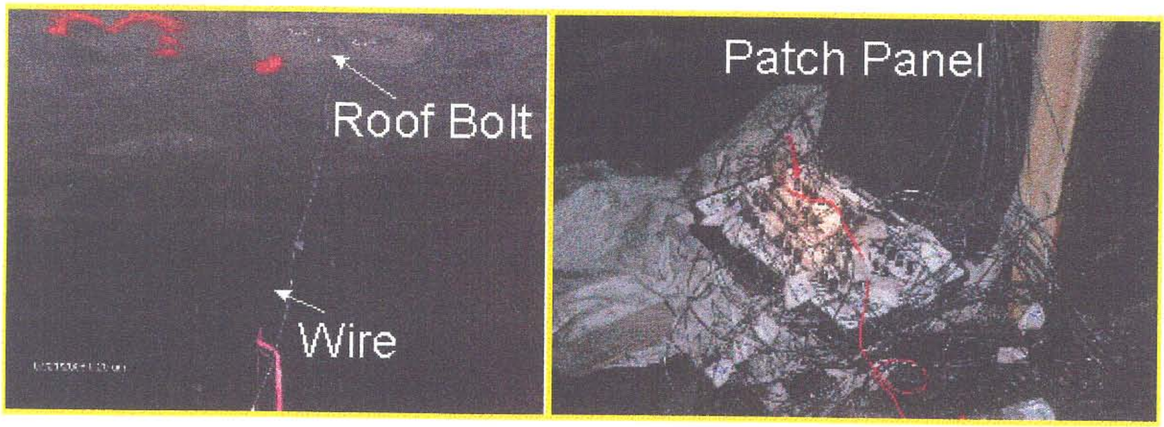


Figure 4. Photos of the underground roof bolts, wire leads, and patch panel equipment.

During Phase II, HRR data were acquired using an eight-channel, earth resistivity instrument. The resistivity instrument was connected to the subsurface HRR line via two, 150 meter long cables that were lowered through the 4010 access hole. The two cables were attached to a 56-channel patch panel (Model HRR-56PP, HGI, Tucson, AZ) that connected the roof bolt electrodes and their associated 56 wires. Figure 4 shows photographs of the underground setup. The HRR survey line end points and the electrode locations of each line were geographically surveyed by an ICG contractor. HRR data acquisition began on the morning of July 20, 2006 and was completed on the same day at approximately 8:00 pm.

On the morning of July 21, 2006, the 56 channel patch panel was retrieved from the mine by ICG employees, the two extension cables were pulled from the borehole using a crane, and all other cabling and electrodes were retrieved from the surface. Figure 5 shows the operations necessary to retrieve the cables, which weighed approximately 90 pounds each.

Figure 5. Photos of the cable retrieval operations.

Phase I MAG and EM surveys were reinitiated on July 25, 2006. Due to the highly uneven terrain at the site, the push-cart could not be used for most areas. Consequently, data for 12 of the 18 acres of the Phase I survey were acquired by individually walking with the equipment along pre-determined transects. To ensure the acquisition of high quality data, field personnel removed all metal from clothes and pockets, wore non-metallic personal protective equipment including non-metallic, composite-toed boots, leather gloves, and non-metallic protective eyewear. All Phase I MAG and EM surveys were completed by July 30, 2006.

2.2 *Equipment*

In order to fully maximize geophysical characterization efforts, HGI employed three different geophysical methods at the subject site, which required four different geophysical instruments.

2.2.1 Magnetometry and Electromagnetic Induction

Total Field Magnetometry

For the magnetic investigation, a proton procession magnetometer (Model G-856, Geometrics, Inc., San Jose, CA) was used for the base station to monitor diurnal variations within the ambient earth's magnetic field. The magnetometer consists of a kerosene-filled sensor, which is connected to a datalogger and 12V battery. Data were typically recorded at a sampling rate of 0.1 Hz (one data point every 10 seconds). At the end of each day, the data were downloaded to a laptop computer for processing and analysis.

A cesium-vapor magnetic gradiometer (Model G-858/G, Geometrics, Inc., San Jose, CA) was used to acquire the total magnetic field and magnetic gradient data across the site. The G-858/G was operated as a dual sensor gradiometer with the sensors oriented vertically with a static separation of one meter. The lower sensor was positioned approximately 30 centimeters from the ground surface. A data logger and control console were used to store the data and monitor data acquisition. Data were recorded at discrete time intervals, equating to a frequency of 5 Hz with an accuracy of 0.2 nanoteslas (nT). Time, date, and magnetic readings were recorded digitally and later downloaded to a laptop PC for processing.

Magnetic data were processed using specialized proprietary and commercial software, such as MAGMAPPER (Geometrics, Inc., San Jose, CA) and Surfer (Golden Software, Golden, CO). Processing included diurnal correction, drift removal, spike removal, data interpolation, and, where needed, filtering. A two-dimensional surface was derived that best fits long-wavelength components within the data. This crucial step (high-pass filtering) effectively removes the regional magnetic field and augments localized anomalies. The resulting map clearly delineates magnetic anomalies and may be compared with results of other geophysical methods (such as EM) to accurately locate specific subsurface objects.

Frequency-Domain Electromagnetics

Electromagnetic data were acquired using a co-planar, two-coil, vertical-axis frequency-domain, electromagnetic conductivity and susceptibility instrument (Model GEM-2, Geophex, Ltd., Raleigh, NC). The GEM-2 consists of a transmitter and a receiver coil separated 1.66 meters, a sensor housing (ski), and electronics console. During data collection the ski was oriented so that the transmitter and receiving coils were parallel to the direction of traverses (in-line). Both in-phase (real) and quadrature (imaginary) component data were acquired simultaneously at 5 frequencies ranging from 5kHz to 20 kHz. The electromagnetic data were converted to electrical conductivity using WinGEM software (Geophex, Ltd.).

Global Positioning System (GPS) Surveying

Geospatial control for the MAG and EM surveys was established using a real-time, differentially-corrected, single receiver, navigation system (Model AgGPS 132, Trimble Navigation, Ltd., Sunnyvale, CA). The GPS was connected directly to the G-858G console for data logging capabilities. The sampling rate of the GPS was fixed at one Hz. The AgGPS 132 provides sub-meter accuracy.

2.2.2 *High Resolution Resistivity (HRR)*

HRR data were acquired using an eight-channel resistivity instrument (Model SuperSting R-8 IP, Advanced Geosciences, Inc, Austin, TX). The SuperSting R-8 IP is a DCpowered, battery operated, low voltage, low amperage, automatic, eight-channel, resistivity and induced polarization (IP) system. This system employs the SuperSting Swift general purpose cables that can be attached in series. Each cable segment contains four smart electrodes. Each electrode has the capability of acting as either a low-amperage current transmitter or as voltage potential measuring receiver.

The SuperSting R-8 IP has the capability of automatically switching between electrodes without physically changing the electrode connections after initial set-up. Automatic switching decreases physical labor, cuts down on human transcription and tracking errors, better allows the operator to control array logistics, and increases the rate and density of data acquired. HGI personnel took advantage of this capability and programmed the SuperSting R-8 IP to use a survey line spread of 112 smart electrodes with inter-electrode spacings ranging from 15 to 825 feet. All data were acquired using a pole-pole electrode configuration.

2.3 Data Processing

2.3.1 Magnetometry

Data processing for the total-field magnetic data began with geo-referencing with respect to the differential GPS data. The GPS data were recorded at a sampling rate of 1 Hz, whereas the G-858/G magnetic data were recorded at a rate of 5 Hz. Linear interpolation was used to geo-reference every magnetic data point based on the time stamp.

After geo-referencing, the total-field magnetic data were corrected for diurnal variations in the earth's magnetic field. The G-856 magnetic data were used for removing these variations by subtracting the base station data from the G-858 roving data. Before diurnal corrections, however, the G-856 base station data were de-spiked and filtered with a low-pass filter to remove high frequency noise.

The last step in time-series filtering of the total-field magnetic data involved the removal of the heading error. Heading errors result in the preferential alignment of the sensors in the earth's magnetic field, which will cause anomalous readings unrelated to any response from buried metallic debris. Heading error was calculated from magnetic data collected in eight distinct directions. A curve was fit for direction of travel versus field strength, which was subsequently subtracted from the data.

After correcting the G-858/G magnetic data for each of the time-series issues, the data were compiled spatially and passed through a low-pass one-dimensional (1-D) spatial filter to remove high frequency noise. Coincident data points (within 0.03 m) were removed to eliminate redundancy.

2.3.2 Electromagnetic Induction

The GEM-2 measures both in-phase and quadrature components of the electromagnetic signal. Typically, the in-phase is related to the magnetic susceptibility and the quadrature is related to the subsurface electrical conductivity, each of which are a function of signal frequency, vertical separation between the coils and the ground, coil orientation (horizontal or vertical), and coil separation. EM measurements were made at five transmitter frequencies; 5, 7.5, 10, 15, and 20 kHz.

The first step in processing the EM data is geo-referencing of each data point with the differential GPS. The GPS data were recorded at a sampling rate of 1 Hz, whereas the GEM-2 EM data were recorded at a sampling rate of 3 Hz. Linear interpolation was used to geo-reference each data point based on the time stamp.

After geo-referencing, measured in-phase and quadrature data were transformed to in-phase susceptibility and conductivity using an inversion algorithm provided to HGI by Geophex, Ltd. The inversion produced in-phase susceptibility and electrical conductivity values as a function of each of the transmitter frequencies and a total average, frequency independent electrical conductivity. Additional corrections were made to compensate for instrumental drift associated with environmental factors and daily setup differences.

After inverting the data and correcting for drift, the data were compiled spatially and passed through a low-pass one-dimensional spatial filter to remove high frequency noise. Coincident data points (within 0.03 m) were removed to eliminate redundancy.

2.3.3 Tomographic Inversion of Electrical Resistivity

Inversion involves calculating the distribution of true electrical resistivities of the subsurface that give rise to the measured apparent resistivity distribution according to the governing equation:

$$\frac{\partial}{\partial x}\left(\frac{1}{\rho}\frac{\partial V}{\partial x}\right)+\frac{\partial}{\partial x}\left(\frac{1}{\rho}\frac{\partial V}{\partial x}\right)+I=0.$$

The objective of the inversion is to obtain an electrical property section that lends itself to enhanced interpretability as it relates to the geological properties of the survey area. Several methods of inversion are presented in Oldenburg and Li (1994), Loke and Barker (1995), and LaBrecque et al. (1996).

The Sago Mine site provided a unique opportunity to conduct resistivity surveys to characterize the electrical properties of the study area using both surface and subsurface electrodes. Roof bolts within the mine workings were used as additional subsurface electrodes that would augment measurements made with surface electrodes. The motivation behind this approach was that the additional subsurface measurements would enhance resolution.

To investigate the utility and enhanced resolution afforded by subsurface electrodes, a modeling exercise was conducted. Using the same model geometry as illustrated in the following examples, a simulation was carried out to generate a set of synthetic field measurements that would be obtained using all possible combinations of 112 (56 surface and 56 subsurface) electrodes.

Figure 6 shows an example of tomographic inversion for an idealized horizontally oriented 10 ohm-m conductive unit in a more resistive 100 ohm-m homogeneous host rock. The top figure shows the schematic of the model. The middle figure shows the resulting measured field data that the earth would generate for the given geologic model. The data are plotted as a standard pseudosection showing contours of apparent resistivity (See Geophysical Theory explanation in Appendix A). The bottom figure shows the resulting inverted representative resistivity section. As can be seen in the inverted section, the conductive unit is clearly visible in the more electrically resistive host rock.

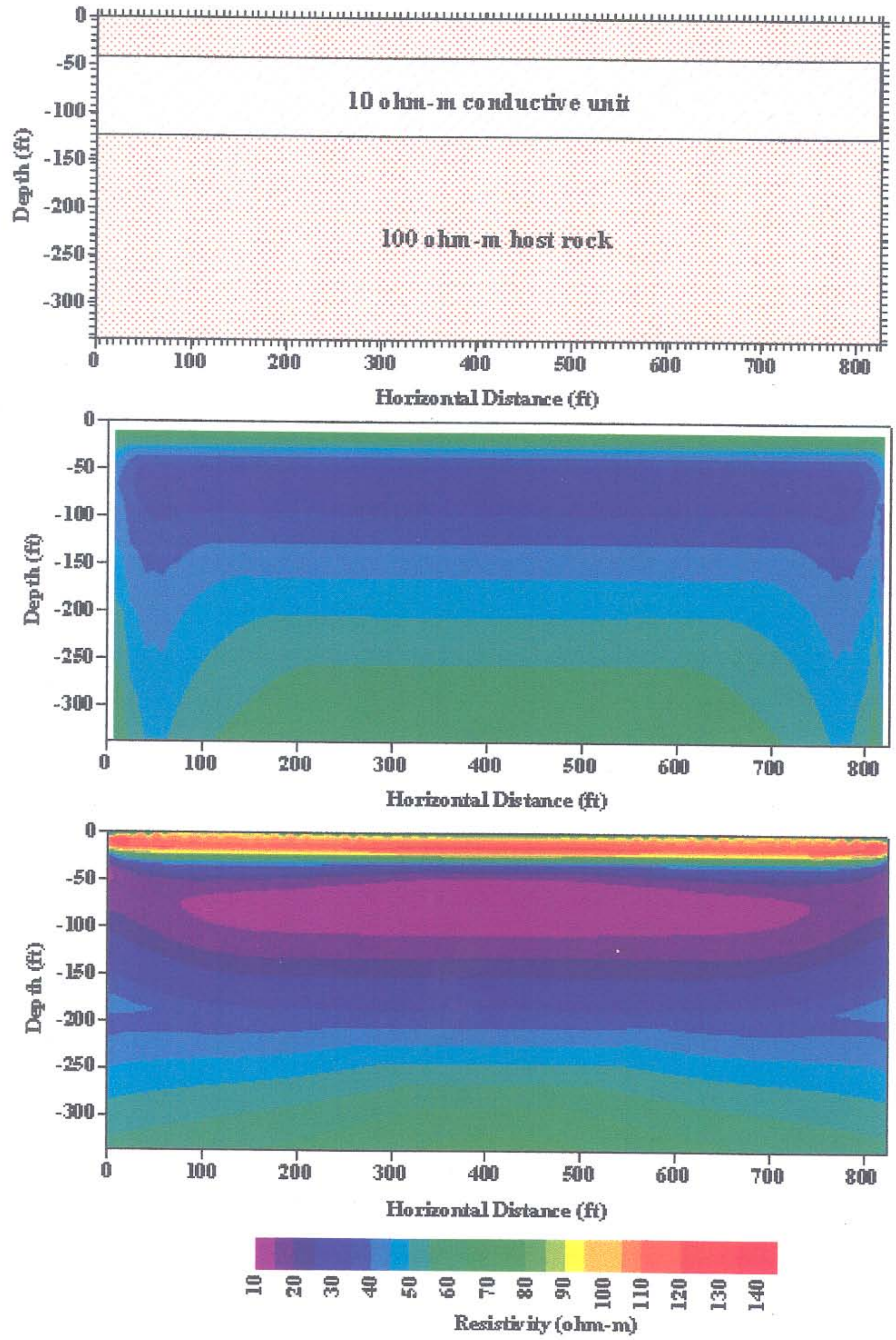
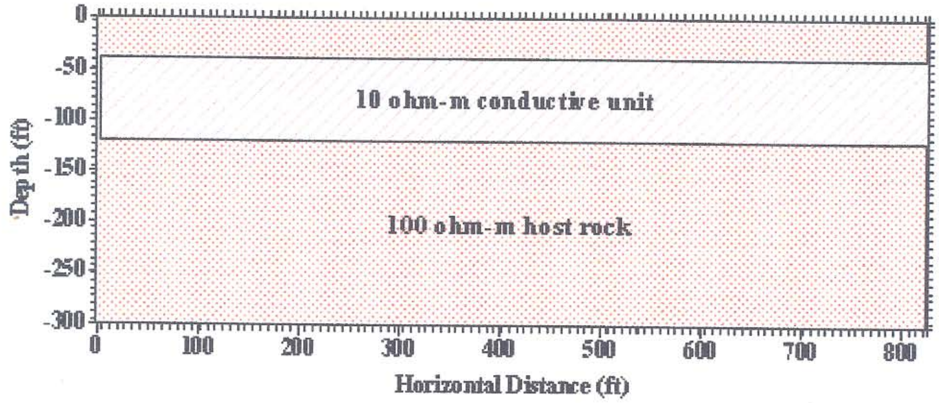


Figure 6. Tomographic inversion for a horizontally oriented conductive unit within a resistive host rock based on measurements made using surface electrodes. Top) Geologic representation of the subsurface, Middle) Measured apparent resistivity of the subsurface, Bottom) Tomographic inversion of the data to reconstruct the subsurface from the measurements.



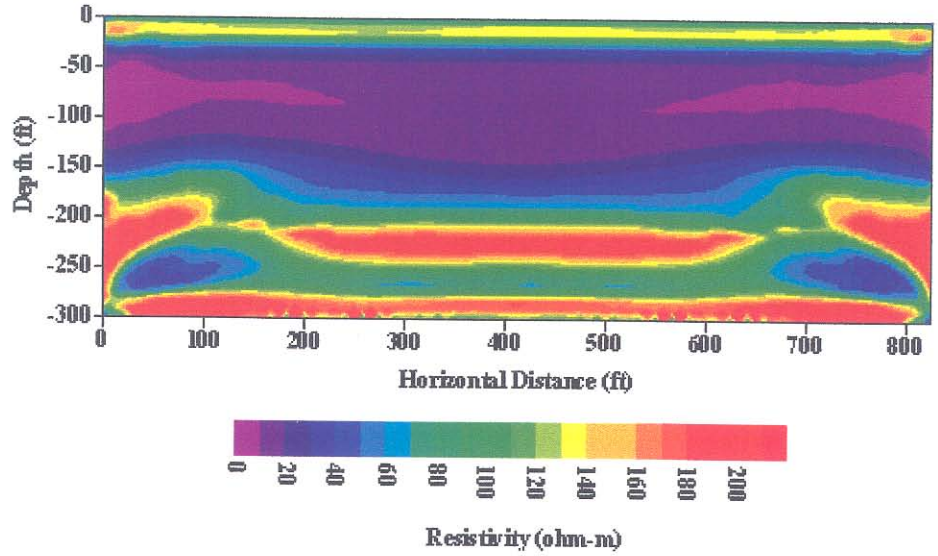
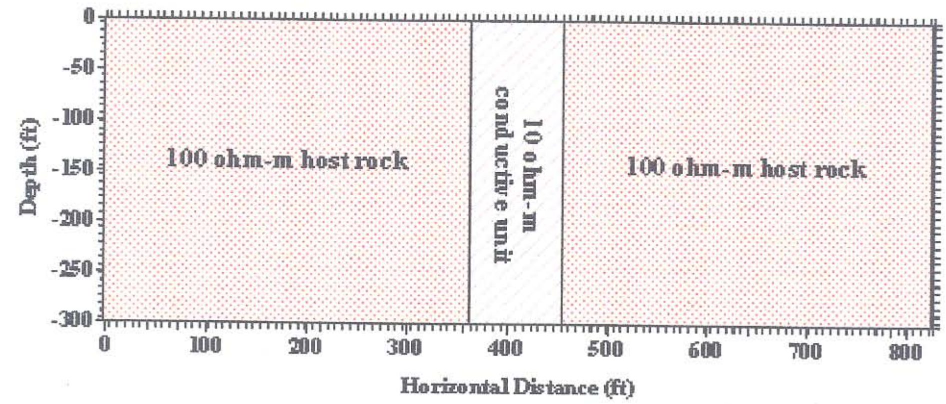


Figure 7. Tomographic inversion for a horizontally oriented conductive unit within a resistive host rock based on measurements made using both surface and subsurface electrodes.

Figure 7 above shows both the geologic model used and the inversion results using both surface and subsurface electrodes. In comparison with the results obtained using surface electrodes only (Fig. 6), the combined surface and subsurface measurement resistivity section shows enhanced resolution at greater depths. The resolution is manifested in the ability to discriminate the high resistivity host rock unit that exists below the conductive unit. This higher resistivity area is not as clearly characterized in the inversion obtained using surface measurements only.



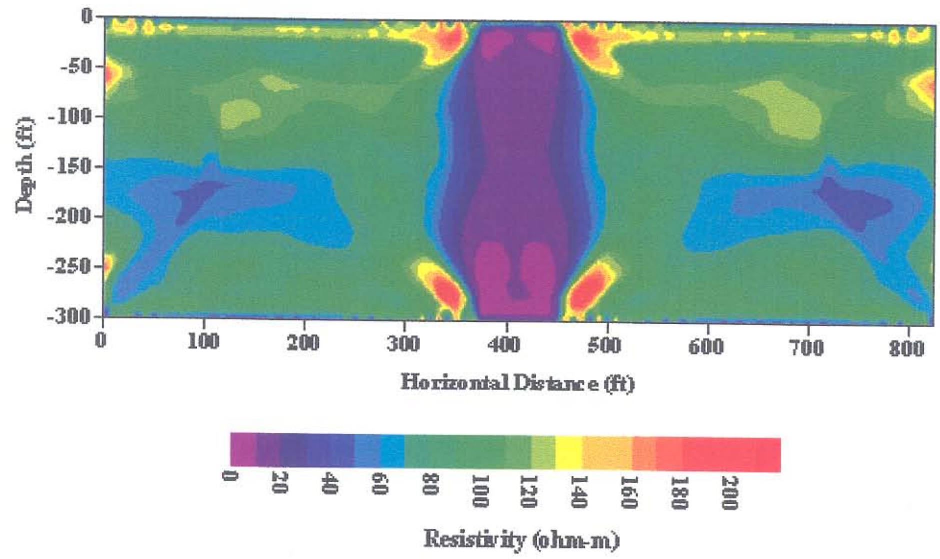


Figure 8. Tomographic inversion for a vertically oriented conductive unit within a resistive host rock based on measurements made using both surface and subsurface electrodes.

A similar modeling exercise was carried out with a vertically oriented 10 ohm-m conductive unit in a 100 ohm-m host rock. This geometry would be most conducive for electrical current flow from the surface to the underground. Figure 8 shows the model and inversion results for a set of synthetic pole-pole array configuration measurements using all possible combinations of 56 surface and 56 subsurface electrodes. Again, the inverted resistivity section clearly shows the conductive unit.

The results of these modeling exercises demonstrate that enhanced resolution is achieved when surface electrode resistivity measurements are augmented with subsurface measurements. Enhanced resolution increases the ability to resolve electrically conductive pathways that may exist within the study site.

3.0 Results & Interpretation

3.1 Electromagnetic Induction

In total, 6.39 line miles were traversed to cover the 18.1 acres of survey area for acquisition of the EM data. To facilitate efficiency in conducting the EM surveys, the study area was divided into 6 different survey zones (Plate 2). The results for each of the 6 zones are discussed separately. The recorded electromagnetic field response is divided into two sub-components; in-phase and conductivity (also referred to as quadrature). The in-phase component is most sensitive to metallic objects and is measured in parts per million (ppm). Under normal conditions, in the absence of any metallic objects, the expected nominal reading should be close to zero. The conductivity component is sensitive to variations in soil conditions and measurements are obtained in units of Siemens per meter (S/m). Conductivity measurements can also be strongly influenced by the presence of metal objects; as these objects are typically much better electrical conductors than the surrounding soil or geologic material. A color contoured plot of in-phase measurements using a transmitter frequency of 10 kHz is shown in Plate 3. Plate 4 shows the color contoured plot of electrical conductivity measurements obtained at 10 kHz. The other four frequencies (5kHz, 7.5 kHz, 15 kHz, and 20 kHz) showed similar responses.

3.1.1 Electromagnetic In-Phase

Zone 1 covered an area of 3.6 acres and consisted of a total of 10 survey lines. Within the southern portion of this survey zone there are several areas where the measured in-phase response exhibit anomalously low values. The majority of these areas coincide with structures or metal objects that were observed and noted during the survey. There is also an area in the central-eastern portion of the zone that exhibits anomalously high in-phase values. This area is associated with the foundation of a demolished structure. The remnants of the foundation were observed to contain rebar reinforcement.

Survey zone 2 covered an area of 2.5 acres and consisted of 10 survey lines. In the southern portion of the grid, two areas exhibit anomalous in-phase responses. These areas were identified during the survey and are associated with buildings and a parked vehicle. In the northwestern corner of the survey zone there are three localized anomalies that are associated with a driveway.

Survey zone 3 covered an area of 3.4 acres and consisted of 10 survey lines. Within this surveyed zone there are anomalously low responses caused by metallic-wire fencing.

Survey zone 4 covered an area of 1.3 acres and consisted of 10 survey lines. This zone contains an area having a rectangular geometry that yields anomalously low in-phase values. This response cannot be attributed to any observed features that may potentially be associated with metallic objects. This feature is labeled as 'unknown' in Plate 3. The response may be caused by buried debris.

Survey zone 5 covered an area of 1.1 acres and consisted of 6 survey lines. Within this survey zone there are two areas where anomalously low in-phase values were measured. An anomaly in the approximate middle of the grid is attributed to metallic items near an observed spring.

Survey zone 6 covered an area of 6.2 acres and consisted of approximately 12 survey lines. Anomalously high in-phase values in areas of this survey zone are associated with known metallic objects. Three areas in particular show anomalously high values. The high responses in the northeastern area of zone 6 are attributed to infrastructure associated with an active gas well, metal fencing, and vehicles. The high response in the western portion of zone 6 is associated with a pipeline.

3.1.2 Electromagnetic Conductivity

The quadrature (conductivity) component survey results shown in Plate 4 indicate conductive areas associated with both surface and subsurface metal structures. In the northern portion of the survey site, (survey zone 6) anomalously high conductivity areas associated with a buried pipeline, an active gas well, and metal fencing are clearly visible. In addition, high conductivity areas are seen in survey zone 2. These conductive anomalies are associated with a building and a parked vehicle. Across the remainder of the survey area, there are no additional conductive anomalies that would indicate the presence of unknown objects in the subsurface.

3.2 Magnetics

In total, 6.39 line miles of MAG data were acquired to cover the 18.1 acres of survey area. To facilitate efficiency in conducting the MAG surveys, the study area was divided into 6 different survey zones. The size, number, and survey coverage within each zone is the same as that of the EM surveys. Plate 2 shows the MAG survey zones and the coverage The results for each of the six zones are discussed independently.

3.2.1 Total Field Magnetics

Referring to Plate 5, the contoured total field data are overlain onto a geo-referenced aerial photo of the Old 2 Left Area.

Overall, anomalous responses can be attributed to surface or shallow subsurface anthropogenic features such as vehicles, fencing, buried pipelines, and old foundations. These features are plotted and identified directly on the plate. Within the surveyed areas, no unexplainable anomalies exist that can be interpreted as an unknown metallic casing providing a vertical pathway for electrical conduction to the mine.

In zone 1, localized responses are caused by an abandoned foundation and metal rubble. A small localized feature within the upper right portion of the zone is probably caused by buried ferrous rubble.

In zone 2, localized responses are caused by vehicles, building structures, fences, and features associated with the driveway. No other anomalous responses exist.

In zone 3, the area is totally void of anomalous responses.

In zone 4, fencing causes anomalous responses along the southeast and northwest edges of the area. No other anomalous responses exist.

In zone 5, two slight responses exist in the northern portion of the grid and may represent some type of ferrous buried pipe or utility. The responses appear to lead to the abandoned foundation.

In zone 6 (north of the road) a linear response is oriented roughly east-west and represents a known buried utility line. A gas well and associated infrastructure cause a large anomaly in the east-central portion of the grid. Vehicles and metal fencing cause a response located in the extreme northeast corner of the grid.

3.2.2 Magnetic Gradient

Referring to Plate 6, the vertical gradient results are overlain onto the geo-referenced aerial photo of the Old 2 Left Area. The individual zone sizes and number of lines are the same as the EM coverage.

Within zone 1, metal stakes and an abandoned foundation cause responses in the east-central and southern portions of the grid. A localized anomaly in the northeast portion of the grid exists and may be caused by ferrous debris.

Within zone 2, above-ground features such as vehicles and buildings are the cause of anomalous responses.

Within zone 3, a few minor and localized anomalous responses exist and are interpreted to represent ferrous scrap.

Within zone 4, two localized features exist along the northeastern grid boundary. These may represent buried metallic debris.

Within zone 5, two anomalies exist within the northern portion of the grid. They appear to be aligned with the abandoned foundation in zone 1 and may represent an old pipeline, although this is only a supposition. These anomalies may need to be ground-truthed by ICG personnel to identify the source.

In zone 6 (north of the road) a linear response is oriented roughly east-west and represents a known buried utility line. A gas well and associated infrastructure causes a large anomaly in the east-central portion of the grid. Vehicles and metal fencing cause a response located in the northeast corner of the grid.

None of the magnetic responses identified as debris, rubble, or any other specific metallic material have a magnetic signature characteristic of a long, vertical, steel well casing.

3.3 High Resolution Resistivity (HRR)

Plate 7 shows the location of the surface resistivity line and underground roof bolt electrode locations overlain on a geo-referenced aerial photo of the Site. The resistivity survey was located in the specific area of influence identified in the field by ICG project personnel. Surface electrode locations are indicated in yellow and roof bolt electrodes are indicated in blue.

In order to create the two-dimensional inverted section, where surface and roof bolt electrode data were integrated, it was necessary to project the actual roof bolt electrode locations to coincide with the surface electrode orientation. This was completed by iteratively determining a mathematical relationship that geometrically projected the roof bolt electrode locations to the surface line. The actual and projected roof bolt locations are shown in Figure 9.

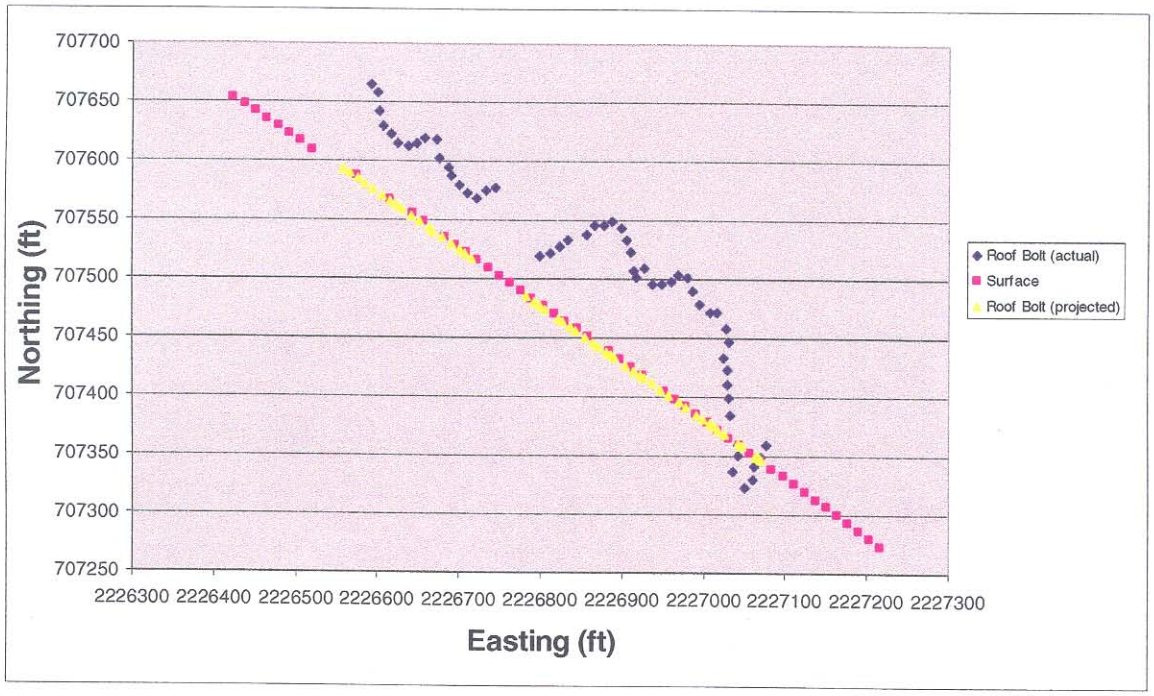


Figure 9: Graph showing projected placement of roof bolt electrodes to surface electrode orientation.

Plate 8 shows the inversion results for the HRR survey. Results are plotted as a function of station location versus elevation. The top image shows the results using surface data only. The bottom image shows the results using data from both surface and roof bolt electrodes. The resistivity values range from 1 to over 1100 ohm-m. Higher resistivity values are indicated in red hues, while lower resistivity values are represented using blue to purple hues. In general, higher values are indicative of relatively low moisture content and/or coarse grained materials while lower values would be indicative of higher moisture content and/or finer-grained material.

To the immediate right of both images, a generalized lithologic log is shown that was constructed from data obtained from borehole 4010 (core log number SF 52-06) that is located approximately 200 feet north of the survey line. This borehole was used to route the resistivity cables down to the mine elevation. Solid brown represents topsoil, stippled brown represents sandstone units, and the green intervals represent clay and shale horizons.

The results using surface data only (top image) indicate that a relatively thin resistive zone exists at the surface that has a thickness ranging from 10 to 50 feet. This zone substantially thins from about station 700 to the eastern end of the line. The high resistivity values shown in this zone are interpreted to represent lithologies with low moisture content. The bottom of this near surface resistive zone correlates with the lithologic log, where sandstone layers transition into predominately shale and clay horizons.

The near surface resistive zone rapidly transitions downwards into a highly conductive zone that is moderately thick (approximately 150 feet). The top of this zone is represented by the sharp change from resistive to conductive values. However, the bottom of the conductive zone is poorly defined due to the increased volumetric averaging that occurs as the depth of investigation increases. The highly conductive values are interpreted as zones of high moisture content that may also be augmented by fine-grained lithologies. The beginning elevation of this conductive zone correlates with the interception of shale and clay layers within core SF 52-06. However, past this depth, little correlation exists between the surface electrode results and the borehole log.

Starting at the approximate elevation of 1500 to 1475 feet, the values gradually increase in resistivity to the end of the section. Again, this gradual increase is due to volumetric averaging. This deeper resistive zone is interpreted to represent moderately dry and more cemented strata.

Referring to the lower image shown on Plate 9, the different resistivity zones are more vertically confined with the incorporation of the roof bolt electrode data. Note however that there is a substantial amount of vertical "streaking" of the data. This is caused by the high density of horizontally dispersed electrodes relative to the large amount of vertical volume of earth that is being imaged. This in turn causes the data to be strongly vertically biased, which is an artifact of the inversion process.

Compared to the surface-only section, the near surface resistive sandstone layer appears to be more consistent in thickness; averaging approximately 40 feet. Some vertical breaks are apparent within this layer (for example at stations 280 and 725), but these are considered to be questionable data at station 280 and a possible fault at 725.

The middle conductive layer appears to have the largest thickness of approximately 100 feet between stations 200 to 400. This conductive zone appears to thin towards the east. Beneath this conductive layer, the values become more resistive.

Good correlation exists between the first two electrically-defined zones and the lithologic log. Clay and shale layers were intercepted within the same general depths as the conductive horizon. Above the conductive layer, the highly resistive zone correlates with sandstone and topsoil. Below the conductive horizon poor correlation exists between the lithology encountered in core SF 52-06 and the resistivity section. A possible explanation is that the lower resistive zone represents more compacted media and thus lower moisture content.

In summary, the resistivity results geophysically indicate a three-layer geologic section; trending from resistive to conductive to resistive as depth increases to the mine level. HGI believes that the results represent naturally occurring geologic conditions. If the results would have had the appearance similar to the modeled results shown in Figure 8, Section 2.3.3, then it would have supported the idea of a vertically conductive pathway. The resistivity results are contrary to this model, and are more similar to the model results shown in Figure 7 of Section 2.3.3.

4.0 Conclusions

Within the limits of the areas surveyed and the resolution of the instruments used, no vertically oriented, metallic or low resistivity conductor was identified.

The results from the MAG and EM surveys provided responses associated with several electrically conductive features including known pipelines, wells, power lines, and other objects. No anomalous signatures were identified within the surveyed areas that are similar to the responses normally associated with a vertical steel well casing or any other vertically oriented, ferrous, or other metallic feature..

The total field magnetometry showed no steel-cased, boreholes within the surveyed area. The gradient magnetic results also showed no unknown boreholes within the surveyed areas.

The EM conductivity results showed no unknown, vertical, metallic well casings in the surveyed areas. The EM in-phase results showed no unknown, vertical, metallic well casings in the surveyed areas.

The results of the HRR survey indicate that natural geologic conditions exist within the subsurface and that no vertically oriented, low resistivity zone could be identified.

APPENDIX A : Geophysical Theory

A.1 Magnetic Gradiometry

Magnetometry is the study of the Earth's magnetic field and is the oldest branch of geophysics (Telford et al., 1990). The Earth's field is composed of three main parts: the main field which is internal, i.e., from a source from within the Earth that varies slowly in time and space; a secondary field which is external to the Earth and varies rapidly in time; and small internal fields constant in time and space which are caused by local magnetic anomalies in the near-surface crust.

Of interest to the geophysicist are the localized anomalies. These anomalies from contrasts in the magnetic susceptibility (k) and are caused by magnetic minerals (mainly magnetite or pyrrhotite) or buried steel. The average values for k are typically less than 1 for sedimentary formations and upwards to 20,000 for magnetic minerals.

The magnetic field is measured with a magnetometer. Magnetometers permit rapid, non-contact surveys to locate buried metallic objects and features. Portable (one person) field units can be used virtually anywhere that a person can walk, although, they may be sensitive to local interferences, such as fences and overhead wires. Airborne magnetometers are towed by aircraft and are used to measure regional anomalies. Field-portable magnetometers may be single- or dual-sensor. Dual-sensor magnetometers are called gradiometers; they measure gradient of the magnetic field; single-sensor magnetometers measure total field.

Magnetic surveys are typically run with two separate magnetometers. The first magnetometer is used as a base station to record the Earth's primary field and the diurnally changing secondary field. The second magnetometer is used as a rover to measure the spatial variation of the earth's field and may include various components (i.e. inclination, declination, and total intensity). By removing the temporal variation and, perhaps, the static value of the base station, from that of the rover, one is left with a residual magnetic field that is the result of local spatial variations only. The rover magnetometer is moved along a predetermined linear grid laid out at the site. Readings are virtually continuous and results can be monitored in the field as the survey proceeds.

The shortcoming with most magnetometers is that they only record the total magnetic field (**F**) and not the separate components of the vector field. This shortcoming can make the interpretation of magnetic anomalies difficult, especially since the strength of the field between the magnetometer and target is reduced as a function of the inverse of distance cubed. Additional complications can include the inclination and declination of the earth's field, the presence of any remnant magnetization associated with the target, and the shape of the target.

A.2 Electromagnetic Induction

Earth materials have the capacity to transmit electrical currents over a wide range, depending on the material property and electrical conductivity. Electrical conductivity is a function of soil type, porosity, saturation, and dissolved salts. Electromagnetic methods seek to identify various earth materials by measuring their electrical characteristics and interpreting results in terms of those characteristics.

Electromagnetic induction methods employ a transmitting (Tx) coil and a receiving (Rx) coil spaced at some given distance. The Tx coil induces eddy currents in the earth, which themselves generate magnetic fields that are influenced by the earth materials within the zone of excitation. Some parts of these fields are intercepted by Rx coil, resulting in an output voltage proportional to the electrical conductivity within the zone. By moving these coils laterally, variations in conductivity can be interpreted to find various buried features and-or objects. The Tx coil frequency and distance between Tx and Rx coils determine the depth of investigation, and the output permits construction of a stratigraphic profile of intervening depth.

A.3 High Resolution Resistivity

The resistivity method is based on the capacity of earth materials to pass electrical current. Earth resistivity is a function of soil type, porosity, moisture, and dissolved salts. The concept behind applying the resistivity method is to detect and map changes or distortions in an imposed electrical field due to heterogeneities in the subsurface.

Resistivity (ρ) is a volumetric property measured in ohm-meters that describes the resistance to current flow within a medium. The inverse, conductivity (σ) in units of Siemens/meter, describes the ease by which current will flow through a medium. Electric current can be propagated in rocks and minerals in one of three ways: electronic (ohmic), electrolytic, and dielectric conduction. Ohmic conductance occurs in metals, where free electrons give rise to direct conduction of current. Rocks and non-metallic minerals have extremely high resistivities (low conductivities) and direct current transmission through these materials is difficult. A porous media, on the other hand, can carry current through ions, which is the second type of current propagation (electrolytic). Electrolytic conduction relies on the molecules within a pore space to have excess or deficiency of electrons. Here, the conduction varies with the mobility, concentration, and degree of dissociation of ions. Electrolytic conduction is relatively slow with respect to ohmic conduction due to the reliance on a physical transport of material resulting in chemical transformation (Telford et al., 1990). The last type of propagation is dielectric conduction, which takes place in poor conductors or insulators. Dielectric conduction occurs under the influence of an externally applied alternating electric field, where atomic electrons are displaced slightly with respect to their nuclei.

In the field, the electric current may be generated by battery or motor-generator driven equipment, depending on the particular application and the amount of power required. Current is introduced into the ground through electrodes (metal rods). Earth-to-electrode coupling is typically enhanced by pouring water around the electrodes. The electrodes are placed along linear transects and provide points for both current transmission and electric potential measurements.

Estimating resistivity is not a direct process. When current (I) is applied and voltage (V) measured, Ohm's law is assumed. Resistance (R) in units of ohms can be calculated:

$$R = \frac{V}{I}$$

Resistivity and resistance are then related through a geometric factor over which the measurement is made. The simplest example is a solid cylinder with a cross sectional area of A and length, L:

$$\rho = R\frac{A}{L}$$

Hence, resistivity can be calculated by knowing the voltage, current, and geometry over which the measurement is made. In the earth, a hemispherical geometry exists. The hemispherical geometry is referred to as a half-space, due to the fact that all current applied at the surface travels into the ground; above the ground, air has an infinite resistivity. Because the volume of earth involved in a resistivity measurement on a non-homogeneous earth is unknown, the concept of apparent resistivity has been introduced.

Field data are acquired using an electrode array. A four-electrode array employs electric current injected into the earth through one pair of electrodes (transmitting dipole) and the resultant electric potential is measured by the other pair (receiving dipole). The most common configurations are dipole-dipole, Wenner and Schlumberger arrays. Their use depends upon site conditions and the information desired. Figure 1 shows the dipole-dipole configuration, where C1 and C2 are connected to the current source and P1 and P2 are connected to the volt meter:

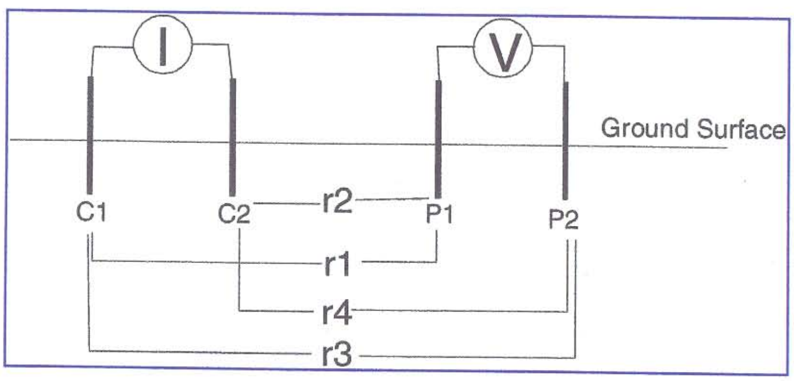


Figure A.1 Dipole-dipole array configuration.

For the four-electrode array, the geometric factor, K, is

$$K = 2\pi \frac{1}{\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \left(\frac{1}{r_3} - \frac{1}{r_4}\right)},$$

where r_1 through r_4 are defined in the schematic.

Since the earth property of resistivity is the desired product, an inverse calculation (or inverse model) is needed to convert the measured electric potential to resistivity. Inversion refers to the operation of estimating earth parameters, given the measured potential, input current, and boundary conditions. The inverse calculation assumes that each measurement of potential was a result of a homogeneous earth:

$$\rho_a = 2\pi \frac{V}{I} K$$

Other assumptions used in the above equation are isotropy (i.e., no directional dependence of resistivity), no displacement currents (using a DC or low frequency current application), and the resistivity is constant throughout such that Laplace's equation can be assumed. Since the degree of heterogeneity is not known *a priori*, a true resistivity is not calculated. To obtain a true resistivity, tomography is required, which generates a model of true resistivity given the measurements of apparent resistivity, electrode arrangement, and other boundary conditions.

hydroGEOPHYSICS, Inc. uses a pole-pole array for its high resolution resistivity (HRR) surveys. For the pole-pole array, one electrode from each of the current and potential pair is fixed effectively at infinity (remote reference), while the other current and potential electrodes act as "rover" electrodes. Practically, the remote reference electrodes are spaced approximately 2 to 10 times the distance of the furthest separation of the rover electrodes, which can be up to 200 meters apart. The pole-pole array provides higher data density, increased signal to noise ratio, and requires less transmitted energy. Roy and Apparao (1971) discuss the superiority of the pole-pole method when conducting shallow (near-surface) surveys.

The calculation of apparent resistivity is simplified in the pole-pole array:

$$\rho_a = 2\pi \frac{V}{I}(n * a)$$

where a is the basic electrode spacing and n is the integer multiplier as the current and potential electrodes incrementally separate. The following schematic (Figure 2) demonstrates the idea of a linear transect of electrodes on the surface with the a-spacing being the separation between each electrode and the n spacing increasing as the potential electrode moves away from the current electrode. The geophysical survey at the Sago Mine Site included a fixed a-spacing of 15 feet for measurements obtained at the surface and n increased from 1 to 56. For a complete survey, each electrode has one turn at transmission, while potential measurements are made using all other electrodes in the array sequentially.

The linear transect arrangement produces a two-dimensional data set of resistivity as a function of x and z, where z is the dimension into the earth and x is along the surface. Although resistivity is a function of the volume over which the measurement is made, its location is typically plotted as a point for ease of representation. The location of the point is a function of n and is referred to as the depth of investigation. Hallof (1957) demonstrated that the intersection of two 45^0 lines (with respect to the surface) extending downward from each of the transmission and receiving electrodes would produce a suitable pseudosection for interpretation. In this fashion, the pole-pole array has data vertically plotted at:

$$z = 0.5na$$

which is a linear plotting method. For HRR, the location of n is a function of the maximum sensitivity of signal, which decreases as a logarithmic function as n increases. Once z is determined, the two-dimensional data set can then be presented as a contour plot, where equivalent values are connected by a contour line or color.

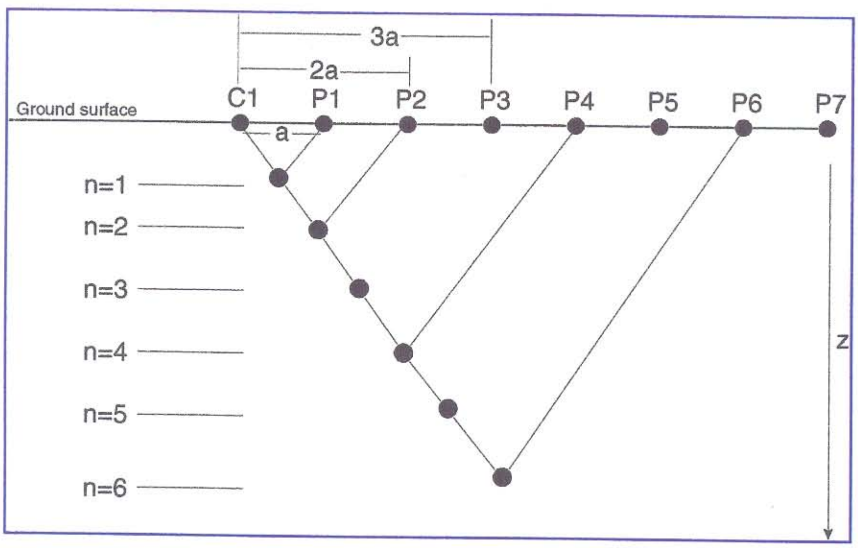
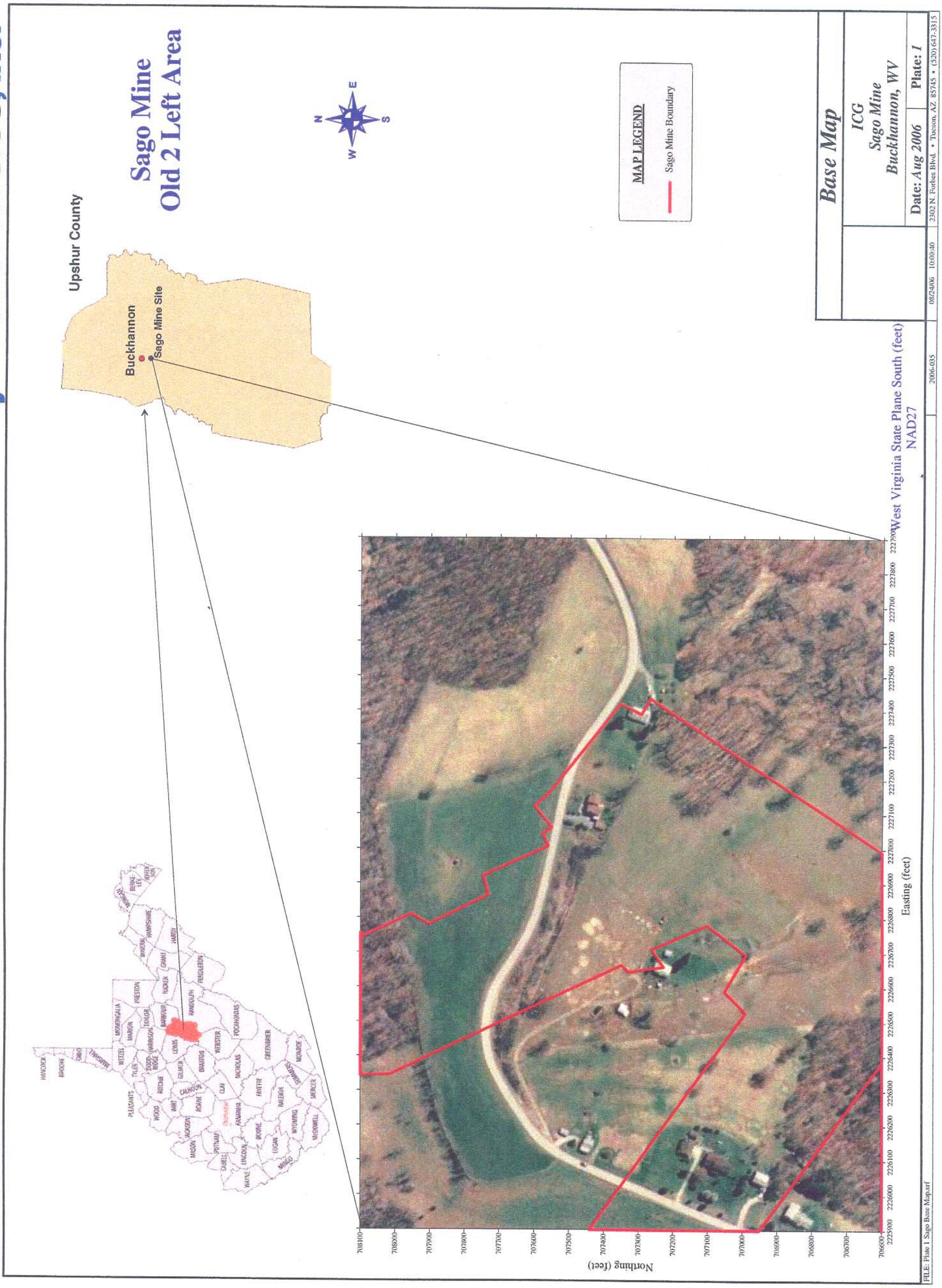


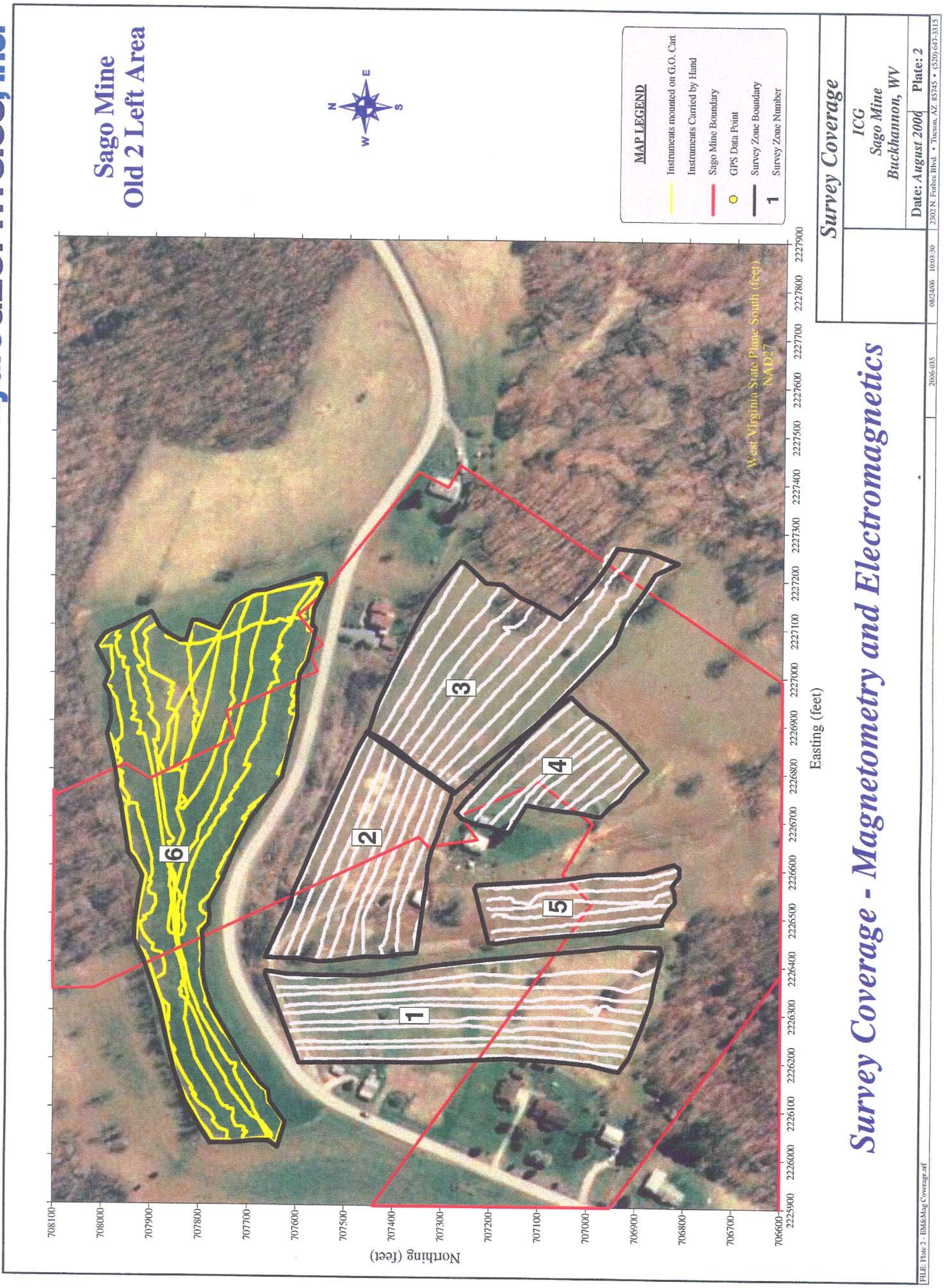
Figure A.2. Construction of two-dimensional apparent resistivity pseudosection.

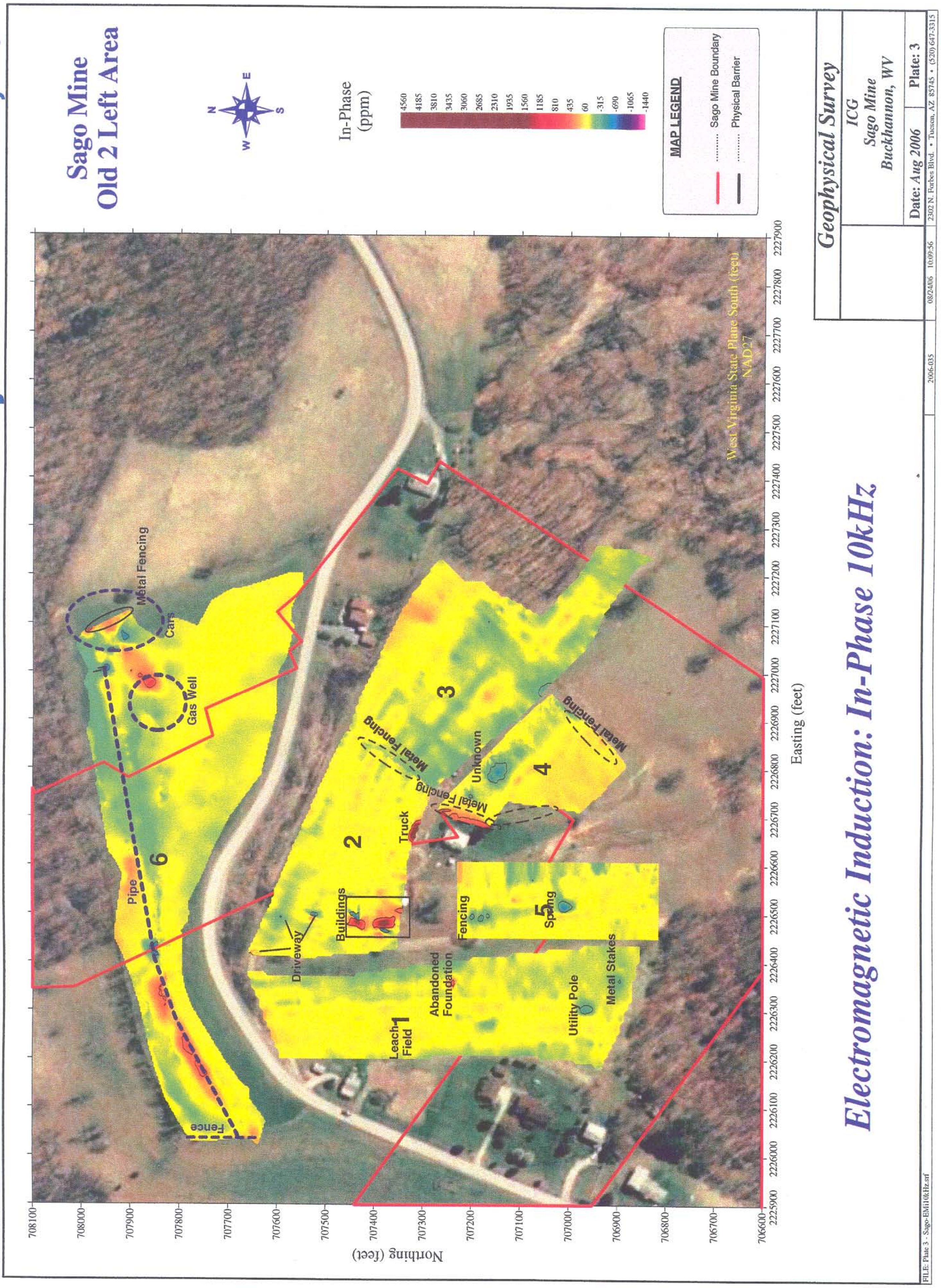
A.3.1 Depth of Investigation

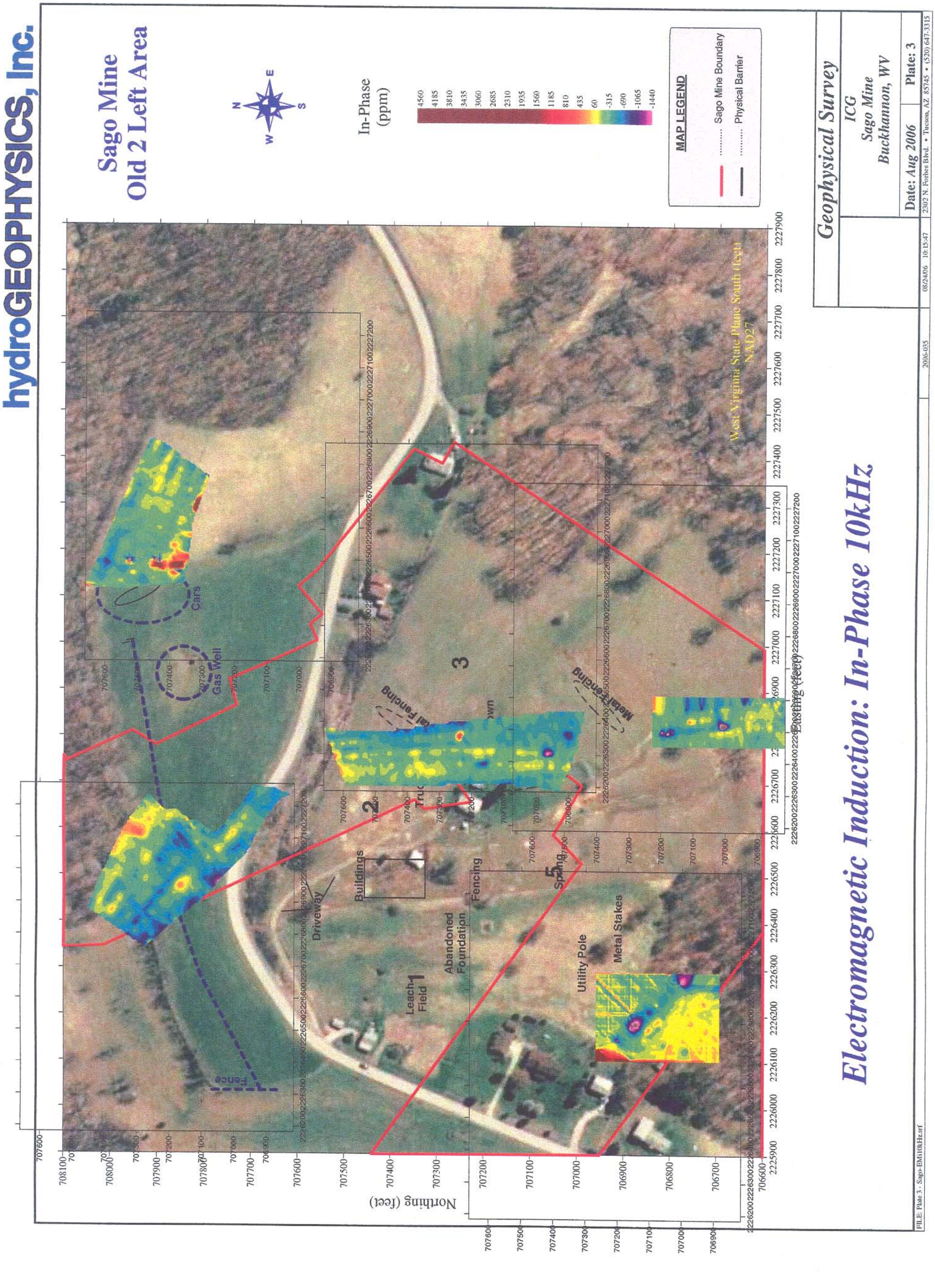
The depth of investigation stems from a need to relate a measurement made at the surface to some particular depth in order that survey parameters can be optimized for target identification (Barker, 1989). Prior to tomographic inversion, apparent resistivity pseudosections were used primarily for interpretation of subsurface electrical anomalies. Field practitioners became quite efficient at locating the depth to specific targets, such as ore bodies. Therefore, the presentation of the pseudosection is important in these regards.

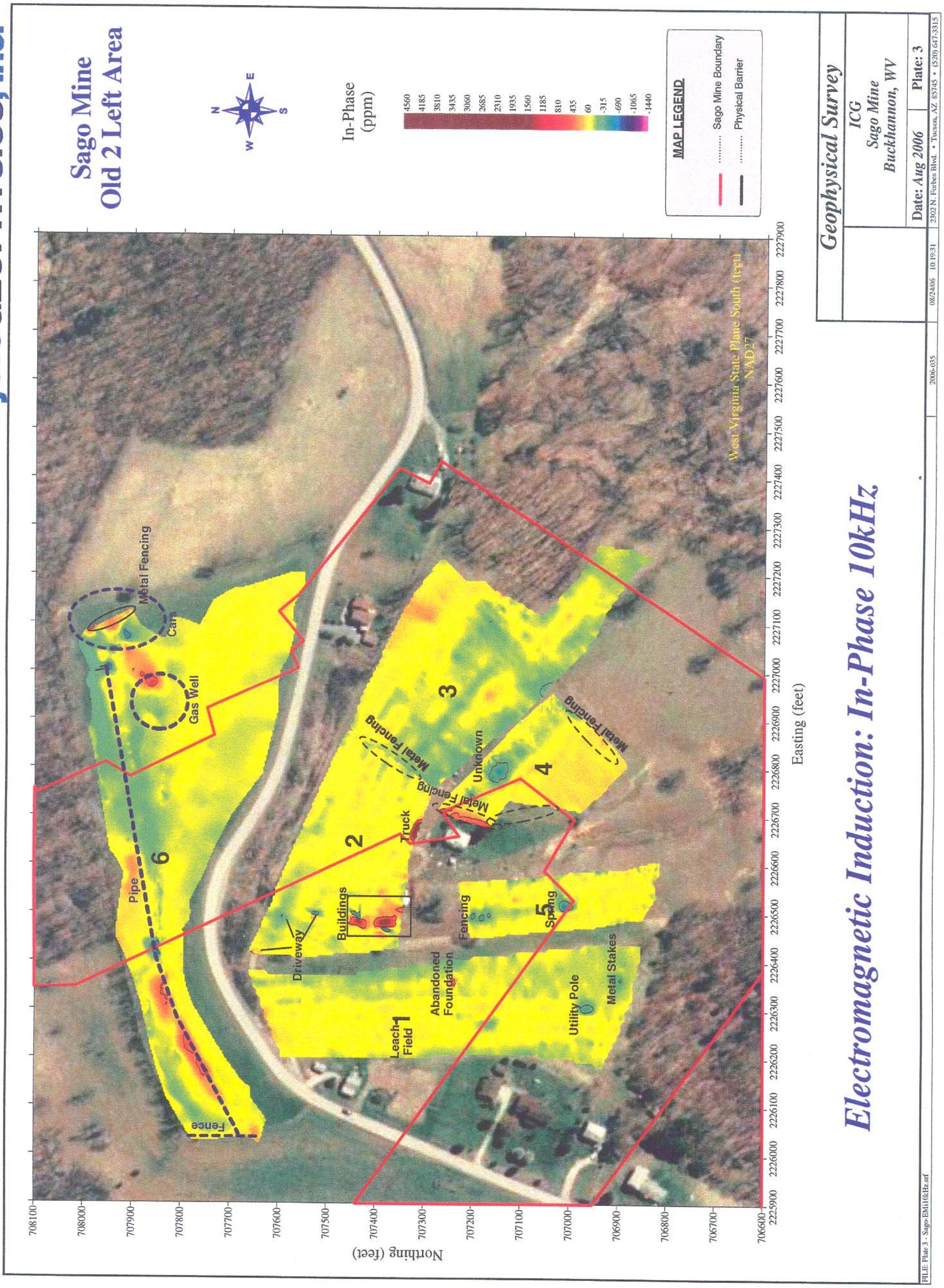
The traditional linear pseudosection of Hallof (1957) has limitations with respect to a physical meaning of the earth. Many researchers, therefore, have taken a closer examination of the plotting method to allow for a more reasonable geological interpretation. The most widely accepted depth of investigation studies are those presented by Roy and Apparao (1971), Roy (1972), and Koefoed (1972), who defined a depth of investigation characteristic (DIC) model for determining the depth of a measurement. The DIC was determined by finding the depth at which a thin horizontal layer within a homogeneous background makes the maximum contribution to the total measured signal at the surface. The depth of investigation is a logarithmic function of electrode spacing and places no emphasis on actual resistivity values. At its extreme, the logarithmic plotting methodology fails when an infinitely conductive layer is placed within the earth. A large electrode separation would still prevent signal from penetrating the layer.

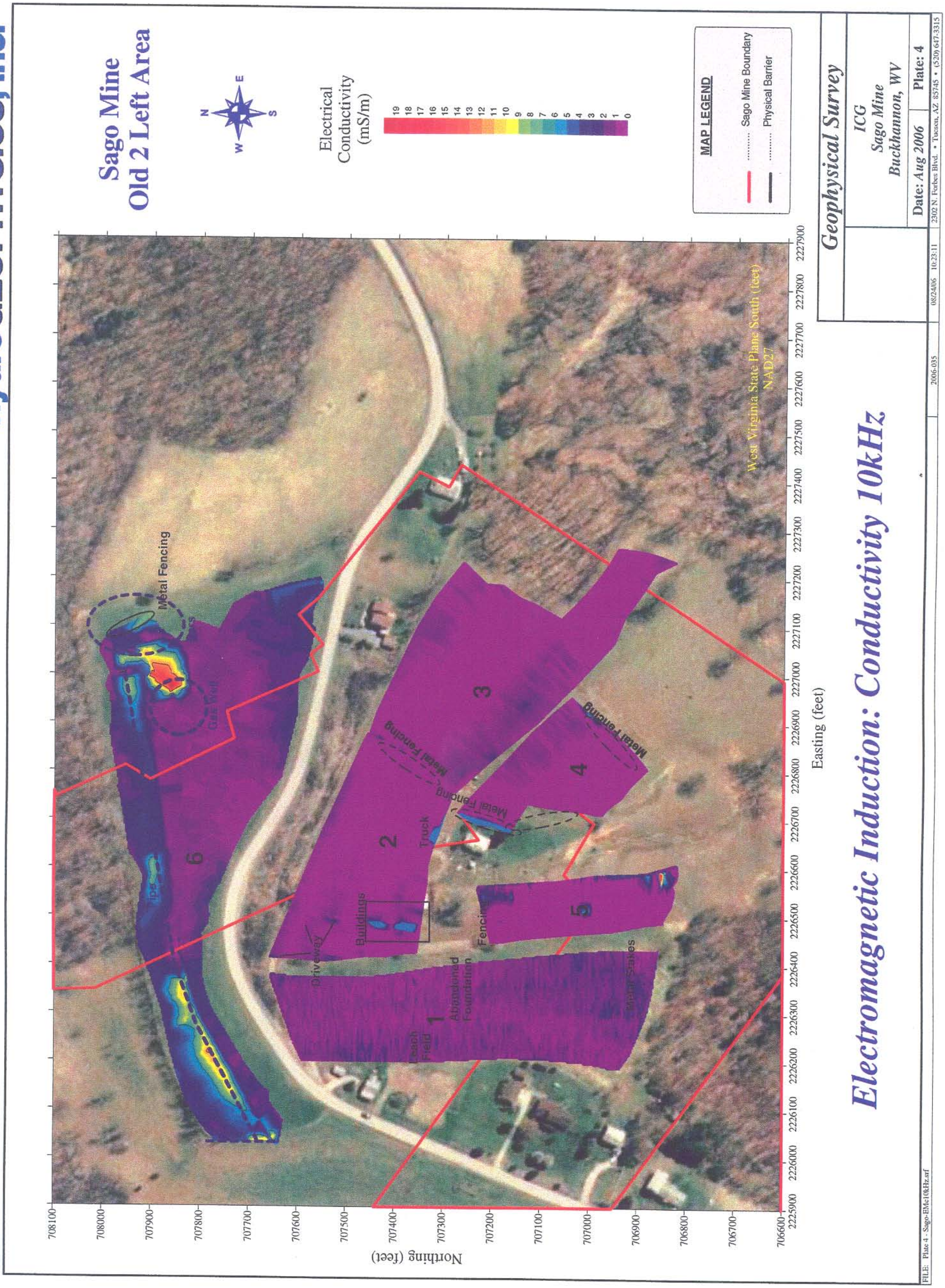

hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
Upshur County
Buckhannon
Sago Mine Site
MAP LEGEND
Sago Mine Boundary
West Virginia State Plane South (feet)
NAD27
Easting (feet)
Northing (feet)
Base Map
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 1
2302 N. Forbes Blvd. • Tucson, AZ 85745 • (520) 647-3315
FILE: Plate 1 Sago Base Map.srf


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
N
E
S
W
MAP LEGEND
Instruments mounted on G.O. Cart
Instruments Carried by Hand
Sago Mine Boundary
GPS Data Point
Survey Zone Boundary
Survey Zone Number
1
2
3
4
5
6
West Virginia State Plane South (feet)
NAD27
Easting (feet)
Northing (feet)
Survey Coverage
ICG
Sago Mine
Buckhannon, WV
Date: August 2006
Plate: 2
2302 N. Forbes Blvd. • Tucson, AZ 85745 • (520) 647-3315
Survey Coverage - Magnetometry and Electromagnetics


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
N
E
S
W
In-Phase (ppm)
4560
4185
3810
3435
3060
2685
2310
1935
1560
1185
810
435
60
-315
-690
-1065
-1440
MAP LEGEND
Sago Mine Boundary
Physical Barrier
Geophysical Survey
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 3
Electromagnetic Induction: In-Phase 10kHz
Easting (feet)
Northing (feet)
West Virginia State Plane South (feet) NAD27
Metal Fencing
Cars
Gas Well
Pipe
Fence
Driveway
Buildings
Truck
Unknown
Fencing
Spring
Abandoned Foundation
Leach Field
Utility Pole
Metal Stakes
1
2
3
4
5
6


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
In-Phase (ppm)
MAP LEGEND
Sago Mine Boundary
Physical Barrier
Cars
Gas Well
Fence
Driveway
Buildings
Fencing
Abandoned Foundation
Leach Field
Utility Pole
Metal Stakes
Spring
Metal Fencing
Northing (feet)
Easting (feet)
West Virginia State Plane South (feet) NAD27
Electromagnetic Induction: In-Phase 10kHz
Geophysical Survey
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 3
2302 N. Forbes Blvd. • Tucson, AZ 85745 • (520) 647-3315


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
In-Phase
(ppm)
4560
4185
3810
3435
3060
2685
2310
1935
1560
1185
810
435
60
-315
-690
-1065
-1440
MAP LEGEND
Sago Mine Boundary
Physical Barrier
Geophysical Survey
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 3
2302 N. Forbes Blvd. • Tucson, AZ 85745 • (520) 647-3315
Metal Fencing
Cars
Gas Well
Pipe
Fence
Driveway
Buildings
Truck
Metal Fencing
Unknown
Abandoned Foundation
Leach Field
Fencing
Spring
Utility Pole
Metal Stakes
West Virginia State Plane South (feet)
NAD27
Easting (feet)
Northing (feet)
Electromagnetic Induction: In-Phase 10kHz


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
Electrical Conductivity (mS/m)
MAP LEGEND
Sago Mine Boundary
Physical Barrier
Geophysical Survey
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 4
Electromagnetic Induction: Conductivity 10kHz
Easting (feet)
Northing (feet)
West Virginia State Plane South (feet)
NAD27
Metal Fencing
Gas Well
Buildings
Driveway
Truck
Abandoned Foundation
Leach Field
Metal Stakes
Fencing
1
2
3
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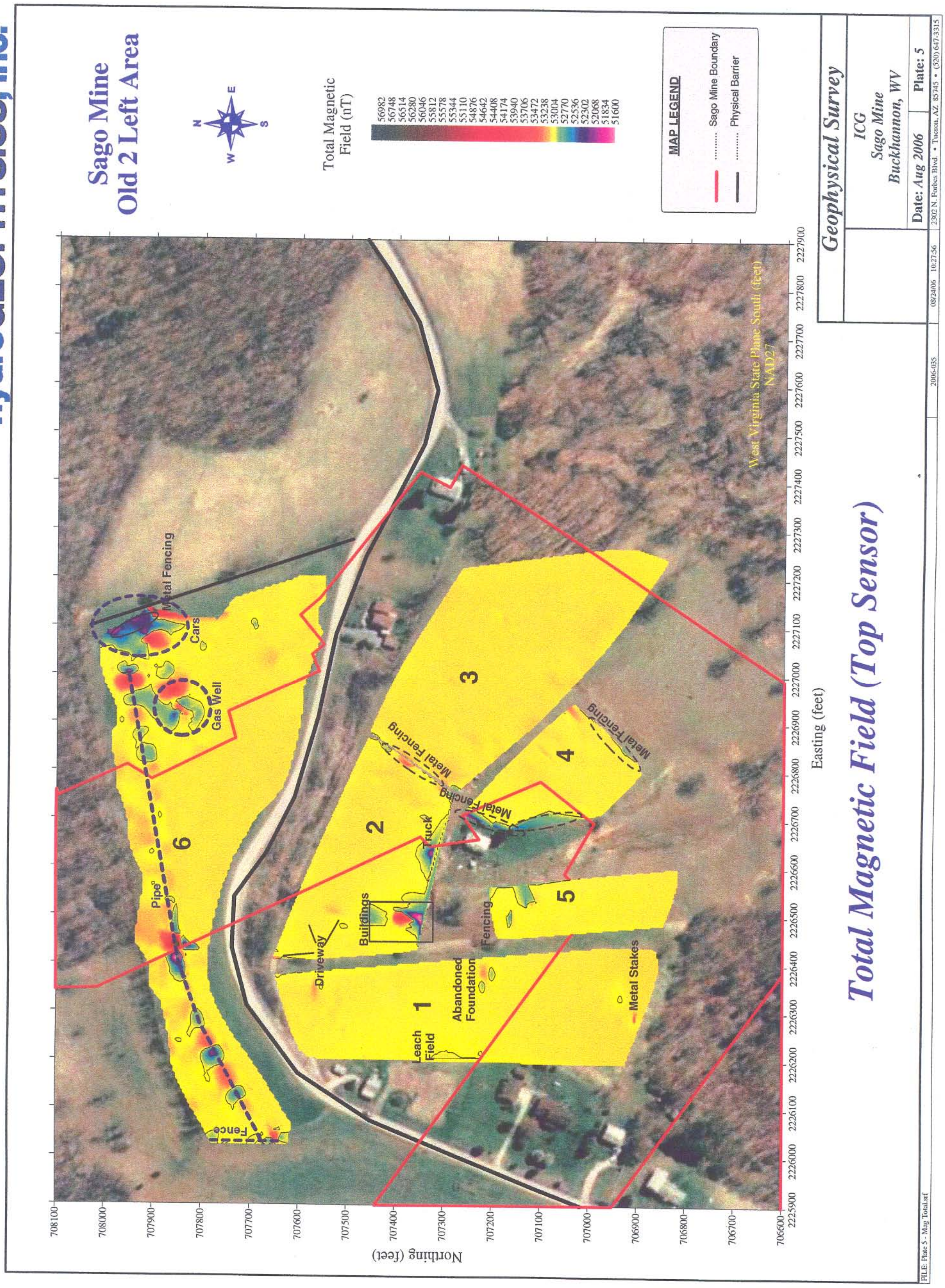
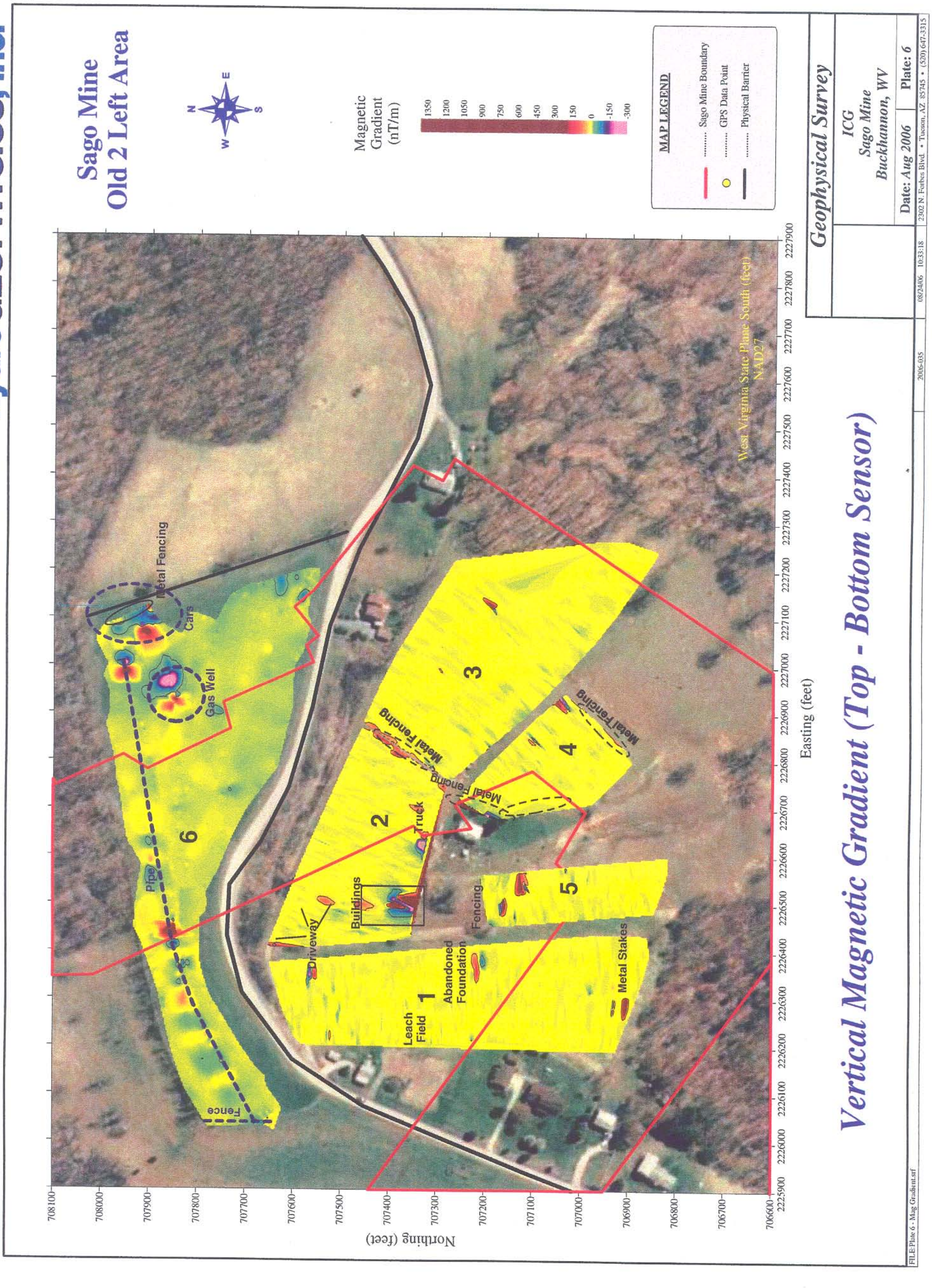
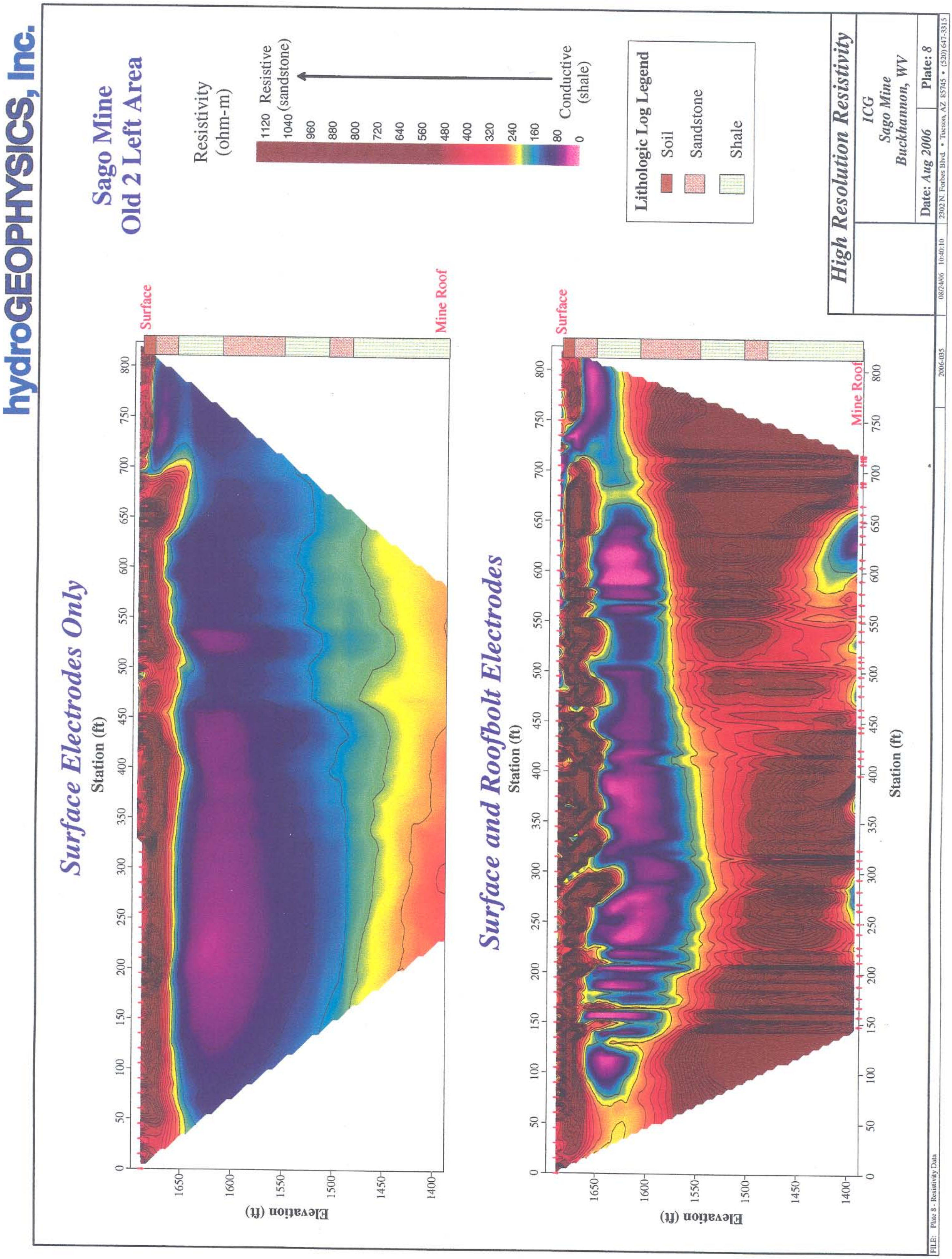

hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
N
E
S
W
Total Magnetic Field (nT)
56982
56748
56514
56280
56046
55812
55578
55344
55110
54876
54642
54408
54174
53940
53706
53472
53238
53004
52770
52536
52302
52068
51834
51600
MAP LEGEND
Sago Mine Boundary
Physical Barrier
Geophysical Survey
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 5
2302 N. Forbes Blvd. • Tucson, AZ 85745 • (520) 647-3315
Metal Fencing
Cars
Gas Well
Pipe
Fence
Driveway
Buildings
Truck
Metal Fencing
Metal Fencing
Metal Fencing
Fencing
Abandoned Foundation
Leach Field
Metal Stakes
1
2
3
4
5
6
West Virginia State Plane South (feet)
NAD27
Easting (feet)
Northing (feet)
Total Magnetic Field (Top Sensor)
FILE: Plate 5 - Mag Total.srf


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
Magnetic Gradient (nT/m)
MAP LEGEND
Sago Mine Boundary
GPS Data Point
Physical Barrier
Geophysical Survey
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 6
Vertical Magnetic Gradient (Top - Bottom Sensor)
Easting (feet)
Northing (feet)
West Virginia State Plane South (feet)
NAD27
Metal Fencing
Cars
Gas Well
Pipe
Fence
Buildings
Driveway
Truck
Leach Field
Abandoned Foundation
Fencing
Metal Stakes


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
N
E
S
W
MAP LEGEND
Sago Mine Boundary
Surface Electrode Location
Roof Bolt Location
Geophysical Survey
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 7
2302 N. Forbes Blvd. • Tucson, AZ 85745 • (520) 647-3315
West Virginia State Plane South (feet)
NAD27
Easting (feet)
Northing (feet)
High Resolution Resistivity Line Location


hydroGEOPHYSICS, Inc.
Sago Mine
Old 2 Left Area
Resistivity
(ohm-m)
1120 Resistive
1040 (sandstone)
960
880
800
720
640
560
480
400
320
240
160
80
0
Conductive
(shale)
Lithologic Log Legend
Soil
Sandstone
Shale
High Resolution Resistivity
ICG
Sago Mine
Buckhannon, WV
Date: Aug 2006
Plate: 8
Surface Electrodes Only
Surface and Roofbolt Electrodes
Station (ft)
Elevation (ft)
Surface
Mine Roof
FILE: Plate 8 - Resistivity Data
2006-035
2302 N. Forbes Blvd. • Tucson, AZ 85745 • (520) 647-3315