GEOServices, LLC-Geotechnical and Materials Engineers
A Universal Engineering Sciences Company

October 25, 2022

Thunder Enterprises
104 Battlecreek Road
Kimball, TN 37380

Attention: Mr. Clarence Howard
clarence@thunderenterprises.com

Subject: **REPORT OF LIMITED GEOPHYSICAL SERVICES**
River Gorge Ranch ERI
Guild, Tennessee
GEOServices Project No. 26-22713

Dear Mr. Howard,

We are submitting the results of the limited geophysical exploration performed to provide information for the proposed development at River Gorge Ranch in Guild, Tennessee. The following limited report presents our findings. Should you have any questions regarding this report, or if we can be of any further assistance, please contact us at your convenience.

Project Information

Project information was provided in email correspondence between Mr. Clarence Howard of Thunder Enterprises and Mr. Derek Kilday of GEOServices, LLC in January of 2022. We understand that a new residential community is planned to be constructed in Guild, Tennessee. This property is located on Aetna Mountain off US Highway 41. At this time, the first Phase of Construction will consist of 370 residential lots across the property. Because this site is in the preliminary design phase, project plans are not available at this time.

Topographic maps from USGS and LIDAR data show that existing site elevations slope from approximately 1650 feet MSL on the edges of the site to 1780 in the center portion of the site. The majority of the site is heavily wooded at this time; however, gravel roads have been constructed throughout the site to allow access for development. We understand that this site has previously been used for strip mining operations, generally located within the northeastern portion of the site.

Field Exploration

Electrical Resistivity Imaging (ER) Survey

The ERI survey was conducted using the Advanced Geosciences, Inc. (AGI) Sting R8 automatic electrode resistivity system. Eight (8) ERI transects were performed across the lot using 28 to 51 electrodes with electrode spacing of ten (10) feet, for transects of 270 to 500 feet in length. A dipole-dipole combined with a strong gradient electrode configuration was used with a maximum "n value" of ten. The ERI data was analyzed using EarthImager 2D, a computer inversion program, which provides a two-dimensional vertical cross-sectional resistivity model (pseudo-section) of the subsurface. The positions and topographic information of the geophysical array lines were recorded using site measurements.

Electrical Resistivity Imaging

Electrical resistivity surveying is a geophysical method in which an electrical current is injected into the earth; the subsequent response (potential) is measured at the ground surface to determine the resistance of the underlying earth materials. The resistivity survey is conducted by applying electrical current into the earth from two implanted electrodes (current electrodes C1 and C2) and measuring the associated potential between a second set of implanted electrodes (potential electrodes P1 and P2). Field readings are in volts. Field readings are then converted to resistivity values using Ohm's Law and a geometric correction factor for the spacing and configuration of the electrodes. The calculated resistivity values are known as "apparent" resistivity values. The values are referred to as "apparent" because the calculations for the values assume that the volume of earth material being measured is electrically homogeneous. Such field conditions are rarely present.

The resistivity of earth materials is controlled by several properties including composition, water content, pore fluid resistivity and effective permeability. For this exploration, the properties that had the primary control on measured resistivity values are composition and effective permeability. The general geological setting of this property area is clay overlying sandstone and shale. However, existing site conditions such as existing fill material and previous grading, may cause trapped water zones and present as low resistivity zones that may produce artifact affects.

For this study, a dipole-dipole combined with a strong gradient resistivity array configuration was used for each test. The dipole-dipole array is different than most other resistivity arrays in that the electrode and current electrodes are kept together using a constant spacing value referred to as an "a spacing". The current and potential electrode sets are moved away from each other using multiples of the "a spacing" value. The number of multiples is referred to as the "n value". For example, an array with an electrode spacing of 5 ft and an "n value" of 6 would have the current and potential electrode sets spaced 30 ft apart with a separation between the two electrodes in the set of 5 ft. By sampling at varying "n values", greater depth measurements can be achieved. Strong Gradient data is collected with the current set of electrodes being kept with a fixed separation (L spacing) and the potential electrodes a minimum distance from the inner current electrodes. Dipole-dipole resistivity data is usually presented in a two- dimensional pseudo-section format. Strong Gradient data is usually presented as a vertical profile of resistivity distribution below the center point between the two current electrodes. The dipole-dipole and strong gradient data is combined and presented as either a contour of the individual data points (using the calculated apparent resistivity values) or as a geological model using least squares analysis. Such least squares analysis was used for this study using the computer software program (EarthImager 2D) developed for the equipment manufacturer.

Apparent resistivity values are calculated using the following formula for a dipole-dipole configuration: $\gamma_a=\pi(b^3/a^2-b)\nabla V/I$:

Where:

γ_a =	apparent resistivity
π=	3.14
a=	"a spacing"
b=	"a spacing" x "n value"
∇V =	voltage between the two potential electrodes
I=	current (in amps)

For a strong gradient configuration, the apparent resistivity is calculated using: $\gamma_a=\pi([s^2-a^2]/4)\nabla V/aI$:

Where:

γ_a =	apparent resistivity
π=	3.14
a=	spacing between the inner set of electrodes
s=	distance between the outer electrode and nearest inner electrode
∇V =	voltage between the two potential electrodes
I=	current (in amps)

Inversion Modeling of Electrical Resistivity Imaging Data

The objective for inversion modeling of resistivity data is to create a description of the actual distribution of earth material resistivity based on the subsurface geology that closely matches the resistivity values that are measured by the instrumentation. This modeling is completed with the use of EarthImager 2D, a proprietary computer program developed by the equipment manufacturer (AGI). When evaluating the validity of the inversion model several factors need to be considered. The RMS, or root mean square error, expresses the quality of fit between the actual and modeled resistivity values for the given set of points in the model. The lower the RMS error the higher the quality of fit between the actual and modeled data sets. In general, inversion models with an RMS error of less than 5 to 10 percent are acceptable. The size of the RMS error is dependent upon the number of bad data points within a data set and the magnitude of how bad the data points are. As part of the modeling process bad data points are typically removed, which decreases the RMS error and improves (with limitations) the quality of the model. The quality of fit between the actual and modeled resistivity values is also expressed as the L-2 norm. When the modeled and actual data sets have converged, the L-2 norm reduces to unity.

However, as the number of data points is reduced, the validity of the inversion model is diminished. Accordingly, when interpreting a particular area of an inversion model the number of data points used to create that portion of the model must be taken into consideration. If very few points are within a particular area of the model, then the modeled solution in that area should be considered suspect and possibly rejected.

The entire ERI transect should be considered suspect if a model has a high RMS error and a large number of removed data points. It is likely that sources of interference have affected the field readings and rendered the modeled solution invalid. Such sources of interference can include buried metallic underground utilities, reinforced concrete slabs, septic leach fields or electrical grounding systems. Accordingly, all efforts need to be made in the field to locate, to the degree possible, the ERI transect lines away from such features. The locations of such features also need to be noted in the field so their potential effects can be considered when interpreting the modeled results. We noted a few such features in each of the array transects that have somewhat affected the data (in particular arrays #5 and #6), however it is our opinion the data is of sufficient quality to provide the following discussion with confidence.

Geologic Conditions

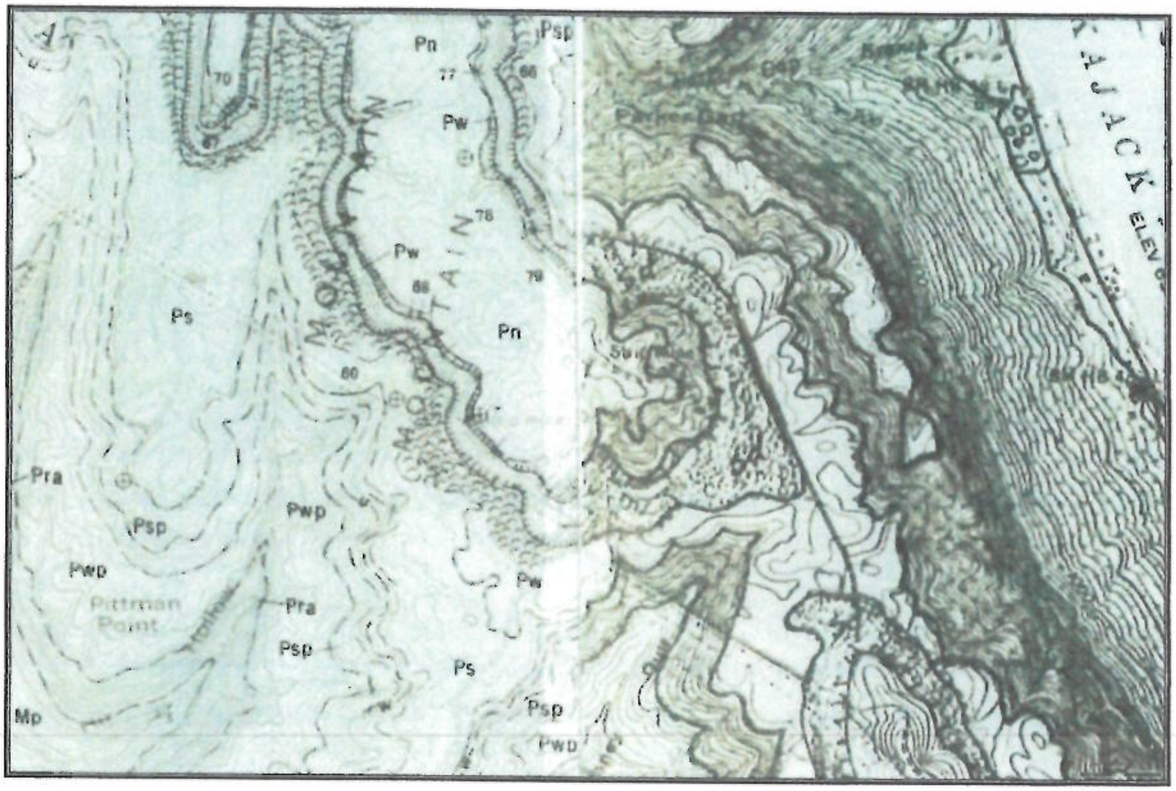

Figure 1 - Geologic Quadrangle Map 1950

The project site lies within the Cumberland Plateau Physiographic Province of eastern-central Tennessee. This Province is characterized by flat-topped mountains separated by narrow valley bottoms which wind between steep canyon-type walls. These canyon walls are formed primarily on resistant beds of sandstone, siltstone, shale, and conglomerate form the lower part of the Pennsylvanian strata. High terraces such as those associated with high-level fluvial deposits along the Cumberland River are remnants of earlier valley bottoms.

Published geologic information indicates that the site is underlain by bedrock of the Crab Orchard Mountains Group. This Group is composed of the Rockcastle Conglomerate, Vandever, Newton Sandstone, Whitwell Shale, and Sewanee Conglomerate formations. This group is typically composed of fine to coarse-grained sandstone, gray shale and siltstone, and sandstone/sandstone conglomerate which typically weathers to produce a thin sandy, silty residual overburden. Bedrock from this group is generally not susceptible to the development of karst conditions and has a low potential for the development of overburden sinkholes.

Available information on historical strip-mining of this site indicates that mining operations targeted the Whitwell Shale coal bearing formation, which is typically 120 feet thick and essentially horizontally bedded, dipping/tilting down from the northwest to southeast about 20 degrees. The western edge of ridge top mined geology ranges from approximately 1700 to 1830 feet MSL and on the eastern edge approximately 1680 to 1810 feet MSL. See image below for red zones (within areas requested to be explored) influenced by strip mining activities.

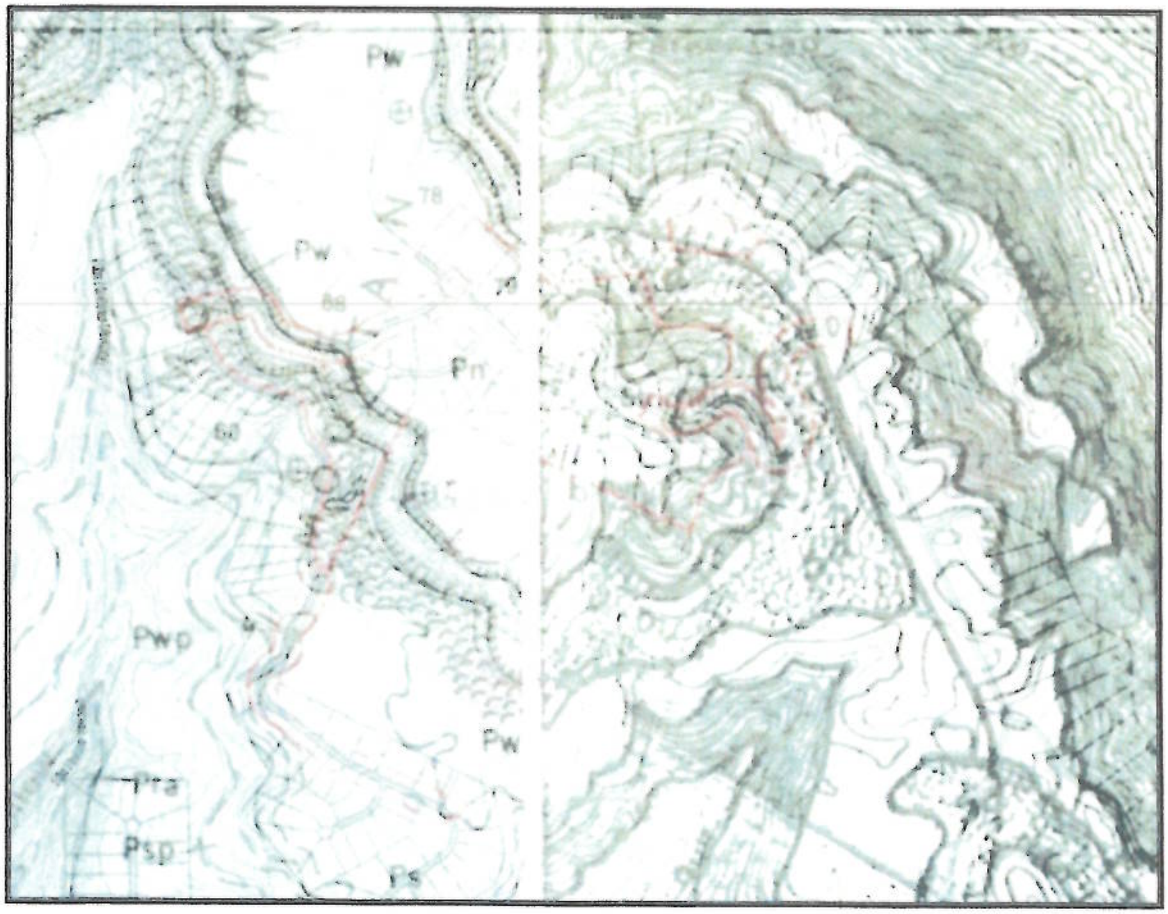

Figure 2 – Geologic Quadrangle Map 1950 with Site Plan Overlay

Within the Whitwell Shale formation one finds three distinct coal seams: the Sewanee Seam near the center of the geology, and the Slate and Richland Coal Seams within the mid to lowest elevation edge of the geology. Each coal seam is less than 36 inches thick. Mined soils and spoils will consist of shales and siltstones that are light brown and dark gray with some more yellowish colored sandstone. The southern elevation boundary of the mined geology is defined by the Sewanee Conglomerate formation, which typically consists of yellowish gray/light brown sandstone/conglomerate sandstone with quartz pebbles. If abundant quartz pebbles are found, published geologic data indicates one is outside of the mined Whitwell Shale geology.

Furthermore, during our desktop research and review of publicly available geologic maps in the area, it appears multiple abandoned adits were noted on site, generally dating to the 1950s. An adit is defined as a horizontal passaged leading into a mine. For ease of review, we have included a geologic map with both the proposed site development and the published approximate location of abandoned adits. It should be noted that GEOServices personnel attempted to hike and observe multiple adit locations, and none were found. Based on the existing site conditions, it appears likely that any adits have since collapsed or have been buried. We note orange surface water in an isolated area, generally on the southern edge of the proposed development (somewhat in the vicinity of adits #29 and 30), was observed. This area was outside the proposed area of development; therefore, GEOS did not attempt to observe the source of the orange stained water. It should be noted that the orange staining is an indicator of iron leachate from likely open mine sources or spoils.

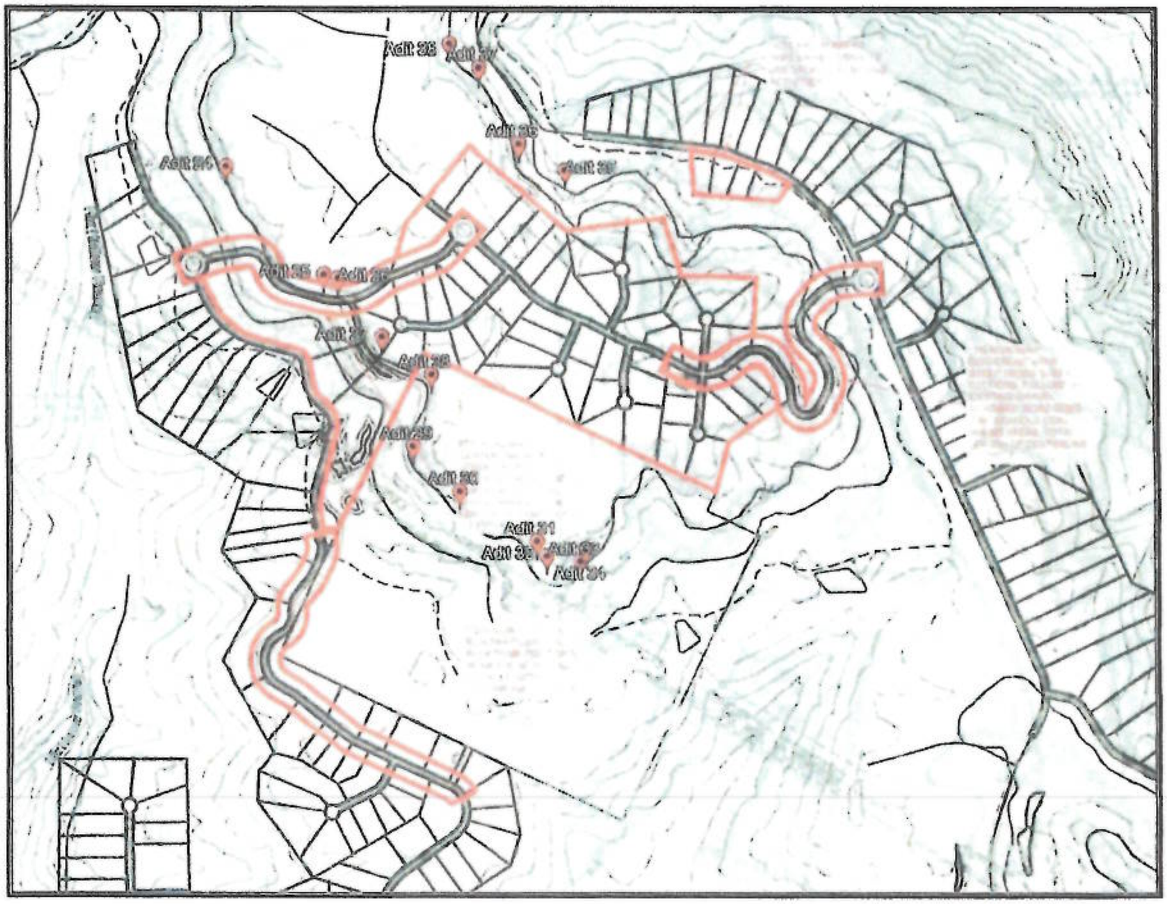

Figure 3 – Geologic Quadrangle Map 1950 with Site Plan Overlay and Abandoned Adits

ERI Arrays

Eight (8) arrays were conducted on the property, located generally within the areas of possible mine spoils (outlined in red). A ninth array was conducted; however we note interference in the data such that we do not deem the final ERI array data usable for discussion. Figure 4 below indicates approximate location of the arrays on site.

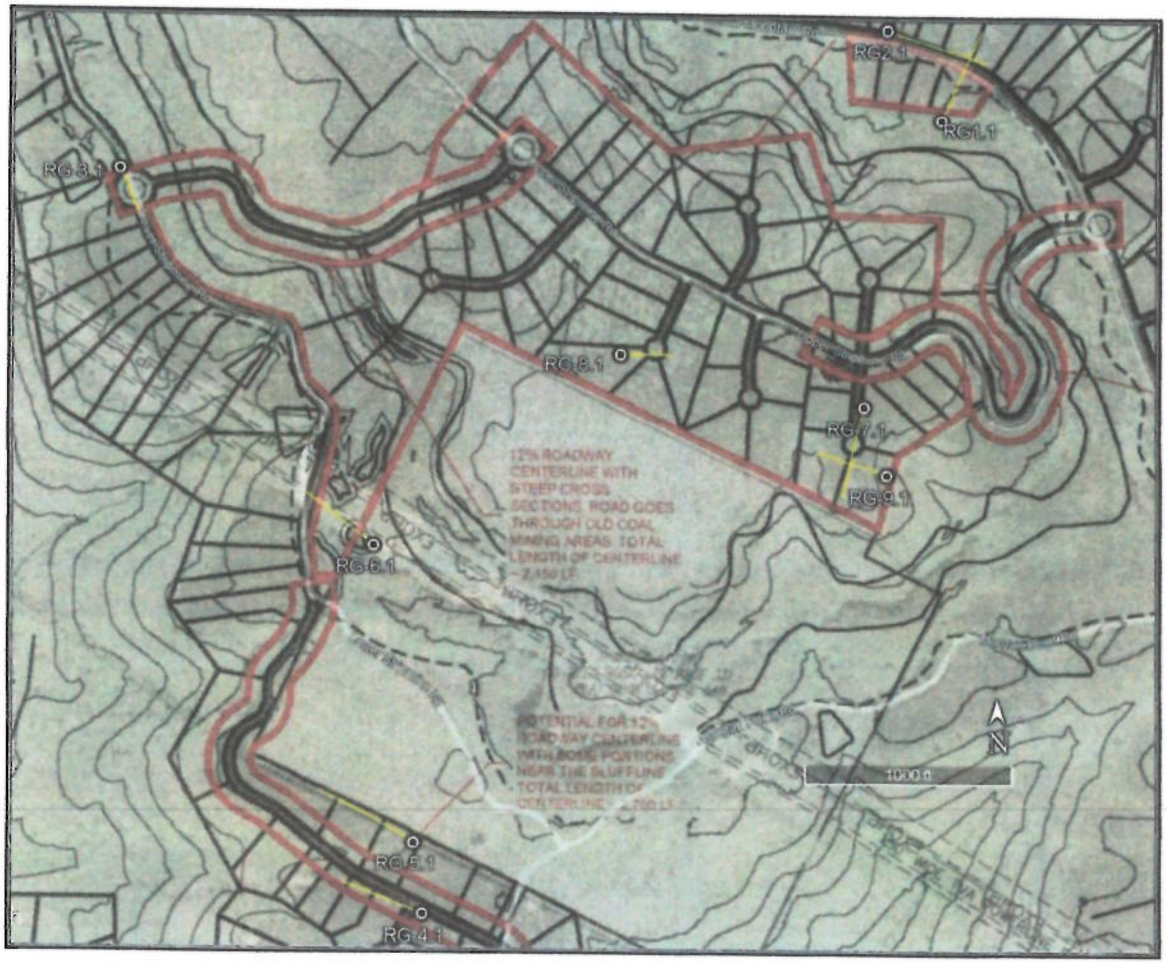

Figure 4 – ERI Transect Locations and Orientations

Subsurface Conditions

Overall, the ERI data indicated a transition from clay, saturated clays, mine spoils, and mass bedrock. Analysis of the attached ERI array images can be simplified by considering that the colors correspond to how easily electricity can travel through the ground. The more easily the electricity can travel (i.e. low resistivity) we may imply that saturated/more moist conditions exist. The harder electricity has to travel (i.e. high resistivity or high resistance), we can imply less water or moisture is located there. Therefore, the purples and blues are likely water traveling through the ground surface and areas where that water/saturated clays extends deeper into the ground we can interpolate as zones of likely mine spoils or water infiltration).

For ease of review, we have included the inverted ERI imagery below. It should be noted that we have provided two (2) data analysis on each ERI transect: low resistance analysis and high resistance analysis. The owner should consider the low resistance analysis as a general discussion on nature of the underlying soils and generally depth to mass bedrock. The owner should consider the high resistance analysis as a general discussion on the underlying concern for voids, large diameter mine spoils, or other mass features.

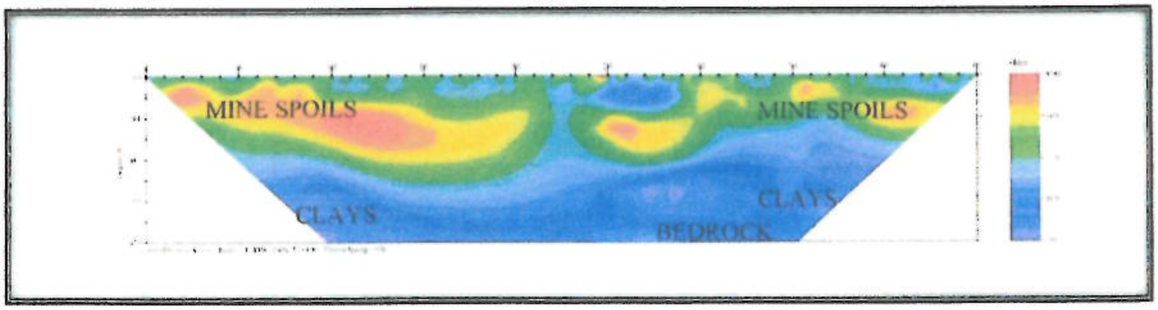

Figure 5 - ERI Array #1 Low Resistance Analysis

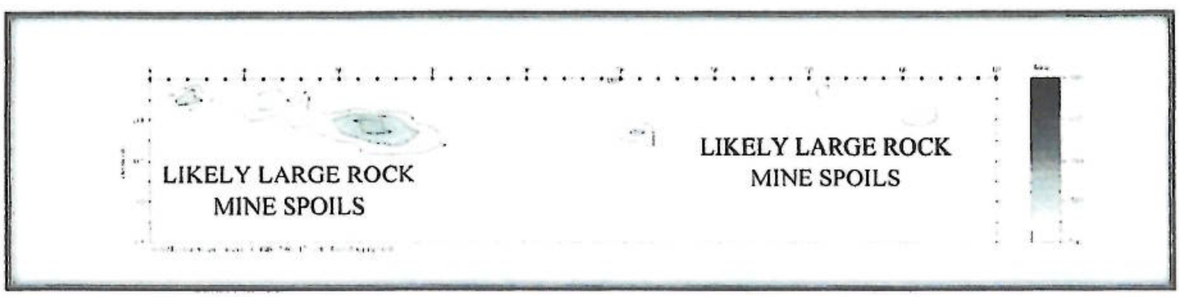

Figure 6 - ERI Array #1 High Resistance Analysis

Notes on ERI Array #1

- *Depth of Mine Spoils 15-25 feet, appears a deeper draw was filled in (up to 30+ feet)*
- *Mine spoil presentation indicate very large rock fragments and low probability of void(s)*
- *Underlying spoils is clays to about 50-65 feet followed by bedrock*

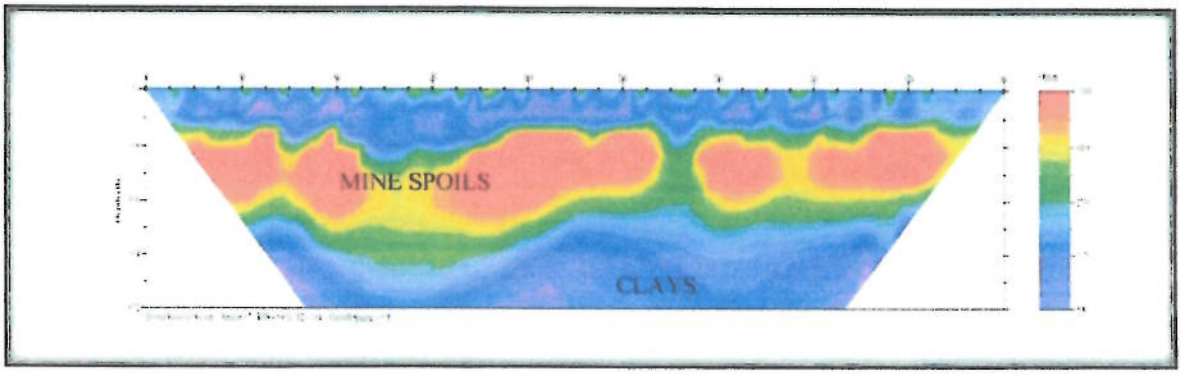

Figure 7 - ERI Array #2 Low Resistance Analysis

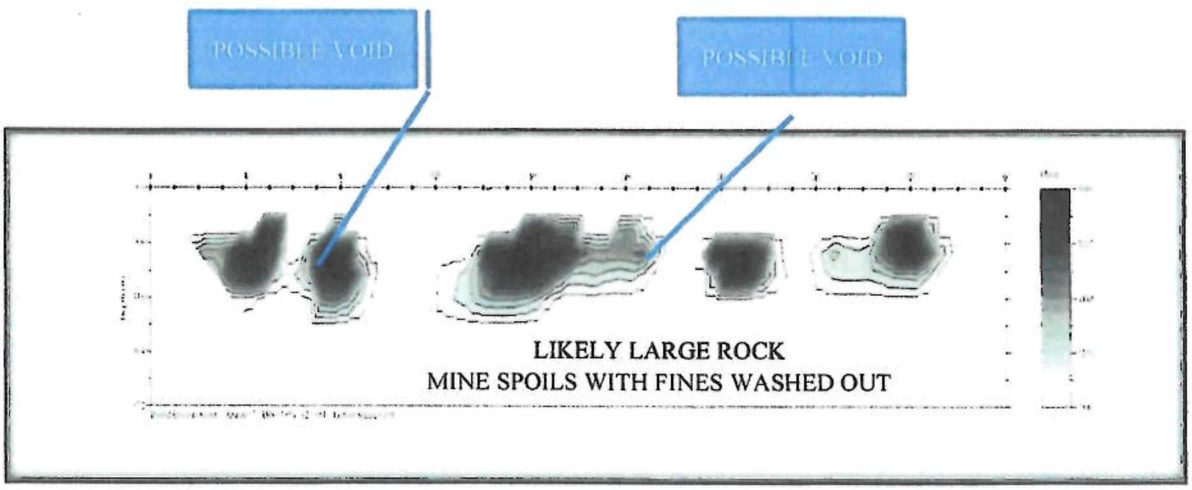

Figure 8 - ERI Array #2 High Resistance Analysis

Notes on ERI Array #2

- *Depth of Mine Spoils 25-40 feet, appears a deeper draw was filled in (up to 45+ feet)*
- *Mine spoil presentation indicate very large rock fragments and moderate probability of void(s)*
- *Underlying spoils is clays to about 50-70 feet, no obvious bedrock*

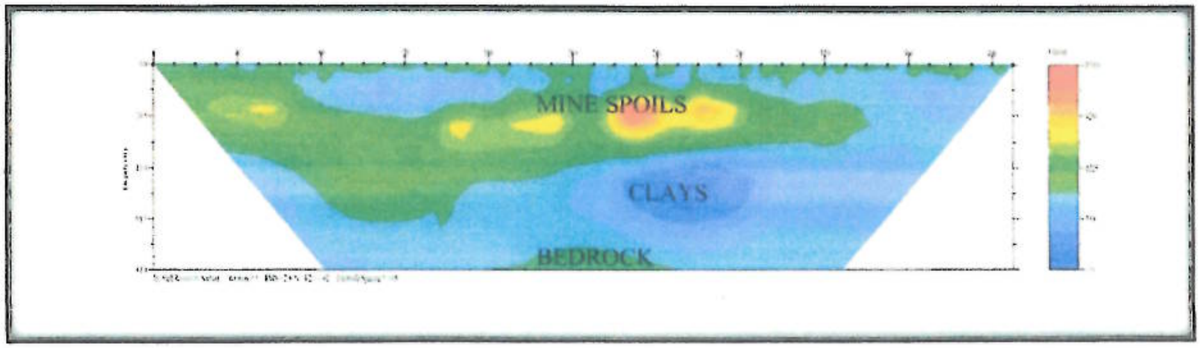

Figure 9 - ERI Array #3 Low Resistance Analysis

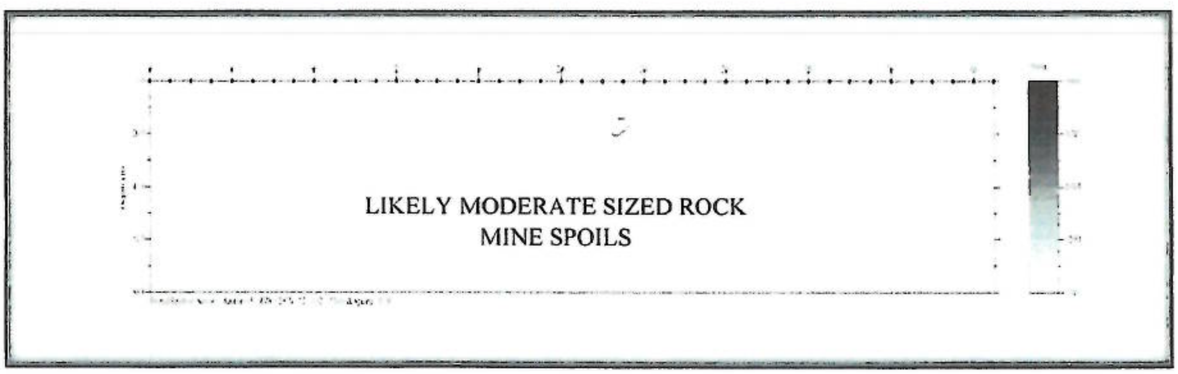

Figure 10 - ERI Array #3 High Resistance Analysis

Notes on ERI Array #3

- *Depth of Mine Spoils 10-20 feet*
- *Mine spoil presentation indicate some moderate sized rock fragments*
- *Underlying spoils is clays to about 20-50 feet followed by bedrock*

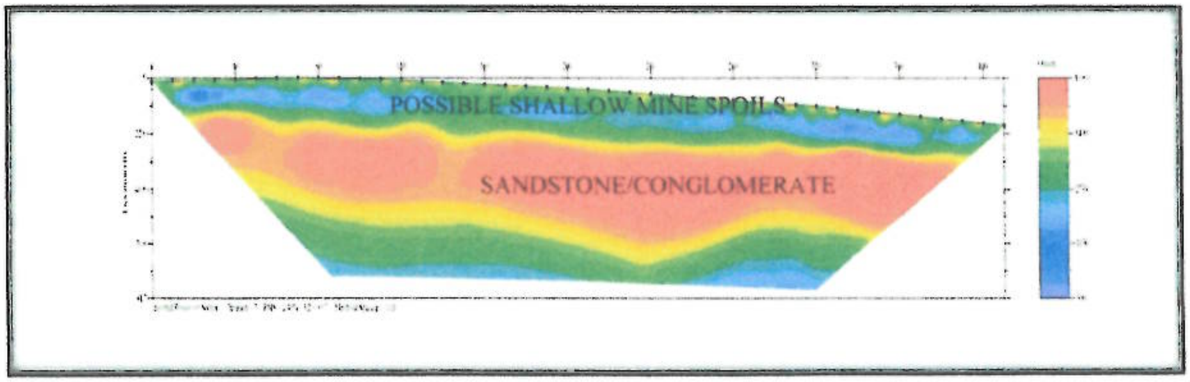

Figure 11 - ERI Array #4 Low Resistance Analysis

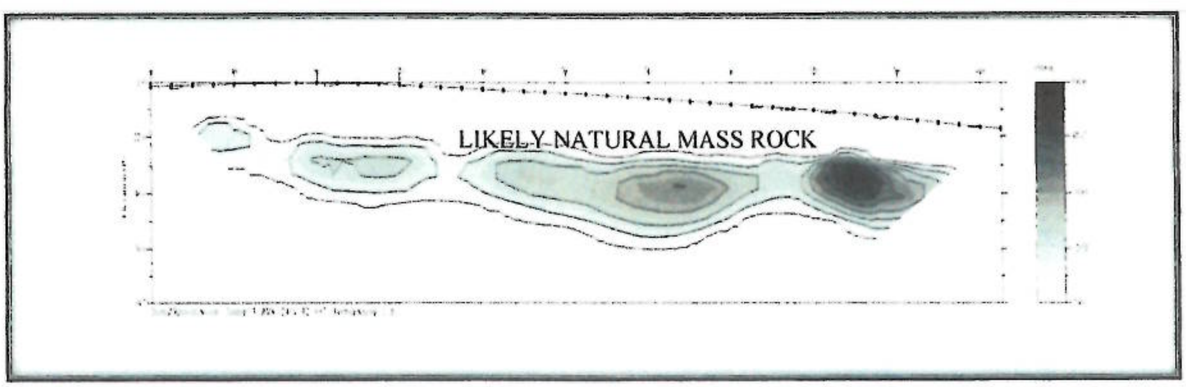

Figure 12 - ERI Array #4 High Resistance Analysis

Notes on ERI Array #4

- *Depth of Mine Spoils, IF ANY, less than 5-8 feet*
- *Apparent sandstone/conglomerate mass rock past 15-20 feet*
- *Thin layer of clay overlying bedrock, anticipate a heavily weathered sand layer at the bedrock depth*

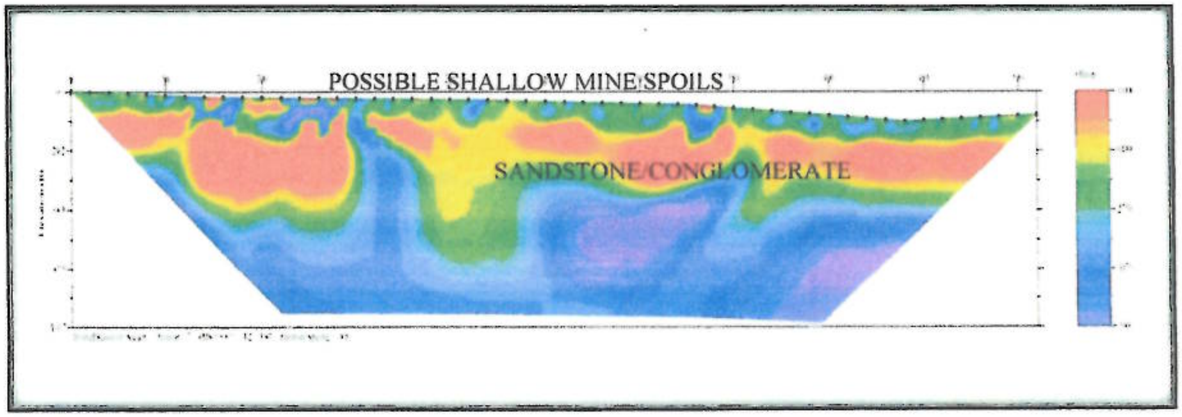

Figure 13 - ERI Array #5 Low Resistance Analysis

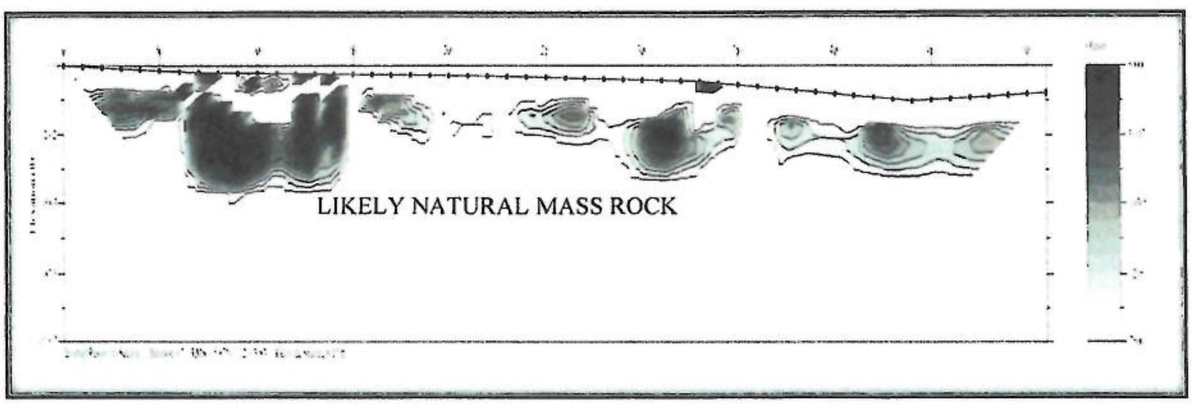

Figure 14 - ERI Array #5 High Resistance Analysis

Notes on ERI Array #5

- LOW QUALITY DATA – UNKNOWN INTERFERRENCE ON SITE
- *Depth of Mine Spoils, IF ANY, less than 5-8 feet*
- *Apparent sandstone/conglomerate mass rock past 15-20 feet*
- *Thin layer of clay overlying bedrock, anticipate a heavily weathered sand layer at the bedrock depth*

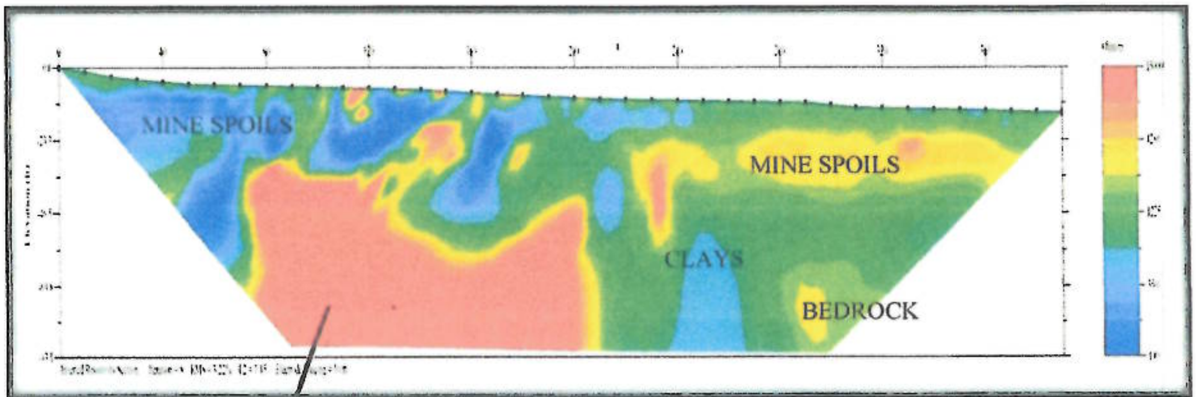

Figure 15 - ERI Array #6 Low Resistance Analysis

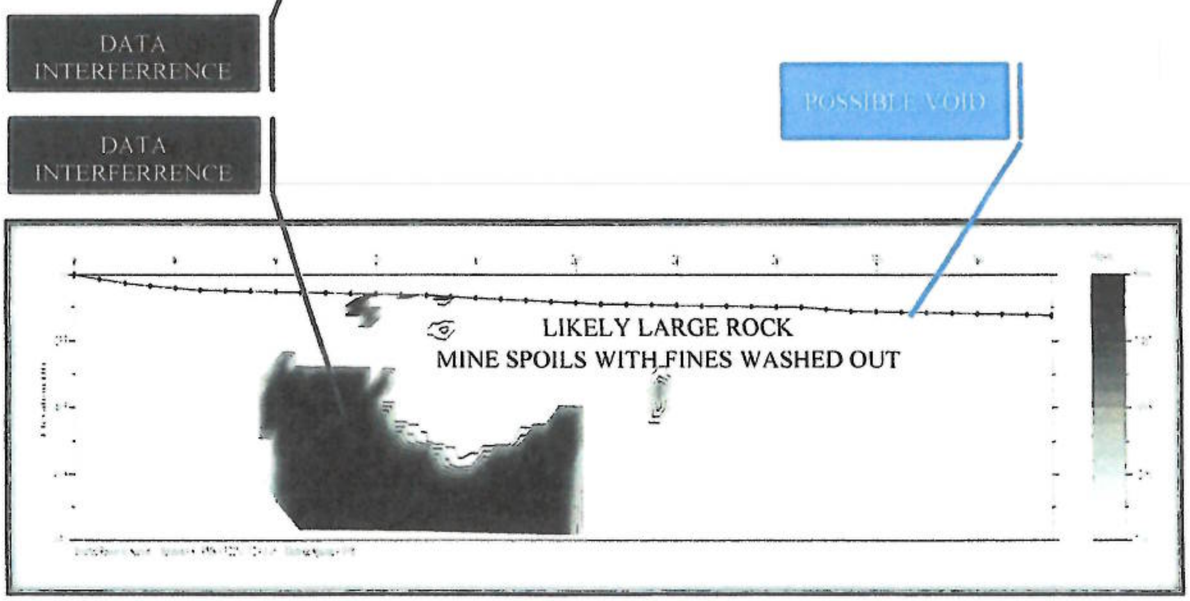

Figure 16 - ERI Array #6 Low Resistance Analysis

Notes on ERI Array #6

- LOW QUALITY DATA – INTERFERRENCE FROM EXISTING UTILITY
- *Depth of Mine Spoils 25-40+ Feet*
- *Apparent sandstone/conglomerate mass rock past 50 feet*

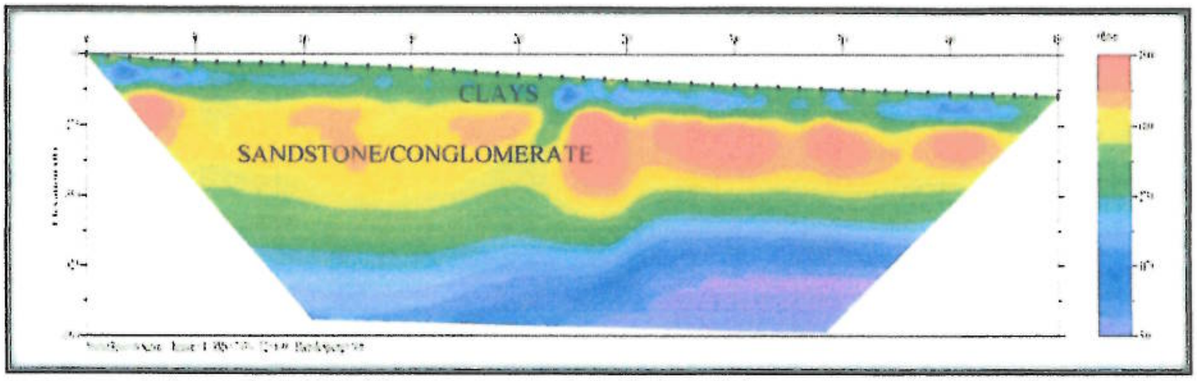

Figure 17 - ERI Array #7 High Resistance Analysis

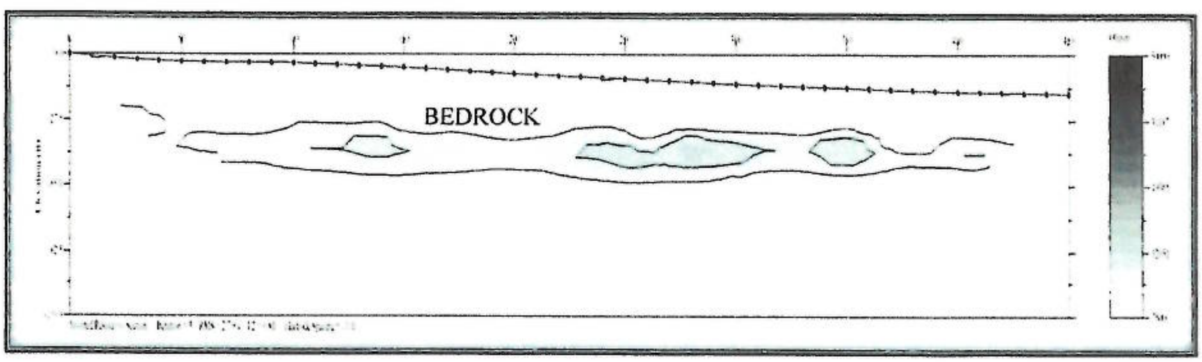

Figure 18 - ERI Array #7 Low Resistance Analysis

Notes on ERI Array #7

- *No mine spoils observed*
- *Apparent sandstone/conglomerate mass rock past 10-20 feet*
- *Thin layer of clay overlying bedrock, anticipate a heavily weathered sand layer at the bedrock depth*

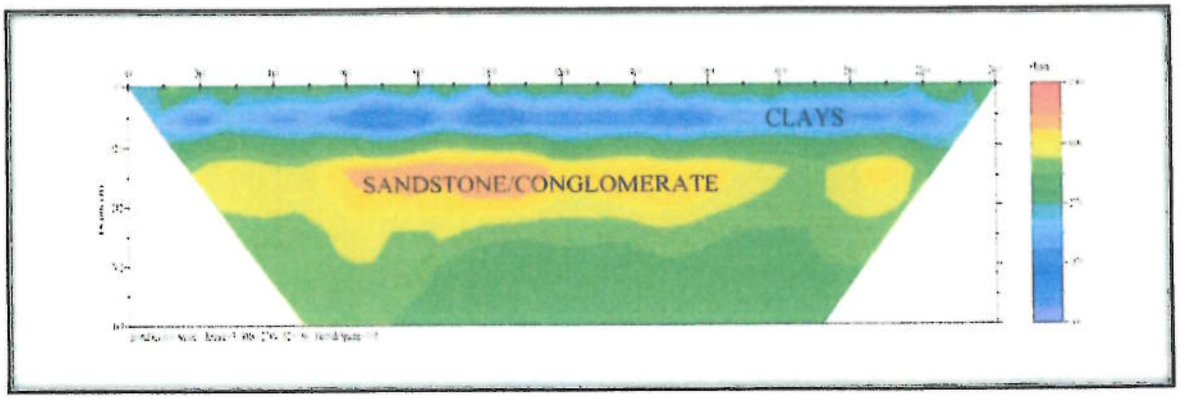

Figure 19 - ERI Array #8 Low Resistance Analysis

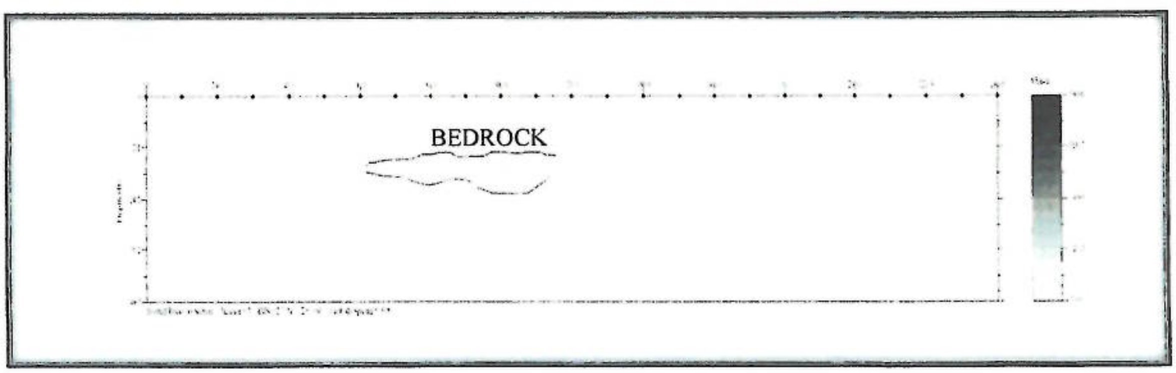

Figure 20 - ERI Array #8 Low Resistance Analysis

Notes on ERI Array #8

- *No mine spoils observed*
- *Apparent sandstone/conglomerate mass rock past 10-20 feet*
- *Thin layer of clay overlying bedrock, anticipate a heavily weathered sand layer at the bedrock depth*

Recommendations

As previously mentioned, the results of the exploration indicate a significant amount of mine spoils with multiple zones exhibiting high resistance anomalies that likely indicate very large diameter rock fill. For ease of review, please see the figure included below with generalized mine spoil depths. This image shows anticipate depth of mine spoils, areas apparently influenced by strip mining activities, and the previously mentioned abandoned adits.

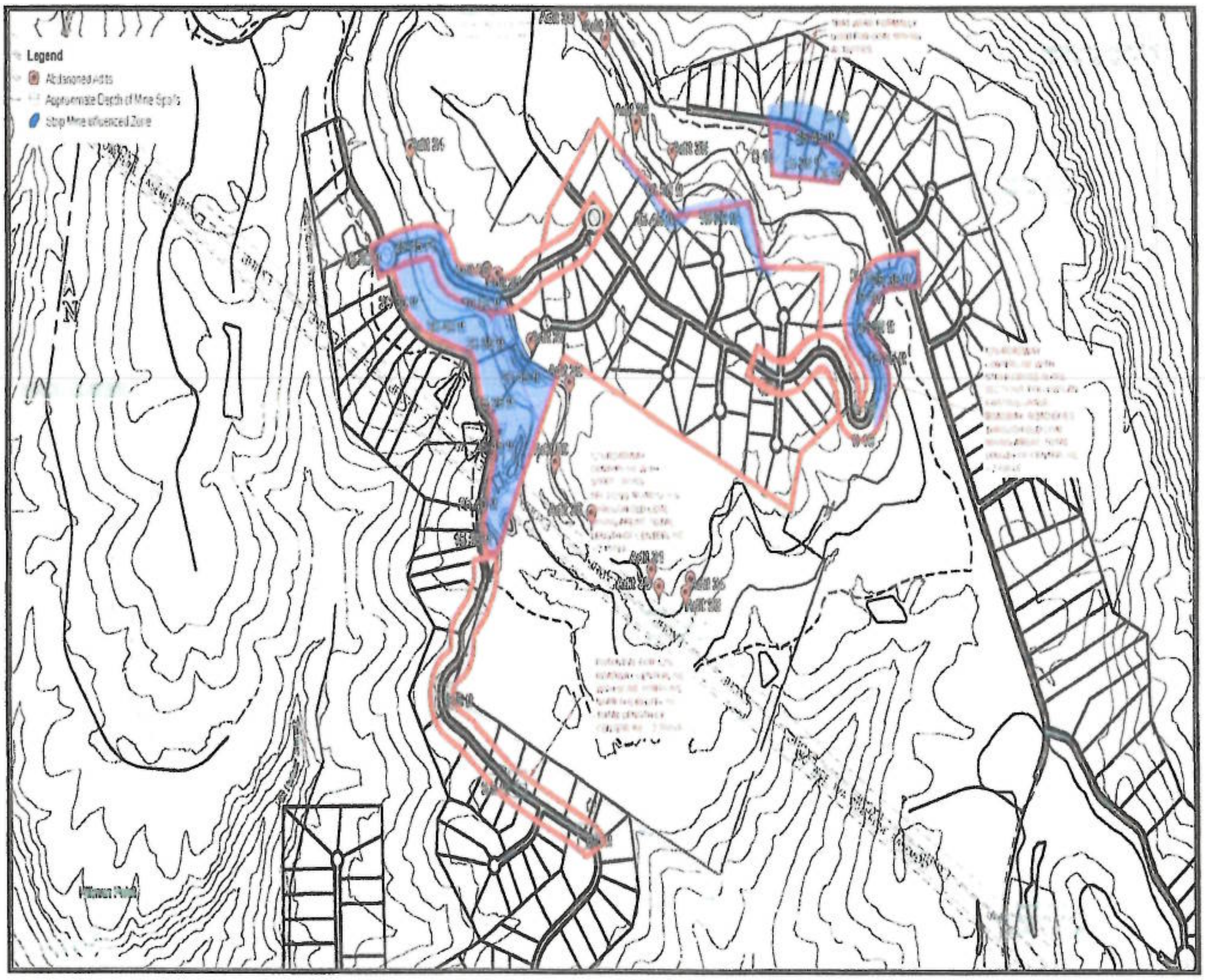

Figure 21 – Mine Spoils Depth

Strip Mine Influenced Zones

We anticipate deep mine spoils will be encountered during grading, in particular during grading of the access roads to the higher elevation lots. Furthermore, we note the majority of the ERI array data collected within the mine spoil zones indicate moderate to very large rock diameter within the spoils. While this program was not geared to determine the size or dimensions of underlying rock fill, we note the presentation of the higher resistance soil spoil zones would indicate rock fragments exceeding 5-10 feet in multiple locations. We note the possible largest of the rock fragments appears generally located on the downside portion of the spoils, indicating large rock was likely pushed over the side during mining activities.

For the above reasons, we recommend limiting the undercutting of mine spoils, where possible, as the mine spoils were likely not placed in any controlled manner. Therefore, earthwork cuts into mine spoils will have a high risk of encountering unstable materials unsuitable for benched/sloped excavations (i.e. we anticipate any cut slopes in mine spoils may become unstable quickly).

However, we understand multiple road crossing and utilities will likely be located within these mine spoil zones. Where required, we highly recommend the owner consider a limited remediation program geared to protect future pavement and utility construction when located in mine spoils. For proposed roadways to be located within the mine spoil zones, we recommend the owner consider the use of a limited undercut and placement of triaxial geogrid. The area should then be brought to grade using compacted dense graded aggregate or compacted mine spoils which have been processed to meet an acceptable gradation for engineered fill. We recommend the depth of this undercut and replacement be a minimum of 5 feet (if in mine spoils).

We also note a few proposed residential lots in which apparently are underlain by abundant mine spoils. We note the northern most lots explored indicated abundant mine spoils with large rock diameters. In these areas, we highly recommend the owner either A) undercut existing mine spoils, B) abandoned residential development in the 4-6 lots, or C) consider alternate use for the area. It is possible to conduct site specific remediation programs for each lot, however this type of remediation would be dependent on the proposed development and acceptable cost-risk analysis. If requested, GEOS can facilitate a discussion on additional alternatives and associated costs. However, based on our experience the additional alternatives typically utilized in this type of environment are likely cost prohibitive for residential development. We also note some of the highest elevation lots, generally located along the northern bluff line, likely contain some mine spoils where the lots extend past the bluff faces. We did not encounter signs of mine spoils at the highest elevations of the site.

Abandoned Adits and/or Horizontal Mine Entrances

As previously mentioned, published geologic data indicates this site experienced strip mining dating back to the early 19th century, however during the early to mid-20th century horizontal mining was extended further into the mountain to increase coal yield. We have provided a map detailing the publicly available locations of abandoned mines, however we anticipate more mines likely existed at one point in time. GEOS personnel attempted to hike to the adit locations using a hand-held GPS unit in combination with the publicly available locations. While some areas of exposed cuts and low-grade coal was observed, no open mines or adits were noted. However, as mentioned previously we did observe free water with iron staining in one portion of the site, which would indicate some amount of groundwater flow thru either a mine or mine spoils. It should be noted that the area with iron-stained water was generally located well outside of the proposed development and the published location of the mine adits in the area of stained water flow appear to be located more than 500 feet away from any proposed lots (see below).

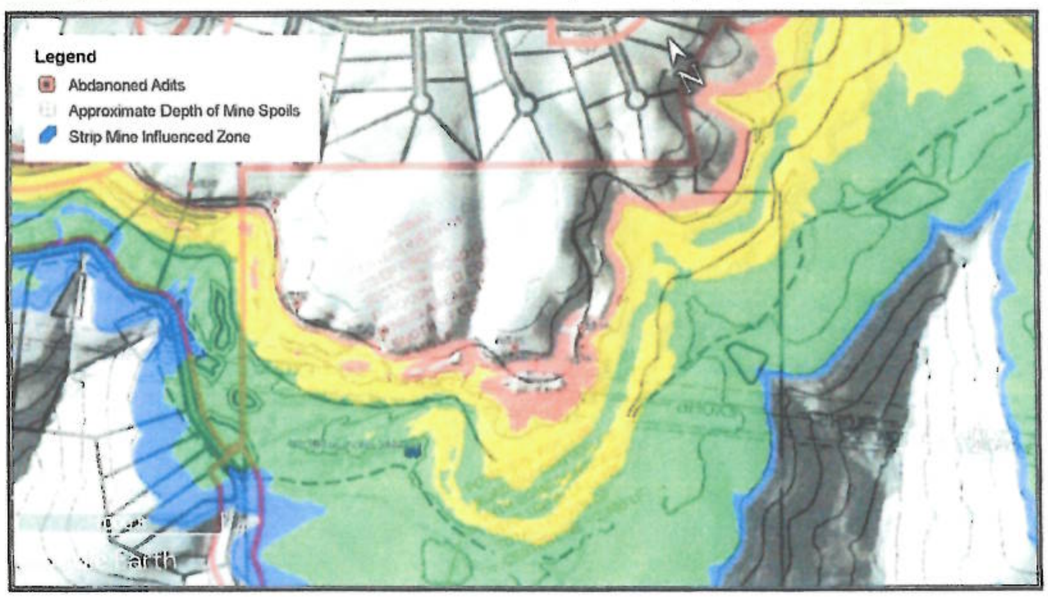

Figure 22 – Iron Stained Water Location

Furthermore, we note that the published geologic information indicates previous mining activities were solely geared towards the three thin coal seams located within the Whitwell Shale Formation. Therefore, while detailed information was not found or determined during the geophysical testing process regarding the existence of open-air mines, we anticipate any mine excavations would be targeted to the Whitwell Shale Formation and coal seams. The highest elevation proposed residential lots are located on what is considered a "cap rock" geologic unit, consisting of the Newton Sandstone formation which overlies the Whitwell Shale formation. In this area, the Newton Sandstone formation averages approximately 120 feet in thickness.

Therefore, while information regarding the existence, continuity, and length of any abandoned mines is not known, we anticipate that the highest elevation proposed lots would generally be underlain by a thick layer of mass sandstone. For this reason, we do not see an increased risk of subsidence to future residential development along the higher elevation lots. However, mass grading and/or extensive blasting in the sandstone formations would likely increase the risk of future distress related to underlying mines.

Closing

GEOServices looks forward to continuing to work with you on this project. If you have any questions or require additional information, please feel free to call us.

Sincerely,

GEOServices, LLC

Matthew B. Haston, P.E.
Senior Geotechnical Engineer

Matthew T. Bible
Geophysical Department Manager

Phoebe G. Anderson
Geophysical Project Coordinator