REPORT OF LIMITED GEOTECHNICAL EXPLORATION

Oak Ridge Aquatic Center – Outdoor Pool

172 Providence Road
Oak Ridge, Tennessee

GEOServices Project No. 21-231026

Submitted to:

City of Oak Ridge
200 South Tulane Avenue
Oak Ridge, Tennessee 37830

Submitted by:

GEOServices, LLC
2561 Willow Point Way
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September 25, 2023

City of Oak Ridge
200 South Tulane Avenue
Oak Ridge, Tennessee 37830

Attention: Mr. John Hetrick
JHetrick@oakridgetn.gov

Subject: **REPORT OF LIMITED GEOTECHNICAL EXPLORATION**
Oak Ridge Aquatic Center – Outdoor Pool
172 Providence Road
Oak Ridge, Tennessee
GEOServices Project No. 21-231026

Dear Mr. Hetrick:

GEOServices, LLC has completed this report of limited geotechnical exploration performed for the subject project. Our services were performed in accordance with GEOServices Proposal No. 11-23348 dated August 4, 2023, and authorized by you.

PROJECT INFORMATION

Initial project information was provided in July of 2021. GEOServices previously issued *Report of Limited Geophysical Services* dated November 3, 2021, which included six (6) ERI lines in attempt to determine the potential karst areas of concern due to the amount of water loss. Several anomalies were noted with some karst concern. We have been provided with an addendum letter titled *ADDENDUM NUMBER ONE FY2023-073*, as prepared by City of Oak Ridge Tennessee and dated February 2, 2023. In addition, we were provided with a survey map of the project site, titled *Municipal Swimming Pool Yard Piping*, as prepared by LD&A. Based on the results of our previous limited geophysical exploration, we recommended an additional exploration consisting of soil test borings in specific areas to better refine the geophysical results.

SCOPE OF STUDY

This geotechnical exploration involved site reconnaissance, private utility locate, geophysical exploration, field drilling, laboratory testing, and engineering analysis. The following sections of this report present discussions of the field exploration and conclusions and recommendations. Following the text of this report figures, test boring records, laboratory test results, and geophysical results are attached.

The geotechnical scope of services did not include an environmental assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, groundwater, or air, on, or below, or around this site. Any statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes.

GEOTECHNICAL EXPLORATION

The site subsurface conditions were explored by drilling five (5) soil test borings in the areas of possible karst concern. The borings were located by GEOServices personnel using a hand-held GPS unit. Prior to drilling, the boring locations were scanned by our subcontractor to check for any underground utilities using ground penetration radar. The concrete slab was cored and removed to measure the underlying basestone layer.

The soil test borings were drilled on September 5, 2023, and advanced using 2¼-inch inside diameter hollow stem augers (HSA) using a track mounted drill rig. The approximate locations of the test borings are shown in Figure 2. The depths in this report reference the ground surface that existed at the time of the exploration. Detailed logs for the borings can be found in Appendix A of this report.

Within each soil test boring, Standard Penetration Testing (SPT) and split-spoon sampling were performed on approximately 2½-foot intervals in the upper 10 feet and at 5-foot intervals thereafter. The drilling was performed in accordance with ASTM D 6151 (hollow stem auger drilling). SPT and split-spoon sampling were performed in accordance with ASTM D 1586. Upon completion, the borings were backfilled with soil cuttings before leaving the site and patched with non-shrinkable grout, assuming that the pool will be reconstructed in the future.

In the split–spoon sampling, a standard 2-inch O.D. split-spoon sampler is driven into the bottom of the boring with a 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampler the last 12 inches of the standard 18 inches of total penetration is recorded as the Standard Penetration Resistance (N-value). These N-values are indicated on the boring logs at the testing depth and provide an indication of the consistency of fine-grained soils.

LABORATORY TEST RESULTS

After completion of the field drilling and sampling phase of this project, the soil samples were returned to our laboratory where they were visually-manually classified in general accordance with the Unified Soil Classification System (USCS – ASTM D2487) by a GEOServices geotechnical professional. Select samples were then tested for moisture content (ASTM D2216) and Atterberg limits (ASTM D4318). The laboratory test results are discussed later in this report and presented in the attachments.

GEOPHYSICAL EXPLORATION

Electrical Resistivity Imaging (ER) Survey

The ERI survey was conducted using the Advanced Geosciences, Inc. (AGI) Sting R8 automatic electrode resistivity system. Six (6) ERI transects were performed across the proposed building locations in accessible areas located away from metal or debris, with electrode spacing of 7 to 10 feet, for total array lengths ranging from approximately 200 to 320 feet. 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 and a TopCon handheld GPS unit.

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 limestone. 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 effects.

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. At this site we note an abundance of buried utilities and abundant rebar which resulted in a relatively high RMS error and multiple zones of missing data points.

GEOLOGIC CONDITIONS

The project site lies within the Appalachian Valley and Ridge Physiographic Province of East Tennessee. This Province is characterized by elongated, northeasterly-trending ridges formed on highly resistant sandstone and shale. Between ridges, broad valleys and rolling hills are formed primarily on less resistant limestone, dolomite, and shale.

Published geologic information indicates that this site is underlain by bedrock of the Chickamauga Group. However, the Chickamauga Group is not differentiated into its individual formations in the immediate area of this site. Where undivided, the Chickamauga Group is primarily composed of calcareous shale with crystalline limestone and minor amounts of sandstone. Bedrock from this geologic setting typically weathers to produce a thick, medium to high-plasticity clay residual soil. Silica in the form of chert is resistant to weathering and typically scattered throughout the residuum.

Since the bedrock underlying the site contains carbonate rock (i.e., limestone/dolomite), the site is susceptible to the hazards of irregular weathering, cave and cavern conditions, and overburden sinkholes. Carbonate rock, while appearing very hard and resistant, is soluble in slightly acidic water. This characteristic, plus differential weathering of the bedrock mass, is responsible for the hazards. Of these hazards, the occurrence of sinkholes is potentially the most damaging to soil supported structures. In East Tennessee, sinkholes occur primarily due to differential weathering of the bedrock and “flushing” or “raveling” of overburden soils into the cavities in the bedrock. The loss of solids creates a cavity or “dome” in the overburden. Growth of the dome over time or excavation over the dome can create a condition in which rapid, local subsidence or collapse of the roof of the dome occurs.

A certain degree of risk with respect to sinkhole formation and subsidence should be considered at any site located within this geologic setting. While a rigorous effort to assess the potential for sinkhole development at this site was beyond our scope of services, we did not encounter any obvious surficial signs of sinkhole activity. However, several closed depressions, which are indicative of past sinkhole activity, were observed on the United States Geological Survey (USGS – Windrock Quadrangle, TN) topographic map in the vicinity of this site. Each of our borings were drilled in areas of possible karst concern, as previously mentioned in our *Report of Limited Geophysical Exploration,* dated November 3, 2021.

Indications of karst activity be identified in the subsurface conditions revealed by the soil test borings drilled as part of this exploration. A common indicator of karst activity in the borings is the presence of a relatively thick, continuous zone of soft soil overlying bedrock. This zone of soft soil above the bedrock surface and between pinnacles in the bedrock is commonly referred to as “epikarst”. Each of the borings (B-1 through B-5) drilled within the anomalies did not encounter soft soil in the zone overlying bedrock which would be indicative of the epikarst and an increased risk of sinkhole development.

It is our opinion that the risk of sinkhole development at this site is no greater than at other sites located within similar geologic settings which have been developed successfully. However, the owner must be willing to accept a moderate risk of sinkhole development at this site. The risk of sinkhole development can be reduced by following the recommendations provided in the *Sinkhole Corrective Actions* section of this report.

SUBSURFACE CONDITIONS

The following subsurface description is of a generalized nature to highlight the subsurface stratification features and material characteristics at the boring locations. The boring logs included at the end of this report should be reviewed for specific information at each boring location. Information on actual subsurface conditions exists only at the specific boring locations and is relevant only to the time that this exploration was performed. Variations may occur and should be expected at the site.

Soil Test Borings

Surficial Materials

Upon completion of our coring activities, each of the borings encountered a surficial layer consisting of approximately 6 to 18 inches of concrete. Underlying the concrete slab, approximately 6 and 18 inches of crushed stone was encountered. We anticipate the actual thickness of concrete and basestone will vary across the site and between our widely spaced borings. As such, we recommend the contractor determine the actual thickness for bidding and construction purposes.

Apparent Fill

Underlying the surficial layer, each of the boring locations encountered apparent fill materials generally consisting of gray, brown, reddish brown, tan, and orangish brown lean (low plasticity) and fat (high plasticity) clayey soils with varying amounts of gravel and sand. In addition, boring B-4 encountered a layer of dark gray gravel with traces of clay. The fill materials extended to depths ranging from approximately 8 to 18 feet below existing grade. We note that three borings (B-2, B-3, and B-5) refused in fill materials. Therefore, the fill may extend to greater depths at these locations.

Residuum

Underlying the fill materials, two borings (B-1 and B-4) encountered residual soils, which generally consisted of tan, gray, and brown lean and fat clayey soils with varying amounts of sand and chert fragments. Beneath the residual soil, boring B-1 encountered weathered rock at approximately 12 feet below existing grade. The weathered rock was manually classified as dark gray and tan limestone.

The SPT N-values within the fill and residual materials generally ranged from 5 bpf (blows per foot) to 50/1" (50 blows per 1 inch of penetration), indicating stiff to hard consistencies within the fine-grained soils and medium dense relative densities within the fine-grained materials. The exceptions were the initial samples in three locations (B-1, B-2, and B-5) and the isolated sample in boring B-3, which had SPT N-values between 2 and 4 bpf, indicating very soft to soft consistencies within the fine-grained materials. We note that SPT N-values greater than 20 bpf may have been influenced by dense materials, such as gravel, weathered rock, or the upper surface of bedrock.

Auger Refusal

Auger refusal was encountered in each of the borings at depths ranging from approximately 8 to 18 feet below existing grade. Auger refusal is a designation applied to materials that cannot be penetrated by the power auger used to drill the borings. Auger refusal may indicate hard materials, such as rock boulders, ledges or pinnacles, or the top of continuous bedrock. However, as previously mentioned three borings (B-2, B-3, and B-5) refused in fill materials, which may be an indication of dense of fill and not underlying bedrock.

Groundwater

Groundwater was encountered in one boring (B-2) at approximately 13 feet below existing grade. We note that stabilized water levels can sometimes be difficult to obtain as the encountered soils are known to be relatively impermeable. In addition, each boring was backfilled upon completion in consideration of safety so delayed water levels were not recorded.

It is possible for groundwater to exist within the depths explored during other times of the year depending upon climatic and rainfall conditions. Additionally, discontinuous zones of perched water may exist within the overburden materials. The groundwater information presented in this report is the information that was collected at the time of our field activities. The following table tabulates the approximate thicknesses of the surficial and fill materials, groundwater depth, depth to weathered rock, and auger refusal depth relative to the existing ground surface.

Table 1 –Boring Summary

Boring Location	Approximate Surficial Materials Depth (Inch)	Approximate Depth of Fill (feet)	Approximate Depth of Groundwater (feet)	Approximate Depth of Weathered Rock (feet)	Approximate Auger Refusal Depth (feet)
B-1	18” C & 18” BS	8	NE	12	15
B-2	6” C & 6” BS	18	13	NE	18
B-3	10” C & 18” BS	8.1	NE	NE	8.1
B-4	10” C & 18” BS	16.3	NE	NE	16.3
B-5	10” C & 18” BS	8	NE	NE	8

NOTES: NE – Not Encountered / C - Concrete / BS - Basestone

Laboratory Test Results

Laboratory testing of selected samples indicated in-situ moisture content values ranging from 9.9 to 33.4 percent which varied with depth. In addition, Atterberg limits testing was performed on a select sample from two borings (B-1 and B-2) at depths ranging from approximately 3.5 to 10 feet below existing grade. These samples yielded liquid limits between 55 and 68 and plasticity indices between 36 and 49, which indicated a soil classification of fat clay (CH) based on the plasticity testing alone. The following summarizes the Atterberg limit test results.

Table 2 –Atterberg Limits Summary

Boring Location	Depth (feet)	Atterberg Limits			Classification
		Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	
B-1	3.5-5	68	19	49	CH – Fat Clay
B-2	8.5-10	55	19	36	CH – Fat Clay

FINDINGS AND RECOMMENDATIONS

As previously mentioned in our *Report of Limited Geophysical Exploration,* subsurface anomalies were encountered across the site. As a result, we drilled five borings to further investigate the anomalies and assess the sinkhole risk.

As described previously, the bedrock underlying the site consists of carbonate rock (i.e. limestone and dolomite). A certain degree of risk with respect to sinkhole formation and subsidence should be considered at any site located within carbonate geologic settings. In such setting, the soil overburden is typically stiffer near the ground surface and becomes softer and “wetter” with increased depth. Therefore, during our field exploration, we looked for characteristics of active conditions, such as elevated moisture contents, soft soils (typically SPT N-values less than 4) which decrease in consistency with depth, and apparent open voids within the soil. Soft zones of soil above the bedrock surface and between pinnacles in the bedrock is commonly referred to as “epikarst” and can be an indicator of on-going sinkhole activity.

Based on the results of our exploration, we did not encounter subsurface conditions which would indicate an elevated risk of sinkhole development. Therefore, we anticipate the existing anomalies are not sinkhole related. It is our opinion that the risk of sinkhole development at this site is no greater than at other sites located within similar geologic settings, which have been developed successfully. However, the owner must be willing to accept the moderate risk of future sinkhole development at this site. The risk of sinkhole development can be also be somewhat reduced by following the recommendations provided in the *Sinkhole Risk Reductions and Corrective Actions* section of this report.

The current standard of geotechnical engineering practice cannot definitely predict where or when solution features will occur. Therefore, the recommendations are based on the field work completed in September of 2023. The geotechnical engineer should be notified if solution features are encountered during construction activities.

We anticipate the anomalies which were identified by the ERI geophysical testing are related to the upper soft and moist fill materials and shallow auger refusal. During our exploration, each location initially encountered lower consistency (very soft to firm) fill materials which were manually described as moist to very moist. The fill materials contained varying amounts of gravel and sand. In addition, shallow auger refusal was encountered in each of the borings at depths ranging from approximately 8 to 16 feet below existing grade. Based on the soil test borings, the high resistance features from the ERI testing appear to correspond to the refusal materials, while the low resistance areas appear to correspond to the soft and moist fill materials.

We understand that the City of Oak Ridge is planning to excavate the existing pool and construct an updated pool. We recommend performing close construction observations during earthwork excavations activities to observe the consistency and suitability to support the proposed construction. Any areas observed to be unsuitable for use as foundation support should be remediated accordingly. Typical remediation would consist of undercutting and replacing with properly compacted structural soil fill or compacted dense graded aggregate. The depth of undercutting should be determined based on observations and tests performed at the time of construction.

Subgrades for lightly loaded slabs and/or pavement areas can typically be supported on materials that proofroll successfully. Proofrolling should be observed by a geotechnical engineer or by a qualified representative in order to help identify areas requiring subgrade support correction. Where the subgrade does not pass proofrolling, remediation, similar to those mentioned above, should be anticipated.

In addition, each of the test locations encountered materials classified as high plasticity (fat) clayey soils at various depths. Therefore, we anticipate these materials will be encountered during construction activities. Typically, these materials are marginally suitable for foundation, slab, or pavement support and will likely impede site grading activities as they are susceptible to moisture changes.

As previously mentioned, we anticipate the majority of the residual soils will be suitable for reuse as structural soil fill; however, the client should understand that some variation should be expected between our widely spaced borings and selective undercut and replacement may be necessary during construction activities. This may include the lower consistency materials, free of deleterious materials, if the soils are scarified (or undercut) and recompacted. The existing fat clays may also be mixed with lower plasticity materials during earthwork grading to produce a material which meets the recommended criteria, or the material may be treated using lime or cement to lower the soil plasticity.

The owner may also wish to consider a program of soil cement modification to improve the subgrade soil for the new pool slab. Cement modification entails the placement and mixing of Portland cement into the clay subgrade soils and re-compacting the material to 98 percent of the standard Proctor maximum dry density. Cement modification serves to stabilize, strengthen, and lower the permeability of the modified soil by way of a pozzolanic reaction which occurs between the calcium hydroxide released during hydration and alumina and silica in the clay soil. The resulting reduction in permeability effectively creates a soil-cement “cap” which helps reduce the potential for downward movement and infiltration of surface water; thereby, helping to reduce the potential for sinkhole development. Cement stabilization would also create a hard subgrade material on which the new pool slab may be supported and lower the soil plasticity to reduce concerns associated with soil shrinkage and swelling of fat clays. GEOServices would be pleased to further discuss soil cement stabilization if it is thought this might be a desirable alternative.

Sinkhole Corrective Actions

Based on our experience, corrective actions would decrease but not eliminate the potential for sinkhole development. Much can be accomplished to decrease the potential of future sinkhole activity by proper grade selection and through the establishment of positive site drainage.

In general, the portions of the site that are excavated to achieve the desired grades will have a higher risk of sinkhole development than the areas that are filled, because of the exposure of relic fractures in the soil to rainfall and runoff. On the other hand, those portions of a site that receive a modest amount of fill will have a decreased risk of sinkhole development caused by rainfall or runoff because the placement of a cohesive soil fill over these areas effectively caps the area with a relatively impervious *blanket* of remolded soil.

Although it is our opinion that the risk of ground subsidence associated with sinkhole formation cannot be eliminated, we have found that several measures are useful in site design and development to reduce this potential risk. These measures include:

- Maintaining positive site drainage to route surface waters well away from structural areas both during construction and for the life of the structure.
- The scarification and re-compaction of the upper 6 to 10 inches of soil in earthwork cut areas.
- Verifying that subsurface piping is carefully constructed, and pressure tested prior to its placement in service. Maintain the subsurface piping and pool to identify leaks and correct them in a timely manner.

Considerations when building within a sinkhole prone area are to provide positive surface drainage both during and after construction. Backfill in utility trenches or other excavations should consist of compacted, well-graded material such as dense graded aggregate or compacted on site soils. The use of an open graded stone (such as No. 57 stone) is not recommended unless the stone backfill is provided an exit path and not allowed to pond. If sinkhole conditions are observed, the type of corrective action is most appropriately determined by a geotechnical engineer on a case-by-case basis. We recommend the client review this report in its entirety to determine the most efficient and economical construction techniques prior to site development.

We strongly encourage the client to confer with the design team and a contractor with regard to the recommendations contained in this report, in an effort to assess potential costs and schedule. Additional onsite testing during construction can further classify the fill materials' suitability for reuse as soil fill.

LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. This report is for our geotechnical work only. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

CLOSURE

We appreciate the opportunity to provide these services. If you have any questions, please feel free to contact us at your convenience.

Sincerely,
GEOServices, LLC

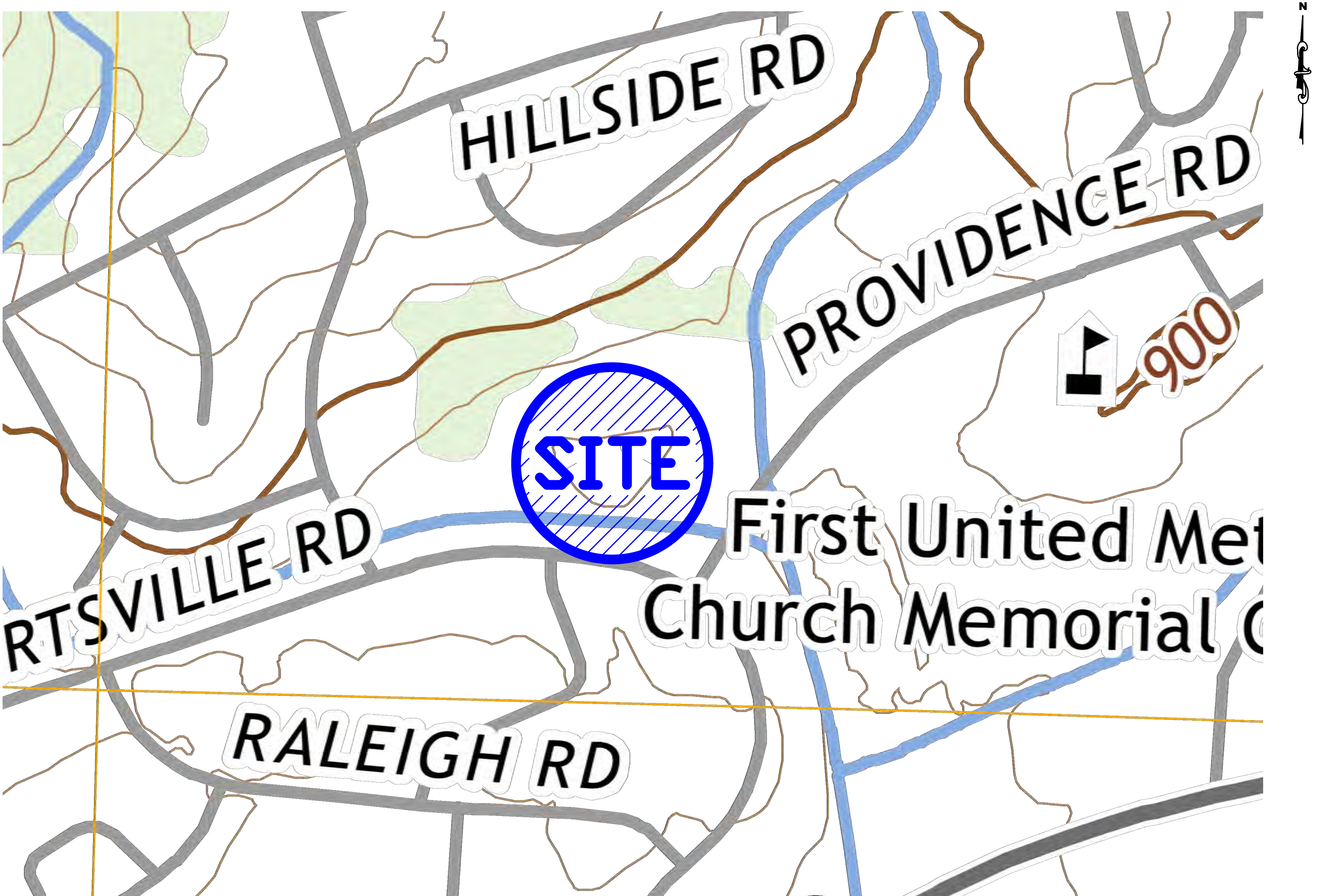
9/25/23

Stephen R Martin, P.E.
Geotechnical Department Manager
TN PE 122,250

Ibrahim M. Aklouk, P.E.
Geotechnical Project Manager
TN PE 127,662

Attachments: Site Vicinity Map, Boring Location Plan, Boring Legend, Boring Logs, Laboratory Test Results, and Geophysical test results

ATTACHMENTS



NOTES:

1.) BASE MAP: USGS QUADRANGLE (WINDROCK, TENNESSEE)

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2561 Willow Point Way, Knoxville, TN 37931
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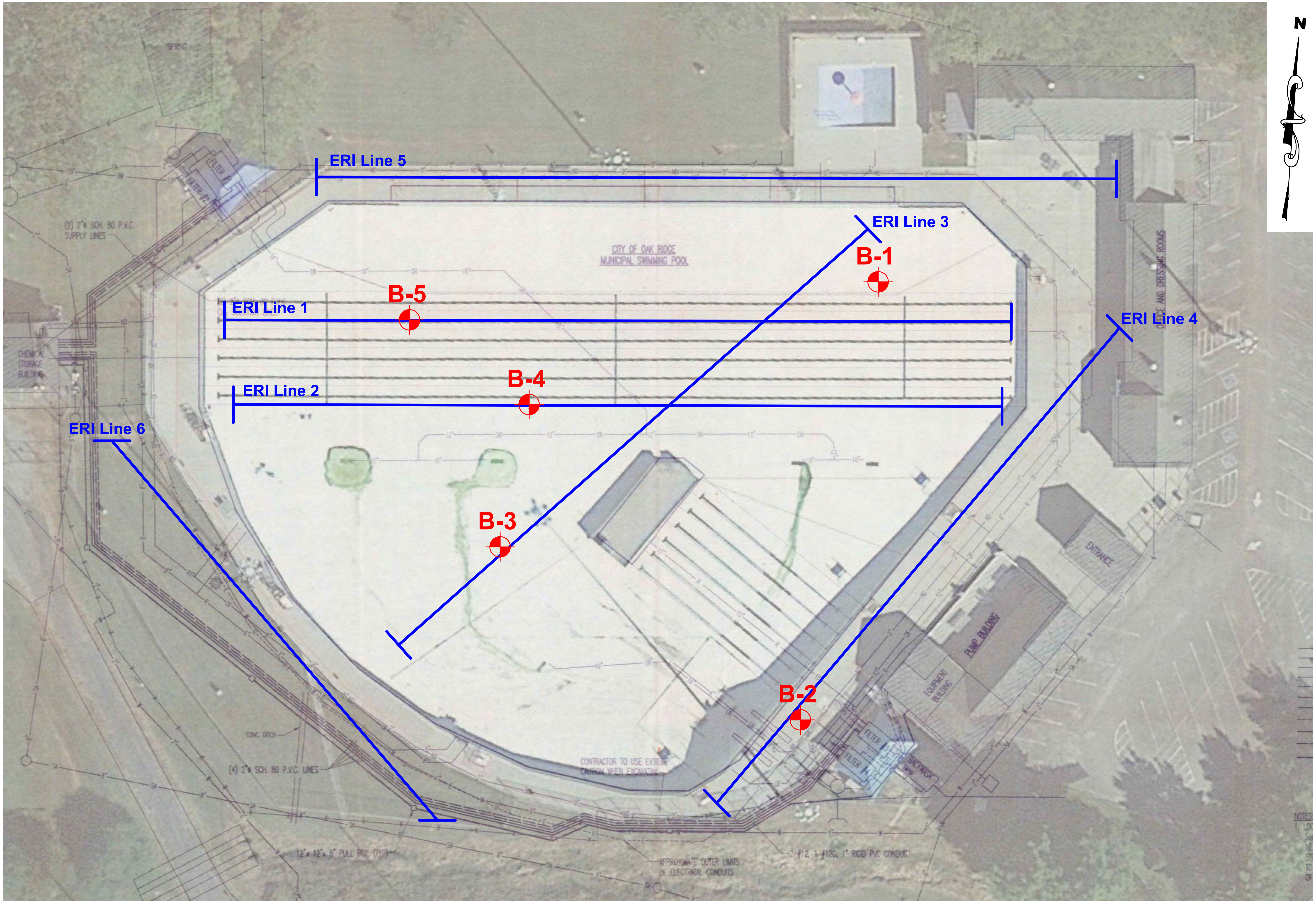
SITE VICINITY MAP

OAK RIDGE AQUATIC CENTER
OUTDOOR POOL

172 PROVIDENCE RD., OAK RIDGE, TN 37830

DRAWN BY:	KSR
APPROVED BY:	SRM
SCALE:	N.T.S.
JOB NO.:	21-231026
DATE:	8/15/23

FIGURE 1



NOTES:

1.) BORING AND ERI LOCATIONS ARE SHOWN IN GENERAL ARRANGEMENT ONLY.
2.) DO NOT USE BORING OR ERI LOCATIONS FOR DETERMINATIONS OF DISTANCES OR QUANTITIES.
3.) BASE MAP PROVIDED BY: Lamar Dunn & Associates, Inc.

LOCATION OF SOIL TEST BORINGS (2023)
LOCATION OF ERI LINES (2021)

SOIL TEST BORING AND ERI LINE LOCATION PLAN

OAK RIDGE AQUATIC CENTER
OUTDOOR POOL

172 PROVIDENCE RD., OAK RIDGE, TN 37830

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Figure 2

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KEY TO SYMBOLS

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

- ASPHALT: Asphalt
- CH: USCS High Plasticity Clay
- CL: USCS Low Plasticity Clay
- CL-ML: USCS Low Plasticity Silty Clay
- CONCRETE: Concrete
- DOLOMITE: Dolomite
- GRAVEL: Gravel / Basestone
- LIMESTONE: Limestone
- ML: USCS Silt
- SANDSTONE: Sandstone
- SC: USCS Clayey Sand
- SC-SM: USCS Silty Clayey Sand
- SHALE: Shale
- SLATE: Slate
- SM: USCS Silty Sand
- SW: USCS Well-graded Sand
- SP: USCS Poorly-graded Sand
- TOPSOIL: Topsoil
- WEATHERED ROCK: Weathered Bedrock
- WOOD: Wood / Mulch

SAMPLE SYMBOLS

- Grab Sample
- No Recovery
- Rock Core
- Shelby Tube
- Split Spoon
- AUGER: Auger Probe

COLOR CODES FOR LITHOLOGIC SYMBOLS

- RED: Fill
- GREEN: Cultivated
- BLUE: Residuum
- MAGENTA: Alluvium
- PINK: Colluvium
- LIGHT GRAY: Weathered Rock
- ORANGE: Loess
- DARK GRAY: Rock Core
- YELLOW: Void
- TEAL: Glacial Outwash / Glacial Till
- PURPLE: Marine

ABBREVIATIONS

LL	- LIQUID LIMIT (%)
PI	- PLASTIC INDEX (%)
W	- MOISTURE CONTENT (%)
DD	- DRY DENSITY (PCF)
NP	- NON PLASTIC
-200	- PERCENT PASSING NO. 200 SIEVE
PP	- POCKET PENETROMETER (TSF)

- ∇ Water Level at Time Drilling, or as Shown
- ▼ Water Level at End of Drilling, or as Shown
- ▼ Water Level After 24 Hours, or as Shown

TV	- TORVANE
PID	- PHOTOIONIZATION DETECTOR
UC	- UNCONFINED COMPRESSION
ppm	- PARTS PER MILLION

GENERAL NOTES

FINE AND COARSE GRAINED SOIL PROPERTIES

PARTICLE SIZE

BOULDERS:	GREATER THAN 300 mm
COBBLES:	75 mm to 300 mm
GRAVEL:	4.74 mm to 75 mm
COARSE SAND:	2mmto4.74mm
MEDIUM SAND:	0.425 mm to 2mm
FINE SAND:	0.075 mm to 0.425 mm
SILTS & CLAYS:	LESS THAN 0.075 mm

COARSE GRAINED SOILS (SANDS & GRAVELS)

N-VALUE	RELATIVE DENSITY
0 - 4	VERY LOOSE
5 - 10	LOOSE
11 - 30	MEDIUM DENSE
31 - 50	DENSE
OVER 50	VERY DENSE

FINE GRAINED SOILS (SILTS & CLAYS)

N-VALUE	CONSISTENCY	Qu, PSF
0 - 2	VERY SOFT	0-500
3 - 4	SOFT	500 -1000
5 - 8	FIRM	1000 - 2000
9 - 15	STIFF	2000 - 4000
16 - 30	VERY STIFF	4000 - 8000
OVER 31	HARD	8000 +

STANDARD PENETRATION TEST (ASTM D1586)

THE STANDARD PENETRATION TEST AS DEFINED BY ASTM D1586 IS A METHOD TO OBTAIN A DISTURBED SOIL SAMPLE FOR EXAMINATION AND TESTING AND TO OBTAIN RELATIVE DENSITY AND CONSISTENCY INFORMATON. THE 1.4 INCH I.D./2.0 INCH O.D. SAMPLER IS DRIVEN 3-SIX INCH INCREMENTS WITH A 140-LB. HAMMER FALLING 30 INCHES. THE BLOW COUNTS REQUIRED TO DRIVE THE SAMPLER THE FINAL 2 INCREMENTS ARE ADDED TOGETHER AND DESIGNATED THE N-VALUE. AT TIMES, THE SAMPLER CAN NOT BE DRIVEN THE FULL 18 INCHES. THE FOLLOWING REPRESENTS OUR INTERPRETATION OF THE STANDARD PENETRATION TEST WITH VARIATIONS.

BLOWS/FOOT (N-VALUE)	DESCRIPTION
25	25 BLOWS DROVE SAMPLER 12" AFTER INITIAL 6" SEATING
75/10"	75 BLOWS DROVE SAMPLER 10" AFTER INITIAL 6" SEATING
50/PR	PENETRATION REFUSAL OF SAMPLER AFTER INITIAL 6" SEATING

SAMPLING SYMBOLS

ST:	UNDISTURBED SAMPLE
SS:	SPLIT SPOON SAMPLE
CORE:	ROCK CORE SAMPLE
AU:	AUGER OR BAG SAMPLE

SOIL PROPERTY SYMBOLS

N:	STANDARD PENETRATION, BPF
M:	MOISTURE CONTENT %
LL:	LIQUID LIMIT %
PI:	PLASTICITY INDEX%
Qp:	POCKET PENETROMETER VALUE, TSF
Qu:	UNCONFINED COMPRESSIVE STRENGTH, TSF
DUW:	DRY UNIT WEIGHT, PCF

ROCK PROPERTIES

ROCK HARDNESS

VERY SOFT:	ROCK DISINTEGRATES OR EASILY COMPRESSES TO TOUCH: CAN BE HARD TO VERY HARD SOIL.
SOFT:	ROCK IS COHERANT BUT BREAKS EASILY TO THUMB PRESSURE AT SHARP EDGES AND IT CRUMBLES WITH FIRM HAND PRESSURE.
MODERATELY HARD:	SMALL PIECES CAN BE BROKEN OFF ALONG SHARP EDGES BY CONSIDERABLE HARD THUMB PRESSURE: CAN BE BROKEN BY LIGHT HAMMER BLOWS.
HARD:	ROCK CAN NOT BE BROKEN BY THUMB PRESSURE, BUT CAN BE BROKEN BY MODERATE HAMMER BLOWS.
VERY HARD:	ROCK CAN BE BROKEN BY HEAVY HAMMER BLOWS.

ROCK QUALITY DESIGNATION (RQD)

PERCENT	QUALITY
90 TO 100	EXCELLENT
75 TO 90	GOOD
50 TO 75	FAIR
25 TO 50	POOR
O TO 25	VERY POOR

GEOS
A UES COMPANY

GEOS A UES COMPANY

BORING NUMBER B-1

PROJECT NAME Oak Ridge Aquatic Center - Outdoor Pool
GEOServices PROJECT# 21-231026
DATE 9/5/23
PROJECT LOCATION 172 Providence Road, Oak Ridge, TN 37830
DRILLING CONTRACTOR M&W Drilling
LOGGED BY KSR **ON-SITE REP.** ---
DRILLING METHOD DPT-8
LATITUDE / LONGITUDE ---
GROUND ELEVATION --- **PROPOSED FFE** ---
NORTHING / EASTING ---
REFUSAL Depth 15.0 ft
TOP OF ROCK ---
BEGAN CORING ---
FOOTAGE CORED (LF) ---
BOTTOM OF HOLE Depth 15.0 ft

GROUND WATER LEVELS:
AT END OF DRILLING --- Dry
AFTER 1 HOUR --- Backfilled
AFTER 24 HOURS --- Backfilled

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0			Concrete (18 Inches)						
			Basestone (18 Inches)						
			(CH) **Fat CLAY** - with trace gravel - tan, brown, dark gray, and light gray - moist (FILL)	SS 1		1-2-2 (4)	21	68	49
5				SS 2		1-1-2 (3)	33		
			(CH) **Fat CLAY** - tan, light gray, and orangish brown - moist - firm (RESIDUUM)	SS 3		2-2-3 (5)	32		
10			**Weathered ROCK** - limestone - dark gray and tan - moist - hard (RESIDUUM)	SS 4		50/1"			
15									

Refusal at 15.0 feet.
Bottom of borehole at 15.0 feet.

NOTES:

BORING NUMBER B-2

GEOS A UES COMPANY

PROJECT NAME Oak Ridge Aquatic Center - Outdoor Pool
GEOServices PROJECT# 21-231026
DATE 9/5/23
PROJECT LOCATION 172 Providence Road, Oak Ridge, TN 37830
DRILLING CONTRACTOR M&W Drilling
LOGGED BY KSR **ON-SITE REP.** ---
DRILLING METHOD DPT-8
LATITUDE / LONGITUDE ---
GROUND ELEVATION --- **PROPOSED FFE** ---
NORTHING / EASTING ---
REFUSAL Depth 18.0 ft
TOP OF ROCK ---
BEGAN CORING ---
FOOTAGE CORED (LF) ---
BOTTOM OF HOLE Depth 18.0 ft

GROUND WATER LEVELS:
▽ **AT END OF DRILLING** 13.00 ft
AFTER 1 HOUR --- Backfilled
AFTER 24 HOURS --- Backfilled

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0			Concrete (6 Inches)						
			Basestone (6 Inches)						
			(CH) **Gravelly Fat CLAY** - reddish brown, dark brown, and dark gray - moist (FILL)	NR 1		2-1-1 (2)			
5				SS 2		2-1-1 (2)	13		
				SS 3		2-1-2 (3)	10		
10			(CH) **Fat CLAY** - with trace gravel - dark gray and dark brown - moist (FILL)	SS 4		3-3-5 (8)	29	55	36
			(CL) **Gravelly Lean CLAY** - light gray and dark gray - moist (Possible FILL) ▽						
15				SS 5		9-9-6 (15)	27		

Refusal at 18.0 feet.
Bottom of borehole at 18.0 feet.

NOTES:

BORING NUMBER B-3

PROJECT NAME Oak Ridge Aquatic Center - Outdoor Pool

GEOServices PROJECT# 21-231026

DATE 9/5/23

PROJECT LOCATION 172 Providence Road, Oak Ridge, TN 37830

DRILLING CONTRACTOR M&W Drilling

LOGGED BY KSR **ON-SITE REP.** ---

DRILLING METHOD DPT-8

LATITUDE / LONGITUDE ---

GROUND ELEVATION --- **PROPOSED FFE** ---

NORTHING / EASTING ---

REFUSAL Depth 8.1 ft

TOP OF ROCK ---

GROUND WATER LEVELS:

BEGAN CORING ---

AT END OF DRILLING --- Dry

FOOTAGE CORED (LF) ---

AFTER 1 HOUR --- Backfilled

BOTTOM OF HOLE Depth 8.1 ft

AFTER 24 HOURS --- Backfilled

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0			Concrete (10 Inches)						
			Basestone (18 Inches)						
			(CH) **Gravelly Fat CLAY** - dark gray, dark brown, and reddish brown - moist (FILL)	SS 1		1-13-12 (25)			
5			(CH) **Fat CLAY** - with trace gravel - dark brown, dark gray, and reddish brown - moist (FILL)	SS 2		3-1-1 (2)			

Refusal at 8.1 feet.
Bottom of borehole at 8.1 feet.

NOTES:

BORING NUMBER B-4

PROJECT NAME Oak Ridge Aquatic Center - Outdoor Pool
GEOServices PROJECT# 21-231026
DATE 9/5/23
PROJECT LOCATION 172 Providence Road, Oak Ridge, TN 37830
DRILLING CONTRACTOR M&W Drilling
LOGGED BY KSR **ON-SITE REP.** ---
DRILLING METHOD DPT-8
LATITUDE / LONGITUDE ---
GROUND ELEVATION --- **PROPOSED FFE** ---
NORTHING / EASTING ---
REFUSAL Depth 16.3 ft
TOP OF ROCK ---
GROUND WATER LEVELS:
BEGAN CORING ---
AT END OF DRILLING --- Dry
FOOTAGE CORED (LF) ---
AFTER 1 HOUR --- Backfilled
BOTTOM OF HOLE Depth 16.3 ft
AFTER 24 HOURS --- Backfilled

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0			Concrete (10 Inches)						
			Basestone (18 Inches)						
			GRAVEL - with trace clay - dark gray - moist (FILL)						
5				SS 1		3-5-8 (13)			
			(CH) **Fat CLAY** - with large gravel and sand - dark gray, light gray, dark brown, and orangish brown - moist (FILL)	SS 2		2-3-4 (7)	20		
			(CH) **Fat CLAY** - with trace gravel - dark gray, light gray, tan, and dark brown - very moist (FILL)	SS 3		2-3-8 (11)	29		
10									
			(CL) **Lean CLAY** - with sand and trace chert fragments - light gray, brown, tan - moist - firm (RESIDUUM)						
15				SS 4		1-1-5 (6)	30		

Refusal at 16.3 feet.
Bottom of borehole at 16.3 feet.

NOTES:

A UES COMPANY

BORING NUMBER B-5

PROJECT NAME Oak Ridge Aquatic Center - Outdoor Pool

GEOServices PROJECT# 21-231026

DATE 9/5/23

PROJECT LOCATION 172 Providence Road, Oak Ridge, TN 37830

DRILLING CONTRACTOR M&W Drilling

LOGGED BY KSR **ON-SITE REP.** ---

DRILLING METHOD DPT-8

LATITUDE / LONGITUDE ---

GROUND ELEVATION --- **PROPOSED FFE** ---

NORTHING / EASTING ---

REFUSAL Depth 8.0 ft

TOP OF ROCK ---

GROUND WATER LEVELS:

BEGAN CORING ---

AT END OF DRILLING --- Dry

FOOTAGE CORED (LF) ---

AFTER 1 HOUR --- Backfilled

BOTTOM OF HOLE Depth 8.0 ft

AFTER 24 HOURS --- Backfilled

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX
0			Concrete (10 Inches)						
			Basestone (18 Inches)						
			(CH) **Fat CLAY** - with gravel - light gray, tan, orangish brown, and dark brown - very moist to moist (FILL)						
5				SS 1		1-1-1 (2)			
				SS 2		1-8-9 (17)			

Refusal at 8.0 feet.
Bottom of borehole at 8.0 feet.

NOTES:

Oak Ridge Aquatic Center - Outdoor Pool

GEOServices Project No. 21-231026

September 19, 2023

SOIL DATA SUMMARY

Boring Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Soil Type	Percent Organic Content
				LL	PL	PI		
B-1	1	3.5-5'	21.1%	68	19	49	CH	
	2	6-7.5'	33.4%					
	3	8.5-10'	32.1%					
B-2	2	3.5-5'	12.6%					
	3	6-7.5'	9.9%					
	4	8.5-10'	29.4%	55	19	36	CH	
	5	13.5-15'	26.5%					
B-4	2	6-7.5'	19.6%					
	3	8.5-10'	29.3%					
	4	13.5-15'	29.8%					

SITE VICINITY MAP - TOPOGRAPHIC BACKGROUND

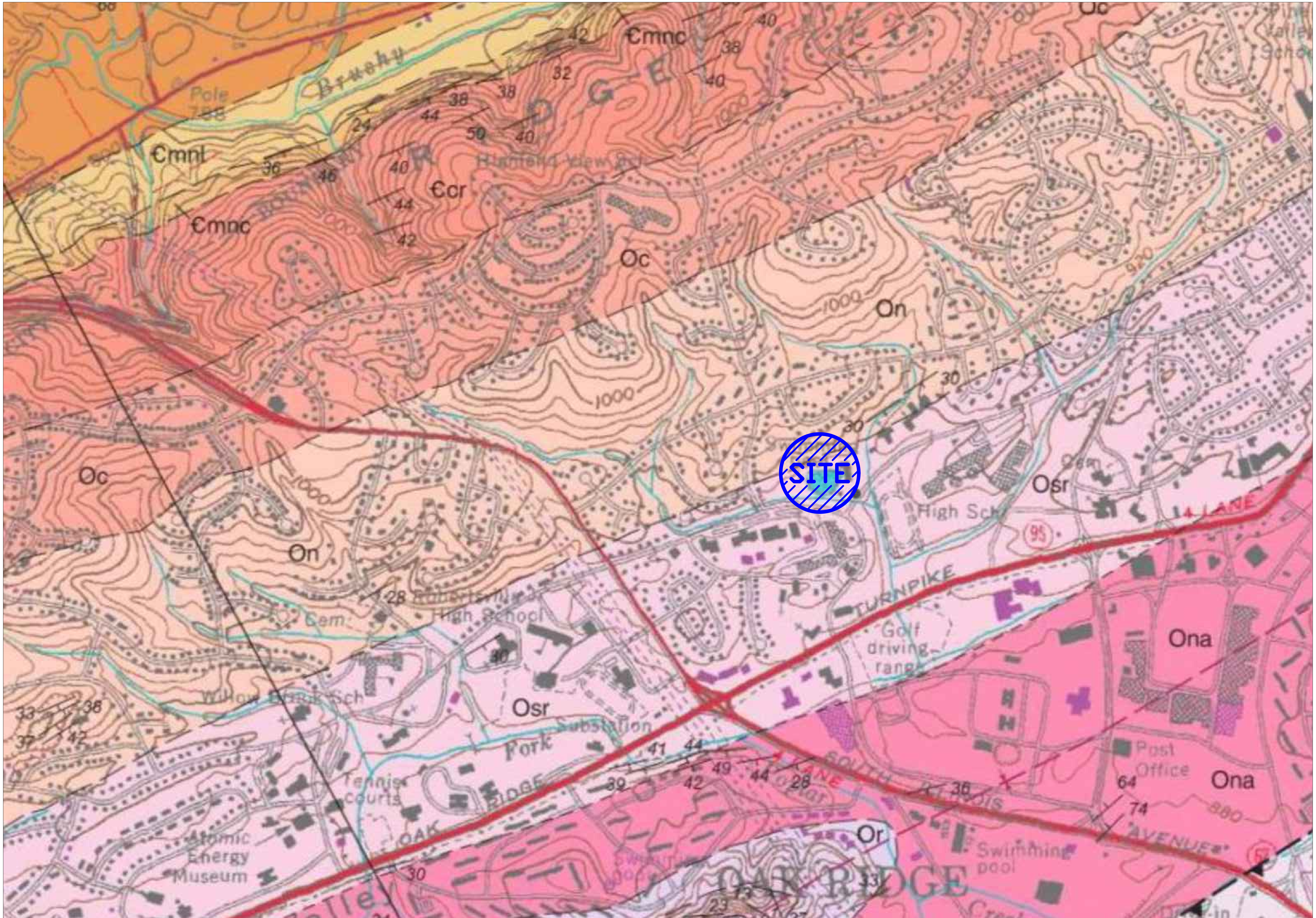
SITE VICINITY MAP
TOPOGRAPHIC

OAK RIDGE POOL DISTRESS
172 PROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	PGA
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS A UES COMPANY
2561 Willow Point Way, Knoxville, TN 37931
Office: 865-539-8242 Fax: 865-539-8252

Figure 3



SITE VICINITY MAP - GEOLOGIC BACKGROUND - USGS WINDROCK TN, QUADRANGLE

SITE VICINITY MAP TOPOGRAPHIC

OAK RIDGE POOL DISTRESS
172 ROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	PGA
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS A UES COMPANY
2561 Willow Point Way, Knoxville, TN 37931
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Figure 4

SITE VICINITY MAP - GOOGLE EARTH AERIAL - ARRAY LOCATION PLAN

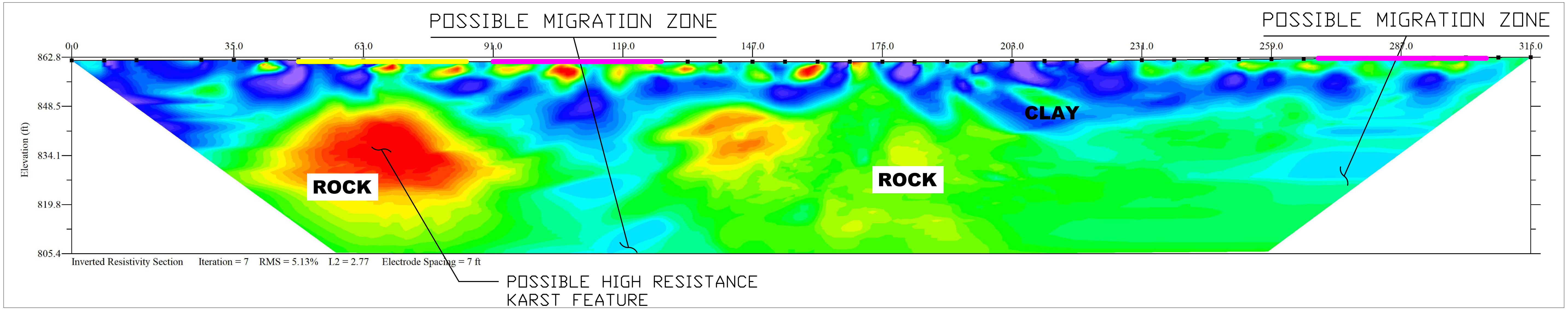
SITE VICINITY MAP
ARRAY LOCATION PLAN

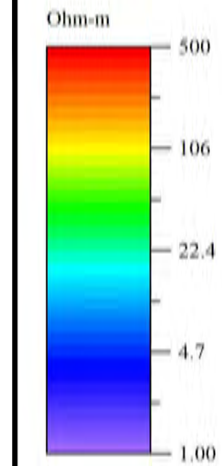
OAK RIDGE POOL DISTRESS
172 ROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	MTB
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	11-2-2021

GEOS A UES COMPANY
2561 Willow Point Way, Knoxville, TN 37931
Office: 865-539-8242 Fax: 865-539-8252

Figure 5.0





ERI ARRAY LOCATION

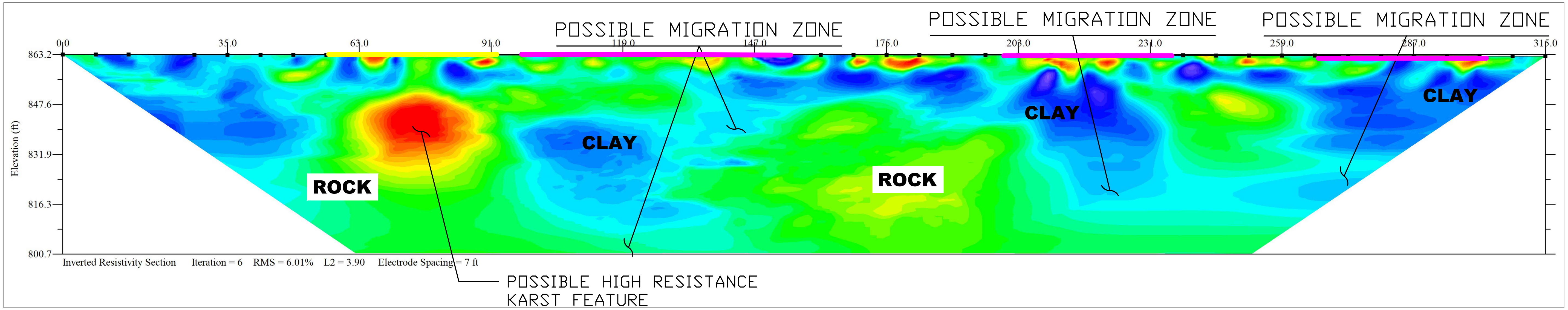
ERI ARRAY LOCATION

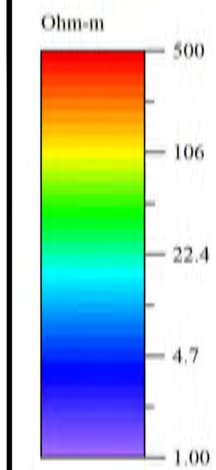
OAK RIDGE POOL DISTRESS
172 PROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	PGA
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS A UES COMPANY
2561 Willow Point Way, Knoxville, TN 37931
Office: 865-539-8242 Fax: 865-539-8252

Figure 5.1





ERI ARRAY LOCATION

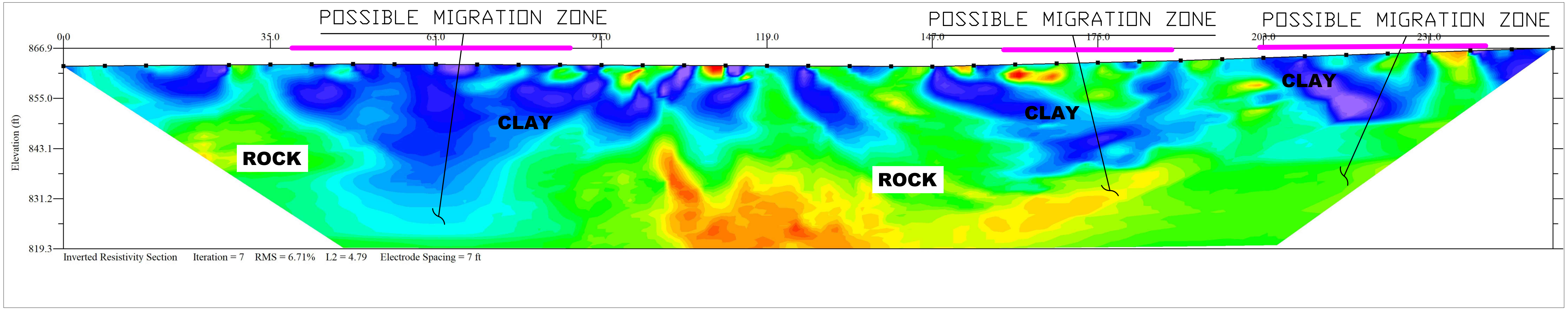
ERI ARRAY LOCATION

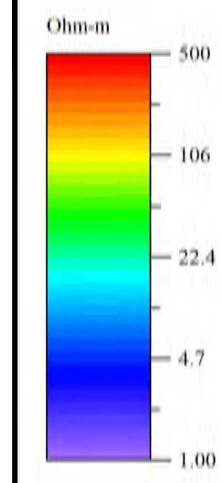
OAK RIDGE POOL DISTRESS
172 PROVIDENCE ROAD
OAK RIDGE, TENNESSEE

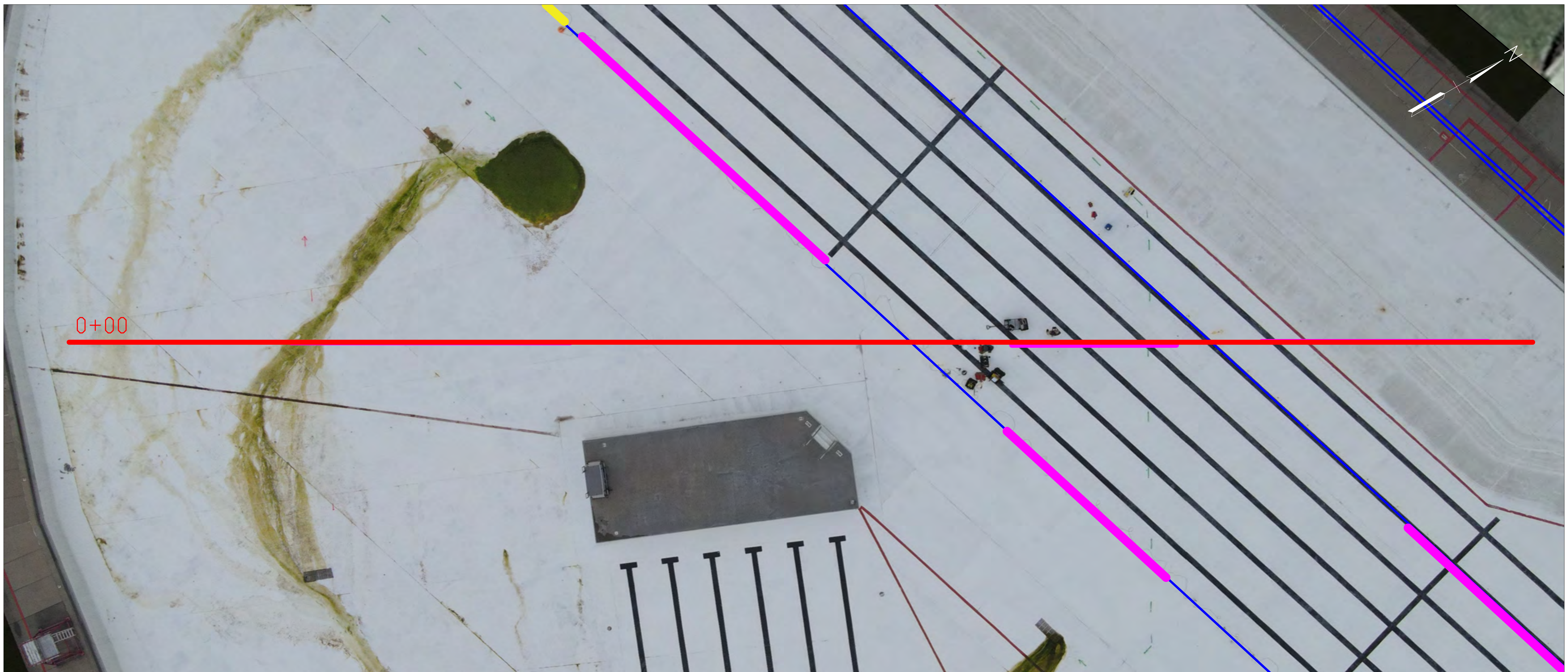
DRAWN BY:	PGA
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS A UES COMPANY
2561 Willow Point Way, Knoxville, TN 37931
Office: 865-539-8242 Fax: 865-539-8252

Figure 5.2







ERI ARRAY LOCATION

ERI ARRAY LOCATION

OAK RIDGE POOL DISTRESS
172 PROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	PGA
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS A UES COMPANY

2561 Willow Point Way, Knoxville, TN 37931
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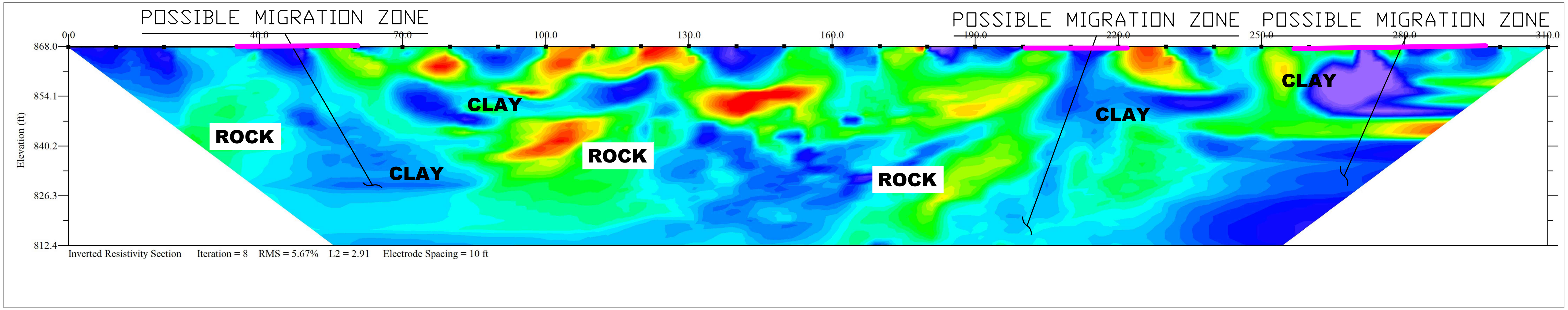
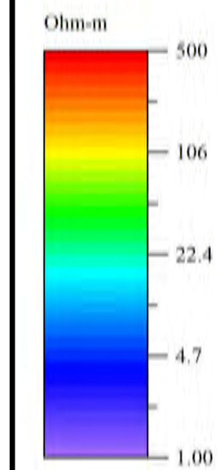
Figure 5.3





ERI ARRAY LOCATION

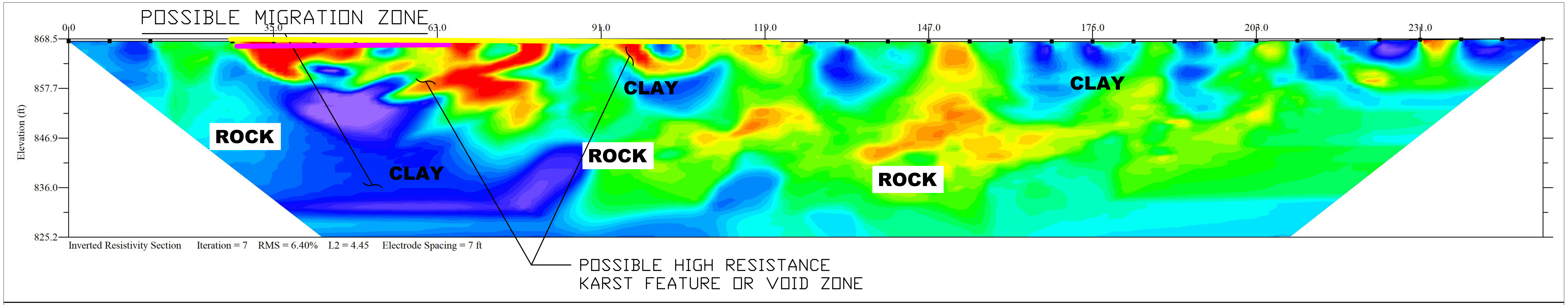
ERI ARRAY LOCATION

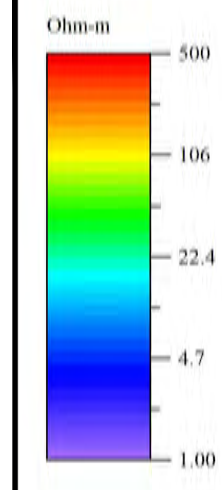
OAK RIDGE POOL DISTRESS
172 PROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	PGA
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS
A UES COMPANY
2561 Willow Point Way, Knoxville, TN 37931
Office: 865-539-8242 Fax: 865-539-8252

Figure 5.4





ERI ARRAY LOCATION

ERI ARRAY LOCATION

OAK RIDGE POOL DISTRESS
172 PROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	PGA
APPROVED BY:	MTB
SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS A UES COMPANY
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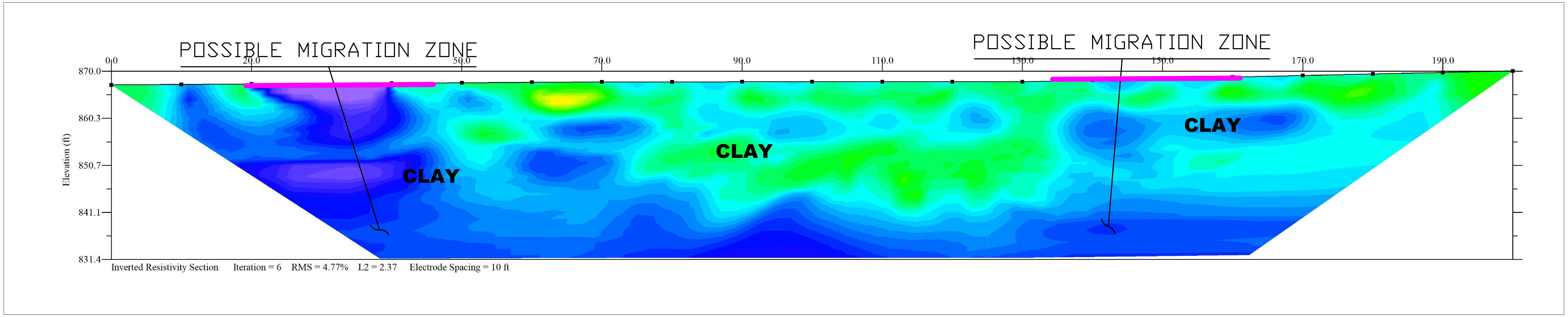
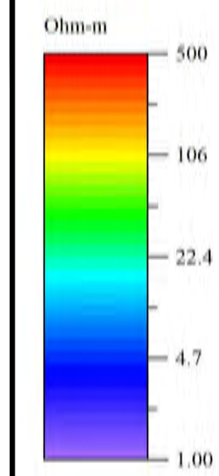
Figure 5.5





ERI ARRAY LOCATION

ERI ARRAY LOCATION

OAK RIDGE POOL DISTRESS
172 PROVIDENCE ROAD
OAK RIDGE, TENNESSEE

DRAWN BY:	PGA
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SCALE:	N.T.S.
JOB NO.:	21-211149
DATE:	10-20-2021

GEOS A UES COMPANY
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Figure 5.6