

July 24, 2009

Kenvirons, Inc. 452 Versailles Road Frankfort, KY 40601

Attention: Mr. Ken Taylor, P.E.

Subject: Report of Geotechnical Exploration KY38 AND MARY WYNN WATER TANKS Harlan County, Kentucky QORE Project No. 24305400

Dear Mr. Taylor:

QORE, Inc. has completed the geotechnical exploration for the proposed tank. The purpose of this exploration was to obtain subsurface data at the sites pursuant to developing sile preparation and foundation recommendations for the proposed construction. We conducted this project according to our proposal KY4934, dated June 15, 2009, which was authorized by Mr. R. Vaughn Williams – Vice President of Kenvirons. Our work scope included exploration at a total of three proposed tank sites and a package waste water treatment plant site. This report covers two of the water tanks. The other tank and package treatment plant sites are covered in separate reports. This report explains our understanding of the project, documents our findings, and presents our conclusions and geotechnical engineering recommendations.

QORE appreciates the opportunity to be of service. We look forward to helping you through project completion. If you have any questions, please call.

Respectfully submitted,

QORE. Inc. FIEHLER Andrew M. Fiehler. 23977 Project Engineer Licensed Kentucky 23,97 Attachments: **Report of Geotechnical Exploration** Appendices

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Michael D. Owens Principal Geotechnical Consultant

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# REPORT OF GEOTECHNICAL EXPLORATION KY38 AND MARY WYNN WATER TANKS HARLAN COUNTY, KENTUCKY QORE Project No. 24305400

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# REPORT OF GEOTECHNICAL EXPLORATION KY38 AND MARY WYNN WATER TANKS HARLAN COUNTY, KENTUCKY QORE Project No. 24305400

# INTRODUCTION

QORE, Inc. has completed the geotechnical exploration for the proposed tank. The purpose of this exploration was to obtain subsurface data at the sites pursuant to developing site preparation and foundation recommendations for the proposed construction. We conducted this project according to our proposal KY4934, dated June 15, 2009, which was authorized by Mr. R. Vaughn Williams – Vice President of Kenvirons. This report explains our understanding of the project, documents our findings, and presents our conclusions and geotechnical engineering recommendations,

# SITE DESCRIPTION

This report covers the proposed KY38 and Mary Wynn water tank sites. The KY38 water tank is located near the entrance to the abandoned Darby Mine No. 1 in eastern Harlan County, just north of Kentucky Highway 38. The proposed tank location was located adjacent to a fuel tank and the access drive for the mine in an overgrown area with chest high weeds. The proposed tank site was relatively level, sloping slightly downhill to the south. A small pond is shown on the site plan; however, the area was very overgrown and our field engineer did not observe the pond condition. Likewise, the dam of the pond was overgrown thus our engineer could not assess the condition of the dam.

The Mary Wynn tank is located in a small clearing in the woods along the crest of a ridgeline. The tank is accessed via a gravel road that extends up the hill from KY Highway 38 about 3 miles west of the KY38 Tank site. The hillsides adjacent to the tank site slope steeply downhill away from the tank. The provided topographic mapping indicates the hillsides are at an approximate slope angle of 1.5:1 H:V. Topographic site location maps showing the locations of the two tanks are included in Appendix A.

# **PROJECT INFORMATION**

The information provided to QORE included location plan maps of the proposed tank sites and general information about the proposed tanks. The ground storage tanks will be the same size, with each one holding 47,000 gallons and being approximately 28 feet tall with a diameter of 17 feet.

The tank structural design will be determined by the tank supplier/constructor thus structural loading information and settlement criteria were not available at the time of this report. Considering the height of the tank, we would expect bearing pressures to exceed 2,000 psf. Settlement tolerances for similar tanks are typically 1.5 inches of total settlement and 0.75 inches of differential settlement. Our work scope included only the tank foundations and does not include evaluating the soil conditions along the access road alignment.

# SITE GEOLOGY

We reviewed the USGS geologic quadrangle map at each of the tank sites. The KY38 tank is located within the *Keokee Quadrangle* (1971), which indicates the site is underlain by the Wise Formation. The Wise is a mixture of siltstone, shale, sandstone, and coal. The sandstones are generally light colored, medium grained, and moderately quartzose. There are four persistent sandstone members within the Wise with the Clover Fork sandstone being mapped immediately below the site. The Clover Fork varies in thickness from 45 to 65 feet. The shale and siltstone portions of the Wise are generally dark gray and can be indistinguishable. The Wise contains several coal beds and coal zones. Kentucky Cabinet for Mines and Minerals mapping indicates that the Darby Mine No. 1, located at the site, mined the Darby Coal seam which is in the formation below the Wise. The mine mapping does not indicate coal mining immediately beneath the proposed KY38 tank site.

The Mary Wynn tank site is located within the *Louellen Quadrangle (1973)* which indicates the site is underlain by the Mingo Formation. The Mingo Formation is a mixture of sandstone, shale, siltstone and coal. The sandstone is generally light to dark gray and massively bedded. The shale and siltstone are both medium to dark gray with fine sand and are interbedded. The Mingo Formation contains several coal beds/zones including the Kellioka coal bed. Mine mapping information available through the Kentucky Cabinet for Mines and Minerals indicates that there is an active mine whose permit area extends beneath the proposed Mary Wynn tank site. Presently, it does not appear that mining has occurred beneath the tank site based on our review of the available mapping. However, the mine mapping shows that mining is planned in the next two years. The Rex Coal Co, Inc. mine is currently mining the Kellioka coal bed. Based on the geologic mapping, the Kellioka coal bed is between 200 and 250 feet below the tank site elevation.

# EXPLORATION METHODS

# **Field Exploration**

We drilled three soil test borings to explore the subsurface conditions at each of the sites. Appendix A contains drawings showing the boring locations and proposed tank location. Mr. Andrew Fiehler, P.E. a QORE staff engineer, was on-site to observe pertinent site features and surface indications of site geology, to direct drilling operations, and to record and log the results of the soil sampling.

We obtained soil samples using a split-barrel sampler driven by an automatic hammer system according to ASTM D1586. Rock coring was used to sample auger refusal material in one boring at each of the sites. The stratification lines shown on the boring records represent the approximate boundaries between soil or rock types. The transitions may be more gradual than shown. Field sampling and testing procedures used by QORE are in general accordance with ASTM procedures and established geotechnical engineering practice. Appendix B contains brief descriptions of field procedures.

# **Laboratory Testing**

Mr. Fiehler returned the recovered soil and rock core samples to the laboratory for testing. QORE performed Atterberg Limits tests and natural moisture content tests on representative samples from each site. Our laboratory test data is summarized in Appendix C.

# SUBSURFACE CONDITIONS

Our work scope included exploration of three water tank sites. For ease of record keeping, borings at the KY38 Tank site were numbered in the 200's (i.e. -B-201) and the Mary Wynn Tank site were numbered in the 300's (i.e. -B-301).

KY38 Tank – Our borings encountered what appeared to be mine waste material. The mine waste material was a mixture of sandstone pieces with lean clay and sand. We were able to penetrate between 8 and 15 feet of the mine waste material with our augers before encountering auger refusal. In boring B-203 we encountered auger refusal at a depth of 8.5 feet at which point rock coring was begun. Auger refusal was believed to be encountered on a boulder as the recovered rock core samples were also a mixture of the sandstone pieces. The coring process was advanced to a depth of 24.5 feet in an effort to encounter bedrock before

being terminated at the direction of the engineer. Bedrock was not encountered in the core hole.

Free groundwater was not encountered in the open borings at the completion of soil augering. Groundwater levels fluctuate with time due to seasonal rainfall, locally heavy precipitation events, construction activities, and other site-specific factors. Therefore, future groundwater levels may be encountered within the depths explored by our borings. It is common to encounter groundwater in perched or trapped zones within fills such as that encountered at the site. Amounts and flow duration from encountered water vary and depends on site specific characteristics and recent rainfall activity.

Mary Wynn Tank – Our borings encountered residual soils extending from the ground surface. We advanced our borings in the small clearing which was void of topsoil. However, outside of the clearing, we observed a layer of leaf litter and topsoil approximately six to eight inches thick. Boring B-301 encountered auger refusal at a depth of 1.5 feet, at which point rock coring was begun. The recovered core samples consisted of interbedded weathered sandstone and silty sand. The recoveries and the Rock Quality Designations (RQD) for the rock coring process indicated poor quality rock.

In borings B-302 and B-303, we were able to penetrate the weathered rock layers with the augers to a depth 14.3 feet in B-302 and the pre-determined termination depth of 15.5 feet in B-303. The Standard Penetration Tests (SPT) in borings B-302 and B-303 indicated layers of weathered sandstone and silty sand similar to the recovered samples from B-301.

# **CONCLUSIONS AND RECOMMENDATIONS**

# **GENERAL DISCUSSION**

**KY38 Tank** - The project site is located on what appears to be a mine waste dump. The site is located at the entrance to an abandoned underground coal mine, which is the likely source of the encountered fill material. We believe it is possible to construct the proposed tank at the project site, provided initial site preparation is performed and some additional design details are included. The site preparation and design details are discussed further in the following sections of the report.

There is an inherent risk of structurally significant settlement involved with leaving any of the existing spoil material in-place beneath the proposed tank. Our recommendations outlined below are intended to help reduce the potential for settlement. To completely remove the risk of settlement of the spoil material would require complete removal of all of the spoil and backfilling the excavation in a controlled manner. Another option for eliminating the risk of settlement of the spoil material would be to found the tank on deep foundations bearing on the underlying bedrock. These options would be more expensive. By constructing the tank on the project site, even implementing our recommendations, the owner must be willing to accept the risk of potentially structurally significant settlement.

Mary Wynn Tank – This tank site is located along the back of a residual ridgeline with steep side slopes. While our borings did not encounter \*solid\* bedrock, we believe that the encountered subsurface conditions are suitable for supporting the proposed water tank.

For ease of discussion, the following sections of the report outline our recommendations for the KY38 Tank. The recommendations for the Mary Wynn Tank begin on Page 8.

# KY38 TANK

# EARTHWORK RECOMMENDATIONS

All topsoil and organic materials should be stripped from the tank area to prepare the area for construction. The stripping can be limited to the immediate construction area. The removed topsoil should be spread in "landscape" areas only, outside of the construction area. Organic material should not be utilized as fill material.

To prepare the tank foundation area, we recommend that the tank footprint, plus a buffer of 10 feet, be excavated to a depth equal to the tank diameter below the foundation elevation. In this case a depth of 17 feet. After the excavation subgrade has been observed by a QORE engineer, the excavation can then be backfilled with compacted, structural fill material to the foundation bearing elevation.

The fill material should be compacted to a target density of at least 95 percent of the standard Proctor maximum dry density. Mine spoll used as structural fill should be placed in 6-inch lifts, unless it is demonstrated that adequate compaction is achieved with maximum lifts up to 12 inches thick. The maximum particle size should be limited to 6 inches in any dimension within the upper 2 feet of the foundation subgrade. We recommend limiting the lift thickness to 6 inches in the top 2 feet of the tank subgrade.

The material excavated from the tank footprint should be suitable for use as backfill. A standard Proctor test was not included in the scope of this project. We recommend that a standard Proctor test be performed prior to placement of the fill to determine the compaction criteria. Some selective culling or crushing of large diameter boulders may be required in order to reuse the excavated material as fill.

It has been our experience that the spoil is most adequately compacted by blading the lift into place, compacting with a CAT 825 or similar compactor, and finish rolling with a loaded scraper or haul truck. The compactor breaks down the material and seats the cobbles while the heavy rubber tired equipment provides the compaction. Since the backfill area will likely prevent access by heavy earthwork equipment, additional passes of the compactor will likely be required to achieve the required compaction. Adequacy of the compaction is determined qualitatively with supplemental data provided by the nuclear density gauge. Our evaluation criteria consists of the following:

- Lift thickness
- Particle size and gradation of material
- Intensity and uniformity of compactive effort and number of passes
- Response of the lift to construction traffic
- Moisture content
- Dry density

The dry density is not the determining factor in assessing the adequacy of the compactive effort and approval of the fill lift. If the contractor uses the recommended equipment, conforms with the material specifications, applies a uniform effort over the entire fill lift, traverses over the fill lift under the normal course of placing subsequent material, and the moisture content is within an acceptable range, the fill performance should be acceptable regardless of the density values obtained in the field. Therefore, only highly trained and qualified personnel should monitor fill placement. The final site grades will also play an important role in the long term performance of the tank and site stability. Our experience with mine waste sites indicates that the materials can degrade and soften when exposed to water. Site grading should direct surface water and tank overflow water away from the tank via paved or concrete lined ditches. A ditch should also be constructed on the uphill side of the tank to direct surface water away from the tank area. Sealing the ground surface around the tank with a layer of clayey soll over the rocky backfill is an effective means of reducing the amount of water allowed into the subgrade.

# FOUNDATION RECOMMENDATIONS

We recommend that the tank be designed to bear on a mat foundation, even though we recommend re-grading the tank site. The foundation should be designed for a maximum allowable bearing pressure of 2,000 psf. Our experience with mine waste sites indicates that the materials can degrade and soften when exposed to water. We recommend that once the foundation excavation has been approved by a QORE engineer, the reinforcing steel be placed and the foundation concrete be poured the same day. If this is not possible, a mud mat or layer of lean concrete should be placed in the excavation to protect the approved subgrade. We recommend that the mud mat be at least 4 inches thick and be poured neat to the excavation walls. The mud mat will also allow the reinforcing steel to be placed and kept clean.

We recommend that a French drain be constructed around the perimeter of the tank foundation. The drain should tie into the site drainage to direct the collected water away from the tank and recompacted area. French drains are typically constructed by lining an excavation with filter fabric and backfilling with open graded crushed stone such as KYDOT #57 stone. The filter fabric should be of sufficient length to overlap at the top of the excavation to completely enclose the stone backfill.

A detailed settlement analysis (with consolidation testing) was beyond the scope of this report. When constructing on spoil fill sites such as this one, the Owner must be willing to accept the risk of settlement, even if some ground modification is performed. The risk of settlement is proportional to the depth and age of the fill, as well as the compactive effort applied to the fill during placement. Due to the heterogeneous composition of the spoil fill, it is difficult to accurately predict a magnitude of expected settlement.

# Seismic Information

The American Water Works Association (AWWA) site classification definitions (as described in AWWA D100-05) are analogous to the 2007 Kentucky Building Code (KBC) site seismic classifications as defined in Table 1615.1.1 of the code. Based on our evaluation of the subsurface conditions at the project site, we recommend a site classification of "E". This relatively low site classification is based partly on the fact that our borings encountered moderately low consistency spoils within the depths explored and did not encounter any residual soil or bedrock.

# MARY WYNN TANK

# EARTHWORK RECOMMENDATIONS

All topsoil and organic materials should be stripped from the tank area to prepare the area for construction. The stripping can be limited to the immediate construction area. Based on field observations at the time of drilling, expect stripping depths of about ½ foot to penetrate the topsoil and leaf litter. Removal of trees should include the rootball. The removed topsoil should be spread in "landscape" areas only, outside of the construction area. Organic material should not be utilized as fill material.

# Structural Fill Placement

The site plans indicate that about two to three feet of soll fill placement will be required at the tank site. Ideally, structural fill is defined as inorganic natural soll with a maximum particle size of 3 inches and maximum dry density of at least 95 pounds per cubic foot (pcf) when tested by the standard Proctor method (ASTM D698) and a plasticity index (PI) of less than 30 percent. Our laboratory testing indicates that the cut material can be used as structural fill. During construction, standard Proctor testing and Atterberg limits testing of proposed fill soils (on-site and/or off-site) should be performed to determine the maximum dry density and plasticity of the soil prior to use as structural soil fill. Soils with a PI greater than or equal to 30 percent may be used in deeper fills, provided they are kept at least 3 feet below the design subgrade elevation.

Fill placement should occur in relatively thin (6 to 8-inch) layers and be compacted to at least 95 percent of the standard Proctor maximum dry density. The moisture content of the fill should be maintained within 3 percent of the soil's optimum moisture content even though compaction may be achieved at moisture contents outside the specified range.

In-place density testing must be performed on structural fill as a check that the previously recommended compaction criteria have been achieved. This allows our project engineer to monitor the quality of the fill construction and verify that his design criterion is being achieved in the field. We further recommend that these tests be performed on a full-time basis by QORE. The testing frequency for density tests performed on a full-time basis can be determined by our personnel based on the area to be tested, the grading equipment used, and construction schedule. Tests should be performed at vertical intervals of 8-inches or less (the recommended lift thickness) as the fill is being placed.

# FOUNDATION RECOMMENDATIONS

Based on the provided design information, we recommend that the tank be founded on a mat foundation. We recommend that the tank foundations be founded on weathered rock and sized for a maximum allowable bearing capacity of 2,500 pounds per square foot (psf). We recommend a minimum foundation bearing elevation of 1821 feet MSL.

Since the foundation bearing surface will likely be weathered sandstone with clay seams, the material will degrade quickly when exposed to water. We recommend that once the foundation excavation has been approved by a QORE engineer, the reinforcing steel be placed and the concrete foundation be poured the same day. If this is not possible, a mud mat or layer of lean concrete can be placed in the excavation to seal the subgrade. We recommend that the mud mat be at least 4 inches thick and be poured neat to the excavation walls. The mud mat will also allow the reinforcing steel to be placed and kept clean.

We also recommend that the site be graded to direct surface water away from the foundations. Backfilling around the foundation with compacted soil fill will help reduce the amount of water which can infiltrate the subgrade.

A detailed settlement analysis with consolidation testing was beyond the scope of this report. With the mat foundation bearing on weathered rock, we anticipate that the settlement will be less than the maximum tolerable settlement of 1.5 inches using the maximum allowable bearing pressure. For this type of foundation system, the differential settlement across the tank is usually about one-half the total settlement.

# Seismic Information

The American Water Works Association (AWWA) site classification definitions (as described in AWWA D100-05) are analogous to the 2007 Kentucky Building Code (KBC) site seismic classifications as defined in Table 1615.1.1 of the code. Based on our evaluation of the subsurface conditions at the project site, we recommend a site classification of "C".

# **FOLLOW-UP SERVICES**

Our services should not end with the submission of this geotechnical report. QORE should be kept involved throughout the design and construction process to maintain continuity and to verify that our recommendations are properly interpreted and implemented. To achieve this, we should be retained to review project plans and specifications with the designers to see that our recommendations are fully incorporated. We also should be retained to monitor and test the site preparation and foundation construction. If we are not allowed the opportunity to continue our involvement on this project, we cannot be held responsible for the recommendations in this report.

Foundation construction will be a critical aspect of this project. Our familiarity with the site and with the foundation recommendations will make us a valuable part of your construction quality assurance team. In addition, a qualified engineering technician should observe and test all structural concrete and steel. Only experienced, qualified persons trained in geotechnical engineering and familiar with foundation construction should be allowed to monitor and test foundations. Normally, full-time monitoring of the site work and foundation installation is appropriate.

# LIMITATIONS

This report has been prepared for the exclusive use of Kenvirons, Inc. for specific application to this project. Our conclusions and recommendations have been prepared using generally accepted standards of geotechnical engineering practice in the Commonwealth of Kentucky. No other warranty is expressed or implied. This company is not responsible for the conclusions, opinions, or recommendations of others based on these data.

Our conclusions and recommendations are based on the limited design information furnished to us, the data obtained from this geotechnical exploration, and our past experience. They do not reflect variations in the subsurface conditions that are likely to exist between our borings and in unexplored areas of the site resulting from the variability of the soils and bedrock at these sites as well as past fill placement at the KY38 tank site. If such variations become apparent during construction, it will be necessary for us to re-evaluate our conclusions and recommendations based upon on-site observation of the conditions.

If the overall design or location of the water tank is changed, the recommendations contained in this report must not be considered valid unless our firm reviews the changes and our recommendations modified and verified in writing. When the design is finalized, we should be given the opportunity to provide the additional service of reviewing the foundation plan, grading plan, and applicable portions of the project specifications. This review will allow us to check whether these documents are consistent with the intent of our recommendations.

We recommend that the owners retain these services and that QORE be allowed to continue our involvement in the project through these phases of construction. Our firm is not responsible for interpretation of the data contained in this report by others, nor do we accept any responsibility for job site safety, which is the sole responsibility of the contractor.

# Important Information about Your Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes:

# While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

# Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geolechnical engineers structure their services to meet the specific needs of their clients. A geolechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geolechnical engineering study is unique, each geolechnical engineering study is unique, each geolechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geolechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — nol even you* — should apply the report for any purpose or project except the one originally contemplated.

# **Read the Full Report**

Serious problems have occurred because these relying on a geolechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

# A Geotechnical Engineering Report is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking fols, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- · completed before important project changes were made.

Typical changes that can crode the reliability of an existing geotechnical engineering report include those that affect:

 The function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,

- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design learn, or
- project ownership.

As a general rule, always inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or flability for problems that occur because their reports do not consider developments of which they were not informed.

# Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the sile; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional lesting or analysis could prevent major problems.

# Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tosts are conducted or samples are taken. Geolechnical englneers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

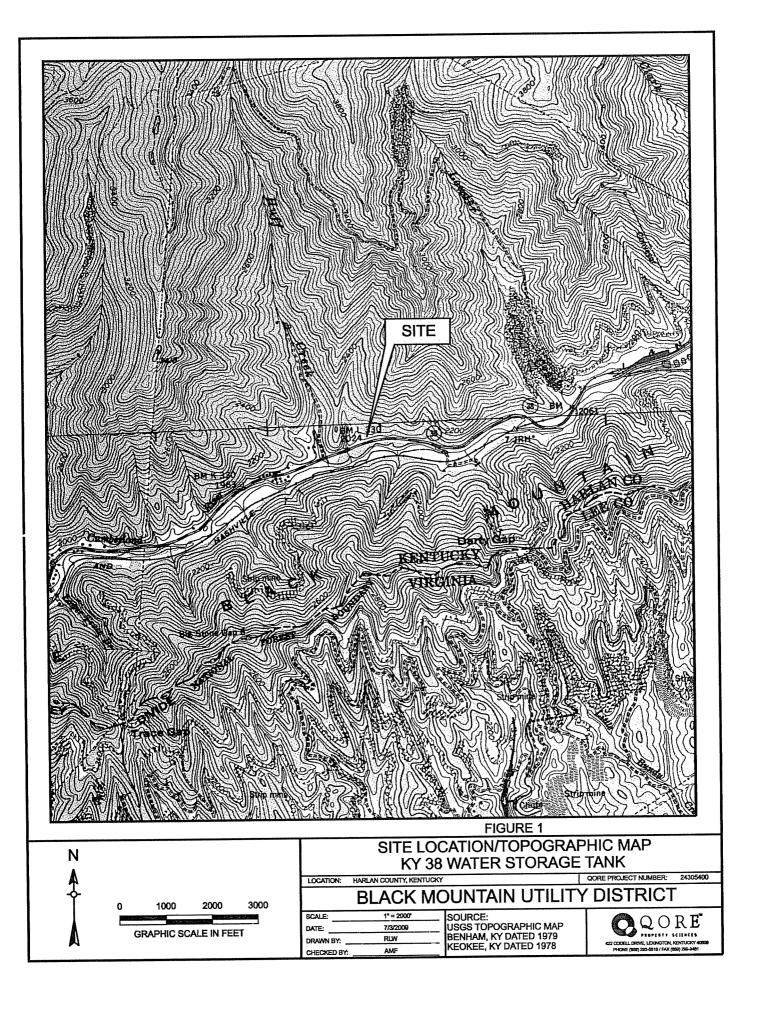
# A Report's Recommendations Are *Not* Final

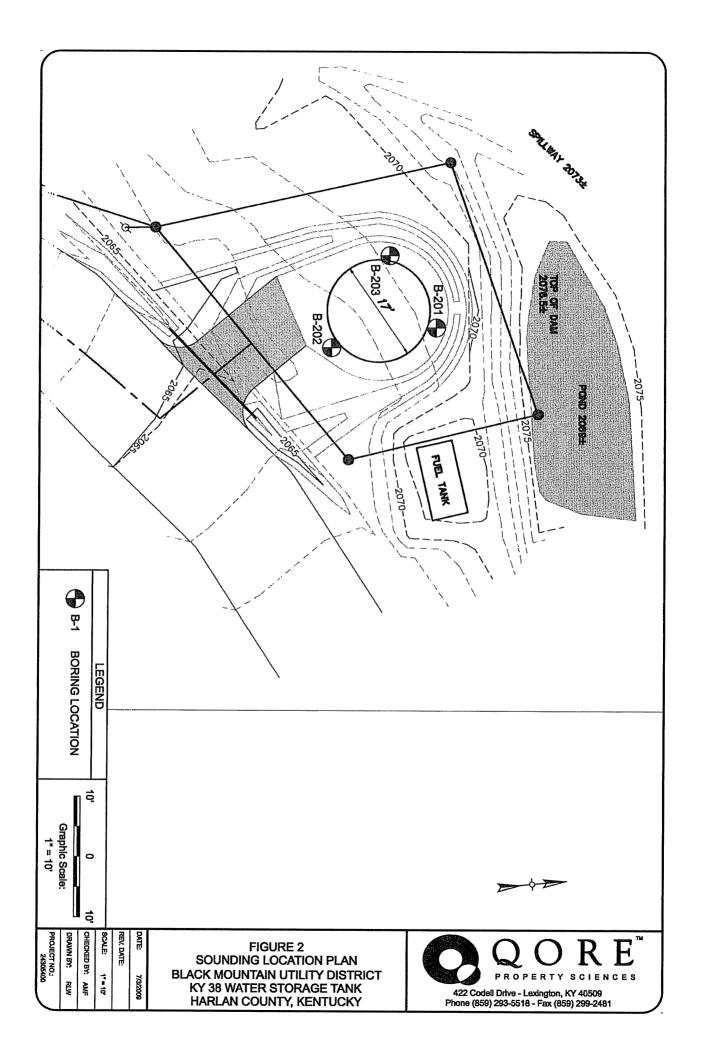
Do not overrely on the construction recommendations included in your report. Those recommendations are not final, because geolechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

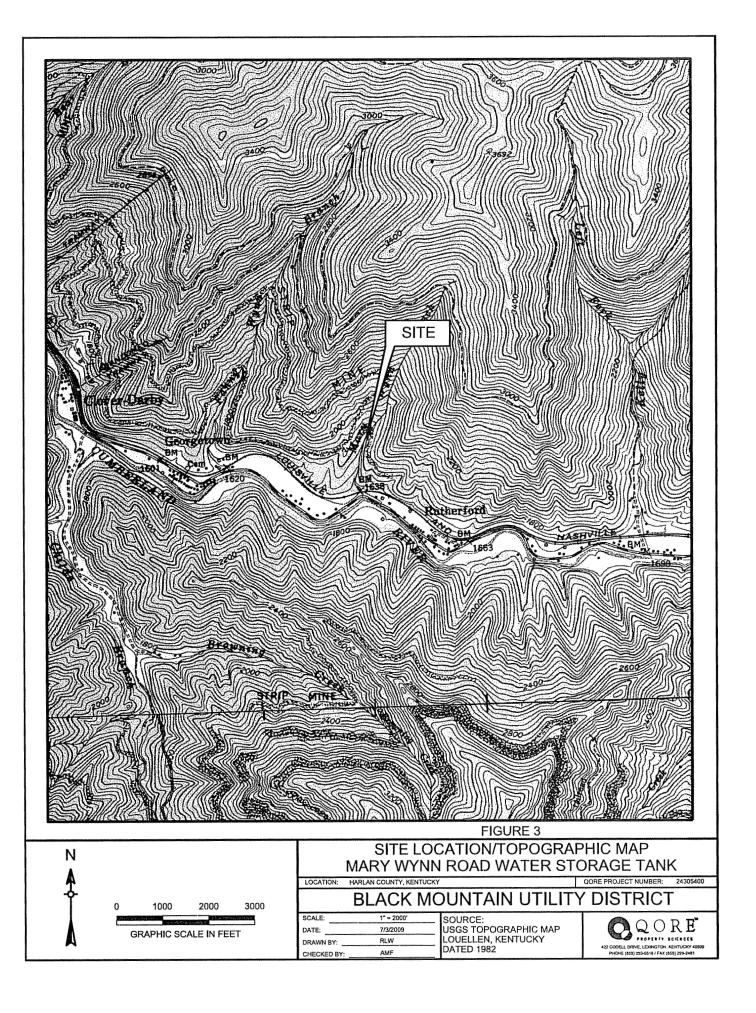
# **APPENDIX A**

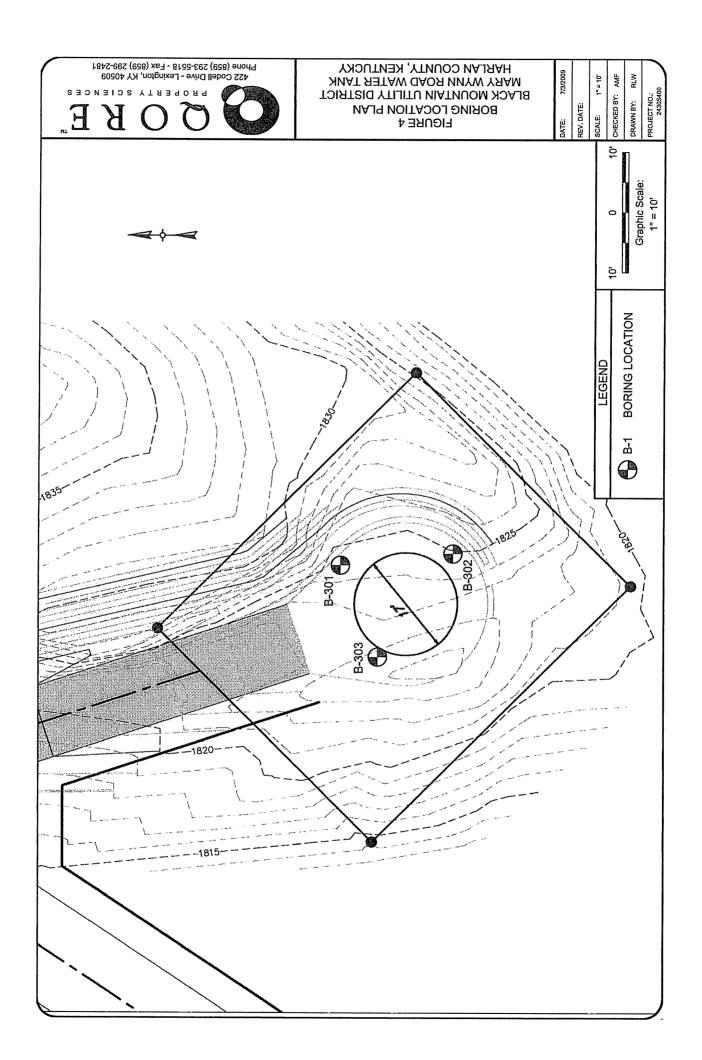
SITE LOCATION/TOPOGRAPHIC MAP

**BORING LOCATION PLAN** 









# **APPENDIX B**

**TEST BORING LEGEND** 

**TEST BORING RECORDS** 

FIELD TESTING PROCEDURES

# **TEST BORING RECORD LEGEND**

COUNSE ENAMED DOLLS     Price Endominant California       ISANDE SERVICE.3     Dit. KS       N     Relative Dansity       D.4.     Very Locee       D.4.     Very Locee       D.4.     Very Soit       D.5.     Sitt Soit       D.5.     Si	COAPSE OD	AINED SOILS	E AND COAR	E GRAINED SO		1	E QIZE
N     Relation Density     N     Consistence     Boulders     Greater funs 300 mm (1/2 ln)       0-4     Very Losse     0-1     Very Soft     0-6.5     Cobble     75 mm (1/2 ln)       5-40     Losse     2.4     Soft     0.5.1     Cobble     75 mm (1/2 ln)       11:30     Firm     5.8     Firm     1.2     Coarset Sand     2 mm (1/2 ln)     0.425 mm (1/2 ln)       11:30     Very Firm     5.15     Siff     2.4     Madian Sand     0.425 mm (1/2 ln)       11:40     Very Firm     5.15     Siff     2.4     Madian Sand     0.425 mm (1/2 ln)       11:40     Very Firm     5.15     Siff     2.4     Madian Sand     0.425 mm (1/2 ln)       11:40     Very Firm     5.15     Siff     3.4     Exact Stand     0.027 mm (1/2 ln)       11:40     Loss Stand     Coarse Sand     2.4     Soft     0.5     Soft       11:40     Loss Stand     Coarse Sand     2.4     Soft     No.5     Soft       11:40     Loss Stand     Coarse Sand     Soft     No.5     Soft     No.5       11:40     Loss Stand     Coarse Sand     Hard     Hard     Hard     Hard     Hard     Hard     Hard     Hard     Hard     Har						PARIGL	E SIZE
5-10     Logen     2-4     Soft     D.5-1     Courses     A.7-rem to 7-rm (Q16 to 3 int)       11.20     Yem     5-15     Simil     2-4     Courses     Courses     Courses     A.7-rem to 4.7-rem to 2-rem       31-60     Dense     5-15     Simil 5-24     Modism Saudo 0425 mm to 2-rem     Ene Saudo 0425 mm to 2-rem     Ene Saudo 0425 mm to 2-rem       31-60     Dense     Simil 5-10     Simil 5-10     Dense     Simil 5-10     Dense     Dense     Simil 5-10     Dense     Dense     Simil 5-10     Dense     Dense     Simil 5-10     Dense     Dense     Dense     Dense     Simil 5-10     Dense     Dense <th>Ń</th> <th>Relative Density</th> <th>Ň</th> <th>Consistency</th> <th></th> <th>Boulders</th> <th>Greater than 300 mm (12 in)</th>	Ń	Relative Density	Ň	Consistency		Boulders	Greater than 300 mm (12 in)
±.10     Logsa     2-4     Seft     D.5-4     Carres     4.74 mm to 75 mm t	n A	Very Lonse	0-1	Very Soft	0-0.5	Cobbles	75 mm to 300 mm (3 to 12 in)
11-00     Vary Pirm     0-15     Strift     2-4     Machine Same     Determine       31-80     Vary Stift     4-9     Pinz Same     Determine     Pinz Same     Determine     Pinz Same     Determine     Pinz Same     Determine     Same     Determine     Same     Determine     Same     Determine     Same     Determine     Same     Determine     Same     Same     Determine     Same					D.5-1	Gravel	
1-93     Denian     16-30     Vany Still     4-8     Fine Sand     0.0425 mm       2-500     View 31     Hend     6-31     Site 6049     Less then 0.025 mm       2-500     Dis A and the company stalling and combined present phonomatics. The barnese of a standard 4-4-4-4 min. D.22-loc: O.D. patiburities stamper is driven three-6-finite-comment with the standard 4-4-4-4 min. D.22-loc: O.D. patiburities is standard 4-4-4-4 min. Patiburities is the standard 4-4-4 m	11-20	Firm	58		3.4 C		
Ourse         Over 31         Hard         Bit at Cays         Lowy         Lowy <thlowy< th=""> <thlowy< th="">         Lowy</thlowy<></thlowy<>	A N N		17.5.2 年末。				
a TXANDARD PENETTATION TEST as advanded values of a method to bolin a distribute of assinution and resting and the intervention is advanted to advante advanted to advanted to advanted to advante advanted to advanted t	Chuer 50	Very Dense	Dver 31	Hard	8+	Silts & Clays	Less than 0.075 mm
ROCK PROPERTIES         ROCK QUALITY DESIGNATION (ROD)         Percent ROD       Quality       Provemine Providence       Rock can be broken by heavy harminer blows.         6-25       Vary Poor       Moderate harmoner blows.       Frock can be broken by heavy harminer blows.         50-75       Fair       State       State broken of blows.       State broken with light harmer blows.         50-75       Fair       State       Frock is otheren to broken with fight harmer blows.         76:80       Good       Vary Soft:       Frock disindigates or cashy compresses when touched; can be hard to very hard soit.         90-100       Excellent       X100       State C       BQ       177/6         ROD +       Length of Gare Run       X100       State C       BQ       177/6         ROD +       Sum of 4 h and longer Rock Perces Recovered       X100       State C       BQ       177/6         ROD +       Sum of 4 h and longer Rock Perces Recovered       X100       State C       BQ       177/6         ROD +       Sum of 4 h and longer Rock Perces Recovered       X100       State C       BQ       177/6         ROD +       State of Core Run       State of	tain relative density	and consistency informatic	on. A standard	1.4-inch I.D./2-i trip. free-fall de	nch O.D. split-t esion, or actual	ed by a rope and ca	whead. The blow counts required
Nucley Constraint     Constraint     Constraint     Constraint       Percent ROD     Quality     Very Hard:     Rock can be broken by beavy hammer blows.       0-25     Very Poor     Rock can be broken by beavy hammer blows.       25-50     Pöör     Hard:     Rock can be broken by beavy hammer blows.       50-75     Fair     Moderate hammor blows.     Smal pinces can be broken of along abare edges by considerable hamper edges and crumbes with mith by hammer blows.       50-75     Fair     Soft     Rock is coherent but breaks with mith and pressure at sharp edges and crumbes with mith pressure at sharp edges and crumbes with mith pressure at sharp edges and crumbes with mith and pressure.       90-100     Excellent     Very Soft:     Rock is coherent but breaks with mith pressure at sharp edges and crumbes with mith and pressure.       90-100     Excellent     X100     Cord Diameter     Indias       90-100     Excellent     X100     Signap deges and crumbes with mith and pressure.       90-100     Excellent     X100     Signap deges and crumbes with mith and pressure.       90-100     Excellent     X100     Signap deges and crumbes with mith and pressure.       90-100     Excellent     X100     Signap deges and crumbes with mith and pressure.       90-100     Excellent     X100     Signap deges and crumbes with mith and pressure.       90-100     Excellent	······································						aine in an inclusion and a state of the stat
Processing     Dotation       0-25     Very Poor       25-50     Poor       25-50     Poor       50-75     Fair       75-90     Good       90-100     Excellent       90-100     E	ROCKQL	JALITY DESIGNATION (RO	2D)		ومحاجد المحاجم والمحاجم والمراجع		通過有許
0.25     Very Poor     moderate hammer blaws.       25-50     Peor     Moderately     Snat pices acts he broken off along sharp edges by considerably hand flumb pressure; can be broken with ligh hammer blaws.       50-75     Fair     Soft:     Rock is coherent but breaks were assly with hammer blaws.       79:80     Goigd     Very Soft:     Rock is coherent but breaks were assly with thom pressure at sharp edges and crumbas with tim hand pressure.       90-100     Excellent     Very Soft:     Rock disinfograbe or assly compresses when touched; can be had to very hard soil.       90-100     Excellent     Sign of 4 to, and boost accel Pieces Resourced X100     Sign of 4 to, and boost accel Pieces Resourced X100       scovery =     Length of Core Run     X100     Sign of 4 to, and boost accel Pieces Resourced X100       SYMBOLS       Solit Press Resourced X100       Symposition of Core Run       Symposition of Core Run       Applicit finderation, BPF       Applicit finderatis       Core Diameter finderat							
25-50     Poor     Hard:     hard flumb pressure; can be broken with light hammer blows.       50-75     Fair     Soft:     Rock is coherent but breaks very easily with thumb pressure.       75-90     Good     Very Soft:     Rock is coherent but breaks very easily with thumb pressure.       90-100     Excellent     Very Soft:     Rock disintegrates or casily compresses when fouched; can be hard to very hard seit.       90-100     Excellent     X100     Si REC     BO       90-100     Excellent     X100     Si REC     BO       100     Excellent     X100     Si REC     NO       100     Length of Core Run     X100     Si REC     NO       100     Length of Core Run     X100     Si REC     NO       100     Length of Core Run     X100     Si REC     NO       100     Length of Core Run     X100     Si REC     NO       101     Length of Core Run     X100     Si REC     NO       102     Stringth of Core Run     X100     Si REC     NO       101     Longth of Core Run     Si REC     NO     Si REC       102     Si REC     Soft.     Soft.     NO     Si REC       103     Longth of Core Run     Si Reco     No     Si Reco <t< td=""><td>0-25</td><td>Very Poor</td><td></td><td>Hard:</td><td>Mock cannol moderate ha</td><td>ne proken by inum mmer blows:</td><td>a hiszais' ant can as nioven ph</td></t<>	0-25	Very Poor		Hard:	Mock cannol moderate ha	ne proken by inum mmer blows:	a hiszais' ant can as nioven ph
50-75     Fair     sharp edges and crumbles with firm hand pressure.       75-90     Good       90-100     Excellent       Vary Soft:       Sharp edges and crumbles with firm hand pressure.       Sold Good       90-100       Excellent       Length of Rock Core Recovered Length of Core Run       X100       Sold Core Run       Nam of 4 In and longer Rock Places Recovered Length of Core Run       SymBoLs       Soll, PROPERTY SYMBOLS       KEY TO MATERIAL TYPES       Nam of 4 In and longer Rock Places Recovered Longth of Core Run       SymBoLS       Soll, PROPERTY SYMBOLS       KEY TO MATERIAL TYPES       Nam of 4 In and longer Rock Places Recovered Longth of Core Run       SymBoLS       Soll, PROPERTY SYMBOLS       KEY TO MATERIAL TYPES       Appeal       Mategraywacke       Provide       Sitt Crushed       Core Standed       Gravel       Linestoley       Sitt Crushed       Sitt Crushed       Core Diameter <td>25-50</td> <td>Poor</td> <td></td> <td></td> <td>hard lhumb p</td> <td>pressure; can be br</td> <td>oken with light hammer blows.</td>	25-50	Poor			hard lhumb p	pressure; can be br	oken with light hammer blows.
XP-90     Good       90-100     Excellent       90-100     Excellent       Length of Flock Core Recovered Length of Core Run     X100       SS REC NQ     NQ     1-7/16       NQ     1-17/16       NQ     1-17/16       NQ     1-17/16       NQ <td>50-75</td> <td>Fair</td> <td></td> <td>Soft:</td> <td>sharp edges</td> <td>and crumbles with</td> <td>firm hand pressure.</td>	50-75	Fair		Soft:	sharp edges	and crumbles with	firm hand pressure.
Lendth of Rock Core Recovered Length of Core Run       X100       Core Diameter BQ       Inclias BQ       Inclias BQ         ROD =       Sum of 4 In, and Jonger Rock Pieces Recovered Length of Core Run       X100       X100       HQ       2-1/2         ROD =       Sum of 4 In, and Jonger Rock Pieces Recovered Length of Core Run       X100       SYMBOLS       SOIL PROPERTY SYMBOLS         ROD =       SYMBOLS       KEY TO MATERIAL TYPES       N:       Standard Penetration, BPF         Asphalt       Digganic Sill Organic Sill       Limestone       Matagraywacke       N:       Standard Penetration, BPF         Clushed Limostono       Weil-Graded Gravel       Sandstone       Phylite       N:       Standard Penetration, BPF         Shot-rock       Weil-Graded Gravel       Sillistone Claystono       Claystono       Motagraywacke       N:       Standard Penetration, M:         Low Plasticity Inogranic Sill       Viell-Graded Sand       Sillistone Claystono       Sillistone Claystono       N: Sample Recovery       N: Sample Sample       N: Sample Recovery         Yigh Plasticity Inogranic Sill       Shy Sand       Gneiss       Sinist       N: Sample Time Reading       N: Sample Time Reading         Low Plasticity Inogranic Sill       Shy Sand       Schist       Schist       Auger or	75-90	Good		Very Soft:			ipresses when touched; can be
Length of Core Run     X100     B3 REC     BQ     1-7/16       RQD +     Sum of 4 In, and Ionsar Rock Pieces Recovered Length of Core Run     X100     HQ     2-1/2       RQD +     Sum of 4 In, and Ionsar Rock Pieces Recovered Length of Core Run     X100     SYMBOLS       SYMBOLS       KEY TO MATERIAL TYPES       KEY TO MATERIAL TYPES     N:     Standard Penetration, BPF       Motagraywacke     N:     Standard Penetration, Standard Penetration, BPF       Motagraywacke     N:     Standard Penetration, Penetration, Standard Penetration, Standard Penetration, Standard Penetration, Standard Penetration, Penetration, Standard Penetration, Standard Penetration, Standard Penetration, Standard Penetratin, Standard Penetration, Standard Penetration, Standard P	90-100	Excellent					
KEY TO MATERIAL TYPES         Solit PROPERTY SYMBOLS         Topsoil       High Plasticity inorganic Sill or Clay       Image and Sills/Clays       Peal       Material         Asphall       Organic Sills/Clays       Limestone       Mategraywacke       N:       Standard Penetration, BPF         Crushed Limostone       Well-Graded Gravel       Sendstone       Phylite       Mategraywacke       N:       Standard Penetration, BPF         Fill Material       Organic Sills/Clays       Well-Graded Gravel       Sendstone       Phylite       Mategraywacke       P:       Plasticity index, %         Fill Material       Opony-Graded Gravel       Sillstone       P:       Finds Compressive Strength Estimated Qu, TSF         Shot-rock Fill       Silty Gravel       Claystono       Sillstone       F:       Finds Content         Low Plasticity Inorganic Silt       Clayey Gravel       Weathered Rock       Dolomite       Imit Sills Sills Sills Single       Imit Sills Spoon Sample       No Sample Recovery'         High Plasticity Inorganic Clay       Silty Sand       Graeiss       Schist       Mater or       Imit Reading         Low Plasticity Inorganic Silt or       Clayey Sand       Schist       Schist       Auger or       Water Level Time Reading		if 4 In, and longer Rock Pie	ces Recovored	.43			
Topsoil       High PlastIcity inorganic Sill or Citay       Peal       Amphibolile       M:       Motagraywacke         Asphall       Organio Sillis/Ciays       Limestone       Motagraywacke       Pi:       Plasticity index, %.         Crushed Limostono       Well-Graded       Sandstone       Phylite       Motagraywacke       Op:       Pocket Penetrometer Value, TSF         Qir       Well-Graded       Sandstone       Phylite       Organio Compressive Strength Estimated Qui, TSF         Fill       Material       Poorly-Graded       Siltstone       Provide       Provide         Shot-rock       Silty Gravel       Siltstone       Provide       Provide       Provide         Low Plasticity Inorganic Silt       Clayed Gravel       Weathered Rock       Weathered Rock       Undisturbed       Op       No Sample Recovery         Low Plasticity Inorganic Silt       Poorly-Graded       Granite       Op       No Sample Recovery       Valor Level After Drilling         High Plasticity Inorganic Clay       Silty Sand       Granite       Op       No Sample Recovery       Valor Level Sample       Poork Core Sample       Extended         Low Plasticity Inorganic Silt or       Silty Sand       Gneiss       Splits       Auger or       Piine Reading				43 X100	RQD		
Asphall       Clay       Clay       Metagraywacke       Pit.       Plasticity index, %         Crushed       Silts/Clays       Well-Graded       Sandstone       Phylite       Pit.       Plasticity index, %         Crushed       Well-Graded       Sandstone       Phylite       Pooteket Penetrometer Value, TSF         Vell-Graded       Sandstone       Phylite       Uncontinued Compressive Strength         Fill       Poorly-Graded       Siltstone       Provide       Provide         Shot-rock       Fill       Silty Gravel       Claystono       Provide       Provide         Low Plasticity       Clayoy Gravel       Weathered       No Sample       No Sample         High Plasticity       Poorly-Graded       Grantle       Silts Spoon       Water Level         Low Plasticity       Poorly-Graded       Grantle       Grantle       Split-Spoon       Water Level         Low Plasticity       Poorly-Graded       Grantle       Grantle       Split-Spoon       Water Level         Horganic Clay       Silty Sand       Graeiss       Schist       No Sample       Extended         Low Plasticity       Silty Sand       Schist       Graeis       Time Resdiring		Length of Core Ru		43 X100	RQD	HQ 	2-1/2 DIL PROPERTY SYMBOLS
Asphall       Clay       Clay       Metagraywacke       Pit       Plasticity index, %         Crushed       Silts/Clays       Limestone       Phylite       Pit       Plasticity index, %         Crushed       Well-Graded       Sandstone       Phylite       Pocket Penetrometer Value, TSF         Well-Graded       Sandstone       Phylite       Uncontinued Compressive Strength         Fill       Poorty-Graded       Siltstone       Provide       Provide         Shot-rock       Silty Gravel       Claystono       Provide       Provide         Low Plasticity       Poorty-Graded       Siltstone       Provide       Provide         Low Plasticity       Clayay Gravel       Weathered       No Sample       No Sample         Notagray       Sand       Dolomite       Provide       Siltstone       Provide         Low Plasticity       Poorty-Graded       Granite       Provide       Provide       Provide         Low Plasticity       Poorty-Graded       Granite       Provide	RQD ≠ <u>Sum c</u>	Length of Core Run Key to Mat		43 X109 SYMBOL	RQD S	HQ N: Star	2-1/2 DIL PROPERTY SYMBOLS indard Penetralion, BPF
Asphall       Organic       Limestone       Motagraywacke       PI:       Plasticity index, %         Crushed       Silts/Clays       Limestone       Phylite       Pi:       Plasticity index, %         Crushed       Limestone       Phylite       Pi:       Plasticity index, %       Op:       Pocket Penetrometer Value, TSF         Qu:       Uncontined Compressive Strength       Estimated Qu, TSF       Op:       Op:       Pocket Penetrometer Value, TSF         Qu:       Poorty-Graded       Siltstone       Phylite       Ory Unit Weight, PCF         Shot-rock       Silty Gravel       Claystono       Fill       Claystono         Low Plasticity       Clayoy Gravel       Weathered       No Sample         High Plasticity       Weil-Graded       Dolomito       No Sample         Low Plasticity       Poorty-Graded       Granite       Indisturbod       No Sample         High Plasticity       Poorty-Graded       Granite       Silty Sand       Greiss       Vater Level         High Plasticity       Silty Sand       Greiss       Schist       Auger or       Extended	RQD ≠ <u>Sum c</u>	Length of Core Run KEY TO MAT	n FERIAL TYPES	43 X109 SYMBOL	RQD S	HQ N: Star M: Mol	2-1/2 DIL PROPERTY SYMBOLS Indard Penetralion, BPF Sture Content, %
Crushed Limostono       Well-Graded Gravel       Sandstone       Phylite       Qu:       Unconlined Compressive Strength Estimated Qu, TSF         Fill Material       Poorly-Graded Gravel       Sillstone       Y       Dry Unit Weight, PCF         Shot-rock Fill       Silly Gravel       Olaystono       Fill Material       Orgony-Graded Gravel       Sillstone         Low Plasticity Inorganic Silt       Clayoy Gravel       Weathered Rock       Weathered Rock       Undisturbed Sample       No Sample Recovery         Low Plasticity Inorganic Clay       Poorly-Graded Sand       Dolomito       Indisturbed Granite       No Sample Recovery         High Plasticity Inorganic Clay       Poorly-Graded Sand       Granite       Indisturbed Granite       Split-Spoon Sample       Water Level After Drilling         High Plasticity Inorganic Clay       Silty Sand       Gneiss       Gneiss       Extended         Low Plasticity Inorganic Silt or       Clayey Sand       Schist       Auger or	RQD ≠ <u>Sum c</u>	Length of Core Run KEY TO MAT High Plasticity Inorganic Sill or City	n FERIAL TYPES	43 X109 SYMBOL	RQD S	HQ N: Star M: Mói LL: Liqu	2-1/2 DIL PROPERTY SYMBOLS Indard Penetralion, BPF sture Content, % Jud Limit, %
Limostono       Gravel       Sandstone       Phylite       Gravel         Fill Material       Poorly-Graded       Siltstone       Dry Unit Weight, PCF         Shot-rock       Silty Gravel       Claystono       F:       Fines Content         Low Plasticity       Clayey Gravel       Weathered       Weathered       No Sample         High Plasticity       Well-Graded       Sand       Dolomite       Inorganic Silt         Low Plasticity       Poorly-Graded       Granite       Inorganic Silt       Split-Spoon         Low Plasticity       Poorly-Graded       Granite       Inorganic Silt       Split-Spoon         Low Plasticity       Poorly-Graded       Granite       Split-Spoon       Water Level         High Plasticity       Sity Sand       Granite       Inorganic Clay       Start Dolomite         Low Plasticity       Sity Sand       Granite       Inorganic Clay       Extended         High Plasticity       Sity Sand       Graeiss       Graeiss       Extended         Low Plasticity       Clayey Sand       Schist       Auger or       Extended	RQD = <u>Sum c</u>	Length of Core Run KEY TO MAT High Plasticity Inorganic Silt or Clay Organic	n FERIAL TYPES	43 X100 SYMBOL	RQD S Amphibolile	HQ N: Star M: Mol LL: Liqu ke Pit Plas	2-1/2 DIL PROPERTY SYMBOLS Indard Penetralion, BPF sture Content, % Jid Limit, % sticity Index, %
Fill Material C Poorly-Graded Gravel Siltstone Claystone Claystone Claystone Claystone F: Fince Content Low Plasticity Inorganic Silt Claysed Weathered Rock Dolomite Claystone	RQD = <u>Sum c</u>	KEY TO MAT KEY TO MAT High Plasticity Inorganic Silt or City Organic Silts/Clays	n FERIAL TYPES	43 X100 SYMBOL	RQD S Amphibolile	HQ N: Star M: Mol LL: Liqu Pl: Plat Qp: Poo	2-1/2 DIL PROPERTY SYMBOLS Indard Penetration, BPF sture Content, % Ind Limit, % sticity Index, % ket Penetrometer Value, TSF
Shot-rock       Fill       Silly Gravel       Claystono       Fill       SAMPLING SYMBOLS         Low Plasticity       Clayey Gravel       Weathered       Weathered       Undisturbed       Sample         High Plasticity       Well-Graded       Dolomito       Dolomito       Split-Spoon       Water Level         Low Plasticity       Poorly-Graded       Granite       Split-Spoon       Water Level         High Plasticity       Silty Sand       Gneiss       Gneiss       Schist       Mater or	RQD = <u>Sum c</u>	Length of Core Run KEY TO MAT High Plasticity Inorganic Sill or Clay Organic Sills/Clays Well-Graded Gravel	TERIAL TYPES	43 X100 SYMBOL:	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pi: Plat Qp: Poo Qu: Uno	2-1/2 DIL PROPERTY SYMBOLS Indard Penetration, BPF sture Content, % Ind Limit, % sticity Index, % thet Penetrometer Value, TSF confined Compressive Strength
Low Plasticity Inorganic Silt High Plasticity Inorganic Silt Clayey Gravel Well-Graded Send Dolomite Low Plasticity Inorganic Clay High Plasticity Inorganic Clay High Plasticity Inorganic Clay Low Plasticity Inorganic Clay Clayey Sand Clayey Sand Schist Clayey Sand Clayey Sand	ROD = <u>Sum c</u> Topsoil Asphall Crushed Limostone	KEY TO MAT KEY TO MAT High Plasticity Inorganic Sill or Clay Organic Sills/Clays Well-Graded Gravel Poorly-Graded	TERIAL TYPES	43 X100 SYMBOL: one	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pit: Plat Qp: Poo Qut: Unic Esti y Dry	2-1/2 DIL PROPERTY SYMBOLS inderd Penetrallon, BPF sture Content, % ind Limit, % sticity index, % thet Penetrometer Value, TSF contined Compressive Strength imated Qu, TSF
High Plasticity       Well-Graded       Dolomito         Low Plasticity       Poorly-Graded       Granite         High Plasticity       Poorly-Graded       Granite         High Plasticity       Poorly-Graded       Granite         High Plasticity       Silty Sand       Granite         Low Plasticity       Silty Sand       Granite         High Plasticity       Silty Sand       Granite         Low Plasticity       Silty Sand       Granite         Low Plasticity       Silty Sand       Schist         Low Plasticity       Clayey Sand       Schist	ROD = Sum c	KEY TO MAT KEY TO MAT High Plasticity Clay Organic Silt or Clay Silts/Clays Well-Graded Gravel	TERIAL TYPES	43 X100 SYMBOL: me one	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pl: Plai Qp: Poo Qu: Unc Esti γ Dry p <sup>2</sup> F: Finc	2-1/2 DIL PROPERTY SYMBOLS Indard Penetration, BPF sture Content, % Ind Limit, % sticity Index, % ket Penetrometer Value, TSF contined Compressive Strength mated Qu, TSF Unit Weight, PCF es Content
Inorganic Silt       Sand         Low Plasticity       Poorly-Graded         Inorganic Clay       Poorly-Graded         High Plasticity       Silty Sand         Gneiss       Gneiss         Low Plasticity       Silty Sand         Gneiss       Schist         Low Plasticity       Clayey Sand         Schist       Auger or	RQD = Sum c	KEY TO MAT KEY TO MAT High Plasticity Inorganic Sill or Clay Organic Sills/Clays Well-Graded Gravel Clay Silly/Graded Gravel Silly Gravel	FERIAL TYPES	43 X100 SYMBOL: one	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pl: Plat Qp: Poo Qu: Unc Esti ý Dry D <sup>2</sup> F: Fink	2-1/2 DIL PROPERTY SYMBOLS indard Penetration, BPF sture Content, % ind Limit, % sticity Index, % sticity Index, % stel Penetrometer Value, TSF contined Compressive Strength imated Qu, TSF Unit Weight, PCF es Content SAMPLING SYMBOLS
Low Plasticity Inorganic Clay Inorganic Clay Inorganic Clay Inorganic Silt or Clayey Sand Clayey Sand Schist Clayey Sand Schist	RQD = Sum c	Length of Core Run KEY TO MAT High Plasticity Inorganic Silt or Clay Organic Silts/Clays Well-Graded Gravel Clayer Silts Gravel Silts Gravel Clayer Gravel	TERIAL TYPES	43 X100 SYMBOL: one	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pl: Plat Qp: Poo Qu: Unc Esti y Dry D <sup>2</sup> F: Fink	2-1/2 DIL PROPERTY SYMBOLS indard Penetralion, BPF sture Content, % ind Limit, % sticity Index, % xet Penetrometer Value, TSF contined Compressive Strength imated Qu, TSF Unit Weight, PCF es Content SAMPLING SYMBOLS sturbod No Sample
Inorganic Clay Gneiss Gneiss Extended Time Reading Clayey Sand Schist Auger or	RQD =     Sum c       Image: Sum c     Sum c	KEY TO MAT KEY TO MAT High Plasticity Inorganic Silt or Clay Organic Silts/Clays Well-Graded Gravel Clayey Gravel Silty Gravel Clayey Gravel Well-Graded Sand	TERIAL TYPES	43 X100 SYMBOL: one	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pit Plat Qp: Poo Qu: Unc Esti Y Dry p F: Fink Samp	2-1/2 DIL PROPERTY SYMBOLS indard Penetration, BPF sture Content, % ind Limit, % sticity Index, % ket Penetrometer Value, TSF contined Compressive Strength innated Qu, TSF Unit Weight, PCF cs Content SAMPLING SYMBOLS sturbod plé No Sample Recovery
Inorganic Silt or Clayey Sand	RQD #     Sum c       Topsoil     Asphall       Crushed     Limostono       Fill Material     Shot-rock       Fill     Low Plasticity       Inorganic Silt     Ling Plasticity       Low Plasticity     Inorganic Silt       Low Plasticity     Inorganic Silt       Low Plasticity     Inorganic Silt	KEY TO MAT KEY TO MAT High Plasticity Inorganic Silt or Clay Organic Silts/Clays Well-Graded Gravel Clayey Gravel Silty Gravel Clayey Gravel Clayey Gravel Well-Graded Sand Poorly-Graded	rERIAL TYPES	43 X100 SYMBOL: one one one	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pl: Plas Qp: Poc Qu: Unc Esti y Dry F: Fink F: Fink Samp Split- Samp	2-1/2 DIL PROPERTY SYMBOLS indard Penetration, BPF sture Content, % ind Limit, % sticity index, % sticity index, % sticity index, % sturbed Compressive Strength imated Qu, TSF Unit Weight, PCF cs Content SAMPLING SYMBOLS sturbed No Sample Recovery Spoon ple Vater Level After Drilling
	ROD #       Sum c         Topsoil       Asphall         Asphall       Crushed         Limostono       Fill Material         Shot-rock       Fill         Low Plasticity       Inorganic Silt         Lino Plasticity       Inorganic Silt         Low Plasticity       Inorganic Silt         Low Plasticity       Inorganic Silt         Low Plasticity       Inorganic Silt         Low Plasticity       Inorganic Clay	KEY TO MAT KEY TO MAT High Plasticity Inorganic Sill or Clay Organic Sills/Clays Well-Graded Gravel Clayey Gravel Silly Gravel Clayey Gravel Clayey Gravel Well-Graded Sand Poorly-Graded Sand	rERIAL TYPES	43 X100 SYMBOL: one one one	RQD S Amphibolite Metagraywac	HQ N: Star M: Mol LL: Liqu Pl: Plas Qp: Poo Qu: Unc Esti y Dry F: Fink F: Fink Sam Split- Sam	2-1/2 DIL PROPERTY SYMBOLS indard Penetralion, BPF sture Content, % ind Limit, % sticity index, % index of the sticitude Sticitude State Compressive Strength inded Qu, TSF Unit Weight, PCF cs Content SAMPLING SYMBOLS sturbod ple No Sample Recovery Spoon ple Water Level After Drilling Core ple Extended



PR	OJECT	: Harlar	i County Water Tanks	ne na na serie a na na nationale.	·· ··			JOB }	10: 243054	00	R	EPOR	T NO:		
-			ON: Harlan County, KY							•					
	EVATIC		yyże w podarzania w stara w st	BORING STAR			200	)9		100000000000000000000000000000000000000			• • •	: 6/	30/2009
	· · · · · · · · ·		D: 4" HSA	RIG TYPE: CN	ME-55	)				HAMA					
		NATER					L	BORI	NG DIAMETR	ER (IN):	4	SI	IEET	1	OF 1
Rei	marks;	KY 38 1	fank					·	1	,					17
Groundwater	ELEV. (FT.)	DEPTH (FT.)	MATERIAL	DESCRIPTION	Lithology	Sample Type	Recovery (in)	RQD (%)	Qu	STAND RI	ARD		ETRAT E (N)	10N	BLOW
	-		FILL - Mixture of Clayey S and sandstone pieces, bro	and (SC), with silt wn and tan, moist		7	10 10								10 - 8 7 - 6 -
			÷			7	10					Þ			4-9-
		• •				7	14							~> <b>6</b>	6-2( 34
						7	10							-	3-11 19
			FILL - Sandstone Boulder			Z	з								8 - 50/
			Auger Relusal at 14.8 feet												
						r.							· · · · · ·		



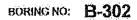
PR	OJECT	Harlan	County Water Tanks				J	OB N	0: 243054	00	REPO	RT NO:		
11.10			DN: Harlan County, KY											
	EVATIO		<u>anna an an</u>	BORING START	ED: 6	/30/	200	9				PLETED	: 6/3	0/2009
	, 1996, 1996, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997, 1997		D: 4" HISA	RIG TYPE CM	E-550	)				HAMM				
GF	ROUNDV	VATER (	( <b>)</b> :				ŧ	ORI	NG DIAMETH	ER (IN):	4 1	HEET	1	OF 1
Re	marks:	KY 38 T	ank							1				
Groundwater	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DI	escription	Lithology	Sample Type	Recovery (in)	ROD (%)	Qu	STAND	ARD PE SISTAI	ICE (N)		BLOWS /6"
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Groundwater	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DES	CRIPTION	Lithology	Sample Type	Recovery (In)	ROD (%)	Qu	STAND RE	esis:		ATION		0V /6"
	-	0 	FILL - Mixture of Clayey Sanc and sandstone pieces, brown	l (SC), with silt and lan, moist		7	12							7- 8-	
		<b>.</b>				/	12							4-	
	-		Auger Refusal at 8.5 feet / Be	ain Cořina		7	10					.0		6-(	
		 10 	FILL - Mixture of Claycy Sand and numerous sandslone bou tan	(SC), with silt Iders, brown and											
		- 15 -								<u> 1997 - 1997 - 19</u> 0					
		- 20													
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Groundwater	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DES	CRIPTION	Lithology	Sample Type	Recovery (in)	ROD (%)	Qü	STANDA	ISTAN	0 30	ATIO 1) 1 40	76*
1.1	1825.1	0	Lean Clay (CL) sandy, STIFF,	orange, moist										
	1824.1		Weathered Sandstone, orang			V	12							8 - 14 - 50/0.4
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DEPTH MATERIAL DESCRIPTION 826.1 0 Lean Clay (CL) sandy, FIRM, tan, moist 821.1 - 5 Sand (SM), sampled as VERY STIFF soil, tan and orange, moist 10	LLING METHOD: 4" HSA RIG TYPE: CME-55 20/0247ER (ft): aarks: Surface elevations measured relative to site benchmark of 18 Mary Wynn Tank S26.1 0 Lean Clay (CL) sandy, FIRM, tan, moist s26.1 0 Lean Clay (CL) sandy, FIRM, tan, moist s21.1 5 Interbedded Weathered Sandstone and silly Sand (SM), sampled as VERY STIFF soil, tan and orange, moist 10	LING METHOD: 4° HSA       RIG TYPE: CME-550         DUNDWATER (0):       Image: Surface elevations measured relative to sile benchmark of 1831.4         Mary Wym Tank       Mary Wym Tank         ELEW. DEPTH       MATERIAL DESCRIPTION       Image: Surface elevation is and ymposited relative to sile benchmark of 1831.4         826.1       0       Lean Clay (CL) sandy, FIRM, tan, moist       Image: Surface end sile benchmark of 1831.4         821.1       5       Interbedded Weathered Sandstone and silly Sand (SM), sampled as VERY STIFF soil, tan and drange, moist       Image: Surface end sile benchmark of 1831.4         821.1       5       Interbedded Weathered Sandstone and silly Sand (SM), sampled as VERY STIFF soil, tan and drange, moist       Image: Surface end sile benchmark of 1831.4         10       -       -       -       -         10       -       -       -       -         10       -       -       -       -         10       -       -       -       -         10       -       -       -       -         -       -       -       -       -       -         -       -       -       -       -       -         -       -       -       -       -       -         -	LING METHOD: 4° HSA RIG TYPE: CME-550 DUNDWATER (ft): arks: Surface elevations measured relative to sile benchmark of 1831.45 ft Mary Wynn Tank SLEW, DEPTH (FT.) MATERIAL DESCRIPTION B25.1 0 Lean Clay (CL) sandy, FIRM, tan, moist 14 821.1 0 Lean Clay (CL) sandy, FIRM, tan, moist 19 10 10 10 10 10 10 10 10 10 10	LING METHOD: 4° HSA RIG TYPE: CME-650 DUNUWATER (ft): BORI sarks: Surface elevations measured relative to sile benchmark of 1831.45 ft Mary Wyrn Tank ELEV. DEPTH ELEV. DEPTH MATERIAL DESCRIPTION B 826.1 0 Lean Clay (CL) sandy, FIRM, tan, moist 14 0 15 - 15 - Augor Refusal at 14.4 feet 10 - 15 - Augor Refusal at 14.4 feet	LLING METHOD: 4" HSA     HIG TYPE: CME-650       2UNIXWATER (t):     BORING DIAMETI       ants: Surface elevations measured relative to site benchmark of 1831.45 ft       Mary Wynn Tank       S25.1     0       Lean Clay (CL) sandy, FIRM, tan, motst       10       5       310.7       15       Augor Refuse! at 14.4 feet	LLING MIETHOD: 4" HSA HIG TYPE: CME-550 HAMME DUNUWATER (9): LEV DEPTH MATERIAL DESCRIPTION HIGH BY DEPTH ATTERIAL DESCRIPTION HIGH BY DEPHN ATTERIAL DESC	LLING METHOD: 4" HSA NG TYPE: CME-550 HAMMERE . 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(FT.) MATERIAL DESCRIPTION State State State Company Setter (CL) sendy, FIRM, tan, moist it is and orenge, moist 	LING METHOD; 4" HSA HG TYPE: CME-550 HAMMER: AUTO DUNUMATER (t): and: Surface islevations measured relative to site benchmark of 1831.45 ft Mary Wynn Tank  SLEV. DEPTH MATERIAL DESCRIPTION S26.1  Lean Clay (CL) sandy, FIRM, tan, moist Head of the surface and site of the surface and site of the surface and orange, moist Head (SM) teampled as VERY STIFF soll, tan and orange, moist  Augor Refusal at 14.4 feet	LING METHOD; 4" HSA ROTYPE: CME-550 HAMMER: AUTO DUNUMATER (b): ansa: Surface elevations measured retellive to site benching to t1831.45 ft Mary Wynn Tank   LEV, DEPTH MATERIAL DESCRIPTION B0



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Groundwater	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DE	SCRIPTION	Lithology.	Sample Type	Recovery (in)	Rap (%)	Qu	STANDARC	TANCE (N)		/6ª
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## FIELD TESTING PROCEDURES

Field Operations. The general field procedures employed by QORE Property Sciences are summarized in ASTM D 420 which is envilled "Investigating and Sampling Soils and Rocks for Engineering Purposes." This recommonded practice lists recognized methods for determining soil and rock distribution and ground water conditions. These includes include geophysical and in situ methods is well as borings.

borings are deliced to obtain subsurface samples using one of several alternate techniques depending upon the subsurface conditions. These techniques are:

- Continuous 2-1/2 or 3-1/4 inch I.D. hollow stem augers;
- b. Wash borings using roller cone or drag bits (mud or water);
- c. Continuous flight augers (ASTM D 1425).

These drilling methods are not capable of penetrating through material designated as "rolusal materials." Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock scams, or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

The subsurface conditions encountered during drilling are reported on a field test boring record by a field engineer who is on sile to deect the drilling operations and log the recovered samples. The record contains information concerning the boring method, samples attainpled and recovered, indications of the presence of various materials such as coarse gravel, cobbles, atc., and observations between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are on file in our office.

The soll and rock samples plus the field being records are reviewed by a geotechnical engineer. The engineer classifies the soils in general accordance with the procedures cutlined in ASTM D 2488 and prepares the final being records that are the basis for all evaluations and recommendations.

The final boring records represent our interpretation of the contents of the field records based on the results of the origineering examinations and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Sell conditions at other locations may allor from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface sold and ground water conditions at these boring locations. The lines designating the interface between soll or refusal materials on the records and on profiles represent approximate boundaries. The transition between materials may be graduat. The final boring records are included with this report. The detailed data collection methods using during this study are discussed on the following pages.

Soil Test Borings: Soil test borings were made at the site at locations shown on the attached Boring Plan. Soil sampling and panetration testing were performed in accordance with ASTM D 1586.

The borings were made by mechanically twisting a 5.5/8" outer diameter auger into the soit. At regular intervals, the drilling loots were removed and samples obtained with a standard 1.4 inch I.D., 2 inch O.D., split tube sampler. The sampler was first seated 6 inches to penetrate any loose cutlings, then driven an additional foot with blows of a 140-pound liammer failing 30 inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "penetration resistance".

Representative portions of the samples, thus obtained, were placed in glass jara and transported to the laboratory. In the laboratory, the samples were exemined to verify the drillar's field classifications. Test Boring Records are attached which graphically show the solt descriptions and penatration resistances.

Soil Auner Soundance: Soil auger soundings were made at the site at the locations shown on the attached Boring Location Plan. The soundings were performed by mechanically twisting a steel auger into the soil. However, innike the soil test binings, a smaller diameter solid etem auger was used and no split-spoor samptes were obtained. The driller provided a general description of the soil encountered by observing the soils brought to the surface by the twisting auger. The auger was advanced until refusal materials were encountered and the refusal depth was noted by the driller. The auger is then withdrawn and the depths to water or caved materials are then includes were encountered by the driller.

Soil suger soundings provide a rapid, economical method of obtaining the approximate bodrock depth, groundwater depth, and general soil conditions : at locations where detailed soil testing and sampling is not required.

Water Level Readings: Water table readings are normally taken in conjunction with borings and are recorded on the "Test Boring Records". These readings indicate the approximate location of the hydrostatic water table at the time of our field investigation. Where impervious solls are encountered (clayey soils) the amount of water scopego into the boring is small, and it is generally not possible to establish the location of the hydrostatic water table through water level readings. The ground water table impacts by dependent upon the amount of precipitation at the sile during a particular period of time. Fluctuations in the water table should be expected with variations in precipitation, surface run-off, evaporation and other factors.

The time of boring water level reported on the boring records is determined by field crows as the dritting tools are advanced. The time of boring water level is datacted by changes in the dritting rate, self samples obtained, etc. Additional water table readings are generally obtained at least 24 hours after the borings are completed. The time tag of at least 24 hours is used to permit stabilization of the ground water table which has been disrupted by the dritting operations. The readings are taken by dropping a weighted line down the boring or using an elactrical probe to detect the water level surface. Occasionally the borings will cave in, preventing water level readings from being obtained or trapping dritting water above the caved in zone. The cave in depth is also measured and recorded on the boring records.

# **APPENDIX C**

SUMMARY OF LABORATORY TEST DATA

LABORATORY TESTING PROCEDURES

Page 1 of 1

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# Laboratory Data Summary

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## LABORATORY TESTING PROCEDURES

Soil Classification: Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply past experience to current problems. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our "Test Boring Records."

The classification system discussed above is primarily qualitative and for detailed acil classification two laboratory tests are necessary: grain size tests and plasticity tests. Using these lest results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM 0 2487). Each of these classification systems and the in-place physical soil properties provides an index for estimating the soil's behavior. The soil classification and physical properties obtained are presented in this report.

Compaction Tests: Compaction tests are run on representative soil samples to determine the dry density obtained by a uniform compactive effort at varying moisture contents. The results of the test are used to determine the moisture content and unit weight desired in the field for similar soils. Proper field compaction is necessary to decrease future settlements, increase the shear strength of the soil and decrease the permeability of the soil.

The two most commonly used compaction tests are the Standard Proctor test and the Modified Proctor test. They are performed in accordance with ASTM D 698 and D 1557, respectively. Generally, the Standard Proctor compaction test is run on sumples from building or parking areas where small compaction equipment is anticipated. The Modified compaction test is generally performed for heavy structures, highways, and other areas where large compaction equipment is expected. In both tests a representative soil sample is placed in a most and compacted with a compaction hammer. Both tests have four alternate methods.

Tost	Melliod	Hammer WL/Fall	Mold Diam.	Run on Matl, Finer Than	No, of Layers	No. of Blows/Lay er
Standard	٨	5.5 lb./12*	4"	No. 4 sieve	- 3	25
D 698	ß	5.5 lb/12"	<b>4</b> "	3/8" stovo	3	25
	C.	\$,5 <b>b</b> ./12"	6"	3/4" sleve	3	50

Test	Method	Hammer WLIFall	Mold Diam.	Run on Mail, Finer Than	No, of Layers	No. of Blows/Lay or
Motlified	Ă	10 lb/18"	A <sup>n</sup>	No. 4 sieve	5	25
D 1557	B	10 lb./18*	.4"	3/8" slovo	5	25
	С	10 lb/18"	6"	3/4" sleve	5	56

The moisture content and unit weight of each compacted sample is determined. Usually 4 to 5 such tests are run at different moisture contents. Test results are presented in the form of a dry unit weight versus moisture content curve. The compaction method used and any deviations from the recommended procedures are noted in this report.

Afterbern Limits: Portions of the samples are taken for Alterborg Limits testing to determine the plasticity characteristics of the soil. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. It is bracketed by the liquid limit (LL) and the plastic limit (PL). The liquid limit is the moisture content at which the soil becomes sufficiently "wet" to flow as a heavy viscous fluid. The plastic limit is the lowest moisture content at which the soil becomes sufficiently "wet" to flow as a heavy viscous fluid. The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into tiny threads. The liquid limit and plastic limit are determined in accordance with ASTM D 4318.

Molsture Content The Molsture Content is determined according to ASTM D 2218.