Report of Geotechnical Exploration

for

Marion Waste Water Treatment Plant

Marion, Kentucky

July 26, 2019

Prepared for

Eclipse Engineers

Somerset, Kentucky

CSI Project Number LX190104

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July 26, 2019

Eclipse Engineers, PLLC
113 W. Mt. Vernon Street
Somerset, Kentucky 42501

Attention: Mr. Alan Robinson, PE

Subject: **Report of Geotechnical Exploration**
Marion Waste Water Treatment Plant
Marion, Kentucky
CSI Project No. LX190104

Dear Mr. Robinson:

Consulting Services Incorporated of Kentucky (CSI) is pleased to present our report for the geotechnical services completed for the proposed Marion Waste Water Treatment Plant on in Marion, Kentucky. We provided our services in general accordance with CSI's proposal number 6265, dated June 25, 2019.

Our report represents information provided to us, readily available published data relevant to the site and site area, our observations and subsurface conditions encountered and our opinion of primary geotechnical conditions (discussion and recommendations) affecting design, construction and performance of the proposed earth supported portions of the project.

We appreciate the opportunity to provide our geotechnical services to you and the design team. Please do not hesitate to contact us for questions or comments about the information contained herein.

Cordially,

Carole A. Gibbs
Staff Engineer

Joseph S. Cooke, PE
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21244
LICENSED PROFESSIONAL ENGINEER

7/26/19

TABLE OF CONTENTS

APPENDICES, FIGURES, PHOTOS AND TABLES

APPENDICES:
- Site Location Plan
- Boring Location Plan
- Boring Logs
- Test Pit Logs
- Sounding Summary Table
- Field Testing Procedures
- Summary of Laboratory Tests
- Specific Laboratory Test Tables
- Laboratory Testing Procedures

List of Figures Page

List of Photos

List of Tables

INTRODUCTION

1 SCOPE OF THE GEOTECHNICAL EXPLORATION

As proposed, we conducted geotechnical services which are summarized in the following report. Our services included a review of the project information provided, conducting a subsurface exploration that used soil borings, rock coring, and test pits to obtain samples for modeling the soil/rock conditions at the subject site, an analysis of the data and information obtained, and providing recommendations for the earth and rock supported portions of the site as listed in our proposal.

2 PROVIDED INFORMATION

Project information was provided to us via email correspondence from your office on June 24 and 25, 2019. We have reviewed the provided documentation which includes pdf's of the Waste Water Treatment plant Overall Site and Location Plan, as well as numerous drawings of individual structures. The project site is located northwest of Highway US 60, on the west side of Pippi Hardin Boulevard, as well as at the existing Waste Water Treatment Plant (WWTP) in Marion, KY. Please reference the Site Location Plan in the Appendix for additional location details.

The proposed construction is for a waste water treatment plant, with necessary appurtenances, drive lanes and parking areas. The buildings are likely single story and structural framing is assumed to be a combination of Concrete Masonry Unit (CMU) and Pre-engeineered Metal Building (PEMB) with shallow spread foundations. Additionally, we expect the pump stations, clarifiers and other WWTP features will primarily consist of cast-in-place concrete and will include some below grade structures. We assume that the areas adjacent to the buildings will be paved, and the drive lanes unpaved.

We have not been provided with any structural loading information at this time. However, we expect that the maximum anticipated foundation loads will not exceed 10 kips per linear foot (for continuous footings) and 150 kips (for isolated footings). Also, we have not been provided expected floor slab live loads. Thus, we have assumed that the floor slab live loads will not exceed 100 pounds per square foot (psf). Tank bottom slabs (and similar) would have loading of 500-750 psf.

Table 1 (on the following page) summarizes the structures supplied to us along with grading information.

Table 1: Project Structures and Grading					
Structure	Approximate Existing Grade (ft.)	Maximum Cut (ft.)	Structure	Approximate Existing Grade (ft.)	Maximum Cut (ft.)
Influent Pump Station	525	22	Clarifier 4	585	24
Headworks Facility	596 (in lowest section)	9.5	PAA Contact Chamber	582	14
Continuously Sequencing Reactor 1	590	15	Cascade Aeration Channel	551 (in lower section)	8
Continuously Sequencing Reactor 2	590	18	RAS/WAS Pump Station	588	21.5
Clarifier 1	586	21	Sludge Holding Tank	583	15.5
Clarifier 2	585	24	Plant Sewer Pump Station	582	28
Clarifier 3	586	21			

If any of the aforementioned information is in error or if the information changes during the course of the project, please contact our office so that we can re-evaluate the new information with respect to our proposed scope of work.

3 AREA/SITE INFORMATION

3A AREA TOPOGRAPHY/PHYSIOGRAPHY

The site is located on the western part of the Pennyrile physiographic region of Kentucky. The region is characterized by thousands of springs, sinkholes, and underground caverns and streams. A line of hills formed by isolated Pennsylvanian- and Mississippian-age sandstones capping more erodable Mississippian-age shales and limestones occurs in the western part of Pennyrile region. Also, complexly faulted strata occur in Crittenden County. Published topographic mapping by the USGS (United States Geologic Survey) indicates the elevations in the project site vicinity range from approximately 540 feet to 620 feet. Figure 1 shows the location of the site with respect to the regional physiography.

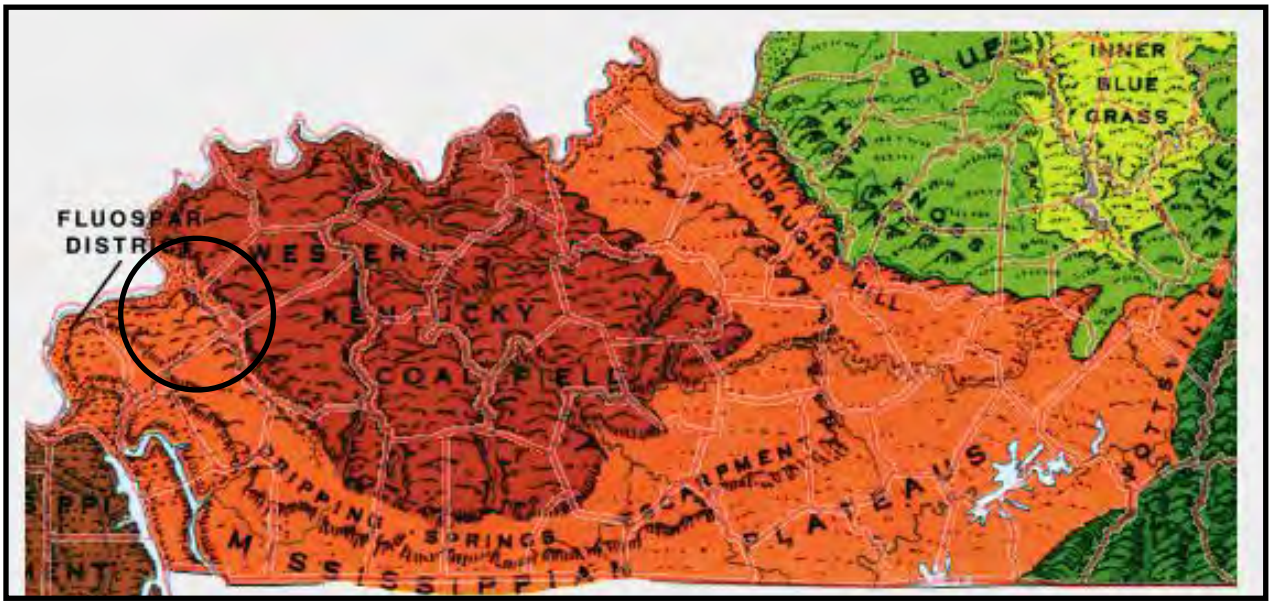


Figure 1. Kentucky Physiographic Map (site vicinity shown in the circle)

3B SITE GEOLOGY

A review of the *USGS Marion Geologic Quadrangle Map, Crittenden and Caldwell Counties, Kentucky (dated 1966)* indicates the project site is underlain by Tar Springs Sandstone Formation of Mississippian aged rock deposits.

As mapped, the Tar Springs Sandstone consists of sandstone and shale in two layers. In the upper layer, the sandstone is light gray and fine-grained, the shale is medium to dark gray, silty, and interbedded in sandstone. In the bottom layer, the sandstone is light gray, fine to very fine grained, and grades vertically into a few thinly interbedded silty shale.

It should be noted that the subsurface conditions encountered during drilling operations and site observations were generally consistent with the data presented on the geologic quadrangle including rock conditions and variable depth to bedrock.

Moore Hill Fault System is mapped approximately half of a mile north of the project site; Claylick Fault System is mapped approximately one mile south of the project site; Chapel Hill Fault is mapped approximately three miles south of the project site. The geologic dip in the area of the project site is approximately five percent to the southeast. Figure 2 shows the location of the site with respect to the area geology.

Figure 2. Site Geology USGS Marion Geologic Quadrangle, dated 1966
(site vicinity indicated by marker)

This site is located in "Western Kentucky" in an area of elevated seismic activity (the Wabash Valley Seismic Zone) and seismic risk of occurrence. We have recommended as Seismic Site Class of "D" for the project. This, along with the project possible being considered a Risk Category III structure, could lead to very costly construction of structure features. If there would be a significant cost advantage to achieve a Site Class of "C", CSI could provide geophysical testing to reassure the site shear wave to possibly improve the recommendation from a "D" to a "C" Seismic Site Class. Reference Figure 3 for further details on Seismic Risk.

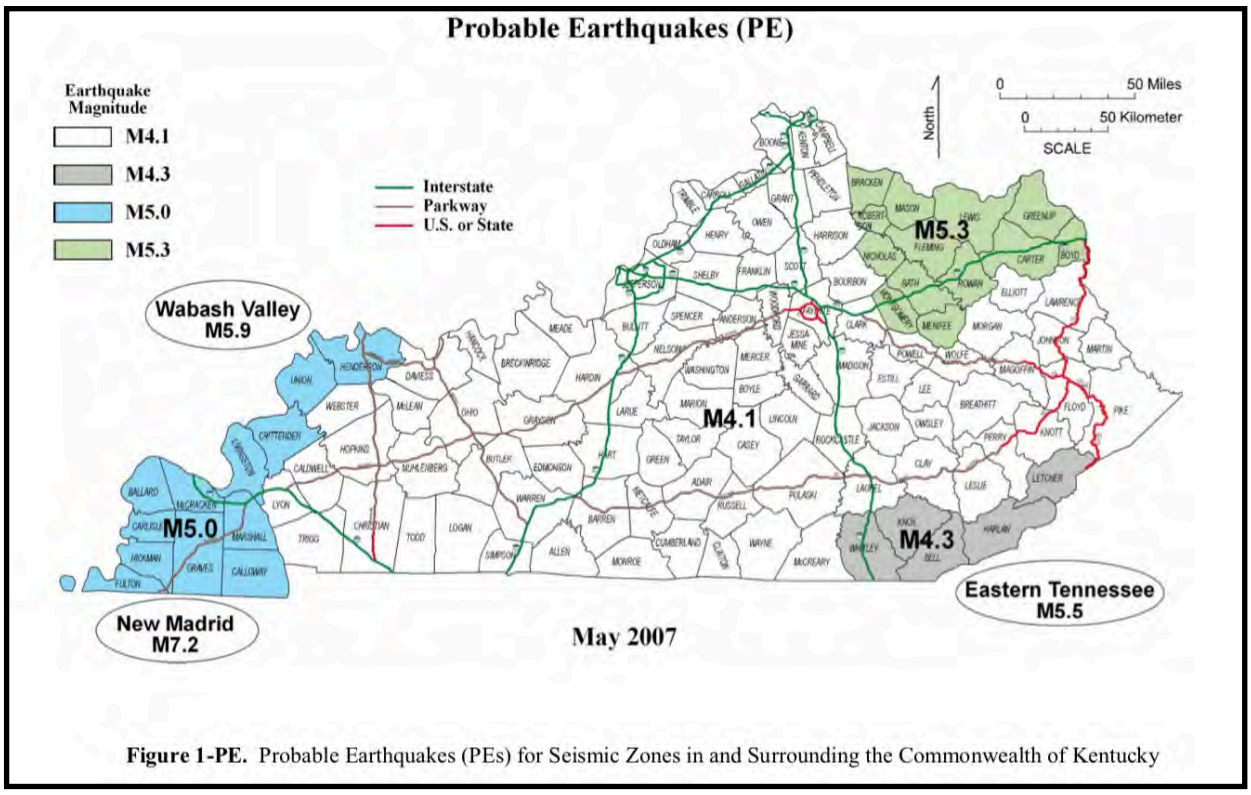


Figure 1-PE. Probable Earthquakes (PEs) for Seismic Zones in and Surrounding the Commonwealth of Kentucky

Figure 3. Seismic Risk Map

3C PUBLISHED SITE SOIL CONDITIONS

According to the USDA Soil Survey of Woodford County (NRCS website), the soils underlying the project site vicinity consist of the following series:

- Lenberg-Frondorf silt loams (LfE), 20 to 50 percent slopes
- Hosmer silt loam (uHosB), 2 to 6 percent slopes
- Zanesville silt loam (ZaC2), 6 to 12 percent slopes

The following are issues listed as characteristics of these series, which we believe could be of interest to the project:

- These soil series are generally listed as moderately well drained to well drained with a depth to water table ranging from approximately 19 inches to greater than 80 inches.
- The depth to restrictive feature for these soils is generally listed as ranging from approximately 20 inches to 80 inches.
- These soils are listed as high risk of corrosion of steel and concrete.

- These soil series are listed as very limited to somewhat limited with respect to site development and construction, including dwellings (with or without basements), local roads and streets, shallow excavations, and small commercial buildings. Particular issues affecting site development and construction include depth to saturated zone, depth to thin cemented pan, low strength, and frost action
- The risks listed that are considered "most problematic" by CSI will be addressed in our report recommendations.

Due to the development of the site vicinity, the soil survey information listed above may no longer be useful since the site soils may have been altered. Thus, the soils described above may be on-site but not in their natural condition. Figure 4 is the soils map from the USDA website.

Figure 4: USDA Soil Survey Map of Project Site
(site bordered in orange)

3D OTHER PUBLISHED SITE INFORMATION

We have reviewed several available aerial photographs, dated as far back as November 1998. The November 1998 aerial photograph indicates the northern project site (along Pippi Hardin Boulevard) was occupied eight rows of structures (assumed to be part of a poultry farm). These structures were demolished between 2004 and 2006. The project site was regraded between 2008 and 2013. Pippi Hardin Boulevard was constructed to the east between 2013 and 2015. Please note the aerial photographs indicate minimal to no changes at the existing WWTP. Please reference the following aerial images for further details.

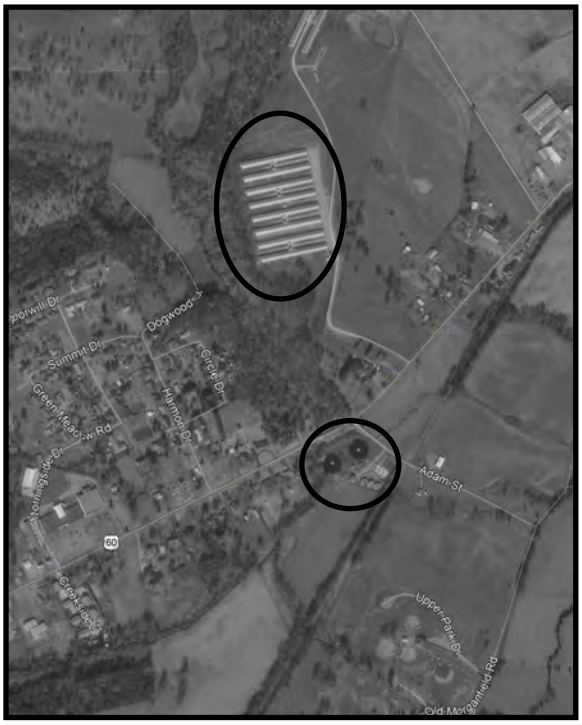


Figure 5: Aerial photograph, dated November 1998 from Google Earth (site vicinity in circle)

Figure 6: Aerial photograph, dated November 2004 from Google Earth (site vicinity in circle)

Figure 7: Aerial photograph, dated July 2006 from Google Earth (site vicinity in circle)

Figure 8: Aerial photograph, dated October 2008 from Google Earth (site vicinity in circle)

Figure 9: Aerial photograph, dated November 2013 from Google Earth (site vicinity in circle)

Figure 10: Aerial photograph, dated October 2015 from Google Earth (site vicinity in circle)

FINDINGS

4 SITE SURFACE OBSERVATIONS

Mrs. Carole Gibbs of CSI conducted a site visit, performed a field reconnaissance, logged soil borings, soundings, and test pits, and directed field operations within the proposed project area on July 9 - July 12, 2019.

The existing WWTP is located in the southern quadrant at the intersection of Highway 60 and Adam Street in Marion, Kentucky. This site is occupied by an existing building, several large tanks, other water treatment features, and some asphalt paved areas (drive lane and parking lot). The existing structures appeared to be in good condition. No cracking was observed in the tanks or along the floor slab of the building. A chain link fence borders the property on all sides. This site is relatively flat to gently sloping.

The new site is located off Pippi Hardin Boulevard in Marion, Kentucky. This site is bordered to the north, west, and south by heavily vegetated areas. Pippi Hardin Boulevard borders the site to the east. Ground cover consisted of grass and weeds. The grass and weeds were mostly approximately knee high to chest high. Thus, we were unable to notice if any ruts were caused by the drill rig or obvious surface conditions in much of the site. Some soft/wet area were observed near the eastern perimeter of the site. This site was gently sloping to the east and to the south. Additionally, we observed in the area that any ditches that weren't lined with gravel were heavily eroded.

An existing gas line and overhead electric lines were observed extending parallel to Pippi Hardin Boulevard. No utilities were marked at the new site or at the existing WWTP. The following photos depict the site conditions as they existed at the time of our geotechnical exploration.

Photo 1. View looking northwest across the project site.

Photo 2. View looking south across the project site.

Photo 3. View looking southwest at existing WWTP.

Photo 4. View looking at existing WWTP building.

5 SUBSURFACE CONDITIONS

The subsurface conditions encountered at each of our soil boring and test pit locations are shown on the Boring and Test Pit Logs in the Appendix. It should be noted that our soil borings were sampled according to the procedures presented in the Appendix. The Boring and Test Pit Logs represent our interpretations of the subsurface conditions based on field logs, visual examination of field samples, and tests of the samples collected. The letters in parentheses following the soil descriptions are the soil classifications in accordance with the Unified Soil Classification System. It should be noted that the stratification lines shown on the logs represent approximate transitions between material types. In-situ stratum changes could occur gradually or at slightly different depths. Water levels shown on the Boring and Test Pit Logs represent the conditions only at the time of our exploration.

5A SOIL CONDITIONS

During our field exploration, we completed 15 borings and 20 soundings for the proposed development. Additionally, we completed 6 test pits to further explore the encountered fill on-site. Please reference the Boring and Test Pit Location Plan in the Appendix for further details.

In general, we encountered the 2 typical profiles: 1. Native soil overlying bedrock and 2. Fill overlying native soil overlying bedrock (encountered where previous structures were). Reference the following tables for additional details.

Table 2. General Soil Conditions Observed - Existing WWTP

Strata	Thickness
Surface Cover: Topsoil	16 inches
Native Soil - orange and gray lean clay (CL) with sand and black oxide staining	Approximately 9 feet

Table 3. General Soil Conditions Observed - New Site (borings)

Strata	Thickness	Notes
Surface Cover: Topsoil	Full range: 1 to 6 inches	Encountered in all borings
Fill - brown, orange and tan mixed clay, with some black oxide staining, fine roots, sand, and rock fragments	Approximately 1 foot to 6 feet	Encountered in 7 borings
Native Soil - orange, tan and gray lean clay (CL) with sand, some silt, black oxide staining, and some weathered rock fragments	Approximately 1 foot to 23 feet	Encountered in all borings

Table 4. General Soil Conditions Observed - New Site (test pits)		
Strata	Thickness	Notes
Surface Cover: Topsoil	Full range: 3 to 6 inches	
Fill - brown, tan and gray mixed clay, with fine roots, some sand, and black oxide staining	Approximately 1 foot to 3 feet	plastic pipe was observed in 2 test pit locations
Native Soil - tan, brown, and gray lean clay (CL), with sand, some silt and black oxide nodules	At least 3 feet	

5B GROUNDWATER CONDITIONS

Water was observed in 4 of our borings and 1 of our test pits upon completion of soil augering or completion of excavation. Please note that a final groundwater reading was not taken at any of our core hole locations since water was used to cool the core bit. Borings and test pits were immediately backfilled due to safety concerns for pedestrians. Also, the Web Soil Survey indicated relatively shallow water could be an issue at these sites.

Other water conditions that usually affect construction and performance of projects consist of trapped/perched water zones which occur in variable areas in the soil mass, at or near existing or former structures, at or near the bedrock bedding planes, or at or near the soil/ rock interface. Additionally, pockets of water could exist within the fill material. Perched water sources are often not linked to the more continuous relatively stable ground water table that typically occurs at greater depths. Site excavation activities or ground disturbance can expose these features and the resulting seepage can vary greatly. Finally, water issues are also dependent upon recent rainfall activity and surface and subsurface drainage patterns in the area.

5C BEDROCK INFORMATION

Auger refusal was encountered in all of our borings at depths ranging from approximately 6 to 26.5 feet and in all of our soundings at depths ranging from approximately 8 feet to 25 feet. Equipment refusal was encountered in 1 of our test pits at a depth of approximately 4 feet. The other 5 test pits were terminated at a predetermined depth of approximately 6 feet. We have interpreted auger refusal to be the top of the bedrock surface. Refusal material was sampled by coring rock at borings B-1, B-3, B-4, B-8, B-10, and B-14. Core water loss was not observed in any of our borings during coring operations. Table 2 summarizes the recovered rock core.

Table 5. General Bedrock Conditions Observed			
Location	Boring Location	Coring Depth Range (ft)	General Description
Existing WWTP	B-1	22.0 - 27.0	Medium Hard, gray sandstone, fine to medium grained, with interbedded shale
New Site	B-3	9.4 - 19.4	Medium Hard to Hard, pink, orange, and gray sandstone, medium to coarse grained
New Site	B-4	14.0 - 19.0	Medium Hard, orange and gray sandstone, medium to coarse grained, with some shale lenses
New Site	B-8	19.5 - 24.5	Hard, gray sandstone, medium to coarse grained, with some interbedded shale
New Site	B-10	22.6 - 27.6	Medium Hard, light to dark gray weathered shale, fine to coarse grained
New Site	B-14	7.1 - 22.1	Medium Hard, red, orange, and gray sandstone, medium to coarse grained, with some interbedded shale

6 LABORATORY TESTING

Laboratory tests were performed on selected recovered samples from our borings. Detailed descriptions of these tests and the results of our testing are included in the Appendix. Tests performed included:

- Natural moisture contents
- Atterberg limits
- Percent fines analysis
- Unconfined compressive strength tests (rock)

GEOTECHNICAL DISCUSSION AND RECOMMENDATIONS

7 DISCUSSION-GEOTECHNICAL ISSUES

Based on our experience with similar projects and the conditions observed during our subsurface exploration, we believe that this site can be adapted for the proposed development. The primary geotechnical concerns are:

- Previous Site Improvements
- Previously Placed (Old) Fill
- Silty and Sandy Soils

- Varying Depth to Bedrock
- Site Seismic Design (Site Class)

The following sections discuss each issue. However, recommendations to address the issues are contained in later sections of the report.

7A PREVIOUS SITE IMPROVEMENTS

Based on reviewed aerial images and provided information, the new area project site was previously occupied by a poultry farm. At our test pit and boring locations we observed fill material assumed to be from these structures. The structures associated with the poultry farm were demolished in the 2000's. Reportedly, the foundations and concrete and the majority of the previous development have been removed. However, expect that some minor previous construction may have left old fill, buried deleterious material or soft pockets of soil or gravel within the proposed site improvement boundaries. Your project budget should include a contingency for remediation of any encountered buried deleterious material or structures.

7B PREVIOUSLY PLACED (OLD) FILL

Previously placed fill was encountered at 7 of our boring locations at the new site. The fill material ranged in thickness from 1 foot to 6 feet. We then excavated 6 test pits within the old fill area at the new site. These sample locations indicated some buried deleterious materials exist within the fill. Old fill materials are often improperly compacted, commonly contain organics and debris, and can be poor bearing materials. Fills placed in an uncontrolled manner have proven to be problematic. The problems generally arise not from settlement, but from erratic differential settling of the fill. The settlement of old fill masses is dependent upon several factors such as fill thickness, degree of compaction, fill contents, and age of the fill mass. Please note that we cannot accurately predict the settlement of old fill. It should be expected that removal of previously placed fill material will be necessary during construction for foundations. Slabs could likely bear on old fill if the subgrade is bridged with geogrid and gravel.

7C SILTY AND SANDY SOILS

Our experience in the area, our borings and test pits, as well as the published site geology, indicate silty soil zones as well as sand lenses are at these sites. Our borings verified the presence of silty and sandy soils at the site. These soils are prone to degradation and become unstable during wet periods of the year and/or under heavy construction traffic. Care must be taken and exercised during earthwork and in areas where construction traffic is expected to minimize repetitive traffic over the site soils. The repetitive traffic will cause the soils to become unstable; therefore, filling operations should only use enough compactive effort to achieve stability and job site requirements for compaction. Also, undercutting and recompaction of these soils usually proves futile (the soil matrix is usually degraded).

During wet periods of weather, undercutting should be expected. Construction excavations or earthwork operations should be avoided during wetter seasons of the year. Again, recompaction, especially of silty soils is problematic and other means of stabilization should be considered.

7D VARYING DEPTH TO BEDROCK

Our borings encountered auger refusal at depths ranging from approximately 6 feet to 26.5 feet. Our soundings encountered auger refusal from approximately 8 feet to 25 feet. Based on the supplied drawings, anticipated foundation excavation limits, and Finished Floor Elevations (FFE's), rock removal will be required in some areas and should be budgeted.

7E SITE SEISMIC DESIGN (SITE CLASS)

As previously mentioned, this site is located in "Western Kentucky" in an area of elevated seismic activity (the Wabash Valley Seismic Zone) and seismic risk of occurrence. We have recommended as Seismic Site Class of "D" for the project. This, along with the project possible being considered a Risk Category III structure, could lead to very costly construction of structure features. If there would be a significant cost advantage to achieve a Site Class of "C", CSI could provide geophysical testing to reassure the site shear wave to possibly improve the recommendation from a "D" to a "C" Seismic Site Class.

8 EARTHWORK

Historically, more change orders (in total number and costs) occur during the earthwork portion of construction than in almost any other part of the project. Further, the site preparation phase of construction always affects the future performance of project structures. Add into this, the fact that earthwork is the portion of work most influenced by wet weather and unknown conditions and time-wise, this section of the report could be the most important to prevent and minimize delays and costs during construction and for the life of the project.

Please review the concerns listed in section 7 prior to reading the following recommendations. If problems occur that the recommendations do not address or do not adequately remedy, please contact CSI as soon as possible.

8A SITE PREPARATION (WORK PRIOR TO MASS FILLING)

- When ready to commence construction, remove/relocate all underground/overhead utilities as required by the construction plans (not expected).
- The site should be cleared/grubbed removing all topsoil and vegetation within the proposed building footprints and pavement areas. Organic materials should be wasted off-site. Topsoil can be stockpiled for use in landscape areas.

- Areas ready to receive new fill should be proofrolled with a heavily loaded dump truck (GVW of 80,000 pounds) or similar equipment judged acceptable by a CSI geotechnical engineer. However, it should be noted that lighter equipment may be needed for proofrollling. The site silty soils can tend to pump/rut even when stable.

- The level of proofroll should be determined by a CSI geotechnical engineer on a case-by-case basis.

- Perform the proofrolling after a suitable period of dry weather to avoid degrading the subgrade.

- Areas which pump, rut, or wave during proofrolling may require undercutting, depending on the location of the area and the use of the area, so the CSI geotechnical engineer should be contacted for guidance.

- Backfill of undercut areas should be performed in accordance with sections 8B, 8C, and 8D.

- Retain CSI to observe the proofrolling operations and make recommendations for any unstable or unsuitable conditions encountered. This can save time on the construction schedule and save unnecessary undercutting.

We recommend that site grading should take place between about late April to early November. Earthwork taking place outside this time period will likely encounter wet conditions and weather conditions that will provide little to no assistance with drying the soils.

8B NEW FILL OPERATIONS

Our laboratory tests indicate that the tested on-site soils are suitable for use as structural fill material provided the material is placed and compacted in accordance with the following guidelines and specifications. Any off-site fill material should be tested and approved before it is imported to the project site.

After the subgrade has been approved to receive new fill, the fill may commence with the following procedures and guidelines recommended:

- Place fill in maximum 8-inch thick loose lifts.

- Building and roadway (or other critical structures) fill compaction requirements should extend to at least 5 feet outside the structure perimeter.

- Fill lifts should be compacted to at least 95 percent of the soil's maximum dry density (ASTM D 698) and maintain the moisture content of compacted fill from minus 3% to plus 1% of optimum moisture.

- Off-site soils with a plasticity index (PI) of greater than 25 should not be used as new fill.

- Maximum particle size of the fill should be limited to 4 inches in any dimension with no large concentrations of large fragments.

- Density testing should be performed as a means to verify percent compaction and moisture content of the material as it is being placed and compacted.

- Observation of fill "stability" is also critical, so it is recommended to observe the operation of the filling equipment traversing over the new fill to document movement (similar to proofrolling).

- Soils should not be "overcompacted" and construction traffic should be kept to minimum to assure compaction is achieved and that the soil is not allowed to "break down".

- Retain a representative of CSI to observe and document fill placement and compaction operations.

8D BACKFILL OPERATIONS (FOUNDATION WALLS, UTILITIES, ETC.)

These materials are placed in more confined areas than mass earthwork materials or pavement materials and therefore cannot be placed in full compliance with section 9B. The following are general recommendations for backfill areas:

- Fill lift thicknesses will vary dependent on compaction equipment available and material types, but in no case should exceed 8 inches.

- The maximum particle size should not exceed 4 inches.

- For crushed stone/aggregate backfills in trenches or wall backfill and when using smaller compaction equipment (such as a plate compactor, trench compactor, or similar) the lift thickness should not exceed 4 inches.

- CSI should be retained to provide additional recommendations for backfill (if necessary).

8E GENERAL NOTES

- For all earthwork operations, positive surface drainage is prudent to keep water from ponding on the surface and to assist in maintaining surface stability.

- The surface should be sealed prior to expected wet weather. This can usually be accomplished with rubber-tired construction equipment or a steel-drum roller.

- If any fill placement problems occur, CSI should be retained to provide additional recommendations, as needed.

9 SITE DRAINAGE

Wet conditions should be expected at both sites. This is especially true at or near the bedrock surface and within sandy pockets or old fill zones in the soil mass. Any exposed spring or water-bearing feature should be day-lighted via french-drains or similar feature to expedite the water flow and minimize potential build up of water in and around new fill masses. Budgets for earthwork should include such dewatering features. CSI should be retained for earthwork observation to assist in minimizing "over-usage" or french drain type drainage features as well as adequate amounts of drainage and to provide options for site drainage in the mass fill areas, especially in the site swale areas.

During construction, water should not be allowed to pond in excavations or undercutting will likely be required. Additionally, allowing water to pond in excavations (especially excavations that approach the soil/rock interface) greatly increases the risk for activating latent Karst features. During the life of the project, slope the subgrade and other site features so that surface water flows away from the site structure. Diversion ditches should be used to keep surface water from accumulating at or near site structures.

For excavations during construction, most free water could likely be removed via sump pumps and open channel flow (ditches) at or near the source of seepage. If normal dewatering measures prove insufficient due to shallow water conditions, CSI should be retained to provide recommendations on the issue.

10 FOUNDATIONS

Based on the information provided and the conditions encountered, shallow spread foundations (continuous, isolated, or combinations thereof) bearing on rock are suitable for the proposed underground structures. Shallow spread footings on soil are suitable for the proposed new buildings or shallow foundation structures. If there are any changes in the project criteria or building location, CSI should be allowed to review the recommendations to determine if any modifications are required.

NOTE: Buildings, equipment or other structures should individually bear on the same bearing material (soil or rock and not a combination of the two) within the limits of each structure.

10A SHALLOW SPREAD FOUNDATIONS ON ROCK

Proposed underground structure foundations may be designed for spread foundations bearing on sound bedrock.

For foundations bearing completely on sound bedrock, spread foundations may be sized using a maximum allowable bearing pressure of 20,000 pounds per square foot (20 ksf). Any voids, soil/soft rock seams, slots, or troughs in the bedrock will require complete removal and backfilling with lean concrete (minimum 2,000 psi) or flowable fill (minimum 300 psi).

A detailed settlement analysis was beyond the scope of this exploration. However, based on the supplied structural loads and foundations bearing on competent limestone, we expect both total settlements and differential settlements will not exceed 1/2 inch between columns or along continuous footing distances of 30 feet or less.

Additional design considerations for spread foundations bearing on bedrock are outlined as follows:

- Design all footings with a minimum 18 inches width;
- Spread foundations bearing on bedrock are not subject to a minimum frost embedment depth.

10B SHALLOW FOUNDATIONS ON ROCK - CONSTRUCTION NOTES

- For spread foundations constructed on top of sound bedrock, we also recommend the following procedures.
- Loose soil, mud, debris, and excess water should be removed from the bearing surface immediately prior to concrete placement.
- Foundation bearing surfaces should be benched to provide nearly-level bearing surfaces.
- A CSI geotechnical engineer should observe all foundation excavations and provide recommendations for treatment of any unsuitable conditions encountered.

10C SHALLOW SPREAD FOUNDATIONS ON SOIL - BUILDINGS (AND SHALLOW FOUNDATION EQUIPMENT)

Shallow spread footings for the buildings may be sized using a maximum allowable bearing pressure of 2,500 psf (pounds per square foot). Foundations should bear on stiff or better residual soils or new fill. Foundations should not bear on the old fill. If rock is encountered within 1 foot of the bottom of the foundation (BOF) elevation (not expected), we recommend that the rock be undercut at least 1 foot below bottom of footing and the excavation backfilled with compacted soil up to the design BOF elevation to provide a “cushion”.

A detailed settlement analysis was beyond the scope of this exploration. However, based on the estimated grade separation wall loads, the anticipated behavior of soil types encountered during field activities, and our experience with similar projects, we expect that total settlements will not exceed 1 inch, and that differential settlements will not exceed 1/2 inch along continuous footing distances of 30 feet or less. We recommend the grade separation wall be designed to accommodate these magnitudes of total and differential settlements.

Settlement estimates are based, in part, upon the assumption that site preparation is performed in accordance with our recommendations and with good quality control of the earthwork. Removal of all old fill and proper placement and compaction of new fill is particularly important in keeping settlements within tolerable limits.

Additional design considerations for project foundations are outlined as follows:

- Design all footings with a minimum 24 inches width.
- All exterior footing bottoms should bear at least 24 inches below finished exterior grading (KBC Table 1805.2.1 for Crittenden County).
- Include control joints at suitable intervals in the grade separation wall and in areas where changes in support from native soil to fill are anticipated, to help accommodate differential foundation movements.

10D SHALLOW FOUNDATIONS ON SOIL - CONSTRUCTION NOTES

Any soils can lose strength if they become wet, so we recommend the foundation subgrades be protected from exposure to water. For foundations construction, we also recommend the following procedures.

- For soils that will remain exposed overnight or for an extended period of time, place a "lean" concrete mudmat over the bearing areas. The concrete should be at least 4 inches thick. Flowable fill concrete or low-strength concrete is suitable for this cover, as conditions allow.
- Disturbed soil should be removed prior to foundation concrete placement.
- Foundation bearing conditions should be benched level.
- Areas loosened by excavation operations should be recompacted prior to reinforcing steel placement.
- Loose soil, debris, and excess surface water should be removed from the bearing surface prior to concrete placement.

- Retain a CSI geotechnical engineer to observe all foundation excavations and provide recommendations for treatment of any unsuitable conditions encountered.

11 SEISMIC SITE CLASSIFICATION

The latest edition of the Kentucky Building Code (KBC) was reviewed to determine the Site Seismic Classification. Based on our review of geologic data, our experience, and subsurface conditions encountered, we recommend a Seismic SITE CLASS "D" for foundation design purposes.

As previously mentioned, this site is located in “Western Kentucky” in an area of elevated seismic activity (the Wabash Valley Seismic Zone) and seismic risk of occurrence. We have recommended as Seismic Site Class of “D” for the project. This, along with the project possible being considered a Risk Category III structure, could lead to very costly construction of structure features. If there would be a significant cost advantage to achieve a Site Class of “C”, CSI could provide geophysical testing to reassure the site shear wave to possibly improve the recommendation from a “D” to a “C” Seismic Site Class.

A detailed geotechnical earthquake engineering analysis was not performed since it was beyond the scope of our authorized work. However, based on a review of published literature and our experience with similar subsurface conditions, we believe the potential for slope instability, liquefaction, and surface rupture due to faulting or lateral spreading resulting from earthquake motions is low. However, this potential could be elevated during wet periods of the year unless adequate drainage is provided.

12 CONCRETE SLAB-ON-GRADE

A grade supported slab is suitable for the proposed buildings, provided the subgrade is prepared according to the recommendations contained within this report. Based on our boring data and proposed grading, we expect new concrete slabs-on-grade to be supported entirely by firm or better newly placed engineered fill. Slabs may bear on the old fill, if the subgrade is deemed stable under a proofroll observed by CSI. We believe that due to the old fill and silty site soils, there will be areas deemed unstable. In that case, CSI should be retained to provide recommendation at that time. For the purposed of planning, Tensar TX140 Geogrid should be used for unstable areas. At least 20,000 square feet of stabilization should be budgeted.

The following features are recommended as part of the floor slab construction:

- Provide isolation joints between the slab and footing supported walls.
- Adequate joint patterns (ACI and ICC guidelines) should be used to permit slab movement due to normal soil settlement, normal subgrade disturbance and material expansion/contraction.

- Place a minimum of 4 inches of clean, compacted gravel or crushed stone beneath the slab to provide a working base. The actual thickness of the gravel layer should be based on design requirements.

- Keep the crushed stone or gravel moist, but not wet, immediately prior to slab concrete placement to minimize curling of the slab due to differential curing conditions between the top and bottom of the slab.

- Retain CSI to review the actual subgrade conditions prior to slab construction and make recommendations for any unsuitable conditions encountered.

Note: Slab subgrade conditions are also considered earthwork areas; thus, the recommendations contained in the Earthwork section of the report apply.

13 BELOW GRADE STRUCTURES

We understand that this project will include the construction of underground structures. Thus, the walls will be subjected to lateral earth pressures due to the backfill behind them. Retaining walls should be designed to provide sufficient drainage at the rear of the wall to relieve hydrostatic pressure.

All temporary slopes should be in compliance with OSHA and any other applicable safety regulations. During construction, temporary slopes (if any) should be regularly evaluated for signs of movement or unstable conditions. Soil slopes should be covered for protection from rain, and surface runoff should be diverted away from the slopes. Additionally, we offer the following design criteria for each of the specific wall types:

- We recommend the walls be backfilled using a compacted, open-graded, granular material such as No. 57 stone. The granular material should be clean and free draining. To utilize the following granular material earth pressure values, the granular material must occupy a minimum backfill zone of 2 feet between the back face of the wall and the soil backfill. This minimum 2 foot wide zone starts at the base of the wall and extends the height of the wall to the finished subgrade elevation.

- The No. 57 stone backfill zone should be drained using a perforated pipe placed near the base of the foundation or through weep holes in the face of the loading dock wall. The perforated pipe should be placed at the lowest elevation where water would accumulate. The perforated pipe should be directed through a solid pipe to daylight, to the storm sewer system, or to a sump/sump pump system.

- A geotextile material (i.e. – filter fabric) must be used as a separator between the granular backfill material and the surrounding soils to prevent soil piping.

- Mass excavation walls or any deep excavation will likely encounter water/wet conditions

- Further, such deep excavations will also encounter sandy or loose/soft soils that will slough. Trench boxes will be needed as well as budgets/plans for cut backs and "flatter" excavation side walls.

The following table presents granular backfill, earth pressure design parameters for Equivalent Hydrostatic Pressures (EHP) and Earth Pressure coefficients. The values given assume the backfill surface is nearly level, the granular backfill is drained, the zone of backfill conforms to the minimum zone detailed above, and no surcharge is placed on the backfill. A unit weight of 100 psf (pounds per square foot) was used for the backfill stone.

Table 6: Granular Material Equivalent Hydrostatic Pressures (EHP) and Earth Pressure Coefficients

Condition	EHP (pcf)	Coefficients
Active	30	$K_a = 0.30$
At Rest	50	$K_o = 0.50$
Passive	300*	$K_p = 3.00$

14 NOTES ON THE REPORT AND RECOMMENDATIONS

We recommend that this complete report be provided to the various design team members, the contractors and the project Owner. Potential contractors should be informed of this report in the "Instructions to Bidders" section of the bid documents. A geotechnical exploration, such as the one we performed, uses widely spaced borings to attempt to model the subsurface conditions at the site. Because no exploration contains complete data or a complete model, there is always a possibility that conditions between borings will be different from those at specific boring locations. Thus, it is possible that some subsurface conditions will not be as anticipated by the project team or contractor. If this report is included or referenced in the actual contract documents, it shall be explicitly understood that this report is for informational purposes only. CSI shall not be responsible for the opinions of, or conclusions drawn by, others.

It has been our experience that the construction process often disturbs soil conditions and this process, no matter how much experience we use to anticipate construction methodology, is not completely predictable. Therefore, changes or modifications to our recommendations are likely needed due to these possible variances. Experienced CSI geotechnical personnel should be used to observe and document the construction procedures and the conditions encountered. Unanticipated conditions and inadequate procedures should be reported to the design team along with timely recommendations to solve the problems created.

We recommend that the Owner retain CSI to provide this service based upon our familiarity with the project, the subsurface conditions and the intent of our recommendations.

This report is based on the supplied project information, the subsurface conditions observed at the time of the report, and our experience with similar conditions. As such, it cannot be applied to other project sites, types, or combinations thereof. If the Project Information section in this report contains incorrect information or if additional information is available, you should convey the correct or additional information to us and retain us to review our recommendations. Our recommendations may then require modification.

No section or portion of this report (including Appendix information) can be used as a stand alone article to make distinct changes or assumptions. The entire report and Appendix should be used together as one resource.

While this report deals with samples of subsurface materials and some comments on water conditions at the site, no assessment of site environmental conditions or the presence of contaminants were performed.

We wish to remind you that our exploration services include storing the soil and rock core samples collected and making them available for inspection for 30 days. The samples are then discarded unless you request otherwise. Please inform us if you wish to keep any of the obtained samples.

APPENDIX

Site Location Plan

Boring, Sounding, and Test Pit Location Plan

Key to Symbols and Descriptions

Boring Logs

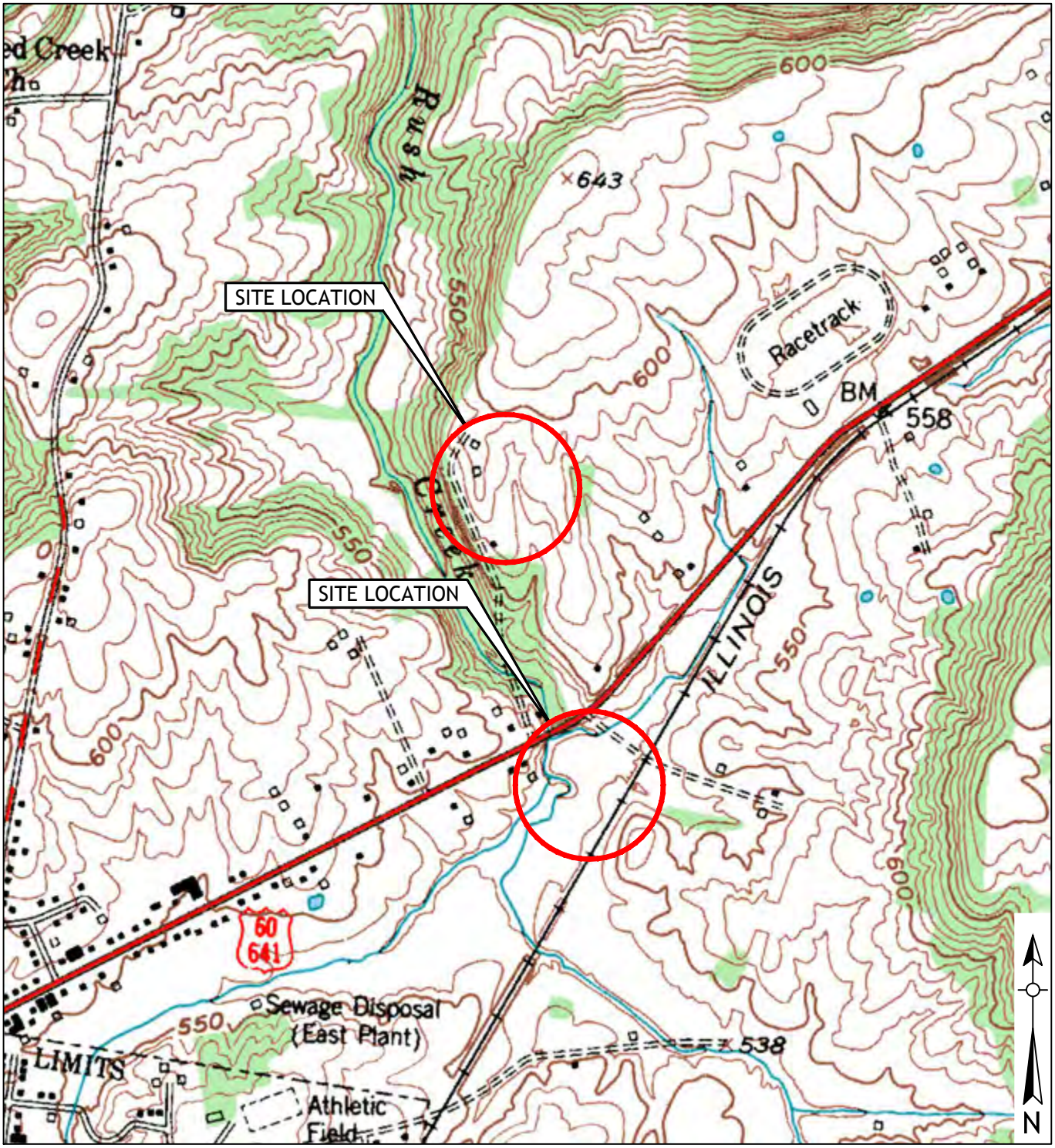
Test Pit Logs

Sounding Summary Table

Field Testing Procedures

Summary of Lab Testing Table(s) and Lab Testing Sheets

Laboratory Testing Procedures



Site Location Plan adapted from USGS Marion, Kentucky Topographic Quadrangle map dated 1954, with further adaptation by CSI personnel.

FOR ILLUSTRATION PURPOSES ONLY

Consulting Services Incorporated of Kentucky
858 Contract Street
Lexington, Kentucky 40505
859.309.6021 Office|888.792.3121 Fax
www.csikentucky.com

SITE LOCATION PLAN	Project No: LX190104	Drawn By: MV
Marion Waste Water Treatment Plant Marion, Kentucky	Date: 7/26/2019	Checked By: CG
	Scale: Not To Scale	Drawing No: SLP - 1

Boring Location Plan adapted from provided " C-1 Overall Site and Location Plan" dated May, 23, 2019, with further adaptation by CSI personnel.
Elevations were determined using Real Time Kinematic Differential GPS referencing the KYCORS network.

FOR ILLUSTRATION PURPOSES ONLY

LEGEND	
B-XXX	BORING LOCATIONS

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Lexington, Kentucky 40505
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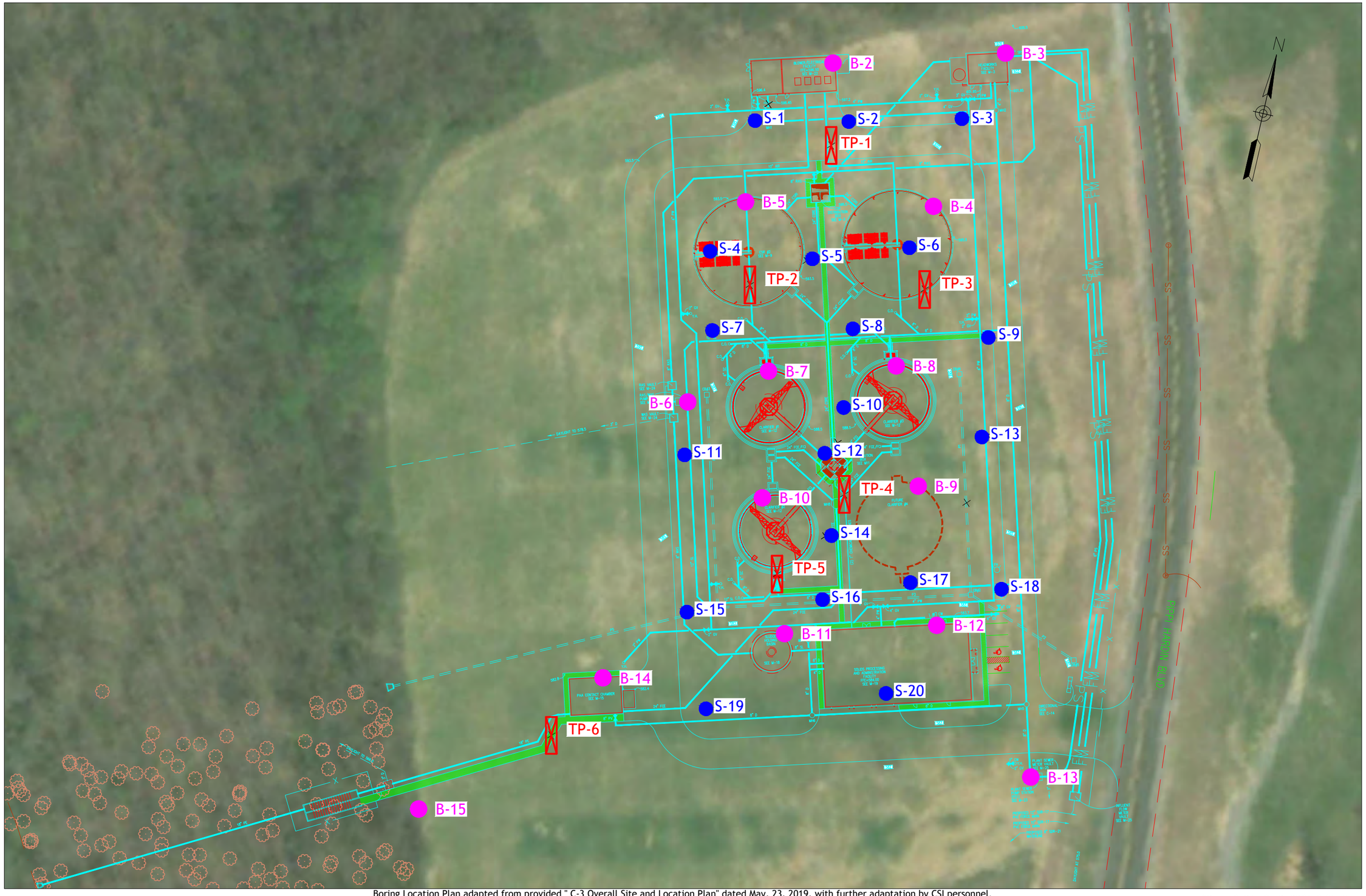
www.csikentucky.com

BORING LOCATION PLAN	Project No: LX190104	Drawn By: CJ
Marion Waste Water Treatment Plant Marion, Kentucky	Date: 7/3/2019	Checked By: CG
	Scale: Not To Scale	Drawing No: BLP - 1



Boring Location Plan adapted from provided " C-3 Overall Site and Location Plan" dated May, 23, 2019, with further adaptation by CSI personnel.
Elevations were determined using Real Time Kinematic Differential GPS referencing the KYCORS network.

FOR ILLUSTRATION PURPOSES ONLY

LEGEND

- S-XXX SOUNDING LOCATIONS
- B-XXX BORING LOCATIONS
- TP-X TEST PIT LOCATIONS

Project No: LX190104
Drawn By: CJ
Date: 7/26/2019
Checked By: CG
Scale: Not To Scale
Drawing No: BLP - 2

LOCATION PLAN

Marion Waste Water Treatment Plant
Marion, Kentucky

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858 Contract Street
Lexington, Kentucky 40505
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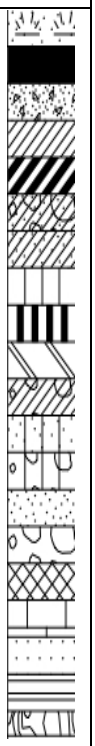
LEXINGTON | LOUISVILLE | CINCINNATI

Geotechnical Boring Information Sheet

Sample Type Symbols

Splitspoon (SPT)
Shelby Tube
Grab
Rock Core
Auger Cuttings

Surface Symbols



Topsoil
Asphalt
Concrete
Lean Clay
Fat Clay
Glacial Till
Sandy Clay
Silt
Elastic Silt
Lean Clay to Fat Clay
Gravelly Clay
Sandy Silt
Gravelly Silt
Sand
Gravel
Fill
Limestone
Sandstone
Shale/Siltstone
Weathered Rock

Samples Strength Descriptors

Cohesive Soils:	N
Very Soft	0-1
Soft	2-4
Firm	5-8
Stiff	9-15
Very Stiff	16-30
Hard	31+
Non-cohesive Soils:	
Very Loose	0-4
Loose	5-10
Firm	11-20
Very Firm	21-30
Dense	30-50
Very Dense	51+

Definitions

SPT-"Splitspoon" or standard penetration test. Blow counts are number of drops required for a 140 lb hammer dropping 30 inches to drive the sampler 6 inches.

N-value is the addition of the last two intervals of the 18-inch sample.

Shelby tubes are often called "undisturbed samples". They are directly pushed into the ground, twisted, allowed to rest for a small period of time and then pulled out of the ground. Tops and bottoms are cleaned and then sealed.

Sample classification is done in general accordance with ASTM D2487 and 2488 using the Unified Soil Classification System (USCS) as a general guide.

Soil moisture descriptions are based on the recovered sample observations. The descriptors are dry, slightly moist, moist, very moist and wet. These are typically based on relative estimates of the moisture condition of a visual estimation of the soils optimum moisture content (EOMC). Dry is almost in a "dusty" condition usually 6 or more percent below EOMC. Slightly moist is from about 6 to 2 percent below EOMC at a point at which the soil color does not readily change with the addition of water. Moist is usually 2 percent below to 2 percent above EOMC and the point at which the soil will tend to begin forming "balls" under some pressure in the hand. Very moist is usually from about 2 percent to 6 percent above EOMC and also the point at which it's often considered "muddy". Wet soil is usually 6 or more percent above EOMC and often contains free water or the soil is in a saturated state.

Silt or Clay is defined at material finer than a standard #200 US sieve (<0.075mm) Sand is defined as material between the size of #200 sieve up to #4 sieve. Gravel is from #4 size sieve material to 3". Cobbles are from 3" to 12". Boulders are over 12".

Rock hardness is classified as follows:

Very Soft:	Easily broken by hand pressure
Soft:	Ends can be broken by hand pressure; easily broken with hammer
Medium:	Ends easily broken with hammer; middle requires moderate blow
Hard:	Ends require moderate hammer blow; middle requires several blows
Very Hard:	Many blows with a hammer required to break core

Rock Quality Designation (RQD) is defined as total combined length of 4" or longer pieces of core divided by the total core run length; defined in percentage.

Water or cave-in observed in borings is at completion of drilling each boring unless otherwise noted.

Strata lengths shown on borings represents a rough estimate. Transition may be more abrupt or gradual. Soil borings are representative of that estimated location at that time and are based on recovered samples. Conditions may be different between borings and between sample intervals. Boring information is not to be considered stand alone but should be taken in context with comments and information in the geotechnical report and the means by which the borings are logged, sampled and drilled.

BORING LOG

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-1**

Project Number: LX190104	Weather: Sunny, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 525.6	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/9/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/9/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
			TOPSOIL - 16 inches	1-2-2 (4)	16		
524	2	CL	LEAN CLAY (CL) - SOFT, orange and gray, with trace fine roots,with some sand, moist	1-1-1 (2)	18		
522	4	CL	SANDY LEAN CLAY (CL) - FIRM to VERY STIFF, gray, with some orange mottling, with some silt, with some black oxide staining, moist	2-3-2 (5)	18	▽	Water observed at 4.5 feet
520	6	CL					
518	8	CL		3-3-4 (7)	18		
516	10	CL		6-9-12 (21)	18		
514	12		Weathered Shale				
512	14			50/2"	2		
510	16						
508	18						
506	20			50/4"	3		
504	22		Auger Refusal at 22.0 feet Begin Coring at 22.0 feet				No core water loss observed
502	24		SANDSTONE - MEDIUM HARD, gray, fine to medium grained, with interbedded shale (highly weathered from 22' - 22.5')		60		REC (%) - 100 RQD (%) - 63 Qu = 1,546 ksf
500	26						
498	28		Coring Terminated at 27.0 feet				

*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

BORING LOG

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
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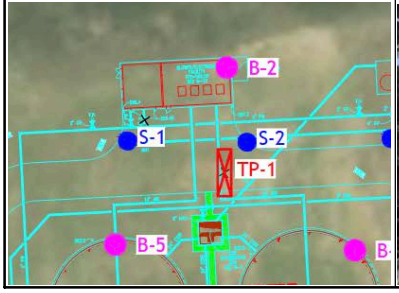
Fax: 888.792.3121

BORING: **B-2**

Project Number: LX190104	Weather: Cloudy, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 595.4	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/10/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/10/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
594	0		TOPSOIL - 4 inches				Dry upon completion of soil augering
		CL	LEAN CLAY (CL) - FIRM to VERY STIFF to STIFF, brown and gray, with sand, with black oxide nodules, moist	2-3-3 (6)	17		
592	2			4-6-10 (16)	18		
590	4			5-5-9 (14)	17		
588	6	CL	LEAN CLAY (CL) - VERY STIFF, orange and gray, with sand, with trace black oxide nodules, with some sandstone fragments, moist	5-10-13 (23)	18		
586	8			10-11-14 (25)	18		
584	10						
582	12		Auger Refusal at 11.7 feet				
580	14						
578	16						
576	18						
574	20						
572	22						
570	24						
568	26						
	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

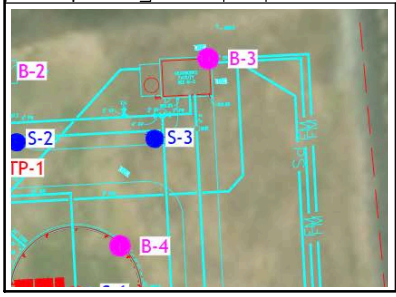
BORING LOG

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-3**

Project Number: LX190104	Weather: Cloudy, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 600.4	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/10/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/11/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
600	0		TOPSOIL - 3 inches	2-4-5 (9)	9		Dry upon completion of soil augering
			FILL - sampled as STIFF to FIRM, brown and tan mixed clay, with sand, with some black oxide nodules, moist				
598	2			2-4-4 (8)	14		
596	4			12-9-8 (17)	18		
594	6	CL	LEAN CLAY (CL) - VERY STIFF to HARD, orange and red, with sand, with some silt, with some sandstone lenses, moist	12-13-18 (31)	18		
592	8						
				50/2"	2		
590	10		SANDSTONE - HARD, orange and pink, highly weathered				No core water loss observed
			Auger Refusal at 9.4 feet Begin Coring at 9.4 feet				
588	12				55		REC (%) - 92 RQD (%) - 40
			SANDSTONE - MEDIUM HARD, pink, gray, and orange, medium to coarse grained				
586	14						Qu = 1,190 ksf
			SANDSTONE - HARD, orange and gray, medium grained				
584	16						REC (%) - 100 RQD (%) - 82
					60		
582	18						
			Coring Terminated at 19.4 feet				
580	20						
578	22						
576	24						
574	26						
572	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

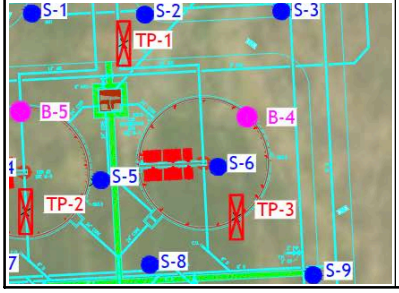
BORING LOG

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-4**

Project Number: LX190104 Name: Marion Waste Water Treatment Plant Client: Eclipse Engineers Location: Marion, Kentucky Logged By: C. Gibbs	Weather: Sunny, 80's Elevation (ft): 591.3 Date Started: 7/10/19 Date Completed: 7/11/19 Checked By: J. Cooke, P.E.	Contractor: Mathes Drilling Drill Rig: Mobile B-53 Method: SFA Hole Size (in): 4

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
590	0		TOPSOIL - 1 inch	1-2-3 (5)	15		Dry upon completion of soil augering
	2		FILL - sampled as FIRM, tan and brown mixed clay, with some fine roots, with some red oxide nodules, with some sand, moist	6-7-8 (15)	18		
588	4	CL	SANDY LEAN CLAY (CL) - STIFF to VERY STIFF, orange and tan, with some red oxide nodules, with some silt, moist	3-4-5 (9)	18		
586	6						
584	8			8-9-10 (19)	18		
582	10	CL	LEAN CLAY (CL) - STIFF, orange and gray, with sand, with silt, with sandstone fragments, moist	6-6-8 (14)	18		
580	12						
578	14		Auger Refusal at 14.0 feet Begin Coring at 14.0 feet				No core water loss observed
576	16		SANDSTONE - MEDIUM HARD, orange and gray, medium to coarse grained, with some shale lenses		58		REC (%) - 97 RQD (%) - 67
574	18						
572	20		Coring Terminated at 19.0 feet				
570	22						
568	24						
566	26						
564	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

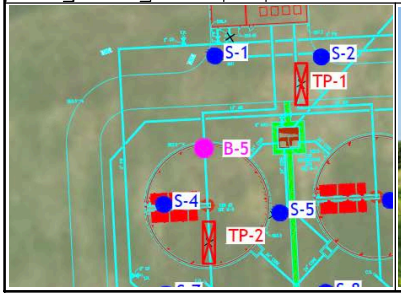
BORING LOG

BORING: **B-5**

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

Project Number: LX190104	Weather: Rainy, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 590.0	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/10/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/10/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
			TOPSOIL - 2 inches	1-5-5 (10)	16		Dry upon completion of soil augering
			FILL - sampled as STIFF, brown and tan clay, with sand, with some fine roots, with some black oxide nodules, moist				
588	2			5-6-7 (13)	18		
586	4	CL	LEAN CLAY (CL) - STIFF, orangish-tan and gray, with sand, with some silt, moist	3-4-6 (10)	18		
584	6						
582	8		LEAN CLAY (CL) - VERY STIFF to STIFF, orange and gray, with sand, with silt, with some red oxide staining, moist	5-7-10 (17)	18		
580	10	CL		4-6-7 (13)	18		
578	12						
576	14		Auger Refusal at 14.2 feet				
574	16						
572	18						
570	20						
568	22						
566	24						
564	26						
562	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

BORING LOG

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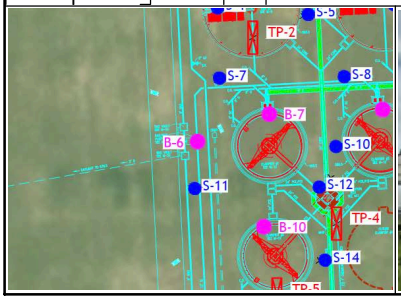
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-6**

Project Number: LX190104 Name: Marion Waste Water Treatment Plant Client: Eclipse Engineers Location: Marion, Kentucky Logged By: C. Gibbs	Weather: Sunny, 80's Elevation (ft): 587.3 Date Started: 7/10/19 Date Completed: 7/10/19 Checked By: J. Cooke, P.E.	Contractor: Mathes Drilling Drill Rig: Mobile B-53 Method: SFA Hole Size (in): 4

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
586	0	CL	TOPSOIL - 4 inches LEAN CLAY (CL) - FIRM, brown and tan, with sand, with some fine roots, with some black oxide nodules, moist	2-3-5 (8)	17		Dry upon completion of soil augering
	2			4-4-4 (8)	16		
584	4	CL	SANDY LEAN CLAY (CL) - FIRM to STIFF, orange and tan, with sand, with some black oxide nodules, moist	4-4-5 (9)	18		
582	6						
580	8	CL	LEAN CLAY (CL) - STIFF to VERY STIFF, orangish-tan and gray, with sand, with sandstone fragments (increasing with depth), moist	6-7-8 (15)	18		
578	10			3-14-15 (29)	11		
576	12						
574	14			4-12-15 (27)	14		
572	16						
570	18						
568	20		SHALE - HARD, tan and gray, sandy, highly weathered	15-28-50/5"	12		
566	22		Auger Refusal at 21.1 feet				
564	24						
562	26						
560	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

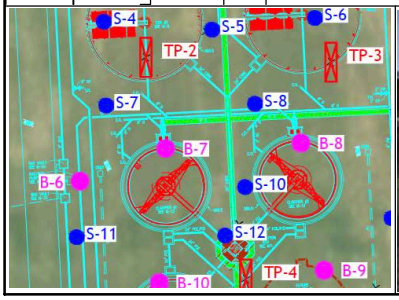
BORING LOG

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-7**

Project Number: LX190104	Weather: Sunny, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 587.6	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/10/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/10/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
			TOPSOIL - 3 inches	2-2-3 (5)	16		Dry upon completion of soil augering
586	2		FILL - sampled as FIRM, orange and tan, with some orange mottling, with sand, with some black oxide nodules, moist	3-3-5 (8)	16		
584	4	CL	LEAN CLAY (CL) - FIRM to STIFF to VERY STIFF, tan and gray, with some orange mottling, with sand, with some black oxide nodules, moist	3-5-7 (12)	13		
582	6						
580	8			6-7-10 (17)	18		
578	10	CL	SANDY LEAN CLAY (CL) - FIRM, tan and orange, with sand, with trace black oxide nodules, moist	2-3-3 (6)	17		
576	12						
574	14	CL	LEAN CLAY (CL) - STIFF to VERY STIFF, orange and gray, sandy, with some sandstone fragments (increasing with depth), moist	4-6-9 (15)	15		
572	16						
570	18						
568	20			6-10-14 (24)	18		
566	22						
564	24			11-15-20 (35)	18		
562	26		SANDSTONE - HARD, gray to orange, highly weathered				
			Auger Refusal at 26.7 feet				
560	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

BORING LOG

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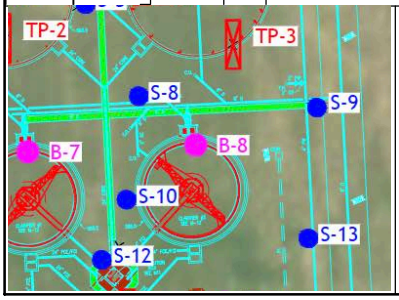
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-8**

Project Number: LX190104	Weather: Sunny, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 587.8	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/10/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/11/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
			TOPSOIL - 2 inches	1-2-3 (5)	15		Dry upon completion of soil augering
586	2		FILL - sampled as FIRM to SOFT, brown and gray mixed clay, with sand, with roots, with some black oxide nodules, moist	2-2-2 (4)	11		
584	4	CL	SANDY LEAN CLAY (CL) - FIRM, orange and tan, with trace black oxide staining, with some silt, moist	2-2-3 (5)	18		
582	6		LEAN CLAY (CL) - STIFF to HARD with FIRM zone, orange, tan, and gray, with sand, with some red oxide nodules, with some weathered sandstone fragments, moist	4-5-7 (12)	18		
580	8						
578	10			3-3-4 (7)	17		
576	12	CL					
574	14			3-6-7 (13)	18		
572	16						
570	18						
568	20			50/2"	0		No core water loss observed
566	22		Auger Refusal at 19.5 feet Begin Coring at 19.5 feet SANDSTONE - HARD, gray, with some interbedded shale, medium to coarse grained		60		REC (%) - 100 RQD (%) - 65 Qu = 1,143 ksf
564	24						
562	26		Coring Terminated at 24.5 feet				
560	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

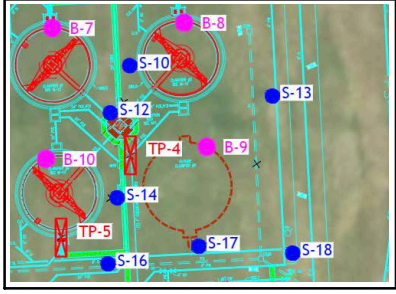
BORING LOG

BORING: **B-9**

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

Project Number: LX190104 Name: Marion Waste Water Treatment Plant Client: Eclipse Engineers Location: Marion, Kentucky Logged By: C. Gibbs	Weather: Sunny, 70's Elevation (ft): 585.9 Date Started: 7/10/19 Date Completed: 7/10/19 Checked By: J. Cooke, P.E.	Contractor: Mathes Drilling Drill Rig: Mobile B-53 Method: SFA Hole Size (in): 4

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
			TOPSOIL - 2 inches	2-3-4 (7)	16		
584	2		FILL - sampled as FIRM to SOFT, brown and gray mixed clay, with sand, with black oxide nodules, with some buried organics (roots), moist	3-3-3 (6)	18		
582	4			1-2-2 (4)	10		
580	6	CL	LEAN CLAY (CL) - SOFT to FIRM, gray, with sand, with trace black oxide nodules, with trace fine roots, moist	3-3-4 (7)	15		
578	8						
576	10		LEAN CLAY (CL) - FIRM to STIFF to HARD, orangish-tan and gray, with sand, with trace black oxide nodules, with trace fine roots, with some weathered shale fragments below 19.5 feet, moist	2-3-4 (7)	14		
574	12						
572	14			4-4-5 (9)	17	▽	Water observed at 14.5 feet
570	16	CL					
568	18						
566	20			10-15-19 (34)	18		
564	22						
562	24			16-35-50/1"	10		
			Weathered Sandstone				
560	26		Auger Refusal at 25.4 feet				
558	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

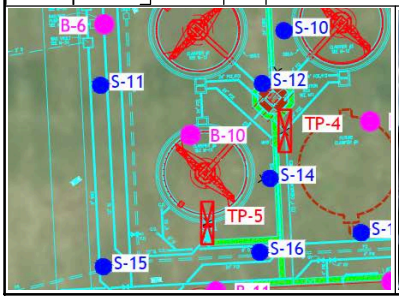
BORING LOG

BORING: **B-10**

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

Project Number: LX190104	Weather: Sunny, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 585.6	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/10/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/11/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
			TOPSOIL - 3 inches	2-3-4 (7)	13		Dry upon completion of soil augering
584	2	CL	LEAN CLAY (CL) - FIRM, brown and gray, with some sand, with some fine roots, with some black oxide nodules, with silt, moist	3-3-4 (7)	16		
582	4	CL	SANDY LEAN CLAY (CL) - FIRM to STIFF, orange and tan, with some black oxide nodules, with some silt, moist	2-3-4 (7)	18		
580	6	CL					
578	8	CL		6-7-8 (15)	18		
576	10	CL		3-6-7 (13)	18		
574	12	CL	LEAN CLAY (CL) - STIFF to HARD, gray, with some orange mottling, with sand, with some sandstone fragments, moist				
572	14	CL		4-6-8 (14)	18		
570	16	CL					
568	18	CL					
566	20	CL		15-20-21 (41)	15		
564	22		SANDSTONE - HARD, orange and red, weathered				
562	24		Auger Refusal at 22.6 feet Begin Coring at 22.6 feet SHALE - MEDIUM HARD, light to dark gray, weathered, fine to coarse grained		60		No core water loss observed REC (%) - 100 RQD (%) - 57
560	26						
558	28		Coring Terminated at 27.6 feet				



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
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BORING LOG

Consulting Services Incorporated
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Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-11**

Project Number: LX190104 Name: Marion Waste Water Treatment Plant Client: Eclipse Engineers Location: Marion, Kentucky Logged By: C. Gibbs	Weather: Sunny, 80's Elevation (ft): 583.4 Date Started: 7/9/19 Date Completed: 7/9/19 Checked By: J. Cooke, P.E.	Contractor: Mathes Drilling Drill Rig: Mobile B-53 Method: SFA Hole Size (in): 4

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
582	0		TOPSOIL - 3 inches				
	2	CL	LEAN CLAY (CL) - FIRM, gray and orange, with some sand, with some black oxide staining, with trace fine roots, moist	1-2-3 (5)	15		
580				2-3-3 (6)	17		
	4			2-3-3 (6)	18		
578	6						
576	8	CL	LEAN CLAY (CL) - STIFF, brown, with black oxide staining, with some sand, moist	4-5-6 (11)	18		
574	10			3-4-5 (9)	18		
572	12						
570	14						
568	16	CL	LEAN CLAY (CL) - VERY STIFF, orange and gray, with some black oxide staining, with sand, with weathered sandstone fragments below 15 feet, moist	6-8-12 (20)	18	▽	Water observed at 15 feet
566	18						
564	20		Auger Refusal at 19.0 feet				
562	22						
560	24						
558	26						
556	28						

*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

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Right Photo: Photo of Boring

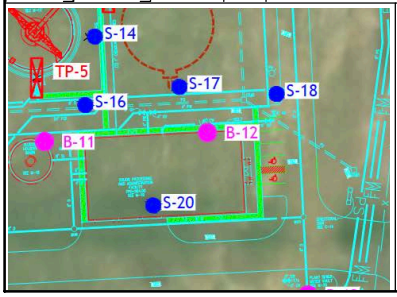
BORING LOG

BORING: **B-12**

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

Project Number: LX190104 Name: Marion Waste Water Treatment Plant Client: Eclipse Engineers Location: Marion, Kentucky Logged By: C. Gibbs	Weather: Sunny, 80's Elevation (ft): 584.0 Date Started: 7/9/19 Date Completed: 7/9/19 Checked By: J. Cooke, P.E.	Contractor: Mathes Drilling Drill Rig: Mobile B-53 Method: SFA Hole Size (in): 4

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
			TOPSOIL - 2 inches	2-5-5 (10)	15		
582	2		FILL - sampled as STIFF to FIRM, gray and orange mixed clay, with some sand, with some fine roots, with buried organics (topsoil, roots) from 4.5 feet to 4.9 feet, moist	3-3-5 (8)	17		
580	4			3-2-3 (5)	12		
578	6	CL	LEAN CLAY (CL) - STIFF, gray, with some black oxide staining, with trace fine roots, with some sand, moist	3-4-5 (9)	18		
576	8		SANDY LEAN CLAY (CL) - FIRM, orange and tan, with some black oxide nodules, with some silt, moist	3-3-5 (8)	16		
574	10	CL					
572	12						
570	14			3-4-6 (10)	18		
568	16	CL	LEAN CLAY (CL) - STIFF, orange and gray, with sand, with black oxide staining, with weathered sandstone fragments, with some silt, moist				
566	18						
564	20		SANDSTONE - HARD, tan to orange, highly weathered	26-30-50/4"	12	▽	Water observed at 19.5 feet
562	22						
560	24			13-26-29 (55)	16		
558	26		Boring Terminated at 25.5 feet				
556	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

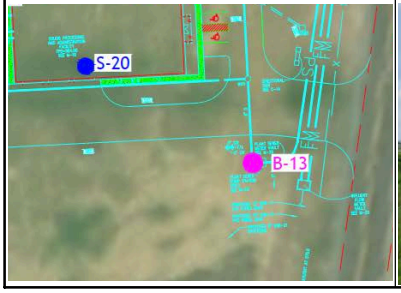
BORING LOG

BORING: **B-13**

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

Project Number: LX190104	Weather: Sunny, 80's	Contractor: Mathes Drilling
Name: Marion Waste Water Treatment Plant	Elevation (ft): 582.5	Drill Rig: Mobile B-53
Client: Eclipse Engineers	Date Started: 7/9/19	Method: SFA
Location: Marion, Kentucky	Date Completed: 7/9/19	Hole Size (in): 4
Logged By: C. Gibbs	Checked By: J. Cooke, P.E.	

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
582	0		TOPSOIL - 4 inches				Dry upon completion of soil augering
		CL	LEAN CLAY (CL) - FIRM, orange, with some gray mottling, with some fine roots, with some sand, moist	1-3-5 (8)	10		
580	2			3-3-4 (7)	15		
578	4	CL	SANDY LEAN CLAY (CL) - STIFF, orange and tan, with some black oxide staining, with some silt, moist	2-5-6 (11)	14		
576	6			6-5-6 (11)	14		
574	8						
572	10	CL	LEAN CLAY (CL) - STIFF, orange and gray, with some black oxide nodules, with trace weathered sandstone fragments, with sand, with silt, moist	4-4-5 (9)	12		
570	12						
568	14	CL	LEAN CLAY (CL) - VERY STIFF, gray, with some orange mottling, with sand, with trace sandstone fragments, moist	4-9-12 (21)	17		
566	16						
564	18		SANDSTONE - HARD, orange and gray, highly weathered				
562	20			12-14-19 (33)	16		
560	22						
558	24			25-50/2"	6		
556	26		Auger Refusal at 25.3 feet				
554	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
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BORING LOG

Consulting Services Incorporated
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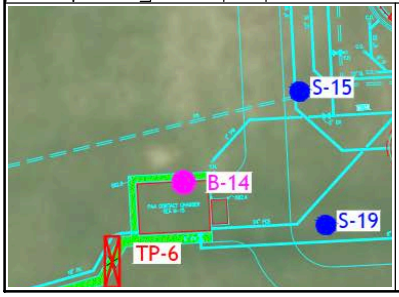
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-14**

Project Number: LX190104 Name: Marion Waste Water Treatment Plant Client: Eclipse Engineers Location: Marion, Kentucky Logged By: C. Gibbs	Weather: Sunny, 80's Elevation (ft): 582.9 Date Started: 7/9/19 Date Completed: 7/11/19 Checked By: J. Cooke, P.E.	Contractor: Mathes Drilling Drill Rig: Mobile B-53 Method: SFA Hole Size (in): 4

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
582	0		TOPSOIL - 3 inches	1-2-1 (3)	10		Dry upon completion of soil augering
		CL	LEAN CLAY (CL) - SOFT, gray, with some roots, with black oxide staining, moist				
580	2			2-3-5 (8)	13		
		CL	SANDY LEAN CLAY (CL) - FIRM, orange and tan, with some weathered sandstone fragments, moist				
578	4			12-11-15 (26)	16		
			SANDSTONE - HARD, light gray and orange, with some red, with some sandy clay seams, weathered				
576	6			20/3"	2		
			Auger Refusal at 7.1 feet Begin Coring at 7.1 feet				No core water loss observed
574	8						
			SANDSTONE - MEDIUM HARD, red, orange, and gray, medium to coarse grained, weathered to highly weathered				REC (%) - 95 RQD (%) - 33
572	10						
	12				114		
570							
568	14						
	16						
566							
	18		SANDSTONE - MEDIUM HARD, orange and gray, with some interbedded shale, medium to coarse grained				REC (%) - 72 RQD (%) - 65
564							
	20				43		
562							
	22		Coring Terminated at 22.1 feet				
560							
	24						
558							
	26						
556							
	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

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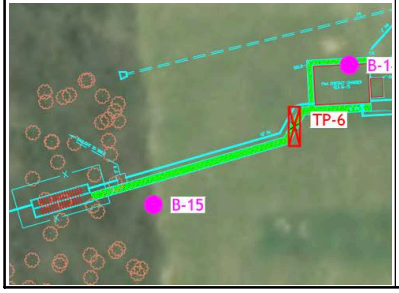
BORING LOG

Consulting Services Incorporated
858 Contract Street
Lexington, Kentucky 40505
Phone: 859.309.6021
Fax: 888.792.3121

BORING: **B-15**

Project Number: LX190104 Name: Marion Waste Water Treatment Plant Client: Eclipse Engineers Location: Marion, Kentucky Logged By: C. Gibbs	Weather: Sunny, 70's Elevation (ft): 575.7 Date Started: 7/10/19 Date Completed: 7/10/19 Checked By: J. Cooke, P.E.	Contractor: Mathes Drilling Drill Rig: Mobile B-53 Method: SFA Hole Size (in): 4

Elev. (ft)	Depth (ft)	Symbol	Description	Blow Counts (N Value)	Recov. (in)	Water Level	Remarks
574	0		TOPSOIL - 6 inches	1-1-2 (3)	11		Dry upon completion of soil augering
		CL	LEAN CLAY (CL) - SOFT, brown, with sand, with some black oxide staining, moist				
	2			17-50/2"	6		
572	4		SANDSTONE - HARD, orange and pink, with sand, highly weathered	30-50/2"	8		
570	6		Auger Refusal at 6.2 feet				
568	8						
566	10						
564	12						
562	14						
560	16						
558	18						
556	20						
554	22						
552	24						
550	26						
548	28						



*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Left Photo: Photo of Boring Location
Right Photo: Photo of Boring

SUMMARY OF SOUNDINGS

Marion Waste Water Treatment Plant

Marion, Kentucky

CSI Project No. LX190104

Sounding	Elevation (ft)*	Depth to Bedrock (ft)
S-1	591.8	15.8
S-2	592.6	12.6
S-3	596.0	8.0
S-4	589.1	20.0
S-5	589.9	13.7
S-6	589.7	14.6
S-7	588.2	20.0
S-8	588.7	19.0
S-9	588.3	17.8
S-10	586.9	25.0
S-11	586.3	11.0
S-12	586.1	19.0
S-13	586.1	24.0
S-14	585.0	21.7
S-15	583.5	9.7
S-16	583.7	17.5
S-17	584.3	24.5
S-18	583.7	21.5
S-19	582.6	11.0
S-20	582.7	20.0

* Elevations were determined using Real Time Kinematic Differential GPS referencing the KYCORS network.

Test Pit: TP-1

Elevation (ft): 591.6

Elev. (ft)	Depth (ft)	Description	DCP	Samples	Symbol	Remarks	Photos
591	0	TOPSOIL - 6 inches				Dry upon completion of soil excavation	
	1	FILL - tan and brown clay, with plastic pipe (approximately 14" long), with some black oxide nodules, with some sand, moist					
590	2	LEAN CLAY (CL) - light reddish-brown and gray, with some black oxide nodules, with sand, moist					
589	3						
588	4						
587	5						
586	6	Test Pit Terminated at 6.0 feet					
585	7						
584							

SAMPLE LEGEND: Grab Sample

*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Consulting Services Incorporated
858 Contract Street
Lexington, KY 40505
Phone: 859.309.6021
Fax: 888.792.3121

CLIENT: Eclipse Engineers
PROJECT: Marion Waste Water Treatment Plant
LOCATION: Marion, Kentucky
JOB NUMBER: LX190105
LOGGED BY: R. Barajas
APPROVED BY: J. Cooke, P.E.

CONTRACTOR: City of Marion Personnel
EQUIPMENT: Case Series 2 Backhoe
METHOD: 24" bucket
DATE STARTED: 7/11/2019
DATE COMPLETED: 7/11/2019
WEATHER: Sunny, 80's

Test Pit: TP-2

Elevation (ft): 589.5

Elev. (ft)	Depth (ft)	Description	DCP	Samples	Symbol	Remarks	Photos
589		TOPSOIL - 6 inches				Dry upon completion of soil excavation	
	1	FILL - tan and light gray, with fine roots, with some black oxide staining, with sand, moist					
588							
	2						
587		LEAN CLAY (CL) - tan and brown, with black oxide nodules, with sand, moist					
	3						
586							
	4						
585							
	5						
584							
	6	Test Pit Terminated at 6.0 feet					
583							
	7						
582							

SAMPLE LEGEND: Grab Sample

*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Consulting Services Incorporated
858 Contract Street
Lexington, KY 40505
Phone: 859.309.6021
Fax: 888.792.3121

CLIENT: Eclipse Engineers
PROJECT: Marion Waste Water Treatment Plant
LOCATION: Marion, Kentucky
JOB NUMBER: LX190105
LOGGED BY: R. Barajas
APPROVED BY: J. Cooke, P.E.

CONTRACTOR: City of Marion Personnel
EQUIPMENT: Case Series 2 Backhoe
METHOD: 24" bucket
DATE STARTED: 7/11/2019
DATE COMPLETED: 7/11/2019
WEATHER: Sunny, 80's

Test Pit: TP-3

Elevation (ft): 589.6

Elev. (ft)	Depth (ft)	Description	DCP	Samples	Symbol	Remarks	Photos
589	0	TOPSOIL - 5 inches				Dry upon completion of soil excavation	
	1	FILL - reddish-brown and dark gray clay, with some fine roots, with sand, with black oxide nodules, moist					
588	2						
587	3	LEAN CLAY (CL) - light gray and tan, sandy, with black oxide nodules, moist					No Photo Available
586	4						
585	5						
584	6	Test Pit Terminated at 6.0 feet					
583	7						
582							

SAMPLE LEGEND: Grab Sample

*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Consulting Services Incorporated
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Lexington, KY 40505
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Fax: 888.792.3121

CLIENT: Eclipse Engineers
PROJECT: Marion Waste Water Treatment Plant
LOCATION: Marion, Kentucky
JOB NUMBER: LX190105
LOGGED BY: R. Barajas
APPROVED BY: J. Cooke, P.E.

CONTRACTOR: City of Marion Personnel
EQUIPMENT: Case Series 2 Backhoe
METHOD: 24" bucket
DATE STARTED: 7/11/2019
DATE COMPLETED: 7/11/2019
WEATHER: Sunny, 80's

Test Pit: TP-4

Elevation (ft): 585.5

Elev. (ft)	Depth (ft)	Description	DCP	Samples	Symbol	Remarks	Photos
585		TOPSOIL - 3 inches					
		FILL - dark brown and gray clay, with fine roots, with sand, moist					
	1						
584							
	2						
583							
	3	LEAN CLAY (CL) - dark gray and tan, sandy, with some black oxide nodules, moist to wet					
582							
	4						
581							
	5						
580							
	6	Test Pit Terminated at 6.0 feet				Water encountered at 6.0 feet	
579							
	7						
578							

SAMPLE LEGEND: Grab Sample

*Elevations were determinted using Real Time Kinematic Differential GPS referencing the KYCORS network.

Consulting Services Incorporated
858 Contract Street
Lexington, KY 40505
Phone: 859.309.6021
Fax: 888.792.3121

CLIENT: Eclipse Engineers
PROJECT: Marion Waste Water Treatment Plant
LOCATION: Marion, Kentucky
JOB NUMBER: LX190105
LOGGED BY: R. Barajas
APPROVED BY: J. Cooke, P.E.

CONTRACTOR: City of Marion Personnel
EQUIPMENT: Case Series 2 Backhoe
METHOD: 24" bucket
DATE STARTED: 7/11/2019
DATE COMPLETED: 7/11/2019
WEATHER: Sunny, 80's

Test Pit: TP-5

Elevation (ft): 584.0

Elev. (ft)	Depth (ft)	Description	DCP	Samples	Symbol	Remarks	Photos
		TOPSOIL - 6 inches				Dry upon completion of soil excavation	
583	1	FILL - tan, gray, and dark brown clay, with fine roots, with plastic pipe (approximately 12" long), with sand, moist					
582	2						
581	3	LEAN CLAY (CL) - tan and brown, with sand, with some black oxide nodules, moist					
580	4	LEAN CLAY (CL) - tan and light gray, sandy, with black oxide staining, moist to wet					
579	5						
578	6						
577	7	Test Pit Terminated at 7.0 feet					

SAMPLE LEGEND: Grab Sample

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METHOD: 24" bucket
DATE STARTED: 7/11/2019
DATE COMPLETED: 7/11/2019
WEATHER: Sunny, 80's

Test Pit: TP-6

Elevation (ft): 582.4

Elev. (ft)	Depth (ft)	Description	DCP	Samples	Symbol	Remarks	Photos
582		TOPSOIL - 4 inches				Dry upon completion of soil excavation	
	1	FILL - tan, brown, and light gray clay, with sand, with some black oxide staining, moist					
581							
	2						
580							
	3	LEAN CLAY (CL) - orangish and brown, with sand, with some blakc oxide nodules, with weathered sandstone fragments, moist					
579		Weathered Sandstone					
	4	Equipment Refusal at 4.0 feet					
578							
	5						
577							
	6						
576							
	7						
575							

SAMPLE LEGEND: Grab Sample

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EQUIPMENT: Case Series 2 Backhoe
METHOD: 24" bucket
DATE STARTED: 7/11/2019
DATE COMPLETED: 7/11/2019
WEATHER: Sunny, 80's

FIELD TESTING PROCEDURES

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

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

a. 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 "refusal materials." Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams, 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 the chief driller. The record contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as coarse gravel, cobbles, etc., 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 soil and rock samples plus the field boring records are reviewed by a geotechnical engineer. The engineer classifies the soils in general accordance with the procedures outlined in ASTM D 2488 and prepares the final boring records, which 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 engineering examinations and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at these boring locations. The lines designating the interface between soil or refusal materials on the records and on profiles represent approximate boundaries. The transition between materials may be gradual. 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 penetration testing were performed in accordance with ASTM D 1586.

The borings were made by mechanically twisting a hollow stem steel auger into the soil. At regular intervals, the drilling tools were removed and soil 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 cuttings, then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "penetration resistance". The penetration resistance, when properly evaluated, is an index to the soil strength and foundation supporting capability.

Representative portions of the soil samples, thus obtained, were placed in glass jars and transported to the laboratory. In the laboratory, the samples were examined to verify the driller's field classifications. Test Boring Records are attached which graphically show the soil descriptions and penetration resistances.

Core Drilling: Refusal materials are materials that cannot be penetrated with the soil drilling methods employed. Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

Prior to coring, casing is set in the drilled hole through the overburden soils, if necessary, to keep the hole from caving. Refusal materials are then cored according to ASTM D 2113 using a diamond-studded bit fastened to the end of a hollow double tube core barrel. This device is rotated at high speeds, and the cuttings are brought to the surface by circulating water. Core samples of the material penetrated are protected and retained in the swivel-mounted inner tube. Upon completion of each drill run, the core barrel is brought to the surface, the core recovered is measured, the samples are removed and the core is placed in boxes for storage.

The core samples are returned to our laboratory where the refusal material is identified and the percent core recovery and rock quality designation is determined by a soils engineer or geologist. The percent core recovery is the ratio of the sample length obtained to the depth drilled, expressed as a percent. The rock quality designation (RQD) is obtained by summing up the length of core recovered, including only the pieces of core which are four inches or longer, and dividing by the total length drilled. The percent core recovery and RQD are related to soundness and continuity of the refusal material. Refusal material descriptions, recoveries, and RQDs are shown on the "Test Boring Records".

Hand Auger Borings and Dynamic Cone Penetration Testing: Hand auger borings are performed manually by CSI field personnel. This consists of manually twisting hand auger tools into the subsurface and extracting “grab” or baggie samples at intervals determined by the project engineer. At the sample intervals, dynamic cone penetration (DCP) testing is performed. This testing involves the manual raising and dropping of a 20-pound hammer, 18 inches. This “driver” head drives a solid-13/4 inch diameter cone into the ground. DCP “counts” are the number of drops it takes for the hammer to drive three 13/4 inch increments, recorded as X-Y-Z values.

Test Pits: Test pits are excavated by the equipment available, often a backhoe or trackhoe. The dimensions of the test pits are based on the equipment used and the power capacity of the equipment. Samples are taken from the spoils of typical buckets of the excavator and sealed in jars or “Ziploc” baggies. Dynamic Cone Penetration or hand probe testing is often performed in the upper few feet as OSHA standards allow. Refusal is deemed as the lack of advancement of the equipment with reasonable to full machine effort.

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 soils are encountered (clayey soils) the amount of water seepage 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 may also be dependent upon the amount of precipitation at the site 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 crews as the drilling tools are advanced. The time of boring water level is detected by changes in the drilling rate, soil samples obtained, etc. Additional water table readings are generally obtained at least 24 hours after the borings are completed. The time lag of at least 24 hours is used to permit stabilization of the ground water table, which has been disrupted by the drilling operations. The readings are taken by dropping a weighted line down the boring or using an electrical probe to detect the water level surface.

Occasionally the borings will cave-in, preventing water level readings from being obtained or trapping drilling water above the caved-in zone. The cave-in depth is also measured and recorded on the boring records.

Summary of Laboratory Results

Borehole	Depth	Sample Type	Liquid Limit	Plastic Limit	Plasticity Index	Class-ification	Water Content (%)	Unconfined Compressive Strength (ksf)	Dry Density (pcf)	Wet Density (pcf)	Max. Dry Density (pcf)	Opt. Water Content (%)	CBR	Swell (%)	RQD	Percent Recovery	k (cm/sec)	% Finer #200
B-1	4.0	SS					19.4											
B-1	6.5	SS	25	15	10	CL	20.1											62.3
B-1	9.0	SS					17.0											
B-1	26.0	RC						1546										
B-2	4.0	SS					15.7											
B-2	9.0	SS					19.7											
B-3	14.4	RC						1190										
B-4	1.5	SS					17.7											
B-4	4.0	SS					23.6											
B-6	4.0	SS	29	16	13	CL	16.9											
B-6	6.5	SS					18.1											79.8
B-6	9.0	SS					19.3											
B-8	22.3	RC						1143										
B-9	9.0	SS					19.6											
B-9	14.0	SS					22.4											
B-9	19.0	SS					18.2											
B-11	1.5	SS					19.3											
B-11	4.0	SS	35	22	13	CL	22.7											97.2
B-11	6.5	SS					18.9											
B-11	9.0	SS					21.9											
B-13	6.5	SS					18.9											
B-13	9.0	SS					19.7											
B-13	14.0	SS					18.4											
B-13	19.0	SS					18.5											
B-14	1.5	SS					18.8											
B-14	4.0	SS					20.1											

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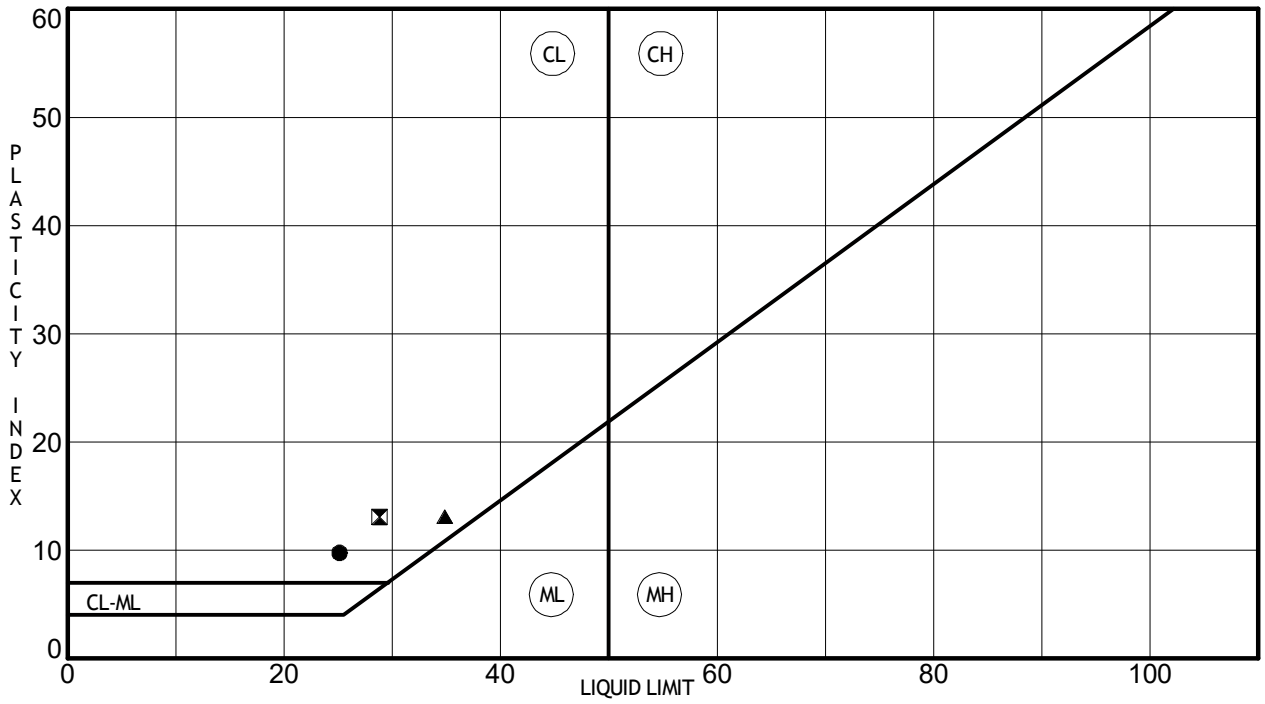
SS - Split Spoon Sample
GRAB - Bulk Grab Sample
k - Coefficient of Permeability
- See Attached test Results

PROJECT INFORMATION

Client: Eclipse Engineers
Project Name: Marion Waste Water Treatment Plant
Project Number: LX190104
Project Location: Marion, Kentucky

Liquid and Plastic Limits Test Report



	Boring	Depth (ft)	LL	PL	PI	Water Content	% < #40	% < #200	USCS	Description
●	B-1	6.5	25	15	10	20.1		62.3	CL	gray SANDY LEAN CLAY
⧓	B-6	4.0	29	16	13	16.9		79.8	CL	orange and tan LEAN CLAY with SAND
▲	B-11	4.0	35	22	13	22.7		97.2	CL	gray and orange LEAN CLAY

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PROJECT INFORMATION

Client: Eclipse Engineers
Project Name: Marion Waste Water Treatment Plant
Project Number: LX190104
Project Location: Marion, Kentucky

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 soil classification two laboratory tests are necessary: grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D 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.

Rock Classification: Rock classifications provide a general guide to the engineering properties of various rock types and enable the engineer to apply past experience to current situations. In our explorations, rock core samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The rock cores are classified according to relative hardness and RQD (see Guide to Rock Classification Terminology), color, and texture. These classification descriptions are included on our Test Boring Records.

Atterberg Limits: Portions of the samples are taken for Atterberg 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 is sufficiently plastic to be manually rolled into tiny threads. The liquid limit and plastic limit are determined in accordance with ASTM D 4318.

Moisture Content: The Moisture Content is determined according to ASTM D 2216.

Percent Finer Than 200 Sieve: Selected samples of soils are washed through a number 200 sieve to determine the percentage of material less than 0.074 mm in diameter.

Rock Strength Tests: To obtain strength data for rock materials encountered, unconfined compression tests are performed on selected samples. In the unconfined compression test, a cylindrical portion of the rock core is subjected to increasing axial load until it fails. The pressure required to produce failure is recorded, corrected for the length to diameter ratio of the core and reported.

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 samples 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 mold and compacted with a compaction hammer. Both tests have three alternate methods.

Test	Method	Hammer Wt./ Fall	Mold Diam.	Run on Material Finer Than	No. of Layers	No. of Blows/ Layer
Standard D 698	A	5.5 lb./12"	4"	No. 4 sieve	3	25
	B	5.5 lb./12"	4"	3/8" sieve	3	25
	C	5.5 lb./12"	6"	3/4" sieve	3	56

Test	Method	Hammer Wt./ Fall	Mold Diam.	Run on Material Finer Than	No. of Layers	No. of Blows/ Layer
Modified D 15557	A	10 lb./18"	4"	No. 4 sieve	5	25
	B	10 lb./18"	4"	3/8" sieve	5	25
	C	10 lb./18"	6"	3/4" sieve	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.

Laboratory California Bearing Ratio Tests: The California Bearing Ratio, generally abbreviated to CBR, is a punching shear test and is a comparative measure of the shearing resistance of a soil. It provides data that is a semi-empirical index of the strength and deflection characteristics of a soil. The CBR is used with empirical curves to design pavement structures.

A laboratory CBR test is performed according to ASTM D 1883. The results of the compaction tests are utilized in compacting the test sample to the desired density and moisture content for the laboratory California Bearing Ratio test. A representative sample is compacted to a specified density at a specified moisture content. The test is performed on a 6-inch diameter, 4.58-inch-thick disc of compacted soil that is confined in a cylindrical steel mold. The sample is compacted in accordance with Method C of ASTM D 698 or D 1557.

CBR tests may be run on the compacted samples in either soaked or unsoaked conditions. During testing, a piston approximately 2 inches in diameter is forced into the soil sample at the rate of 0.05 inch per minute to a depth of 0.5 inch to determine the resistance to penetration. The CBR is the percentage of the load it takes to penetrate the soil to a 0.1 inch depth compared to the load it takes to penetrate a standard crushed stone to the same depth. Test results are typically shown graphically.

Consolidation Tests: Consolidation tests are conducted on representative soil samples to determine the change in height of the sample with increasing load. The results of these tests are used to estimate the settlement and time rate of settlement of structures constructed on similar soils. A consolidation test is performed according to ASTM D2435 on a single section of an undisturbed sample extruded from a sample tube. The sample is trimmed into a disc 2.5 inches in diameter and 0.75 inch thick. The disc is confined in a stainless steel ring and sandwiched between porous plates. It is then subjected to incrementally increasing vertical loads, and the resulting deformations are measured with a micrometer dial gauge. Void ratio are then calculated from these deformation readings. The test results are typically provided in tabular form or in the form of plots of void ratio versus applied stress (e-log p curves).

Organic Content: The Organic Content is determined according to ASTM D2974. The moisture content is first determined by drying portions of the sample at 105 degrees Celsius. The ash content is then determined by igniting the oven-dried sample from the moisture content determination in a muffle furnace at 440 degrees Celsius. The substance remaining after ignition is the ash. The organic content is expressed as a percentage by subtracting the percent ash from one hundred.

Direct Shear Tests: Direct shear tests are performed according to ASTM D3080 to determine the shear strength parameters of the soil. The specimen of soil is placed in a rigid box that is divided horizontally into two frames. The specimen is then confined under a vertical or normal stress and horizontal force is applied to fail the specimen along a horizontal plane at its mid-height.

Because drainage of the soil specimen cannot be easily controlled, undrained tests (i.e., UU and CU tests) are possible only on impervious soils and pore pressure measurements cannot be made. Drained tests (i.e., CD tests), however, are possible on all soil types. Since the drainage paths through the specimen are short and pore water pressures are dissipated fairly rapidly, the direct shear test is well suited to the CD test.

A minimum of three test specimens are required to establish the strength envelope of a soil. The soil parameters obtained are the cohesion and angle of internal friction.

Unconfined Compression Tests: The unconfined compression test is an unconsolidated-undrained triaxial shear test with no lateral confining pressure. This test is used to determine the shear strength of clayey soils. An unconfined compression test is performed according to ASTM D2166 on a single section of an undisturbed sample extruded from a sampling tube. The sample is trimmed to a length-to-diameter ratio of about 2 and placed in the testing device. Incrementally increasing vertical loads are applied until the sample fails. Test results are provided in the form of a stress-strain curve or a value representing the unconfined compressive strength of the sample.

Grain Size Tests: Grain Size Tests are performed to determine the soil classification and the grain size distribution. The soil samples are prepared for testing according to ASTM D421 (dry preparation) or ASTM D2217 (wet preparation). The grain size distribution of soils coarser than a number 200 sieve (0.074 mm opening) is determined by passing the samples through a standard set of nested sieves. Materials passing the number 200 sieve are suspended in water and the grain size distribution calculated from the measured settlement rate. These tests are conducted in accordance with ASTM D422.

Triaxial Shear Tests: Triaxial shear tests are used to determine the strength characteristics and friction angle of a given soil sample. Triaxial tests are also used to determine the elastic properties of the soil specimen. Triaxial shear tests are performed on several sections of a relatively undisturbed sample extruded from the sampling tube. The samples are trimmed into cylinders 1.4 to 2.8 inches in diameter and encased in rubber membranes. Each is then placed in a compression chamber and confined by all around water pressure. Samples are then subjected to additional axial and/or lateral loads, depending on the soil and the field conditions to be simulated. The test results are typically presented in tabular form or in the form of stress-strain curves and Mohr envelopes or p-q plots.

Three types of triaxial tests are normally performed. The most suitable type of triaxial test is determined by the loading conditions imposed on the soil in the field and the soil characteristics.

1. Consolidated-Undrained (designated as a CU or R Test).

2. Consolidated-Drained (designated as a CD or S Test).

3. Unconsolidated-Undrained (designated as a UU or Q Test).