GEOTECHNICAL EXPLORATION
ELEPHANT MANAGEMENT FACILITY - ADDITIONS AND ALTERATIONS
SAINT LOUIS ZOO
ST. LOUIS, MISSOURI

Prepared for:

SAINT LOUIS ZOO
ST. LOUIS, MISSOURI

Prepared by:

GEOTECHNOLOGY, LLC, DBA UES.
ST. LOUIS, MISSOURI

Date:

AUGUST 26, 2024

Project No.:

J046147.01

SAFETY
TEAMWORK
RESPONSIVENESS
INTEGRITY
VALUE
EXCELLENCE

August 26, 2024

Ms. Marta Comas
Saint Louis Zoo
One Government Drive
St. Louis, Missouri 63110

Re: Geotechnical Exploration
Elephant Management Facility - Additions and Alterations
Saint Louis Zoo
St. Louis, Missouri
UES Project No. J046147.01

Dear Ms. Comas:

Presented in this report are the results of our geotechnical exploration completed for the Elephant Management Facility – Additions and Alterations in St. Louis, Missouri. Our services were performed in general accordance with our Proposal P046147.01, which was dated June 28, 2024, and authorized on July 11, 2024.

We appreciate the opportunity to provide geotechnical services for this project. If you have any questions regarding this report, or if we can be of any additional service to you, please do not hesitate to contact us.

Respectfully submitted,

UES

STATE OF MISSOURI
ANTHONY W. ROTH
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PROFESSIONAL ENGINEER
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EXECUTIVE SUMMARY

The executive summary is provided solely for the purpose of overview and a number of details are omitted, each of which could be crucial to the recommended application of this report. A party who relies on this report should read the entire report.

- The project involves the design and construction of an addition and alterations to the existing Elephant Management Facility at the Saint Louis Zoo River's Edge campus located at One Government Drive in St. Louis, Missouri.

- Structural loads were not provided. Based on our experience with similar projects we have assumed that maximum column and wall loads will not exceed 150 kips per column, 6 kips per lineal foot, and 200 pounds per square foot for slabs, respectively.

- The site stratigraphy comprises random fill, fat and lean clay, and shale. Borings were terminated at a depth of approximately 25 feet. Groundwater was encountered in one boring at 9 feet.

- The existing fill is considered uncontrolled and potentially compressible. Existing fill materials should be entirely removed and replaced from the footprint of the proposed addition. The fill should also be removed to a minimum depth of 2 feet below pavement subgrades and two times the footing width below low retaining walls and other lightly loaded structures. Partial removal and replacement of the fill can be utilized as a risk-based, reduced-cost alternative.

- Based on the results of the borings, our local knowledge of the soil conditions and the general procedures of the 2018 Edition of the International Building Code (IBC), the soil profile at the project site may be defined as Class C (Very Dense Soil and Soft Rock).

- Design and construction recommendations for floor slabs, pavements, lightly loaded foundation footings, and retaining walls are also provided.

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1.0 INTRODUCTION

Geotechnology, LLC, dba UES, prepared this geotechnical exploration report for the Saint Louis Zoo for the Elephant Management Facility – Additions and Alterations project at the Saint Louis Zoo River's Edge campus located at One Government Drive in St. Louis, Missouri. Our services documented in this report were provided in general accordance with the scope of services described in our Proposal P046147.01, dated June 28, 2024. Our services were authorized by issuance of the July 11, 2024 Work Order under the May 27, 2021 Master Services Agreement.

The purposes of the geotechnical exploration were to develop a general subsurface profile at the site and prepare recommendations for the geotechnical aspects of the design and construction of the project as defined in our proposal. Our scope of services included site reconnaissance, geotechnical borings, laboratory testing, engineering analyses, and preparation of this report.

A copy of "Important Information about This Geotechnical-Engineering Report", published by the Geotechnical Business Council (GBC) of the Geoprofessional Business Association (GBA), is included in Appendix A for your review. The publication discusses report limitations and ways to manage risk associated with subsurface conditions.

2.0 PROJECT INFORMATION

The project involves the design and construction of an addition to the existing Elephant Management Facility, which will also include various alterations to the existing structure. The planned construction will include a single-story, slab on grade structure connected to the Elephant Management Facility.

Framing for the addition will include masonry walls and structural steel. Structural loads were not provided. For the purposes of this report, we have assumed loads to be on the order of 150 kips for columns, 6 kips per lineal foot for walls, and 200 pounds per square foot for slabs.

The proposed building addition location is currently a sand-covered yard used for elephants on the west side of the existing Elephant Management Facility. The sand yard is generally level and approximate to the planned building slab elevation. A cast-in-place retaining wall accommodates grade changes to the west and south, where grades vary from approximately 2 to 6 feet higher than the sand yard. A shade sail covers the sand yard and is supported by steel columns, the existing building, and retaining wall. The retaining wall will remain and be independent of the planned building.

3.0 GEOTECHNICAL EXPLORATION

The field geotechnical exploration consisted of drilling three borings, designated as Borings B-1 through B-3, at the approximate locations shown on Figure 2 in Appendix B. The boring locations were located in the field by measuring distances from existing features. The elevations at the boring locations, as shown on the boring logs, were estimated from the USGS National Map. If more precise locations are required, the client should retain a registered surveyor to establish boring locations and elevations.

The borings were drilled on July 23 and July 24, 2024, with a track-mounted CME 55LC drill rig advancing hollow-stem augers, as indicated on the boring logs presented in Appendix C. Sampling of the overburden soils was accomplished ahead of the augers at the depths indicated on the boring logs, with either 2-inch-outside-diameter (O.D.) split-spoons or 3-inch-O.D., thin-walled Shelby tube samplers in general accordance with the procedures outlined by ASTM D1586 and ASTM D1587, respectively. Standard Penetration Tests (SPTs) were performed on the split-spoon samples using an automatic hammer to obtain the standard penetration resistance or N-value[1] of the sampled material. An explanation of the terms and symbols used on the boring logs are also proved in Appendix C.

A geologist from UES provided direction during field exploration, observed drilling and sampling, assisted in obtaining samples, and prepared field logs of the material encountered. The boring logs represent conditions observed at the time of exploration and have been edited to incorporate results of the laboratory tests.

Unless noted on the boring logs, the lines designating the changes between various strata represent approximate boundaries. The transition between materials could be gradual or could occur between recovered samples. The stratification given on the boring logs, or described herein, is for use by UES in its analyses and should not be used as the basis of design or construction cost estimates without realizing that there can be variation from that shown or described.

The boring logs and related information depict subsurface conditions only at the specific locations and times where sampling was conducted. The passage of time could result in changes in conditions, interpreted to exist, at or between the locations where sampling was conducted.

Representative portions of the split-spoon samples were placed in glass jars to preserve sample moisture. The Shelby tubes were capped and taped at their ends to preserve sample moisture and unit weight, and the tubes were transported and stored in an upright position. The glass jars

[1] The standard penetration resistance, or N-value, is defined as the number of blows required to drive the split-spoon sampler 12 inches with a 140-pound hammer falling 30 inches. Since the split spoon sampler is driven 18 inches or until refusal, the blows for the first 6 inches are for seating the sampler, and the number of blows for the final 12 inches is the N-value. Additionally, “refusal” of the split-spoon sampler occurs when the sampler is driven less than 6 inches with 50 blows of the hammer.

and Shelby tubes were marked and labeled in the field for identification when returned to our laboratory.

4.0 LABORATORY REVIEW AND TESTING

Laboratory testing was performed on soil samples to assess engineering and index properties. Laboratory testing of selected soil samples included the following: moisture content, Atterberg limits, and unconsolidated undrained triaxial compression (UU). The results of these tests are presented on the boring logs.

5.0 SUBSURFACE CONDITIONS

5.1 Stratigraphy

The soil stratigraphy consists generally of fill soil underlain by natural fat clay soil, some lean clay, and shale to the predetermined termination depths of approximately 25 feet. Further descriptions of each soil type encountered are below.

Fill. Fill is present in Borings B-1, -2, and -3 to depths of approximately 3 to 6 feet. The fill consists generally of fine sand, and lean and fat clay with variable amounts of gravel and brick rubble. SPT N-values in the fill range from 3 to 21 blows per foot (bpf). Moisture contents in the fill ranges from 8 to 34 percent.

Lean Clay Soil. Lean clay soil occurs in Boring B-3 at depths of approximately 6 to 12 feet and is medium stiff in consistency. The SPT N-value in the lean clay is 5 blows per foot (bpf). The lean clay has a shear strength of 520 pounds per square foot (psf) based on UU triaxial strength test, and a dry unit weight determination of 86 pounds per cubic foot (pcf). Moisture contents in the soil ranges from 24 to 33 percent. Liquid and plastic limits from the Atterberg limits test are 43 and 20, respectively.

Fat Clay Soil. Fat clay soil occurs in Borings B-1, -2, and -3 at depths of approximately 6 to 22 feet and is soft to very stiff in consistency. SPT N-values in the fat clay range from 3 to 16 bpf. The fat clay has an undrained shear strength of 1,880 psf based on UU triaxial strength tests, and a dry unit weight determination of 98 pcf. Moisture content in the soil ranges from 19 to 27 percent. Liquid and plastic limits from the Atterberg limits test ranges from 52 to 63 and 23 to 24, respectively.

Shale. Shale occurs in Borings B-1 and B-2 at an approximate depth of 20 feet and extends to the depth of boring termination. Moisture content in the sampled shale is 16 percent.

5.2 Groundwater

Groundwater was observed during drilling in Boring B-3 at approximate depth of 9 feet. Groundwater was not observed in the other borings. Groundwater levels might not have stabilized before backfilling, which is typical in low permeability, cohesive soils. Groundwater could be trapped within permeable zones of fill. Consequently, the observed or lack of groundwater levels might not represent present or future levels. Groundwater levels could vary over time due to the effects of seasonal variation in precipitation, recharge from creeks or rivers nearby, or other factors not evident at the time of exploration. Excavations that remain open could collect groundwater.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Geotechnical features that affect project construction include existing uncontrolled fill. The presence of uncontrolled fill complicates the project and is discussed further below.

UES has prepared the following conclusions and recommendations based on our understanding of the proposed project, the field and laboratory data presented in this report, engineering analyses, and our experience and judgment.

6.1 Existing Fill

Existing fill materials consisting of loose, fine sand and lean clay with trace gravel were encountered in the borings to depths of approximately 3 to 6 feet. The N-values suggest that the fill might have received some compactive effort during placement. The age, quality, and compactive effort of the fill, however, cannot be accurately determined.

Since documentation on the existing fill is not available, the more conservative approach is to consider the existing fill as uncontrolled and potentially compressible. Structures, floor slabs, and pavements underlain by uncontrolled fill are at risk of greater than normal total and differential settlement.

Existing fill materials should be entirely removed and replaced from within and to a 5-foot horizontal distance beyond the footprint of the structure. Existing fill should also be removed to a minimum depth of 2 feet below pavement subgrades. Beneath, lightly loaded structures (i.e., less than 50 kips), fill should be removed to two times the footing width. The overexcavations can be backfilled with compacted, well-graded crushed rock.

As an alternative, the client could elect to take a risk-based approach, remediating the fill only below the footings as directed above, then proofrolling the remainder of the building footprint and pavement areas as described below. Soft areas identified during the proofroll should be remediated. Partial removal and replacement includes a risk of detrimental settlement that can be accepted by the owner as a balance for reduced construction costs.

6.2 Site Preparation and Earthwork

Site Preparation. Site grading plans have not been established at this time. However, in general, all cut areas and areas to receive fill and backfill should be stripped of topsoil, asphalt, soft soil, other deleterious materials, and rubble fill, if any.

The exposed subgrade should be proofrolled. Any soft soil or yielding areas should be excavated and backfilled with soil or crushed rock compacted to the levels provided in subsequent paragraphs.

Temporary Excavations and Shoring. The contractor should review slope height, slope inclination or excavation depths with respect to local, state, or federal safety regulations, e.g. OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations. Depending on the planned depths we anticipate site geometry will permit for the below-grade stormwater detention basin and stormwater pipe excavation slopes to be laid back to a stable configuration. For excavations less than 20 feet deep, the OSHA classification for the natural could be considered as Type B and fill materials should be considered as Type C. Consequently, temporary slopes in Type B soils may be constructed at 1V:1H and Type C soil may be constructed at 1V:1.5H. However, cut slopes taller than 20 feet must be designed by a professional engineer.

If the excavations cannot be backsloped, temporary shoring may be required. While many different types and configurations of retention systems can be used, the more common type of excavation support applicable are soil nails with shotcrete, steel piles with timber lagging and bracing, sheeting piling and trench boxes. Design of temporary shoring systems is beyond the scope of our services. The design of the system is often the responsibility of the contractor performing the work. The contractor should also be responsible for monitoring the performance of the retention system. OSHA regulations should be followed with respect to bracing equipment. Worker safety and classification of soil type is the responsibility of the contractor.

Suitable Fill Material. The underlying high plasticity clay should not be used as fill below floor slabs or pavement unless it is covered with at least 3 or 2 feet, respectively, of lower plasticity soil (liquid limit less than 45 percent) or contains 40 percent gravel. Imported fill, if required may include non-organic materials designated CL, ML, CL-ML, SW, GW and GM by ASTM D 2487.

Poorly graded “clean” granular materials should not be used as fill, as these materials tend to create a reservoir for water, resulting in softening of the underlying cohesive soil subgrade or, in the presence of high-plasticity clay, could lead to heaving. If clean granular aggregate is used as fill, full encapsulation in 4-ounce nonwoven synthetic filter fabric (e.g. Mirafi 140N) is required to reduce the potential for infiltration of silts and fine sands into the void space which can cause settlements adjacent to the trench.

Fill and Backfill Placement. Fill or backfill should be placed in uniformly thick lifts and compacted. The loose lift thickness should not exceed 8 inches. The fill should be systematically compacted to the levels given in Table 1, Compaction Summary. Fill containing rubble should be compacted with a 10-ton vibratory roller until no subgrade yielding is observed. The soil should be placed at a moisture content compatible with the required unit weight. Depending on the soil moisture at the time of construction, aeration or wetting could be required to achieve proper compaction.

Deleterious material should not be included in fill, and the fill should not be placed on soft materials on frozen ground.

Table 1. Compaction Summary

Category	Minimum Compaction [a]
General soil fill	90%
Rock backfill	95%
Floor slab subgrade	90%[b]
Floor slab rock base course	95%

[a] Measured as a percent of the maximum dry unit weight as determined by the modified Proctor test in a laboratory (ASTM D 1557).
[b] Moisture content within 3% of optimum moisture content.

Trench Backfill. Utilities might be located under the pavement and/or floor slab. Settlement of trench backfill can result in localized pavement/slab failures. The magnitude of settlement can be reduced by mechanically compacting the trench backfill. In this method, the soil or granular material is placed and compacted in horizontal layers. The degree of compaction should be similar to that required in the fill adjacent to the trench or as recommended in Table 1, Compaction Summary. Permeable backfill can collect water and promote subgrade softening, result in the migration of fines, loss of subgrade support, drop-outs and/or in the presence of potentially expansive soils, slab heaving.

Subgrade Protection. Drainage of the construction areas should be provided to protect the foundation excavations, floor slab subgrades and temporary slopes from the detrimental effects of weather conditions during construction. Finished subgrades and foundation excavations should be kept free of standing water. Concrete should be placed in foundations the same day they are excavated.

Floor slabs and pavement areas will be exposed to weather and disturbances from installation of utilities and normal traffic. Disturbance is generally easier to repair in summer and fall months by reworking of the upper soils. More difficulty will be experienced in the wetter seasons, such as spring and winter. We recommend minimizing construction traffic on the prepared subgrades.

Collection and Disposal of Site Water. Management of the site water is important in the successful performance of pavement and foundations. Water from surface runoff, downspouts, and subsurface drains, if any, should be collected and discharged through an effective site drainage system. Control of surface runoff should be maintained in compliance with the rules and regulations set forth in the Federal Water Pollution Control Act. Additionally, permits related to site grading activities and control of storm water during construction activities should be obtained from the applicable governmental jurisdiction(s).

6.3 Shallow Foundations

Bearing Capacity. Strip and spread footings for the building should be proportioned for a net allowable bearing pressure of 2,000 psf, provided they bear of natural or compacted soil. The minimum lateral dimensions for strip and spread footings should be 18 and 24 inches, respectively. Exterior footings and footings in unheated interior areas should be embedded 30 inches below the lowest adjacent exterior grade to provide protection from seasonal moisture variations and frost penetration.

The subgrade of each footing excavation should be observed by a representative of UES, to verify that the exposed soil is consistent with that described in the subsurface exploration and has the required strength to develop the design bearing capacity. If encountered, zones of soft soil should be excavated until soils capable of supporting the required bearing capacity are exposed.

Shallow foundations, proportioned and constructed as recommended above, are expected to settle approximately 1 inch. Differential settlement between any two adjacent footings could be approximately ¾-inch. Estimated values of settlement contained in this report are based on our experience. Consolidation tests and corresponding settlement calculations have not been made.

Uplift Capacity. Uplift loads for the building can be resisted with the dead weight of the footing, and the weight of soil above the footing. A unit weight of 120 pounds per cubic foot (pcf) can be used for determining the soil weight above the footing, and the volume of soil acting on the footing can include a wedge of material within a line that extends from the top of footing and away from the footing edge to the ground surface at an angle of 30 degrees from the vertical.

Lateral Capacity. Lateral loads can be resisted by frictional resistance between the base of the foundation and supporting soil and passive resistance acting on the side of the footing. Resistance to sliding can be computed assuming an ultimate coefficient of friction of 0.4; however, the ultimate resistance must be limited to 500 psf. The ultimate passive resistance may be computed based on an equivalent fluid pressure of 225 pcf but the upper 30 inches should be neglected. Safety factors of 2 and 3 should be applied to determine the allowable sliding and passive resistance, respectively.

6.4 Floor Slabs

The slab-on-grade should be underlain by a 4- to 6-inch layer of crushed rock placed atop properly prepared subgrades and compacted as indicated in Table 1, Compaction Summary. A 15-mil or thicker plastic sheet should be placed below the floor to reduce the potential for moisture to permeate the slab and reduce the potential for mold growth in the building. Notwithstanding other structural considerations, the slab-on-grade floor should be designed to allow for differential movements that normally occur between the floor slab, columns, and foundation walls.

6.5 Lateral Earth Pressures

Below-grade walls shall be designed to resist lateral soil loads. Design lateral pressures from surcharge loads shall be added to the lateral earth pressure load. Lateral earth pressures can vary with wall restraint conditions, type of backfill, slope of ground surface behind the wall, and method of backfill compaction.

Design values are given herein for soil lateral loads on walls with horizontal backfill, subject to active and at-rest conditions. Walls anticipated with fixed-heads or rigid walls should be designed for at-rest earth pressures. Walls that are permitted to tilt should be designed for active earth pressures.

Table 2. Lateral Earth Pressure Design Values

Description of Backfill	Design soil lateral load (psf per foot of depth)	
	At-rest	Active
Inorganic clays of low to medium plasticity (CL)	69h + 0.58q	49h + 0.41q
Well graded gravel-sand mix (GW/SW) (e.g., 1-inch-minus)	57h + 0.44q	36h + 0.28q

Where:

q = surcharge load, psf
h = depth below adjacent grade, feet

In giving these values, it is assumed that hydrostatic pressures will not develop behind the walls and that the wall backfill will be compacted as recommended in the Site Grading section of this report. Therefore, the walls should be provided with a drain system to allow for dissipation of hydrostatic pressures. Undrained walls may be subjected to additional pressures from groundwater, perched water, pipe leakages or surface water infiltration.

For the above equations to be valid for sand and gravel backfill, the backfill should be placed in a wedge extending upward and away from the edge of the wall footing at a 45-degree angle of flatter. If sand and gravel are to be placed within a steeper wedge, the values for low plasticity soil given above should be used. Further, any soft uncompacted soil on the excavation slope should be removed prior to placement of backfill. Design drawings should reflect this requirement.

6.6 Seismic Site Classification and Seismic Design Parameters

<u>Site Class</u>. The site soil is defined as Class C, Very Dense Soil and Soft Rock. The site class designation is based on the results of the borings and our local knowledge of the geologic conditions in the area. The assessment of the soil and/or rock properties below the boring termination depths is based on our professional opinion in accordance with the IBC.

Spectral Acceleration Values. The site is within the City of St. Louis and hence, under jurisdiction of Ordinance 70794 for the adoption of the IBC 2018, the mapped maximum considered earthquake spectral response acceleration at short period (S_S) and at 1-second period (S_1) of 0.434 g and 0.157 g, respectively, may be used. Spectral response acceleration for design, S_{DS} and S_{D1}, that correspond to Site Class C are 0.377 g and 0.157 g, respectively.

6.7 Pavement Design and Construction

A pavement design and analysis were beyond the scope of our services. Standard asphaltic concrete pavement design for a given service life requires evaluation of the soil by California Bearing Ratio (CBR) tests or other methods, estimates of daily traffic volumes and axle weights, drainage requirements, and the desired level of maintenance.

Asphaltic pavement sections are frequently used in the St. Louis region that are thinner than would typically result from a pavement design. These reduced thickness sections often perform adequately; however, maintenance or an overlay is generally required sooner than would be required for a thicker, designed section. Based on our experience with projects of similar nature, pavement sections consisting of 3 inches of asphalt over 6 inches of well-graded crushed rock and 4 inches of asphalt over 8 inches of well-graded crushed rock often used in parking areas and main drive lanes, respectively, subjected to automobile traffic only. The pavement performance can be enhanced by lime treating the subgrade soils or incorporating a geogrid below the crushed rock. Where heavy wheeled loads are concentrated, particularly at truck loading areas, concrete pavement should be used and typically consist of 7 inches of concrete over 4 inches of well-graded crushed rock.

Regardless of which pavement sections are selected, the soil subgrade should be stable and the top 12 inches compacted to the levels provided in Table 1, Compaction Summary. Pavement service life can decrease substantially if the pavement is constructed on a poor subgrade, if it has poor surface or subsurface drainage, and/or if the pavement is not maintained. Periodic maintenance, such as filling cracks and sealing, is required for pavement sections to achieve their design life.

If pavements are not constructed immediately after grading, the subgrade should be shaped to prevent ponding. Minor ponding, of even short duration, can cause softening of a soil subgrade. If there is a lapse of time between grading and paving, or if the subgrade is disturbed by construction activities, the subgrade should be proof-rolled with a loaded, tandem-wheeled dump truck. Soft spots observed during initial construction or proof-rolling should be removed and placed with compacted soil or rock, possibly combined with a geotextile or geogrid. The rock base course and soil subgrade should be compacted to the levels provided in Table 1, Compaction Summary.

Depending on when the pavement is constructed, the subgrade might not support construction equipment such as rock trucks or asphalt trucks which have heavier axle loads than those vehicles which the pavement section is expected to support. Such conditions will be more apparent during wetter periods of the year. Overexcavation of soft subgrade and placement of additional base course and/or geogrid could be required to construct the pavement during these periods.

7.0 RECOMMENDED ADDITIONAL SERVICES

The conclusions and recommendations given in this report are based on: UES's understanding of the proposed design and construction, as outlined in this report; site observations; interpretation of the exploration data; and our experience. Since the intent of the design recommendations is best understood by UES, we recommend that UES be included in the final design and construction process, and be retained to review the project plans and specifications to confirm that the recommendations given in this report have been correctly implemented. We recommend that UES be retained to participate in prebid and preconstruction conferences to reduce the risk of misinterpretation of the conclusions and recommendations in this report relative to the proposed construction of the subject project.

Since actual subsurface conditions between boring locations could vary from those encountered in the borings, our design recommendations are subject to adjustment in the field based on the subsurface conditions encountered during construction. Therefore, we recommend that UES be retained to provide construction observation services as a continuation of the design process to confirm the recommendations in this report and to revise them accordingly to accommodate differing subsurface conditions. Construction observation is intended to enhance compliance with project plans and specifications. It is not insurance, nor does it constitute a warranty or guarantee of any type. Regardless of construction observation, contractors, suppliers, and others are solely responsible for the quality of their work and for adhering to plans and specifications.

8.0 LIMITATIONS

This report has been prepared on behalf of, and for the exclusive use of, the client for specific application to the named project as described herein. If this report is provided to other parties, it should be provided in its entirety with all supplementary information. In addition, the client should make it clear that the information is provided for factual data only, and not as a warranty of subsurface conditions presented in this report.

UES has attempted to conduct the services reported herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions. The recommendations and conclusions contained in this report are professional opinions. The report is not a bidding document and should not be used for that purpose.

Our scope for this phase of the project did not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors noted or unusual or suspicious items or conditions observed are strictly for the information of our client. Our scope did not include an assessment of the effects of flooding and erosion of creeks or rivers adjacent to or on the project site.

The analyses, conclusions, and recommendations contained in this report are based on the data obtained from the geotechnical exploration. The field exploration methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Consequently, subsurface conditions could vary gradually, abruptly, and/or nonlinearly between sample locations and/or intervals.

The conclusions or recommendations presented in this report should not be used without UES's review and assessment if the nature, design, or location of the facilities is changed, if there is a lapse in time between the submittal of this report and the start of work at the site, or if there is a substantial interruption or delay during work at the site. If changes are contemplated or delays occur, UES must be allowed to review them to assess their impact on the findings, conclusions, and/or design recommendations given in this report. UES will not be responsible for any claims, damages, or liability associated with any other party's interpretations of the subsurface data or with reuse of the subsurface data or engineering analyses in this report.

The recommendations included in this report have been based in part on assumptions about variations in site stratigraphy that can be evaluated further during earthwork and foundation construction. UES should be retained to perform construction observation and continue its geotechnical engineering service using observational methods. UES cannot assume liability for the adequacy of its recommendations when they are used in the field without UES being retained to observe construction.

APPENDIX A – IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL-ENGINEERING REPORT

Important Information about This

Geotechnical-Engineering Report

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

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

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

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

Read the Full Report

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

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

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

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

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

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

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

Subsurface Conditions Can Change

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

Most Geotechnical Findings Are Professional Opinions

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

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

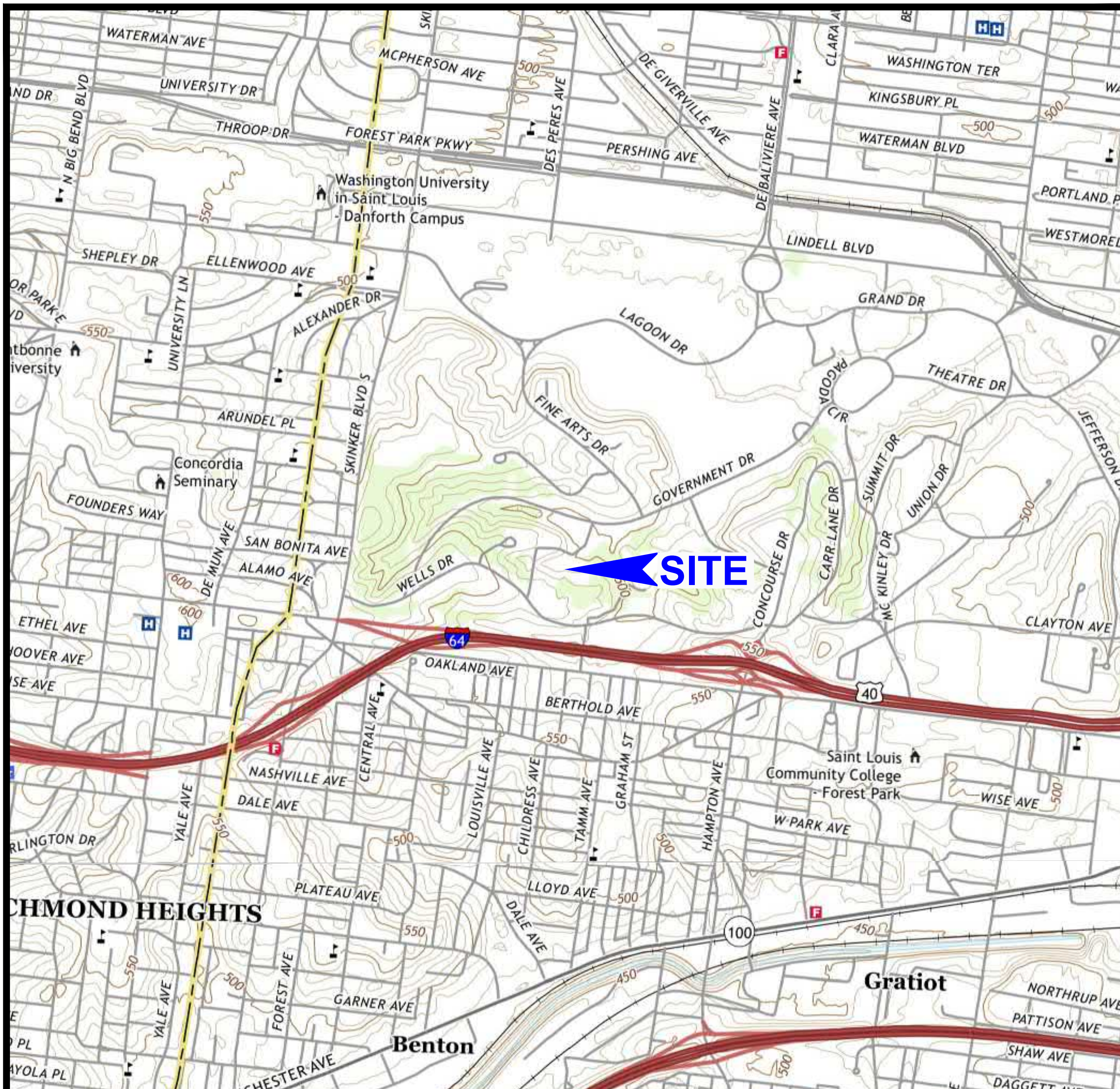
Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL *of the Geoprofessional Business Association*

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

APPENDIX B – FIGURES



NOTES

1. Plan adapted from 7.5 minute U.S.G.S. maps for Clayton, Missouri and Webster Groves, Missouri-Illinois quadrangles, last revised in 2021.

0 2,000 4,000

SCALE IN FEET

N

Drawn By: WAH	Ck'd By: HMB	App'vd By: AWR
Date: 7-25-24	Date: 7-26-24	Date: 8-21-24

UES™

Elephant Management Facility
Additions and Alterations
Saint Louis Zoo
St. Louis, Missouri

SITE LOCATION AND TOPOGRAPHY

Project Number J046147.01	FIGURE 1

NOTES

1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments.

2. Borings were located in the field with reference to site features and are shown approximate only.

LEGEND

● Boring Location

0 20 40 80

SCALE IN FEET

N

Drawn By: WAH	Ck'd By: HMB	App'vd By: AWR
Date: 7-25-24	Date: 7-26-24	Date: 8-21-24

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Additions and Alterations
Saint Louis Zoo
St. Louis, Missouri

AERIAL PHOTOGRAPH OF SITE AND BORING LOCATIONS

Project Number J046147.01

FIGURE 2

APPENDIX C – BORING INFORMATION

Boring Logs

Boring Log Terms and Symbols

Surface Elevation: 508

Datum: NAVD88

Completion Date: 7/23/2024

SHEAR STRENGTH, tsf: Δ - UU/2, ○ - QU/2, ▯ - SV (0.5, 1.0, 1.5, 2.0, 2.5)

STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)

WATER CONTENT, %: PL ⊢—●—⊣ LL (10, 20, 30, 40, 50)

DEPTH IN FEET	DESCRIPTION OF MATERIAL	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
0	FILL: brown fine sand	2-4-4	SS1
2	FILL: brown fine sand, gray lean clay with gravel		
3	Medium stiff to very stiff, gray FAT CLAY - (CH)	1-3-4	SS2
5		7-10-11	SS3
8	Medium stiff to stiif, brown and gray FAT CLAY - CH	2-4-5	SS4
15		1-3-3	SS5
16	Very stiff, grayish-tan and maroon, shaley FAT CLAY - CH		
20		3-6-10	SS6
20	Highly weathered, very weak, brown and gray to maroon SHALE		
25		6-12-20	SS7
25	Boring terminated at 25 feet.		

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM __ FEET

RR DRILLER EER LOGGER

CME 55BP DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 98 %

REMARKS:

Drawn by: WAH	Checked by: HMB	App'vd. by: AWR
Date: 7/25/2024	Date: 8/2/2024	Date: 8/21/2024

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Elephant Management Facility Additions and Alterations St. Louis Zoo St. Louis, Missouri

LOG OF BORING: B-1

Project No. J046147.01

LOG OF BORING 2002 WL J046147.01 BORING LOGS.GPJ 00 CLONE ME.GPJ 8/26/24

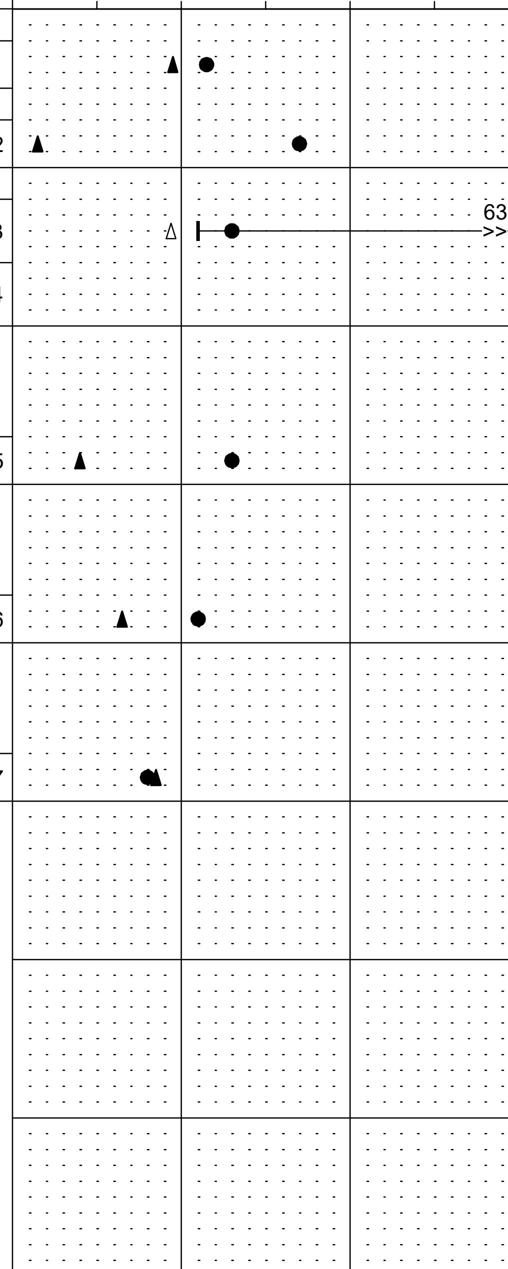
Surface Elevation: 508	Completion Date: 7/23/2024
Datum: NAVD88	

SHEAR STRENGTH, tsf: ∆ - UU/2 ○ - QU/2 ▯ - SV (0.5, 1.0, 1.5, 2.0, 2.5)

STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)

WATER CONTENT, % PL ● LL (10, 20, 30, 40, 50)

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	FILL: brown fine sand			
	FILL: brown and gray lean clay with gravel		18-13-6	SS1
5	FILL: gray fat clay		1-2-1	SS2
10	Stiff, brown and gray FAT CLAY - (CH)		98	ST3
				ST4
15	Medium stiff, brown and gray FAT CLAY - CH		2-3-5	SS5
20	Stiff, grayish-tan and maroon, shaley FAT CLAY - CH		3-5-8	SS6
	Severely weathered, extremely weak, maroon to brown, clayey SHALE		5-8-9	SS7
25	Boring terminated at 25 feet.			
30				
35				



NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

X FREE WATER NOT ENCOUNTERED DURING DRILLING

DRILLING DATA

__ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM __ FEET

RR DRILLER EER LOGGER

CME 55BP DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 98 %

REMARKS:

Drawn by: WAH	Checked by: HMB	App'vd. by: AWR
Date: 7/25/2024	Date: 8/2/2024	Date: 8/21/2024

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Elephant Management Facility
Additions and Alterations
St. Louis Zoo
St. Louis, Missouri

LOG OF BORING: B-2

Project No. J046147.01

Surface Elevation: 508 | Completion Date: 7/24/2024

Datum: NAVD88

SHEAR STRENGTH, tsf: Δ - UU/2 ○ - QU/2 ▯ - SV (0.5, 1.0, 1.5, 2.0, 2.5)

STANDARD PENETRATION RESISTANCE ▲ N-VALUE (BLOWS PER FOOT) (ASTM D 1586)

WATER CONTENT, % PL ⊢ ● ⊣ LL (10, 20, 30, 40, 50)

DEPTH IN FEET	DESCRIPTION OF MATERIAL	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
0	Asphaltic Concrete - 3 inches		
	Rock Base - 6 inches		
	FILL: asphalt fragments and gravel	8-5-4	SS1
	FILL: brown lean clay with brick and gravel	1-2-19	SS2
5			
	Medium stiff, brown LEAN CLAY, trace sand - (CL)	1-3-2	SS3
	▽ (groundwater at 9 feet)	86	ST4
10			
	Medium stiff, brown FAT CLAY - CH		
15		2-3-4	SS5
	Medium stiff, grayish-brown and maroon, shaley FAT CLAY - CH		
20		2-3-4	SS6
	Stiff, orange and maroon, shaley FAT CLAY - CH		
		2-6-7	SS7
25	Boring terminated at 25 feet.		
30			
35			

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002 WL J046147.01 BORING LOGS.GPJ 00 CLONE ME.GPJ 8/26/24

GROUNDWATER DATA

ENCOUNTERED AT 9 FEET ▽

DRILLING DATA

__ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM __ FEET

RR DRILLER EER LOGGER

CME 55BP DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 98 %

REMARKS:

Drawn by: WAH	Checked by: HMB	App'vd. by: AWR
Date: 7/25/2024	Date: 8/2/2024	Date: 8/21/2024

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Elephant Management Facility
Additions and Alterations
St. Louis Zoo
St. Louis, Missouri

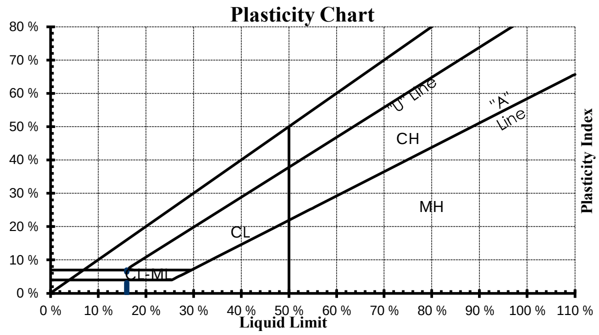
LOG OF BORING: B-3

Project No. J046147.01

BORING LOG: TERMS AND SYMBOLS

LEGEND

CS	Continuous Sampler
GB	Grab Sample
NQ	NQ Rock Core
PST	Three-Inch Diameter Piston Tube Sample
SS	Split-Spoon Sample (Standard Penetration Test)
ST	Three-Inch Diameter Shelby Tube Sample
*	Sample Not Recovered
PL	Plastic Limit (ASTM D4318)
LL	Liquid Limit (ASTM D4318)
SV	Shear Strength from Field Vane (ASTM D2573)
UU	Shear Strength from Unconsolidated-Undrained Triaxial Compression Test (ASTM D2850)
QU	Shear Strength from Unconfined Compression Test (ASTM D2166)



SOIL GRAIN SIZE

US STANDARD SIEVE

	12"		3"		3/4"		4		10		40		200		
BOULDERS		COBBLES		GRAVEL: COARSE		GRAVEL: FINE		SAND: COARSE		SAND: MEDIUM		SAND: FINE		SILT	CLAY
	300		76.2		19.1		4.76		2.00		0.42		0.074	0.005	

SOIL GRAIN SIZE IN MILLIMETERS

UNIFIED SOIL CLASSIFICATION SYSTEM

Major Divisions			*Symbol*	*Description*
Coarse-Grained Soils (More than 50% Larger than No. 200 Sieve Size)	Gravel and Gravelly Soil	Clean Gravels Little or no Fines	GW	Well-Graded Gravel, Gravel- Sand Mixture
			GP	Poorly-Graded Gravel, Gravel-Sand Mixture
		Gravels with Appreciable Fines	GM	Silty Gravel, Gravel-Sand-Silt Mixture
			GC	Clayey-Gravel, Gravel-Sand-Clay Mixture
	Sand and Sandy Soils	Clean Sands Little or no Fines	SW	Well-Graded Sand, Gravelly Sand
			SP	Poorly-Graded Sand, Gravelly Sand
		Sands with Appreciable Fines	SM	Silty Sand, Sand-Silt Mixture
			SC	Clayey-Sand, Sand-Clay Mixture
Fine-Grained Soils (More than 50% Smaller than No. 200 Sieve Size)	Silts and Clays	Liquid Limit Less Than 50	ML	Silt, Sandy Silt, Clayey Silt, Slight Plasticity
			CL	Lean Clay, Sandy Clay, Silty Clay, Low to Medium Plasticity
			OL	Organic Silts or Lean Clays, Low Plasticity
	Silts and Clays	Liquid Limit Greater Than 50	MH	Silt, High Plasticity
			CH	Fat Clay, High Plasticity
			OH	Organic Clay, Medium to High Plasticity
	Highly Organic Soils		PT	Peat, Humus, Swamp Soil

STRENGTH OF COHESIVE SOILS

Consistency	*Undrained Shear Strength (tsf)*	*Unconfined Comp. Strength (tsf)*
Very Soft	less than 0.125	less then 0.25
Soft	0.125 to 0.25	0.25 to 0.5
Medium Stiff	0.25 to 0.5	0.5 to 1.0
Stiff	0.5 to 1.0	1.0 to 2.0
Very Stiff	1.0 to 2.0	2.0 to 3.0
Hard	greater than 2.0	greater than 4.0

DENSITY OF GRANULAR SOILS

Descriptive Term	*Approximate N_{60}-Value Range*
Very Loose	0 to 4
Loose	5 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	>50

N-Value (Blow Count) is the last two, 6-inch drive increments (i.e. 4/7/9, N = 7 + 9 = 16). Values are shown as a summation on the grid plot and shown in the Unit Dry Weight/SPT column.

RELATIVE COMPOSITION

Trace	0 to 10%
Little	10 to 20%
Some	20 to 35%
And	35 to 50%

OTHER TERMS

Layer - Inclusion greater than 3 inches thick.
Seam - Inclusion 1/8-inch to 3 inches thick
Parting - Inclusion less than 1/8-inch thick
Pocket - Inclusion of material that is smaller than sample diameter

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Relative composition and Unified Soil Classification System (USCS) designations are based on visual descriptions and are approximate only. If laboratory tests were performed to classify the soil, the USCS designation is shown in parenthesis.