GEOTECHNICAL EVALUATION REPORT
215 BELTWAY CONNECTION
CENTENNIAL PARKWAY TO DECATUR BOULEVARD – SEGMENT "B"
LAS VEGAS, NEVADA

Project No. 20174206E2
June 19, 2019

Prepared for:

GCW Engineers\Surveyors
1555 South Rainbow Boulevard
Las Vegas, Nevada 89146

Prepared by:

Geotechnical & Environmental Services, Inc.
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June 19, 2019
Project No. 20164206E2

Mr. John Tobin
Senior Vice President
GCW Engineers\Surveyors
1555 South Rainbow Boulevard
Las Vegas, Nevada 89146

RE: ***Geotechnical Evaluation***
215 Beltway Connection
Centennial Parkway to Decatur Boulevard – Segment "B"
Las Vegas, Nevada

Dear Mr. Tobin:

Geotechnical & Environmental Services, Inc. (GES) is pleased to present this Geotechnical Evaluation Report for the proposed 215 Beltway Connection, Centennial Parkway to Decatur Boulevard Segment "B" project in Las Vegas, Nevada.

This report includes the findings of our geologic review, results from our subsurface explorations and laboratory testing programs, and recommendations for design and construction of the proposed pedestrian bridges, ramp undercrossing structure, and associated improvements.

We appreciate this opportunity to provide our professional services. If you have any questions or comments regarding this information, please feel free to contact our office.

Sincerely,

Geotechnical & Environmental Services, Inc.

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CENTENNIAL PARKWAY TO DECATUR BOULEVARD – SEGMENT “B”
LAS VEGAS, NEVADA

1. INTRODUCTION

Geotechnical & Environmental Services, Inc. (GES) is pleased to present this report containing the results of a geotechnical evaluation for the proposed 215 Beltway Connection, Centennial Parkway to Decatur Boulevard – Segment “B” Project in Las Vegas, Nevada. Segment “B” encompasses the Sky Pointe Drive Pedestrian crossing, Oso Blanca Road pedestrian bridge, and the West-North (WN) undercrossing. Figure A-1 presents a vicinity map showing the approximate locations of each structure included as part of this project within the Las Vegas Valley. The following sections present the purpose and scope of our geotechnical evaluation, and project and site descriptions.

1.1. PURPOSE AND SCOPE

The purpose of this geotechnical evaluation was to provide general subsurface information and recommendations to aid in the design and construction of the proposed Sky Pointe Drive Pedestrian crossing, Oso Blanca Road pedestrian bridge, and the WN undercrossing. The scope of this study included a review of design drawings provided by GCW Engineers and Surveyors, referenced geologic literature and maps, subsurface explorations, soil sampling, laboratory testing of selected soil samples, engineering evaluations and preparation of this report.

GES reviewed existing geotechnical data obtained and summarized by Nevada Department of Transportation (NDOT) in their Geotechnical Exploration Report titled Geotechnical Data Report US 95/CC-215 Interchange and Vicinity Clark County with project number: EA 73518 and dated June 2016.

1.2. PROJECT DESCRIPTION

Our understanding of the project is based upon correspondence with GCW personnel, our experience with similar projects, review of aerial photographs, and our experience in the project vicinity. Our design recommendations are based on the following guide and codes, as applicable:

- AASHTO LRFD Bridge Design Specifications, Seventh Edition (AASHTO, 2014)
- Uniform Standard Specifications for Public Works’ Construction, Off-Site Improvements (USS) (RTCSS, 2003).

- Standard Specifications for Road and Bridge Construction, Nevada Department of Transportation (NDOT, 2014) (SSNDOT).

Based on our understanding, the project will include the design and construction of a multi-span pedestrian crossing (Sky Pointe Drive Bridge), a single span pedestrian bridge (Oso Blanca Road), and a ramp undercrossing structure (WN undercrossing). Drilled shafts will support the Sky Pointe pedestrian crossing while spread footing foundations will be designed to support the Oso Blanca Road pedestrian bridge. The WN undercrossing will be constructed of reinforced concrete and will include lighting and other improvements as necessary for future improvements. We understand that the bridge structures will be constructed of structural steel and reinforced concrete.

The project design elements based on our understanding include:

- The Sky Pointe Structure will consist of a five-span bridge crossing of approximately 12 feet wide and 741 feet long and is anticipated to be supported by 6-foot diameter drilled shafts at each pier location and a 3-foot diameter shaft at Abutment No. 1 support location west of the proposed Sky Pointe Drive.
- The Oso Blanca structure will consist of a single-span pedestrian bridge of approximately 12-feet wide and 112-feet long supported on spread footings at the two bridge support locations on the east and west side of the realigned Oso Blanca Road and associated improvements.
- The WN ramp undercrossing structure will consist of a 66-foot long concrete slab and a tunnel length of 46 feet. The total clearance in the tunnel is 14-feet.

Structural load information for the pedestrian bridges provided by GCW is summarized in the following table:

Table 1.2 –Project Load Information

Location	**Structural Loads (kips)**			
	Sky Pointe Drive Pedestrian Crossing			
	Dead Loads	Live Loads	Total Service Loads	Total Strength Loads
Abutment 1	440	60	500	655
Pier 1	915	195	1110	1485
Pier 2	915	195	1110	1485
Pier 3	650	115	765	1014
Pier 4	895	190	1085	1452
Pier 5	370	60	430	568
Oso Blanca Road Pedestrian Bridge				
Abutment 1	540	60	600	780
Abutment 2	540	60	600	780

1.3. SITE DESCRIPTION

A portion of the project including the Sky Point pedestrian crossing is located to the south of Sky Pointe Drive and east of the existing Frontage Road in Las Vegas, Nevada. The portion of the project encompassing the west-north ramp undercrossing structure is located west of the existing Frontage Road between Sky Pointe Drive and Bruce Woodbury Beltway. The Oso Blanca single-span pedestrian bridge is located to the west of the US-95 Interstate and north of the Bruce Woodbury Beltway and will span over the realigned Oso Blanca Road to be located west of the existing road. At the time of our field explorations, the project area included undeveloped areas located between existing roadways and fully improved areas. The attached Figure No. A-2 includes the anticipated general location of each planned pedestrian bridge and location of the undercrossing structure.

2. DISCUSSION

The following sections describe the geology, seismicity, liquefaction, mapped soil conditions, field exploration, laboratory testing, and subsurface materials and conditions for the project.

2.1. GEOLOGY

The subject site is located in the Las Vegas Valley, a fault-bounded graben structure surrounded by mountain ranges. The Las Vegas Valley is physiographically characteristic of the Basin and Range Province with generally northwest-trending parallel mountain ranges and an intervening basin. Unlike many basins within the Basin and Range Province, which are internally draining, the Las Vegas Valley is unique in that the basin drains through the Las Vegas Wash to Lake Mead and the Colorado River.

Tertiary and Quaternary unconsolidated alluvial deposits, derived from the surrounding mountain ranges, fill the valley. These deposits may be up to 4,000 feet thick at the site near the center of the valley. The surrounding mountain ranges are comprised of sedimentary and igneous rocks. Alluvial fan deposits, consisting of sand and gravel, slope down from the mountain fronts towards the valley floor. Sediments are typically less coarse, grading from fine sand and silt to clay near the valley bottom. Beds of amorphous and crystalline gypsum are common. Zones of calcareous cemented deposits (caliche) are present at various locations and depths throughout the valley.

The subject site is located on the referenced Geologic Map of the Tule Springs Park Quadrangle, Nevada, (Bell, J.W., Et al. 1998) within an area of interfluvial and fan-terrace remnants overlying and inset into spring and paludal deposits (Qsp_{3b}) and within an area of spring and paludal deposits comprising extensive fine-grained valley-bottom fill (Qts_e). The Qsp_{3b} unit is characterized by well-developed, tightly packed desert pavement; dark rock varnish; and moderately to strongly etched surface carbonate clasts. The Qts_e unit is comprised of light brown to yellowish brown silt, fine sandy silt, and light gray to gray organic mud; locally light green clay.

2.2. SEISMICITY

The U.S. National Oceanic and Atmospheric Administration Earthquake Catalog lists about 800 events of magnitude greater than or equal to 4.0 with epicenters within about 120 miles of Las Vegas. Only 19 events greater than or equal to magnitude 4.0 are estimated to have occurred during the 1881 through 1938 period in the southern Nevada region.

After about 1947, nuclear testing began at the Nevada Test Site. Therefore, many of the recorded earthquakes after about 1947 may be due to nuclear blasts occurring more than about 60 miles from the subject site. Several hundred earthquakes occurred from 1936 to 1965 near Hoover Dam, presumably due to filling of the Lake Mead reservoir, with 24 of these events reportedly greater than or equal to magnitude 4.0.

Based on a review of referenced geologic maps and literature, the nearest Quaternary-age (last 1.6 million years) fault is located approximately 0.82 mile southeast of the planned pedestrian crossing (dePolo and Bell, 2000). Other mapped Quaternary-age tectonic faults are the Eglington fault (which geologists have debated may also be potentially active) and the Frenchman Mountain fault; these faults are located approximately 3 miles southeast and approximately 14.7 miles southeast of the planned pedestrian crossing structure, respectively. The nearest mapped Holocene active fault (i.e., a fault that has moved within the last 10,000 years) is the Black Hills fault, located approximately 23 miles southeast of the planned bridge structure. The nearest mapped fissure zone is located about 3 miles southeast of the site near Ann Road and Decatur Boulevard (dePolo and Bell, 2000). Based on the results of our review of available literature, it is our opinion that the potential for fault-related surface rupture at the site is low.

2.3. LIQUEFACTION

Liquefaction is a phenomenon in which loose, saturated soils lose shear strength under short-term (dynamic) loading conditions. Ground shaking of sufficient duration results in the loss of grain-to-grain contact in potentially liquefiable soils due to a rapid increase in pore water pressure, causing the soil to behave as a fluid for a short period of time.

To be potentially liquefiable, a soil is typically cohesionless with a grain-size distribution generally consisting of sand and silt. It is generally loose to medium dense and has a relatively high moisture content, which is typical near or below groundwater. The potential for liquefaction decreases with increasing clay and gravel content but increases as the ground acceleration and duration of shaking increase. Potentially liquefiable soils need to be subjected to sufficient magnitude and duration of ground shaking for liquefaction to occur. Effects of liquefaction can include relatively large total and differential settlements, flotation of subsurface structures, slope failures, lateral ground displacements (lateral spreading), surface subsidence, ground cracking, and sand boils.

An in-depth evaluation of the potential for liquefaction at the site was outside the scope of this geotechnical evaluation. Qualitatively, the subsurface soils composed primarily of stiff to very stiff lean clay with gravel, very dense clayey gravel, strongly cemented caliche, and the depth at which groundwater was encountered at the site indicate a low liquefaction potential at the subject site.

2.4. MAPPED SOIL DATA

Based on review of the Clark County Soil Guidelines Map (CCBD, 1998), the project site is located in a previously mapped standard geotechnical consideration area with mixed alluvial sand and gravel. Based on review of the Clark County Expansive Soil Guidelines Map (CCDDS, 2006), a portion of the project encompassing Oso Blanca Road pedestrian bridge is located in a standard geotechnical consideration area having none to low swell potential (0 to 4 percent) with the Sky Pointe pedestrian crossing and the west-north ramp undercrossing structure located in a special geotechnical consideration area having moderate swell potential (4 to 8 percent).

2.5. FIELD EXPLORATION

GES evaluated the subsurface conditions along the planned Sky Pointe Drive bridge crossing site by drilling seven exploratory borings between November 12, 2018 and November 20, 2018. Each boring was drilled near bridge support locations on the east and west side of the future Sky Pointe Drive. Exploratory boring B-1 and B-3 were advanced to approximately 65 and 69.5 feet below the ground surface, respectively, where practical auger refusal was encountered on strongly cemented soils. Boring B-2 and B-4 through B-7 were advanced to approximately 85 feet below the ground surface. Figure A-2 presents a site plan showing the approximate location of each of the subsurface explorations. The locations were recorded by GES personnel using a handheld GPS unit at the time the explorations were performed. The elevations were obtained from Google Earth and are considered approximate.

GES representatives directed the subsurface explorations, while maintaining detailed logs of the subsurface conditions, classifying the soils encountered, and obtaining soil samples. The soils encountered were classified in general accordance with the Unified Soil Classification System (USCS). Logs of the subsurface conditions encountered in the exploratory borings are presented in Appendix A. Also included in the appendix is a Key to Symbols and Terms (Figure No. A-3) utilized on the exploration logs.

The borings were drilled with a Mobile B-90 truck-mounted drill rig and a Diedrich D-50 track-mounted drill rig using 8-inch nominal outside diameter hollow-stem augers (H.S.A.). Solid Stem Augers with a 4-inch diameter were used on exploratory boring B-7 where a strongly cemented soil layer was encountered. Ring-lined soil samples and penetration resistance (i.e., blow counts) were obtained with a 3-inch outside diameter ring-lined drive sampler (modified California) in general accordance with ASTM D3550, or a 2-inch outside diameter standard penetration test (SPT) split-spoon sampler in general accordance with ASTM D1586. The sampler was driven with a 140-pound automatic trip hammer falling about 30 inches. The blow count obtained from driving the sampler was used to evaluate the density and consistency of the in-place soil. A thin walled sampler (e.g., Shelby tube) was also attempted at selected depths in each boring in accordance with ASTM D1587 in order to obtain relatively undisturbed soil samples. Bulk samples were also obtained at selected subsurface intervals and from the ground surface at borings B-1, B-3, and B-6.

Auger cuttings from the drilling operations were spread across the project site for disposal at the end of each work day. The boreholes were backfilled with bentonite slurry and/or controlled low-strength material (CLSM).

Pocket penetrometer tests were also performed in the field on selected fine-grained, clayey specimens as an indication of soil strength. The results of the pocket penetrometer tests are shown on the boring logs at their respective sampling depths as referenced in Appendix A.

Drill rates were generally obtained where layers of strongly cemented soils were encountered within the borings. Drill rates were obtained by measuring the time required to drill through a known depth. The measured time elapsed and the distance drilled were converted to drill rates and were recorded on the boring logs in seconds per foot. The drilling rates are a qualitative indication of the relative hardness of the cemented soils but are also influenced by drilling method, bit size, bit wear, drilling pressure and other features. The drill rates, given in seconds per foot, are listed on the boring logs in Appendix A at the depths where cemented soils were encountered.

2.6. LABORATORY TESTING

The laboratory testing program included tests to classify the on-site soils and to assess engineering and physical properties of the on-site soils. The test results are presented on the boring logs in Appendix A and on test reports presented in Appendix B. Detailed descriptions of the laboratory tests performed are also presented in Appendix B. A summary of selected laboratory test results is provided in the table below.

Table 2.6. Summary of Selected Laboratory Test Results

Test	Test Results	Notes
Atterberg Limits Liquid Limit Plastic Limit Plasticity Index	No value to 97 Non-plastic to 37 Non-plastic to 60	Generally non-plastic to high plastic soils
Moisture content	2.8 to 30.5 percent	--
Dry density	73.2 to 119.7 pounds per cubic foot	--
Material passing #200 sieve	18 to 95 percent	--
Consolidation – Compression Index, Cc	0.08 to 0.15	--
Direct Shear Test – Angle of Internal Friction	28 to 31 degrees	--
Direct Shear Test – Cohesion	0.10 to 0.34 ksf	--
Swell Potential	0 to 4 percent	None to low swell potential
Sodium Content	0.01 to 0.02	--
Sulfate Content	0.08 to 0.35 percent	Negligibly to severely deleterious to concrete
Sodium Sulfate Content	0.016 to 0.059 percent	Low chemical heave (salt heave) potential
Total Salts (Solubility)	0.11 to 0.45 percent	Low soluble
Sulfide**	ND* to 1.6mg/kg	--
pH	8.15 to 8.41	--
Reduction-oxidation**	339 to 350 mV	--
Chloride Content	ND* to 300 mg/kg	Low corrosion potential
Resistivity	400 to 878 Ohms-cm	Severely to very severely corrosive to steel

*Not detected; ** Consult a corrosion engineer

The test results are presented in Appendix A on the boring logs and on test reports presented in Appendix B. Detailed descriptions of the laboratory tests performed are also presented in Appendix B.

2.7. SUBSURFACE MATERIALS AND CONDITIONS

The following sections describe the fill and native soils encountered in the borings. Detailed information regarding subsurface materials and conditions are presented on the boring logs in Appendix A.

2.7.1. FILL

Fill material was not encountered in our exploratory borings. Fill placed without documentation to indicate that the fill soils were placed under the supervision of a geotechnical engineer are considered uncontrolled. The term uncontrolled fill soil refers to material which was placed without engineering observation, testing, or documentation; uncontrolled fill is considered unsuitable for the support of proposed improvements. Our scope did not include an evaluation of the existing fill soils or certification of existing fill or improvements.

2.7.2. NATIVE SOIL

The native subsurface soils encountered in the borings generally consisted of moist to wet and stiff to very stiff lean clay with gravel with weakly to moderately cemented layers at intermittent levels, and moist to wet and medium dense to very dense clayey gravel. Detailed information regarding subsurface materials and conditions, are presented on the exploration logs in Appendix A.

Strongly cemented soils, with varied thickness, were generally encountered in all of the borings at the site at depths of between approximately 33 to 74 feet below the existing ground surface. The approximate depth that strongly cemented soil was first encountered in the borings, the approximate layer thicknesses, and hardness of the materials encountered are summarized in the following table. Additional layers of cemented soils could be encountered beyond or between our exploration locations at varying elevations.

Table 2.7.2 Approximate Depth to Initial Cemented Soil Layer

Boring No.	Approximate Depth to First Cemented Layer (feet)	Approximate Thickness of Initial Cemented Layer (feet)	Degree of Hardness
B-1	33	9	Very Hard
B-2	33	3	Very Hard
B-3	33	7	Very Hard
B-4	46	3	Hard
B-5	32	3	Very Hard
B-6	30	2	Hard
B-7	31	4	Very Hard

In addition, weakly and/or moderately cemented soils were encountered within the soil layers at varying depths in all seven borings. Weak, moderate and strong cementation is identified on the boring logs at the depths encountered.

2.7.3. GROUNDWATER

Groundwater was encountered in four of the borings drilled for the project. Groundwater was encountered during drilling at depths ranging from approximately 58½ to 69 feet below the ground surface. Approximate groundwater depths are shown on the boring logs in Appendix A and are summarized in Table 2.7.3. Information from Las Vegas Valley Depth to Shallow Groundwater Map indicates groundwater levels deeper than 100 feet near the site.

Table 2.7.3. – Groundwater Depths Encountered

Exploration No.	Depth to Groundwater Encountered During Drilling (feet)	Approximate Surface Elevation (feet)	Approximate Groundwater Elevation (feet)
B-2	63	2,394	2,331
B-5	58.5	2,384	2,325.5
B-6	65	2,380	2,315
B-7	69	2,377	2,308

Groundwater depth measured 1 day after drilling

Design groundwater elevation is 2,331 feet. Groundwater levels should be anticipated to fluctuate due to seasonal precipitation, groundwater withdrawal and recharge, irrigation practices, and potential future dewatering efforts within and/or near the subject site. A detailed evaluation of possible groundwater fluctuations is beyond the scope of this study.

3. SUBSURFACE PROFILES & GEOTECHNICAL PARAMETERS

Soil profiles with geotechnical design parameters for each boring associated with a foundation are presented in Appendix C. The geotechnical parameters are largely based on our review of the Triaxial test results performed by NDOT as part of the CC215-US95 Interchange project (NDOT 2016). GES should be notified of subsurface discrepancies observed during drilled shaft drilling.

4. FINDINGS

Based on the results of our field exploration and laboratory testing programs, it is our opinion that there are no known geologic or geotechnical conditions that would prevent development of the site. It is also our opinion that there are some geotechnical considerations that will affect site development, such as the following:

- Fill materials were not encountered in our subsurface explorations. Fill placed without documentation to indicate that the fill soils were placed under the supervision of a geotechnical engineer are considered uncontrolled. The term "uncontrolled fill" soil refers to fill which was placed without engineering observation, testing, or documentation; uncontrolled fill is considered unsuitable for the support of proposed improvements. Our scope did not include an evaluation of the existing fill soils or certification of existing fill or improvements.
- Weakly to moderately cemented soils were encountered in all the borings during our field exploration. Weakly and moderately cemented soil refers to cemented soil that will crumble or break with little or considerable finger pressure, respectively. In general, very dense or weakly to moderately cemented soils can be excavated with a backhoe and medium hard cemented soils can be excavated with a ripper tooth or by a backhoe with extreme difficulty.
- Strongly cemented soils were encountered in all the borings at the site at depths of between approximately 33 to 74 feet below the existing ground surface. Additional cemented soil layers may likely be encountered at different depths and locations between our borings. Strongly cemented soil refers to rock-like soil that will not crumble or break at any finger pressure. To excavate medium hard to hard, and/or hard cemented rock-like materials, a heavy-duty excavator or trencher, Caterpillar D-10 Dozer or larger (or equivalent) with ripper, hoe-ram, headache ball, rock-saw or similar rock excavation techniques is recommended and will likely be needed. Where thick layers of very hard cemented materials are to be excavated, blasting is sometimes needed for removal. A detailed excavatability or rippability evaluation is beyond the scope of this study. The contractor should perform the independent investigations necessary to determine the type of equipment required to perform the work. If the contractor(s) have any questions regarding site conditions, site preparation, or the recommendations provided, they

should contact a representative of GES for any needed clarifications prior to submitting earthwork bids.

- Based on the results of our laboratory testing and our understanding of the subject project, it is our opinion that the level of verification and inspection should be continuous during grading and drilled shaft construction.
- Groundwater was encountered in four borings at depths between 58½ to 69 feet below the existing ground surface. Information from Las Vegas Valley Depth to Shallow Groundwater Map indicates groundwater levels deeper than 100 feet near the site. A groundwater elevation of 2,331 feet was used in our analysis. Groundwater levels should be anticipated to fluctuate due to seasonal precipitation, groundwater withdrawal and recharge, irrigation practices, and existing and potential future dewatering efforts within and/or near the subject site. A detailed evaluation of possible groundwater fluctuations was beyond the scope of this study.
- Due to the consistency and types of soils encountered at the site and the depth to groundwater, it is our opinion that the potential for distress resulting from liquefaction at the site is low.
- Based on the results of our review of available literature and the distance to mapped faults and fissures, it is our opinion that the potential for fault-related surface rupture at the project site is low.
- The tested site soils have none to low expansion potential as described in Section 1803.5.3.2 and Table 1808.6.1.1 of the SNA to the 2012 IBC.
- Based on the laboratory test results, and in accordance with Table 1804.3.1 of the SNA to the 2012 IBC (SNBO, 2013), the solubility of the tested soils is considered low.
- The tested soils have a negligible to severe concrete sulfate exposure as defined in Tables 4.2.1 and 4.3.1 of American Concrete Institute (ACI) Publication 318-11 per Section 1904.1 and 1904.2 of the 2012 IBC. It is our opinion that concrete in contact with soils at the site should be designed for a severe sulfate exposure.
- The tested soils have a severe to very severe corrosion potential to buried metals based on the chemical testing performed.
- The average shear wave velocity method for evaluating Site Class is described in Table C3.10.3.1-1 (Method A) in the referenced LRFD Bridge Design Specifications (AASHTO, 2014). Based on the conditions encountered during our subsurface explorations, and the referenced

shear wave velocity information, a Site Class C, as described in Table 3.10.3.1-1 in the LRFD Bridge Design Specifications is appropriate for design of this project.

5. RECOMMENDATIONS

The following sections present recommendations concerning the proposed Sky Pointe Drive pedestrian crossing, WN ramp undercrossing, and Oso Blanca Road pedestrian bridge improvements. These recommendations are based upon our understanding of the project, the engineering properties of the tested on-site soils, the geologic conditions that are presented in this report, and the assumption that an adequate number of tests and observations will be made during construction to evaluate compliance with these recommendations.

5.1. EARTHWORK

Based on the results of our field exploration and laboratory testing programs and our stated understanding of the proposed project, it is our opinion that the following earthwork recommendations for the proposed improvements are applicable to the project.

5.1.1. OVEREXCAVATION AND SITE PREPARATION

Proposed improvement areas should be cleared of any pavements, surface obstructions, debris, organics (including vegetation), and other deleterious material. Materials generated from clearing operations should be removed from the project site for disposal.

We recommend that the full depth of any on-site undocumented fill and surficial loose and/or disturbed soils, at the time construction begins, be removed from proposed structure and improvement areas, including bridge, block retaining/screen wall, pavement, and exterior flatwork areas. These excavated soils may be stockpiled for later use as borrow or granular backfill or backfill if they comply with the recommendations provided in this report.

Proposed improvement areas should be cleared of any pavements, flatwork, surface obstructions, debris, organics (including vegetation), and other deleterious material. Materials generated from clearing operations should be removed from the project site for disposal.

We recommend that the on-site soils be overexcavated and a zone of processed, moisture-conditioned and compacted backfill or granular backfill should be provided beneath site improvements and shallow foundations. After the removal of unsuitable soils has been performed, as described previously, the on-site native soils should be overexcavated to the depths summarized in the table below:

Table 5.1.1 Recommended Overexcavation Depths

Proposed Improvement	Minimum Overexcavation Depth*
Structure Shallow Foundations	12 inches below bottom of shallow footings
Concrete Slabs-on-Grade	12 inches below existing grade or the bottom of supportive gravel (Type II Aggregate Base)
Concrete Flatwork/ Site Improvements	

*Overexcavation depths may need to be increased to remove unsuitable material

During construction the geotechnical consultant should observe exposed materials, after recommended removals of unsuitable materials, to evaluate whether additional removal down to competent materials is needed. After the recommended excavations are performed, the native soils should be scarified to a depth of at least 6 inches, moisture conditioned to between optimum and 3 percent above the optimum moisture content and compacted to at least 95 percent of the maximum dry density, as determined by AASHTO T180. The soil preparation area should extend laterally a minimum of 2 feet beyond the edges of exterior concrete flatwork and pavement. The vertical and lateral extent of the recommended excavations should be evaluated under the direction of the geotechnical consultant. Scarification efforts may be terminated at depths where strongly cemented material is encountered, as evaluated in the field by the geotechnical consultant.

5.1.2. BACKFILL OR GRANULAR BACKFILL AND BORROW SUITABILITY

Samples of materials proposed for use as imported backfill, granular backfill or borrow should be submitted to the geotechnical consultant for testing and evaluation prior to being transported to the site. Based on the subsurface soils encountered in our explorations, the native shallow soils do not appear to meet specifications for backfill, granular backfill or borrow. Imported materials and on-site materials that have been excavated, stockpiled, and processed for use as backfill or granular backfill should satisfy the recommendations provided in Sections 704.03.10, 704.03.11 and/or 704.03.12 in the 2014 NDOT Standard Specifications. Additional fill materials should be free of debris, organic materials, and other deleterious materials including asphalt concrete pavement and concrete rubble.

5.1.3. FILL PLACEMENT

Areas to receive backfill or granular backfill should be prepared prior to fill placement as described in Section 5.1.1 of this report. Backfill or granular backfill should be uniformly moisture conditioned to between optimum and 3 percent above the optimum moisture content, placed in horizontal, loose lifts up to 8 inches thick, and compacted to 95 percent of the maximum dry density, or more, as determined by AASHTO T310. The fill lift thickness should not exceed 8 inches in loose thickness.

If fill material is placed where the existing ground surface is steeper than 5:1 (horizontal to vertical), the surface on which fill is to be placed should be benched. We recommend that benches be 8 feet or wider or be of sufficient width to permit operation by compaction equipment. Benches should include approximately 2-foot high vertical or near-vertical intervening steps, cut to expose suitable soil as evaluated in the field by the geotechnical consultant during earthwork operations. Preparation of the benching surface in areas to receive fill should include scarification and moisture-conditioning to a depth of approximately 6 inches, and compaction to a relatively non-yielding condition, prior to placement of fill.

5.1.4. OBSERVATION AND TESTING

A qualified geotechnical consultant should perform appropriate observation and testing services during grading and construction operations. These services should include observation of removal of soft, loose, or otherwise unsuitable soils, evaluation of subgrade conditions where soil removals are performed, and performance of observation and testing services during placement and compaction of backfill or granular backfill and backfill soils. In-place density and moisture tests should be performed in accordance with AASHTO T310. The test frequency should be at least one test per 100 cubic yards of fill material placed or at least 2 tests per lift of fill material placed, whichever is more. Additional field tests may also be performed in structural and non-structural areas at the discretion of the geotechnical consultant.

Observation and testing of soils should be performed on a continuous basis during grading and drilled shaft construction.

5.2. EXCAVATION CONSIDERATIONS

The following sections provide recommendations to aid in the successful performance of excavations at the project site and include recommendations regarding temporary excavations and cemented soil considerations.

5.2.1. TEMPORARY EXCAVATIONS

Excavations should not undermine existing footings. Excavations should be located a minimum lateral distance from the existing foundation equal to or greater than the proposed depth of excavation. If excavations are proposed near existing foundations or slopes, the owner should be contacted to evaluate the necessary measures to be taken on a case by case basis.

Temporary slope surfaces should be kept moist to retard raveling and sloughing. Water should not be allowed to flow over the top of excavations in an uncontrolled manner. Stockpiled material and/or equipment should be kept back from the top of excavations a distance equivalent to the depth of the excavation or more. Workers should be protected from falling debris, sloughing and raveling in accordance with Occupational Safety and Health Administration regulations. Temporary excavations should be observed by the project’s geotechnical consultant so that appropriate additional recommendations may be provided based on the actual field conditions. Temporary excavations are time sensitive and failures are possible.

Excavations greater than 4 feet in depth into uncemented soils are not anticipated to stand vertically. Excavations greater than 4 feet in depth should be sloped back in accordance with the maximum allowable slope ratios presented in Appendix B to Subpart P of Occupational Safety and Health Standards for the Construction Industry (OSHA) 29 CFR, State of Nevada, Division of Occupational Safety and Health, Part 1926. Based on the results of our explorations, the on-site soils preliminarily classify as Type C as defined by OSHA (Federal Register 29 CFR, Part 1926, Subpart P-excavation). The soil type definitions in Appendix A to Subpart P of OSHA 29 CFR, Part 1926 should be applied to soils encountered in excavations to determine the maximum allowable slope ratio. As an alternative to sloped excavation sidewalls, excavations could be shored and braced. Shoring and bracing should be designed in accordance with Appendices C and D to Subpart P of OSHA 29 CFR, Part 1926. Safety of construction personnel is the responsibility of the contractor.

5.2.2. CEMENTED SOIL CONSIDERATIONS

Weakly to moderately cemented soils were encountered in all the borings during our field exploration. Weakly and moderately cemented soil refers to cemented soil that will crumble or break with little or considerable finger pressure, respectively. In general, very dense or weakly to moderately cemented soils can be excavated with a backhoe and medium hard cemented soils can be excavated with a ripper tooth or by a backhoe with extreme difficulty. In general, to excavate moderately hard to hard, hard, and very hard rock-like materials, a heavy-duty excavator or trencher, Caterpillar D-10 Dozer (or equivalent) or larger, ripper, hoe-ram, headache ball, rock-saw or similar rock excavation techniques may be needed. Where thick layers of very hard cemented materials are to be excavated, blasting is sometimes needed for removal. A detailed excavatability or rippability evaluation is beyond the scope of this study. The contractor should perform the independent investigations necessary to determine the type of equipment required to perform the work. If the contractor(s) have any questions regarding site conditions, site preparation, or the recommendations provided, they should contact a representative of GES for any needed clarifications prior to submitting earthwork bids.

Strongly cemented soils were encountered in all the borings at the site at depths of between approximately 33 to 74 feet below the existing ground surface. Additional cemented soil layers will likely be encountered at different depths and locations between our borings. The following additional recommendations are provided in anticipation of strongly cemented soil being encountered during construction. A detailed excavatability or rippability evaluation was beyond the scope of this study. The contractor should perform the independent investigations necessary to determine the type of equipment required to perform the work. If the contractor(s) have any questions regarding site conditions, site preparation, or the recommendations provided, they should contact a representative of GES for any needed clarifications prior to submitting earthwork bids.

Overexcavation and/or scarification efforts may be terminated at depths where medium hard to very hard, strongly cemented material is encountered, as evaluated in the field by the geotechnical consultant.

Due to the potential for differential settlement, structure footings (including retaining wall footings) should not bear on both strongly cemented and non-cemented or weakly cemented soils. If both cemented and non-cemented/weakly-cemented soils are present at the footing base, as evaluated by the geotechnical consultant, the cemented soil should be overexcavated approximately 12 inches and replaced with backfill or granular backfill, or the uncemented soil should be overexcavated down to strongly cemented soil and the excavated material replaced with lean concrete.

Oversize material is anticipated to be generated during excavation of strongly cemented material. These materials will need to be crushed prior to being used as backfill or granular backfill and backfill or removed from the site and disposed of in a suitable manner. Bulking of this material should be anticipated when it is excavated, processed/crushed, and compacted. For planning purposes, up to approximately 10 percent bulking, or more, should be anticipated.

Rock excavation techniques such as use of heavy-duty ripping equipment, heavy-duty backhoe, headache ball, hoe-ram, and/or rock saw should be anticipated if strongly cemented soils are encountered. The contractor should be aware of the potential for (and take adequate precautions to reduce the potential for) vibrational damage to adjacent or nearby structures, and take appropriate precautions, when using heavy impact equipment during removal of strongly cemented materials. Pre-construction documentation of existing distress to structures near construction areas, and monitoring of these structures and ground motions generated, should be considered to reduce the potential for damage and construction-related claims.

5.3. MATERIAL VOLUME CHANGES

Based on our experience, it is our opinion that there will be a reduction in volume when the native uncemented soils are excavated and compacted. Shrinkage of the native uncemented soils is estimated to be in the range of 10 to 20 percent when compacted to at least 95 percent of the maximum dry density (AASHTO T180). Accordingly, with shrinkage of 10 to 20 percent, one cubic yard of excavated native soils compacted to 95 percent relative compaction would generate approximately 0.90 to 0.80 cubic yards of backfill or granular backfill, respectively. A bulking factor of approximately 10 percent should be anticipated for the excavation of strongly cemented soils.

5.4. UNDERGROUND UTILITIES

Trenches for underground utilities should be excavated to the depths shown on the approved improvement plans. The bottom of trench excavations should be founded on undisturbed, stiff to very stiff, or dense to very dense native soils or compacted embankment fill. If the trench is excavated below the grade shown on the approved improvement plans, the bottom may be filled using soils meeting the specifications for Backfill or Granular Backfill presented in Section 704 of the 2014 NDOT Standard Specifications. These soils should be moisture conditioned and compacted as recommended for backfill in Section 5.1.3 above.

Trenches for flexible pipes should be excavated to provide a width more than 1.5 times the outside pipe diameter and have more than 12 inches of horizontal clearance on each side of the pipe for pipe zone backfill placement and compaction. Trenches for rigid pipes should be excavated to provide a minimum width of the outside pipe diameter times 1.33 for pipe zone backfill placement and compaction. If CLSM is used as pipe zone, the trench width may be reduced to the outside pipe diameter plus 12 inches and enough room for the proper placement of the CLSM. CLSM should be sampled and tested for compressive strength according to Section 704.03.07 of the USS at a frequency of once per placement day or every 100 cubic yards, whichever is more. The contractor should excavate trenches to a dimension that allows compaction of the pipe zone and bedding within the trench widths described above.

Excavated native soils may be used for on-site utility trench backfill provided they meet the recommendations for imported backfill or granular backfill detailed in Section 5.1.2 above. Cemented soils encountered during trench excavation will require processing and evaluation prior to use as trench backfill. Soils used for on-site trench backfill should be moisture conditioned to within 2 percent of the optimum moisture content, placed in 8-inch maximum loose lifts, and compacted to at least 95 percent of the maximum dry density per AASHTO T180. Suitability and placement of trench backfill should be evaluated during construction. In-place density and moisture tests of on-site trench backfill should be performed in general accordance with AASHTO T310; the test frequency should be at least one test per 200 linear feet of fill material placed per each vertical foot of compacted fill.

Off-site utility trench backfill placement procedures should meet the specifications outlined in the latest edition of the referenced Clark County Uniform Standard Specifications for Public Works Construction (USS).

Due to the nature of the on-site soils, ponding or jetting of utility trench backfill will not be acceptable. Trench backfill should be compacted by mechanical means only.

5.5. FOUNDATIONS

The following sections present foundation recommendations for shallow spread footings and drilled shafts to be used for this project.

5.5.1. SPREAD FOOTINGS

Footings should be designed based on the bearing and sliding resistance parameters presented in this section, which assume that footings will bear on medium dense to very dense native material, or on adequately placed and compacted backfill meeting Section 704.03.10 of the 2014 NDOT Standard Specifications or entirely on cemented soils (caliche). Due to the potential for differential settlement, footings should not bear on both caliche and non-cemented soils. If both cemented and non-cemented soils are present at the footing base, the cemented soils should be overexcavated 12 inches and replaced with compacted backfill or granular backfill.

Spread footings should be established at least 2 feet below the lowest adjacent final compacted subgrade. Spread footings should be at least 2 feet wide.

The nominal bearing resistance values for both strength limit and service limit states for various footing configurations in general accordance AASHTO LRFD Bridge Design Specifications, Section 10 based on angle of internal friction of 34 degrees and unit weight of 130 pounds per cubic foot (pcf) are discussed in this section. The formulas and parameters for bearing resistance and nominal bearing resistance for various depths to bottom of footing for the strength limit are provided in Appendix C. The formulas and parameters for bearing resistance and bearing resistance with 1-inch limiting settlement for the service limit are provided in Appendix C.

It should be noted that the information presented in Appendix C are derived based on the soil parameters assumed in the calculation. If the soil conditions encountered are different from those used in the analysis, Geotechnical & Environmental Services, Inc. should be immediately notified so that we may review the situation that exists and make supplementary recommendations as needed.

5.5.2. DRILLED SHAFT FOUNDATIONS

Analysis of axial loading and anticipated lateral deflections of drilled shafts to support the bridge were evaluated in accordance with American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications (AASHTO, 2014). The results of our axial analyses are provided in Appendix C. The information provided in these appendices is based on results obtained from analyses performed using our laboratory test results, encountered subsurface soil conditions, and anticipated loading conditions provided by GCW.

Design Criteria for Drilled Shaft Foundations

Soil profiles with geotechnical design parameters for each boring associated with a foundation are presented in Appendix C. The geotechnical parameters are largely based on our review of the Triaxial test results performed by NDOT as part of the CC215-US95 Interchange project (NDOT 2016). Based on the subsurface conditions encountered in our explorations, we judge the soil profiles to be representative of the soils anticipated to be encountered during construction of drilled shafts. GES should be notified of subsurface discrepancies observed during drilled shaft drilling.

Downward Axial Resistance

Axial drilled shaft capacities were formulated using skin friction resistance in accordance with the methods outlined in Section 10.8 of the AASHTO LRFD Bridge Design Specifications (AASHTO, 2014). Axial resistance analysis was performed using a spreadsheet that was developed based on Section 10.8.3.5 of the AASHTO LRFD Design Specifications (AASHTO, 2014). As requested by GCW, analysis was performed for 36-inch and 72-inch diameter shafts for the abutments and piers, respectively. Spreadsheet outputs from axial analysis are provided in Appendix C.

Evaluation of the neutral plane was performed in accordance with Section 9.8.2.7 of the referenced Federal Highway Administration (FHWA) manual (Hannigan, 2006). Settlement due to downdrag at the neutral plane was evaluated using the computer program Settle 3D (Rocscience, 2010). The software utilized Boussinesq's method to compute the stress distribution due to the loads. The results of our settlement analyses are summarized in the following table.

Table 5.5.2-1. Summary of Drilled Shaft Analyses

Location	Drilled Shaft Length (feet)	Axial Load at Strength Limit State (kips)	Approximate Total Settlement (inches)
Abutment 1	37	793	0.70
Pier 1	29	1591	<0.25
Pier 2	40	1799	<0.25
Pier 3	28	1460	<0.25
Pier 4	35	1468	<0.25
Pier 5	14	570	<0.25

Lateral Loading

For lateral loading, drilled shafts in a single row may be considered to act individually when the center-to-center spacing is greater than five shaft diameters in the direction normal to loading. The table below presents the lateral load reduction factors to be applied for various pile spacing for in-line loading. Linear interpolation may be used for intermediate spacing. Lateral load analyses will be performed by others.

Table 5.5.2-2. Lateral Load Reduction Factors

Center-To-Center Shaft Spacing for In-Line Loading in Diameters	Ratio of Lateral Resistance of Shaft in Group to Single Shaft
5	1.0
3	0.8

5.6. DRILLED SHAFT CONSTRUCTION CONSIDERATIONS

As discussed previously, strongly cemented soils (caliche) were encountered in our subsurface explorations. Accordingly, difficult drilled shaft excavation conditions should be anticipated. Drilled shaft excavation activities will be impeded by strongly cemented soils. Rock excavation and heavy-duty excavation techniques should be anticipated.

Groundwater (2,331 feet design elevation) is anticipated to be encountered at the site. Accordingly, casing of drilled shaft excavations, use of drilling mud, and other special excavation techniques should be considered. We recommend that the contractor be prepared to take appropriate measures during construction to reduce the potential for caving of the drilled holes, including the use of casing and/or drilling mud. In addition, we recommend that measures, such as placement of concrete by tremie method below groundwater, are implemented so that aggregate and cement do not segregate during concrete placement. When possible, reinforcing steel and shaft concrete should be placed the same day the shaft excavation is drilled. To aid in reducing the potential for “blowout” between adjacent (less than 3 shat diameters) shaft excavations, it may be necessary to drill and fill the shafts alternately, allowing the concrete to cure 8 hours or more before drilling the adjacent shaft. Concrete compressive strength and steel reinforcement should be specified in accordance with recommendations of a qualified structural engineer.

Crosshole sonic logging (CSL) should be considered to evaluate concrete integrity of the drilled shafts. To perform CSL in drilled shafts, vertical 2-inch diameter steel tubes (equal in length to the shaft plus 3 feet) need to be placed on reinforcing cages prior to concrete placement. The CSL tubes should extend to within a few inches of the bottom of the excavation and should be filled with water within 4 hours of concrete placement. The number and layout of the CSL tubes will depend on the diameter of the drilled shaft. CSL should be performed 4 to 8 days after placement of concrete.

The bottom and sidewalls of each drilled shaft excavation should be evaluated in the field during construction by the geotechnical consultant. The geotechnical consultant should compare the encountered conditions with those assumed for design. If the encountered geotechnical conditions are significantly different than those used in design of the drilled shaft, our office should be notified and additional recommendations, if warranted, will be provided upon request. The contractor should make provisions to provide for the integrity of the excavation and to make sure that the excavations are cleaned and straight, and that sloughed, loose, or soft soil is removed from the bottom of excavations prior to placement of concrete.

Concrete should be placed in the drilled shaft excavation as soon as practicable after drilling and evaluation by the geotechnical consultant. Concrete should have an ultimate strength not less than that specified and should be workable and plastic so that it may be placed without segregation. Concrete should be cast-in-place against undisturbed earth in the hole in such a manner to provide for the exclusion of appreciable amounts of foreign matter in the concrete. The shafts should be adequately reinforced for lateral and uplift loads, as recommended by the project structural engineer.

5.7. SEISMIC DESIGN PARAMETERS

The average shear wave velocity method for evaluating Site Class is described in Table C3.10.3.1-1 (Method A) in the referenced LRFD Bridge Design Specifications (AASHTO, 2014). Based on the conditions encountered during our subsurface explorations, and the referenced shear wave velocity information, a Site Class C, as described in Table 3.10.3.1-1 in the LRFD Bridge Design Specifications is appropriate for design of this project.

As indicated in the referenced AASHTO LRFD Bridge Design Specifications (AASHTO, 2014), the subject site is in an area (approximately 36.27791 degrees latitude and -115.26054 degrees longitude) characterized by a Horizontal Peak Ground Acceleration of approximately 0.15g with a 7 percent probability of exceedance in 75 years. Additional seismic design parameters are provided in the following table.

Table 5.7. – AASHTO Seismic Design Parameters – Site Class C

Parameters	**Value**			**Reference (AASHTO, 2014)**
	Zero Period	**Short Period**	**Long Period**	
Mapped Maximum Considered Earthquake Spectral Response Acceleration, PGA, Ss, and S_1	0.15g	0.40g*	0.15g*	Figures 3.10.2.1-1, 3.10.2.1-2, and 3.10.2.1-3
Site Coefficient, Fpga, Fa, and Fv	1.2	1.2	1.65	Tables 3.10.3.2-1, 3.10.3.2-2, and 3.10.3.2-3
Design Spectral Response Acceleration, A_S, S_{DS}, and S_{D1}	0.18g	0.48g	0.25g	Equations 3.10.4.2-3, 3.10.4.2-3, and 3.10.4.2-6

*Minimum value allowed by NDOT in Clark County for Ss is 0.4 and for PGA and S_1 are 0.15 as presented in Figure 12.3H of the referenced Structures Manual (NDOT, 2008). Estimated values for PGA, Ss and S_1 are 0.15, 0.39 and 0.12, respectively as mapped in the referenced specifications (AASHTO, 2014).

5.8. LATERAL EARTH PRESSURES

Retaining elements should be designed according to the recommendations in this report. Retaining walls with level backfill should be designed to resist the lateral earth pressures for the appropriate conditions presented in Table 5.8.

Table 5.8. Lateral Earth Pressures and Sliding Resistance

Parameter	Strength Limit State
Coefficient of Active Earth Pressure, k_a	0.33
Coefficient of At-rest Earth Pressure, k_o	0.50
Coefficient of Passive Earth Pressure, k_p	9.0
Factored Coefficient of Passive Earth Pressure, k_p	6.192
Sliding Passive Resistance Factor, φ_{ep}	***0.5
Factored Passive Lateral Earth Pressure, p_p	805 psf/ft** of depth
Nominal Sliding Resistance for Cast-in place Concrete, R_τ	0.675(V)* where V is total vertical force

*The nominal sliding resistance is based on an internal friction angle, ϕ_f, of 34 degrees.

**Factored passive lateral earth pressure is based on an internal angle of 34 degrees and a unit weight of 130 pcf.

***additional factor to be used when using passive to resist sliding.

Backfill placed behind retaining walls or subsurface walls should consist of backfill or granular backfill meeting the criteria presented in this report. Backfill placed behind retaining walls should be placed in 8-inch maximum vertical lifts and should be compacted to between 90 and 95 percent of the maximum laboratory dry density as evaluated per AASHTO T180. Over-compaction adjacent to retaining walls or subsurface walls should be avoided.

5.9. EXTERIOR CONCRETE FLATWORK CONSTRUCTION

Concrete flatwork should be at least 4 inches in thickness. Potential for chemical heave is low according to chemical testing results performed as part of this study. Accordingly, aggregate base course materials beneath concrete flatwork should be 4 inches in thickness, or more, and should consist of Type II Aggregate Base or other similar material approved by the geotechnical engineer. Aggregate base should be uniformly placed and compacted to at least 95 percent of the maximum dry density.

The existing on-site subgrade soils beneath concrete flatwork should be prepared as described in section 4.1 of this report, including moisture-conditioning to between optimum and 3 percent above optimum moisture content and compaction to 90 percent, or more, of the maximum dry density as evaluated by AASHTO T180 prior to the placement of supportive aggregate base.

Excessive slump (due to a high water-cement ratio) of the concrete and/or improper curing procedures could lead to excessive shrinkage, cracking or curling of slabs and other flatwork. Concrete placement and curing operations should be performed in accordance with the American Concrete Institute (ACI) Manual of Concrete Practice (ACI, 2011).

5.10. SOIL CORROSIVITY

The corrosion potential of onsite soils to concrete and buried metal was evaluated in the laboratory using representative samples obtained from the exploratory borings. Laboratory testing was performed to assess the effects of sulfate content on concrete and soil resistivity on buried metal. Results of these tests are presented in Appendix B. Recommendations regarding concrete to be utilized in construction of proposed improvements and for buried metal pipes are provided in the following sections.

5.10.1. CONCRETE

Chemical tests performed on selected samples of on-site soils indicated sulfate contents of 0.08 to 0.35 percent by weight. Based on review of the referenced American Concrete Institute Manual of Concrete Practice (ACI, 2011), the tested soil is considered negligibly to severely deleterious to concrete. However, based on our experience with projects in the vicinity of the subject site, we recommend that concrete in contact with on-site soils, along with subsurface walls up to 12 inches above finished grade, contain Type V cement, and have a design compressive strength of at least 4,500 pounds per square inch (psi), and a maximum water to cement ratio of 0.45. In addition, it is recommended that reinforcing bars in cast-against-grade concrete, except for exterior concrete flatwork, be covered by approximately 3 inches or more of concrete. Concrete should be placed with an approximate 4-inch slump, or as specified by the structural engineer of record, and good densification procedures should be used during placement to reduce the potential for honeycombing. Structural concrete should be placed, concrete samples should be obtained, and the concrete slump should be tested by the project's geotechnical consultant in accordance with ACI recommendations and project specifications.

5.10.2. BURIED METAL

Laboratory resistivity test results performed on representative samples of on-site soils indicate electrical resistivity values ranging from approximately 400 to 878 Ohms-centimeters (Ohms-cm) at saturated moisture contents, which is severely to very severely corrosive to buried metals. We recommend that a Corrosion Engineer be consulted for protection recommendations regarding metal in contact with onsite soils. These corrosion reduction methods may include utilization of protective coatings, pipe sleeves, and/or appropriate cathodic protection as recommended by a qualified corrosion engineer. Where permitted by jurisdictional building codes, the use of plastic pipes for buried utilities should also be considered.

5.11. DRAINAGE AND MOISTURE PROTECTION

Infiltration of water into subsurface soils can lead to soil movement and associated distress, and chemically and physically related deterioration of concrete structures. To reduce the potential for infiltration of moisture into subsurface soils, we recommend the following:

- Positive drainage should be established and maintained away from proposed structures.
- A relatively impermeable barrier should be placed against retaining structures where retained soil is in contact with the retaining wall so that unsightly staining of the exposed wall face and potential for degradation of the wall will be reduced.
- Paved areas should have a surface gradient of 2 percent or more. In addition, surface runoff from surrounding areas should be intercepted, collected, and not permitted to flow onto the pavement or infiltrate the base and subgrade. We recommend that perimeter swales, edge drains, curbs and gutters, or combination of these drainage devices, be constructed to reduce the adverse effects of surface water runoff.
-

5.12. PLAN REVIEW

The recommendations presented in this report are based on the findings of our geotechnical evaluation. Project grading and foundation plans should be reviewed by the geotechnical engineer to evaluate whether the project grading and foundation plans are consistent with the geotechnical design criteria presented in this report.

5.13. PRE-CONSTRUCTION MEETING

We recommend that the owner or the owner’s representative, the engineer of record, the contractor, material testing firm, and the geotechnical consultant should attend a pre-construction meeting to discuss the plans and the project.

6. LIMITATIONS

The recommendations contained in this report are based on field exploration, laboratory testing, review of referenced maps and literature, and our understanding of the proposed construction. The soil data used in the preparation of this report were obtained from seven borings and existing information provided by GCW personnel. It is possible that variation in the soil conditions will exist between the locations explored. Therefore, if any soil conditions are encountered that are different from those outlined in this report, Geotechnical & Environmental Services, Inc. should be immediately notified so that we may review the situation that exists and make supplementary recommendations as needed. In addition, if the scope of the proposed construction, including the types of structures, anticipated loads and maximum cut and fill depths, changes from what is described in this report, our firm should be notified. A detailed excavatability or rippability evaluation is beyond the scope of this study.

The recommendations presented in this report assume that an adequate number of tests and observations will be made during construction to evaluate compliance with the recommendations. These tests and observations should be provided under the direction of a qualified geotechnical consultant. Such testing and observations should include but not be limited to the following:

- Review of site construction plans for conformance with the soils investigation.
- Observation and testing during site preparation, grading, footing and other excavations, and placement of fill, aggregate base, concrete, asphalt concrete, and steel reinforcement.
- Consultation as may be required during construction.

Our services were performed using that degree of care and skill ordinarily exercised under similar circumstances by reputable engineering firms in this or similar localities. No other warranties, either express or implied, are included or intended in this report.

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APPENDIX A

SUBSURFACE STUDY

Esri, HERE, Garmin, © OpenStreetMap contributors, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

🟧 Approximate Pedestrian Bridge Locations

🟩 Approximate Ramp Undercrossing Location

0 175 350 700 1,050 1,400 Feet

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SITE VICINITY MAP
215 BELTWAY CONNECTION
CENTENNIAL PKWY TO DECATUR BLVD-SEGMENT "B"
LAS VEGAS, NEVADA

Drawn By: JB	Date Drawn: 12/21/2018
Project No. 20174206E2	Figure No. A-1

J:\GES\Clients\Las Vegas Office\Projects\2017_Projects\20174206\E2 (Sky Pointe Ped. Bridge)\ArcGIS

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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BORING LOCATION MAP
215 BELTWAY CONNECTION
CENTENNIAL PKWY TO DECATUR BLVD-SEGMENT "B"
LAS VEGAS, NEVADA

Drawn By: JB

Date Drawn: 12/21/2018

Project No. 20174206E2

Figure No. A-2a

J:\GES\Clients\Las Vegas Office\Projects\2017_Projects\20174206\E2 (Sky Pointe Ped. Bridge)\ArcGIS

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

⌖	**BI-32**	NDOT Borings 2013
⌖	**BI-82**	NDOT Boring 2016

0 25 50 100 150 200
Feet

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NOTE: Data presented on this map is a compilation of GIS Metadata extracted from a variety of sources. Major Streets, Airports, and Railroads is data obtained from the Southern Nevada GIS Management Office. This data is downloaded by GES for incorporation into drawings generated by GES. Data contained within this page is to be used for informational purposes only. GES has not modified the data contained herein and uses it as it is acquired from the respective agency.

BORING LOCATION MAP 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD-SEGMENT "B" LAS VEGAS, NEVADA	Drawn By: SS	Date Drawn: 06/18/2018
	Project No. 20174206E2	Figure No. A-2b

J:\GES\Clients\Las Vegas Office\Projects\2017_Projects\20174206\E2 (Sky Pointe Ped. Bridge)\ArcGIS

KEY TO SYMBOLS AND TERMS

Terms used according to the Unified Soil Classification System

Consistency or Condition of Soils

Fine-Grained Soils (Silt and Clay): Major portion passing #200 sieve

California Sampler* (blows/foot)	SPT** (blows/foot)	Relative Consistency	Unconfined Compressive Strength (tsf)	Manual Manipulation
< 2	< 2	Very Soft	< 0.25	Thumb will penetrate soil more than 1 in.
2-5	2-4	Soft	0.25-0.50	Thumb will penetrate soil about 1 in.
5-10	4-8	Firm	0.50-1.00	Thumb will penetrate soil about $\frac{1}{4}$ in.
10-20	8-15	Stiff	1.00-2.00	Thumb will not indent soil but readily indented with thumbnail.
>20	>15	Very Stiff	>2.00	Thumbnail will not indent soil.

*ASTM D3550 using a 140-pound hammer falling 30 inches.
**ASTM D1586

Coarse-Grained Soils (Sand and Gravel): Major portion retained on #200 sieve

Modified California Sampler* (blows/foot)	SPT** (blows/foot)	Relative Density	Behavior of $\frac{1}{2}$-inch Diameter Probe Rod
0-7	0-4	Very Loose	Easily penetrated when pushed by hand.
7-18	4-10	Loose	Firmly penetrated when pushed by hand.
18-50	10-30	Medium Dense	Easily penetrated when driven by 1 lb. hammer.
50-90	30-50	Dense	Penetrated less than 1 inch when driven with a 1 lb. hammer.
>70	>50	Very Dense	Penetrated less than $\frac{1}{4}$ inch when driven with a 1 lb. hammer.

*ASTM D3550 using a 140-pound hammer falling 30 inches.
**ASTM D1586

Cementation	Characteristic
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

Hardness	Characteristic
Moderately Hard	Can be readily scratched by a knife blade; scratch leaves a heavy trace of dust and scratch is readily visible after the powder has been blown away.
Hard	Can be scratched with difficulty; scratch produces little powder and is often faintly visible; traces of the knife steel may be visible.
Very Hard	Cannot be scratched with pocket knife. Leave knife steel marks on surface.

Misc. Symbols

—⋀⋁—	Exploration continues
▽	Initial groundwater depth
▼	Measured groundwater depth (after 24 hours or more)

Constituent Percentages

Trace - < 5%

Few - 5 to 10%

Little - 15-25%

Some - 30-45%

Mostly - 50-100%

Moisture Condition

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp but no visible water

Wet - Visible free water, usually soil is below water table

Strata Group Symbols

■	AC - Asphalt Concrete PCC - Portland Cement Concrete
▨	CL- Low plasticity clay
▨	CH - High plasticity clay
▩	CL-ML - Silty low plasticity clay
▥	ML - Silt
▥	MH - Elastic silt
▨	SC - Clayey sand
▥	SM - Silty sand
⁘	SP - Poorly graded sand
░	SW - Well - graded sand
▩	GC - Clayey Gravel
▩	GM - Silty gravel
⁘	GP - Poorly graded gravel
⁘	GW - Well - graded gravel
▩	CG - Cemented sand and gravel
▦	CALI - Caliche

Soil Sampler Symbols

◩	Air Knife
⧗	Bulk Sample
■	California Sampler
◪	Standard Penetration Test
▮	Core Barrel
◧	Shelby Tube

Notes

1. Subsurface explorations were performed using the equipment listed on the exploration logs.
2. Subsurface explorations were performed on the date(s) shown on the exploration logs.
3. Soil sampler(s) were driven with a 140 pound hammer falling 30 inches (unless otherwise noted in the text of this report).
4. The transitions between soil types shown on the exploration logs as occuring abruptly at particular depths may in actuality be a gradual progression from one soil type to the next.
5. Exploration logs are subject to the limitations, conclusions, and recomendations presented in this report.

Disclaimer

This Key to Symbols and Terms is part of a report prepared by Geotechnical & Environmental Services, Inc. and should be used with the report. The descriptions on the exploration logs apply only at the specific exploration locations and at the time the explorations were made. They are not warranted to be representative of subsurface conditions at other locations or times.

Figure No. A-3

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BORING LOG
B-1

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.278270, W: 115.262120
EXPLORATION DATE: 11/16/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50
ELEVATION: 2,394-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: Not Encountered
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	0					CL	NATIVE: Dark brown lean CLAY with gravel and moist.	10.7						
2392	2													
	4													
				■	7 9 11		...brown to dark brown and very stiff.	14.7	105.1					PP >4.5
2388	6													
	8													
2384	10			■	9 11 16		...with caliche nodules and caliche gravel, weakly cemented.							PP >4.5
	12													
2380	14													
				■	21		...gravelly.							
	16			■	15 12	CL-ML	Brown to white silty CLAY with sand, gravel and gypsum powder, moist and very stiff.							PP >4.5
2376	18													
	20			■	8 14 17	SC	Brown to light brown clayey SAND with gravel, moist and medium dense.	10.2	107.1	31	42	19		
2372	22													
	24													
				■	14 10 10	CH	Brown gravelly fat CLAY, dry and very stiff.	11.0	100.3					PP >4.5
2368	26													

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-1

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.278270, W: 115.262120
EXPLORATION DATE: 11/16/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50
ELEVATION: 2,394-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: Not Encountered
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2364	28 30 32		▨	■	9 50/2		...light brown, wealky to moderately cemented.							PP >4.5
2360 2356	34 36 38 40		▦	■	50/6	CALI	Light brown CALICHE, strongly cemented, dry and very hard.							DR=130 DR=120 DR=450 DR=220 DR=200 DR=350 DR=220 DR=150
2352	42 44		▨			CL	Light brown gravelly CLAY, wet and very stiff.							PP >4.5
2348 2344 2340	46 48 50 52 54		▦	■	50/3	CALI	Light brown CALICHE, strongly cemented, dry and very hard.							DR=70 DR=120 DR=200 DR=240 DR=300
			▩	■	23	GC	Light brown clayey GRAVEL with sand,	17.4	102.7	33	76	44		

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made.
It is not intended to be representative of subsurface conditions at other locations or times.

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC. **Figure No.** A-4

BORING LOG
B-1

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.278270, W: 115.262120
EXPLORATION DATE: 11/16/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50
ELEVATION: 2,394-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: Not Encountered
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	56			■	22 21		weakly to moderately cemented, dry and very stiff.							
2336	58													
	60					CALI	Light brown CALICHE, strongly cemented, dry and very hard.							DR=840 DR=1200 DR=1200 DR=900 DR=1000
2332	62													
	64				50/0									
2328	66						**END OF BORING AT 65.5 FEET**							
	68													
2324	70													
	72													
2320	74													
	76													
2316	78													
	80													
2312	82													

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-2

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.278147, W: 115.261571
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,394-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/19/18 & 11/20/18
EQUIPMENT: B-90
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 63-feet (Approximate)
DATE ENCOUNTERED: 11/20/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetrometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	0		▨			CL	NATIVE: Dark brown lean CLAY with gravel and dry.							
2392	2													
	4													
2388	6			■	5 8 7		...dark brown to brown, stiff.	10.3	97.6					PP >4.5
	8													
2384	10			◪	9 10 8		...brown.							PP >4.5
	12													
2380	14													
	16			■	12 9 9		...sandy lean clay	10.1	91.2		36	14		PP >4.5
2376	18													
	20		⁘	■	11 12 10	SC	Light brown to white clayey SAND with gravel, dry and medium dense.	11.5	87.3	34	52	44		PP >4.5
2372	22													
	24													
2368	26		▨	◪	6 11 11	CL	Brown lean CLAY with gravel, dry and very stiff.							

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

Figure No. A-5

BORING LOG
B-2

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.278147, W: 115.261571
EXPLORATION DATE: 11/19/18 & 11/20/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: B-90
ELEVATION: 2,394-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 63-feet (Approximate)
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: 11/20/18
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
 2364	28 30				24		...light brown, gravelly and wet.							
	32				50/4	GC	Light brown clayey GRAVEL, moderately cemented, moist and very dense.							
2360	34				50/1	CALI	Light brown CALICHE, strongly cemented, dry and very hard.							DR=60 DR=185
 2356	36 38 40				11 14	CL-ML	Light brown gravelly silty CLAY, moist and very stiff.	16.8	106.2					
2352	42				21	CH	Light brown fat CLAY with yellowish smears, weakly to moderately cemented, moist and very stiff.							PP=4.5
	44					CALI	Light brown CALICHE, strongly cemented, dry and very hard.							
2348	46				12 13 14	SC	Brown to light brown clayey SAND with gravel, moist and very stiff.	17.3		40	80	49		
	48					CALI	Light brown CALICHE, strongly cemented, dry and very hard.							DR=240
2344 2340	50 52 54				3 4 30	CL	Light brown lean CLAY with gravel, weakly cemented, moist and very stiff.							PP=4.5
					50/4	CALI	Light brown CALICHE, moderately cemented.							DR=150

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GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

BORING LOG
B-2

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.278147, W: 115.261571
EXPLORATION DATE: 11/19/18 & 11/20/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: B-90
ELEVATION: 2,394-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 63-feet (Approximate)
DATE ENCOUNTERED: 11/20/18
MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	56						dry and very hard.							
														DR=192
2336	58													
	60					CL	Brown lean CLAY, moist and stiff.							
2332	62					CALI	Light brown CALICHE, moderately cemented, dry and very hard.							DR=300
			▽											DR=310
	64													DR=420
				▬	50/1									DR=560
2328	66													DR=420
														DR=450
	68													DR=600
														DR=660
2324	70													DR=500
														DR=480
	72													
2320	74					CL	Brown lean CLAY, wet and very stiff.							
				■	4 5 7			20.4	103.2	95	29	10		PP=2.5
	76													
2316	78													
	80													
2312	82													

BORING LOG
B-2

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.278147, W: 115.261571
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,394-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/19/18 & 11/20/18
EQUIPMENT: B-90
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 63-feet (Approximate)
DATE ENCOUNTERED: 11/20/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetrometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	84		▨											
			▨	■	7 10 13		...with sand.							
2308	86		▨	■										PP=3.0
							END OF BORING AT 86.5 FEET							
	88													
2304	90													
	92													
2300	94													
	96													
2296	98													
	100													
2292	102													
	104													
2288	106													
	108													
2284	110													

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made.
It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-3

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.278149, W: 115.261232
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,396-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/15/18
EQUIPMENT: D-50
LOGGER/DRILLER: Badrzadeh/Luis-Sanchez

INITIAL DEPTH TO WATER: Not Encountered
DATE ENCOUNTERED: N/A

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2396	0	⧗	▨			CL	NATIVE: Dark brown sandy lean CLAY and dry.	9.3						
	5		▨	■	11 15 19		...with trace gravel, weakly cemented and very stiff.	13.3	104.8					PP>4.5
	10		●	■	10 10 10	GC	Brown clayey GRAVEL with caliche nodules, dry and medium dense.	12.7	99.8	46	31	14		
	15		●	■	23 23 24		...with sand and dense.	2.8	119.7					
2376	20		▨	■	16 28 37	CL	Light brown lean CLAY with gravel, weakly to moderately cemented, dry and very stiff.							PP >4.5
	25		●	■	10 17 21	GC	Brown clayey GRAVEL with caliche nodules, dry and medium dense to dense.	8.3	103.2	21	28	10		

Elevation / depth scale: 2396 – 0; 2 ; 2392 – 4; 6; 2388 – 8; 10; 2384 – 12; 14; 2380 – 16; 18; 2376 – 20; 22; 2372 – 24; 26

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-3

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.278149, W: 115.261232
EXPLORATION DATE: 11/15/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50
ELEVATION: 2,396-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Luis-Sanchez

INITIAL DEPTH TO WATER: Not Encountered
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetrometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2368	28					SC	Brown clayey SAND with gravel, slightly moist and dense.							
	30			■	15 18 27			25.3	90.6	24	75	48		
2364	32													
						CALI	Light brown CALICHE, strongly cemented, dry and very hard.							
	34			■	50/2									DR = 345 DR = 450 DR = 316
2360	36													
	38													
2356	40			■	23 27 36	CL	Light brown lean CLAY with gravel, dry and very stiff.							PP>4.5
	42													
2352	44													
				■	30 24 19		...gravelly, weakly cemented.	8.8	106.5					
	46													
2348	48													
	50			■	50/1	GC	Brown clayey GRAVEL, moderately cemented, dry and very dense.							DR = 136
2344	52													
	54					CL	Brown gravelly lean CLAY, dry, and very stiff.							
				■	28									DR = 600

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-3

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.278149, W: 115.261232
EXPLORATION DATE: 11/15/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50
ELEVATION: 2,396-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Luis-Sanchez

INITIAL DEPTH TO WATER: Not Encountered
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2340	56				50/1	CALI	Brown CALICHE, strongly cemented, dry and very hard.							DR = 1800
	58													DR = 2300 DR = 2300
2336	60													DR = 840 DR = 1600 DR = 1600
	62													DR = 650 DR = 960
2332	64													DR = 1560 DR = 1080
	66													DR = 3000
2328	68													DR = 2160
					50/0		...Practical auger refusal at 69.5 feet.							
	70						**END OF BORING AT 69.5 FEET**							
2324	72													
	74													
2320	76													
	78													
2316	80													
	82													

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC. **Figure No.** A-6

BORING LOG
B-4

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.2779066, W: 115.2605376
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,388-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/12/18
EQUIPMENT: D-50
LOGGER/DRILLER: Solares/Snell

INITIAL DEPTH TO WATER: Not Encountered
DATE ENCOUNTERED: N/A

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2388	0					CL	NATIVE: Dark brown lean CLAY and dry.	5.1						
	2													
2384	4													
				■	12 12 14		...brown, gravelly, dry and very stiff.							
	6													
2380	8													
	10			■	15 25 19									
						GC	Light brown clayey GRAVEL, moist and medium dense.							
2376	12													
	14													
				■	16 18 24		...gravel >2" in diameter.	7.4	94.7					
2372	16													
	18													
2368	20			■	9 14 31		...white, increase in gravel amount.							
	22													
2364	24					CL	Light brown lean CLAY with gravel, moist and very stiff.							
	26			■	9 14 26			21.4	94.9					

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-4

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.2779066, W: 115.2605376
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,388-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/12/18
EQUIPMENT: D-50
LOGGER/DRILLER: Solares/Snell

INITIAL DEPTH TO WATER: Not Encountered
DATE ENCOUNTERED: N/A

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2360	28													
	30				10 11 7		...brown and gravelly.							PP>4.5
2356	32													
	34				6 25 50/1		...brown to light brown with gravel and sand.							DR = 156
2352	36													
	38													
2348	40				11 37 50/3	SC	Brown clayey SAND with gravel, moist and very dense.	13.4	90.7	39	34	15		
	42													
2344	44				10 12 47									
	46					CALI	Brown to light brown CALICHE with gravel, weakly to moderately cemented, moist and dense.							DR = 600 DR = 480 DR = 600
2340	48				50/3	CL	Light reddish brown gravelly CLAY, weakly cemented, moist and very stiff.							DR = 240
	50													
2336	52													
	54				50/4			11.1	109.3					

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-4

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.2779066, W: 115.2605376
EXPLORATION DATE: 11/12/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50
ELEVATION: 2,388-feet (Approximate)
LOGGER/DRILLER: Solares/Snell

INITIAL DEPTH TO WATER: Not Encountered
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2332	56					CALI	Brown CALICHE, moist, moderately to strongly cemented and very hard.							
														DR = 180
	58													DR = 240
														DR = 840
2328	60													DR = 480
														DR = 900
	62													
2324	64													
					50/0									
	66													DR = 1800
														DR = 300
2320	68													DR = 180
														DR = 360
	70													DR = 240
						CL	Light brown lean CLAY, with gravel, wet and very firm.							
2316	72													
	74													
				■	50/4	GC	Brown clayey GRAVEL, wet and very dense.							
2312	76													
						CL	Brown sandy lean CLAY with multicolored nodules of cemented sand, moist and very stiff.							
	78													
2308	80													
	82													

BORING LOG
B-4

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.2779066, W: 115.2605376
EXPLORATION DATE: 11/12/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50
ELEVATION: 2,388-feet (Approximate)
LOGGER/DRILLER: Solares/Snell

INITIAL DEPTH TO WATER: Not Encountered
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2304	84		▨											
	86		▨	■	11 15 18			27.1	98.3					
							END OF BORING AT 86.5 FEET							
2300	88													
	90													
2296	92													
	94													
2292	96													
	98													
2288	100													
	102													
2284	104													
	106													
2280	108													
	110													

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

BORING LOG
B-5

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.27785, W: 115.2601621
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,384-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/13/18
EQUIPMENT: D-120
LOGGER/DRILLER: Solares/Luis-Sanchez

INITIAL DEPTH TO WATER: 58.5-feet (Approximate)
DATE ENCOUNTERED: 11/13/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2384	0					CL	NATIVE: Light brown sandy lean CLAY with gravel and dry.							
	2													
2380	4													
				■	12 22 22		...brown and very stiff.							
	6													
2376	8													
	10			■	17 19 24		...white to light brown, trace gravel and very stiff.	7.4	89.9	59	29	10		
2372	12													
	14													
				■	19 18 17		...gravelly and very stiff.							
2368	16													
	18													
2364	20			■	14 17 18	CH	Gray gravelly fat CLAY with white nodules, moist and very stiff.							
	22													
2360	24													
				■	50/4									
	26													

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BORING LOG
B-5

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.27785, W: 115.2601621
EXPLORATION DATE: 11/13/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-120
ELEVATION: 2,384-feet (Approximate)
LOGGER/DRILLER: Solares/Luis-Sanchez

INITIAL DEPTH TO WATER: 58.5-feet (Approximate)
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: 11/13/18
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2356	28													
	30			■	22 31 50/5	GW-GC	Light brown and white well-graded GRAVEL with clay and sand, moist and dense.	6.2	109.7					
2352	32					CALI	Gray to brown CALICHE, moist, moderately to strongly cemented and very hard.							DR = 420 DR = 180 DR = 180
	34													
2348	36			■	25 34 46	CL	Dark brown gravelly lean CLAY with sand, moist and very stiff.							
	38						...frequent gravel.							
2344	40			■	46 43 38		...brown.							
	42													
2340	44			▬	50/1									
	46						...increased gravel amount.							
2336	48													
	50			■	12 28 17	SC	Light brown clayey SAND with gravel, moist and dense.	30.5	87.5	18	73	40		
2332	52													
	54													
				▬	50/1	CALI	Brown CALICHE, moist, moderately to strongly							

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BORING LOG
B-5

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.27785, W: 115.2601621
EXPLORATION DATE: 11/13/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-120
ELEVATION: 2,384-feet (Approximate)
LOGGER/DRILLER: Solares/Luis-Sanchez

INITIAL DEPTH TO WATER: 58.5-feet (Approximate)
DATE ENCOUNTERED: 11/13/18
MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2328	56						cemented and very dense.							DR = 180
														DR = 240
	58													DR = 180
2324	60													
														DR = 300
	62													DR = 120
														DR = 180
2320	64					CH	Light brown gravelly fat CLAY, wet and very stiff.							
				■	21 14 14			28.3	94.8					
	66													
2316	68													
	70													
2312	72													
	74													
				■	22 24 27		...brown and moist.	27.9	97.7					
2308	76													
	78													
2304	80													
	82													

BORING LOG
B-5

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.27785, W: 115.2601621
EXPLORATION DATE: 11/13/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-120
ELEVATION: 2,384-feet (Approximate)
LOGGER/DRILLER: Solares/Luis-Sanchez

INITIAL DEPTH TO WATER: 58.5-feet (Approximate)
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: 11/13/18
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2300	84		▨											
			▨	■	25 25 24			22.4	105.5					
	86		▨											
							END OF BORING AT 86.5 FEET							
2296	88													
	90													
2292	92													
	94													
2288	96													
	98													
2284	100													
	102													
2280	104													
	106													
2276	108													
	110													

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BORING LOG
B-6

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.277656, W: 115.259685
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,380-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/12/18
EQUIPMENT: D-56
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 65-feet (Approximate)
DATE ENCOUNTERED: 11/12/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2380	0	☒				SC	NATIVE: Brown clayey SAND with gravel and dry.	5.2						
	2													
2376	4													
				■	12 16 23									
	6					ML	Light brown sandy SILT, dry and very stiff.							PP = 4.5
2372	8													
	10			■	6 9 13									
						CL-ML	Light brown clayey SILT with sand, dry and very stiff.							PP >4.5
2368	12													
	14													PP >4.5
				■	12 21 47	ML	Light brown SILT, dry and very stiff.	6.4	92.0	96	NV	NP		
2364	16													
	18													
2360	20			■	19 23 37	CL-ML	Light brown to white silty CLAY with gravel, dry and very dense.							PP >4.5
	22													
2356	24													
				■	18 20 35									
	26					CL	Brown to white lean CLAY with gravel, sand and caliche nodules, weakly cemented, dry and very stiff.							PP >4.5

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GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC. **Figure No.** A-9

BORING LOG
B-6

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.277656, W: 115.259685
EXPLORATION DATE: 11/12/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-56
ELEVATION: 2,380-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 65-feet (Approximate)
MEASURED DEPTH TO WATER: N/A
DATE ENCOUNTERED: 11/12/18
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2352	28													
	30				50/2	CALI	Light brown to white CALICHE, strongly cemented, dry and hard.							
2348	32					CL	Brown gravelly lean CLAY, dry to moist and very stiff.							
	34													
2344	36				15 20 34			11.2	109.3					PP >4.5
						CALI	Light brown to white CALICHE, strongly cemented, dry and hard.							DR = 90
	38					CL	Light brown to white lean CLAY with caliche nodules, weakly to moderately cemented, dry to moist and very stiff.							
2340	40				44 50/3									
						CALI	Light brown CALICHE, strongly cemented, dry and very hard.							PP >4.5 DR = 110
	42													
2336	44					GC	Light brown clayey GRAVEL with sand, moist and medium dense.							
	46				14 11 14		...cobbles.	21.5	92.1	21	97	60		
2332	48													
	50				50/0	CALI	Light brown CALICHE, strongly cemented, dry and very hard.							DR = 480
2328	52													DR = 480 DR = 1500 DR = 1500
	54				50/2									DR = 780 DR = 140

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BORING LOG
B-6

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.277656, W: 115.259685
EXPLORATION DATE: 11/12/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-56
ELEVATION: 2,380-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 65-feet (Approximate)
DATE ENCOUNTERED: 11/12/18
MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2324	56													
	58													
2320	60													
	62					CL	Brown sandy lean CLAY with caliche nodules, wet and very stiff.							
2316	64													
			▽	■	14 50/3									
	66													
2312	68													
	70													
2308	72													
	74													
				■	8 10 17		...trace gravel.	22.0	106.9					PP = 4.0
2304	76													
	78													
2300	80													
	82													

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BORING LOG
B-6

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.277656, W: 115.259685
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,380-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/12/18
EQUIPMENT: D-56
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 65-feet (Approximate)
DATE ENCOUNTERED: 11/12/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
2296	84		▨											
			▨	■	7 10 15		...trace gravel.	26.3	100.4					PP = 4.5
	86		▨											
							END OF BORING AT 86.5 FEET							
2292	88													
	90													
2288	92													
	94													
2284	96													
	98													
2280	100													
	102													
2276	104													
	106													
2272	108													
	110													

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BORING LOG
B-7

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.277489, W: 115.259137
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,377-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/13/18 & 11/14/18
EQUIPMENT: D-50 & D-120
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 69-feet (Approximate)
DATE ENCOUNTERED: 11/14/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	0		▨			CL	NATIVE: Dark brown sandy lean CLAY, trace gravel and dry.							
2376														
	2													
	4													
2372				■	25 41 21		...less sand and very stiff.	9.5		81	30	12	4	
	6													
	8													
2368														
	10			■	30 29 22		...brown to white, gravelly, weakly cemented and very stiff.							PP >4.5
	12													
2364														
	14													
				■	13 16 19		...white, with caliche nodules, weakly cemented.	18.2	92.6					PP >4.5
	16													
2360														
	18													
	20			■	12 18 28		...brown to white, gravelly, weakly cemented.							
2356			▥			CL-ML	Brown to white silty CLAY with gravel and caliche nodules, dry and very stiff.							PP >4.5
	22													
	24													
2352			▨	■	10 12 22	CL	Whitish brown gravelly CLAY with sand, weakly cemented, dry and very stiff.	15.3	98.9					PP >4.5
	26													

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BORING LOG
B-7

PROJECT: 215 Beltway Connection - Segment B
PROJECT NO.: 20174206E2
BORING LOCATION: N: 36.277489, W: 115.259137
EXPLORATION DATE: 11/13/18 & 11/14/18
EXPLORATION SIZE (dia.): 8-inch
EQUIPMENT: D-50 & D-120
ELEVATION: 2,377-feet (Approximate)
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 69-feet (Approximate)
DATE ENCOUNTERED: 11/14/18
MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	28					SC	Brown clayey SAND with gravel, slightly moist and dense.							
2348														
	30				22 23 50/4		...light brown to white.	12.7	73.2	41	32	12		
						CALI	Brown CALICHE, dry, strongly cemented and very hard.							DR = 156
	32													
2344														
	34													
					32 25 13	CL	Brown gravelly lean CLAY with sand, dry and very stiff.							
	36													
2340														
	38													
	40				50/4	CALI	Brown CALICHE, dry, strongly cemented and very dense.							DR = 60
2336														
	42													
	44													
2332					50/1									DR = 1000
	46													DR = 1050
	48													
2328														
	50				50/0									DR = 900 DR = 1100
	52					CL	Brown lean CLAY with gravel, moist and very stiff.							
2324														
	54													

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BORING LOG
B-7

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.277489, W: 115.259137
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,377-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/13/18 & 11/14/18
EQUIPMENT: D-50 & D-120
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 69-feet (Approximate)
DATE ENCOUNTERED: 11/14/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	56		▨											
2320			▨											
	58		▨											
	60		▨											
2316			▨											
	62		▨											
	64		▨											
2312			▨											
	66		▨				...gravelly lean CLAY.							
	68		▨											
2308			▽				...wet.							
	70		▨											
	72		▨											
2304			▨											
	74		▨				...stiff.							
	76		▨											
2300			▨											
	78		▨											
	80		▨											
2296			▨											
	82		▨				...more gravel.							

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GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

BORING LOG
B-7

PROJECT: 215 Beltway Connection - Segment B
BORING LOCATION: N: 36.277489, W: 115.259137
EXPLORATION SIZE (dia.): 8-inch
ELEVATION: 2,377-feet (Approximate)

PROJECT NO.: 20174206E2
EXPLORATION DATE: 11/13/18 & 11/14/18
EQUIPMENT: D-50 & D-120
LOGGER/DRILLER: Badrzadeh/Snell

INITIAL DEPTH TO WATER: 69-feet (Approximate)
DATE ENCOUNTERED: 11/14/18

MEASURED DEPTH TO WATER: N/A
DATE MEASURED: N/A

ELEVATION	DEPTH	BULK SAMPLE	STRATA GROUP SYMBOL	SAMPLER TYPE	BLOWS	STRATA GROUP	DESCRIPTION	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	% PASSING # 200 SIEVE	LL	PI	SWELL (%)	NOTES PP = Pocket Penetometer (tsf) DR = Drill Rate (sec/ft.) MDD = Max. Dry Density (pcf)
	84		▨											
2292							**END OF BORING AT 85.0 FEET**							
	86													
	88													
2288														
	90													
	92													
2284														
	94													
	96													
2280														
	98													
	100													
2276														
	102													
	104													
2272														
	106													
	108													
2268														
	110													

The descriptions contained within this exploration log apply only at the specific exploration location and at the time the exploration was made. It is not intended to be representative of subsurface conditions at other locations or times.

APPENDIX B

LABORATORY TEST RESULTS

Laboratory tests were conducted on representative soil samples for the purpose of classification and to evaluate their engineering and physical properties. The amount and selection of the types of testing for a given study are based on the geotechnical conditions of the project. A summary of the various laboratory tests conducted for this project are presented below.

1. IN-PLACE MOISTURE CONTENT AND DENSITY

   The in-place moisture content and density of soil samples obtained from the borings were measured in general accordance with ASTM D2937. The in-place moisture content and density are a qualitative indication of soil consistency and compressibility. The results of these tests are presented on the boring logs in Appendix A (Figure A-4 through Figure A-10) at the respective sampling depths.

2. GRAIN SIZE DISTRIBUTION

   Grain size distribution tests were performed by sieve analysis in general accordance with AASHTO T27. Soil samples are oven dried to a constant weight and sorted by a number of different sized sieves. The amount of material retained on each sieve is measured and the percent of material passing each sieve is evaluated. The test results are presented as particle size distribution curves on Figure B-1 through Figure B-4.

3. ATTERBERG LIMITS

   Atterberg limit tests were performed on selected samples in general accordance with AASHTO T89 and T90. The results of the tests are shown at the respective sampling depths on the exploration logs in Appendix A and on the grain size distribution curves in this appendix. The results are also presented in Figures B-5 and B-8.

4. CONSOLIDATION

   Two one-dimensional consolidation tests were performed on relatively undisturbed samples in general accordance with AASHTO T216. The tests were performed on 1-inch high samples having a diameter of 2.42 inches obtained from a ring-lined sampler. The samples were placed in the consolidometer, loaded incrementally, and then incrementally unloaded. The samples were saturated near the estimated overburden pressure during the loading process. The sample deformation was measured during each load increment. Results of the consolidation tests are presented on Figures B-9 and B-10.

5. DIRECT SHEAR STRENGTH

Direct shear strength tests were performed on selected soil samples obtained from a thick-walled ring-lined sampler using a constant strain rate direct shear machine in general accordance with AASHTO T236. In the shear machine, the samples were inundated with water, loaded to successive normal pressures, and then sheared beyond the peak shear strength until the residual shear strength was obtained. The results of the tests are presented graphically as Mohr-Coulomb failure surfaces and stress-strain diagrams on Figure B-11 through Figure B-13.

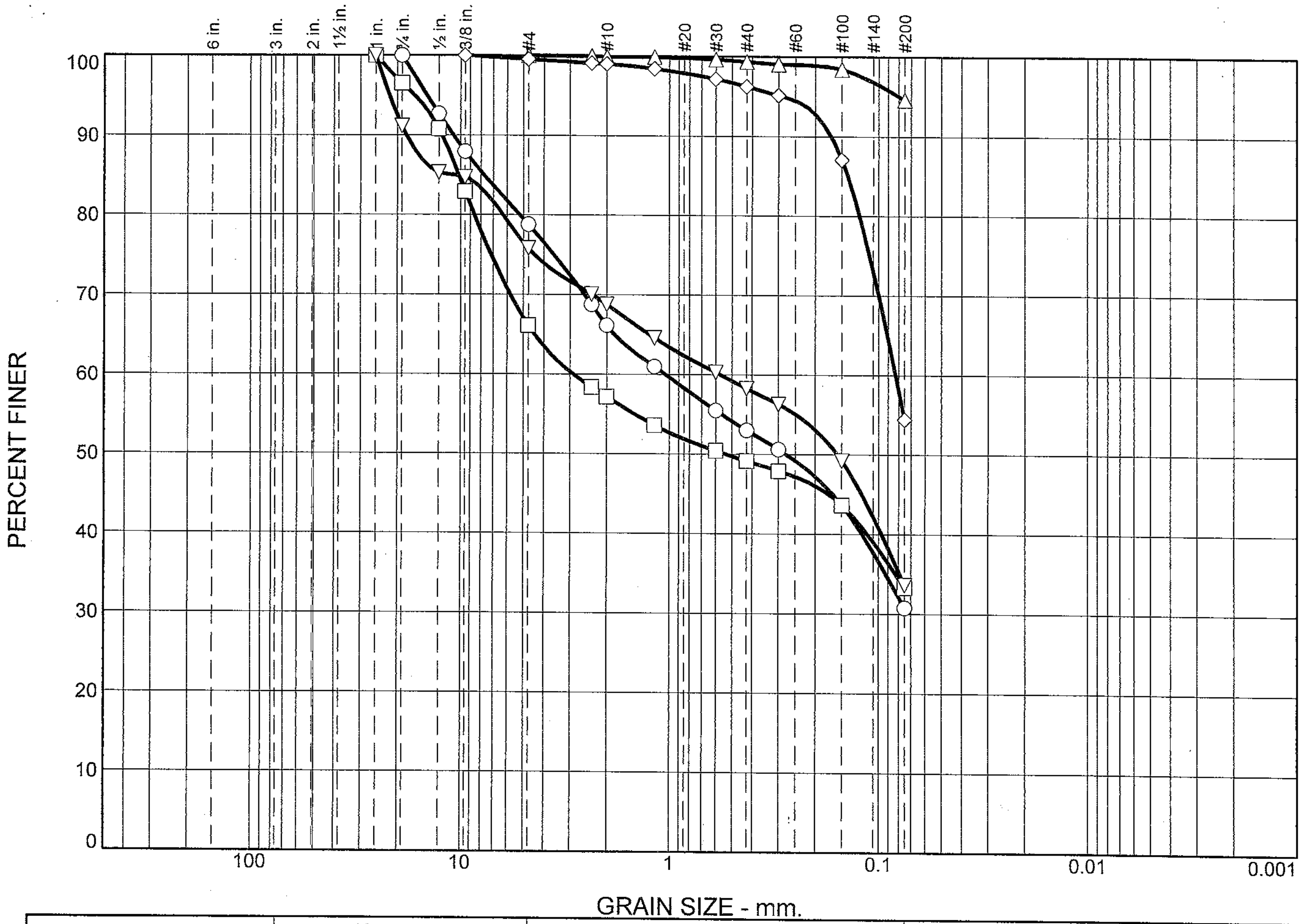
6. SWELL POTENTIAL

Swell tests were performed on selected soil samples obtained from a thick-walled ring-lined sampler in general accordance with Section 1803.5.3.2 of the SNA to the 2012 IBC. A vertical confining pressure of approximately 60 pounds per square foot was applied to each oven-dried sample and then the sample was inundated with water. The deformation of each sample was recorded until 3 consecutive readings were the same. The results of the swell tests are presented on Figure B-14.

7. CHEMICAL TESTS

Soil samples were tested with a suite of chemical corrosivity tests to aid in evaluating the potential for concrete degradation and corrosion of buried metal. The suite of chemical corrosivity tests included sodium content, water soluble sulfate, total available water soluble sodium sulfate, total salts (solubility), sulfide content, pH, reduction-oxidation (red-ox) potential, and soluble soil chlorides. The tests were performed by Silver State Analytical Laboratories. The results of the tests are presented on Figure B-15 and Figure B-22.

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	21	13	13	22	31	
□	0	3	31	9	8	16	33	
△	0	0	0	0	1	4	95	
◇	0	0	0	1	3	42	54	
▽	0	9	15	7	11	24	34	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	LAB #18-491	B-1	20.0'-21.5'	Clayey sand with gravel	SC
□	LAB #18-494	B-1	55.0'-56.5'	Clayey gravel with sand	GC
△	LAB #18-496	B-1	75.0'-76.5'	Lean clay	CL
◇	LAB #18-494	B-2	15.0'-16.5'	Sandy lean clay	CL
▽	LAB #18-494	B-2	20.0'-21.5'	Clayey sand with gravel	SC

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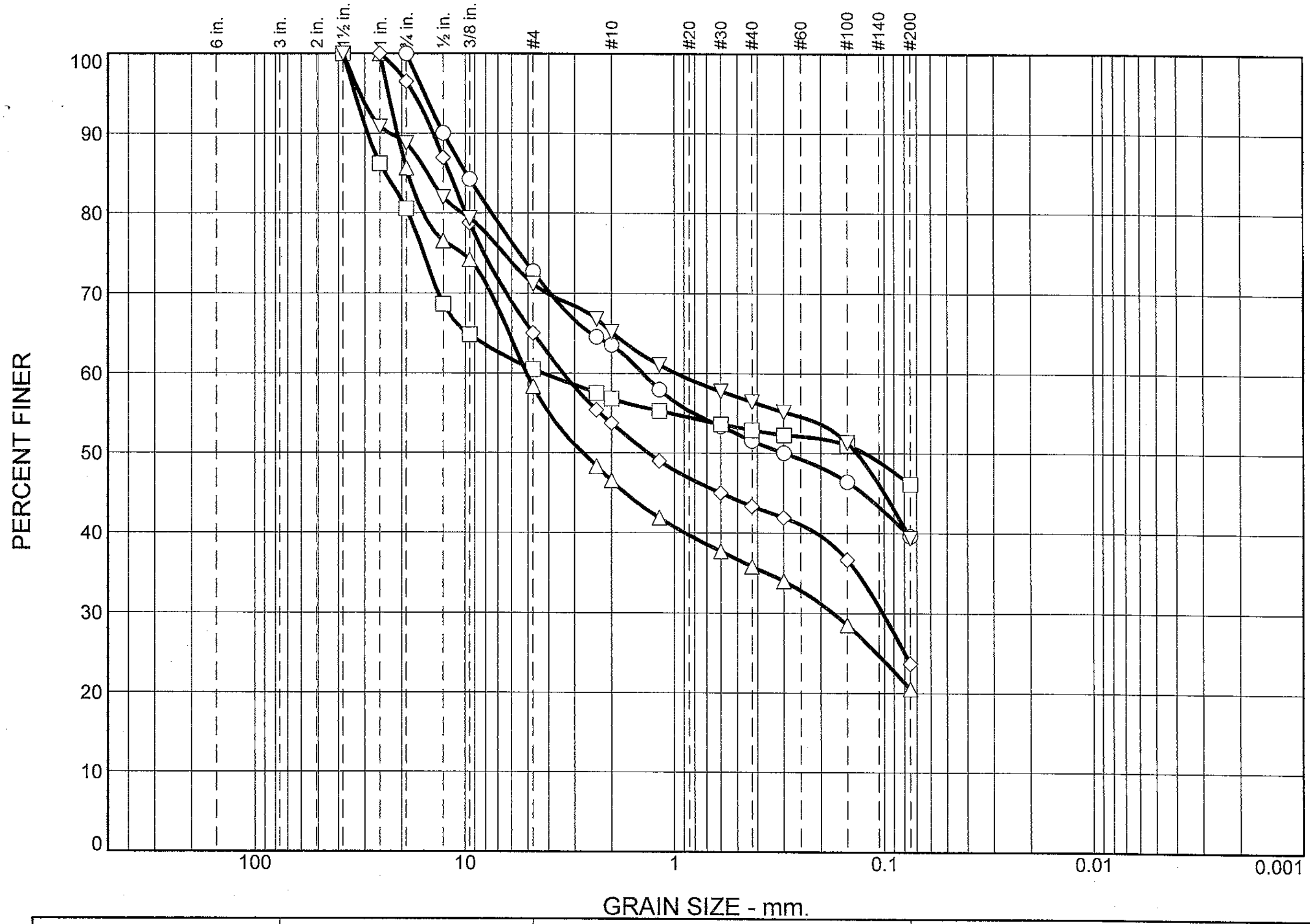
Client: GCW
Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"
Project No.: 20174206E2 **Figure** B-1

Tested By: ○ K. MARIN □ C. BYER △ C. BYER ◇ C. BYER ▽ C. BYER

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	27	9	12	12	40	
□	0	19	21	3	4	7	46	
△	0	14	28	11	11	15	21	
◇	0	4	31	11	11	19	24	
▽	0	11	18	6	9	17	39	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	LAB #18-494	B-2	45.0'-46.5'	Clayey sand with gravel	SC
□	LAB #18-491	B-3	10.0'-11.5'	Clayey gravel	GC
△	LAB #18-491	B-3	25.0'-26.5'	Clayey gravel with sand	GC
◇	LAB #18-491	B-3	30.0'-31.5'	Clayey sand with gravel	SC
▽	LAB #18-491	B-4	40.0'-41.5'	Clayey sand with gravel	SC

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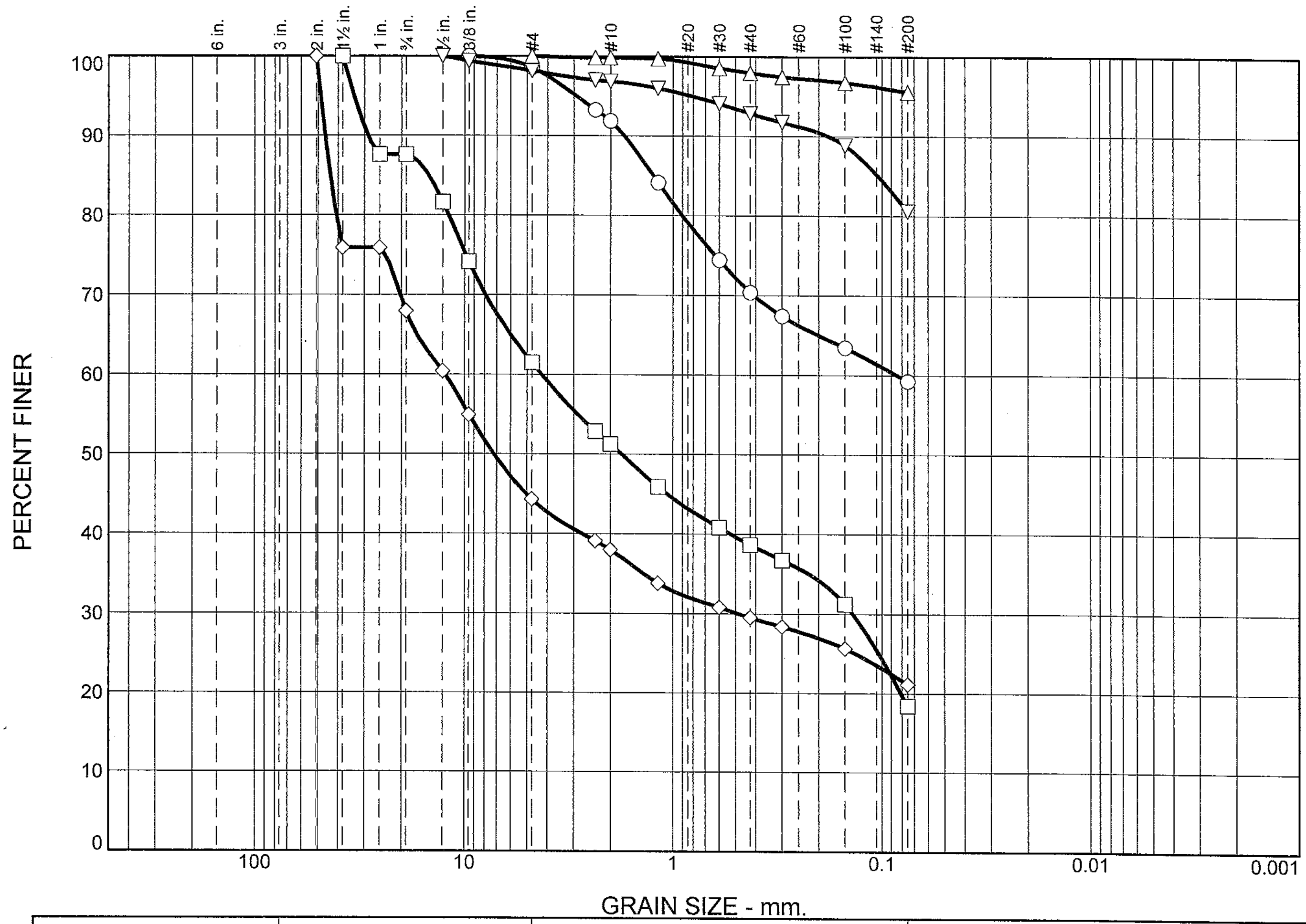
Client: GCW
Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"
Project No.: 20174206E2 **Figure** B-2

Tested By: ○ C. BYER □ C. BYER △ K. MARIN ◇ K. MARIN ▽ K. MARIN

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	1	7	22	11	59	
□	0	12	27	10	12	21	18	
△	0	0	0	0	2	2	96	
◇	0	32	24	6	8	9	21	
▽	0	0	2	1	4	12	81	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	LAB #18-491	B-5	10.0'-11.5'	Sandy lean clay	CL
□	LAB #18-491	B-5	50.0'-51.5'	Clayey sand with gravel	SC
△	LAB #18-491	B-6	15.0'-16.5'	Silt	ML
◇	LAB #18-491	B-6	45.0'-46.5'	Clayey gravel with sand	GC
▽	LAB #18-491	B-7	5.0'-6.5'	Lean clay with sand	CL

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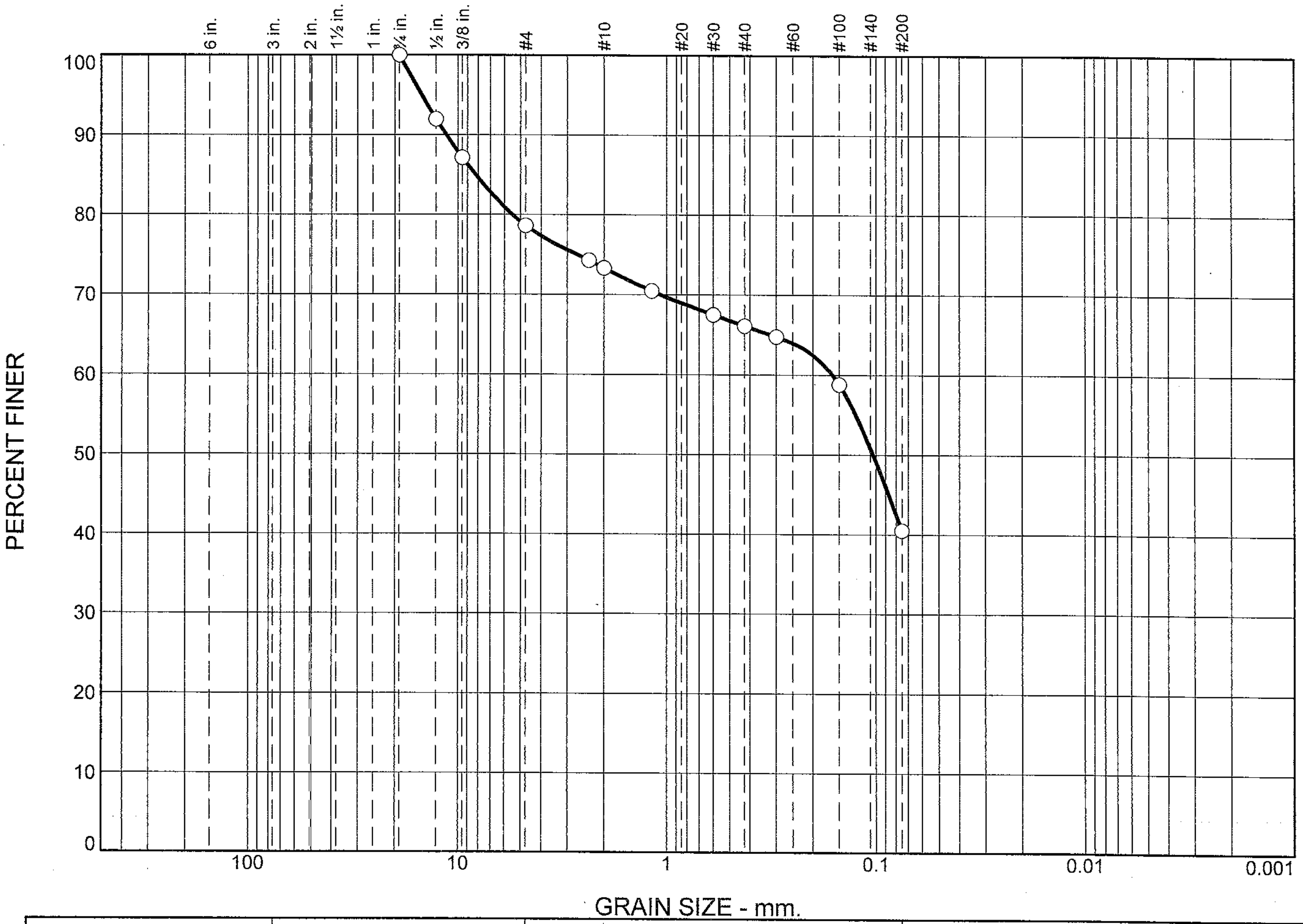
Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"

Project No.: 20174206E2 **Figure** B-3

Tested By: K. MARIN

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	21	6	7	25	41	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	LAB #18-491	B-7	30.0'-31.4'	Clayey sand with gravel	SC

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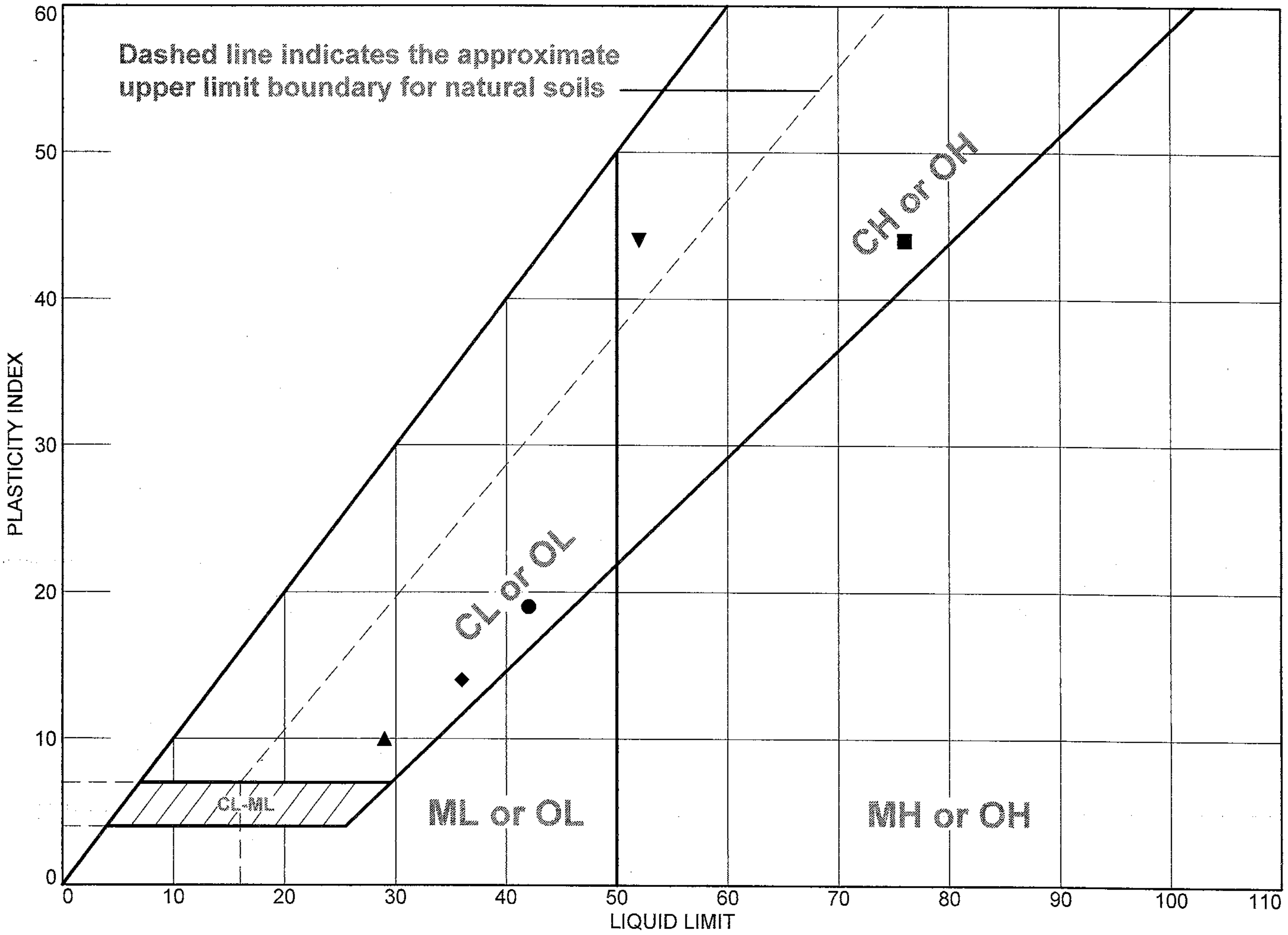
Client: GCW
Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"
Project No.: 20174206E2 **Figure** B-4

Tested By: K. MARIN

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clayey sand with gravel	42	23	19	53	31	SC
■	Clayey gravel with sand	76	32	44	49	33	GC
▲	Lean clay	29	19	10	99	95	CL
◆	Sandy lean clay	36	22	14	96	54	CL
▼	Clayey sand with gravel	52	8	44	58	34	SC

Project No. 20174206E2 **Client:** GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"

● **Location:** B-1 @ 20.0'-21.5' **Depth:** 20.0'-21.5' **Sample Number:** B-1
■ **Location:** B-1 @ 55.0'-56.5' **Depth:** 55.0'-56.5' **Sample Number:** B-1
▲ **Location:** B-2 @ 75.0'-76.5' **Depth:** 75.0'-76.5' **Sample Number:** B-1
◆ **Location:** B-2 @ 15.0'-16.5' **Depth:** 15.0'-16.5' **Sample Number:** B-2
▼ **Location:** B-2 @ 20.0'-21.5' **Depth:** 20.0'-21.5' **Sample Number:** B-2

Remarks:

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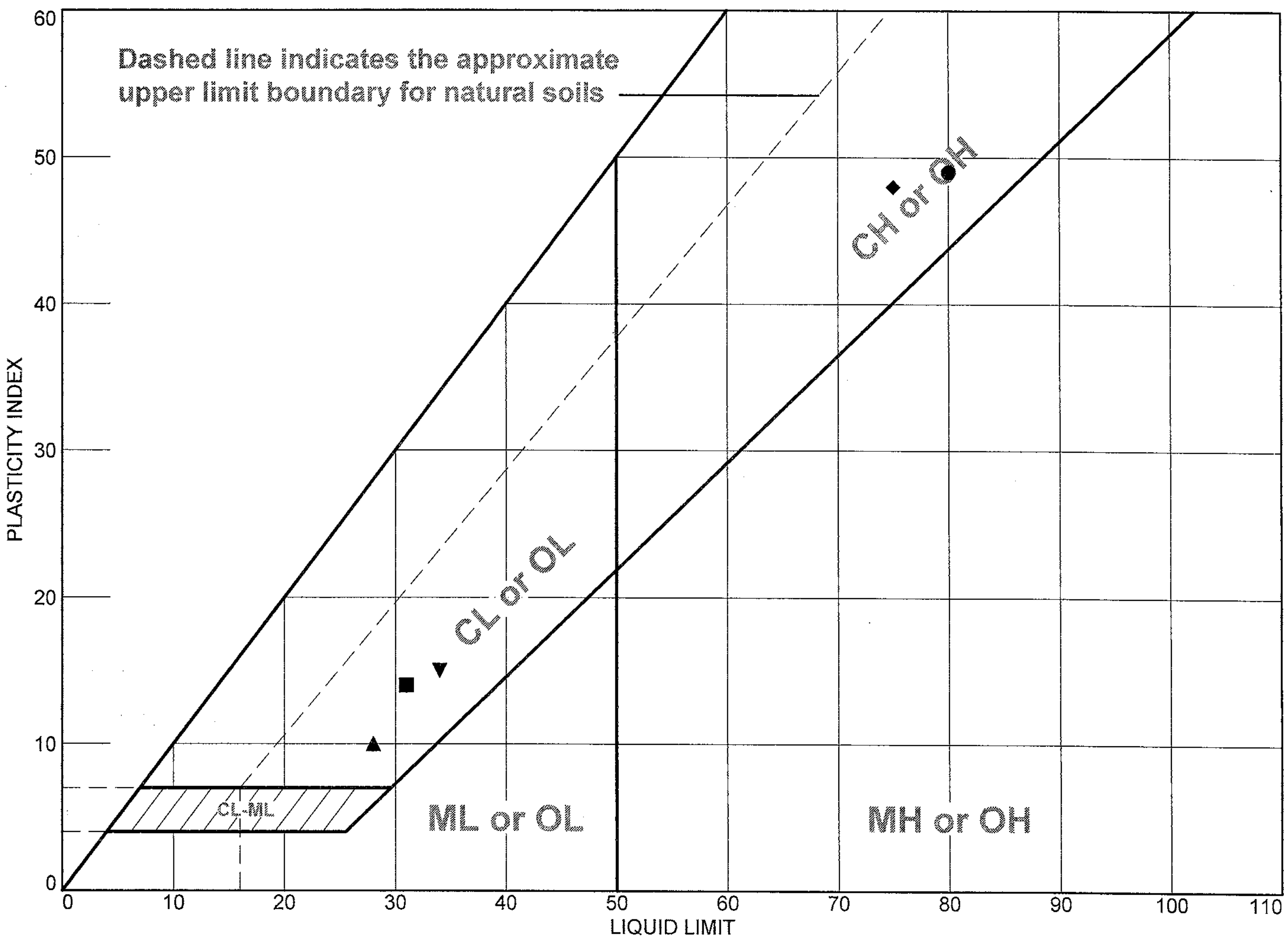
Figure B-5

Tested By: K. MARIN

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clayey sand with gravel	80	31	49	52	40	SC
■	Clayey gravel	31	17	14	53	46	GC
▲	Clayey gravel with sand	28	18	10	36	21	GC
◆	Clayey sand with gravel	75	27	48	43	24	SC
▼	Clayey sand with gravel	34	19	15	56	39	SC

Project No. 20174206E2 **Client:** GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"

● **Location:** B-2 @ 45.0'-46.5' **Depth:** 45.0'-46.5' **Sample Number:** B-2
■ **Location:** B-3 @ 10.0'-11.5' **Depth:** 10.0'-11.5' **Sample Number:** B-3
▲ **Location:** B-3 @ 25.0'-26.5' **Depth:** 25.0'-26.5' **Sample Number:** B-3
◆ **Location:** B-3 @ 30.0'-31.5' **Depth:** 30.0'-31.5' **Sample Number:** B-3
▼ **Location:** B-4 @ 40.0'-41.5' **Depth:** 40.0'-41.5' **Sample Number:** B-4

Remarks:

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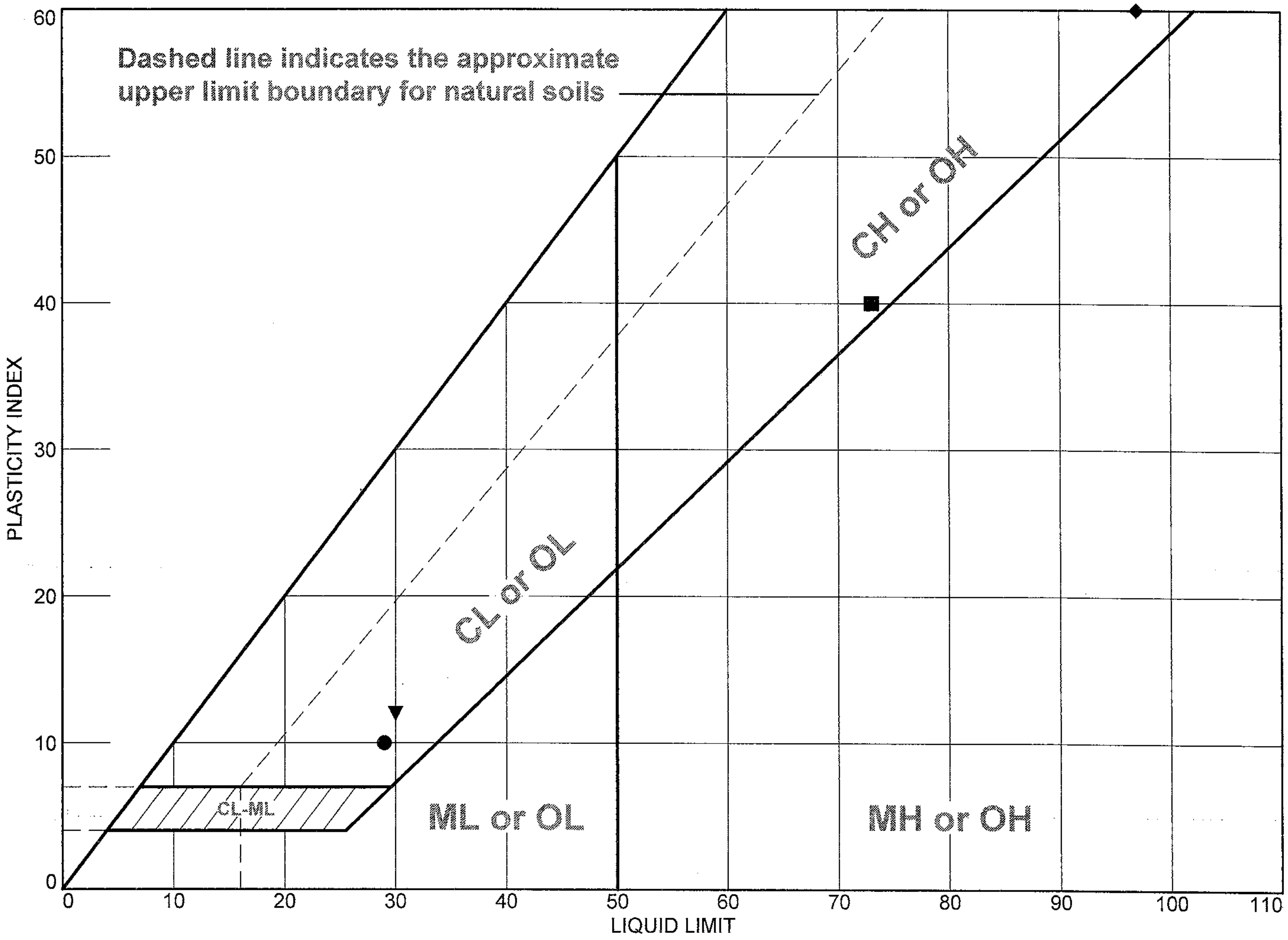
Figure B-6

Tested By: K. MARIN

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sandy lean clay	29	19	10	70	59	CL
■	Clayey sand with gravel	73	33	40	39	18	SC
▲	Silt	NV	NP	NP	98	96	ML
◆	Clayey gravel with sand	97	37	60	30	21	GC
▼	Lean clay with sand	30	18	12	93	81	CL

Project No. 20174206E2 **Client:** GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"

● **Location:** B-5 @ 10.0'-11.5' **Depth:** 10.0'-11.5' **Sample Number:** B-5
■ **Location:** B-5 @ 50.0'-51.5' **Depth:** 50.0'-51.5' **Sample Number:** B-5
▲ **Location:** B-6 @ 15.0'-16.5' **Depth:** 15.0'-16.5' **Sample Number:** B-6
◆ **Location:** B-6 @ 45.0'-46.5' **Depth:** 45.0'-46.5' **Sample Number:** B-6
▼ **Location:** B-7 @ 5.0'-6.5' **Depth:** 5.0'-6.5' **Sample Number:** B-7

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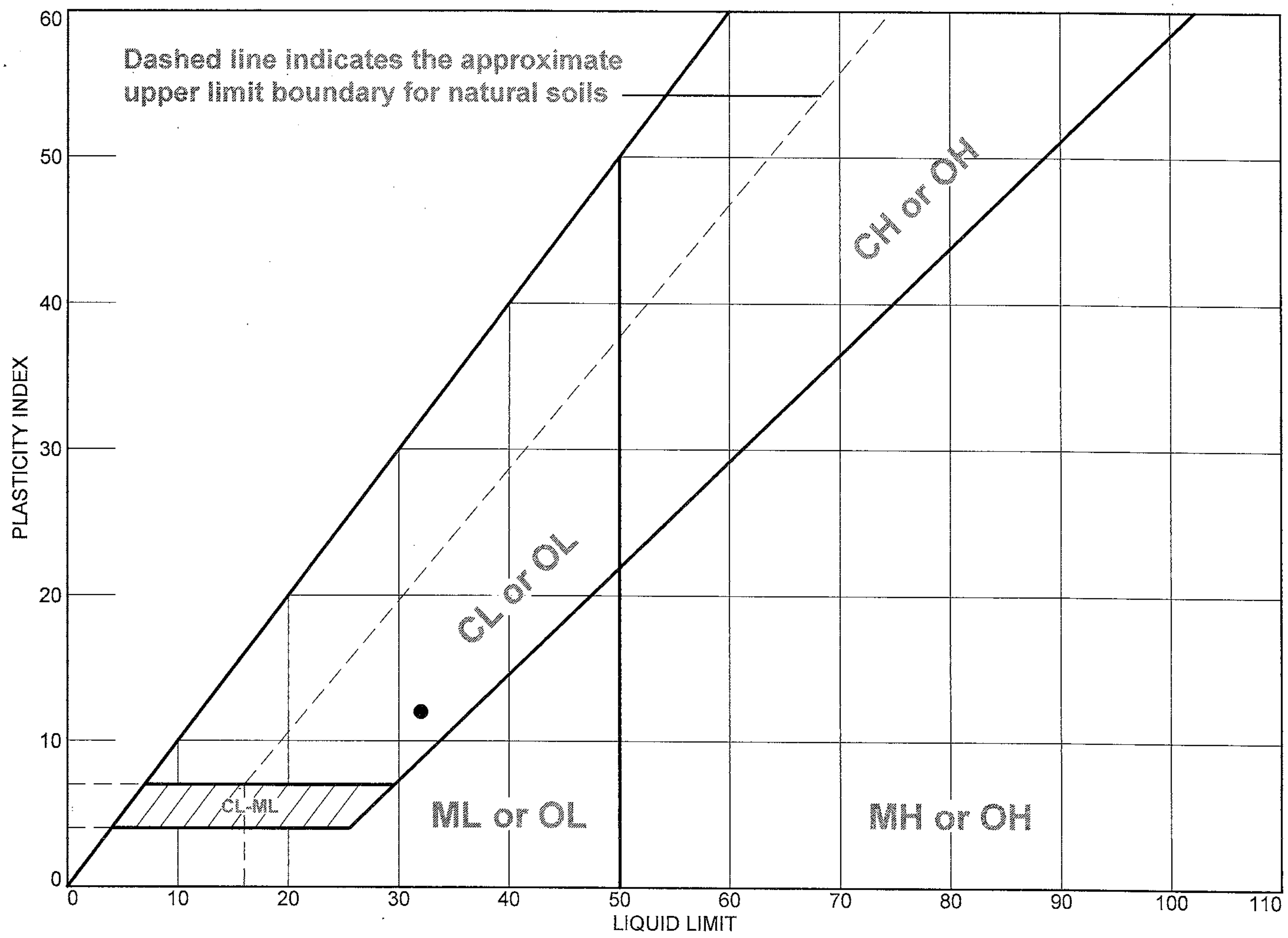
Remarks:

Figure B-7

Tested By: K. MARIN

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clayey sand with gravel	32	20	12	66	41	SC

Project No. 20174206E2 **Client:** GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"

● **Location:** B-7 @ 30.0'-31.4' **Depth:** 30.0'-31.4' **Sample Number:** B-7

Remarks:

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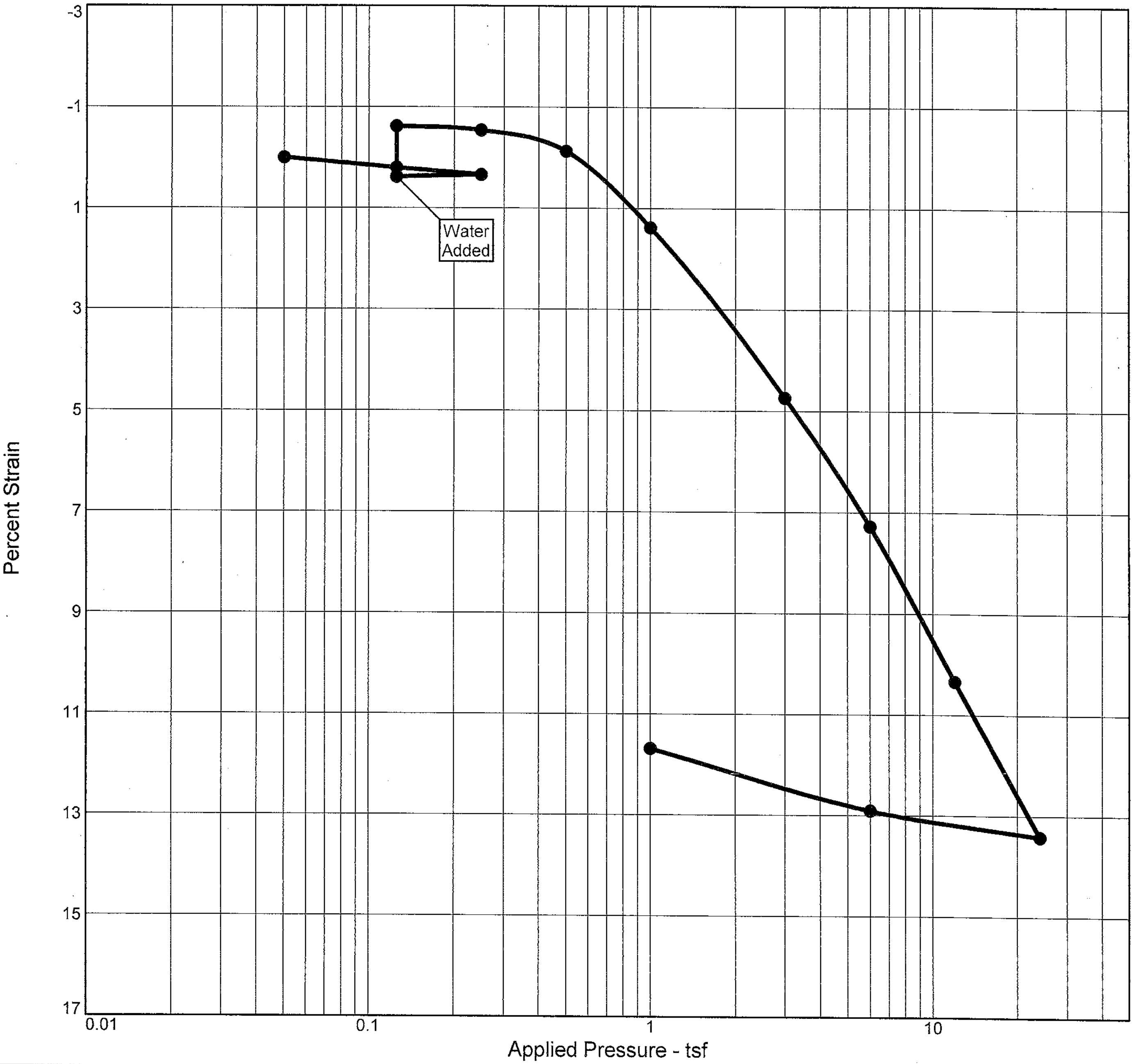
Figure B-8

Tested By: K. MARIN

CONSOLIDATION



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_s	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
47.9 %	8.3 %	114.1	28	10	2.60	1.51	1.4	0.15	0.01	0.7	1.0	0.449

MATERIAL DESCRIPTION	USCS	AASHTO
Clayey gravel with sand	GC	A-2-4(0)

Project No. 20174206E2 **Client:** GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"

Location: B-3 @ 25.0'-26.5' **Depth:** 25.0'-26.5' **Sample Number:** B-3

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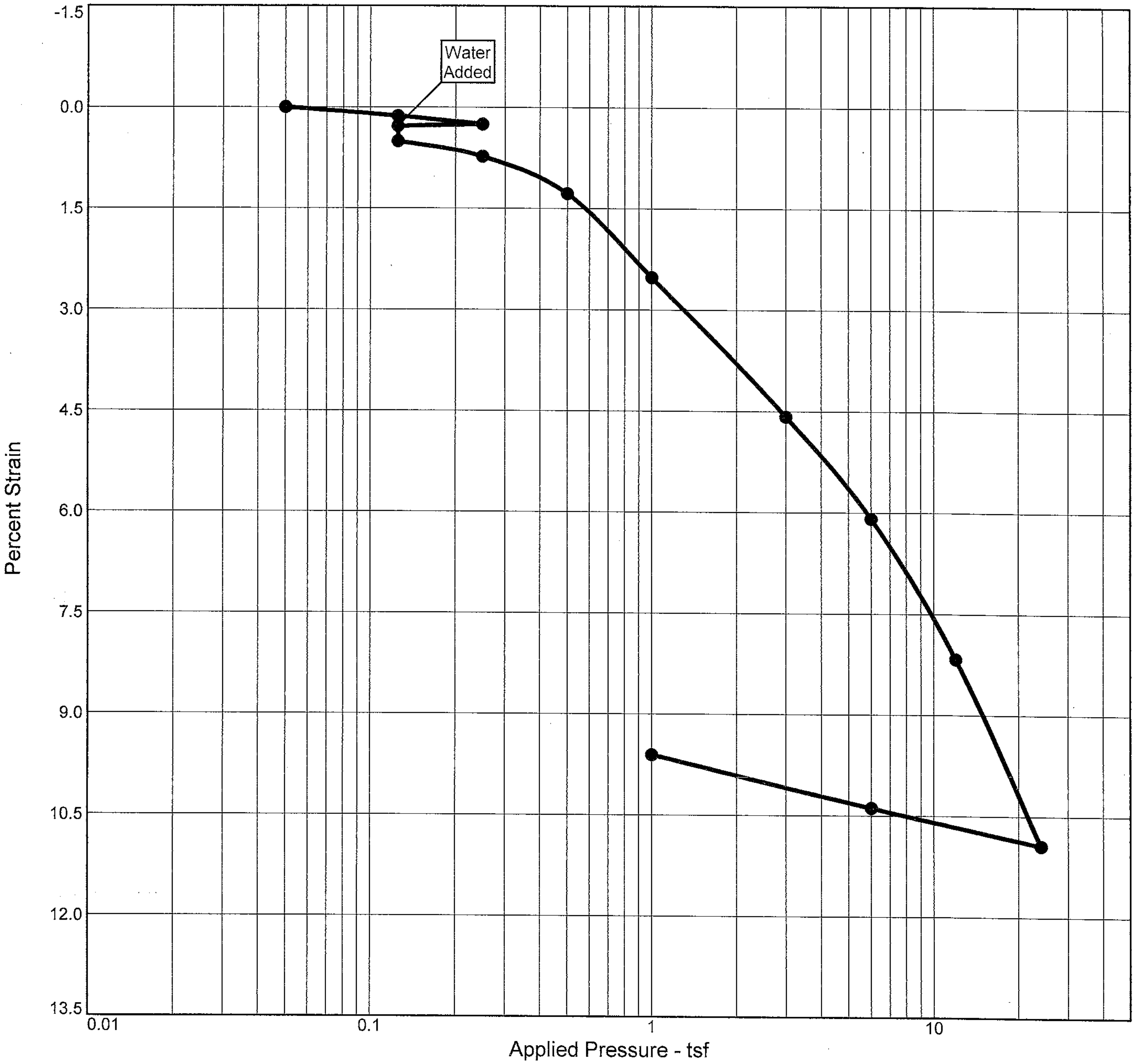
Remarks:

Figure B-9

Tested By: A. SANDERS

CONSOLIDATION



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_s	Swell Press. (tsf)	Clpse. %	e_o
Sat.	Moist.											
18.4 %	6.5 %	86.2	NV	NP	2.60	.71	0.5	0.08	0.01		0.2	0.911

MATERIAL DESCRIPTION	USCS	AASHTO
Silt	ML	A-4(0)

Project No. 20174206E2 **Client:** GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"

Location: B-6 @ 15.0'-16.5' **Depth:** 15.0'-16.5' **Sample Number:** B-6

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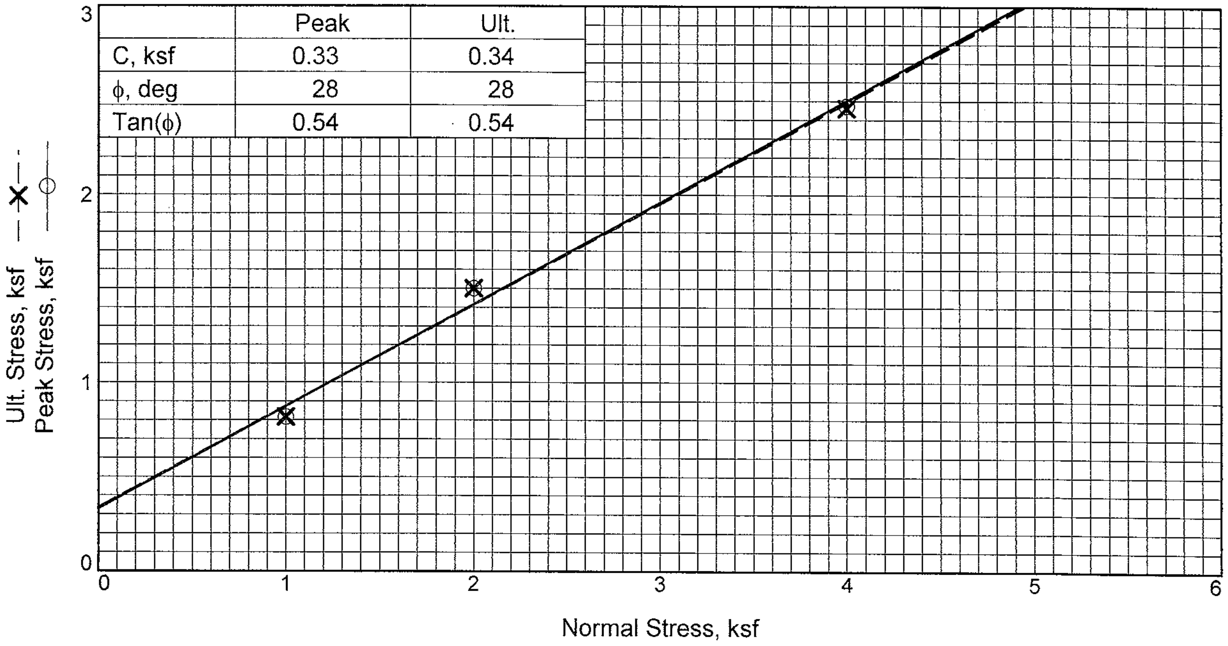
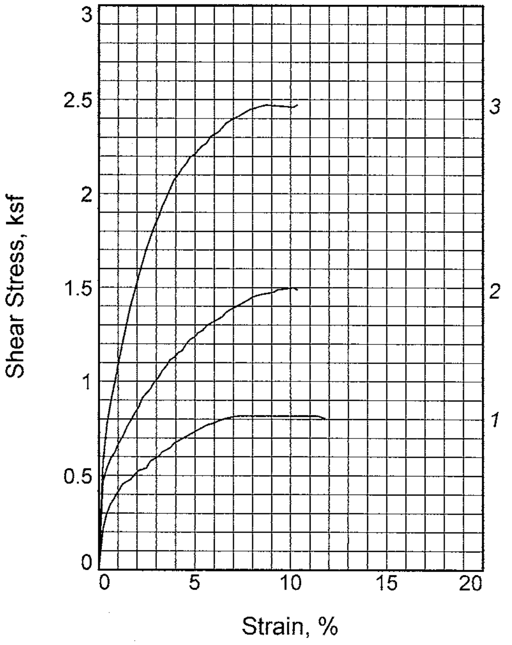
Remarks:

Figure B-10

Tested By: A. SANDERS



	Peak	Ult.
C, ksf	0.33	0.34
ϕ, deg	28	28
Tan(ϕ)	0.54	0.54



	Sample No.	1	2	3
Initial	Water Content, %	7.4	7.4	7.4
	Dry Density, pcf	91.5	86.1	89.0
	Saturation, %	24.8	21.7	23.3
	Void Ratio	0.7744	0.8845	0.8238
	Diameter, in.	2.42	2.42	2.42
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	7.4	7.4	7.4
	Dry Density, pcf	91.5	86.1	89.0
	Saturation, %	24.8	21.7	23.3
	Void Ratio	0.7744	0.8845	0.8238
	Diameter, in.	2.42	2.42	2.42
	Height, in.	1.00	1.00	1.00
	Normal Stress, ksf	1.00	2.00	4.00
	Peak Stress, ksf	0.82	1.50	2.47
	Strain, %	11.4	10.1	8.7
	Ult. Stress, ksf	0.82	1.50	2.46
	Strain, %	9.3	10.1	10.1
	Strain rate, in./min.	0.050	0.050	0.050

Sample Type:
Description: Sandy lean clay

LL= 29 **PL=** 19 **PI=** 10
Assumed Specific Gravity= 2.6
Remarks:

Figure B-11

Client: GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"
Location: B-5 @ 10.0'-11.5'
Sample Number: B-5 **Depth:** 10.0'-11.5'
Proj. No.: 20174206E2 **Date Sampled:** 11/16/18

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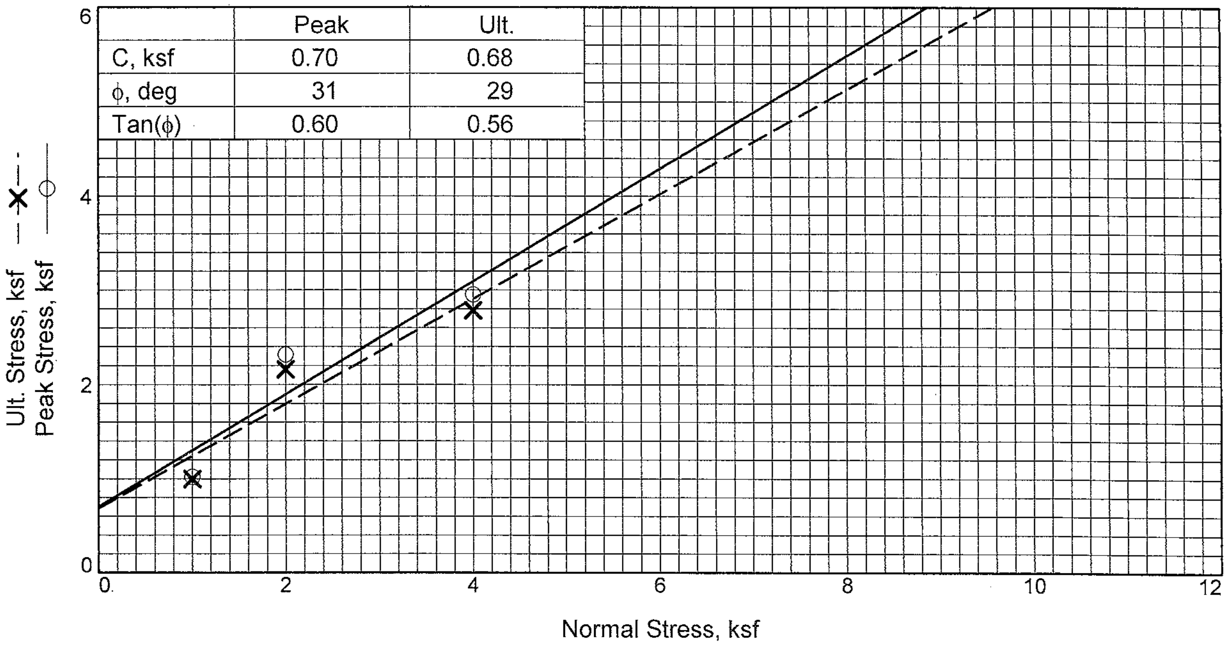
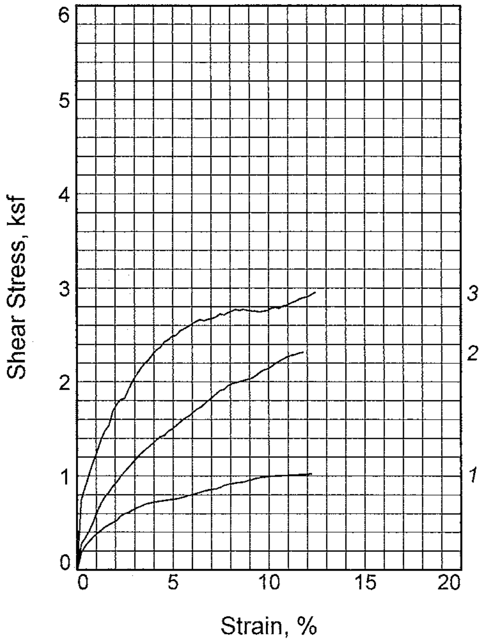
Tested By: C. BYER



	Peak	Ult.
C, ksf	0.70	0.68
ϕ, deg	31	29
Tan(ϕ)	0.60	0.56



	Sample No.	1	2	3
Initial	Water Content, %	21.5	21.5	21.5
	Dry Density, pcf	84.0	87.9	85.5
	Saturation, %	60.0	66.2	62.3
	Void Ratio	0.9331	0.8458	0.8989
	Diameter, in.	2.42	2.42	2.42
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	21.5	21.5	21.5
	Dry Density, pcf	84.0	87.9	85.5
	Saturation, %	60.0	66.2	62.3
	Void Ratio	0.9331	0.8458	0.8989
	Diameter, in.	2.42	2.42	2.42
	Height, in.	1.00	1.00	1.00
	Normal Stress, ksf	1.00	2.00	4.00
	Peak Stress, ksf	1.02	2.32	2.95
	Strain, %	12.2	11.8	12.4
	Ult. Stress, ksf	1.00	2.16	2.78
	Strain, %	10.1	10.1	10.1
	Strain rate, in./min.	0.050	0.050	0.050

Sample Type:
Description: Clayey gravel with sand

LL= 97 **PL=** 37 **PI=** 60
Assumed Specific Gravity= 2.6
Remarks:

Figure B-12

Client: GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"
Location: B-6 @ 45.0'-46.5'
Sample Number: B-6 **Depth:** 45.0'-46.5'
Proj. No.: 20174206E2 **Date Sampled:** 11/16/18

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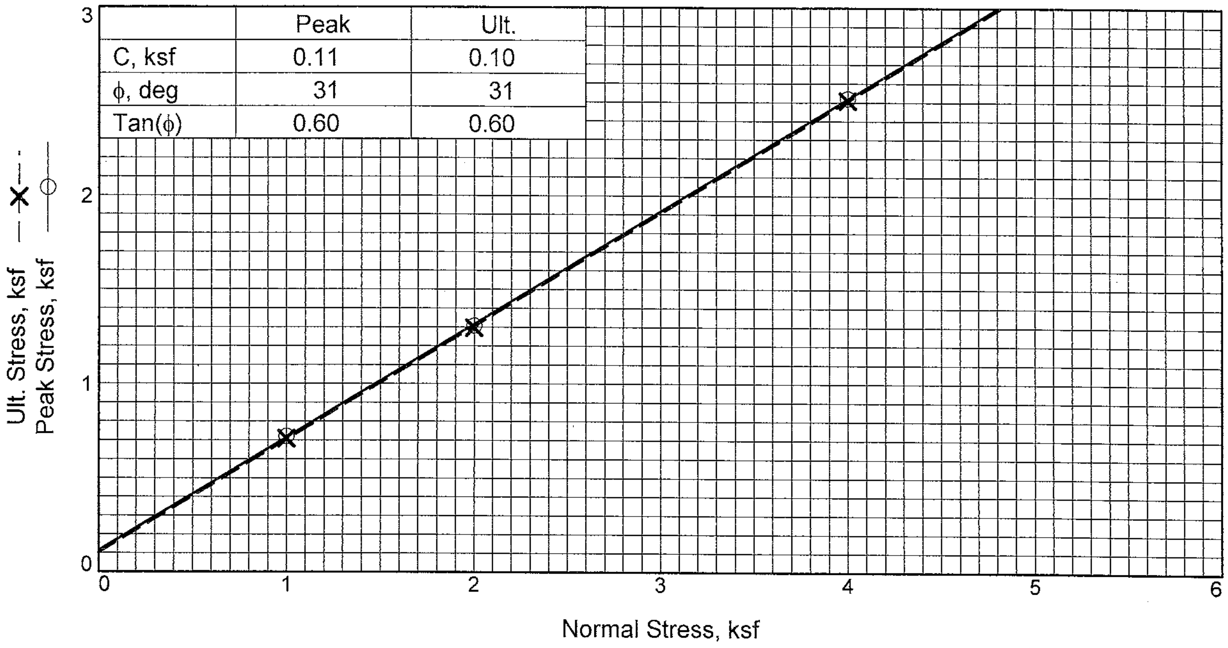
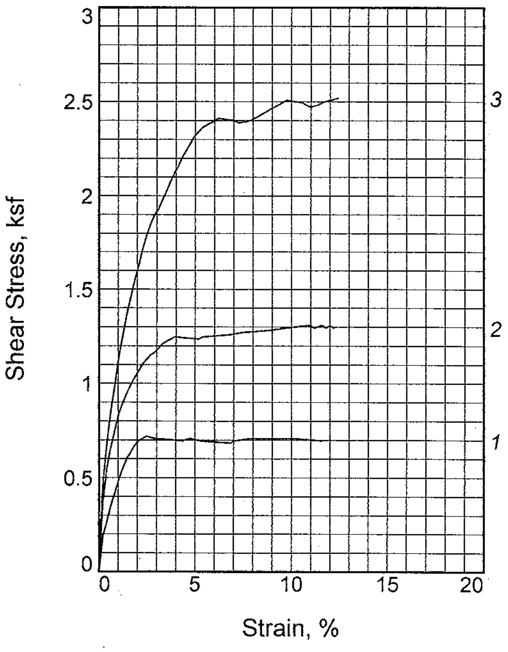
Tested By: C. BYER



	Peak	Ult.
C, ksf	0.11	0.10
ϕ, deg	31	31
Tan(ϕ)	0.60	0.60



	Sample No.	1	2	3
Initial	Water Content, %	15.3	15.3	15.3
	Dry Density, pcf	96.0	92.6	91.1
	Saturation, %	57.4	52.7	50.7
	Void Ratio	0.6916	0.7535	0.7827
	Diameter, in.	2.42	2.42	2.42
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	15.3	15.3	15.3
	Dry Density, pcf	96.0	92.6	91.1
	Saturation, %	57.4	52.7	50.7
	Void Ratio	0.6916	0.7535	0.7827
	Diameter, in.	2.42	2.42	2.42
	Height, in.	1.00	1.00	1.00
	Normal Stress, ksf	1.00	2.00	4.00
	Peak Stress, ksf	0.72	1.31	2.52
	Strain, %	2.5	11.0	12.4
	Ult. Stress, ksf	0.71	1.30	2.51
	Strain, %	10.1	9.7	9.7
	Strain rate, in./min.	0.050	0.050	0.050

Sample Type:
Description: Clayey sand with gravel

LL= 32 **PL=** 20 **PI=** 12
Assumed Specific Gravity= 2.6
Remarks:

Figure B-13

Client: GCW

Project: 215 BELTWAY CONNECTION CENTENNIAL PKWY TO DECATUR BLVD - SEGMENT "B"
Location: B-7 @ 30.0'-31.4'
Sample Number: B-7 **Depth:** 30.0'-31.4'
Proj. No.: 20174206E2 **Date Sampled:** 11/26/18

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SERVICES, INC.
GES

Tested By: C. BYER

GEOTECHNICAL &
ENVIRONMENTAL
SERVICES, INC.

SWELL TEST SUMMARY

7150 PLACID STREET
LAS VEGAS NV, 89119
1-702-365-1001

Project Name: 215 Beltway Connection Centennial Pkwy to Decatur Blvd - Segment "B"
Project No.: 20174206E1
Sample Dates: 11/16/2018
Client: GCW
Test Method: SNBC 1803.5.3.2
Report Date: 11/30/2018

LAB NUMBER	SAMPLE LOCATION	SAMPLE DEPTH (feet)	SOIL TYPE (USCS)	TEST CONDITION	SURCHARGE LOAD (psf)	INITIAL DRY DENSITY[1] (pcf)	INITIAL MOISTURE CONTENT[2] (%)	FINAL MOISTURE CONTENT (%)	EXPANSION[3] (%)
18-491	B-7	5.0-6.5	CL	Remolded	60	118.7	9.0	15.4	4

1 Remolded samples were remolded to approximately 95% of the estimated soil maximum dry density (ASTM D 1557).
2 Moisture content prior to oven drying.
3 Positive values refer to swell. Negative values refer to collapse.

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Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT:	GES	**Collection Date:**	
Project:	20174206E2		
Lab ID:	18111057-01	**Matrix:**	SOIL
Client Sample ID:	18-491, B-1@0.0'-5.0'		

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SULFIDE - SOILS				**SM 4500S2 F**		Analyst: **SBK**
Sulfide	ND	1.00		mg/L	1	11/29/2018 4:40:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. CHLORIDE - SOILS				**SM 4500CL B**		Analyst: **SBK**
Chloride	ND	50		mg/Kg	5	11/28/2018 1:31:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SODIUM SULFATES - CALCULATION 0NLY.				**CALCULATION**		Analyst: **SBK**
Sodium Sulfate as Na2SO4	0.0220	0		%	1	11/28/2018 3:21:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. PH - SOILS				**SM 9045C**		Analyst: **SBK**
pH	8.41	0		pH Units	1	11/28/2018 4:30:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. REDUCTION - OXIDATION POTENTIAL - SOILS				**SM 2580 B**		Analyst: **SBK**
Oxidation-Reduction Potential	350	1.00		mV	1	11/29/2018 1:26:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. RESISTIVITY BY AASHTO T-288				**AASHTO T288**		Analyst: **SBK**
Resistivity, Minimum	785	0		Ohms-cm	1	11/28/2018 1:59:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SULFATE (SO4)				**SM 4500 SO4 E**		Analyst: **SBK**
Sulfate	0.0900	0.0100		%	1	11/28/2018 1:30:36 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SODIUM (NA)				**ASTM D2791**		Analyst: **SBK**
Sodium	0.0100	0.0100		%	1	11/28/2018 1:32:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. TOTAL SALTS (SOLUBILITY)				**SM 2540 C**		Analyst: **SBK**

Qualifiers:
(Qual)

*	Value exceeds Maximum Contaminant Level.	C	Value is below Minimum Compound Limit.
DF	Dilution Factor.	H	Holding times for preparation or analysis exceeded.
MCL	Maximum Contaminant Level.	ND	Not Detected at the PQL.
PQL	Practical Quantitation Limit.		

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Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT: GES
Project: 20174206E2
Lab ID: 18111057-01
Client Sample ID: 18-491, B-1@0.0'-5.0'
Collection Date:
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. TOTAL SALTS (SOLUBILITY)				**SM 2540 C**		Analyst: **SBK**
Solubility	0.170	0.0100		%	1	11/28/2018 11:26:00 AM

Qualifiers: (Qual)				
	*	Value exceeds Maximum Contaminant Level.	C	Value is below Minimum Compound Limit.
	DF	Dilution Factor.	H	Holding times for preparation or analysis exceeded.
	MCL	Maximum Contaminant Level.	ND	Not Detected at the PQL.
	PQL	Practical Quantitation Limit.		

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Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT: GES
Project: 20174206E2
Lab ID: 18111057-02
Client Sample ID: 18-491, B-3@0.0-'5.0'
Collection Date:
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SULFIDE - SOILS				**SM 4500S2 F**		Analyst: **SBK**
Sulfide	ND	1.00		mg/L	1	11/29/2018 4:40:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. CHLORIDE - SOILS				**SM 4500CL B**		Analyst: **SBK**
Chloride	89	50		mg/Kg	5	11/28/2018 1:31:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SODIUM SULFATES - CALCULATION 0NLY.				**CALCULATION**		Analyst: **SBK**
Sodium Sulfate as Na2SO4	0.0160	0		%	1	11/28/2018 3:21:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. PH - SOILS				**SM 9045C**		Analyst: **SBK**
pH	8.15	0		pH Units	1	11/28/2018 4:30:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. REDUCTION - OXIDATION POTENTIAL - SOILS				**SM 2580 B**		Analyst: **SBK**
Oxidation-Reduction Potential	339	1.00		mV	1	11/29/2018 1:26:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. RESISTIVITY BY AASHTO T-288				**AASHTO T288**		Analyst: **SBK**
Resistivity, Minimum	878	0		Ohms-cm	1	11/28/2018 1:59:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SULFATE (SO4)				**SM 4500 SO4 E**		Analyst: **SBK**
Sulfate	0.0800	0.0100		%	1	11/28/2018 1:30:36 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SODIUM (NA)				**ASTM D2791**		Analyst: **SBK**
Sodium	0.0100	0.0100		%	1	11/28/2018 1:32:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. TOTAL SALTS (SOLUBILITY)				**SM 2540 C**		Analyst: **SBK**

Qualifiers: (Qual)

*	Value exceeds Maximum Contaminant Level.	C	Value is below Minimum Compound Limit.
DF	Dilution Factor.	H	Holding times for preparation or analysis exceeded.
MCL	Maximum Contaminant Level.	ND	Not Detected at the PQL.
PQL	Practical Quantitation Limit.		

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Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT: GES
Project: 20174206E2
Lab ID: 18111057-02
Client Sample ID: 18-491, B-3@0.0-'5.0'
Collection Date:
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. TOTAL SALTS (SOLUBILITY)				**SM 2540 C**		Analyst: **SBK**
Solubility	0.110	0.0100		%	1	11/28/2018 11:26:00 AM

Qualifiers: (Qual)	*	Value exceeds Maximum Contaminant Level.	C	Value is below Minimum Compound Limit.
	DF	Dilution Factor.	H	Holding times for preparation or analysis exceeded.
	MCL	Maximum Contaminant Level.	ND	Not Detected at the PQL.
	PQL	Practical Quantitation Limit.		

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Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT: GES
Project: 20174206E2
Lab ID: 18111057-04
Client Sample ID: 18-491, B-6@0.0'-5.0'
Collection Date:
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SULFIDE - SOILS				**SM 4500S2 F**		Analyst: **SBK**
Sulfide	ND	1.00		mg/L	1	11/29/2018 4:40:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. CHLORIDE - SOILS				**SM 4500CL B**		Analyst: **SBK**
Chloride	300	100		mg/Kg	10	11/28/2018 1:31:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SODIUM SULFATES - CALCULATION 0NLY.				**CALCULATION**		Analyst: **SBK**
Sodium Sulfate as Na2SO4	0.0590	0		%	1	11/28/2018 3:21:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. PH - SOILS				**SM 9045C**		Analyst: **SBK**
pH	8.27	0		pH Units	1	11/28/2018 4:30:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. REDUCTION - OXIDATION POTENTIAL - SOILS				**SM 2580 B**		Analyst: **SBK**
Oxidation-Reduction Potential	354	1.00		mV	1	11/29/2018 1:26:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. RESISTIVITY BY AASHTO T-288				**AASHTO T288**		Analyst: **SBK**
Resistivity, Minimum	400	0		Ohms-cm	1	11/28/2018 1:59:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SULFATE (SO4)				**SM 4500 SO4 E**		Analyst: **SBK**
Sulfate	0.350	0.0100		%	1	11/28/2018 1:30:36 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SODIUM (NA)				**ASTM D2791**		Analyst: **SBK**
Sodium	0.0200	0.0100		%	1	11/28/2018 1:32:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. TOTAL SALTS (SOLUBILITY)				**SM 2540 C**		Analyst: **SBK**

Qualifiers: (Qual)

*	Value exceeds Maximum Contaminant Level.	C	Value is below Minimum Compound Limit.
DF	Dilution Factor.	H	Holding times for preparation or analysis exceeded.
MCL	Maximum Contaminant Level.	ND	Not Detected at the PQL.
PQL	Practical Quantitation Limit.		

Figure B-19

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Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT:	GES	**Collection Date:**	
Project:	20174206E2		
Lab ID:	18111057-04	**Matrix:**	SOIL
Client Sample ID:	18-491, B-6@0.0'-5.0'		

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. TOTAL SALTS (SOLUBILITY)		**SM 2540 C**				Analyst: **SBK**
Solubility	0.450	0.0100		%	1	11/28/2018 11:26:00 AM

Qualifiers:
(Qual)

* Value exceeds Maximum Contaminant Level.
DF Dilution Factor.
MCL Maximum Contaminant Level.
PQL Practical Quantitation Limit.
C Value is below Minimum Compound Limit.
H Holding times for preparation or analysis exceeded.
ND Not Detected at the PQL.

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Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT: GES
Project: 20174206E2
Lab ID: 18111057-03
Client Sample ID: 18-491, B-4@0.0'-5.0'

Collection Date:
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SULFIDE - SOILS				**SM 4500S2 F**		Analyst: **SBK**
Sulfide	1.60	1.00		mg/L	1	11/29/2018 4:40:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. CHLORIDE - SOILS				**SM 4500CL B**		Analyst: **SBK**
Chloride	140	50		mg/Kg	5	11/28/2018 1:31:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. SODIUM SULFATES - CALCULATION 0NLY.				**CALCULATION**		Analyst: **SBK**
Sodium Sulfate as Na2SO4	0.0380	0		%	1	11/28/2018 3:21:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. PH - SOILS				**SM 9045C**		Analyst: **SBK**
pH	8.23	0		pH Units	1	11/28/2018 4:30:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. REDUCTION - OXIDATION POTENTIAL - SOILS				**SM 2580 B**		Analyst: **SBK**
Oxidation-Reduction Potential	350	1.00		mV	1	11/29/2018 1:26:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. RESISTIVITY BY AASHTO T-288				**AASHTO T288**		Analyst: **SBK**
Resistivity, Minimum	507	0		Ohms-cm	1	11/28/2018 1:59:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SULFATE (SO4)				**SM 4500 SO4 E**		Analyst: **SBK**
Sulfate	0.210	0.0100		%	1	11/28/2018 1:30:36 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. WATER SOLUBLE SODIUM (NA)				**ASTM D2791**		Analyst: **SBK**
Sodium	0.0100	0.0100		%	1	11/28/2018 1:32:00 PM
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. TOTAL SALTS (SOLUBILITY)				**SM 2540 C**		Analyst: **SBK**

Qualifiers:
(Qual)

*	Value exceeds Maximum Contaminant Level.
DF	Dilution Factor.
MCL	Maximum Contaminant Level.
PQL	Practical Quantitation Limit.
C	Value is below Minimum Compound Limit.
H	Holding times for preparation or analysis exceeded.
ND	Not Detected at the PQL.

Revision v1

Figure B-21

Analytical Report

WO#: **18111057**
Date Reported: **11/29/2018**

CLIENT: GES
Project: 20174206E2
Lab ID: 18111057-03
Client Sample ID: 18-491, B-4@0.0'-5.0'
Collection Date:
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
SOIL 6. CORROSION SUITE W/RES-AASHTO,SOL. **TOTAL SALTS (SOLUBILITY)**				**SM 2540 C**		Analyst: **SBK**
Solubility	0.340	0.0100		%	1	11/28/2018 11:26:00 AM

Qualifiers: **(Qual)**	*	Value exceeds Maximum Contaminant Level.	C	Value is below Minimum Compound Limit.
	DF	Dilution Factor.	H	Holding times for preparation or analysis exceeded.
	MCL	Maximum Contaminant Level.	ND	Not Detected at the PQL.
	PQL	Practical Quantitation Limit.		

Revision v1

APPENDIX C

DESIGN CALCULATIONS

Nominal Bearing Resistance - Strength Limit

Soil Parameters:

γ	0.130	kcf	= total unit weight of soil
ϕ	34 0.593	degrees radians	= internal angle of friction of soil

General Nominal Bearing Resistance Equation

$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma}$ Equation 10.6.3.1.2a-1 (Nominal Bearing Resistance, ksf)

$c =$ 0 ksf Cohesion neglected for calculation

$Dw =$ 50 ft design groundwater Depth

$C_{wq} =$ 1

$C_{w\gamma} =$ 0.5 to 1.0 per Table 10.6.3.1.2a-2

General Nominal Bearing Resistance Equation reduces to:

$q_n = \gamma D_f N_{qm} + 0.5\gamma B N_{\gamma m}$

Bearing Capacity Factors

$N_{qm} = N_q s_q d_q i_q$ Equation 10.6.3.1.2a-3 (Modified Surcharge Bearing Capacity Factor, dim)

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$ Equation 10.6.3.1.2a-4 (Modified Unit Weight Bearing Capacity Factor, dim)

$d_q = 1.0$ Depth Correction Factor taken as 1.0 per discusion beneath Table 10.6.3.1.2a-4

$i_q = 1.0$

$i_\gamma = 1.0$ Load Inclination Factors neglected per Commentary Section C10.6.3.1.2a

$s_q = 1 + (B/L) \tan \phi$

$s_\gamma = 1 - 0.4\,(B/L)$ Shape Correction Factors per Table 10.6.3.1.2a-3

By substitution, General Nominal Bearing Resistance Equation further reduces to:

$q_n = \gamma D_f N_q C_{wq}[1+(B/L)\tan\phi_f] + 0.5\gamma B N_\gamma C_{w\gamma}[1-0.4(B/L)]$

Bearing Capacity Factors from ASSHTO LRFD Bridge Design Specifications Table 10.6.3.1.2a-1

N_q 29.4

N_γ 41.1

Figure C-1 Soil Parameters and Formulas for Bearing Resistance

Nominal Bearing Resistances for various depths to bottom of footing

Depth, D_f 2 ft

Effective Footing Width, B' (ft)	Nominal Bearing Resistance (ksf)				
	Effective Length to Effective Width Ratio, L'/B' (dim)				
	1	2	3	4	≥ 5
6	22.4	23.0	23.3	23.4	23.4
8	25.6	27.3	27.9	28.2	28.3
10	28.8	31.6	32.5	33.0	33.3
12	32.0	35.9	37.1	37.8	38.2
14	35.2	40.1	41.8	42.6	43.1
16	38.4	44.4	46.4	47.4	48.0
18	41.6	48.7	51.0	52.2	52.9

Depth, D_f 5 ft

Effective Footing Width, B' (ft)	Nominal Bearing Resistance (ksf)				
	Effective Length to Effective Width Ratio, L'/B' (dim)				
	1	2	3	4	≥ 5
6	41.6	38.4	37.3	36.8	36.4
8	44.8	42.6	41.9	41.6	41.3
10	48.0	46.9	46.6	46.4	46.3
12	51.2	51.2	51.2	51.2	51.2
14	54.4	55.5	55.8	56.0	56.1
16	57.6	59.7	60.4	60.8	61.0
18	60.8	64.0	65.1	65.6	65.9

Depth, D_f 8 ft

Effective Footing Width, B' (ft)	Nominal Bearing Resistance (ksf)				
	Effective Length to Effective Width Ratio, L'/B' (dim)				
	1	2	3	4	≥ 5
6	60.8	53.7	51.3	50.2	49.4
8	64.0	58.0	56.0	55.0	54.4
10	67.2	62.3	60.6	59.8	59.3
12	70.4	66.5	65.2	64.6	64.2
14	73.6	70.8	69.9	69.4	69.1
16	76.8	75.1	74.5	74.2	74.0
18	80.0	79.3	79.1	79.0	78.9

Linear interpolation may be used for intermediate values of bottom of footing depth (D_f), effective footing width (B'), and effective footing length (L'). A resistance factor, φ_b, of 0.45 should be used for factored resistance.

Limiting settlement at the service limit state

Settlement of footings bearing on soil per AASHTO *LRFD Bridge Design Specifications Section 10.6.2.4*

S_t $= S_e+S_c+S_s$ Equation 10.6.2.4.1-1 (Total Settlement, ft)

$$S_e = \frac{\left[q_0\left(1-\nu^2\right)\sqrt{A'}\right]}{144 E_s \beta_z}$$

Equation 10.6.2.4.2-1 (Elastic Settlement, ft)

S_c $= 0$ Consolidation Settlement is not applicable for the soils encountered

S_s $= 0$ Secondary Settlement is not applicable for the soils encountered

A' = effective area of footing in ft^2

β_z from Table 10.6.2.4.2-1 based on L/B, assuming rigid footing

Table 10.6.2.4.2-1 with linear interpolations included for intermediate L/B

L/B	β_z	
1	1.08	given
2	1.1	given
3	1.15	given
4	1.195	interpolated
5	1.24	given
6	1.274	interpolated
7	1.308	interpolated
8	1.342	interpolated
9	1.376	interpolated
10	1.41	given

Elastic Constants for lower end of "Dense Sand" per Table C10.4.6.3-1

ν	0.30		= Poisson's ratio
E_s	6.94	ksi	= Young's modulus

Allowable Net Bearing Resistance Equation

$$q_{all} = \frac{144 S_e E_s \beta_z}{\left(1-\nu^2\right)\sqrt{A'}}$$

Equation 10.6.2.4.2-1 (Solved for Bearing Pressure, ksf)

Limiting Settlement Assumed

S_{max} 1 in x (1 ft/12 in) = 0.083 ft

Figure C-3 Soil Parameters and Formulas for Settlement of Footing

Effective Footing Width, B' (ft)	Nominal Bearing Resistance (ksf) for a Limiting Settlement of 1-inch							
	Effective Length to Effective Width Ratio, L'/B' (dim)							
	1	2	4	8	15	20	25	30
6	16.47	11.86	9.11	7.24	5.55	4.81	4.30	3.93
8	12.35	8.90	6.84	5.43	4.16	3.61	3.23	2.94
10	9.88	7.12	5.47	4.34	3.33	2.89	2.58	2.36
12	8.24	5.93	4.56	3.62	2.78	2.40	2.15	1.96
14	7.06	5.08	3.91	3.10	2.38	2.06	1.84	1.68
16	6.18	4.45	3.42	2.71	2.08	1.80	1.61	1.47

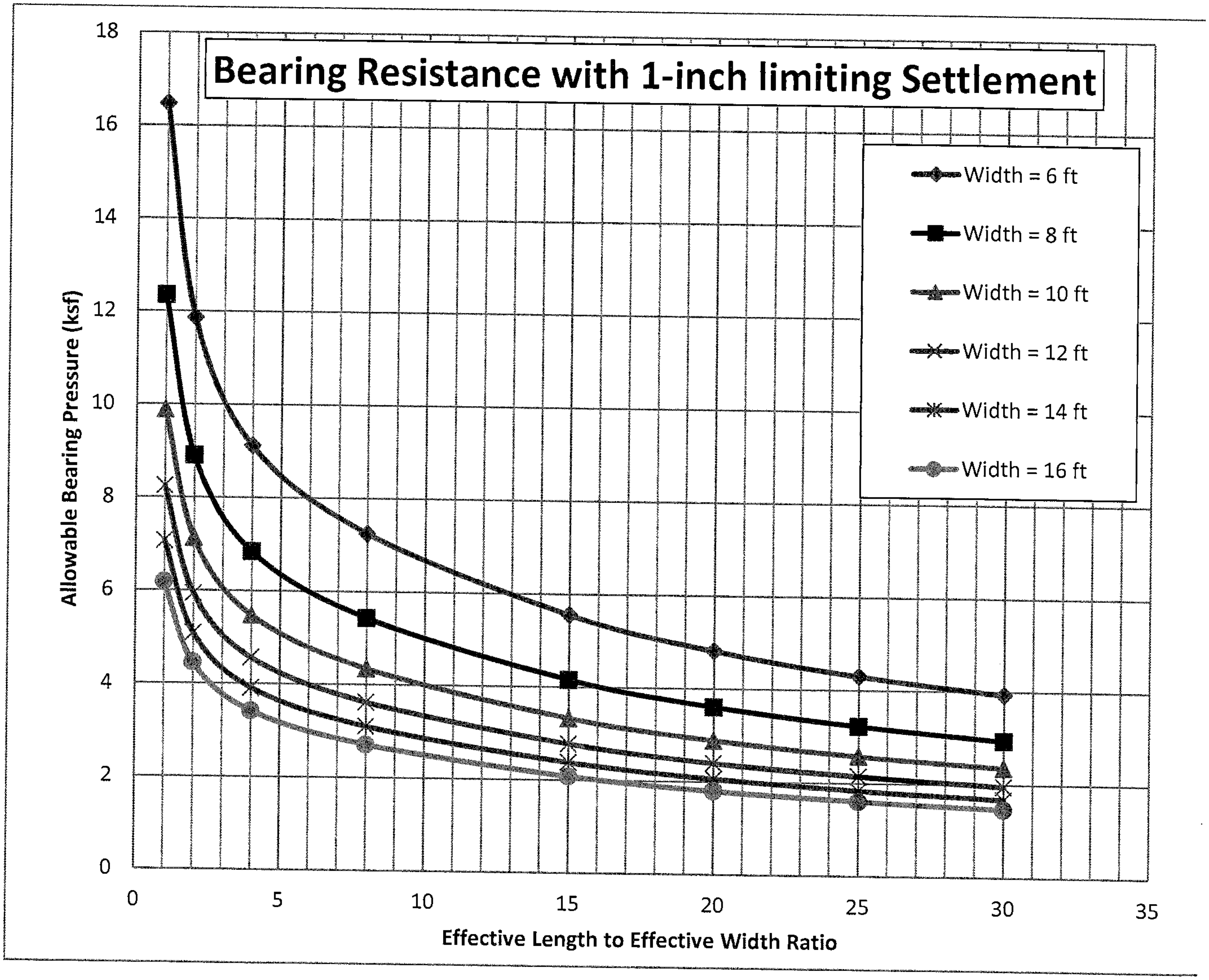

Figure C-4 Nominal Bearing Resistance for Limiting Settlement of 1 inch

LRFD Drilled Shaft Axial Analysis - Abut 1- 6'-dia updated loads 6-19-19.xlsx

Drilled Shaft Axial Resistance per AASHTO LRFD Bridge Design Specifications Section 10.8

Abutment 1 - 3 ft diameter

Factored Vertical Loads provided by the Structural Engineer

$Q_{service}$ = 600 kips = maximum factored service limit vertical load

$Q_{strength}$ = 780 kips = maximum factored strength limit vertical load

☐ single shaft per pier ☑ Load Test Performed

input cells

☑ Cap firmly on at least firm/medium dense soil, no potential scour

Soil Model, based on: B-2

Notes:

Drilled Shaft Properties

Shaft Diameter 3.00 ft shaft diameter 36 inches
Ground Surface Elevation 2394.0 ft
Top of Shaft Elevation 2391.0 ft
Groundwater Elevation 2331.0 ft
Top of Native Elevation 2394.0 ft
A_p 7.07 ft^2 = area of shaft tip
A_s 9.42 ft^2/ft = area of shaft side surface per unit length
f'_c 4.50 ksi = concrete compressive strength
E_c 3860.8 ksi = concrete elastic modulus (Eq. C5.4.2.4-1)
D_0 3.0 ft = depth to top of shaft
γ_0 0.120 kcf = unit weight of soil above top of shaft
C-T-C 4.0 x Diameter = center to center spacing
Configuration Single Row

Soil Layer No.	Depth* to Top of Layer	Depth to Bottom of Layer	Soil Type	Soil Type per Table 10.5.5.2.4-1	Unit Weight, γ_t (kcf)	Undrained Shear Strength for Clay, S_u (ksf)	SPT Blow Count Adjusted for Hammer Effeciency, N_{60} (blows/foot)	Uniaxial Compressive Strength of Rock, q_u (ksf)	Estimated Young's Modulus from Table C10.4.6.3-1, E_s (ksi)	Elevation at Top of Layer	Elevation at Bottom of Layer
1	0	17	Clay	Clay	0.1100	2.75	20	n/a	10	2391	2374
2	17	30	Sand	Sand	0.1150	n/a	30	n/a	6	2374	2361
3	30	33	Caliche	Rock	0.1400	12	50	n/a	30	2361	2358
4	33	45	Clay	Clay	0.1240	4	40	n/a	12	2358	2346
5	45	47	Caliche	Rock	0.1400	n/a	50	n/a	30	2346	2344
6	47	52	Clay	Clay	0.1160	3	53	n/a	12	2344	2339
7	52	57	Caliche	Rock	0.1400	n/a	50	n/a	30	2339	2334
8	57	67	Clay	Clay	0.1100	2.5	30	n/a	10	2334	2324
9	67	77	Caliche	Rock	0.1400	n/a	50	n/a	30	2324	2314
10			None	None	n/a	n/a	n/a	n/a	n/a		
11			None	None	n/a	n/a	n/a	n/a	n/a		
12			None	None	n/a	n/a	n/a	n/a	n/a		
13			None	None	n/a	n/a	n/a	n/a	n/a		
14			None	None	n/a	n/a	n/a	n/a	n/a		
15			None	None	n/a	n/a	n/a	n/a	n/a		
16			None	None	n/a	n/a	n/a	n/a	n/a		
17			None	None	n/a	n/a	n/a	n/a	n/a		
18			None	None	n/a	n/a	n/a	n/a	n/a		
19			None	None	n/a	n/a	n/a	n/a	n/a		
20			None	None	n/a	n/a	n/a	n/a	n/a		

*Zero is at the Top of the Drilled Shaft, which is no higher than the surrounding finished grade.

LRFD Drilled Shaft Axial Analysis - Abut 1- 6'-dia updated loads 6-19-19.xlsx

Equations and Constants

Zone of Excluded Side Friction at top of Shaft:		
Depth to Construction Joint/bottom of CMP	0	ft
Permanent Casing Length	0	ft
Depth of Exclusion Zone	5	ft
Maximum Side Resistance in Exclusion Zone	0	ksf

Factored Resistance

$R_R = \eta\varphi R_n = \eta\varphi_{qp}R_p+\eta\varphi_{qs}R_s$ Eq. 10.8.3.5-1

$\eta R_p = \eta q_pA_p$ Eq. 10.8.3.5-2

$\eta R_s = \eta q_sA_s$ Eq. 10.8.3.5-3

Constants

p_a = atmospheric pressure = 2.12 ksf

Unit Side Resistance

Cohesive Soil (clay)

$q_s = \alpha S_u$ Eq. 10.8.3.5.1b-1

$\alpha = 0.55$ for $S_u/p_a \leq 1.5$ Eq. 10.8.3.5.1b-2

$\alpha = 0.55-0.1(S_u/p_a-1.5)$ for $1.5 \leq S_u/p_a \leq 2.5$ Eq. 10.8.3.5.1b-3

$\alpha = 0$ for top five feet from the ground surface

Cohesionless Soil (sand and gravel)

$q_s = \beta\sigma'_v$ Eq. 10.8.3.5.2b-1

$\beta = (1-\sin\phi'_f)(\sigma'_p/\sigma'_v)^{\sin\varphi'f}\tan\varphi'_f$ Eq. 10.8.3.5.2b-2

$\phi'_f = 27.5 + 9.2 \log[(N_1)_{60}]$ Eq. 10.8.3.5.2b-3

$\sigma'_p = p_a\ 0.47\ (N_{60})^m$ for sand Eq. 10.8.3.5.2b-4

$\sigma'_p = p_a\ 0.15\ (N_{60})$ for gravel Eq. 10.8.3.5.2b-5

Rock

$q_s = p_aC[\ \min(q_u,f'_c)\ /p_a]^{0.5}$ C = 1.0 Eq. 10.8.3.5.4b-1 not used

$q_s = p_a0.65\alpha_E(q_u/p_a)^{0.5}$ Eq. 10.8.3.5.4b-2 used in calculations

α_E = joint modification factor

Unit Tip Resistance*

Cohesive Soil (clay)

$q_p = N_cS_u \leq 80$ ksf Eq. 10.8.3.5.1c-1

$N_c = 6[1+0.2(Z/D)] \leq 9$ Eq. 10.8.3.5.1c-2

Cohesionless Soil (sand and gravel)

$q_p = 1.2N_{60} \leq 60$ ksf for $N_{60} \leq 50$ Eq. 10.8.3.5.2c-1

Rock

$q_p = 2.5q_u$ Eq. 10.8.3.5.4c-1

LRFD Drilled Shaft Axial Analysis - Abut 1- 6'-dia updated loads 6-19-19.xlsx

Table 10.8.3.5.4b-1 Estimation of α_E

RQD (%)	α_E value Closed Joints	 Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45 ⟵ With no specific data on RQD, etc., assume worst case

E_m/E_i is the ratio of rock mass modulus to intact rock modulus

*Unit tip resistance presented in the table below is the lesser of the unit tip resistance of the current layer or the average unit tip resistance for the layers in the range of 2 diameters below the tip of the shaft, to account for weaker layers within the zone of influence of the shaft tip.

from Table 10.5.5.2.4-1 Resistance Factors for Geotechnical Resistance of Drilled Shafts (abbreviated for ease of display)

	Resistance Factors for Shaft Side Resistance	Resistance Factors for Shaft Tip Resistance*
Soil Type	φ_{qs}	φ_{qp}
Clay	0.70	0.70
IGM	0.70	0.70
Rock	0.70	0.70
Sand	0.70	0.70

*Resistance Factors used for Shaft Tip Resistance do not consider load testing that was performed.

$Q_{strength}$	780	kips	= maximum factored strength limit vertical load
L_{min}	37	ft	=minimum required shaft length
R_R	793	kips	= factored resistance for the strength limit state at L_{min}
	615	kips	= factored side resistance for the strength limit state at L_{min}
R_n	1133	kips	= nominal resistance at L_{min}

Group efficiency factor for firm, soft, and very soft clays

Linearly interpolated, based on Section 10.7.3.9 (AASHTO, 2014)

C-T-C	η
2.50	0.65
6.00	1.00

C-T-C 4.00 ⟶ η = 1.00

Group efficiency factor for sands

Linearly interpolated, based on Table 10.8.3.6.3-1 (AASHTO, 2014)

C-T-C	η
2.00	0.90
3.00	1.00

C-T-C	η
2.50	0.67
3.00	0.80
4.00	1.00

Single Row 1.00

C-T-C 4.00 ⟶ η = 1.00

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
1	1	Clay	0.415	0.0	0.0	0.0	20.4	143.9	143.9	1	143.9	0.70	0.70	0	101	101
2	1	Clay	0.525	0.0	0.0	0.0	21.5	151.7	151.7	1	151.7	0.70	0.70	0	106	106
3	1	Clay	0.635	0.0	0.0	0.0	22.6	159.4	159.4	1	159.4	0.70	0.70	0	112	112
4	1	Clay	0.745	0.0	0.0	0.0	23.7	167.2	167.2	1	167.2	0.70	0.70	0	117	117
5	1	Clay	0.855	0.0	0.0	0.0	24.8	175.0	175.0	1	175.0	0.70	0.70	0	122	122
6	1	Clay	0.965	1.5	14.2	14.2	24.8	175.0	189.2	1	189.2	0.70	0.70	10	122	132
7	1	Clay	1.075	1.5	14.2	28.5	24.8	175.0	203.5	1	203.5	0.70	0.70	20	122	142

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Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
8	1	Clay	1.185	1.5	14.2	42.7	24.8	175.0	217.7	1	217.7	0.70	0.70	30	122	152
9	1	Clay	1.295	1.5	14.2	57.0	24.8	175.0	232.0	1	232.0	0.70	0.70	40	122	162
10	1	Clay	1.405	1.5	14.2	71.2	24.8	175.0	246.2	1	246.2	0.70	0.70	50	122	172
11	1	Clay	1.515	1.5	14.2	85.5	24.8	175.0	260.5	1	260.5	0.70	0.70	60	122	182
12	1	Clay	1.625	1.5	14.2	99.7	24.8	175.0	274.7	1	274.7	0.70	0.70	70	122	192
13	1	Clay	1.735	1.5	14.2	114.0	24.8	175.0	289.0	1	289.0	0.70	0.70	80	122	202
14	1	Clay	1.845	1.5	14.2	128.2	24.8	175.0	303.2	1	303.2	0.70	0.70	90	122	212
15	1	Clay	1.955	1.5	14.2	142.5	24.8	175.0	317.5	1	317.5	0.70	0.70	100	122	222
16	1	Clay	2.065	1.5	14.2	156.7	24.8	175.0	331.7	1	331.7	0.70	0.70	110	122	232
17	1	Clay	2.175	1.5	14.2	171.0	24.8	175.0	346.0	1	346.0	0.70	0.70	120	122	242
18	2	Sand	2.288	2.0	19.2	190.1	36.0	254.5	444.6	1	444.6	0.70	0.70	133	178	311
19	2	Sand	2.403	2.1	19.8	209.9	36.0	254.5	464.4	1	464.4	0.70	0.70	147	178	325
20	2	Sand	2.518	2.2	20.4	230.3	36.0	254.5	484.8	1	484.8	0.70	0.70	161	178	339
21	2	Sand	2.633	2.2	21.0	251.3	36.0	254.5	505.8	1	505.8	0.70	0.70	176	178	354
22	2	Sand	2.748	2.3	21.5	272.8	36.0	254.5	527.3	1	527.3	0.70	0.70	191	178	369
23	2	Sand	2.863	2.3	22.1	294.9	36.0	254.5	549.4	1	549.4	0.70	0.70	206	178	385
24	2	Sand	2.978	2.4	22.6	317.4	36.0	254.5	572.0	1	572.0	0.70	0.70	222	178	400
25	2	Sand	3.093	2.4	23.1	340.5	36.0	254.5	595.0	1	595.0	0.70	0.70	238	178	417
26	2	Sand	3.208	2.5	23.5	364.1	36.0	254.5	618.6	1	618.6	0.70	0.70	255	178	433
27	2	Sand	3.323	2.5	24.0	388.0	36.0	254.5	642.6	1	642.6	0.70	0.70	272	178	450
28	2	Sand	3.438	2.6	24.4	412.5	36.0	254.5	667.0	1	667.0	0.70	0.70	289	178	467
29	2	Sand	3.553	2.6	24.8	437.3	36.0	254.5	691.8	1	691.8	0.70	0.70	306	178	484
30	2	Sand	3.668	2.7	25.2	462.6	36.0	254.5	717.1	1	717.1	0.70	0.70	324	178	502
31	3	Rock	3.795	12.0	113.0	575.6	60.0	424.2	999.8	1	999.8	0.70	0.70	403	297	700
32	3	Rock	3.935	12.0	113.0	688.6	60.0	424.2	1112.8	1	1112.8	0.70	0.70	482	297	779
33	3	Rock	4.075	12.0	113.0	801.7	60.0	424.2	1225.9	1	1225.9	0.70	0.70	561	297	858
34	4	Clay	4.207	2.0	19.3	820.9	36.0	254.5	1075.5	1	1075.5	0.70	0.70	575	178	753
35	4	Clay	4.331	2.0	19.3	840.2	36.0	254.5	1094.7	1	1094.7	0.70	0.70	588	178	766
36	4	Clay	4.455	2.0	19.3	859.5	36.0	254.5	1114.0	1	1114.0	0.70	0.70	602	178	780
37	4	Clay	4.579	2.0	19.3	878.7	36.0	254.5	1133.3	1	1133.3	0.70	0.70	615	178	793

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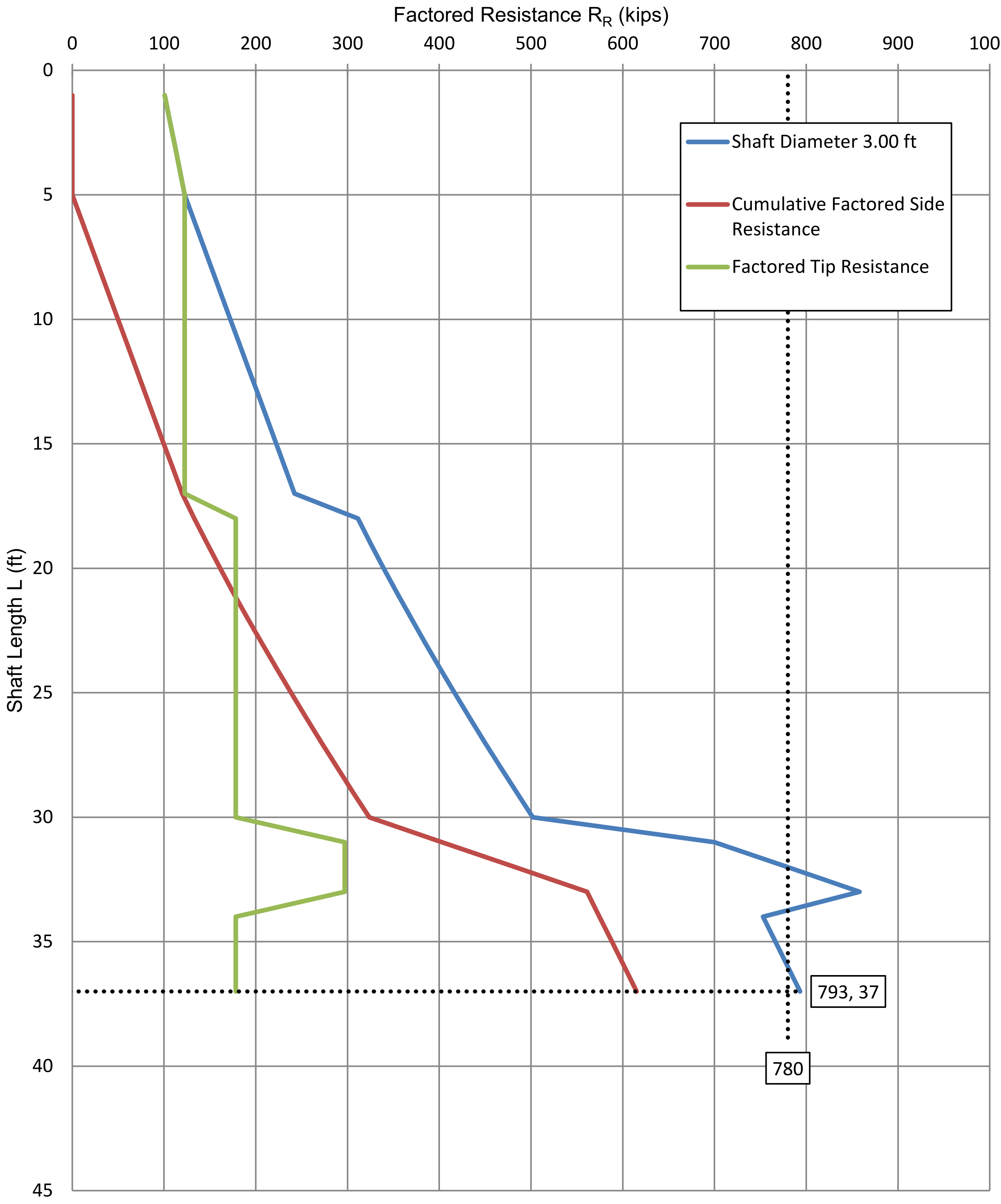
Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
38	4	Clay	4.703											#N/A	#N/A	#N/A
39	4	Clay	4.827											#N/A	#N/A	#N/A
40	4	Clay	4.951											#N/A	#N/A	#N/A
41	4	Clay	5.075											#N/A	#N/A	#N/A
42	4	Clay	5.199											#N/A	#N/A	#N/A
43	4	Clay	5.323											#N/A	#N/A	#N/A
44	4	Clay	5.447											#N/A	#N/A	#N/A
45	4	Clay	5.571											#N/A	#N/A	#N/A
46	5	Rock	5.703											#N/A	#N/A	#N/A
47	5	Rock	5.843											#N/A	#N/A	#N/A
48	6	Clay	5.971											#N/A	#N/A	#N/A

LRFD Drilled Shaft Axial Analysis - Abut 1- 6'-dia updated loads 6-19-19.xlsx

Drilled Shaft Factored Axial Resistance - Strength Limit State



LRFD Drilled Shaft Axial Analysis - Pier 1- 6'-dia updated loads 6-13-19.xlsx

Drilled Shaft Axial Resistance per AASHTO LRFD Bridge Design Specifications Section 10.8

Factored Vertical Loads provided by the Structural Engineer

$Q_{service}$ = 1110 kips = maximum factored service limit vertical load

$Q_{strength}$ = 1485 kips = maximum factored strength limit vertical load

input cells

☑ single shaft per pier ☑ Load Test Performed

☑ Cap firmly on at least firm/medium dense soil, no potential scour

Soil Model, based on: B-3

Notes: strongest profile

Pier 1 - 6 ft diameter

Drilled Shaft Properties

Shaft Diameter 6.00 ft shaft diameter 72 inches
Ground Surface Elevation 2396.0 ft
Top of Shaft Elevation 2391.0 ft
Groundwater Elevation 2331.0 ft
Top of Native Elevation 2396.0 ft
A_p 28.27 ft^2 = area of shaft tip
A_s 18.85 ft^2/ft = area of shaft side surface per unit length
f'_c 4.50 ksi = concrete compressive strength
E_c 3860.8 ksi = concrete elastic modulus (Eq. C5.4.2.4-1)
D_0 5.0 ft = depth to top of shaft
γ_0 0.120 kcf = unit weight of soil above top of shaft
C-T-C 0.0 x Diameter = center to center spacing
Configuration Single Row

Soil Layer No.	Depth* to Top of Layer	Depth to Bottom of Layer	Soil Type	Soil Type per Table 10.5.5.2.4-1	Unit Weight, γ_t (kcf)	Undrained Shear Strength for Clay, S_u (ksf)	SPT Blow Count Adjusted for Hammer Effeciency, N_{60} (blows/foot)	Uniaxial Compressive Strength of Rock, q_u (ksf)	Estimated Young's Modulus from Table C10.4.6.3-1, E_s (ksi)	Elevation at Top of Layer	Elevation at Bottom of Layer
1	0	5	Clay	Clay	0.1150	2.75	29	n/a	10	2391	2386
2	5	15	Sand	Sand	0.1230	n/a	39	n/a	10	2386	2376
3	15	20	Clay	Clay	0.1150	4	50	n/a	10	2376	2371
4	20	28	Sand	Sand	0.1130	n/a	35	n/a	6	2371	2363
5	28	35	Caliche	Rock	0.1400	n/a	50	n/a	30	2363	2356
6	35	45	Clay	Clay	0.1160	3	36	n/a	10	2356	2346
7	45	50	Sand	Sand	0.1250	n/a	50	n/a	10	2346	2341
8	50	66	Caliche	Rock	0.1400	n/a	50	n/a	30	2341	2325
9	66	76	Caliche	Rock	0.0770	n/a	50	n/a	30	2325	2315
10			None	None	n/a	n/a	n/a	n/a	n/a		
11			None	None	n/a	n/a	n/a	n/a	n/a		
12			None	None	n/a	n/a	n/a	n/a	n/a		
13			None	None	n/a	n/a	n/a	n/a	n/a		
14			None	None	n/a	n/a	n/a	n/a	n/a		
15			None	None	n/a	n/a	n/a	n/a	n/a		
16			None	None	n/a	n/a	n/a	n/a	n/a		
17			None	None	n/a	n/a	n/a	n/a	n/a		
18			None	None	n/a	n/a	n/a	n/a	n/a		
19			None	None	n/a	n/a	n/a	n/a	n/a		
20			None	None	n/a	n/a	n/a	n/a	n/a		

*Zero is at the Top of the Drilled Shaft, which is no higher than the surrounding finished grade.

LRFD Drilled Shaft Axial Analysis - Pier 1- 6'-dia updated loads 6-13-19.xlsx

Equations and Constants

Zone of Excluded Side Friction at top of Shaft:		
Depth to Construction Joint/bottom of CMP	0	ft
Permanent Casing Length	0	ft
Depth of Exclusion Zone	5	ft
Maximum Side Resistance in Exclusion Zone	0	ksf

Factored Resistance

$R_R = \eta\varphi R_n = \eta\varphi_{qp}R_p + \eta\varphi_{qs}R_s$ Eq. 10.8.3.5-1

$\eta R_p = \eta q_p A_p$ Eq. 10.8.3.5-2

$\eta R_s = \eta q_s A_s$ Eq. 10.8.3.5-3

Constants

p_a = atmospheric pressure = 2.12 ksf

Unit Side Resistance

Cohesive Soil (clay)

$q_s = \alpha S_u$ Eq. 10.8.3.5.1b-1

$\alpha = 0.55$ for $S_u/p_a \leq 1.5$ Eq. 10.8.3.5.1b-2

$\alpha = 0.55-0.1(S_u/p_a-1.5)$ for $1.5 \leq S_u/p_a \leq 2.5$ Eq. 10.8.3.5.1b-3

$\alpha = 0$ for top five feet from the ground surface

Cohesionless Soil (sand and gravel)

$q_s = \beta\sigma'_v$ Eq. 10.8.3.5.2b-1

$\beta = (1-\sin\phi'_f)(\sigma'_p/\sigma'_v)^{\sin\varphi'f}\tan\varphi'_f$ Eq. 10.8.3.5.2b-2

$\phi'_f = 27.5 + 9.2\log[(N_1)_{60}]$ Eq. 10.8.3.5.2b-3

$\sigma'_p = p_a\, 0.47\,(N_{60})^m$ for sand Eq. 10.8.3.5.2b-4

$\sigma'_p = p_a\, 0.15\,(N_{60})$ for gravel Eq. 10.8.3.5.2b-5

Rock

$q_s = p_a C[\min(q_u, f'_c)/p_a]^{0.5}$ C = 1.0 Eq. 10.8.3.5.4b-1 not used

$q_s = p_a 0.65\alpha_E(q_u/p_a)^{0.5}$ Eq. 10.8.3.5.4b-2 used in calculations

α_E = joint modification factor

Unit Tip Resistance*

Cohesive Soil (clay)

$q_p = N_c S_u \leq 80$ ksf Eq. 10.8.3.5.1c-1

$N_c = 6[1+0.2(Z/D)] \leq 9$ Eq. 10.8.3.5.1c-2

Cohesionless Soil (sand and gravel)

$q_p = 1.2N_{60} \leq 60$ ksf for $N_{60} \leq 50$ Eq. 10.8.3.5.2c-1

Rock

$q_p = 2.5q_u$ Eq. 10.8.3.5.4c-1

LRFD Drilled Shaft Axial Analysis - Pier 1- 6'-dia updated loads 6-13-19.xlsx

Table 10.8.3.5.4b-1 Estimation of α_E

RQD (%)	α_E value	
	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

E_m/E_i is the ratio of rock mass modulus to intact rock modulus

← With no specific data on RQD, etc., assume worst case

*Unit tip resistance presented in the table below is the lesser of the unit tip resistance of the current layer or the average unit tip resistance for the layers in the range of 2 diameters below the tip of the shaft, to account for weaker layers within the zone of influence of the shaft tip.

from Table 10.5.5.2.4-1 Resistance Factors for Geotechnical Resistance of Drilled Shafts (abbreviated for ease of display and reduced by 20% for lack of redundancy)

	Resistance Factors for Shaft Side Resistance	Resistance Factors for Shaft Tip Resistance*
Soil Type	φ_{qs}	φ_{qp}
Clay	0.56	0.56
IGM	0.56	0.56
Rock	0.56	0.56
Sand	0.56	0.56

*Resistance Factors used for Shaft Tip Resistance do not consider load testing that was performed.

$Q_{strength}$	1485	kips	= maximum factored strength limit vertical load
L_{min}	29	ft	=minimum required shaft length
R_R	1591	kips	= factored resistance for the strength limit state at L_{min}
	641	kips	= factored side resistance for the strength limit state at L_{min}
R_n	2842	kips	= nominal resistance at L_{min}

Group efficiency factor for firm, soft, and very soft clays

Linearly interpolated, based on Section 10.7.3.9 (AASHTO, 2014)

C-T-C	η
2.50	0.65
6.00	1.00

C-T-C 0.00 ⟶ η = 1.00

Group efficiency factor for sands

Linearly interpolated, based on Table 10.8.3.6.3-1 (AASHTO, 2014)

C-T-C	η
2.00	0.90
3.00	1.00

C-T-C	η
2.50	0.67
3.00	0.80
4.00	1.00

Single Row 1.00

C-T-C 0.00 ⟶ η = 1.00

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
1	1	Clay	0.658	0.0	0.0	0.0	19.5	552.0	552.0	1	552.0	0.56	0.56	0	309	309
2	1	Clay	0.773	0.0	0.0	0.0	20.1	567.5	567.5	1	567.5	0.56	0.56	0	318	318
3	1	Clay	0.888	0.0	0.0	0.0	20.6	583.1	583.1	1	583.1	0.56	0.56	0	327	327
4	1	Clay	1.003	0.0	0.0	0.0	21.2	598.6	598.6	1	598.6	0.56	0.56	0	335	335
5	1	Clay	1.118	0.0	0.0	0.0	21.7	614.2	614.2	1	614.2	0.56	0.56	0	344	344
6	2	Sand	1.237	1.3	24.8	24.8	46.8	1323.0	1347.8	1	1347.8	0.56	0.56	14	741	755
7	2	Sand	1.360	1.4	26.7	51.5	45.6	1289.1	1340.6	1	1340.6	0.56	0.56	29	722	751

LRFD Drilled Shaft Axial Analysis - Pier 1- 6'-dia updated loads 6-13-19.xlsx

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
8	2	Sand	1.483	1.5	28.6	80.1	44.4	1255.2	1335.2	1	1335.2	0.56	0.56	45	703	748
9	2	Sand	1.606	1.6	30.4	110.4	43.2	1221.3	1331.7	1	1331.7	0.56	0.56	62	684	746
10	2	Sand	1.729	1.7	32.1	142.6	42.0	1187.3	1329.9	1	1329.9	0.56	0.56	80	665	745
11	2	Sand	1.852	1.8	33.8	176.4	40.8	1153.4	1329.8	1	1329.8	0.56	0.56	99	646	745
12	2	Sand	1.975	1.9	35.4	211.8	39.6	1119.5	1331.3	1	1331.3	0.56	0.56	119	627	746
13	2	Sand	2.098	2.0	37.0	248.8	38.4	1085.6	1334.3	1	1334.3	0.56	0.56	139	608	747
14	2	Sand	2.221	2.0	38.5	287.2	37.2	1051.6	1338.9	1	1338.9	0.56	0.56	161	589	750
15	2	Sand	2.344	2.1	39.9	327.2	36.0	1017.7	1344.9	1	1344.9	0.56	0.56	183	570	753
16	3	Clay	2.463	2.0	38.6	365.7	36.0	1017.7	1383.4	1	1383.4	0.56	0.56	205	570	775
17	3	Clay	2.578	2.0	38.6	404.3	36.0	1017.7	1422.0	1	1422.0	0.56	0.56	226	570	796
18	3	Clay	2.693	2.0	38.6	442.8	36.0	1017.7	1460.5	1	1460.5	0.56	0.56	248	570	818
19	3	Clay	2.808	2.0	38.6	481.4	36.0	1017.7	1499.1	1	1499.1	0.56	0.56	270	570	839
20	3	Clay	2.923	2.0	38.6	519.9	36.0	1017.7	1537.7	1	1537.7	0.56	0.56	291	570	861
21	4	Sand	3.037	2.5	46.8	566.8	42.0	1187.3	1754.1	1	1754.1	0.56	0.56	317	665	982
22	4	Sand	3.150	2.5	47.8	614.6	42.0	1187.3	1801.9	1	1801.9	0.56	0.56	344	665	1009
23	4	Sand	3.263	2.6	48.7	663.3	42.0	1187.3	1850.6	1	1850.6	0.56	0.56	371	665	1036
24	4	Sand	3.376	2.6	49.6	712.9	42.0	1187.3	1900.2	1	1900.2	0.56	0.56	399	665	1064
25	4	Sand	3.489	2.7	50.4	763.3	42.0	1187.3	1950.6	1	1950.6	0.56	0.56	427	665	1092
26	4	Sand	3.602	2.7	51.2	814.5	42.0	1187.3	2001.8	1	2001.8	0.56	0.56	456	665	1121
27	4	Sand	3.715	2.8	52.0	866.5	42.0	1187.3	2053.8	1	2053.8	0.56	0.56	485	665	1150
28	4	Sand	3.828	2.8	52.7	919.2	42.0	1187.3	2106.5	1	2106.5	0.56	0.56	515	665	1180
29	5	Rock	3.954	12.0	226.2	1145.4	60.0	1696.2	2841.6	1	2841.6	0.56	0.56	641	950	1591
30	5	Rock	4.094											#N/A	#N/A	#N/A
31	5	Rock	4.234											#N/A	#N/A	#N/A
32	5	Rock	4.374											#N/A	#N/A	#N/A
33	5	Rock	4.514											#N/A	#N/A	#N/A
34	5	Rock	4.654											#N/A	#N/A	#N/A
35	5	Rock	4.794											#N/A	#N/A	#N/A

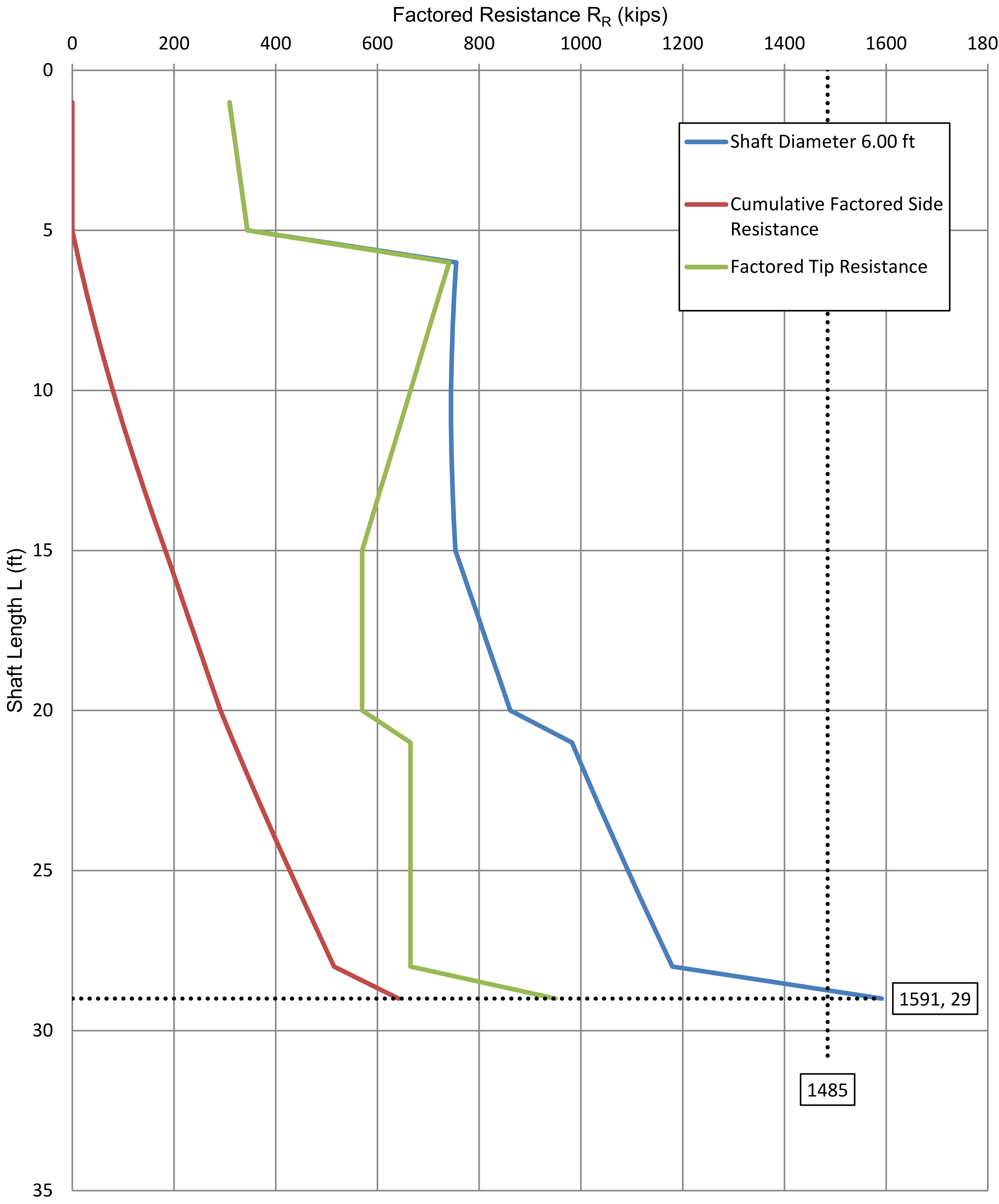
LRFD Drilled Shaft Axial Analysis - Pier 1- 6'-dia updated loads 6-13-19.xlsx

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
36	6	Clay	4.922											#N/A	#N/A	#N/A
37	6	Clay	5.038											#N/A	#N/A	#N/A
38	6	Clay	5.154											#N/A	#N/A	#N/A

LRFD Drilled Shaft Axial Analysis - Pier 1- 6'-dia updated loads 6-13-19.xlsx

Drilled Shaft Factored Axial Resistance - Strength Limit State



LRFD Drilled Shaft Axial Analysis - Pier 2- 6'-dia updated loads 6-13-19.xlsx

Drilled Shaft Axial Resistance per AASHTO LRFD Bridge Design Specifications Section 10.8

Pier 2 - 6 ft diameter

Factored Vertical Loads provided by the Structural Engineer

$Q_{service}$ = 1110 kips = maximum factored service limit vertical load

$Q_{strength}$ = 1485 kips = maximum factored strength limit vertical load

☑ single shaft per pier ☑ Load Test Performed

☑ Cap firmly on at least firm/medium dense soil, no potential scour

input cells

Soil Model, based on: B-4

Notes:

Drilled Shaft Properties

Shaft Diameter 6.00 ft shaft diameter 72 inches
Ground Surface Elevation 2388.0 ft
Top of Shaft Elevation 2387.0 ft
Groundwater Elevation 2331.0 ft
Top of Native Elevation 2388.0 ft
A_p 28.27 ft^2 = area of shaft tip
A_s 18.85 ft^2/ft = area of shaft side surface per unit length
f'_c 4.50 ksi = concrete compressive strength
E_c 3860.8 ksi = concrete elastic modulus (Eq. C5.4.2.4-1)
D_0 1.0 ft = depth to top of shaft
γ_0 0.120 kcf = unit weight of soil above top of shaft
C-T-C 0.0 x Diameter = center to center spacing
Configuration Single Row

Soil Layer No.	Depth* to Top of Layer	Depth to Bottom of Layer	Soil Type	Soil Type per Table 10.5.5.2.4-1	Unit Weight, γ_t (kcf)	Undrained Shear Strength for Clay, S_u (ksf)	SPT Blow Count Adjusted for Hammer Effeciency, N_{60} (blows/foot)	Uniaxial Compressive Strength of Rock, q_u (ksf)	Estimated Young's Modulus from Table C10.4.6.3-1, E_s (ksi)	Elevation at Top of Layer	Elevation at Bottom of Layer
1	0	10	Clay	Clay	0.1000	3	34	n/a	10	2387	2377
2	10	23	Gravel	Sand	0.1110	n/a	45	n/a	12	2377	2364
3	23	39	Clay	Clay	0.1100	4.3	40	n/a	10	2364	2348
4	39	45	Sand	Sand	0.1100	n/a	50	n/a	12	2348	2342
5	45	48	Caliche	Rock	0.1400	n/a	50	n/a	30	2342	2339
6	48	55	Clay	Clay	0.1140	4.5	50	n/a	10	2339	2332
7	55	70	Caliche	Rock	0.0800	n/a	50	n/a	30	2332	2317
8	70	80	Clay	Clay	0.0600	3	25	n/a	8	2317	2307
9			None	None	n/a	n/a	n/a	n/a	n/a		
10			None	None	n/a	n/a	n/a	n/a	n/a		
11			None	None	n/a	n/a	n/a	n/a	n/a		
12			None	None	n/a	n/a	n/a	n/a	n/a		
13			None	None	n/a	n/a	n/a	n/a	n/a		
14			None	None	n/a	n/a	n/a	n/a	n/a		
15			None	None	n/a	n/a	n/a	n/a	n/a		
16			None	None	n/a	n/a	n/a	n/a	n/a		
17			None	None	n/a	n/a	n/a	n/a	n/a		
18			None	None	n/a	n/a	n/a	n/a	n/a		
19			None	None	n/a	n/a	n/a	n/a	n/a		
20			None	None	n/a	n/a	n/a	n/a	n/a		

*Zero is at the Top of the Drilled Shaft, which is no higher than the surrounding finished grade.

LRFD Drilled Shaft Axial Analysis - Pier 2- 6'-dia updated loads 6-13-19.xlsx

Equations and Constants

Zone of Excluded Side Friction at top of Shaft:		
Depth to Construction Joint/bottom of CMP	0	ft
Permanent Casing Length	0	ft
Depth of Exclusion Zone	5	ft
Maximum Side Resistance in Exclusion Zone	0	ksf

Factored Resistance

$R_R = \eta\varphi R_n = \eta\varphi_{qp}R_p+\eta\varphi_{qs}R_s$ Eq. 10.8.3.5-1

$\eta R_p = \eta q_p A_p$ Eq. 10.8.3.5-2

$\eta R_s = \eta q_s A_s$ Eq. 10.8.3.5-3

Constants

p_a = atmospheric pressure = 2.12 ksf

Unit Side Resistance

Cohesive Soil (clay)

$q_s = \alpha S_u$ Eq. 10.8.3.5.1b-1

$\alpha = 0.55$ for $S_u/p_a \le 1.5$ Eq. 10.8.3.5.1b-2

$\alpha = 0.55-0.1(S_u/p_a-1.5)$ for $1.5 \le S_u/p_a \le 2.5$ Eq. 10.8.3.5.1b-3

$\alpha = 0$ for top five feet from the ground surface

Cohesionless Soil (sand and gravel)

$q_s = \beta\sigma'_v$ Eq. 10.8.3.5.2b-1

$\beta = (1-\sin\phi'_f)(\sigma'_p/\sigma'_v)^{\sin\varphi'f}\tan\varphi'_f$ Eq. 10.8.3.5.2b-2

$\phi'_f = 27.5 + 9.2 \log[(N_1)_{60}]$ Eq. 10.8.3.5.2b-3

$\sigma'_p = p_a\ 0.47\ (N_{60})^m$ for sand Eq. 10.8.3.5.2b-4

$\sigma'_p = p_a\ 0.15\ (N_{60})$ for gravel Eq. 10.8.3.5.2b-5

Rock

$q_s = p_aC[\ \min(q_u,f'_c)\,/p_a]^{0.5}$ C = 1.0 Eq. 10.8.3.5.4b-1 not used

$q_s = p_a0.65\alpha_E(q_u/p_a)^{0.5}$ Eq. 10.8.3.5.4b-2 used in calculations

α_E = joint modification factor

Unit Tip Resistance*

Cohesive Soil (clay)

$q_p = N_cS_u \le 80$ ksf Eq. 10.8.3.5.1c-1

$N_c = 6[1+0.2(Z/D)] \le 9$ Eq. 10.8.3.5.1c-2

Cohesionless Soil (sand and gravel)

$q_p = 1.2N_{60} \le 60$ ksf for $N_{60} \le 50$ Eq. 10.8.3.5.2c-1

Rock

$q_p = 2.5q_u$ Eq. 10.8.3.5.4c-1

LRFD Drilled Shaft Axial Analysis - Pier 2- 6'-dia updated loads 6-13-19.xlsx

Table 10.8.3.5.4b-1 Estimation of α_E

	α_E value	
RQD (%)	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

E_m/E_i is the ratio of rock mass modulus to intact rock modulus

← With no specific data on RQD, etc., assume worst case

*Unit tip resistance presented in the table below is the lesser of the unit tip resistance of the current layer or the average unit tip resistance for the layers in the range of 2 diameters below the tip of the shaft, to account for weaker layers within the zone of influence of the shaft tip.

from Table 10.5.5.2.4-1 Resistance Factors for Geotechnical Resistance of Drilled Shafts (abbreviated for ease of display and reduced by 20% for lack of redundancy)

	Resistance Factors for Shaft Side Resistance	Resistance Factors for Shaft Tip Resistance*
Soil Type	φ_{qs}	φ_{qp}
Clay	0.56	0.56
IGM	0.56	0.56
Rock	0.56	0.56
Sand	0.56	0.56

*Resistance Factors used for Shaft Tip Resistance do not consider load testing that was performed.

$Q_{strength}$ 1485 kips = maximum factored strength limit vertical load

L_{min} 40 ft =minimum required shaft length

R_R 1799 kips = factored resistance for the strength limit state at L_{min}

849 kips = factored side resistance for the strength limit state at L_{min}

R_n 3213 kips = nominal resistance at L_{min}

Group efficiency factor for firm, soft, and very soft clays

Linearly interpolated, based on Section 10.7.3.9 (AASHTO, 2014)

C-T-C	η
2.50	0.65
6.00	1.00

C-T-C 0.00 ⟶ η = 1.00

Group efficiency factor for sands

Linearly interpolated, based on Table 10.8.3.6.3-1 (AASHTO, 2014)

C-T-C	η
2.00	0.90
3.00	1.00

C-T-C	η
2.50	0.67
3.00	0.80
4.00	1.00

Single Row 1.00

C-T-C 0.00 ⟶ η = 1.00

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
1	1	Clay	0.170	0.0	0.0	0.0	18.9	534.3	534.3	1	534.3	0.56	0.56	0	299	299
2	1	Clay	0.270	0.0	0.0	0.0	19.5	551.3	551.3	1	551.3	0.56	0.56	0	309	309
3	1	Clay	0.370	0.0	0.0	0.0	20.1	568.2	568.2	1	568.2	0.56	0.56	0	318	318
4	1	Clay	0.470	0.0	0.0	0.0	20.7	585.2	585.2	1	585.2	0.56	0.56	0	328	328
5	1	Clay	0.570	0.0	0.0	0.0	21.3	602.2	602.2	1	602.2	0.56	0.56	0	337	337
6	1	Clay	0.670	1.7	31.1	31.1	21.9	619.1	650.2	1	650.2	0.56	0.56	17	347	364
7	1	Clay	0.770	1.7	31.1	62.2	22.5	636.1	698.3	1	698.3	0.56	0.56	35	356	391

LRFD Drilled Shaft Axial Analysis - Pier 2- 6'-dia updated loads 6-13-19.xlsx

Calculations for Factored Geotechncial Resistance of Drilled Shafts

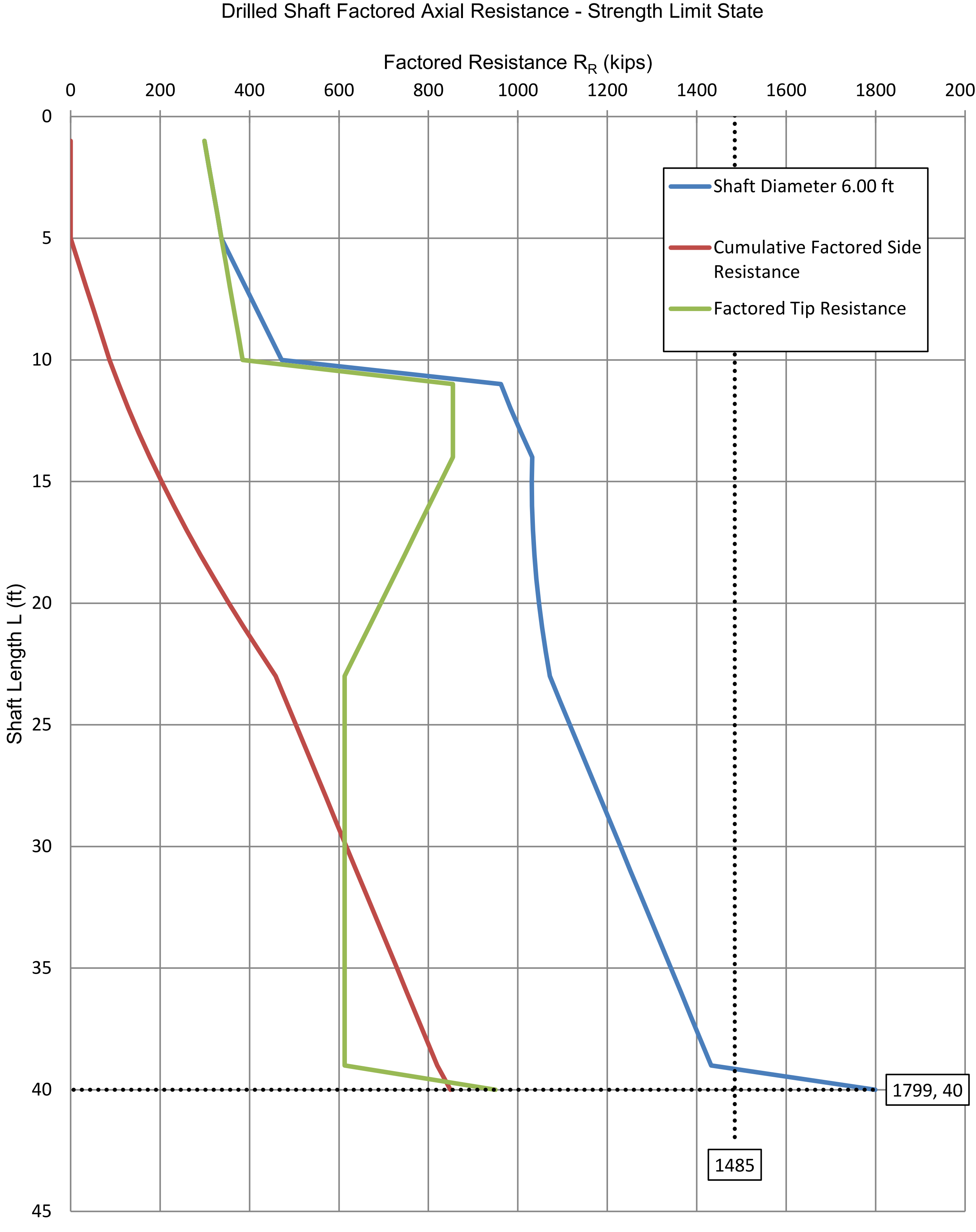
										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
8	1	Clay	0.870	1.7	31.1	93.3	23.1	653.0	746.3	1	746.3	0.56	0.56	52	366	418
9	1	Clay	0.970	1.7	31.1	124.4	23.7	670.0	794.4	1	794.4	0.56	0.56	70	375	445
10	1	Clay	1.070	1.7	31.1	155.5	24.3	687.0	842.5	1	842.5	0.56	0.56	87	385	472
11	2	Sand	1.176	1.9	36.0	191.5	54.0	1526.6	1718.1	1	1718.1	0.56	0.56	107	855	962
12	2	Sand	1.287	2.1	38.8	230.4	54.0	1526.6	1756.9	1	1756.9	0.56	0.56	129	855	984
13	2	Sand	1.398	2.2	41.6	271.9	54.0	1526.6	1798.5	1	1798.5	0.56	0.56	152	855	1007
14	2	Sand	1.509	2.3	44.2	316.1	54.0	1526.6	1842.7	1	1842.7	0.56	0.56	177	855	1032
15	2	Sand	1.620	2.5	46.7	362.8	52.3	1478.5	1841.4	1	1841.4	0.56	0.56	203	828	1031
16	2	Sand	1.731	2.6	49.2	412.1	50.6	1430.5	1842.5	1	1842.5	0.56	0.56	231	801	1032
17	2	Sand	1.842	2.7	51.6	463.7	48.9	1382.4	1846.1	1	1846.1	0.56	0.56	260	774	1034
18	2	Sand	1.953	2.9	53.9	517.6	47.2	1334.3	1851.9	1	1851.9	0.56	0.56	290	747	1037
19	2	Sand	2.064	3.0	56.1	573.7	45.5	1286.3	1860.0	1	1860.0	0.56	0.56	321	720	1042
20	2	Sand	2.175	3.1	58.3	632.0	43.8	1238.2	1870.2	1	1870.2	0.56	0.56	354	693	1047
21	2	Sand	2.286	3.2	60.4	692.4	42.1	1190.2	1882.5	1	1882.5	0.56	0.56	388	666	1054
22	2	Sand	2.397	3.3	62.3	754.7	40.4	1142.1	1896.8	1	1896.8	0.56	0.56	423	640	1062
23	2	Sand	2.508	3.4	64.3	819.0	38.7	1094.0	1913.0	1	1913.0	0.56	0.56	459	613	1071
24	3	Clay	2.618	2.1	40.3	859.3	38.7	1094.0	1953.3	1	1953.3	0.56	0.56	481	613	1094
25	3	Clay	2.728	2.1	40.3	899.6	38.7	1094.0	1993.6	1	1993.6	0.56	0.56	504	613	1116
26	3	Clay	2.838	2.1	40.3	939.9	38.7	1094.0	2033.9	1	2033.9	0.56	0.56	526	613	1139
27	3	Clay	2.948	2.1	40.3	980.2	38.7	1094.0	2074.2	1	2074.2	0.56	0.56	549	613	1162
28	3	Clay	3.058	2.1	40.3	1020.5	38.7	1094.0	2114.5	1	2114.5	0.56	0.56	571	613	1184
29	3	Clay	3.168	2.1	40.3	1060.8	38.7	1094.0	2154.8	1	2154.8	0.56	0.56	594	613	1207
30	3	Clay	3.278	2.1	40.3	1101.1	38.7	1094.0	2195.1	1	2195.1	0.56	0.56	617	613	1229
31	3	Clay	3.388	2.1	40.3	1141.4	38.7	1094.0	2235.4	1	2235.4	0.56	0.56	639	613	1252
32	3	Clay	3.498	2.1	40.3	1181.6	38.7	1094.0	2275.7	1	2275.7	0.56	0.56	662	613	1274
33	3	Clay	3.608	2.1	40.3	1221.9	38.7	1094.0	2316.0	1	2316.0	0.56	0.56	684	613	1297
34	3	Clay	3.718	2.1	40.3	1262.2	38.7	1094.0	2356.3	1	2356.3	0.56	0.56	707	613	1320
35	3	Clay	3.828	2.1	40.3	1302.5	38.7	1094.0	2396.6	1	2396.6	0.56	0.56	729	613	1342

LRFD Drilled Shaft Axial Analysis - Pier 2- 6'-dia updated loads 6-13-19.xlsx

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
36	3	Clay	3.938	2.1	40.3	1342.8	38.7	1094.0	2436.9	1	2436.9	0.56	0.56	752	613	1365
37	3	Clay	4.048	2.1	40.3	1383.1	38.7	1094.0	2477.2	1	2477.2	0.56	0.56	775	613	1387
38	3	Clay	4.158	2.1	40.3	1423.4	38.7	1094.0	2517.5	1	2517.5	0.56	0.56	797	613	1410
39	3	Clay	4.268	2.1	40.3	1463.7	38.7	1094.0	2557.8	1	2557.8	0.56	0.56	820	613	1432
40	4	Sand	4.378	2.8	52.9	1516.6	60.0	1696.2	3212.8	1	3212.8	0.56	0.56	849	950	1799
41	4	Sand	4.488											#N/A	#N/A	#N/A
42	4	Sand	4.598											#N/A	#N/A	#N/A
43	4	Sand	4.708											#N/A	#N/A	#N/A
44	4	Sand	4.818											#N/A	#N/A	#N/A
45	4	Sand	4.928											#N/A	#N/A	#N/A
46	5	Rock	5.053											#N/A	#N/A	#N/A
47	5	Rock	5.193											#N/A	#N/A	#N/A
48	5	Rock	5.333											#N/A	#N/A	#N/A
49	6	Clay	5.460											#N/A	#N/A	#N/A
50	6	Clay	5.574											#N/A	#N/A	#N/A
51	6	Clay	5.688											#N/A	#N/A	#N/A

LRFD Drilled Shaft Axial Analysis - Pier 2- 6'-dia updated loads 6-13-19.xlsx



LRFD Drilled Shaft Axial Analysis - Pier 3- 6' -dia updated loads 6-13-19.xlsx

Drilled Shaft Axial Resistance per AASHTO LRFD Bridge Design Specifications Section 10.8

Pier 3 based on Boring B-5

Factored Vertical Loads provided by the Structural Engineer

$Q_{service}$ = 765 kips = maximum factored service limit vertical load

$Q_{strength}$ = 1014 kips = maximum factored strength limit vertical load

input cells

☑ single shaft per pier

☑ Load Test Performed

☑ Cap firmly on at least firm/medium dense soil, no potential scour

Soil Model, based on: B-5

Notes:

Drilled Shaft Properties

Shaft Diameter	6	ft	shaft diameter 72 inches
Ground Surface Elevation	2384.0	ft	
Top of Shaft Elevation	2381.0	ft	
Groundwater Elevation	2331.0	ft	
Top of Native Elevation	2384.0	ft	
A_p	28.27	ft^2	= area of shaft tip
A_s	18.85	ft^2/ft	= area of shaft side surface per unit length
f'_c	4.00	ksi	= concrete compressive strength
E_c	3640.0	ksi	= concrete elastic modulus (Eq. C5.4.2.4-1)
D_0	3.0	ft	= depth to top of shaft
γ_0	0.120	kcf	= unit weight of soil above top of shaft
C-T-C	0.0	x Diameter	= center to center spacing
Configuration	Single Row		

Soil Layer No.	Depth* to Top of Layer	Depth to Bottom of Layer	Soil Type	Soil Type per Table 10.5.5.2.4-1	Unit Weight, γ_t (kcf)	Undrained Shear Strength for Clay, S_u (ksf)	SPT Blow Count Adjusted for Hammer Effeciency, N_{60} (blows/foot)	Uniaxial Compressive Strength of Rock, q_u (ksf)	Estimated Young's Modulus from Table C10.4.6.3-1, E_s (ksi)	Elevation at Top of Layer	Elevation at Bottom of Layer
1	0	27	Clay	Clay	0.1000	3	31	n/a	10	2381	2354
2	27	32	Caliche	Rock	0.1400	n/a	50	n/a	30	2354	2349
3	32	46	Clay	Clay	0.1150	4.3	50	n/a	12	2349	2335
4	46	52	Sand	Sand	0.0600	n/a	35	n/a	7	2335	2329
5	52	60	Caliche	Rock	0.0800	n/a	50	n/a	30	2329	2321
6	60	62	Caliche	Rock	0.0700	n/a	50	n/a	30	2321	2319
7	62	86	Clay	Clay	0.0540	4.8	18	n/a	10	2319	2295
8	86	91	Clay	Clay	0.0540	4.8	30	n/a	10	2295	2290
9	91	97	Clay	Clay	0.0540	4.8	18	n/a	10	2290	2284
10	97	107	Clay	Clay	0.0540	4.8	18	n/a	10	2284	2274
11			None	None	n/a	n/a	n/a	n/a	n/a		
12			None	None	n/a	n/a	n/a	n/a	n/a		
13			None	None	n/a	n/a	n/a	n/a	n/a		
14			None	None	n/a	n/a	n/a	n/a	n/a		
15			None	None	n/a	n/a	n/a	n/a	n/a		
16			None	None	n/a	n/a	n/a	n/a	n/a		
17			None	None	n/a	n/a	n/a	n/a	n/a		
18			None	None	n/a	n/a	n/a	n/a	n/a		
19			None	None	n/a	n/a	n/a	n/a	n/a		
20			None	None	n/a	n/a	n/a	n/a	n/a		

*Zero is at the Top of the Drilled Shaft, which is no higher than the surrounding finished grade.

LRFD Drilled Shaft Axial Analysis - Pier 3- 6' -dia updated loads 6-13-19.xlsx

Equations and Constants

Zone of Excluded Side Friction at top of Shaft:

Depth to Construction Joint/bottom of CMP	0	ft
Permanent Casing Length	0	ft
Depth of Exclusion Zone	5	ft
Maximum Side Resistance in Exclusion Zone	0	ksf

Factored Resistance

$R_R = \eta\varphi R_n = \eta\varphi_{qp}R_p+\eta\varphi_{qs}R_s$ Eq. 10.8.3.5-1

$\eta R_p = \eta q_p A_p$ Eq. 10.8.3.5-2

$\eta R_s = \eta q_s A_s$ Eq. 10.8.3.5-3

Constants

p_a = atmospheric pressure = 2.12 ksf

Unit Side Resistance

Cohesive Soil (clay)

$q_s = \alpha S_u$ Eq. 10.8.3.5.1b-1

$\alpha = 0.55$ for $S_u/p_a \le 1.5$ Eq. 10.8.3.5.1b-2

$\alpha = 0.55-0.1(S_u/p_a-1.5)$ for $1.5 \le S_u/p_a \le 2.5$ Eq. 10.8.3.5.1b-3

$\alpha = 0$ for top five feet from the ground surface

Cohesionless Soil (sand and gravel)

$q_s = \beta\sigma'_v$ Eq. 10.8.3.5.2b-1

$\beta = (1-\sin\phi'_f)(\sigma'_p/\sigma'_v)^{\sin\varphi'f}\tan\varphi'_f$ Eq. 10.8.3.5.2b-2

$\phi'_f = 27.5 + 9.2 \log[(N_1)_{60}]$ Eq. 10.8.3.5.2b-3

$\sigma'_p = p_a\ 0.47\ (N_{60})^m$ for sand Eq. 10.8.3.5.2b-4

$\sigma'_p = p_a\ 0.15\ (N_{60})$ for gravel Eq. 10.8.3.5.2b-5

Rock

$q_s = p_a C[\ \min(q_u,f'_c)\ /p_a]^{0.5}$ C = 1.0 Eq. 10.8.3.5.4b-1 not used

$q_s = p_a 0.65\alpha_E(q_u/p_a)^{0.5}$ Eq. 10.8.3.5.4b-2 used in calculations

α_E = joint modification factor

Unit Tip Resistance*

Cohesive Soil (clay)

$q_p = N_c S_u \le 80$ ksf Eq. 10.8.3.5.1c-1

$N_c = 6[1+0.2(Z/D)] \le 9$ Eq. 10.8.3.5.1c-2

Cohesionless Soil (sand and gravel)

$q_p = 1.2N_{60} \le 60$ ksf for $N_{60} \le 50$ Eq. 10.8.3.5.2c-1

Rock

$q_p = 2.5q_u$ Eq. 10.8.3.5.4c-1

LRFD Drilled Shaft Axial Analysis - Pier 3- 6' -dia updated loads 6-13-19.xlsx

Table 10.8.3.5.4b-1 Estimation of α_E

RQD (%)	α_E value	
	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

E_m/E_i is the ratio of rock mass modulus to intact rock modulus

← With no specific data on RQD, etc., assume worst case

*Unit tip resistance presented in the table below is the lesser of the unit tip resistance of the current layer or the average unit tip resistance for the layers in the range of 2 diameters below the tip of the shaft, to account for weaker layers within the zone of influence of the shaft tip.

from Table 10.5.5.2.4-1 Resistance Factors for Geotechnical Resistance of Drilled Shafts (abbreviated for ease of display and reduced by 20% for lack of redundancy)

	Resistance Factors for Shaft Side Resistance	Resistance Factors for Shaft Tip Resistance
Soil Type	φ_{qs}	φ_{qp}
Clay	0.56	0.56
IGM	0.56	0.56
Rock	0.56	0.56
Sand	0.56	0.56

$Q_{strength}$	1014	kips	= maximum factored strength limit vertical load
L_{min}	28	ft	=minimum required shaft length
R_R	1460	kips	= factored resistance for the strength limit state at L_{min}
	510	kips	= factored side resistance for the strength limit state at L_{min}
R_n	2607	kips	= nominal resistance at L_{min}

Group efficiency factor for firm, soft, and very soft clays

Linearly interpolated, based on Section 10.7.3.9 (AASHTO, 2014)

C-T-C	*η*
2.50	0.65
6.00	1.00

C-T-C 0.00 ⟶ η = 1.00

Group efficiency factor for sands

Linearly interpolated, based on Table 10.8.3.6.3-1 (AASHTO, 2014)

C-T-C	*η*
2.00	0.90
3.00	1.00

C-T-C	*η*
2.50	0.67
3.00	0.80
4.00	1.00

Single Row 1.00

C-T-C 0.00 ⟶ η = 1.00

Calculations for Factored Geotechncial Resistance of Drilled Shafts

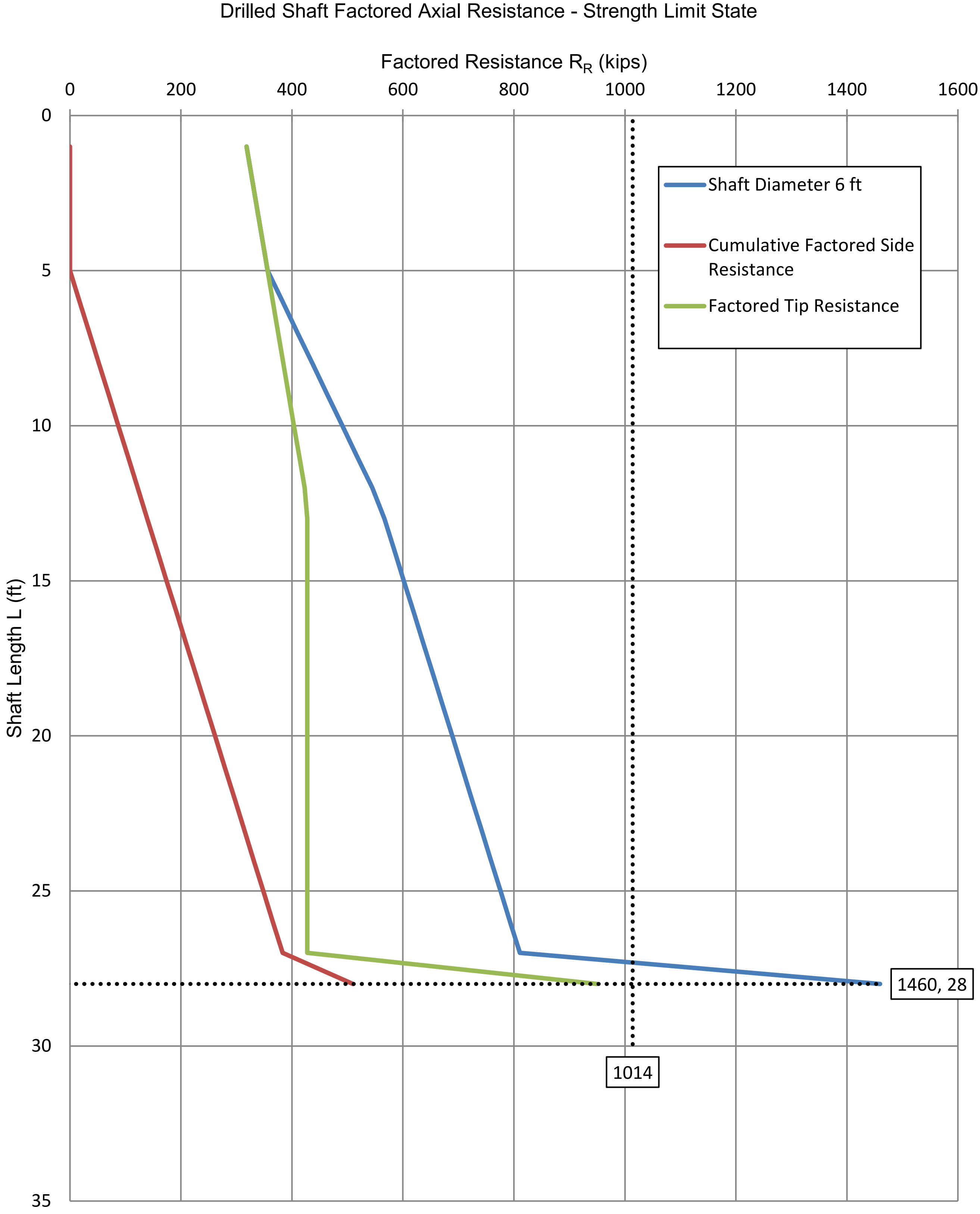
										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
1	1	Clay	0.410	0.0	0.0	0.0	20.1	568.2	568.2	1	568.2	0.56	0.56	0	318	318
2	1	Clay	0.510	0.0	0.0	0.0	20.7	585.2	585.2	1	585.2	0.56	0.56	0	328	328
3	1	Clay	0.610	0.0	0.0	0.0	21.3	602.2	602.2	1	602.2	0.56	0.56	0	337	337
4	1	Clay	0.710	0.0	0.0	0.0	21.9	619.1	619.1	1	619.1	0.56	0.56	0	347	347
5	1	Clay	0.810	0.0	0.0	0.0	22.5	636.1	636.1	1	636.1	0.56	0.56	0	356	356
6	1	Clay	0.910	1.7	31.1	31.1	23.1	653.0	684.1	1	684.1	0.56	0.56	17	366	383
7	1	Clay	1.010	1.7	31.1	62.2	23.7	670.0	732.2	1	732.2	0.56	0.56	35	375	410

LRFD Drilled Shaft Axial Analysis - Pier 3- 6' -dia updated loads 6-13-19.xlsx

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
8	1	Clay	1.110	1.7	31.1	93.3	24.3	687.0	780.3	1	780.3	0.56	0.56	52	385	437
9	1	Clay	1.210	1.7	31.1	124.4	24.9	703.9	828.3	1	828.3	0.56	0.56	70	394	464
10	1	Clay	1.310	1.7	31.1	155.5	25.5	720.9	876.4	1	876.4	0.56	0.56	87	404	491
11	1	Clay	1.410	1.7	31.1	186.6	26.1	737.8	924.5	1	924.5	0.56	0.56	105	413	518
12	1	Clay	1.510	1.7	31.1	217.7	26.7	754.8	972.5	1	972.5	0.56	0.56	122	423	545
13	1	Clay	1.610	1.7	31.1	248.8	27.0	763.3	1012.1	1	1012.1	0.56	0.56	139	427	567
14	1	Clay	1.710	1.7	31.1	279.9	27.0	763.3	1043.2	1	1043.2	0.56	0.56	157	427	584
15	1	Clay	1.810	1.7	31.1	311.0	27.0	763.3	1074.3	1	1074.3	0.56	0.56	174	427	602
16	1	Clay	1.910	1.7	31.1	342.1	27.0	763.3	1105.4	1	1105.4	0.56	0.56	192	427	619
17	1	Clay	2.010	1.7	31.1	373.2	27.0	763.3	1136.5	1	1136.5	0.56	0.56	209	427	636
18	1	Clay	2.110	1.7	31.1	404.3	27.0	763.3	1167.6	1	1167.6	0.56	0.56	226	427	654
19	1	Clay	2.210	1.7	31.1	435.4	27.0	763.3	1198.7	1	1198.7	0.56	0.56	244	427	671
20	1	Clay	2.310	1.7	31.1	466.5	27.0	763.3	1229.8	1	1229.8	0.56	0.56	261	427	689
21	1	Clay	2.410	1.7	31.1	497.6	27.0	763.3	1260.9	1	1260.9	0.56	0.56	279	427	706
22	1	Clay	2.510	1.7	31.1	528.7	27.0	763.3	1292.0	1	1292.0	0.56	0.56	296	427	724
23	1	Clay	2.610	1.7	31.1	559.8	27.0	763.3	1323.1	1	1323.1	0.56	0.56	314	427	741
24	1	Clay	2.710	1.7	31.1	590.9	27.0	763.3	1354.2	1	1354.2	0.56	0.56	331	427	758
25	1	Clay	2.810	1.7	31.1	622.1	27.0	763.3	1385.3	1	1385.3	0.56	0.56	348	427	776
26	1	Clay	2.910	1.7	31.1	653.2	27.0	763.3	1416.4	1	1416.4	0.56	0.56	366	427	793
27	1	Clay	3.010	1.7	31.1	684.3	27.0	763.3	1447.5	1	1447.5	0.56	0.56	383	427	811
28	2	Rock	3.130	12.0	226.2	910.5	60.0	1696.2	2606.7	1	2606.7	0.56	0.56	510	950	1460

LRFD Drilled Shaft Axial Analysis - Pier 3- 6' -dia updated loads 6-13-19.xlsx



Drilled Shaft Axial Resistance per AASHTO LRFD Bridge Design Specifications Section 10.8

Pier 4 - 6 ft diameter

Factored Vertical Loads provided by the Structural Engineer

$Q_{service}$ = 1085 kips = maximum factored service limit vertical load

$Q_{strength}$ = 1452 kips = maximum factored strength limit vertical load

input cells

☑ single shaft per pier ☑ Load Test Performed

☑ Cap firmly on at least firm/medium dense soil, no potential scour

Soil Model, based on: B-6

Notes:

Drilled Shaft Properties

Shaft Diameter 6.00 ft shaft diameter 72 inches

Ground Surface Elevation 2380.0 ft

Top of Shaft Elevation 2380.0 ft

Groundwater Elevation 2331.0 ft

Top of Native Elevation 2380.0 ft

A_p 28.27 ft^2 = area of shaft tip

A_s 18.85 ft^2/ft = area of shaft side surface per unit length

f'_c 4.50 ksi = concrete compressive strength

E_c 3860.8 ksi = concrete elastic modulus (Eq. C5.4.2.4-1)

D_0 0.0 ft = depth to top of shaft

γ_0 0.120 kcf = unit weight of soil above top of shaft

C-T-C 0.0 x Diameter = center to center spacing

Configuration Single Row

Soil Layer No.	Depth* to Top of Layer	Depth to Bottom of Layer	Soil Type	Soil Type per Table 10.5.5.2.4-1	Unit Weight, γ_t (kcf)	Undrained Shear Strength for Clay, S_u (ksf)	SPT Blow Count Adjusted for Hammer Effeciency, N_{60} (blows/foot)	Uniaxial Compressive Strength of Rock, q_u (ksf)	Estimated Young's Modulus from Table C10.4.6.3-1, E_s (ksi)	Elevation at Top of Layer	Elevation at Bottom of Layer
1	0	11	Sand	Sand	0.1150	n/a	40	n/a	10	2380	2369
2	11	30	Clay	Clay	0.1000	4	40	n/a	12	2369	2350
3	30	33	Caliche	Rock	0.1400	n/a	50	n/a	30	2350	2347
4	33	37	Clay	Clay	0.1100	4	50	n/a	10	2347	2343
5	37	38	Caliche	Rock	0.1400	n/a	50	n/a	30	2343	2342
6	38	41	Clay	Clay	0.1100	4.8	50	n/a	10	2342	2339
7	41	44	Caliche	Rock	0.1400	n/a	50	n/a	30	2339	2336
8	44	50	Gravel	Sand	0.0600	n/a	50	n/a	9	2336	2330
9	50	60	Caliche	Rock	0.0800	n/a	50	n/a	30	2330	2320
10			None	None	n/a	n/a	n/a	n/a	n/a		
11			None	None	n/a	n/a	n/a	n/a	n/a		
12			None	None	n/a	n/a	n/a	n/a	n/a		
13			None	None	n/a	n/a	n/a	n/a	n/a		
14			None	None	n/a	n/a	n/a	n/a	n/a		
15			None	None	n/a	n/a	n/a	n/a	n/a		
16			None	None	n/a	n/a	n/a	n/a	n/a		
17			None	None	n/a	n/a	n/a	n/a	n/a		
18			None	None	n/a	n/a	n/a	n/a	n/a		
19			None	None	n/a	n/a	n/a	n/a	n/a		
20			None	None	n/a	n/a	n/a	n/a	n/a		

*Zero is at the Top of the Drilled Shaft, which is no higher than the surrounding finished grade.

LRFD Drilled Shaft Axial Analysis - Pier 4- 6'-dia updated loads 6-13-19.xlsx

Equations and Constants

Zone of Excluded Side Friction at top of Shaft:

Depth to Construction Joint/bottom of CMP	0	ft
Permanent Casing Length	0	ft
Depth of Exclusion Zone	5	ft
Maximum Side Resistance in Exclusion Zone	0	ksf

Factored Resistance

$R_R = \eta\varphi R_n = \eta\varphi_{qp}R_p+\eta\varphi_{qs}R_s$ Eq. 10.8.3.5-1

$\eta R_p = \eta q_p A_p$ Eq. 10.8.3.5-2

$\eta R_s = \eta q_s A_s$ Eq. 10.8.3.5-3

Constants

p_a = atmospheric pressure = 2.12 ksf

Unit Side Resistance

Cohesive Soil (clay)

$q_s = \alpha S_u$ Eq. 10.8.3.5.1b-1

$\alpha = 0.55$ for $S_u/p_a \le 1.5$ Eq. 10.8.3.5.1b-2

$\alpha = 0.55\text{-}0.1(S_u/p_a\text{-}1.5)$ for $1.5 \le S_u/p_a \le 2.5$ Eq. 10.8.3.5.1b-3

$\alpha = 0$ for top five feet from the ground surface

Cohesionless Soil (sand and gravel)

$q_s = \beta\sigma'_v$ Eq. 10.8.3.5.2b-1

$\beta = (1\text{-}\sin\phi'_f)(\sigma'_p/\sigma'_v)^{\sin\varphi'f}\tan\varphi'_f$ Eq. 10.8.3.5.2b-2

$\phi'_f = 27.5 + 9.2 \log[\ (N_1)_{60}\ ]$ Eq. 10.8.3.5.2b-3

$\sigma'_p = p_a\ 0.47\ (N_{60})^m$ for sand Eq. 10.8.3.5.2b-4

$\sigma'_p = p_a\ 0.15\ (N_{60})$ for gravel Eq. 10.8.3.5.2b-5

Rock

$q_s = p_a C[\ \min(q_u,f'_c)\ /p_a]^{0.5}$ C = 1.0 Eq. 10.8.3.5.4b-1 not used

$q_s = p_a 0.65\alpha_E(q_u/p_a)^{0.5}$ Eq. 10.8.3.5.4b-2 used in calculations

α_E = joint modification factor

Unit Tip Resistance*

Cohesive Soil (clay)

$q_p = N_c S_u \le 80$ ksf Eq. 10.8.3.5.1c-1

$N_c = 6[1+0.2(Z/D)] \le 9$ Eq. 10.8.3.5.1c-2

Cohesionless Soil (sand and gravel)

$q_p = 1.2N_{60} \le 60$ ksf for $N_{60} \le 50$ Eq. 10.8.3.5.2c-1

Rock

$q_p = 2.5q_u$ Eq. 10.8.3.5.4c-1

LRFD Drilled Shaft Axial Analysis - Pier 4- 6'-dia updated loads 6-13-19.xlsx

Table 10.8.3.5.4b-1 Estimation of α_E

	α_E value	
RQD (%)	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

E_m/E_i is the ratio of rock mass modulus to intact rock modulus

← With no specific data on RQD, etc., assume worst case

*Unit tip resistance presented in the table below is the lesser of the unit tip resistance of the current layer or the average unit tip resistance for the layers in the range of 2 diameters below the tip of the shaft, to account for weaker layers within the zone of influence of the shaft tip.

from Table 10.5.5.2.4-1 Resistance Factors for Geotechnical Resistance of Drilled Shafts (abbreviated for ease of display and reduced by 20% for lack of redundancy)

	Resistance Factors for Shaft Side Resistance	Resistance Factors for Shaft Tip Resistance*
Soil Type	φ_{qs}	φ_{qp}
Clay	0.56	0.56
IGM	0.56	0.56
Rock	0.56	0.56
Sand	0.56	0.56

*Resistance Factors used for Shaft Tip Resistance do not consider load testing that was performed.

$Q_{strength}$	1452	kips	= maximum factored strength limit vertical load
L_{min}	35	ft	=minimum required shaft length
R_R	1468	kips	= factored resistance for the strength limit state at L_{min}
	898	kips	= factored side resistance for the strength limit state at L_{min}
R_n	2622	kips	= nominal resistance at L_{min}

Group efficiency factor for firm, soft, and very soft clays

Linearly interpolated, based on Section 10.7.3.9 (AASHTO, 2014)

C-T-C	η
2.50	0.65
6.00	1.00

C-T-C 0.00 ⟶ η = 1.00

Group efficiency factor for sands

Linearly interpolated, based on Table 10.8.3.6.3-1 (AASHTO, 2014)

C-T-C	η	C-T-C	η
2.00	0.90	2.50	0.67
3.00	1.00	3.00	0.80
		4.00	1.00

Single Row 1.00

C-T-C 0.00 ⟶ η = 1.00

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
1	1	Sand	0.058	0.0	0.0	0.0	48.0	1357.0	1357.0	1	1357.0	0.56	0.56	0	760	760
2	1	Sand	0.173	0.0	0.0	0.0	48.0	1357.0	1357.0	1	1357.0	0.56	0.56	0	760	760
3	1	Sand	0.288	0.0	0.0	0.0	46.4	1310.5	1310.5	1	1310.5	0.56	0.56	0	734	734
4	1	Sand	0.403	0.0	0.0	0.0	44.7	1264.0	1264.0	1	1264.0	0.56	0.56	0	708	708
5	1	Sand	0.518	0.0	0.0	0.0	43.1	1217.5	1217.5	1	1217.5	0.56	0.56	0	682	682
6	1	Sand	0.633	0.7	14.1	14.1	41.4	1171.0	1185.1	1	1185.1	0.56	0.56	8	656	664
7	1	Sand	0.748	0.9	16.3	30.4	39.8	1124.5	1154.9	1	1154.9	0.56	0.56	17	630	647

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Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
8	1	Sand	0.863	1.0	18.4	48.8	38.1	1078.0	1126.8	1	1126.8	0.56	0.56	27	604	631
9	1	Sand	0.978	1.1	20.4	69.2	36.5	1031.5	1100.7	1	1100.7	0.56	0.56	39	578	616
10	1	Sand	1.093	1.2	22.3	91.5	34.8	985.1	1076.5	1	1076.5	0.56	0.56	51	552	603
11	1	Sand	1.208	1.3	24.2	115.7	33.2	938.6	1054.2	1	1054.2	0.56	0.56	65	526	590
12	2	Clay	1.315	2.0	38.6	154.2	33.2	938.6	1092.8	1	1092.8	0.56	0.56	86	526	612
13	2	Clay	1.415	2.0	38.6	192.8	34.0	961.2	1154.0	1	1154.0	0.56	0.56	108	538	646
14	2	Clay	1.515	2.0	38.6	231.3	34.8	983.8	1215.1	1	1215.1	0.56	0.56	130	551	680
15	2	Clay	1.615	2.0	38.6	269.9	35.6	1006.4	1276.3	1	1276.3	0.56	0.56	151	564	715
16	2	Clay	1.715	2.0	38.6	308.4	36.0	1017.7	1326.2	1	1326.2	0.56	0.56	173	570	743
17	2	Clay	1.815	2.0	38.6	347.0	36.0	1017.7	1364.7	1	1364.7	0.56	0.56	194	570	764
18	2	Clay	1.915	2.0	38.6	385.5	36.0	1017.7	1403.3	1	1403.3	0.56	0.56	216	570	786
19	2	Clay	2.015	2.0	38.6	424.1	36.0	1017.7	1441.8	1	1441.8	0.56	0.56	237	570	807
20	2	Clay	2.115	2.0	38.6	462.6	36.0	1017.7	1480.4	1	1480.4	0.56	0.56	259	570	829
21	2	Clay	2.215	2.0	38.6	501.2	36.0	1017.7	1518.9	1	1518.9	0.56	0.56	281	570	851
22	2	Clay	2.315	2.0	38.6	539.8	36.0	1017.7	1557.5	1	1557.5	0.56	0.56	302	570	872
23	2	Clay	2.415	2.0	38.6	578.3	36.0	1017.7	1596.0	1	1596.0	0.56	0.56	324	570	894
24	2	Clay	2.515	2.0	38.6	616.9	36.0	1017.7	1634.6	1	1634.6	0.56	0.56	345	570	915
25	2	Clay	2.615	2.0	38.6	655.4	36.0	1017.7	1673.1	1	1673.1	0.56	0.56	367	570	937
26	2	Clay	2.715	2.0	38.6	694.0	36.0	1017.7	1711.7	1	1711.7	0.56	0.56	389	570	959
27	2	Clay	2.815	2.0	38.6	732.5	36.0	1017.7	1750.2	1	1750.2	0.56	0.56	410	570	980
28	2	Clay	2.915	2.0	38.6	771.1	36.0	1017.7	1788.8	1	1788.8	0.56	0.56	432	570	1002
29	2	Clay	3.015	2.0	38.6	809.6	36.0	1017.7	1827.3	1	1827.3	0.56	0.56	453	570	1023
30	2	Clay	3.115	2.0	38.6	848.2	36.0	1017.7	1865.9	1	1865.9	0.56	0.56	475	570	1045
31	3	Rock	3.235	12.0	226.2	1074.4	60.0	1696.2	2770.6	1	2770.6	0.56	0.56	602	950	1552
32	3	Rock	3.375	12.0	226.2	1300.6	60.0	1696.2	2996.8	1	2996.8	0.56	0.56	728	950	1678
33	3	Rock	3.515	12.0	226.2	1526.8	60.0	1696.2	3223.0	1	3223.0	0.56	0.56	855	950	1805
34	4	Clay	3.640	2.0	38.6	1565.3	36.0	1017.7	2583.1	1	2583.1	0.56	0.56	877	570	1447
35	4	Clay	3.750	2.0	38.6	1603.9	36.0	1017.7	2621.6	1	2621.6	0.56	0.56	898	570	1468

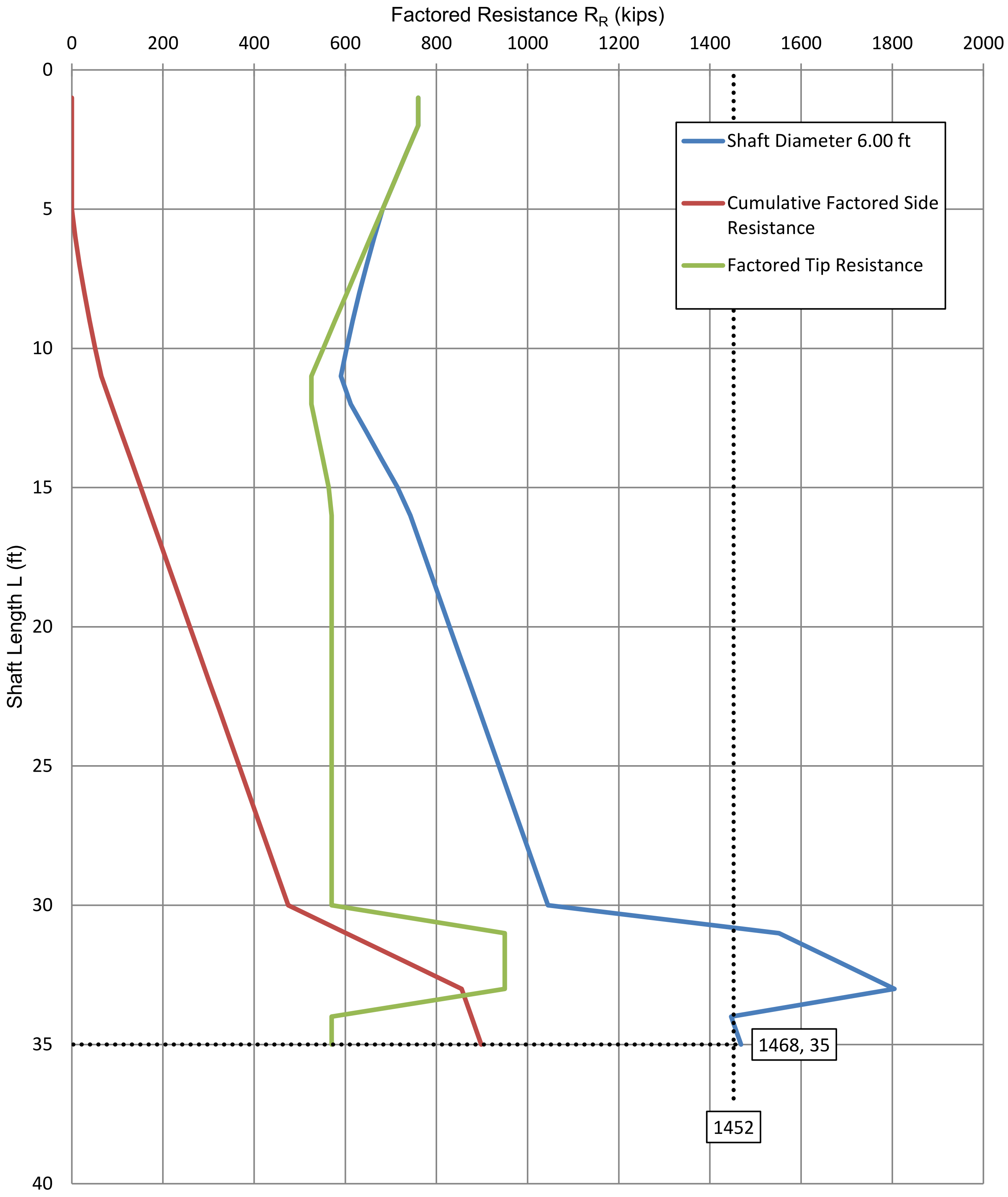
LRFD Drilled Shaft Axial Analysis - Pier 4- 6'-dia updated loads 6-13-19.xlsx

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
36	4	Clay	3.860											#N/A	#N/A	#N/A
37	4	Clay	3.970											#N/A	#N/A	#N/A
38	5	Rock	4.095											#N/A	#N/A	#N/A
39	6	Clay	4.220											#N/A	#N/A	#N/A
40	6	Clay	4.330											#N/A	#N/A	#N/A
41	6	Clay	4.440											#N/A	#N/A	#N/A
42	7	Rock	4.565											#N/A	#N/A	#N/A

LRFD Drilled Shaft Axial Analysis - Pier 4- 6'-dia updated loads 6-13-19.xlsx

Drilled Shaft Factored Axial Resistance - Strength Limit State



LRFD Drilled Shaft Axial Analysis - Pier 5- 6'-dia updated loads 6-13-19.xlsx

Drilled Shaft Axial Resistance per AASHTO LRFD Bridge Design Specifications Section 10.8

Pier 5 - 6 ft diameter

Factored Vertical Loads provided by the Structural Engineer

$Q_{service}$ = 430 kips = maximum factored service limit vertical load

$Q_{strength}$ = 568 kips = maximum factored strength limit vertical load

input cells

☑ single shaft per pier ☑ Load Test Performed

☑ Cap firmly on at least firm/medium dense soil, no potential scour

Soil Model, based on: B-7

Notes: Moderate Profile

Drilled Shaft Properties

Shaft Diameter	6.00	ft	
Ground Surface Elevation	2377.0	ft	
Top of Shaft Elevation	2377.0	ft	
Groundwater Elevation	2331.0	ft	
Top of Native Elevation	2377.0	ft	
A_p	28.27	ft^2	= area of shaft tip
A_s	18.85	ft^2/ft	= area of shaft side surface per unit length
f'_c	4.50	ksi	= concrete compressive strength
E_c	3860.8	ksi	= concrete elastic modulus (Eq. C5.4.2.4-1)
D_0	0.0	ft	= depth to top of shaft
γ_0	0.120	kcf	= unit weight of soil above top of shaft
C-T-C	0.0	x Diameter	= center to center spacing
Configuration	Single Row		

shaft diameter 72 inches

Soil Layer No.	Depth* to Top of Layer	Depth to Bottom of Layer	Soil Type	Soil Type per Table 10.5.5.2.4-1	Unit Weight, γ_t (kcf)	Undrained Shear Strength for Clay, S_u (ksf)	SPT Blow Count Adjusted for Hammer Effeciency, N_{60} (blows/foot)	Uniaxial Compressive Strength of Rock, q_u (ksf)	Estimated Young's Modulus from Table C10.4.6.3-1, E_s (ksi)	Elevation at Top of Layer	Elevation at Bottom of Layer
1	0	21	Clay	Clay	0.0960	3	34	n/a	10	2377	2356
2	21	28	Clay	Clay	0.1110	3.25	40	n/a	10	2356	2349
3	28	31	Sand	Sand	0.1170	n/a	50	n/a	10	2349	2346
4	31	35	Caliche	Rock	0.1400	n/a	50	n/a	30	2346	2342
5	35	40	Clay	Clay	0.1150	4	32	n/a	10	2342	2337
6	40	52	Caliche	Rock	0.1140	n/a	50	n/a	30	2337	2325
7	52	81	Clay	Clay	0.0600	3	25	n/a	8	2325	2296
8	81	91	Clay	Clay	0.0600	3	25	n/a	8	2296	2286
9			None	None	n/a	n/a	n/a	n/a	n/a		
10			None	None	n/a	n/a	n/a	n/a	n/a		
11			None	None	n/a	n/a	n/a	n/a	n/a		
12			None	None	n/a	n/a	n/a	n/a	n/a		
13			None	None	n/a	n/a	n/a	n/a	n/a		
14			None	None	n/a	n/a	n/a	n/a	n/a		
15			None	None	n/a	n/a	n/a	n/a	n/a		
16			None	None	n/a	n/a	n/a	n/a	n/a		
17			None	None	n/a	n/a	n/a	n/a	n/a		
18			None	None	n/a	n/a	n/a	n/a	n/a		
19			None	None	n/a	n/a	n/a	n/a	n/a		
20			None	None	n/a	n/a	n/a	n/a	n/a		

*Zero is at the Top of the Drilled Shaft, which is no higher than the surrounding finished grade.

Equations and Constants

Zone of Excluded Side Friction at top of Shaft:		
Depth to Construction Joint/bottom of CMP	0	ft
Permanent Casing Length	0	ft
Depth of Exclusion Zone	5	ft
Maximum Side Resistance in Exclusion Zone	0	ksf

Factored Resistance

$R_R = \eta\varphi R_n = \eta\varphi_{qp}R_p+\eta\varphi_{qs}R_s$ Eq. 10.8.3.5-1

$\eta R_p = \eta q_p A_p$ Eq. 10.8.3.5-2

$\eta R_s = \eta q_s A_s$ Eq. 10.8.3.5-3

Constants

p_a = atmospheric pressure = 2.12 ksf

Unit Side Resistance

Cohesive Soil (clay)

$q_s = \alpha S_u$ Eq. 10.8.3.5.1b-1

$\alpha = 0.55$ for $S_u/p_a \leq 1.5$ Eq. 10.8.3.5.1b-2

$\alpha = 0.55-0.1(S_u/p_a-1.5)$ for $1.5 \leq S_u/p_a \leq 2.5$ Eq. 10.8.3.5.1b-3

$\alpha = 0$ for top five feet from the ground surface

Cohesionless Soil (sand and gravel)

$q_s = \beta\sigma'_v$ Eq. 10.8.3.5.2b-1

$\beta = (1-\sin\phi'_f)(\sigma'_p/\sigma'_v)^{\sin\varphi'f}\tan\varphi'_f$ Eq. 10.8.3.5.2b-2

$\phi'_f = 27.5 + 9.2 \log[(N_1)_{60}]$ Eq. 10.8.3.5.2b-3

$\sigma'_p = p_a\ 0.47\ (N_{60})^m$ for sand Eq. 10.8.3.5.2b-4

$\sigma'_p = p_a\ 0.15\ (N_{60})$ for gravel Eq. 10.8.3.5.2b-5

Rock

$q_s = p_a C[\ \min(q_u,f'_c)\ /p_a]^{0.5}$ C = 1.0 Eq. 10.8.3.5.4b-1 not used

$q_s = p_a 0.65\alpha_E(q_u/p_a)^{0.5}$ Eq. 10.8.3.5.4b-2 used in calculations

α_E = joint modification factor

Unit Tip Resistance*

Cohesive Soil (clay)

$q_p = N_c S_u \leq 80$ ksf Eq. 10.8.3.5.1c-1

$N_c = 6[1+0.2(Z/D)] \leq 9$ Eq. 10.8.3.5.1c-2

Cohesionless Soil (sand and gravel)

$q_p = 1.2N_{60} \leq 60$ ksf for $N_{60} \leq 50$ Eq. 10.8.3.5.2c-1

Rock

$q_p = 2.5q_u$ Eq. 10.8.3.5.4c-1

LRFD Drilled Shaft Axial Analysis - Pier 5- 6'-dia updated loads 6-13-19.xlsx

Table 10.8.3.5.4b-1 Estimation of α_E

	α_E value	
RQD (%)	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

E_m/E_i is the ratio of rock mass modulus to intact rock modulus

← With no specific data on RQD, etc., assume worst case

*Unit tip resistance presented in the table below is the lesser of the unit tip resistance of the current layer or the average unit tip resistance for the layers in the range of 2 diameters below the tip of the shaft, to account for weaker layers within the zone of influence of the shaft tip.

from Table 10.5.5.2.4-1 Resistance Factors for Geotechnical Resistance of Drilled Shafts (abbreviated for ease of display and reduced by 20% for lack of redundancy)

	Resistance Factors for Shaft Side Resistance	Resistance Factors for Shaft Tip Resistance*
Soil Type	φ_{qs}	φ_{qp}
Clay	0.56	0.56
IGM	0.56	0.56
Rock	0.56	0.56
Sand	0.56	0.56

*Resistance Factors used for Shaft Tip Resistance do not consider load testing that was performed.

$Q_{strength}$ 568 kips = maximum factored strength limit vertical load

L_{min} 14 ft =minimum required shaft length

R_R 570 kips = factored resistance for the strength limit state at L_{min}

157 kips = factored side resistance for the strength limit state at L_{min}

R_n 1018 kips = nominal resistance at L_{min}

Group efficiency factor for firm, soft, and very soft clays

Linearly interpolated, based on Section 10.7.3.9 (AASHTO, 2014)

C-T-C	η
2.50	0.65
6.00	1.00

C-T-C 0.00 ⟶ η = 1.00

Group efficiency factor for sands

Linearly interpolated, based on Table 10.8.3.6.3-1 (AASHTO, 2014)

C-T-C	η
2.00	0.90
3.00	1.00

C-T-C	*η*
2.50	0.67
3.00	0.80
4.00	1.00

Single Row 1.00

C-T-C 0.00 ⟶ η = 1.00

Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
1	1	Clay	0.048	0.0	0.0	0.0	18.3	517.3	517.3	1	517.3	0.56	0.56	0	290	290
2	1	Clay	0.144	0.0	0.0	0.0	18.9	534.3	534.3	1	534.3	0.56	0.56	0	299	299
3	1	Clay	0.240	0.0	0.0	0.0	19.5	551.3	551.3	1	551.3	0.56	0.56	0	309	309
4	1	Clay	0.336	0.0	0.0	0.0	20.1	568.2	568.2	1	568.2	0.56	0.56	0	318	318
5	1	Clay	0.432	0.0	0.0	0.0	20.7	585.2	585.2	1	585.2	0.56	0.56	0	328	328
6	1	Clay	0.528	1.7	31.1	31.1	21.3	602.2	633.3	1	633.3	0.56	0.56	17	337	355
7	1	Clay	0.624	1.7	31.1	62.2	21.9	619.1	681.3	1	681.3	0.56	0.56	35	347	382

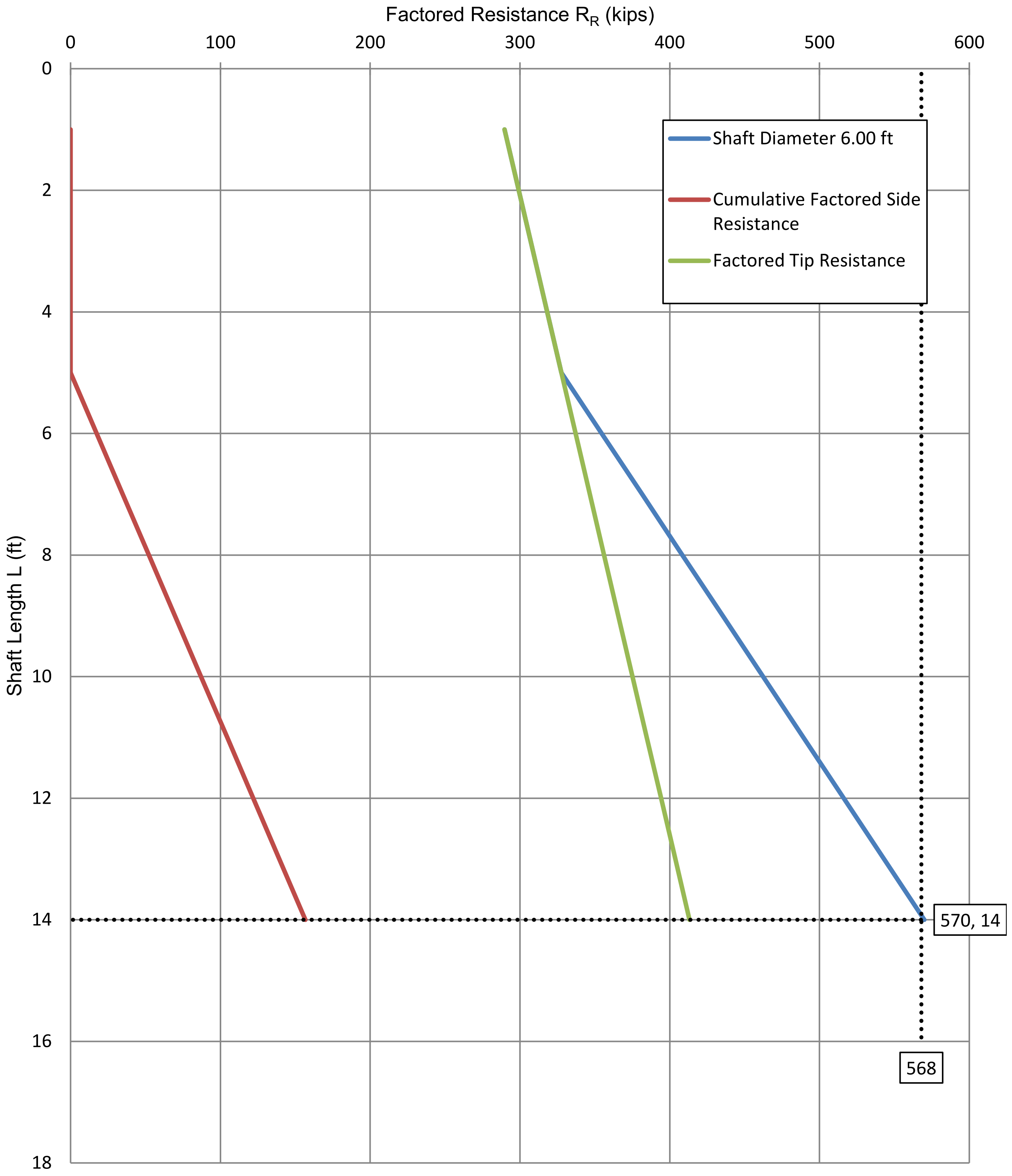
LRFD Drilled Shaft Axial Analysis - Pier 5- 6'-dia updated loads 6-13-19.xlsx

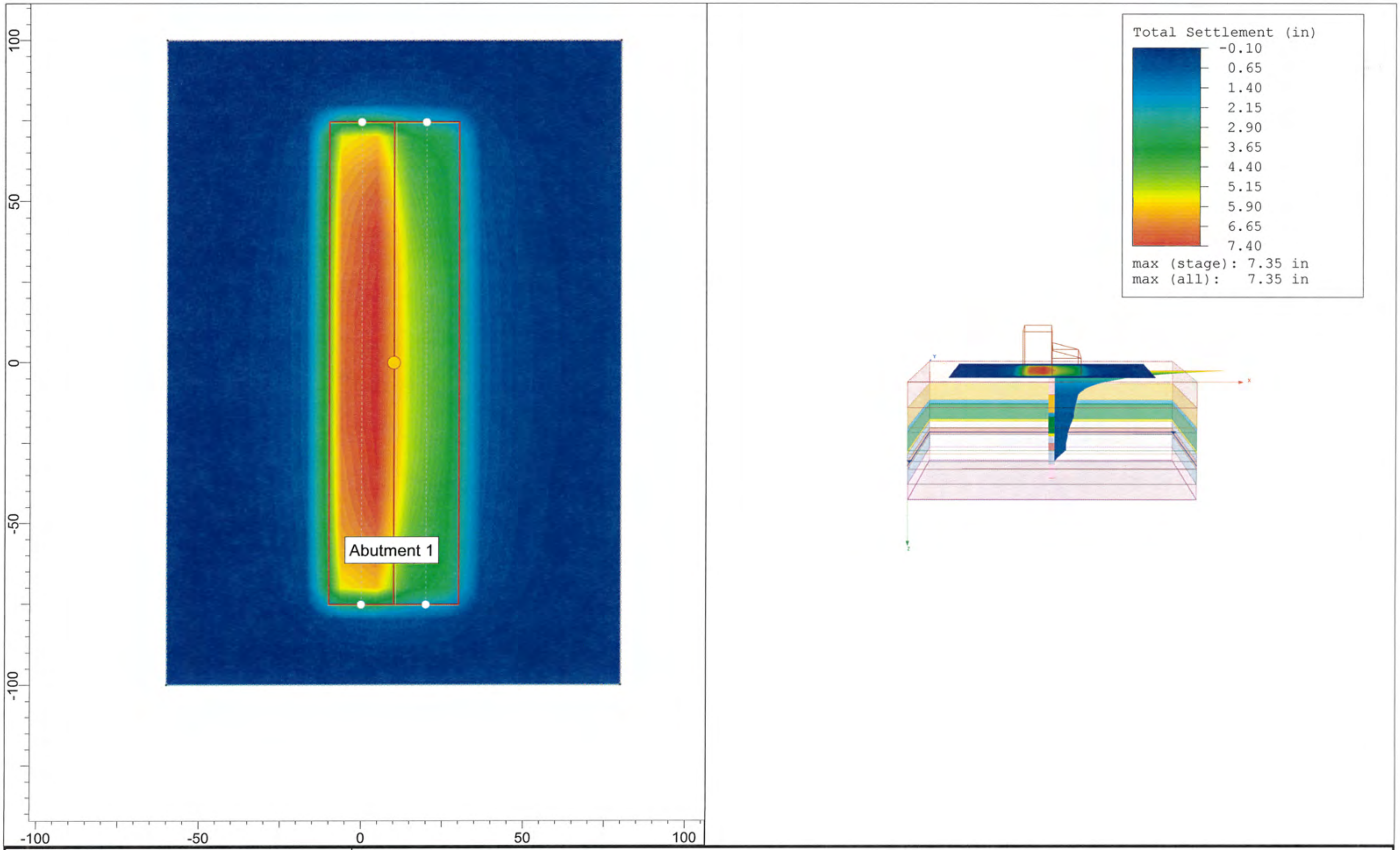
Calculations for Factored Geotechncial Resistance of Drilled Shafts

										Service Limit State		Strength Limit State				
Shaft Length	Soil Layer No.	Soil Type per Table 10.5.5.2.4-1	Total Vertical Effective Stress	Unit Side Resistance	Nominal Side Resistance per Unit Length	Cumulative Nominal Side Resistance	Unit Tip Resistance	Nominal Tip Resistance	Total Nominal Resistance	Resistance Factor for Shaft Side & Tip Resistance	Factored Resistance	Resistance Factor for Shaft Side Resistance	Resistance Factor for Shaft Tip Resistance	Cumulative Factored Side Resistance	Factored Tip Resistance	Factored Resistance
L			σ'_v	q_{si}	ηR_{si}	ηR_s	q_{pi}	ηR_p	ηR_n	φ	ηR_R	φ_{qs}	φ_{qp}	$\eta R_s \varphi_{qs}$	$\eta R_p \varphi_{qp}$	R_R
(ft)			(ksf)	(ksf)	(kips/ft)	(kips)	(ksf)	(kips)	(kips)		(kips)			(kips)	(kips)	(kips)
8	1	Clay	0.720	1.7	31.1	93.3	22.5	636.1	729.4	1	729.4	0.56	0.56	52	356	408
9	1	Clay	0.816	1.7	31.1	124.4	23.1	653.0	777.4	1	777.4	0.56	0.56	70	366	435
10	1	Clay	0.912	1.7	31.1	155.5	23.7	670.0	825.5	1	825.5	0.56	0.56	87	375	462
11	1	Clay	1.008	1.7	31.1	186.6	24.3	687.0	873.6	1	873.6	0.56	0.56	105	385	489
12	1	Clay	1.104	1.7	31.1	217.7	24.9	703.9	921.6	1	921.6	0.56	0.56	122	394	516
13	1	Clay	1.200	1.7	31.1	248.8	25.5	720.9	969.7	1	969.7	0.56	0.56	139	404	543
14	1	Clay	1.296	1.7	31.1	279.9	26.1	737.8	1017.8	1	1017.8	0.56	0.56	157	413	570
15	1	Clay	1.392											#N/A	#N/A	#N/A
16	1	Clay	1.488											#N/A	#N/A	#N/A
17	1	Clay	1.584											#N/A	#N/A	#N/A
18	1	Clay	1.680											#N/A	#N/A	#N/A
19	1	Clay	1.776											#N/A	#N/A	#N/A
20	1	Clay	1.872											#N/A	#N/A	#N/A
21	1	Clay	1.968											#N/A	#N/A	#N/A
22	2	Clay	2.072											#N/A	#N/A	#N/A
23	2	Clay	2.183											#N/A	#N/A	#N/A
24	2	Clay	2.294											#N/A	#N/A	#N/A
25	2	Clay	2.405											#N/A	#N/A	#N/A
26	2	Clay	2.516											#N/A	#N/A	#N/A
27	2	Clay	2.627											#N/A	#N/A	#N/A
28	2	Clay	2.738											#N/A	#N/A	#N/A
29	3	Sand	2.852											#N/A	#N/A	#N/A
30	3	Sand	2.969											#N/A	#N/A	#N/A
31	3	Sand	3.086											#N/A	#N/A	#N/A
32	4	Rock	3.214											#N/A	#N/A	#N/A

LRFD Drilled Shaft Axial Analysis - Pier 5- 6'-dia updated loads 6-13-19.xlsx

Drilled Shaft Factored Axial Resistance - Strength Limit State





Project	Sky Pointe Ped Bridge Abutment 1		
Analysis Description	Embankment Settlement		
Drawn By	DHT	Company	Geotechnical & Environmental Services, Inc.
Date	6/19/19, 10:50 AM	File Name	Abut 1 embankment 061919.s3z

SETTLE3D 3.017

Settle3D Analysis Information
Sky Pointe Ped Bridge Abutment 1

Project Settings

Document Name	Abut 1 embankment 061919.s3z
Project Title	Sky Pointe Ped Bridge Abutment 1
Analysis	Embankment Settlement
Author	DHT
Company	Geotechnical & Environmental Services, Inc.
Date Created	6/19/19, 10:50 AM
Stress Computation Method	Westergaard
Time-dependent Consolidation Analysis	
Time Units	days
Permeability Units	feet/year
Use settlement cutoff	
Load/Insitu vertical stress ratio	0.1
Use average properties to calculate layered stresses	

Stage Settings

Stage #	Name	Time [days]
1	Geostatic	0
2	Construct East and West Embankment	1
3	End of Emankment Construction	30
4	60 days after end of embankment construction	90
5	35 yrs after embankment construction	12805

Results

Time taken to compute: 2.43618 seconds

Stage: Geostatic = 0 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	0
Effective Stress [ksf]	0	8.3622
Total Stress [ksf]	0	9.735
Total Strain	0	0
Pore Water Pressure [ksf]	0	1.3728
Excess Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.0051	16.7105
Over-consolidation Ratio	1	2.5
Void Ratio	0	1.1
Permeability [ft/y]	0	19.2839
Coefficient of Consolidation [ft^2/y]	0	100
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	2.91189

Stage: Construct East and West Embankment = 1 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	6.83749
Consolidation Settlement [in]	0	6.68362
Immediate Settlement [in]	0	0.153868
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	4.40142
Effective Stress [ksf]	0	8.3622
Total Stress [ksf]	0	10.4026
Total Strain	0	0.217158
Pore Water Pressure [ksf]	0	2.0404
Excess Pore Water Pressure [ksf]	0	0.964206
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0051	16.7105
Over-consolidation Ratio	1	2.47277
Void Ratio	0	1.1
Permeability [ft/y]	0	95.7545
Coefficient of Consolidation [ft^2/y]	0	100
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	2.91189

Stage: End of Emankment Construction = 30 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.00021521	7.02953
Consolidation Settlement [in]	-0.00021521	6.87566
Immediate Settlement [in]	0	0.153868
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	4.40142
Effective Stress [ksf]	0	8.37958
Total Stress [ksf]	0	10.4026
Total Strain	-2.10202e-005	0.217158
Pore Water Pressure [ksf]	0	2.18331
Excess Pore Water Pressure [ksf]	0	0.810508
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0051	16.7105
Over-consolidation Ratio	1	2.47277
Void Ratio	0	1.10005
Permeability [ft/y]	0	95.7545
Coefficient of Consolidation [ft^2/y]	0	100
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	36.5212
Undrained Shear Strength	0	2.9131

Stage: 60 days after end of embankment construction = 90 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.0977
Consolidation Settlement [in]	0	6.94383
Immediate Settlement [in]	0	0.153868
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	4.40142
Effective Stress [ksf]	0	8.50935
Total Stress [ksf]	0	10.4026
Total Strain	0	0.217158
Pore Water Pressure [ksf]	0	2.07038
Excess Pore Water Pressure [ksf]	0	0.697577
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0051	16.7105
Over-consolidation Ratio	1	2.47277
Void Ratio	0	1.1
Permeability [ft/y]	0	95.7545
Coefficient of Consolidation [ft^2/y]	0	100
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	70.7251
Undrained Shear Strength	0	2.92206

Stage: 35 yrs after embankment construction = 12805 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.35394
Consolidation Settlement [in]	0	7.20007
Immediate Settlement [in]	0	0.153868
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	4.40142
Effective Stress [ksf]	0	9.0298
Total Stress [ksf]	0	10.4026
Total Strain	0	0.217158
Pore Water Pressure [ksf]	0	1.37284
Excess Pore Water Pressure [ksf]	-2.29677e-005	4.08396e-005
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0051	16.7105
Over-consolidation Ratio	1	2.47277
Void Ratio	0	1.1
Permeability [ft/y]	0	95.7545
Coefficient of Consolidation [ft^2/y]	0	100
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	2.95696

Embankments

1. Embankment

Center Line	(0, -75.19) to (0, 74.567)
Number of Layers	1
Near End Angle	90 degrees
Far End Angle	90 degrees
Base Width	20

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Construct East and West Embankment = 1 d	0	90	30	0.145	90	0

2. Embankment

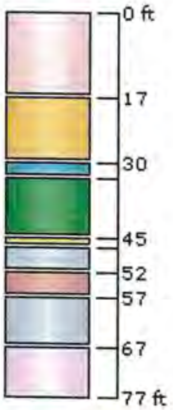
Center Line	(20, -75.19) to (20, 74.567)
Number of Layers	2
Near End Angle	90 degrees
Far End Angle	90 degrees
Base Width	20

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Construct East and West Embankment = 1 d	0	90	12	0.145	90	0
2	Construct East and West Embankment = 1 d	0	90	5	0.145	14.5	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Very stiff sandy lean clay -1	17	0	No
2	silty sand with gravel - 2	13	17	No
3	Caliche - 3	3	30	No
4	Sandy lean clay with gravel - 4	12	33	No
5	Caliche 5	2	45	No
6	very stiff sandy lean clay -6	5	47	No
7	Caliche 7	5	52	No
8	sandy lean clay -8	10	57	No
9	Caliche- 9	10	67	No



Soil Properties

Property	Sandy lean clay with gravel - 4	silty sand with gravel - 2	Very stiff sandy lean clay -1	Caliche - 3	Caliche 5	Caliche-9	sandy lean clay -8	Caliche 7	very stiff sandy lean clay -6
Color	🟩	🟧	⬜	🟦	🟨	⬜	⬜	🟥	⬜
Unit Weight [kips/ft^3]	0.12	0.13	0.12	0.132	0.132	0.132	0.12	0.132	0.125
Saturated Unit Weight [kips/ft^3]	0.13	0.135	0.13	0.132	0.132	0.132	0.13	0.132	0.13
Immediate Settlement	Disabled	Enabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Es [ksf]		2000							
Esur [ksf]		2000							
Primary Consolidation	Enabled	Disabled	Enabled	Disabled	Disabled	Disabled	Enabled	Disabled	Enabled
Material Type	Non-Linear		Non-Linear				Non-Linear		Non-Linear
Cce	0.072		0.072				0.09		0.072
Cre	0.0145		0.0145				0.0145		0.0145
OCR	2.5	2	2.5	1	2.5	2	1	1	2.5
Cv [ft^2/y]	100		100				100		100
B-bar	1		1				1		1
Undrained Su A [kips/ft2]	0	0	0	0	0	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1	1	1	1	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft^3

Piezometric Line Entities

ID	Depth (ft)
1	55 ft

Query Points

Point #	(X,Y) Location	Number of Divisions
1	10, 0	Auto: 89

Field Point Grid

Number of points	294
Expansion Factor	2

Grid Coordinates

X [ft]	Y [ft]
104.879	149.446
104.879	-150.069
-84.8785	-150.069
-84.8785	149.446

APPENDIX D

NDOT EXPLORATION LOGS

NEVADA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 1 OF 4

START DATE 6/17/13
END DATE 6/18/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-26
E.A. # 73518
GROUND ELEV. 2438.90 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
6/18/13	68.00	2370.9

STATION "X" 60+03
OFFSET 429' Left
ENGINEER Boomhower
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
									SANDY GRAVEL Dry, tan	
									1.00	
	2.50									
	4.00	A	SPT	5 8 14	22	85		ML	**SANDY SILT** Dry, medium dense, pale brown (10 YR 6/3)	
									4.50	
2433.9	5 5.00									
	5.60	B	SPT	35 20/0.1'	20/0.1'	100		SC	**CLAYEY SAND with GRAVEL** Dry, very dense, very pale brown (10 YR 7/3)	(B) Last 10 blows; no progress. Hard drilling @ 6.0'. Progress 0.1'/5 minutes. Broke through @ 6.3'.
	7.50 7.70	C	SPT	20/0.2'	20/0.2'	0				(C) Last 10 blows; no progress. No sample recovered.
2428.9	10 10.00									
	11.50	D	SPT	13 32 26	58	65			**CLAYEY SAND** Dry to moist, hard, light gray (10 YR 7/2)	
	12.50									
	14.00	E	SPT	12 11 11	22	55			**CLAYEY SAND** Dry to moist, very stiff, pinkish gray (7.5 YR 7/2) to brown (7.5 YR 4/4)	
									14.50	
2423.9	15 15.00									
	16.50	F	SPT	8 9 10	19	85		CL ML	**SANDY SILTY CLAY** Dry to moist, medium dense, light yellowish brown (10 YR 6/4)	
									17.00	
	17.50									
	19.00	G	CMS	12 10 11	21	95		SC	**CLAYEY SAND with GRAVEL** Dry to moist, medium dense, light yellowish brown (10 YR 6/4)	
									18.80	
2418.9	20 20.50	H	SPT	5 6 21	27	80		CL	**SANDY LEAN CLAY** Dry to moist, medium dense to hard, light gray (10 YR 7/2) to brown (10 YR 5/3)	(H) Lightly cemented from 20.4' - 20.5'.
									23.00	
2413.9	25 25.00							GC GM		
	26.50	I	CMS	14 22 30	52	95			**SILTY CLAYEY GRAVEL with SAND** Dry to moist, dense, light yellowish brown (10 YR 6/4) with multicolored gravel	
									26.50	
	28.00	J	SPT	9 7 11	18	75		GC	**CLAYEY GRAVEL with SAND** Dry to moist, dense, light yellowish brown (10 YR 6/4) with multicolored gravel	
									30.00	

NEVADA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 2 OF 4

START DATE 6/17/13
END DATE 6/18/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-26
E.A. # 73518
GROUND ELEV. 2438.90 (ft)
HAMMER DROP SYSTEM Automatic

STATION "X" 60+03
OFFSET 429' Left
ENGINEER Boomhower
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL

DATE	DEPTH ft	ELEV. ft
6/18/13	68.00	2370.9

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
								MH		
2403.9	35 35.00 36.50	K	CMS	11 12 11	23	45			**SANDY ELASTIC SILT with GRAVEL** Dry to moist, medium dense, pale brown (10 YR 6/3)	
	38.00	L	SPT	3 5 7	12	40		SM	36.50 **SILTY SAND with GRAVEL** Dry to moist, medium dense, pale brown (10 YR 6/3)	(L) Rock in sampler shoe. End day 1 drilling @ 38.0'.
2398.9	40									
									43.00	
2393.9	45 45.00 45.10	M	CMS	10/0.1'	10/0.1'	0				Hard drilling @ 44.0'. Progress 0.1'/5 minutes. (M) Last 10 blows; no progress. No sample recovered. Hard drilling from 45.0' - 48.0'. Progress 3.0'/30 minutes @ 250 psi down pressure.
2388.9	50 50.00 50.70	N	CMS	7 25/0.2'	25/0.2'	85		SC	**CLAYEY SAND** Dry to moist, very stiff to very hard, mottled brown (7.5 YR 5/3) to pink (7.5 YR 7/3)	(N) Last 10 blows; no progress. Hard drilling from 50.0' - 55.0'. Progress 5.0'/45 minutes @ 250 psi down pressure.
2383.9	55									Hard drilling from 55.0' - 59.0'. Progress 4.0'/15 minutes @ 250 psi down pressure.
									60.00	

NEVADA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 3 OF 4

START DATE 6/17/13
END DATE 6/18/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-26
E.A. # 73518
GROUND ELEV. 2438.90 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
6/18/13	68.00	2370.9

STATION "X" 60+03
OFFSET 429' Left
ENGINEER Boomhower
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
										Hard drilling from 60.0' - 62.0'. Progress 2.0'/20 minutes @ 250 psi down pressure.
2373.9	65 65.00 65.40	O	CMS	25/0.4'	25/0.4'	100		CL	**LEAN CLAY with SAND** Moist, stiff to very stiff, brown (7.5 YR 5/4)	(O) Last 10 blows; no progress.
	▽									
2368.9	70 70.00 71.50	P	CMS	7 9 10	19	95			**LEAN CLAY with SAND** Moist to wet, stiff, pale brown (10 YR 6/3) 71.50	(P) Free water on sampler @ 70.0'.
	73.00	Q	SPT	2 2 7	9	125		CH	**FAT CLAY** Moist to wet, stiff, pale brown (10 YR 6/3)	
2363.9	75 75.00 76.70	R	CMS	9 12 17	29	135			**FAT CLAY** Moist to wet, very stiff, brown (7.5 YR 5/4) 76.70	
	78.20	S	SPT	6 7 11	18	115		CL	**LEAN CLAY** Moist to wet, very stiff, brown (7.5 YR 5/4)	
2358.9	80									
2353.9	84.80 85 86.50	T	CMS	12 9 24	33	125			85.80	
								SC	86.50 **CLAYEY SAND** Moist to wet, very stiff, brown (7.5 YR 5/4)	
	88.00	U	SPT	14 14 22	36	80		GC	**CLAYEY GRAVEL with SAND** Moist to wet, hard, brown (7.5 YR 5/4)	
									90.00	

NEVADA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 4 OF 4

START DATE 6/17/13
END DATE 6/18/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-26
E.A. # 73518
GROUND ELEV. 2438.90 (ft)
HAMMER DROP SYSTEM Automatic

STATION "X" 60+03
OFFSET 429' Left
ENGINEER Boomhower
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
6/18/13	68.00	2370.9

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
2343.9	95 95.00 95.10	V	CMS	20/0.1'	20/0.1'	0			95.10 **END BI-26 @ 95.1'**	(V) Last 10 blows; no progress. No sample recovered.
2338.9	100									
2333.9	105									
2328.9	110									
2323.9	115									

NEVADA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 1 OF 5

START DATE 7/22/13
END DATE 7/23/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-31
E.A. # 73518
GROUND ELEV. 2431.50 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
7/23/13	65.00	2366.5

STATION "X" 59+50
OFFSET 219' Left
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	2.50								2.00	
	4.00	A	SPT	16 12 14	26	45		GC GM	**SILTY CLAYEY GRAVEL with SAND** Moist, dense, yellowish brown (10 YR 5/4) with dark gravel	(A) Sampler shoe blocked with rock.
2426.5	5 5.00								4.50	
	6.50	B	SPT	6 5 6	11	85		CL	**SANDY LEAN CLAY** Moist, stiff, very pale brown (10 YR 7/4)	
	7.50									
	9.00	C	SPT	10 11 15	26	95			**SANDY LEAN CLAY** Moist, very stiff, very pale brown (10 YR 7/4)	
2421.5	10 10.00								9.50	
	11.50	D	CMS	8 10 14	24	85		CL	**SANDY SILTY CLAY** Moist, stiff, light yellowish brown (10 YR 6/4) to white (10 YR 8/1)	
	13.00	E	SPT	6 7 8	15	85			**SANDY LEAN CLAY** Moist, stiff, light yellowish brown (10 YR 6/4) to white (10 YR 8/1)	
2416.5	15 15.00								14.00	
	16.50	F	CMS	8 17 22	39	85		GC	**CLAYEY GRAVEL with SAND** Moist, dense, multicolored, light yellowish brown (10 YR 6/4) to brownish yellow (10 YR 6/8) 16.50	
	18.00	G	SPT	9 11 14	25	75		SC	**CLAYEY SAND with GRAVEL** Moist, dense, multicolored, light yellowish brown (10 YR 6/4) to brownish yellow (10 YR 6/8)	
2411.5	20 20.00								19.00	
	21.50	H	CMS	5 11 14	25	85		GM	**SILTY GRAVEL with SAND** Moist, medium dense, multicolored, light yellowish brown (10 YR 6/4) to brownish yellow (10 YR 6/8)	
	23.00	I	SPT	12 17 14	31	65			**SILTY GRAVEL with SAND** Moist, dense, multicolored, light yellowish brown (10 YR 6/4) to brownish yellow (10 YR 6/8)	
2406.5	25 25.00								24.00	
	26.50	J	CMS	11 11 46	57	55		GC	**CLAYEY GRAVEL with SAND** Moist, dense, multicolored, light yellowish brown (10 YR 6/4) to brownish yellow (10 YR 6/8)	
	28.00	K	SPT	15 15 16	31	60			**CLAYEY GRAVEL** Moist, dense, multicolored, light yellowish brown (10 YR 6/4) to brownish yellow (10 YR 6/8)	
	30.00								30.00	

NEVADA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 2 OF 5

START DATE 7/22/13
END DATE 7/23/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-31
E.A. # 73518
GROUND ELEV. 2431.50 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
7/23/13	65.00	2366.5

STATION "X" 59+50
OFFSET 219' Left
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	31.50	L	CMS	4 17 22	39	95		CL	**GRAVELLY LEAN CLAY with SAND** Moist, very stiff, moist, reddish yellow (7.5 YR 6/6)	
	33.00	M	SPT	7 9 11	20	85			**LEAN CLAY with SAND** Moist, very stiff, reddish yellow (7.5 YR 6/6)	
									34.00	
2396.5	35 35.00									
	35.70	N	CMS	21	50/0.2'	100		SC	**CLAYEY SAND with GRAVEL** Moist, very dense, very pale brown (10 YR 8/2) to light yellowish brown (10 YR 6/4)	
	35.90	O	SPT	50/0.2'	50/0.2'	0				(O) 50 blows; no progress. No sample recovered.
									37.80	Moderately hard drilling, smooth penetration, weak to moderate cementation.
2391.5	40 40.00 40.10	P	SPT	10/0.1'	10/0.1'	0			**WEAKLY TO MODERATELY CEMENTED MATERIALS**	(P) 10 blows; no progress. No sample recovered.
									43.50	
2386.5	45 45.00							GM		
	46.40	Q	SPT	5 13 50/0.4'	50/0.4'	70			**SILTY GRAVEL with SAND** Moist, very dense, multicolored, light gray (5 YR 7/1) mottled with olive yellow (2.5 YR 6/8) 46.40	
									WEAKLY CEMENTED MATERIALS	
2381.5	50 50.00 50.10	R	SPT	20/0.1'	20/0.1'	0				(R) 22 blows; no progress. No sample recovered.
									STRONGLY CEMENTED MATERIALS	
2376.5	55									Hard drilling - .08 ft/min @ 300 psi down.
	60.00									

NEVADA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 3 OF 5

START DATE 7/22/13
END DATE 7/23/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-31
E.A. # 73518
GROUND ELEV. 2431.50 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
7/23/13	65.00	2366.5

STATION "X" 59+50
OFFSET 219' Left
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	61.50	S	SPT	13 20 40	60	115		CL ML	**SILTY CLAY with SAND** Moist, hard, pale brown (10 YR 6/3) to very pale brown (10 YR 8/2) 62.00	
									WEAKLY CEMENTED MATERIALS 63.00	
2366.5	▽ 65 65.00							CL		
	66.50	T	CMS	20 25 35	60	100			**LEAN CLAY with GRAVEL** Moist, hard, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) 66.50	(T) Free water on sampler @ 65.0'.
	68.00	U	SPT	18 12 16	28	95		CL ML	**SILTY CLAY** Moist, very stiff, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) 69.00	
2361.5	70 70.00							CL		
	71.50	V	CMS	7 9 15	24	100			70.80 **LEAN CLAY** Moist, stiff, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6)	
	73.00	W	SPT	6 7 10	17	115		CH	**FAT CLAY** Moist, very stiff, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) 74.00	
2356.5	75 75.00									
	76.50	X	CMS	10 11 15	26	95			**LEAN CLAY with SAND** Moist, very stiff, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6)	
	78.00	Y	SPT	4 7 13	20	125		CL	**LEAN CLAY with SAND** Moist, very stiff, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6)	
2351.5	80 80.00									
	81.50	Z	CMS	12 25 41	66	115			**GRAVELLY LEAN CLAY** Moist, hard, multicolored, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) with very pale brown (10 YR 8/2) 81.30	
	83.00	AA	SPT	34 48 42	90	95		GC	**CLAYEY GRAVEL with SAND** Moist, very dense, multicolored, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) with very pale brown (10 YR 8/2) 84.00	
2346.5	85 85.00									
	86.50	BB	CMS	11 18 37	55	115			**GRAVELLY LEAN CLAY** Moist, hard, multicolored, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) with very pale brown (10 YR 8/2)	
	88.00	CC	SPT	9 11 51	62	120		CL	**LEAN CLAY with SAND** Moist, very hard, multicolored, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) with very pale brown (10 YR 8/2)	
	90.00								90.00	

NEVADA DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 4 OF 5

START DATE 7/22/13
END DATE 7/23/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-31
E.A. # 73518
GROUND ELEV. 2431.50 (ft)
HAMMER DROP SYSTEM Automatic

STATION "X" 59+50
OFFSET 219' Left
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL

DATE	DEPTH ft	ELEV. ft
7/23/13	65.00	2366.5

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	91.50	DD	CMS	12 36 51	87	95		GC	**CLAYEY GRAVEL with SAND** Moist, very dense, multicolored, light brown (7.5 YR 6/4) to reddish yellow (7.5 YR 6/6) with very pale brown (10 YR 8/2)	
	92.00	EE	SPT	25 20/0.0'	20/0.0'	100			92.00	
									WEAKLY TO MODERATELY CEMENTED MATERIALS	
2336.5	95								95.00	
2331.5	100 100.00									
	101.50	FF	CMS	25 33 38	71	115			**SILTY CLAY** Moist, hard, light yellowish brown (10 YR 6/4)	
	103.00	GG	SPT	10 12 21	33	125			**SILTY CLAY with SAND** Moist, hard, light yellowish brown (10 YR 6/4)	
2326.5	105							CL ML		
2321.5	110 110.00									
	111.50	HH	CMS	20 35 46	81	85			**SILTY CLAY** Moist, hard, light yellowish brown (10 YR 6/4)	
	113.00	II	SPT	12 11 14	25	140			**SILTY CLAY** Moist, very stiff, light yellowish brown (10 YR 6/4)	
2316.5	115								115.00	
								CL		
	120.00								120.00	

NEVADA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 5 OF 5

START DATE 7/22/13
END DATE 7/23/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-31
E.A. # 73518
GROUND ELEV. 2431.50 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
7/23/13	65.00	2366.5

STATION "X" 59+50
OFFSET 219' Left
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	121.50	JJ	CMS	10 18 28	46	100		CL	**LEAN CLAY with SAND** Moist, very stiff, light yellowish brown (10 YR 6/4)	
	123.00	KK	SPT	7 5 13	18	125			**LEAN CLAY** Moist, very stiff, light yellowish brown (10 YR 6/4) 123.00	
									END BI-31 @ 123.0'	
2306.5	125									
2301.5	130									
2296.5	135									
2291.5	140									
2286.5	145									

NEVADA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 1 OF 2

START DATE 7/24/13
END DATE 7/25/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-32
E.A. # 73518
GROUND ELEV. 2439.40 (ft)
HAMMER DROP SYSTEM Automatic

STATION "X" 59+01
OFFSET 334' Left
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	2.50								2.00	
	4.00	A	SPT	19 22 21	43	80		SM	**SILTY SAND with GRAVEL** Moist, dense, very pale brown fines (10 YR 7/3) with dark gravel 4.50	
2434.4	5 5.00									
	6.00	B	SPT	21 50	50	90		SC	**CLAYEY SAND with GRAVEL** Moist, very dense, very pale brown fines (10 YR 7/3) with dark gravel. 7.00	
	7.50 7.70	C	SPT	20/0.2'	20/0.2'	0				(C) Last 10 blows; no progress. No sample recovered.
2429.4	10 10.00							GP GC		
	11.50	D	SPT	46 24 12	36	65			**POORLY GRADED GRAVEL with SILTY CLAY and SAND** Moist, dense, very pale brown (10 YR 7/3) to white fines (10 YR 8/1) 12.00	
	12.50								**SILTY SAND** Moist, dense, very pale brown (10 YR 7/4)	
	14.00	E	SPT	7 10 29	39	85				
2424.4	15 15.00							SM		
	16.50	F	CMS	11 21 31	52	100			**SILTY SAND** Moist, dense, very pale brown (10 YR 7/4) fines with dark gravel 17.00	
	18.00	G	SPT	9 10 8	18	85		CL ML	**SANDY SILTY CLAY** Moist, medium dense, light yellowish brown (10 YR 6/4) mottled light gray (10 YR 7/2) and very dark grayish brown (10 YR 3/2) 19.00	
2419.4	20 20.00							SM		
	21.50	H	CMS	21 26 22	48	95			**SILTY SAND with GRAVEL** Moist, dense, light yellowish brown (10 YR 6/4) mottled light gray (10 YR 7/2) with dark gravel 21.50	
	23.00	I	SPT	9 9 18	27	80		GC	**CLAYEY GRAVEL with SAND** Moist, dense, light yellowish brown (10 YR 6/4) mottled light gray (10 YR 7/2) with dark gravel 24.00	
2414.4	25 25.00									
	26.50	J	CMS	17 22 22	44	100		GC GM	**SILTY CLAYEY GRAVEL with SAND** Moist, dense, light yellowish brown (10 YR 6/4) mottled light gray (10 YR 7/2) with dark gravel	
	28.00	K	SPT	12 12 19	31	85			**SILTY CLAYEY GRAVEL with SAND** Moist, dense, light yellowish brown (10 YR 6/4), mottled light gray (10 YR 7/2) with dark gravel 29.00	
	30.00							GC	30.00	

NEVADA DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 2 OF 2

START DATE 7/24/13
END DATE 7/25/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-32
E.A. # 73518
GROUND ELEV. 2439.40 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft

STATION "X" 59+01
OFFSET 334' Left
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	31.50	L	CMS	12 23 23	46	85		GC	**CLAYEY GRAVEL with SAND** Moist, dense, light gray (10 YR 7/1) to very pale brown (10 YR 7/3) to white (10 YR 8/1) mottled with light reddish brown (5 YR 6/4) and light brownish gray (10 YR 6/2) 31.50	
	33.00	M	SPT	11 13 40	53	85		GM	**SILTY GRAVEL with SAND** Moist, very dense, light gray (10 YR 7/1) to very pale brown (10 YR 7/3) to white (10 YR 8/1) 34.00	
2404.4	35 35.00									
	36.50	N	CMS	16 16 23	39	65		GC	**CLAYEY GRAVEL with SAND** Moist, medium dense, light gray (10 YR 7/1) to very pale brown (10 YR 7/3) to white (10 YR 8/1) 36.50	
	38.00	O	SPT	17 25 28	53	60		GW	**WELL GRADED GRAVEL with SAND** Moist, dense, light gray (10 YR 7/1) to very pale brown (10 YR 7/3) to white (10 YR 8/1) 39.00	
2399.4	40 40.00									
	41.50	P	SPT	10 8 9	17	40		GC	**CLAYEY GRAVEL with SAND** Moist, medium dense, light gray (10 YR 7/1) to very pale brown (10 YR 7/3) to white (10 YR 8/1) 43.50	
2394.4	45 45.00 45.10	Q	SPT	10/0.1'	10/0.1'	0			**STRONGLY CEMENTED MATERIAL** 48.50	43.5' - 45.0' progress 0.08'/min. (Q) 10 blows; no progress. No sample recovered. 45.0' - 48.5' progress 0.16'/min.
2389.4	50 50.00 50.30	R	SPT	50/0.3'	50/0.3'	0			**WEAKLY CEMENTED MATERIAL OR GRAVELLY SOILS** 53.00	48.5' - 53.0' progress 1.5'/min. (R) No sample recovered.
2384.4	55								**STRONGLY CEMENTED MATERIAL** 59.00	53.0' - 59.0' progress 0.04' - 0.08' ft/min.
									END BI-32 @ 59.0'	No groundwater encountered.

NEVADA DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 1 OF 3

START DATE 8/6/13
END DATE 8/7/13
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-33
E.A. # 73518
GROUND ELEV. 2384.10 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft

STATION "X" 90+94
OFFSET 243' Left
ENGINEER Boomhower
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE		BLOW COUNT			LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
		NO.	TYPE	6 inch Increments	Last 1 foot	Percent Recov'd				
									GRAVELLY SAND Dry, tan	
									1.00	
2379.1	5 5.00 6.50	A	SPT	16 28 38	66	95		CL	**LEAN CLAY** Dry, very hard, light gray (10 YR 7/2)	
									8.20	
2374.1	10 10.00 11.50	B	SPT	17 24 31	55	85		SC SM	**SILTY CLAYEY SAND with GRAVEL** Dry, hard, light gray (10 YR 7/2)	
									13.20	
2369.1	15 15.00 16.50	C	SPT	8 7 9	16	80		CH	**FAT CLAY with SAND <U>>** Dry, very stiff, mottled white (5 Y 8/1) to light olive gray (5 Y 6/2)	
									18.20	
2364.1	20 20.00 21.50	D	CMS	11 13 13	26	95		CL	**LEAN CLAY with SAND** Dry, very stiff, mottled white (5 Y 8/1) to light olive gray (5 Y 6/2)	
									21.50	
	23.00	E	SPT	5 5 6	11	85		CH	**SANDY FAT CLAY** Dry to moist, stiff, light gray (5 Y 7/2)	
									24.00	
2359.1	25 25.00 26.50	F	CMS	3 5 13	18	95		CL	**LEAN CLAY with SAND** Dry to moist, stiff, light gray (5 Y 7/2)	
	28.10	G	SPT	7 4 1	5	55			**LEAN CLAY** Moist, medium stiff, white (5 Y 8/1)	(G) Last blow - sampler driven 0.6'.
	30.00								30.00	

NEVADA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 2 OF 2

START DATE 1/8/14
END DATE 1/8/14
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-43
E.A. # 73518
GROUND ELEV. 2425.00 (ft)
HAMMER DROP SYSTEM Automatic(ETR 74%)

GROUNDWATER LEVEL

DATE	DEPTH ft	ELEV. ft

STATION "XP" 203+64
OFFSET 304' Right
ENGINEER Lawrence
EQUIPMENT Diedrich D-120(#1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	31.50	H	SPT	11 10 15	25	75		GC	**CLAYEY GRAVEL with SAND** Moist to dry, hard, very pale brown (10 YR 7/3)	
	33.20									
2390.0	35 35.00 36.50	I	SPT	17 16 22	38	85		SC	**CLAYEY SAND with GRAVEL** Moist to dry, hard, very pale brown (10 YR 7/3 to 10 YR 8/2)	
	38.20									
2385.0	40 40.00 41.50	J	SPT	20 36 45	81	95		GC	**CLAYEY GRAVEL with SAND** Moist to dry, hard, very pale brown (10 YR 7/3 to 10 YR 8/2)	(J) Weakly cemented nodules in sample.
2380.0	45 45.00 46.50	K	SPT	7 11 19	30	75			**CLAYEY GRAVEL with SAND** Moist to dry, hard, very pale brown (10 YR 7/3 to 10 YR 8/2)	(K) Strongly cemented nodules in sample.
	47.30								**GRAVELLY WEAKLY CEMENTED MATERIALS, HARD DRILLING**	.1 ft/min 47.5' - 48.5' 300 psi down.
	48.50									
2375.0	50 50.00 50.10	L	SPT	50/0.1'	50/0.1'	0			**MODERATELY TO STRONGLY CEMENTED MATERIALS, HARD DRILLING**	(L) No sample recovered. .05 ft/min 50.0' - 51.5' 300 psi down.
	51.80								**END BI-43 @ 51.8'**	.01 ft/min 51.5' - 51.8' 300 psi down. No groundwater encountered.
2370.0	55									

NEVADA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING

EXPLORATION LOG

SHEET 1 OF 3

START DATE 1/8/14
END DATE 1/9/14
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-44
E.A. # 73518
GROUND ELEV. 2421.00 (ft)
HAMMER DROP SYSTEM Automatic

STATION "XP" 202+61
OFFSET 337' Right
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ______ DATE ______

GROUNDWATER LEVEL

DATE	DEPTH ft	ELEV. ft
1/9/14	60.50	2360.5

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	2.50 2.70	A	SPT	50/0.2'	50/0.2'	0				(A) No sample recovered.
2416.0	5 5.00 5.10	B	SPT	50/0.1'	50/0.1'	0				(B) No sample recovered.
	7.50 7.70	C	SPT	50/0.2'	50/0.2'	0				(C) No sample recovered.
2411.0	10 10.00 10.10	D	SPT	50/0.1'	50/0.1'	0				(D) No sample recovered.
									12.50	
2406.0	15 15.00 16.50	E	SPT	15 20 31	51	55			**CLAYEY GRAVEL with SAND** Dry to moist, very dense, very pale brown (10 YR 7/3)	
2401.0	20 20.00 21.50	F	SPT	24 24 21	45	80		GC	**CLAYEY GRAVEL with SAND** Dry to moist, dense, very pale brown (10 YR 7/3)	
2396.0	25 25.00 26.50	G	SPT	17 37 30	67	80			**CLAYEY GRAVEL with SAND** Dry to moist, very dense, very pale brown (10 YR 7/3)	(G) Weakly cemented nodules in sample.
	30.00								30.00	

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SHEET 2 OF 3

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LOCATION Northwest Las Vegas - Clark County
BORING BI-44
E.A. # 73518
GROUND ELEV. 2421.00 (ft)
HAMMER DROP SYSTEM Automatic

STATION "XP" 202+61
OFFSET 337' Right
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
1/9/14	60.50	2360.5

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	30.80	H	SPT	47 50/0.3'	50/0.3'	100		GC	CLAYEY GRAVEL with SAND Dry to moist, very dense, very pale brown (10 YR 7/3)	(H) Weakly cemented nodules in sample.
									33.00	
2386.0	35 35.00 36.50	I	SPT	13 12 21	33	95		CH	SANDY FAT CLAY with GRAVEL Dry to moist, hard, very pale brown (10 YR 7/3) to white (10 YR 8/1)	
									38.20	
2381.0	40 40.00 41.50	J	SPT	23 45 65	110	85		SC	CLAYEY SAND with GRAVEL Dry to moist, very dense, very pale brown (10 YR 7/2) and white (10 YR 8/1)	(J) Weakly cemented nodules in sample.
										End day 1 drilling @ 43'.
									45.00	
2376.0	45 45.00 45.10	K	SPT	50/0.1'	50/0.1'	0				(K) No sample recovered.
									WEAKLY TO STRONGLY CEMENTED MATERIALS	
										1.25 ft/min 400 psi down, 45' - 50'.
2371.0	50 50.00 50.10	L	SPT	50/0.1'	50/0.1'	0			WEAKLY TO MODERATELY CEMENTED MATERIALS	(L) No sample recovered.
										1.25 ft/min 400 psi down, 50' - 55'.
2366.0	55 55.00 55.10	M	SPT	50/0.1'	50/0.1'	0			WEAKLY TO MODERATELY CEMENTED MATERIALS	(M) No sample recovered.
										1.6 ft/min 400 psi down , 55' - 60'.
	60.00								60.00	

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SHEET 3 OF 3

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LOCATION Northwest Las Vegas - Clark County
BORING BI-44
E.A. # 73518
GROUND ELEV. 2421.00 (ft)
HAMMER DROP SYSTEM Automatic

STATION "XP" 202+61
OFFSET 337' Right
ENGINEER Lawrence
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft
1/9/14	60.50	2360.5

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
	∇ 60.50	N	SPT	50/0.5'	50/0.5'	100		CL ML	**SANDY SILTY CLAY** Moist to wet, very hard, very pale brown (10 YR 7/3) to white (10 YR 8/1)	(N) Free water on sampler.
									63.00	
2356.0	65 65.00 66.00	O	CMS	51 78	78	90		CL	**LEAN CLAY** Moist to wet, very hard, very pale brown (10 YR 7/3 to 10 YR 8/2)	
2351.0	70 70.00 71.50	P	CMS	27 44 46	90	55			**LEAN CLAY with SAND** Moist to wet, hard, very pale brown (10 YR 7/3 to 10 YR 8/2)	(P) Pocket penetrometer reading - 2.5, 3.5, 4.5 tsf.
									71.50 **END BI-44 @ 71.5'**	
2346.0	75									
2341.0	80									
2336.0	85									

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EXPLORATION LOG

SHEET 1 OF 2

START DATE 1/9/14
END DATE 1/9/14
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-45
E.A. # 73518
GROUND ELEV. 2423.00 (ft)
HAMMER DROP SYSTEM Automatic(ETR 74%)

STATION "XP" 204+54
OFFSET 307' Right
ENGINEER Lawrence
EQUIPMENT Diedrich
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL

DATE	DEPTH ft	ELEV. ft

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
									2.00	
	2.50 4.00	A	SPT	23 21 21	42	95		SC SM	**SILTY, CLAYEY SAND with GRAVEL** Dry to moist, dense, light yellowish brown (10 YR 6/4)	
									4.50	
2418.0	5 5.00 5.20	B	SPT	50/0.2'	50/0.2'	0				(B) No sample recovered.
	7.50 7.80	C	SPT	50/0.3'	50/0.3'	0				(C) No sample recovered.
									9.00	
2413.0	10 10.00 11.50	D	SPT	46 45 71	116	100			**CLAYEY GRAVEL with SAND** Dry to moist, very dense, very pale brown (10 YR 7/3)	(D) 0.4' @ 50 blows, 20 blows for final 0.1'.
2408.0	15 15.00 16.50	E	SPT	23 20 24	44	80			**CLAYEY GRAVEL with SAND** Dry to moist, dense, very pale brown (10 YR 7/3)	
								GC		
2403.0	20 20.00 21.50	F	SPT	30 28 43	71	85			**CLAYEY GRAVEL with SAND** Dry to moist, very dense,very pale brown (10 YR 7/3)	
2398.0	25 25.00 26.50	G	SPT	12 13 17	30	65			**CLAYEY GRAVEL with SAND** Dry to moist, dense, very pale brown (10 YR 7/3)	
									28.20	
	30.00							SC	30.00	

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SHEET 2 OF 2

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LOCATION Northwest Las Vegas - Clark County
BORING BI-45
E.A. # 73518
GROUND ELEV. 2423.00 (ft)
HAMMER DROP SYSTEM Automatic(ETR 74%)

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft

STATION "XP" 204+54
OFFSET 307' Right
ENGINEER Lawrence
EQUIPMENT Diedrich
OPERATOR Pypkowski
DRILLING METHOD 6" H.S.A
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE		BLOW COUNT			LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
		NO.	TYPE	6 inch Increments	Last 1 foot	Percent Recov'd				
	31.50	H	SPT	11 13 14	27	100		SC	**CLAYEY SAND with GRAVEL** Dry to moist, dense, very pale brown (10 YR 7/3 to 10 YR 8/2)	
2388.0	35 35.00 36.50	I	SPT	13 16 11	27	95			**CLAYEY SAND with GRAVEL** Dry to moist, dense, very pale brown (10 YR 7/3 to 10 YR 8/2)	
									38.20	
2383.0	40 40.00 41.50	J	CMS	23 25 38	63	85		GM	**SILTY GRAVEL with SAND** Dry to moist, dense, very pale brown (10 YR 7/3 to 10 YR 8/2)	
									43.20	
									Gravelly or weakly cemented materials	
2378.0	45 45.00 45.10	K	SPT	50/0.1'	50/0.1'	0			45.00 **STRONGLY CEMENTED MATERIALS HARD DRILLING** 45.80 **END BI-45 @ 45.8'**	(K) No sample recovered. 0.1 ft/min 300 psi down. No groundwater encountered.
2373.0	50									
2368.0	55									

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SHEET 1 OF 2

START DATE 10/25/16
END DATE 10/25/16
JOB DESCRIPTION US95 / CC-215 System-to-System Interchange
LOCATION Northwest Las Vegas - Clark County
BORING BI-82
E.A. # 73518
GROUND ELEV. 2442.70 (ft)
HAMMER DROP SYSTEM Automatic

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft

STATION "X" 57+95
OFFSET 183' Left
ENGINEER Boomhower
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Altamirano
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

ELEV. (ft)	DEPTH (ft)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT 6 inch Increments	BLOW COUNT Last 1 foot	Percent Recov'd	LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
									SANDY GRAVEL, Dry, tan	
									1.50	
2437.7	5									
	8.00 8.20	A	SPT	20/0.2'	20/0.2'	0				(A) Last 10 blows, no progress. No sample recovered.
2432.7	10									
	13.00 13.20	B	SPT	20/0.2'	20/0.2'	0				(B) Last 10 blows, no progress. No sample recovered.
									14.00	
2427.7	15									
	18.00 19.50	C	SPT	13 31 25	56	85		SC SM	SILTY CLAYEY SAND with GRAVEL Dry, very dense, very pale brown (10 YR 7/3)	
2422.7	20									
									21.20	
	23.00 24.50	D	CMS	19 29 48	77	100		SC	CLAYEY SAND with GRAVEL Dry, dense to very dense, pale brown (10 YR 6/3)	
2417.7	25 26.00	E	SPT	21 23 38	61	75			CLAYEY SAND with GRAVEL Dry, dense to very dense, pale brown (10 YR 6/3)	
									27.00	
	28.00 29.50	F	SPT	18 25 29	54	75		SC SM	SILTY CLAYEY SAND with GRAVEL Dry, dense to very dense, pale brown (10 YR 6/3)	
									30.00	

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SHEET 2 OF 2

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LOCATION Northwest Las Vegas - Clark County
BORING BI-82
E.A. # 73518
GROUND ELEV. 2442.70 (ft)
HAMMER DROP SYSTEM Automatic

STATION "X" 57+95
OFFSET 183' Left
ENGINEER Boomhower
EQUIPMENT Diedrich D-120 (Unit 1627)
OPERATOR Altamirano
DRILLING METHOD 6" H.S.A.
BACKFILLED ________ DATE ________

GROUNDWATER LEVEL		
DATE	DEPTH ft	ELEV. ft

ELEV. (ft)	DEPTH (ft)	SAMPLE		BLOW COUNT			LAB TESTS	USCS Group	MATERIAL DESCRIPTION	REMARKS
		NO.	TYPE	6 inch Increments	Last 1 foot	Percent Recov'd				
	33.00 34.50	G	SPT	38 45 49	94	65		SC SM	**CLAYEY SAND with GRAVEL** Dry, dense to very dense, pale brown (10 YR 6/3)	
2407.7	35								36.20	
	38.00 39.50	H	SPT	8 14 24	38	65		CH	**SANDY FAT CLAY** Dry to moist, hard, light yellowish brown (10 YR 6/4)	
2402.7	40								41.20	
	43.00 44.50	I	CMS	15 14 36	50	100		GM	**SILTY GRAVEL with SAND** Dry to moist, dense, light gray (10 YR 7/2) to light brown (7.5 YR 6/3)	
2397.7	45								46.50 **END BI-82 @ 46.5'**	Hard drilling from 44.5' to 46.0'. Progress 1.5'/25 minutes @ 400 psi down pressure.
2392.7	50									
2387.7	55									