Geotechnical Engineering Report

Ellicott Highway Bridge Replacement Project
North of State Highway 94 over Black Squirrel Creek
El Paso County, Colorado

October 14, 2021(Revised May 17, 2022)
Terracon Project No. 23205146

Prepared for:

Alfred Benesch and Company Inc
Denver, Colorado

Prepared by:

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October 14, 2021(Revised May 17, 2022)

Alfred Benesch and Company Inc
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Attn: Mr. Daniel Bechtold
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Re: Geotechnical Engineering Report
Ellicott Highway Bridge Replacement Project
North of State Highway 94 over Black Squirrel Creek
El Paso County, Colorado
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Mr. Bechtold:

We have completed the Geotechnical Engineering services for the project referenced above. This study was performed in general accordance with Terracon Proposal No. P23205146 dated January 13, 2021, and the Supplement to Agreement for Services dated May 13, 2022. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the bridge and pavements for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

COLORADO LICENSED PROFESSIONAL ENGINEER
SCOTT B. MYERS
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5/18/2022

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REPORT TOPICS

Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

FIGURES

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed bridge structure and adjacent pavements to be located at north of State Highway 94 over Black Squirrel Creek in El Paso County, Colorado. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Seismic site classification per AASHTO
- Lateral earth pressures
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of five test borings (Boring Nos. B-1 to B-5) to depths of about 5 to 55-1/2 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and as separate graphs in the **Exploration Results** section.

This report was revised on May 17, 2022 to incorporate the current Pikes Peak Regional Asphalt Paving Specifications, dated April 28, 2022 and the Engineering Criteria Manual (ECM) County of El Paso, Colorado revised October 14, 2020.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located approximately 1.8 miles north of the intersection of State Highway 94 and Ellicott Highway in the vicinity of Black Squirrel Creek in El Paso County, Colorado. Approximate Latitude/Longitude: 38.8627° N 104.3874° W See **Site Location**
Existing Improvements	The site is currently developed with a 3-span, approximate 145-foot precast, pre-stressed double tee bridge that was built in 1965. Pavements leading to the bridge consist of flexible asphalt concrete pavements.
Current Ground Cover	Asphalt concrete within the roadway limits and earthen, moderately to well vegetated shoulders.
Existing Topography	Black Squirrel Creek is about 6 to 8 feet below the surface of the existing bridge. The approaches to the bridge vary in slope from about 0.44 to 1.2 percent.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	Our understanding of the project comes from: ■ El Paso County Request for Quote (RFQ #17-067-63) dated December 7, 2020 ■ Kickoff meeting on February 10, 2021 ■ Client provided General Layout dated September 20, 2021 ■ Client provided Proposed Boring Plan dated March 18, 2021 ■ Client provided undated Roadway Profile
Project Description	We understand the existing bridge structure will be removed and replaced with a three-span bridge structure. The existing roadway horizontal alignment is expected to remain the same, but the vertical profile of the approaches may require some modification. Minor grading of the channel may be performed but will be minimized as much as possible.
Finished Grades	Reported to be within 3 to 4 feet of existing grade at the bridge abutments.
Grading/Slopes	Up to 4 feet fill is assumed to be required to develop final grades. Slopes as steep as 2H:1V (Horizontal: Vertical) but no higher than 8 feet are being considered along the stream embankment. Stability analysis of the final stream embankment configurations has not been requested as part of our scope of services

Item	Description
Below-Grade Structures	None reported as part of site development.
Free-Standing Retaining Walls	We anticipate the design may include wingwalls at the bridge abutments. Terracon has not been requested to provide design of retaining walls at this site.
Pavements	We understand that approaches will be designed as rural major collectors based on the Engineering Criteria Manual (ECM) County of El Paso, Colorado revised October 14, 2020.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Asphalt**	Asphalt; about 5 inches
2	**Fill**	Existing fill materials consisting of sand with varying amounts of clay; various densities
3	**Native Sand**	Native sand soils with varying amounts of silt and clay; loose to very dense
4	**Native Clay**	Native lean clay soil with varying amounts of sand; medium stiff to very stiff

As noted in the **General Comments**, the characterization is based upon widely spaced borings at the site, and variations are likely. Stratification boundaries on the boring logs represent the approximate location of changes in soil and material types; in situ, the transition between materials may be gradual.

Groundwater Conditions

Groundwater was encountered at a depth of 50 feet in Boring No. B-2. Groundwater was not encountered in the remaining borings at the time of our field exploration to the maximum depths explored of 55-1/2 feet for the bridge borings and 5 feet for the pavement thickness borings.

Groundwater was also not measured in Boring No. B-3 during a delayed groundwater measurement taken 24 hours after drilling. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the boring was performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Zones of perched and/or trapped groundwater may also occur at times in the subsurface soils overlying clay soils. The location and amount of perched water is dependent upon several factors, including hydrologic conditions, type of site development, irrigation demands on or adjacent to the site, seasonal fluctuations, and weather conditions.

Laboratory Testing

Laboratory test results indicate that the sand soils are non-expansive. The results of laboratory testing completed for this project can be found in the **Exploration Results** section of this report.

GEOTECHNICAL OVERVIEW

Based on the results of our field investigation, laboratory testing program and geotechnical analyses, development of the site is considered feasible from a geotechnical viewpoint provided that the conclusions and considerations provided herein are incorporated into the design and construction of the project.

We have identified the following geotechnical conditions that could impact design and construction of the proposed project.

Existing Fill Materials

About 6 to 8-1/2 feet of existing fill materials were encountered in Borings B-1 and B-3 for the bridge abutments. The fill depths presented in the boring logs are approximate and the total depth, lateral extent, and composition of fill materials present on the site may not become evident until construction and should be expected to vary across the site.

We do not possess any information regarding whether the fill encountered was placed under the observation of a geotechnical engineer. However, based on the age of the existing bridge, it is our opinion the presence of the existing fill along the approached to the bridge will not significantly impact the performance of the new bridge foundations or pavements. To improve performance of new pavements on the existing fill, we recommend a portion of the fill materials be scarified, moisture conditioned and compacted prior to pavement construction.

Although there exists the potential for construction debris and/or domestic trash to be encountered within the fill on some portions of the site, it is our opinion the potential for encountering construction debris and domestic trash is considered to be low. The fill materials should be observed for the presence of trash and debris during site grading and construction.

The existing fill materials are considered suitable for reuse as fill below pavements provided any deleterious materials are removed. Some additional removal and replacement may be required if unsuitable or loose materials are exposed.

Existing Structures

We understand that the new bridge will be constructed in roughly the same footprint as the existing bridge after it is demolished. We recommend that all existing bridge foundations be completely removed and backfilled with new engineered as recommended in the **Earthwork** section of this report. The demolition contractor should be aware of project requirements for complete removal of existing features, observation and testing of the base of demolition excavations prior to backfilling, use of appropriate backfill materials, and proper placement, compaction, and testing of backfill materials so that removal of the demolition contractor's backfill materials and replacement under controlled conditions is not necessary when new construction commences.

EARTHWORK

The following presents recommendations for site preparation, excavation, subgrade preparation, and placement of engineered fills on the project. All earthwork on the project should be observed and evaluated by Terracon.

Site Preparation

Strip and remove existing pavements, approach slabs, vegetation, organics, and other deleterious materials from proposed structure and pavement areas. All exposed surfaces should be free of mounds and depressions that could prevent uniform compaction.

Stripped materials consisting of vegetation, unsuitable fills, and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations.

Where possible, the site should be initially graded to create a relatively level surface to receive fill and to provide for a relatively uniform thickness of fill beneath the proposed structures and improvement areas. All exposed areas that will receive fill, once properly cleared, should be scarified to a minimum depth of 12 inches, conditioned to near optimum moisture content, and compacted. It is imperative the moisture content of prepared materials be protected from moisture loss.

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment.

Depending upon seasonal conditions, surface water may infiltrate into the excavations on the site. Water seeping into excavations at this site could most likely be controlled by shallow trenches leading to a sump pit where the water could be removed by pumping.

The stability of subgrade soils may be affected by precipitation, repetitive construction traffic, or other factors. If unstable conditions are encountered or develop during construction, workability may be improved by overexcavation of wet zones and mixing these soils with crushed gravel. Use of geotextiles could also be considered as a stabilization technique. Lightweight excavation equipment may be required to reduce subgrade pumping.

While not anticipated, if new fill is placed along the stream embankment on existing slopes steeper than 4H:1V (Horizontal to Vertical), the embankment should be continuously benched in general accordance with the Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction. A 2-foot deep key should be excavated at the base of the existing slope and backfilled with approved and compacted material. In general, benches should have a minimum vertical face height of about 2 feet and a maximum vertical face height of 5 feet and should be cut wide enough to accommodate compaction equipment. Benches should be sloped at about 2 percent toward the slope face.

Material Types

Fill for this project should consist of engineered fill. Engineered fill is fill that meets the criteria presented in this report and has been properly documented.

Engineered fill should meet the following material property requirements:

Fill Type [1,2]	USCS and AASHTO Classification	Acceptable Location for Placement
On-site sand soils	SM, SC, SP, SW-SM A-1 through A-5	On-site sand soils are considered suitable for reuse as compacted fill below pavement areas, embankments, and as general fill for this project.
CDOT Class 1	Varies	CDOT Class 1 structure backfill is considered suitable for use as engineered fill below the proposed bridge abutments and for embankment construction.

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. Care should be taken during the fill placement process to avoid zones of dis-similar fill. Improvements constructed over varying fill types are at a higher risk of differential movement compared to improvements over a uniform fill zone.

Imported soils for engineered fill (if required) should consist of granular materials meeting the specifications for CDOT Class I structure backfill, as outlined below:

Gradation	Percent Finer by Weight (AASHTO T 27)
2”	100
No. 4 Sieve	30-100
No. 50 Sieve	10-60
No. 200 Sieve	5-20

- Liquid Limit .... 35 (max)
- Plasticity Index .... 6 (max)

Compaction Requirements

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift.

Item	Description
Fill Lift Thickness	6 inches or less in loose thickness when heavy, self-propelled compaction equipment is used. 8 inches or less in loose thickness may be used when the contractor is able to achieve the required density within 24 inches of the structure per CDOT 2019 Standard Specifications for Road and Bridge Construction (CDOT Specifications) Section 206.03.
Compaction Requirements [1,2]	Minimum of 95% of the material’s modified Proctor maximum dry density (AASHTO T180) for Class 1 structure backfill per CDOT Specifications Section 206.03.
Moisture Content of Cohesionless Soils (Sand Soils)	-2 to +2% of the optimum moisture content

1. We recommend that engineered fill be tested for water content and compaction during placement. Should the results of the in-place density tests indicate the specified water or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified water and compaction requirements are achieved.
2. Water levels should be maintained low enough to allow for satisfactory compaction to be achieved without the compacted fill material pumping when proofrolled.

Slopes

For new slopes in compacted fill or cut areas where saturation of the slopes will not occur, we suggest slopes of 3H:1V or flatter to reduce erosion and maintenance problems. Some local raveling and/or surface sloughing should be anticipated on slopes constructed at this angle until vegetation is reestablished. If saturated or steeper slopes and/or slopes over about 10 feet in height are anticipated, or if structures or other surcharge loads will be located within a distance of the slope height from the crest of the slope, the slopes should be evaluated for stability on an individual basis.

The face of all slopes should be compacted to the minimum specification for fill embankments. Alternatively, fill slopes can be over-built and trimmed to compacted soil. Slopes should be revegetated as soon as possible to reduce the potential for erosion problems. Seeded slopes should be protected with erosion mats until the vegetation is established. Surface drainage should be designed to direct water away from slope faces and to prevent ponding adjacent to the crest or toe of the slope.

Excavation

Excavations into the subsurface soils will encounter a variety of conditions. The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards.

Soils penetrated by the proposed excavations may vary significantly across the site. The soil classifications are based solely on the materials encountered in the exploratory borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Grading and Drainage

All grades must be adjusted to provide positive drainage away from the structure during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. After construction and prior to project completion, we recommend that verification of final grading be performed to document that positive drainage has been achieved.

Earthwork Construction Considerations

Upon completion of grading operations, care should be taken to maintain the moisture content of the subgrade prior to construction of pavements. Construction traffic over prepared subgrades should be minimized and avoided to the extent practical.

The site should also be graded to prevent ponding of surface water on prepared subgrade or in excavations. In areas where water is allowed to pond over a period of time, the affected area should be removed and allowed to dry out. If constraints do not allow for moisture conditioning of affected soils as recommended in this report, the affected area should be overexcavated and replaced with engineered fill. As an alternative, geotextiles could also be considered as a stabilization technique.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during excavations, subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; and backfilling of excavations into the completed subgrade.

DRIVEN PILE FOUNDATION RECOMMENDATIONS

We understand that driven piles are being considered to support the proposed replacement bridge. Our design values were developed based on the recommendations presented in the American Association of State Highway Transportation Officials (AASHTO) LRFD Bridge Design Specifications (9th Edition, 2020).

We understand HP12x53 and HP12x74 piles are being considered for the proposed bridge foundation elements. We should be contacted to provide additional recommendations if different pile sizes are considered.

Driven Pile Axial Compression Resistance

Nominal axial compression resistance verses depth for single piles are presented in the **Nominal Pile Axial Compression Plots** section of this report. Variable subsurface soil conditions were encountered, and variation in the pile lengths should be anticipated. It has been our experience that non-displacement piles, such as “H” sections, sometimes “run” or require greater length to confirm design capacity than initially predicted on the basis of static analyses.

The geotechnical resistance should be confirmed by dynamic testing, meaning the nominal geotechnical resistance indicated by the dynamic testing multiplied by the resistance factor should be greater than or equal to the factored structural axial load of the pile. Based on Table 10.5.5.2.3-1 of AASHTO, if dynamic tests with signal matching are performed on at least two piles per site condition, but on no less than two percent of the production piles, a resistance factor of 0.65 can be used for designing piles for the strength limit state. We recommend dynamic testing with CAPWAP analysis be performed on at least one test pile at each abutment and bent, so that the resistance factor of 0.65 can be used in relation to the estimated capacity developed for that soil profile.

As indicated in Section 10.5.5.3 of AASHTO, resistance factors for extreme limit state, including the design of foundations to resist earthquake loads, shall be taken as 1.0, except when considering uplift (when applicable).

We estimate settlements to be on the order of 1 inch or less for properly installed piles, not including elastic compression of the pile under service conditions. Differential settlement across the bridge should be expected to be on the order of about ½ inch or less. The majority of the settlement is anticipated to occur as the load is being applied with the remaining settlement occurring within the first year of construction.

Downdrag

Settlement resulting from existing fills or the placement of new fill may induce a downdrag load on the piles at the abutments. However, based on the age of the existing bridge we anticipate existing fills have been in place for a period of at least 20 years. Based on the length of time the existing fill has been in place, it is our opinion downdrag as a result of the existing fill will not significantly impact the capacity of the new piles. In addition, because 4 feet or less of new fill is being placed for the new abutments, it is our opinion the new fill will also not significantly impact the capacity of the new piles.

Driven Pile Lateral Resistance

To satisfy forces in the horizontal direction using the computer program LPile©, driven piles may be designed using the following parameters:

Boring B-1 – North Abutment

L-Pile Parameters

Layer	Depth to Bottom of Layer [1] (ft)	Soil Type (p-y) Curve Model	Total Unit Weight (pcf)	Friction Angle Φ'	Cohesion (psf)	Soil Modulus (pci)	Soil Strain, e_{50}
Stratum 1	6	Stiff Clay w/out free water	115	---	1,500	Allow L-Pile Program to choose values based on the other parameters in this table.	
Stratum 2	8.5	Sand (Reese)	115	32	---		
Stratum 3	27	Sand (Reese)	115	34	---		
Stratum 4	32	Sand (Reese)	115	31	---		
Stratum 5	42	Sand (Reese)	115	34	---		

Boring B-1 – North Abutment

L-Pile Parameters

Layer	Depth to Bottom of Layer [1] (ft)	Soil Type (p-y) Curve Model	Total Unit Weight (pcf)	Friction Angle Φ’	Cohesion (psf)	Soil Modulus (pci)	Soil Strain, e_{50}
Stratum 6	49	Sand (Reese)	115	29	---		
Stratum 7	55-1/2	Sand (Reese)	115	30	---		

1. Below assumed top of pile elevation of 6,096.5 feet.
2. Groundwater was considered to be at a depth greater than 55-1/2 feet for design purposes. Actual groundwater levels may vary from this depth.

Boring B-2 – Bent

L-Pile Parameters

Layer	Depth to Bottom of Layer [1] (ft)	Soil Type (p-y) Curve Model	Total Unit Weight (pcf)	Friction Angle Φ’	Cohesion (psf)	Soil Modulus (pci)	Soil Strain, e_{50}
Stratum 1	6	Sand (Reese)	115	31	---	Allow L-Pile Program to choose values based on the other parameters in this table.	
Stratum 2	10	Sand (Reese)	115	32	---		
Stratum 3	22	Sand (Reese)	115	34	---		
Stratum 4	29	Sand (Reese)	115	30	---		
Stratum 5	37	Sand (Reese)	115	33	---		
Stratum 6	55-1/2	Sand (Reese)	115/53 [2]	30	---		

1. Below assumed top of pile elevation of 6,090 feet.
2. Groundwater was considered to be at a depth of 50 feet for design purposes. Actual groundwater levels may vary from this depth. A total unit weight of 53 pcf should be used for design purposes below the depth of groundwater.

Boring B-3 – South Abutment							
L-Pile Parameters							
Layer	**Depth to Bottom of Layer [1] (ft)**	**Soil Type (p-y) Curve Model**	**Total Unit Weight (pcf)**	**Friction Angle Φ'**	**Cohesion (psf)**	**Soil Modulus (pci)**	**Soil Strain, e_{50}**
Stratum 1	6	Stiff Clay w/out free water	100	---	750	Allow L-Pile Program to choose values based on the other parameters in this table.	
Stratum 2	12	Sand (Reese)	115	30	---		
Stratum 3	27	Sand (Reese)	115	33	---		
Stratum 4	37	Sand (Reese)	115	30	---		
Stratum 5	42	Sand (Reese)	115	33	---		
Stratum 7	55-1/2	Stiff Clay w/out free water	110	---	1500		

1. Below assumed top of pile elevation of 6,095.5 feet.
2. Groundwater was considered to be at a depth greater than 55-1/2 feet for design purposes. Actual groundwater levels may vary from this depth.

Lateral analysis should account for the center-to-center spacing and P-Y multiplier values per the following table:

Pier Center-to-Center Spacing (In Direction of Loading)	P-multiplier, P_M Row 1	P-multiplier, P_M Row 2	P-multiplier, P_M Row 3 and Higher
3 x diameter	0.8	0.4	0.3
5 x diameter	1.0	0.85	0.7

The load capacities provided herein are based on the stresses induced in the supporting soil strata. The structural capacity of the piles should be checked to assure they can safely accommodate the combined stresses induced by axial and lateral forces. Lateral deflections of piles should be evaluated using an appropriate analysis method, and will depend upon the pile's diameter, length, configuration, stiffness, and "fixed-head" or "free-head" condition. We can provide additional analyses and estimates of lateral deflections for specific loading conditions upon request. The load-carrying capacity of piles may be increased by increasing the section for H-piles and/or length.

Driven Pile Construction Considerations

We recommend a wave equation analysis of pile driving (WEAP) be completed using the selected pile type and the Contractor's pile driving equipment. The analysis should be completed prior to the start of driving production piles at the site. The WEAP analysis should be used to establish preliminary driving criteria and to confirm the contractor's selected hammer is capable of installing the pile and mobilizing adequate axial resistance without damaging the pile. Production driving criteria should be determined by dynamic testing.

The contractor should select a driving hammer and cushion combination that can install the selected piling without overstressing the pile material. The hammer should have a rated energy in foot-pounds at least equal to 15 percent of the design compressive load resistance in pounds. The contractor should submit the pile driving plan and the pile hammer-cushion combination to the engineer for evaluation of the driving stresses in advance of pile installation. During driving, a maximum of 10 blows per inch is recommended to reduce the potential of pile damage.

Difficult driving conditions could be encountered in coarse grained sands. Consideration should be given to using protective points and/or flange stiffening if H-piles are used to reduce the risk of damaging the pile. The contractor should be prepared to cut or splice piles, as necessary. Splicing of piles should be in accordance with specifications provided by the project Structural Engineer.

Pile driving conditions, hammer efficiency, and stress on the pile during driving could be better evaluated during installation using a Pile Driving Analyzer (PDA). A Terracon representative should observe pile driving operations. Each pile should be observed and checked for buckling, crimping, and alignment in addition to recording penetration resistance, depth of embedment, and general pile driving operations.

SEISMIC CONSIDERATIONS

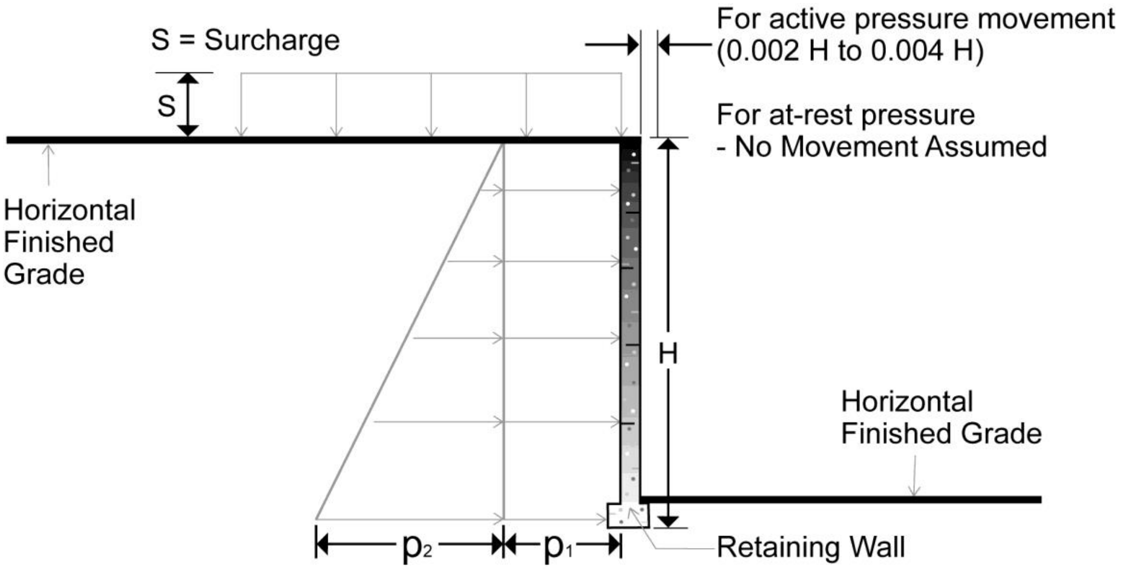
Based on our subsurface exploration and laboratory testing, it is our opinion that the soils have a low risk of liquefaction. The following table presents the seismic site classification based on the 2020 AASHTO LRFD Bridge Design Specifications and the subsurface conditions encountered within the borings:

Code Used	Site Classification
2020 AASHTO LRFD Bridge Design Specifications [1,2]	D

1. In general accordance with the 2020 AASHTO LRFD Bridge Design Specifications, Section 3.10.
2. The 2020 AASHTO LRFD Bridge Design Specifications requires a site subsurface profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100-foot subsurface profile determination. The deepest borings of this exploration extended to a maximum depth of about 55-1/2 feet and this seismic site class definition considers that similar subsurface conditions exist below the maximum depth of the subsurface exploration.

LATERAL EARTH PRESSURES

Reinforced concrete walls with unbalanced backfill levels on opposite sides (if applicable) should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Earth Pressure Conditions	Lateral Earth Pressure Coefficient	Equivalent Fluid Density (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (Ka)	On-site soils: 0.33 Class I: 0.28	On-site soils: 40 Class I: 35	On-site soils: (0.33)S Class I: (0.28)S	On-site soils:(40)H Class I: (35)H
At-Rest (Ko)	On-site soils: 0.50 Class I: 0.44	On-site soils: 60 Class I: 55	On-site soils: (0.50)S Class I: (0.44)S	On-site soils: (60)H Class I: (55)H
Passive (Kp)	On-site soils: 3.0 Class I: 3.5	On-site soils: 300 Class I: 400	---	---

Applicable conditions to the above include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 H to 0.004 H, where H is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance.
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 120 pcf
- Horizontal backfill, compacted to at least 95 percent of modified Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No dynamic loading
- No safety factor included in soil parameters

We recommend that a drain be installed behind retaining walls. If a drain is not installed behind retaining walls, the combined hydrostatic and lateral earth pressures should be calculated for granular backfill using an equivalent fluid weighing 85 and 90 pcf for active and at-rest conditions, respectively.

The above pressures do not include the influence of surcharge which should be added. Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent lateral pressures more than those provided.

The preceding data are applicable only to cast-in-place concrete or modular block walls up to 10 feet in height. **If taller single walls, tiered walls, or Mechanically Stabilized Earth (MSE) walls will be included in the proposed development, additional site-specific studies and laboratory testing will be required.** In addition, the wall designer should perform standard wall design practices including analysis for overturning, sliding, bearing capacity, and global stability, and results of these analyses should be provided for our review. Additional sampling, laboratory testing and document review associated with retaining walls is beyond the original scope of work but can be performed as a separate scope, for a separate fee.

CORROSIVITY

The following table lists the results of laboratory water-soluble sulfate testing performed on samples obtained during our field exploration. These values should be used to help determine potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials that will be used for project construction. Refer to the **Summary of Laboratory Test Results** contained in the **Exploration Results** section for the complete results of the corrosivity testing performed on the site soils in conjunction with this geotechnical exploration.

The corrosion information presented is specific to the samples tested. If the actual soils that will be in contact with the structures at the site are different than those tested, then additional corrosion testing should be performed. Terracon is not a corrosion engineer, and our scope of work was limited to performing corrosion laboratory tests on selected samples, presenting these results, and providing a brief comparison of the results to selected criteria. A qualified corrosion engineer should be consulted if corrosion of underground utilities and structures is a concern.

Boring No.	Sample Depth (feet)	Water-Soluble Chloride (%)	pH	Soil Resistivity (ohm.cm)	Water-Soluble Sulfate [1] (%)
B-3	1 - 5	0.0018	7.6	2924	0.002

1. Results of water-soluble sulfate testing indicate that samples of the on-site soils have an exposure class of S0 when classified in accordance with Table 19.3.1.1 of the American Concrete Institute (ACI) Design Manual. The results of the testing indicate ASTM Type I Portland Cement is suitable for project concrete in contact with on-site soils. However, if there is no (or minimal) cost differential, use of ASTM Type II Portland Cement is recommended for additional sulfate resistance of construction concrete. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 19.

Based on the 2020 CDOT Bridge Design Manual and the specified minimum corrosion rate based on criteria established by the California Department of Transportation (2013), the US Army Corps of Engineers (2012), and the Florida Department of Transportation (2016), the thickness of sacrificial steel shall be calculated based on a minimum corrosion rate of 0.001 inch per year where aggressive soil or rock is present. Based on a 75-year pile design life, a sacrificial steel thickness of 0.075 inch should be considered for corrosion loss.

PAVEMENTS

Design of pavement thicknesses for proposed pavements for this project was based on the procedures outlined in the October 14, 2020 version of the El Paso County, “Engineering Criteria Manual”, Revision 6 (Standards). All pavement construction and pavement materials should conform to the latest version of the Pikes Peak Regional Asphalt Paving Specifications.

Design Traffic

We understand North Ellicott Highway will have a classification of a Major Collector. Based on the Standards, traffic loading for North Ellicott Highway was taken as the minimum 18-kip Equivalent Single Axle Load (ESAL) for a Rural Major Collector of 273,750 ESALs.

We should be contacted to confirm and/or modify the recommendations contained herein if actual traffic volumes differ from the assumed values shown above.

Subgrade Soils

Laboratory test results indicate that the subgrade soils and backfill materials classify as A-2-6 and A-1-b soil types with a group index of 0 according to the American Association of State Highway and Transportation Officials (AASHTO) classification system. The pavement thicknesses presented in this report are based on the pavement subgrades consisting of A-2-6 soils.

A Hveem Stabilometer R-value test (AASHTO T 190) was performed on a sample of the A-2-6 soils, resulting in an R-value of 26. The R-value was used to calculate a resilient modulus (M_R) of about 6,010 psi based on the Standards.

Subgrade Preparation

Strip and remove existing pavements, vegetation, organics, and other deleterious materials from proposed pavement areas. All exposed surfaces should be free of mounds and depressions that could prevent uniform compaction.

Stripped materials consisting of vegetation, unsuitable fills, and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations.

Where possible, the site should be initially graded to create a relatively level surface to receive fill and to provide for a relatively uniform thickness of fill beneath the proposed pavement areas. All exposed areas that will receive fill, once properly cleared, should be scarified to a minimum depth of 12 inches, conditioned to near optimum moisture content, and compacted. It is imperative the moisture content of prepared materials be protected from moisture loss.

Swell Potential and Subgrade Treatment Requirements

Based on the results of the laboratory testing and our experience in the area, the sand soils are non-expansive. Subgrade treatment due to the presence of expansive soils is not required.

Recommended Minimum Pavement Sections

The pavement thickness designs were performed using the asphalt and aggregate base course strength coefficients and minimum thicknesses as recommended in the Standards. The following strength coefficients were used for the pavement designs.

Component	Strength Coefficient
Hot Mix Asphalt (HMA)	0.44
Aggregate Base Course (ABC) [1]	0.11

1. Aggregate Base Course should have a CBR of 80+ or an R-value of 78+.

Using the traffic volume assumptions and resilient modulus of the A-2-6 soils, a structural number (SN) of 2.8 was determined based on the Standards.

Recommended alternatives for hot mix asphalt (HMA) and portland cement concrete pavements using the traffic loading, subgrade soil strengths, and the Standards are summarized in the table below:

Traffic Area	Alternative	Recommended Pavement Thickness (Inches)			
		Hot Mix Asphalt (HMA)	Aggregate Base Course (ABC)	Portland Cement Concrete	Total
North Ellicott Highway	A	6-1/2	--	--	6-1/2
	B	4-1/2	8	--	12-1/2
	C	--	--	6 [1]	6 [1]

1. Minimum pavement thickness based on the Standards.

Details of the pavement thickness calculations are presented in the **Pavement Design Calculations** section of this report.

Concrete pavement joint spacing and reinforcement should be in accordance with CDOT and/or AASHTO requirements.

Pavement Maintenance

Future performance of pavements constructed at this site will be dependent upon several factors, including:

- Maintaining stable moisture content of the subgrade soils both before and after pavement construction.
- Providing for a planned program of preventative maintenance.

The performance of all pavements can be enhanced by minimizing excess moisture, which can reach the subgrade soils. The following recommendations should be implemented:

- Site grading at a minimum 2 percent grade onto or away from the pavements.
- Water should not be allowed to pond behind curbs, if curbs are constructed.
- Compaction of any utility trenches for areas adjacent to pavements to the same criteria as the pavement subgrade.
- Compaction of shoulders adjacent to pavements to the same criteria as the pavement subgrade.

Preventative maintenance should be planned and provided for an ongoing pavement management program in order to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration.

Preventative maintenance consists of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). Preventative maintenance is usually the first priority when implementing a planned pavement maintenance program.

Pavement Construction Considerations

All pavement construction and pavement materials should conform to the latest version of the Pikes Peak Regional Asphalt Paving Specification. Pavements will be subject to post-construction movement. Maximum grades practical should be used for paving to prevent areas where water can pond. In addition, allowances in final grades should take into consideration post-construction movement, particularly if such movement would be critical.

As construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may not be suitable for pavement construction and corrective action will be required. The subgrade should be carefully evaluated at the time of pavement construction for signs of disturbance or excessive rutting. If disturbance has occurred, pavement subgrade areas should be reworked, moisture conditioned, and properly compacted to the recommendations in this report immediately prior to paving.

We recommend the pavement areas be rough graded and then thoroughly proofrolled with a loaded tandem axle dump truck prior to final grading and paving. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. All pavement areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving.

The placement of a partial pavement thickness for use during construction is not recommended without a detailed pavement analysis incorporating construction traffic. In addition, if the actual traffic varies from the assumptions outlined above, we should be contacted to confirm and/or modify the pavement thickness recommendations outlined above.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials, or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

Contents:

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Boring Layout and Elevations: The locations of the borings are presented in the **Site Location and Exploration Plans**. The borings were located in the field by overlaying the site plan on Google Earth, recording the latitude and longitude coordinates, and staking the borings using a handheld, recreational-grade GPS unit. The accuracy of the latitude and longitude values is typically about +/- 25 feet when obtaining the values using this method. Elevations of borings were obtained from the topographic site plan to the nearest foot. The accuracy of the boring locations and elevations should only be assumed to the level implied by the methods used.

Subsurface Exploration Procedures: We advanced the soil borings with a truck-mounted drill rig using continuous flight augers. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration was recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. A 3-inch outer diameter split-barrel sampling spoon with 2.5-inch inner diameter ring lined sampler was used for sampling in the upper 14 feet. Ring-lined, split-barrel sampling procedures were similar to standard split spoon sampling procedure; however, blow counts were recorded for 6-inch intervals for a total of 12 inches of penetration. The samples were placed in appropriate containers, taken to our soil laboratory for testing, and classified by a geotechnical engineer. Where encountered, the depth to groundwater was observed in the boring during drilling and sampling. Boring No. B-3 was left open for a period of 24 hours and a delayed groundwater measurement was taken at that time.

Our exploration team prepared field boring logs as part of standard drilling operations which included the sampling depths, penetration distances, and other relevant sampling information. Field logs include visual classifications of materials encountered during drilling, and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent the geotechnical engineer's interpretation, and include modifications based on observations and laboratory tests.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. The following testing was performed:

- Water content
- Unit dry weight
- Swell/consolidation
- Grain size analyses
- Atterberg limits
- Chemical analyses – water soluble chloride, pH, electrical resistivity, water soluble sulfate

The laboratory testing program included examination of the soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System and, where applicable, in accordance with AASHTO.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Ellicott Highway Bridge Replacement Project ■ El Paso County, Colorado
October 14, 2021 (Revised May 17, 2022) ■ Terracon Project No. 23205146

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Ellicott Highway Bridge Replacement Project ■ El Paso County, Colorado
October 14, 2021 (Revised May 17, 2022) ■ Terracon Project No. 23205146

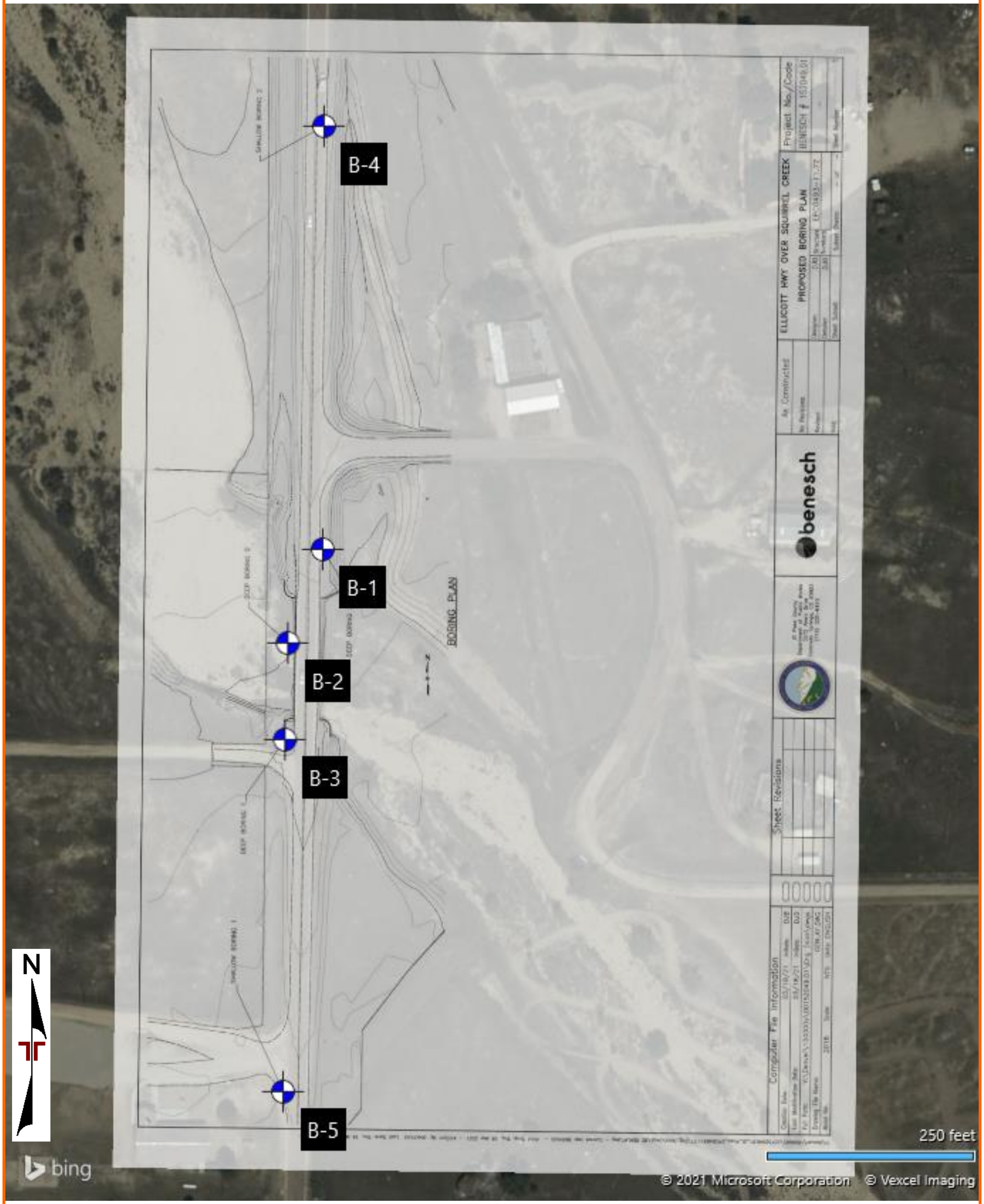
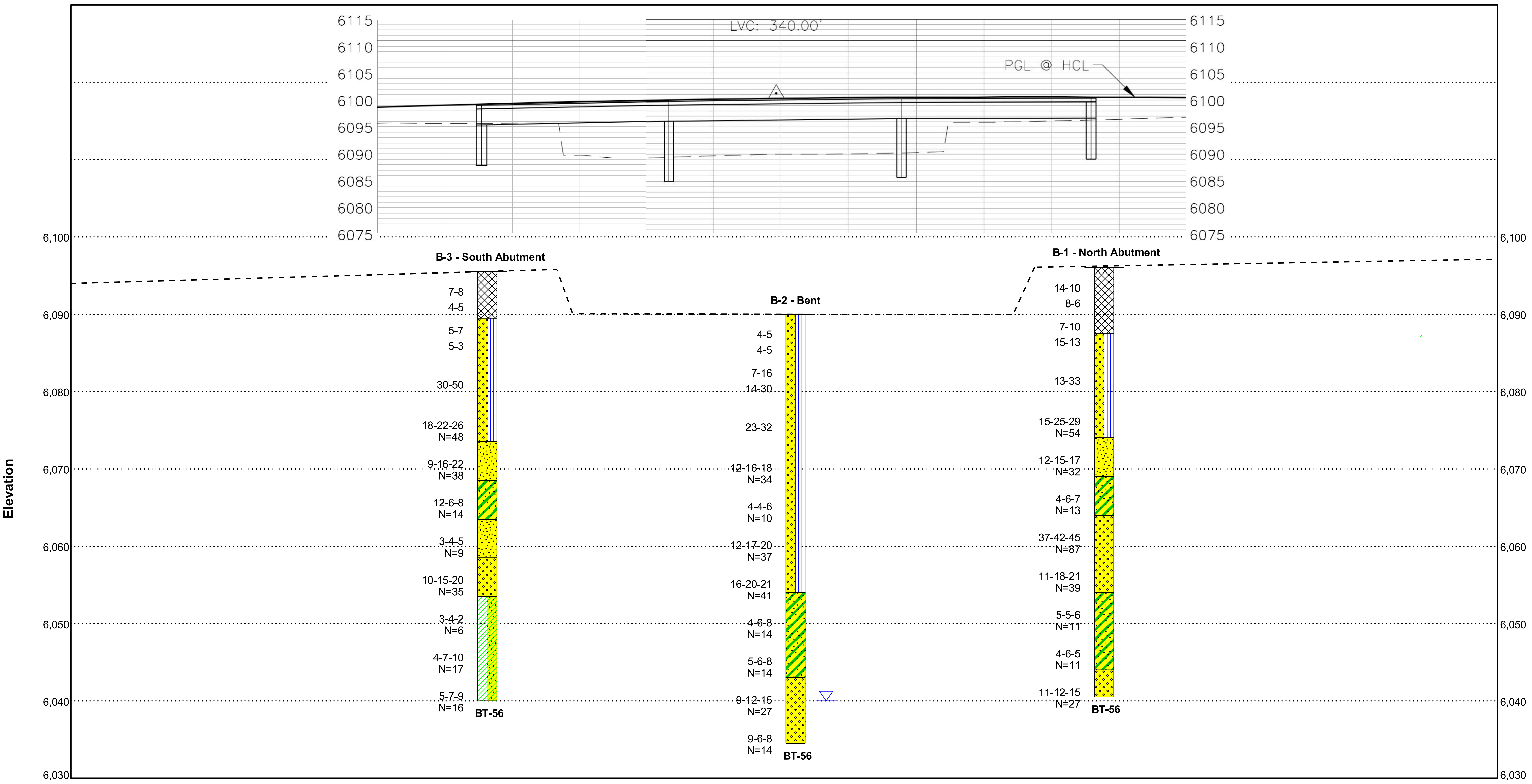


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

MAP PROVIDED BY MICROSOFT BING MAPS.



Explanation

B-3 — Borehole Number

Borehole Lithology

AR
BT — Borehole Termination Type

▽ Water Level Reading at time of drilling.

▼ Water Level Reading after drilling.

▨	Lean Clay
▥	Silty Sand
▦	Fill
▥	Well-graded Sand with Silt
▒	Poorly-graded Sand
▨	Clayey Sand

NOTES: See Exhibit Number of Exhibit to which to refer client to view orientation of soil profile. for orientation of soil profile.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project Manager: TAC	Project No.: 23205146
Drawn by: TAR	Scale: AS SHOWN
Approved by: SBM	File Name: SUB PROFILE
Date: 10/8/2021	

Terracon
4172 Center Park Dr
Colorado Springs, CO
PH. 719-597-2116 FAX. 719-597-2117

SUBSURFACE PROFILE

ELLICOTT HIGHWAY BRIDGE REPLACEMENT PROJECT
N. OF SH-94 OVER BLACK SQUIRREL CREEK
EL PASO COUNTY, COLORADO

EXHIBIT

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: **Highway Bridge Replacement Project**

CLIENT: **Alfred Benesch & Company Inc**

SITE: **N. of SH-94 over Black Squirrel Creek**
El Paso County, Colorado

LOCATION See Exploration Plan

Latitude: 38.8631° Longitude: -104.3873°

Approximate Surface Elev.: 6096.0 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	FIELD TEST RESULTS	SWELL	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2	8.5	**FILL - CLAYEY SAND (SC)**, fine to coarse grained, dark brown to light brown, loose to medium dense	6087.5+/-	14-10		5.0	97		
				8-6	-0.2 @ 500 psf	7.7	110	30-17-13	29
				7-10		9.2	111		
3	22.0	**WELL GRADED SAND WITH SILT (SW-SM)**, fine to coarse grained, light brown, medium dense to very dense	6074+/-	15-13		2.7	114		
				13-33	0.0 @ 500 psf	5.1	118	NP	6
				15-25-29 N=54		5.7			
	27.0	**POORLY GRADED SAND (SP)**, fine to medium grained, brown, dense with iron oxidation staining below 24 feet	6069+/-	12-15-17 N=32		7.6			
	32.0	**CLAYEY SAND (SC)**, fine to medium grained, brown, medium dense	6064+/-	4-6-7 N=13		10.8			
	42.0	**WELL GRADED SAND (SW)**, fine to coarse grained, brown, dense to very dense	6054+/-	37-42-45 N=87		7.7			
				11-18-21 N=39		7.3			
	52.0	**CLAYEY SAND (SC)**, fine to medium grained, brownish gray, medium dense	6044+/-	5-5-6 N=11		21.4			
				4-6-5 N=11		18.9			
	55.5	**WELL GRADED SAND (SW)**, fine to coarse grained, brown, medium dense	6040.5+/-	11-12-15 N=27		16.2			

Boring Terminated at 55.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8-inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

None encountered while drilling

Terracon
4172 Center Park Dr
Colorado Springs, CO

Boring Started: 05-05-2021	Boring Completed: 05-05-2021
Drill Rig: CME-550	Driller: Vine Laboratories
Project No.: 23205146	

BORING LOG NO. B-2

PROJECT: Highway Bridge Replacement Project

CLIENT: Alfred Benesch & Company Inc

SITE: N. of SH-94 over Black Squirrel Creek
El Paso County, Colorado

LOCATION See Exploration Plan

Latitude: 38.8628° Longitude: -104.3875°

Approximate Surface Elev.: 6090.0 (Ft.) +/-

MODEL LAYER	DEPTH		ELEVATION (Ft.)
3		**WELL GRADED SAND WITH SILT (SW-SM)**, fine to coarse grained, brown, loose to dense	
	36.0	**CLAYEY SAND (SC)**, fine to coarse grained, brown, medium dense	6054+/-
	47.0	**WELL GRADED SAND (SW)**, fine to coarse grained, brown, medium dense	6043+/-
	55.5	***Boring Terminated at 55.5 Feet***	6034.5+/-

FIELD TEST RESULTS	SWELL	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
4-5		15.4	96		
4-5		8.1	98		
7-16		8.7	115		
14-30		4.0	120		
23-32		5.1	109		
12-16-18 N=34		4.9			
4-4-6 N=10		8.5			
12-17-20 N=37		4.7			
16-20-21 N=41		2.9			
4-6-8 N=14		16.0			
5-6-8 N=14		18.0			
9-12-15 N=27		18.2			
9-6-8 N=14		20.0			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8-inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

▽ *50 feet while drilling*

Terracon
4172 Center Park Dr
Colorado Springs, CO

Boring Started: 05-20-2021	Boring Completed: 05-01-2021
Drill Rig: CME-550	Driller: Vine Laboratories
Project No.: 23205146	

BORING LOG NO. B-3

PROJECT: Highway Bridge Replacement Project

CLIENT: Alfred Benesch & Company Inc

SITE: **N. of SH-94 over Black Squirrel Creek**
El Paso County, Colorado

LOCATION See Exploration Plan

Latitude: 38.8625° Longitude: -104.3875°

Approximate Surface Elev.: 6095.5 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2		**FILL - CLAYEY SAND (SC)**, fine to coarse grained, light brown, loose 6.0 6089.5+/-				7-8 4-5		6.3 9.1	102 101		
3		**WELL GRADED SAND WITH SILT (SW-SM)**, fine to coarse grained, light brown, loose to dense 22.0 6073.5+/-	10 20			5-7 5-3 30-50 18-22-26 N=48	-1.8 @ 500 psf	3.7 11.0 9.1 11.2	110 106 121	NP	9
		POORLY GRADED SAND (SP), fine to medium grained, brown, dense with iron oxidation staining below 24 feet 27.0 6068.5+/-				9-16-22 N=38		7.9			
		CLAYEY SAND (SC), fine to medium grained, brown, medium dense 32.0 6063.5+/-	30			12-6-8 N=14		14.4			
		POORLY GRADED SAND (SP), fine to medium grained, brown, loose 37.0 6058.5+/-				3-4-5 N=9		10.0			
		WELL GRADED SAND (SW), fine to coarse grained, brown, dense 42.0 6053.5+/-	40			10-15-20 N=35		10.8			
4		**LEAN CLAY WITH SAND (CL)**, light brown, medium stiff to very stiff 55.5 6040+/-	50			3-4-2 N=6 4-7-10 N=17 5-7-9 N=16		25.2 26.2			

Boring Terminated at 55.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8-inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed groundwater readings taken.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

None measured while drilling

None observed after 24 hours

Terracon
4172 Center Park Dr
Colorado Springs, CO

Boring Started: 05-06-2021	Boring Completed: 05-06-2021
Drill Rig: CME-55	Driller: Vine Laboratories
Project No.: 23205146	

BORING LOG NO. B-4

Page 1 of 1

PROJECT: Highway Bridge Replacement Project

CLIENT: Alfred Benesch & Company Inc

SITE: **N. of SH-94 over Black Squirrel Creek**
El Paso County, Colorado

LOCATION See Exploration Plan

Latitude: 38.8645° Longitude: -104.3873°

Approximate Surface Elev.: 6099.5 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.4	**ASPHALT**, about 5 inches thick	6099+/-			⋈	6-7		16.2	111		
3			**SILTY SAND (SM)**, fine to medium grained, brown, loose				⋈	4-7	0.0 @ 500 psf	8.4	120	NP	22
		5.0		6094.5+/-			⋈	5-6		10.0	111		
			Boring Terminated at 5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8-inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

None encountered while drilling

Terracon
4172 Center Park Dr
Colorado Springs, CO

Boring Started: 05-06-2021	Boring Completed: 05-06-2021
Drill Rig: CME-55	Driller: Vine Laboratories
Project No.: 23205146	

BORING LOG NO. B-5

Page 1 of 1

PROJECT: Highway Bridge Replacement Project

CLIENT: Alfred Benesch & Company Inc

SITE: **N. of SH-94 over Black Squirrel Creek**
El Paso County, Colorado

LOCATION See Exploration Plan

Latitude: 38.8613° Longitude: -104.3875°

Approximate Surface Elev.: 6092.0 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
3	▨	1.5	**SILTY SAND (SM)**, fine grained, dark brown, very loose, rootlets to 1.5 feet	6090.5+/-			⧖	1-2		14.7	84		
	▨	3.5	**WELL GRADED SAND (SW)**, fine to coarse grained, dark brown, dense	6088.5+/-			⧖	14-22		2.4	110		
4	▨	5.0	**LEAN CLAY (CL)**, dark brown, very stiff	6087+/-			⧖	14-19		4.7	117		
			Boring Terminated at 5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8-inch Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations were interpolated from a topographic site plan.

Notes:

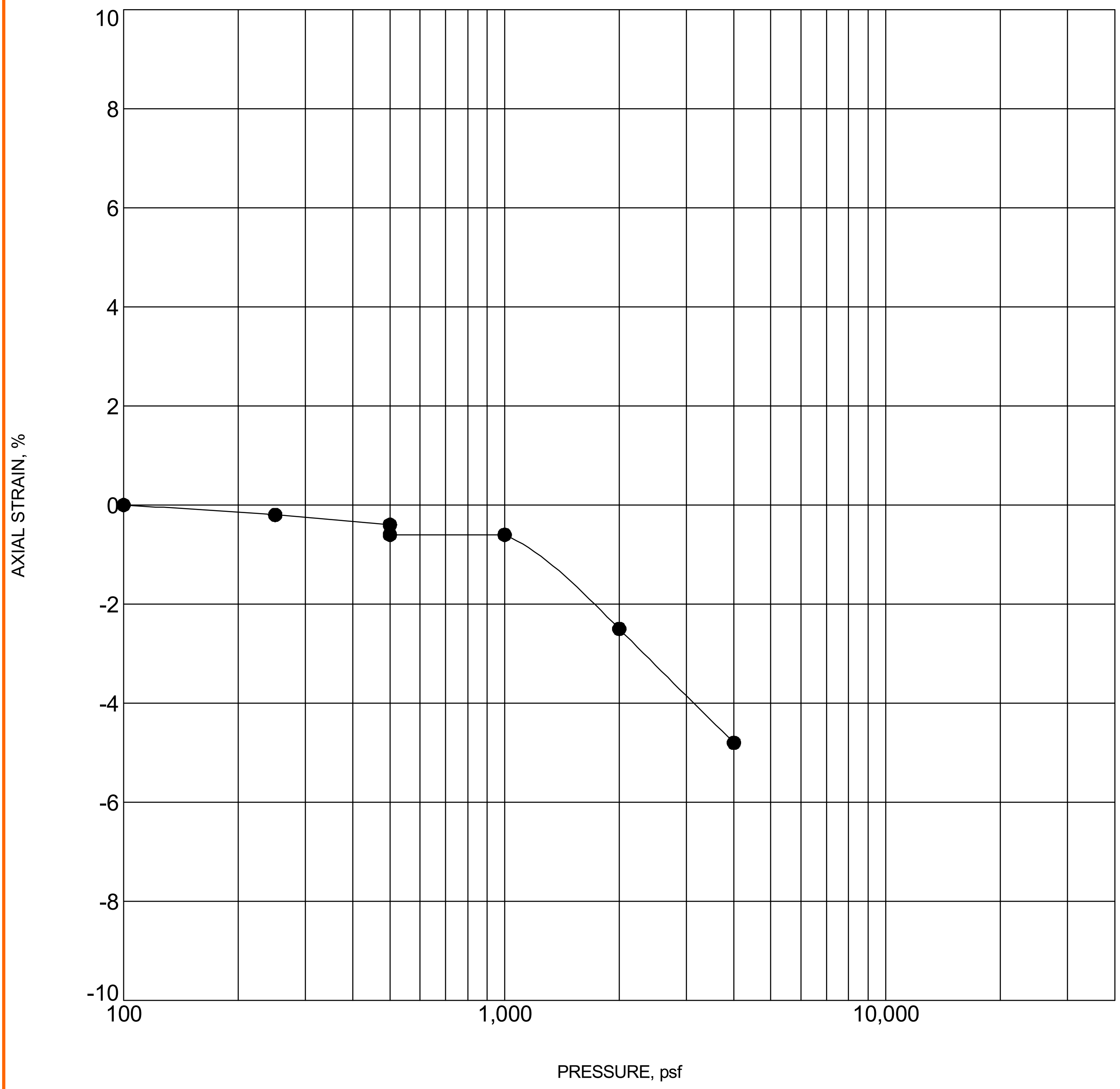
WATER LEVEL OBSERVATIONS

None encountered while drilling

4172 Center Park Dr
Colorado Springs, CO

Boring Started: 05-05-2021	Boring Completed: 05-05-2021
Drill Rig: CME-550	Driller: Vine Laboratories
Project No.: 23205146	

SWELL CONSOLIDATION TEST



Specimen Identification		Classification	γ_d, pcf	WC, %
●	B-1 4 - 5 ft	FILL - CLAYEY SAND (SC)	110	7.7

NOTES: Water was added at 500 psf.

PROJECT: Ellicott Highway Bridge Replacement Project

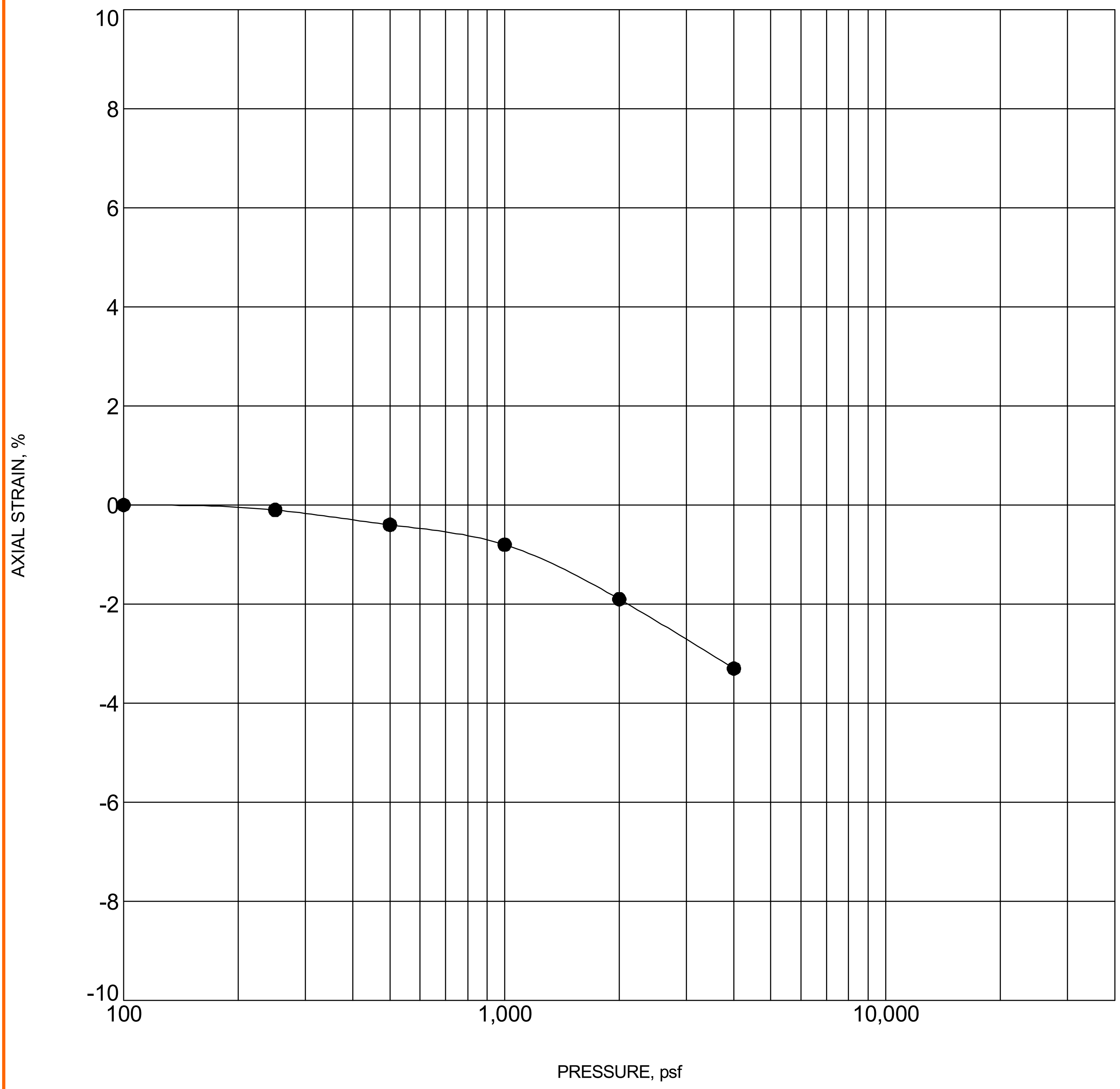
SITE: N. of SH-94 over Black Squirrel Creek
El Paso County, Colorado

Terracon
4172 Center Park Dr
Colorado Springs, CO

PROJECT NUMBER: 23205146

CLIENT: Alfred Benesch & Company Inc

SWELL CONSOLIDATION TEST



Specimen Identification			Classification	γ_d, pcf	WC, %
●	B-1	14 - 15 ft	WELL GRADED SAND with SILT (SW-SM)	118	5.1

NOTES: Water was added at 500 psf.

PROJECT: Ellicott Highway Bridge Replacement Project

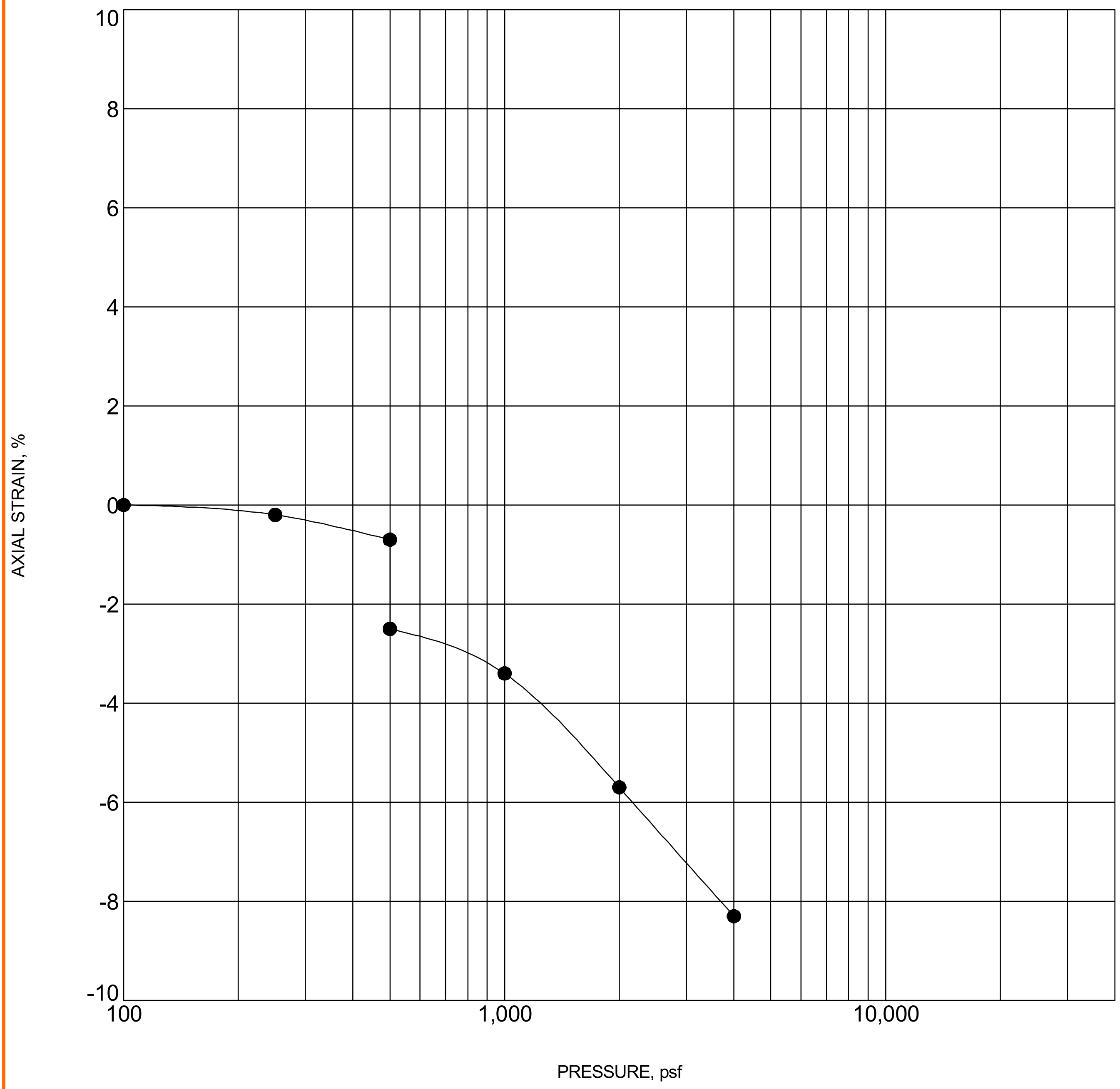
SITE: N. of SH-94 over Black Squirrel Creek
El Paso County, Colorado

Terracon
4172 Center Park Dr
Colorado Springs, CO

PROJECT NUMBER: 23205146

CLIENT: Alfred Benesch & Company Inc

SWELL CONSOLIDATION TEST



Specimen Identification			Classification	γ_d, pcf	WC, %
●	B-3	7 - 8 ft	WELL GRADED SAND with SILT (SW-SM)	110	3.7

NOTES: Water was added at 500 psf.

PROJECT: Ellicott Highway Bridge Replacement Project

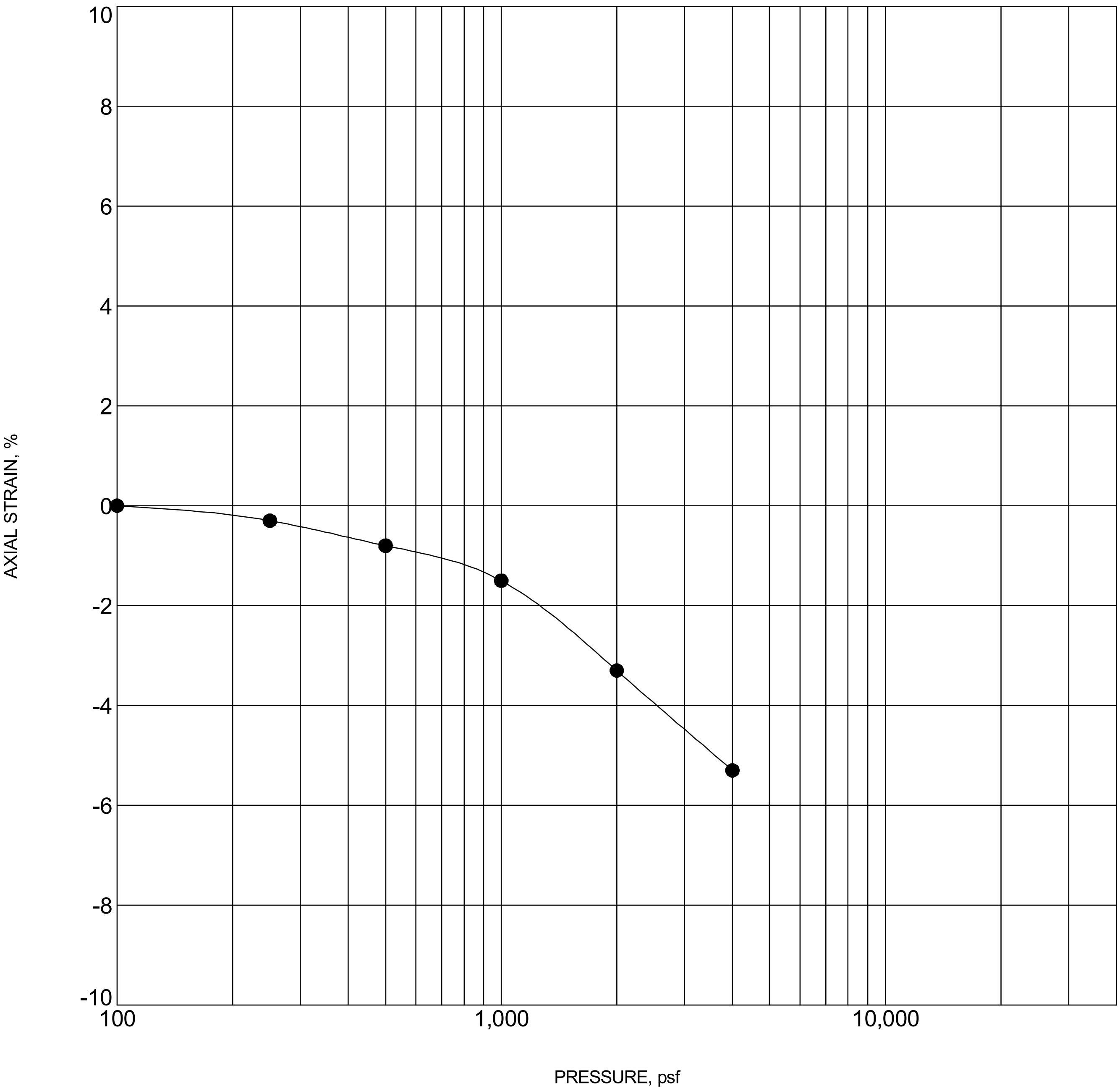
SITE: N. of SH-94 over Black Squirrel Creek
El Paso County, Colorado

Terracon
4172 Center Park Dr
Colorado Springs, CO

PROJECT NUMBER: 23205146

CLIENT: Alfred Benesch & Company Inc

SWELL CONSOLIDATION TEST



Specimen Identification			Classification	γ_d, pcf	WC, %
●	B-4	2 - 3 ft	SILTY SAND (SM)	120	8.4

NOTES: Water was added at 500 psf.

PROJECT: Ellicott Highway Bridge Replacement Project

SITE: N. of SH-94 over Black Squirrel Creek
El Paso County, Colorado

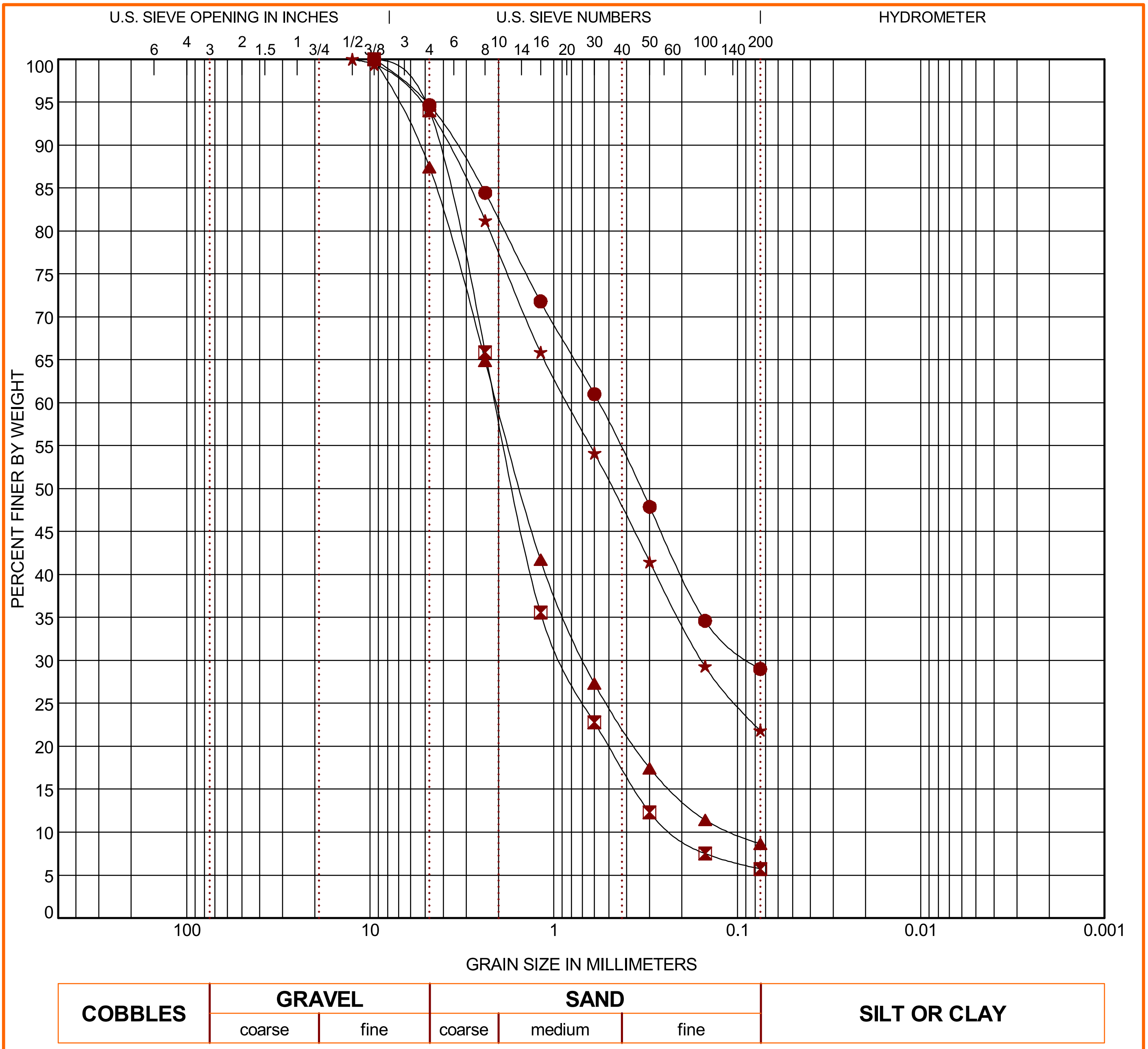
Terracon
4172 Center Park Dr
Colorado Springs, CO

PROJECT NUMBER: 23205146

CLIENT: Alfred Benesch & Company Inc

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	4 - 5	CLAYEY SAND (SC)	A-2-6 (0)	7.7	30	17	13		
☒	B-1	14 - 15	WELL-GRADED SAND with SILT (SW-SM)	A-1-b (0)	5.1	NP	NP	NP	1.74	9.57
▲	B-3	7 - 8	WELL-GRADED SAND with SILT (SW-SM)	A-1-b (0)	3.7	NP	NP	NP	2.16	19.40
★	B-4	2 - 3	SILTY SAND (SM)	A-1-b (0)	8.4	NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	4 - 5	9.5	0.569	0.085		5.3	65.7		29.0	
☒	B-1	14 - 15	9.5	2.064	0.879	0.216	6.0	88.3		5.7	
▲	B-3	7 - 8	9.5	2.04	0.681	0.105	12.6	78.8		8.6	
★	B-4	2 - 3	12.5	0.841	0.156		6.1	72.1		21.8	

PROJECT: Ellicott Highway Bridge Replacement Project

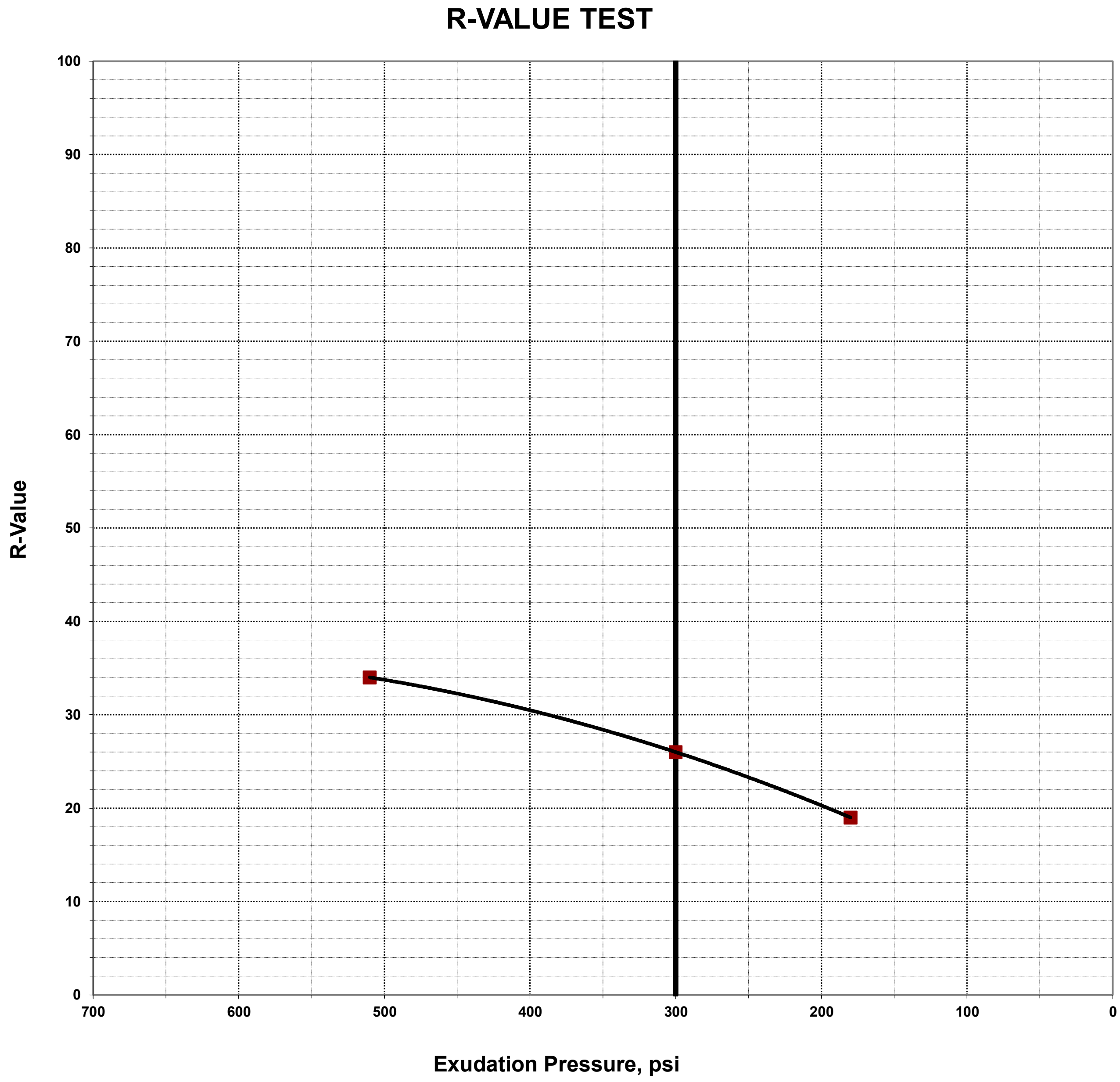
SITE: N. of SH-94 over Black Squirrel Creek
El Paso County, Colorado

Terracon
4172 Center Park Dr
Colorado Springs, CO

PROJECT NUMBER: 23205146

CLIENT: Alfred Benesch & Company Inc

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 23205146 ELLICOTT HIGHWAY .GPJ TERRACON_DATATEMPLATE.GDT 10/13/21



	Specimen Identification	Compaction Pressure (psi)	Dry Density (pcf)	Moisture Content (%)	R-Value at 300 psi
🟥	B-1 @ 1.0' - 5.0'	123.3	131.3	6.2	26

Terracon

Client: Alfred Benesch & Company Inc
Project: Ellicott Highway Bridge Replacement Project
Project Number: 23205146
Site: N. of SH-94 over Black Squirrel Creek

Colorado Analytical
LABORATORIES, INC.

Analytical Results

TASK NO: 210514014

Report To: Tyler Compton
Company: Terracon, Inc. - Colo Springs
4172 Center Park Drive
Colo. Springs CO 80916

Bill To: Tyler Compton
Company: Terracon, Inc. - Accounts Payable
18001 W. 106th St
Suite 300
Olathe KS 66061

Task No.: 210514014
Client PO:
Client Project: Ellicot HWY Bridge 23205146

Date Received: 5/14/21
Date Reported: 5/21/21
Matrix: Soil - Geotech

Customer Sample ID B-3 @ 1-5ft
Lab Number: 210514014-01

Test	Result	Method
Chloride - Water Soluble	**0.0018 %**	AASHTO T291-91/ ASTM D4327
pH	**7.6 units**	AASHTO T289-91
Resistivity	**2924 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.002 %**	AASHTO T290-91/ ASTM D4327

Abbreviations/ References:

AASHTO - American Association of State Highway and Transportation Officials.
ASTM - American Society for Testing and Materials.
ASA - American Society of Agronomy.
DIPRA - Ductile Iron Pipe Research Association Handbook of Ductile Iron Pipe.

Shane Nielson

DATA APPROVED FOR RELEASE BY

SUMMARY OF LABORATORY TEST RESULTS

Ellicott Highway Bridge Replacement Project - El Paso County, Colorado
Terracon Project No. 23205146

Boring No.	Depth (ft)	USCS Class.	Initial Water Content (%)	Initial Dry Density (pcf)	Swell/Consolidation		R-Value	Particle Size Distribution, Percent Passing by Weight					Atterberg Limits		Water Soluble Sulfates (%)	Water Soluble Chlorides (%)	pH	Resistivity (ohm.cm)	Remarks
					Surcharge (ksf)	Swell (%)		3/4"	#4	#16	#50	#200	LL	PI					
B1	1 - 5	SC					26												
B1	2	SC	5.0	97															4
B1	4	SC	7.7	110	0.5	-0.2		100	95	72	48	29	30	13					4
B1	7	SC	9.2	111															4
B1	9	SW-SM	2.7	114															4
B1	14	SW-SM	5.1	118	0.5	0.0		100	94	36	12	6	NV	NP					4
B1	19	SW-SM	5.7																4
B1	24	SP	7.6																4
B1	29	SC	10.8																4
B1	34	SW	7.7																4
B1	39	SW	7.3																4
B1	44	SC	21.4																4
B1	49	SC	18.9																4
B1	54	SW	16.2																4
B2	2	SW-SM	15.4	96															4
B2	4	SW-SM	8.1	98															4
B2	7	SW-SM	8.7	115															4
B2	9	SW-SM	4.0	120															4
B2	14	SW-SM	5.1	109															4
B2	19	SW-SM	4.9																4
B2	24	SW-SM	8.5																4
B2	29	SW-SM	4.7																4
B2	34	SW-SM	2.9																4
B2	39	SC	16.0																4
B2	44	SC	18.0																4
B2	49	SW	18.2																4

Notes:
Initial Dry Density and Initial Water Content are in-situ values unless otherwise noted.
* = Partially disturbed sample
\- = Compression/settlement
NV = no value
NP = non-plastic

Remarks:
1 Remolded Compacted density (about 95% of ASTM D698 maximum density near optimum moisture content)
2 Remolded Compacted density (about 95% of ASTM D1557 maximum density near optimum moisture content)
3 Water added to sample
4 Dry density and/or moisture content determined from one ring of a multi-ring sample
5 Minus #200 Only
6 Moisture-Density Relationship Test Method ASTM D698/AASHTO T99
7 Moisture-Density Relationship Test Method ASTM D1557/AASHTO T180

SUMMARY OF LABORATORY TEST RESULTS

Ellicott Highway Bridge Replacement Project - El Paso County, Colorado
Terracon Project No. 23205146

Boring No.	Depth (ft)	USCS Class.	Initial Water Content (%)	Initial Dry Density (pcf)	Swell/Consolidation		R-Value	Particle Size Distribution, Percent Passing by Weight					Atterberg Limits		Water Soluble Sulfates (%)	Water Soluble Chlorides (%)	pH	Resistivity (ohm.cm)	Remarks
					Surcharge (ksf)	Swell (%)		3/4"	#4	#16	#50	#200	LL	PI					
B2	54	SW	20.0																4
B3	1 - 5	SC													0.002	0.0018	7.6	2924	
B3	2	SC	6.3																4
B3	4	SC	9.1																4
B3	7	SW-SM	3.7																4
B3	9	SW-SM	11																4
B3	14	SW-SM	9.1																4
B3	19	SW-SM	11.2																4
B3	24	SP	7.9																4
B3	29	SC	14.4																4
B3	34	SP	10																4
B3	39	SW	10.8																4
B3	44	CL	25.2																4
B3	49	CL	26.2																4
B4	0.5	SM	16.2	111															4
B4	2	SM	8.4	120	0.5	0.0		100	94	66	41	22	NV	NP					3,4
B4	4	SM	10	111															4
B5	0	SM	14.7	84															4
B5	2	SW	2.4	110															4
B5	4	CL	4.7	117															4

Notes:
Initial Dry Density and Initial Water Content are in-situ values unless otherwise noted.
* = Partially disturbed sample
\- = Compression/settlement
NV = no value
NP = non-plastic

Remarks:
1 Remolded Compacted density (about 95% of ASTM D698 maximum density near optimum moisture content)
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5 Minus #200 Only
6 Moisture-Density Relationship Test Method ASTM D698/AASHTO T99
7 Moisture-Density Relationship Test Method ASTM D1557/AASHTO T180

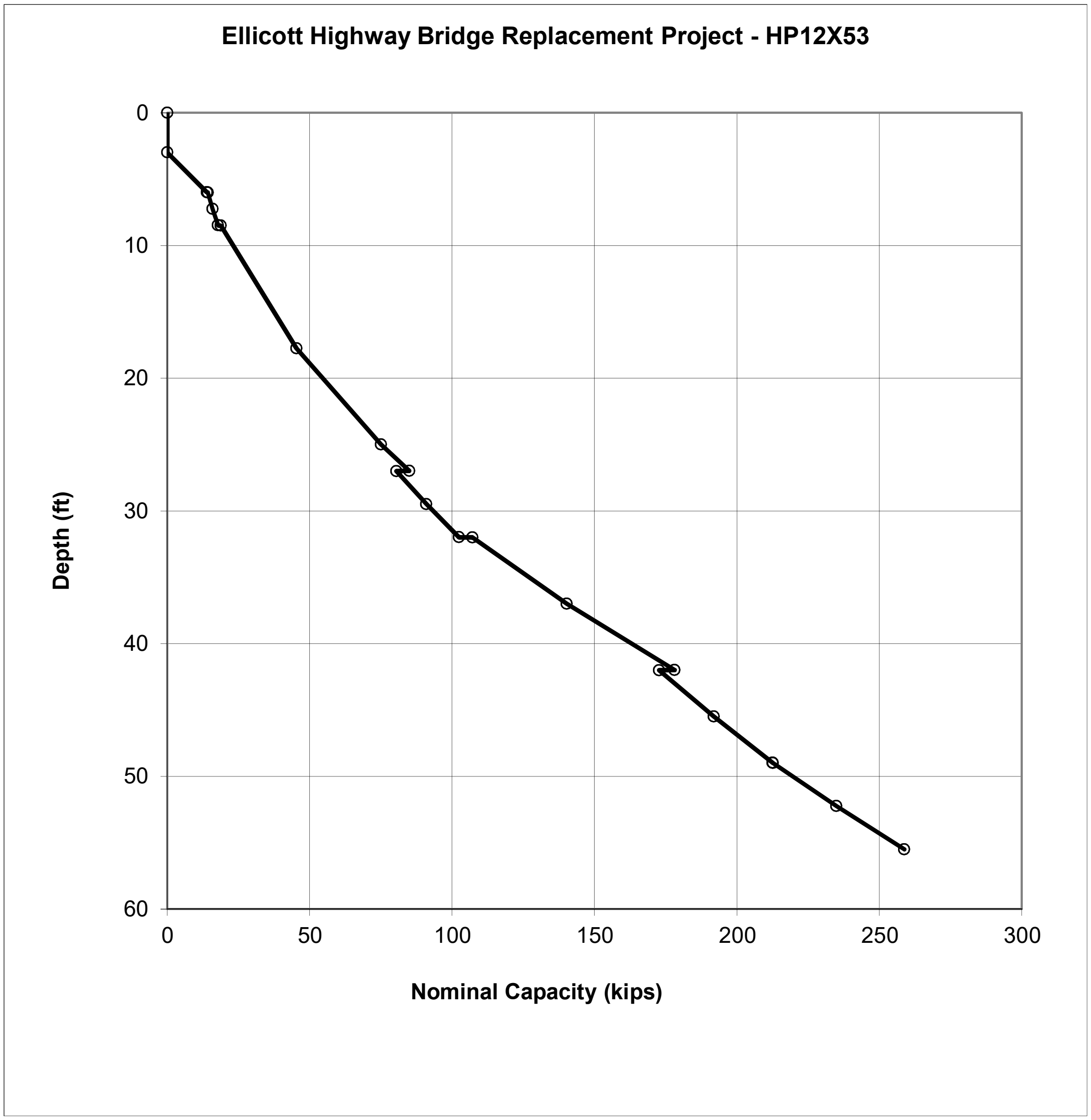
NOMINAL PILE AXIAL COMPRESSION PLOTS

Contents:

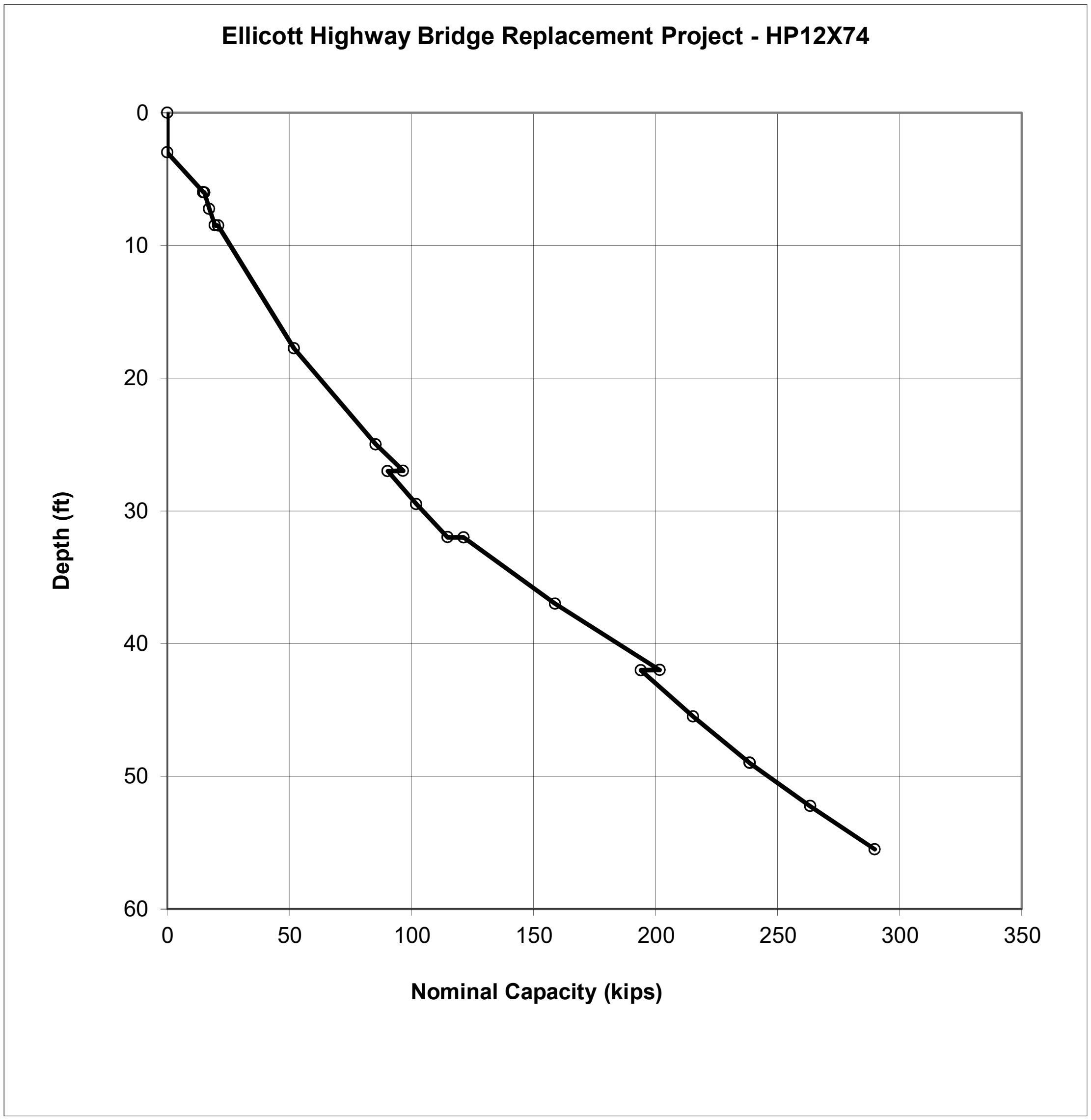
Note: All attachments are one page unless noted above.

Driven Pile Capacity

Project Name: Ellicott Highway Bridge Replacement Project
Project Number: 23205146
Notes: Boring No. B-1 - North Abutment
Date: 10/1/2021

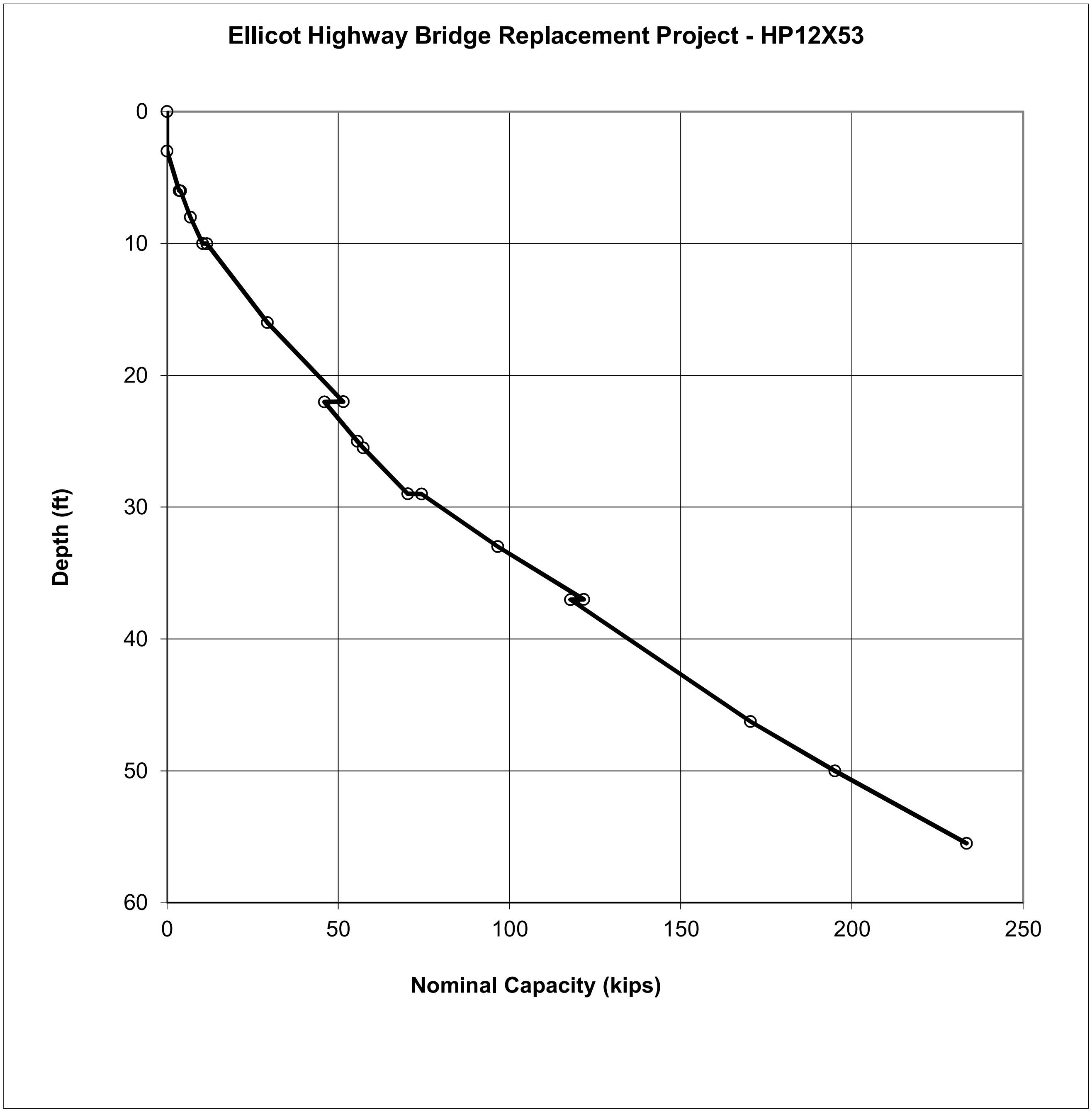


Project Name: Ellicott Highway Bridge Replacement Project
Project Number: 23205146
Notes: Boring No. B-1 - North Abutment
Date: 10/1/2021



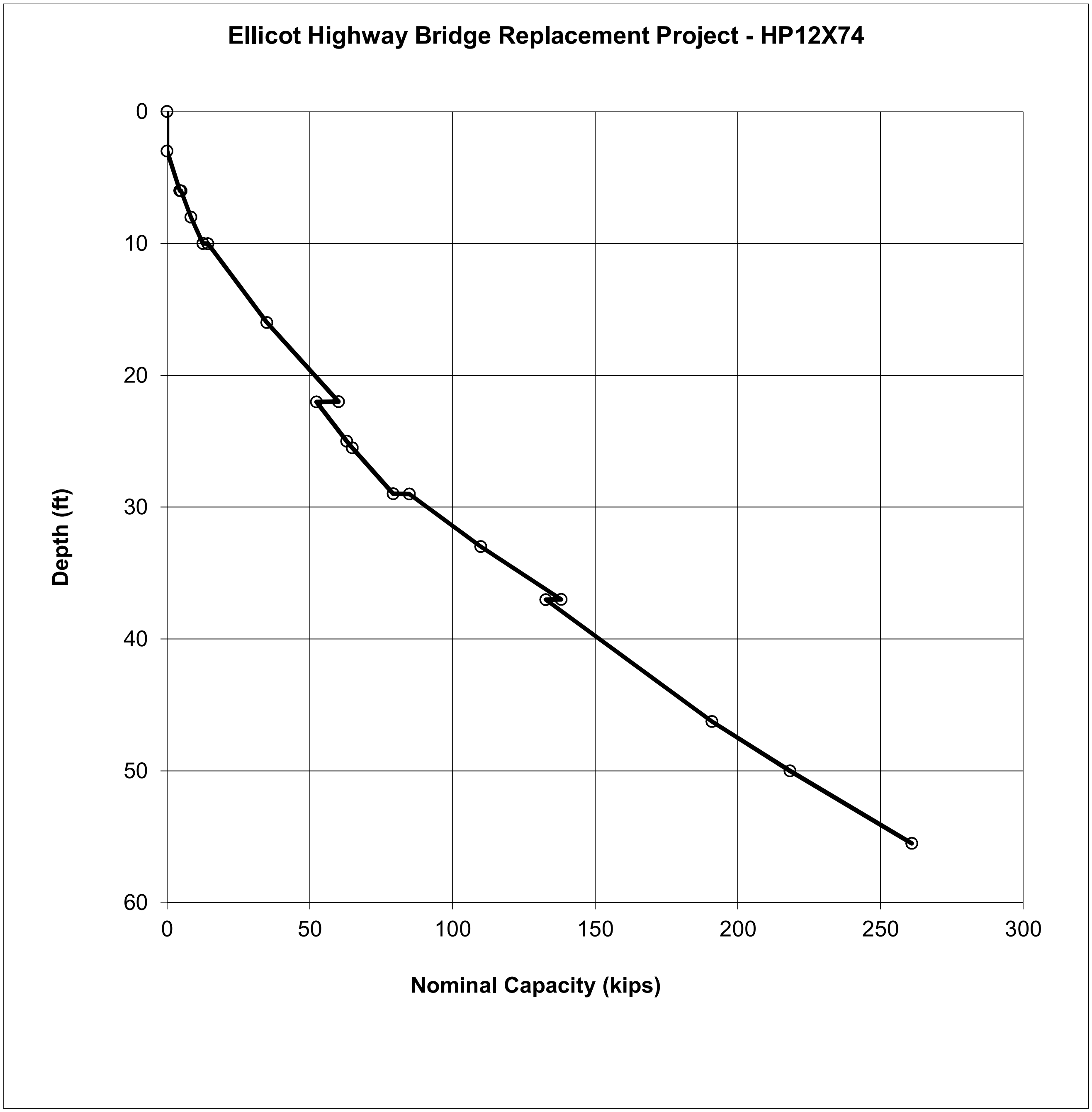
Driven Pile Capacity

Project Name: Ellicot Highway Bridge Replacement Project
Project Number: 23205146
Notes: Boring No. B-2 - Bent
Date: 10/1/2021



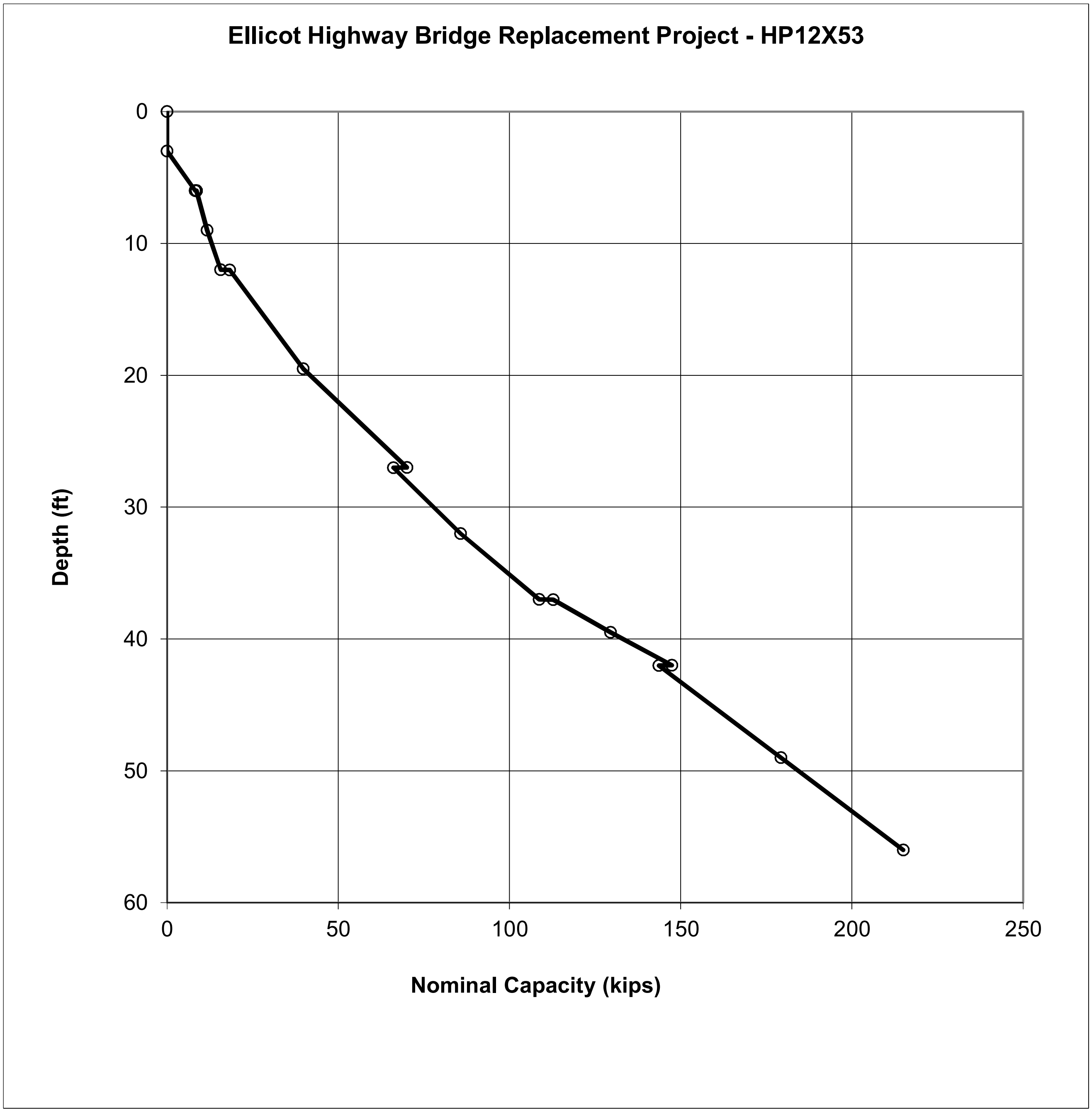
Driven Pile Capacity

Project Name: Ellicot Highway Bridge Replacement Project
Project Number: 23205146
Notes: Boring No. B-2 - Bent
Date: 10/1/2021



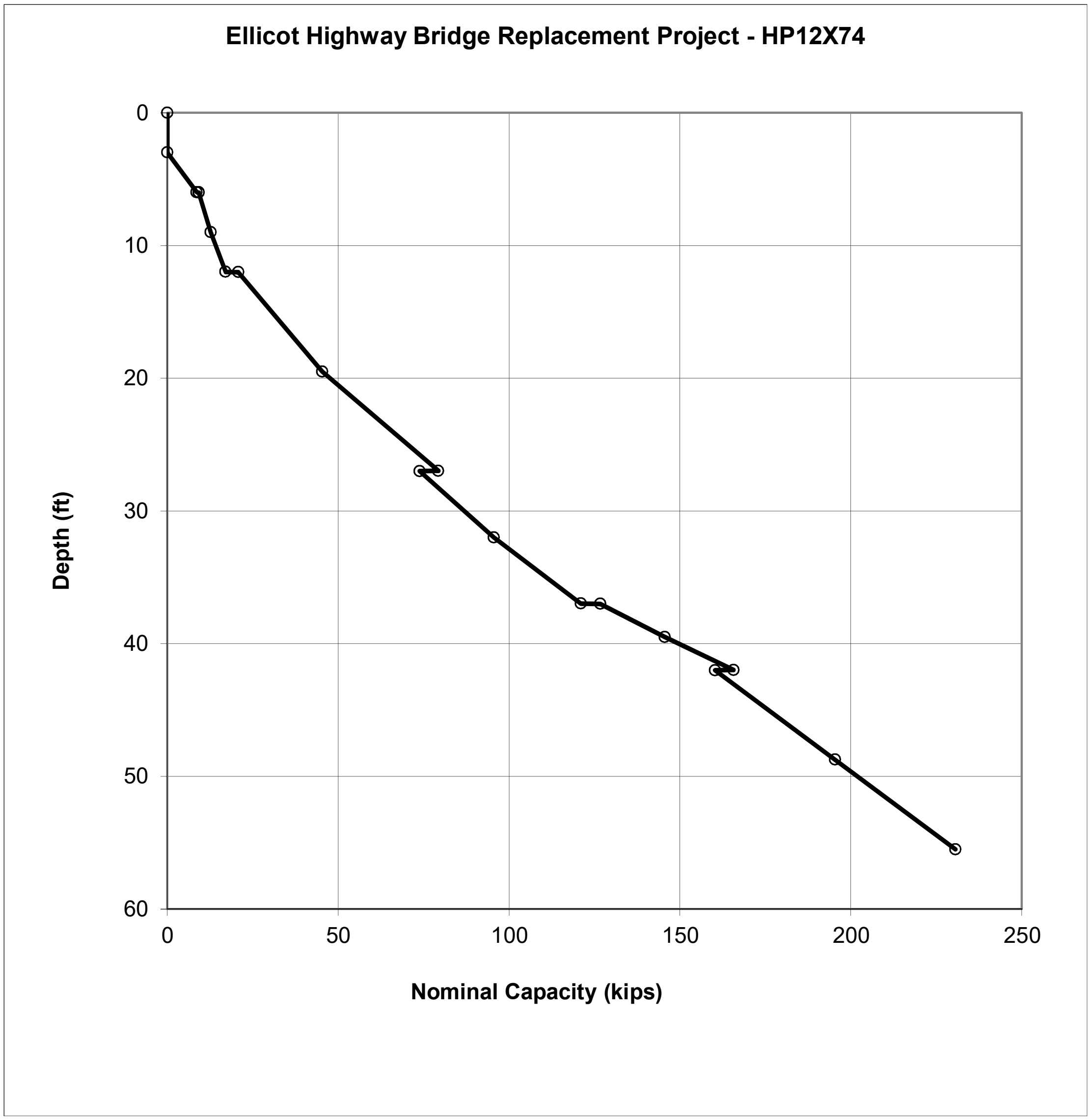
Driven Pile Capacity

Project Name: Ellicot Highway Bridge Replacement Project
Project Number: 23205146
Notes: Boring B-3 - South Abutment
Date: 10/1/2021



Driven Pile Capacity

Project Name: Ellicot Highway Bridge Replacement Project
Project Number: 23205146
Notes: Boring B-3 - South Abutment
Date: 10/1/2021



PAVEMENT DESIGN CALCULATIONS

Contents:

Note: All attachments are one page unless noted above.

North Ellicott Highway - Flexible Asphalt Design Calculations

DESIGN DATA

Design Life - Years = 20

Traffic Load - 18 kip ESAL's = 273,750

R-value = 26

Soil Support Value - S_1 = 4.9

Resilient Modulus - M_R (psi) = 6,010

Reliability - R (%) = 80

Serviceability Index - SI = 2.5

Serviceability Loss - PSI = 2.0

Overall Deviation - S_o = 0.44

DESIGN CALCULATION RESULTS

Based on the following equation:

$\log_{10}(18k\ ESAL) = Z_R x S_o + 9.36 x \log_{10}(SN+1) - 0.20$
$+\log_{10}(PSI/(4.2-1.5))/(0.4+(1094/(SN+1)^{5.19})) + 2.32 x \log_{10}(M_R) - 8.07$

Structural Number - SN = 2.8

PAVEMENT THICKNESS DESIGN EQUATION

$SN = C_1D_1+C_2D_2m_2$

where

C_1 = Strength Coefficient - Asphalt = 0.44

C_2 = Strength Coefficient - Aggregate Base Course = 0.11

m_2 = Drainage Coefficient = 1.0

D_1 = Depth of Asphalt (inches)

D_2 = Depth of Stabilized Base (inches)

PAVEMENT THICKNESS RESULTS

Full Depth Asphalt

D_1 = 6.5 inches

Asphalt + Aggregate Base Course

D_1 (Asphalt) = 4.5 inches

D_2 (Aggregate Base Course) = 8.0 inches

North Ellicott Highway - Rigid Concrete Design Calculations

DESIGN DATA

Design Life - Years = 20
Traffic Load - 18 kip ESAL's = 273,750
Modulus of Subgrade Reaction - k (psi/in) = 310
Modulus of Rupture - S'c (psi) = 650
Modulus of Elasticity - E_c (psi) = 3,400,000
Drainage Coefficient - C_d = 1.0
Load Transfer Coefficient - J = 4.2
Reliability - R (%) = 80
Serviceability Index - SI = 2.5
Serviceability Loss - PSI = 2.0
Overall Deviation - S_o = 0.34

DESIGN CALCULATION RESULTS

Based on the following equation:

$$\log_{10}(18k\ ESAL) = Z_R x S_o + 7.35 x \log_{10}(D+1) - 0.60$$
$$+\log_{10}(PSI/(4.2-1.5))/(1.0+(1.624x10^{7}/(D+1)^{8.46}))$$
$$+(4.22-0.32p_t) x \log_{10}(S'_c x C_a x (D^{0.73}-1.132)/215.63 x J(D^{0.75}-18.42/(E_c/k)^{0.25})))$$

RIGID PAVEMENT THICKNESS

D = 6 inches (Minimum per Standards)

SUPPORTING INFORMATION

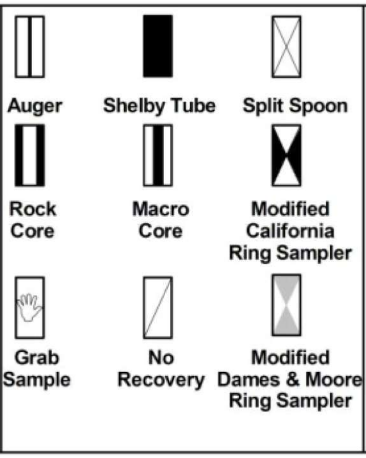
Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING



WATER LEVEL

- ▽ Water Initially Encountered
- ▽ Water Level After a Specified Period of Time
- ▼ Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
N	N value
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS	RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance				BEDROCK		
	Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Ring Sampler Blows/Ft.	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)
	Very Loose	0 - 3	0 - 5	Very Soft	less than 500	0 - 1	< 3	< 24	< 20	Soft
	Loose	4 - 9	6 - 14	Soft	500 to 1,000	2 - 4	3 - 5	24 - 35	20 - 29	Firm
	Medium Dense	10 - 29	15 - 46	Medium-Stiff	1,000 to 2,000	4 - 8	6 - 10	36 - 60	30 - 49	Medium Hard
	Dense	30 - 50	47 - 79	Stiff	2,000 to 4,000	8 - 15	11 - 18	61 - 96	50 - 79	Hard
	Very Dense	> 50	≥ 80	Very Stiff	4,000 to 8,000	15 - 30	19 - 36	> 96	>79	Very Hard
				Hard	> 8,000	> 30	> 36			

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
		Gravels with Fines: More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines: More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI plots below "A" line		MH	Elastic Silt[K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \qquad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.