8.3
Geotechnical Investigation

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TRANSMITTAL

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DATE: March 25, 2020

PROJECT: 19-182-00

ATTENTION: Mr. Mauricio Lacuelli

SUBJECT: Preliminary Geotechnical Investigation Report, Cannon Street/Serrano Avenue Intersection Widening, City of Orange, California

DISTRIBUTION:

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Preliminary Geotechnical Investigation Report
Cannon Street/Serrano Avenue
Intersection Widening
City of Orange, California

Prepared For
MICHAEL BAKER INTERNATIONAL

March 25, 2020

GMU Project No. 19-182-00

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INTRODUCTION

PURPOSE

This report presents the results of our limited geotechnical foundation investigation of soil and geologic conditions for the proposed retaining wall that will be constructed along right lane of Cannon Street as part of the Cannon Street/Serrano Avenue Intersection Widening Improvement project.

SCOPE

The scope of our geotechnical foundation investigation, as outlined in our August 29, 2019 proposal and further revised with the City and you, was as follows:

1. Staked two (2) hollow stem auger, truck-mounted drill holes locations, coordinated with the City of Orange, and contacted Underground Service Alert (USA/Dig Alert) in order to provide advance notification of the subsurface drill holes planned within the project site.

2. Performed a field subsurface exploration program consisting of:

    - Advancing two (2) HSA drill holes to a maximum depth of approximately 31 feet below the existing grade with the right lane of Cannon Street.
    - Logging of the subsurface material and obtaining bulk, SPT, and drive soil samples for geotechnical laboratory testing.

3. Performed laboratory testing on soil samples obtained from the drill holes. Testing included moisture and density, gradation, Atterberg limits, maximum density, shear strength characteristics, consolidation, R-value, and full chemical analysis.

4. Interpreted and evaluated the field and laboratory data collected from this investigation, and performed geotechnical engineering design analyses.

6. Prepared and distributed this formal preliminary geotechnical investigation for the project, containing our final geotechnical conclusions and recommendations to support the main project submittal and permitting processes.

LOCATION

The site, as shown on the attached Plate 1 – Location Map, is located on the north bound, easterly lane of Cannon Street and extends approximately 150 feet south of Serrano Avenue, in the City of Orange, California.

PROJECT DESCRIPTION

We understand from our review of the reference (1) plans that proposed project will consist of demolishing of existing privacy wall that is located along the north bound, right lane of Cannon Street south of Serrano Avenue, and construction of new retaining wall to widening the existing right turn lane. The new retaining wall is planned to be constructed within the existing descending slope and is anticipated to retain approximately 14 to 22 feet of soil.

SUBSURFACE EXPLORATION

A subsurface investigation was performed by GMU on January 27, 2020 within the existing right lane of Cannon Street. The exploration performed consisted of excavating two (2) drill holes to a maximum depth of 31 feet below the existing grade in order to observe subsurface conditions and to obtain disturbed (bulk) and relatively undisturbed (drive) samples for geotechnical laboratory testing. The exploratory drill holes were drilled utilizing an eight-inch-diameter, hollow-stem-auger, truck-mounted drill rig and logged by our field engineer. The earth materials encountered were classified in accordance with the Unified Soil Classification System.

The drill hole locations are shown on Plate 2 – Geotechnical Map, and logs of the drill holes are contained in Appendix A.

LABORATORY TESTING

Laboratory testing was performed on bulk and relatively undisturbed samples collected from the exploratory borings during our recent subsurface exploration. Testing on soil samples included the following:

- Moisture and density
- Sieve analysis and hydrometer
- Atterberg limits
- Maximum density
- Consolidation
- Direct shear

- R-value
- Corrosion (pH, resistivity, chlorides, soluble sulfates)

The results of our laboratory testing are summarized on Table B-1 included in Appendix B.

GEOLOGIC FINDINGS

SUBSURFACE MATERIALS

Engineered Fill (Qafe)

Engineered fill soils underlie the site and were observed by others during the previous grading operations (see the reference (1) report) for the adjacent development. The fill depth is approximately 6 to 9 feet.

Alluvial Deposits (Qal)

Alluvial deposits were encountered during our subsurface investigation and underlie the fill material. The alluvial deposits are between approximately 8 and 11 feet in thickness and in general consist of light brown to yellow brown, brown, damp to moist, loose to medium dense, silty sands and clayey sands.

Terrace Deposits (Qt)

Terrace deposits were encountered below the alluvial deposits to the maximum depth of the exploration (31 feet below the existing grade). In general, the terrace deposits consist of light yellow brown to red brown, damp to moist, medium dense to very dense, clayey sands.

Geologic structure of these subsurface material are shown on Plate 3 – Geotechnical Section.

GROUNDWATER

Groundwater was not encountered during our subsurface investigation to a maximum depth of 31 feet below the existing grade. Depth of the high groundwater table was estimated to be deeper than 40 feet in California Geological Survey report (CDMG, 2001). Groundwater conditions may vary across the site due to stratigraphic and hydrologic conditions and may change over time because of seasonal and meteorological fluctuations, or activities by humans at this site and nearby sites. Based on this information, groundwater is not anticipated to impact the proposed improvements.

SEISMIC CONDITIONS

Faulting and Seismicity

Based on our review of the referenced geologic maps and literature, the site is not located within an official Alquist-Priolo Earthquake Fault Zone, and no known active faults are shown on the reviewed geologic maps crossing the site. The nearest known active fault is the Elsinore-Whittier fault, which is located approximately 3 miles north of the site and capable of generating a maximum characteristic earthquake magnitude (Mw) of 7.8. Given the proximity of the site to these and numerous other active and potentially active faults, the site will likely be subject to earthquake ground motions in the future.

Seismic Hazard Zones

The subject property is not located within an area mapped as having the potential for seismic-induced landsliding, nor it is located within an areas designated as having the potential for liquefaction, as shown on the Seismic Hazard Zone Map for the Orange Quadrangle (CDMG, 1998).

GEOTECHNICAL ENGINEERING FINDINGS

FOUNDATION SYSTEMS

Due to the proposed retaining wall planned within an existing slope, and in order to satisfy the CBC structural setback, we recommend that the proposed retaining wall be supported on a pile foundation system embedded into competent alluvial and terrace deposits.

SOIL EXPANSION AND CORROSION

Assessment of soil expansion and corrosion is based on the predominant soil types encountered in the borings, laboratory testing, and our experience working with similar soils in the area. The engineered fills are anticipated to be corrosive to ferrous metals and characterized by a negligible sulfate exposure to concrete. However, based on the high chloride levels in the tested soil samples, the site should be characterized as corrosive per Caltrans standards.

SOIL EXPANSION

Based on laboratory testing of the on-site soils performed previously by Others in accordance with their reference (1) report, the existing near surface material of the subject site is anticipated to have a medium expansion potential. Therefore, expansive soil criteria should be considered in the design.

SOIL CORROSION

Corrosion testing was performed on a soils representative of on-site conditions. The results of the testing are summarized below.

Boring	Depth (ft)	Formation; Soil Type	pH	Soluble Sulfates (ppm)	Soluble Chlorides (ppm)	Min. Resistivity (Ω/cm)
DH-2	0-5	Qafe	8.6	130	864	1,070

According to Caltrans Corrosion Guidelines (November 2012, Version 2.0), soils are considered corrosive to concrete and foundation elements if one or more of the following conditions exist: chloride concentration is 500 ppm or greater, sulfate concentration is 2000 ppm or greater, or the pH is 5.5 or less. Consequently, the site native soils are considered corrosive.

The onsite soils are also severely corrosive to ferrous metals. The laboratory testing program performed for this project does not address the potential for corrosion to copper piping. In this regard, a corrosion engineer should be consulted to perform more detailed testing and develop appropriate mitigation measures (if necessary).

EXCAVATION CHARACTERISTICS

The majority of the soil materials underlying the site can be excavated with scrapers and other conventional grading equipment.

CONCLUSIONS AND RECOMMENDATIONS

DEVELOPMENT FEASIBILITY

Based on our geotechnical findings, it is our opinion that proposed improvements are feasible and practical from a geotechnical standpoint if accomplished in accordance with the City of Orange grading and building requirements and the recommendations presented herein. It is also the opinion of GMU Geotechnical that proposed grading and construction will not adversely affect the geologic stability of existing improvements or adjoining properties provided grading and construction are performed in accordance with the recommendations provided in this report.

SITE PREPARATION AND GRADING

General

All site preparation and grading should be performed in accordance with City of Orange requirements, Caltrans standards, and the recommendations presented in this report.

Demolition, Clearing, and Suitability

Prior to the start of the planned improvements, some of the existing improvements will need to be demolished. All demolished improvements will need to be removed and disposed of off-site, and all significant organic materials such as weeds, grasses, groundcover, shrubs, construction debris, or other decomposable materials should be removed from areas to be graded. Cavities and excavations created upon removal of subsurface obstructions, such as buried utilities, should be cleared of loose soil, shaped to provide access for backfilling and compaction equipment, and then backfilled with properly compacted fill.

GMU should provide periodic observation and testing services during demolition operations to document compliance with the above recommendations. In addition, should unusual or adverse soil conditions or buried structures be encountered during grading that are not described herein, these conditions should be brought to the immediate attention of the project geotechnical consultant for corrective recommendations.

FILL MATERIAL AND PLACEMENT

Suitability

All on-site soil material, less any organics or decomposable debris allowing for rock or broken concrete materials smaller than 6 inches in diameter, is suitable for use as compacted fill.

Compaction Standard and Methodology

All soil material used as compacted fill, processed in-place, or used to backfill trenches, should be moistened, dried, or blended as necessary to a minimum of 2% over the optimum moisture content and compacted to at least 90% relative compaction as determined by ASTM Test Method D 1557.

Material Blending

Existing surficial soils that have dried out are generally below optimum moisture content. In addition, the on-site soils are expected to have variable moisture content depending on the season in which work is performed and the irrigation practices at the time of construction. The majority

of the materials to be handled during grading will require some blending and addition of water to meet acceptable moisture ranges for sufficient compaction (i.e., minimum 2% above optimum moisture content).

TEMPORARY EXCAVATIONS

Temporary excavations for demolitions, earthwork, footings, and utility trenches are expected. We anticipate that unsurcharged excavations with vertical side slopes less than 3 feet high will generally be stable. Our recommendations for temporary excavations are as follows:

- Temporary, unsurcharged excavation sides over 3 feet in height to maximum allowable slope excavation of 20 feet should be sloped based on a Type C soil in accordance with OSHA requirements.

- Where sloped excavations are created, the tops of the slopes should be barricaded so that vehicles and storage loads do not encroach within 10 feet of the tops of the excavated slopes. A greater setback may be necessary when considering heavy vehicles, such as concrete trucks and cranes. GMU should be advised of such heavy vehicle loadings so that specific setback requirements can be established.

- If the temporary construction slopes are to be maintained during the rainy season, berms are recommended to be graded along the tops of the slopes in order to prevent runoff water from entering the excavation and eroding the slope faces.

Our temporary excavation recommendations are provided only as **minimum** guidelines. All work associated with temporary excavations should meet the minimal requirements as set forth by CALOSHA. Temporary slope construction, maintenance, and safety are the responsibility of the contractor.

SEISMIC DESIGN

No active faults have been mapped within the subject site, and the site is not within a designated Alquist-Priolo Earthquake Fault Zone. However, the site is located in the seismically active region of southern California. The Elsinore-Whittier fault zones is located about 3 miles north of the site. A site-specific probabilistic seismic hazard analysis (PSHA) was performed utilizing Caltrans ARS Online program (version 3.0.2) to evaluate the likelihood of various ground motion levels at the site as reflected in peak horizontal ground acceleration (PHGA) and acceleration response spectra (ARS).

Coordinates of N33.8198º and W117.7952º were utilized for evaluation of the ARS. An average shear-wave velocity for the upper 100 feet (V_{S30}) was estimated to be 935 feet per second (285 m/s) based on empirically correlated blowcounts (N_{60}) at Drilled Holes DH-1 & DH-2.

Table below provides the Caltrans design acceleration response spectra for designing the proposed retaining wall.

Site Specific Caltrans Acceleration Spectra

Period (sec)	Caltrans ARS (g) V_{S30}=285 m/s
PGA	0.55
0.1	1
0.2	1.33
0.3	1.42
0.5	1.26
0.75	1.01
1.0	0.83
2.0	0.4
3.0	0.25
4.0	0.18
5.0	0.13

The results of the hazard deaggregation indicated that the total hazard for Design Earthquake, as defined by Caltrans, was primarily dominated by earthquakes with a mean magnitude of 6.63 with a mean site-source distance of 13 miles for the PGA

It should be recognized that much of southern California is subject to some level of damaging ground shaking as a result of movement along the major active (and potentially active) fault zones that characterize this region. Design utilizing the Caltrans ARS is not meant to completely protect against damage or loss of function. Therefore, the preceding parameters should be considered as minimum design criteria.

FOUNDATION SYSTEM DESIGN CRITERIA

Pile Foundation System

It is expected that the proposed mid-slope retaining wall will be supported on pole foundations. As a minimum, the pile foundations should be at least 24 inches in diameter and at least 10 feet below the flat area of the adjacent backyard to achieve the skin friction provided below;

however, the actual dimensions should be determined by the project structural engineer based on the following design parameters.

Bearing Materials. The pile foundations may bear into competent alluvial and terrace deposits as approved by a representative from GMU.

Axial Capacity. An allowable average unit skin friction of 375 psf may be used for design of the pile foundation, provided that the foundation is embedded a minimum of 10 feet below the flat part of the adjacent backyard.

Lateral Load Design. Lateral loads may be resisted by passive resistance within the adjacent earth materials. Due to the downsloping conditions, we recommend an allowable passive earth pressure of 100 psf per foot of depth be used for the upper 8 feet of the site soils below the pile cap and an allowable passive of pressure of 230 psf per foot for portion of the pile that is deeper than 8 feet; however, passive resistance should be disregarded within the upper 2 feet due to loose soil encountered during our exploration. The passive resistance value may be applied over an area equivalent to two pile diameters when the piles are distances greater than 3 times of the pile diameter.

CIDH Construction: The proper construction of CIDH piles is critical to ensure satisfactory foundation support. Care in drilling and placement of steel and concrete will be essential to the quality of the piles. If a flight auger is used for drilling, it will be necessary to drill the bottom 3 feet with a bucket-auger to achieve adequate cleanout of loose or disturbed soil. Alternative methods for cleaning the bottom of the pile boring may be considered. Prior to steel and concrete placement, pile borings should be observed and accepted by GMU representative. Concrete placement by pumping and trimie tube starting from the bottom of the pile boring is recommended. Concrete placement should be continuous. Based on our field exploration, caving may occur within the alluvial deposits, therefore, the contractor should anticipate casing or other approved methods to support the holes during drilling.

RETAINING WALLS DESIGN AND CONSTRUCTION

General

The following criterion is considered applicable to the design and construction of retaining walls at the subject site. The design considers retaining walls that are retaining more than 6 feet of earth (i.e., from top of footing to top of retaining portion of wall) with level backfill condition. In addition, the design assumes the use of select backfill in accordance with Plate 4 – Retaining Wall Construction Detail.

Foundation Recommendations

The wall foundation may be sized based on recommendations found within the Pile Foundation Recommendations section of this report.

Wall Design Parameters

Active Equivalent Fluid Pressure:	45 pcf – level backfill / unrestrained wall (Assumes the use of select soils in backfill zone with sand equivalent)
Weight of Backfill:	125 pcf
Control/Construction Joints:	As a minimum, maximum spacing of 15 feet and at angle points
Waterproofing:	The back side of all retaining walls should be waterproofed down to the top of the foundation prior to placing subdrains or backfill. The design and selection of the waterproofing system is outside the scope of our report and is outside our purview.
Concrete:	0.50 w/c ratio Type II/V cement (geotechnical perspective only).
Wall Backfill and Drainage:	In conformance with Sections 19-6 and 19-3.02C of the Caltrans 2015 Standard Specifications and Retaining Wall Construction Detail Diagram and Notes for backfill and drainage requirements (Plate 4), whichever is more restrict. Materials for structure backfill should be compacted to a relative compaction not less than 95%.

The values presented above assume that the supported grade is level and that surcharge loads are not applied. Appropriate surcharge should be applied and incorporated into the design by the project structural engineer. In addition, these pressures are calculated assuming that a drainage system will be installed behind the retaining walls and that external hydrostatic pressure will not develop behind the walls. Where adequate drainage is not provided behind the walls, further evaluation should be conducted by a geotechnical engineer and the lateral earth pressure values will need to be adjusted accordingly.

The unrestrained values are applicable only when the walls are designed and constructed as cantilevered walls allowing sufficient wall movement to mobilize “active” pressure

conditions. This wall movement should not be less than .01 H (H = height of wall) for the unrestrained values to be applicable.

Wall Dynamic Lateral Load

Given the general seismicity and for retaining walls that are retaining 6 feet or more of soil, it is recommended that the walls also be designed for a seismic lateral load or increment. The total dynamic lateral load may be represented by an equivalent fluid pressure (EFP) of 25 pcf. The dynamic lateral load may be considered to be a triangle with the maximum pressure at the bottom.

STRUCTURAL CONCRETE

Laboratory tests performed indicate that the on-site soils are classified as having a "negligible" sulfate exposure and "S0" sulfate exposure category per ACI 318-14, Table 19.3.1.1. However, due to the low soil resistivity and chloride contents obtained from the tests, the on-site soil is severely corrosive to ferrous metals such as reinforcing steel**. On this basis, we recommend that a Type II/V cement with a maximum water to cement ratio of 0.50 be used for structural elements (i.e., foundations, walls, etc.) or per Caltrans requirements, whichever is more restrict.** Utilization of CBC moderate sulfate level requirements will also serve to reduce the permeability of the concrete and help minimize the potential of water and/or vapor transmission through the concrete. Wet curing of the concrete per ACI Publication 308 is also recommended.

The aforementioned recommendations in regard to concrete are made from a soils perspective only. Final concrete mix design is beyond our purview. All applicable codes, ordinances, regulations, and guidelines should be followed in regard to designing a durable concrete with respect to the potential for sulfate exposure from the on-site soils and/or changes in the environment.

CORROSION PROTECTION OF METAL STRUCTURES

Corrosion protection and reinforcement concrete cover requirements shall be considered per Caltrans standards.

SURFACE DRAINAGE

Surface drainage should be carefully controlled during and after grading to prevent ponding and uncontrolled runoff adjacent to the structures. Particular care will be required during grading to maintain slopes, swales, and other erosion control measures needed to direct runoff toward

permanent surface drainage facilities. Positive drainage of at least 2% away from the perimeters of the structures and site pavements should be incorporated into the design. In addition, it is recommended that nuisance water be directed away from the perimeter of the structures by the use of area drains in adjacent landscape and flatwork areas and roof drains tied into the site storm drain system.

UTILITY TRENCH BACKFILL CONSIDERATIONS

General

New utility line pipeline trenches should be backfilled with both select bedding materials beneath and around the pipes (pipe zone) and compacted soil above the pipe bedding. Recommendations for the types of the materials to be used and the proper placement of these materials are provided in the following sections.

Pipe Zone

The pipe bedding and shading materials should extend from at least 6 inches below the pipes to at least 12 inches above the crown of the pipes. Pipe bedding should consist of either clean sand with a sand equivalent (SE) of at least 30, or crushed rock. If crushed rock is used, it should consist of ¾-inch crushed rock that conforms to Table 200-1.2.1 (A) of the 2018 "Greenbook" and should be separated from the native soils by a geofabric layer such as Mirafi 160N or equivalent. Pipe bedding should also meet the minimum requirements of the City of Orange. If the requirements of the City are more stringent, they should take precedence over the geotechnical recommendations. Sufficient laboratory testing should be performed to verify the bedding meets the minimum requirements of the Greenbook and City of Orange grading codes.

Based on our subsurface exploration and knowledge of the onsite materials, the soils that will be excavated from the pipeline trenches will not meet the recommendations for pipe bedding materials; therefore, imported materials will be required for pipe bedding.

Granular pipe bedding material having a sand equivalent of 30 or greater should be properly placed in thicknesses not exceeding 3 feet, and then sufficiently flooded or jetted in place.

Trench Backfill

All existing soil material within the limits of the site are considered suitable for use as trench backfill above the pipe bedding zone if care is taken to remove all significant organic and other decomposable debris, moisture condition the soil materials as necessary, and separate and selectively place and/or stockpile any inert materials larger than 6 inches in maximum diameter.

Imported soils are not anticipated for backfill since the on-site soils are suitable. However, if imported soils are used, the soils should consist of clean, granular materials with physical and chemical characteristics similar to or better than those described herein for on-site soils. Any imported soils to be used as backfill should be evaluated and approved by GMU prior to placement.

Soils to be used as trench backfill should be moistened, dried, or blended as necessary to achieve a minimum of 2% over optimum moisture content (i.e., if the optimum moisture content is 10.5%, the compacted fill's moisture content shall be at least 12.5%), placed in loose lifts no greater than 8 inches thick, and mechanically compacted/densified to at least 90% relative compaction as determined by ASTM Test Method D 1557. Jetting is not permitted in this trench zone.

No rock or broken concrete greater than 6 inches in maximum diameter should be utilized in the trench backfills.

PLAN REVIEW / GEOTECHNICAL TESTING DURING GRADING / FUTURE REPORTS

Plan Review

Our office should review the final approved precise grading plans and retaining wall plans and calculations for the site and comment on the anticipated effects of any major changes from the plan reviewed for this report.

FUTURE SERVICES

GMU should review the final construction plans to confirm they are consistent with our recommendations provided in this report.

Geotechnical Testing

It is recommended that geotechnical observation and testing be performed by GMU during the following stages of precise grading and construction:

- During site clearing and grubbing.
- During removal of any buried irrigation lines or other subsurface structures.

- During all phases of precise grading including over-excavation, temporary excavations, removals, scarification, ground preparation, moisture conditioning, proof-rolling, over-excavation, and placement and compaction of all fill materials.
- During installation of all foundations elements.
- During backfill of underground utilities.
- During waterproof and backfill of retaining walls.
- During installation of drainage systems.
- During pavement section placement and compaction.
- When any unusual conditions are encountered.

LIMITATIONS

All parties reviewing or utilizing this report should recognize that the findings, conclusions, and recommendations presented represent the results of our professional geological and geotechnical engineering efforts and judgments. Due to the inexact nature of the state of the practice of these professions and the possible occurrence of undetected variables in subsurface conditions, we cannot guarantee that the conditions actually encountered during grading and site construction will be identical to those observed, sampled, and interpreted during our study, or that there are no unknown subsurface conditions which could have an adverse effect on the use of the property. We have exercised a degree of care comparable to the standard of practice presently maintained by other professionals in the fields of geotechnical engineering and engineering geology, and believe that our findings present a reasonably representative description of geotechnical conditions and their probable influence on the grading and use of the property.

Our conclusions and recommendations are based on the assumption that our firm will act as the geotechnical engineer of record during construction and grading of the project to observe the actual conditions exposed, to verify our design concepts and the grading contractor's general compliance with the project geotechnical specifications, and to provide our revised conclusions and recommendations should subsurface conditions differ significantly from those used as the basis for our conclusions and recommendations presented in this report. Since our conclusions and recommendations are based on a limited amount of current and previous geotechnical exploration and analysis, all parties should recognize the need for possible revisions to our conclusions and recommendations during grading of the project.

It should be further noted that the recommendations presented herein are intended solely to minimize the effects of post-construction soil movements. Consequently, minor cracking and/or distortion of all on-site improvements should be anticipated.

This report has not been prepared for the use by other parties or projects other than those named or described herein. This report may not contain sufficient information for other parties or other purposes.

CLOSURE

We are pleased to present the results of our geotechnical foundation investigation for this project. The Plates and Appendices that complete this report are listed in the Table of Contents.

If you have any questions concerning our findings or recommendations, please do not hesitate to contact us and we will be happy to discuss them with you.

Respectfully submitted,

Nadim Sunna, MS, PE 84197
Senior Engineer

Ali Bastani, PhD, PE, GE
Director of Engineering

ns/19-182-00 (3-25-2020)

REFERENCES

(1) G.A. Nicoll and Associates, Soil and Geologic Investigation, Tracts 9708, 9709 and 9710, Orange, California, G.A. Nicoll Project No. 1643, dated January 1977.

(2) California Building Standards Commission and International Conference of Building Officials, 2019, *2019 California Building Code.*

(3) California Department of Conservation, Division of Mines and Geology, Seismic Hazard Zone Report for the Orange 7.5-Minute Quadrangle, Orange County, California, Seismic Hazard Zone Report 011, dated 1997 (Revised 2001).

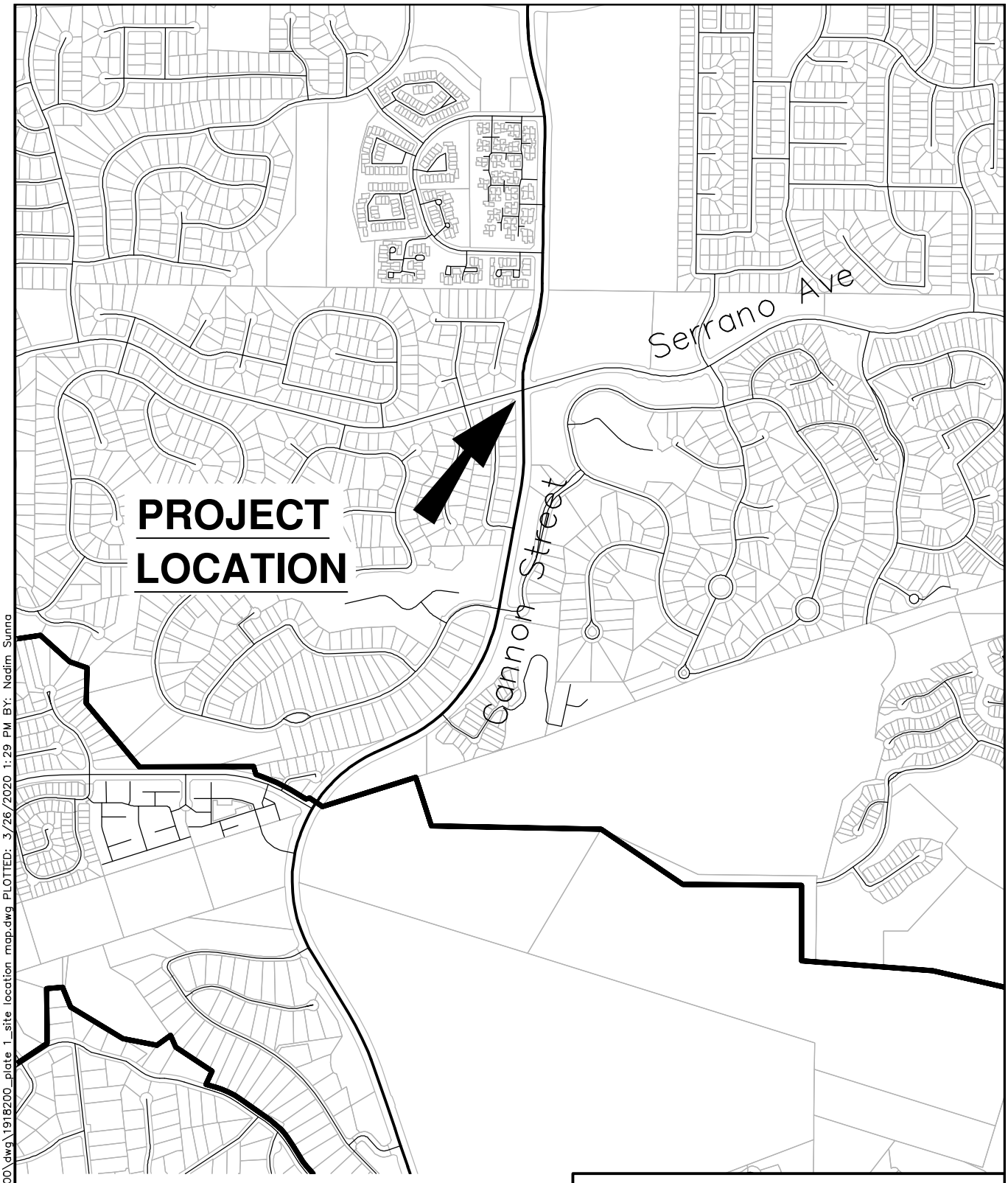
(4) California Geological Survey, Earthquake Zones of Required Investigation, Orange Quadrangle, dated April 15, 1998.

(5) Caltrans, Corrosion Guidelines, Version 2.0, dated November 2012.

(6) Standard Specifications for Public Works Construction, by Public Works Standards, Inc., 2018, *The Greenbook 2018 Edition*.

(7) U.S. Geological Survey, 2013a, 2008 Interactive De-aggregations Program; web site address: http://geohazards.usgs.gov/deaggint/2008/.

(8) U.S. Geological Survey, 2013b, U.S. Seismic Design Maps, web site address: http://earthquake.usgs.gov/hazards/designmaps/usdesign.php.



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Location

Cannon St. & Serrano Ave.
Orange, CA.

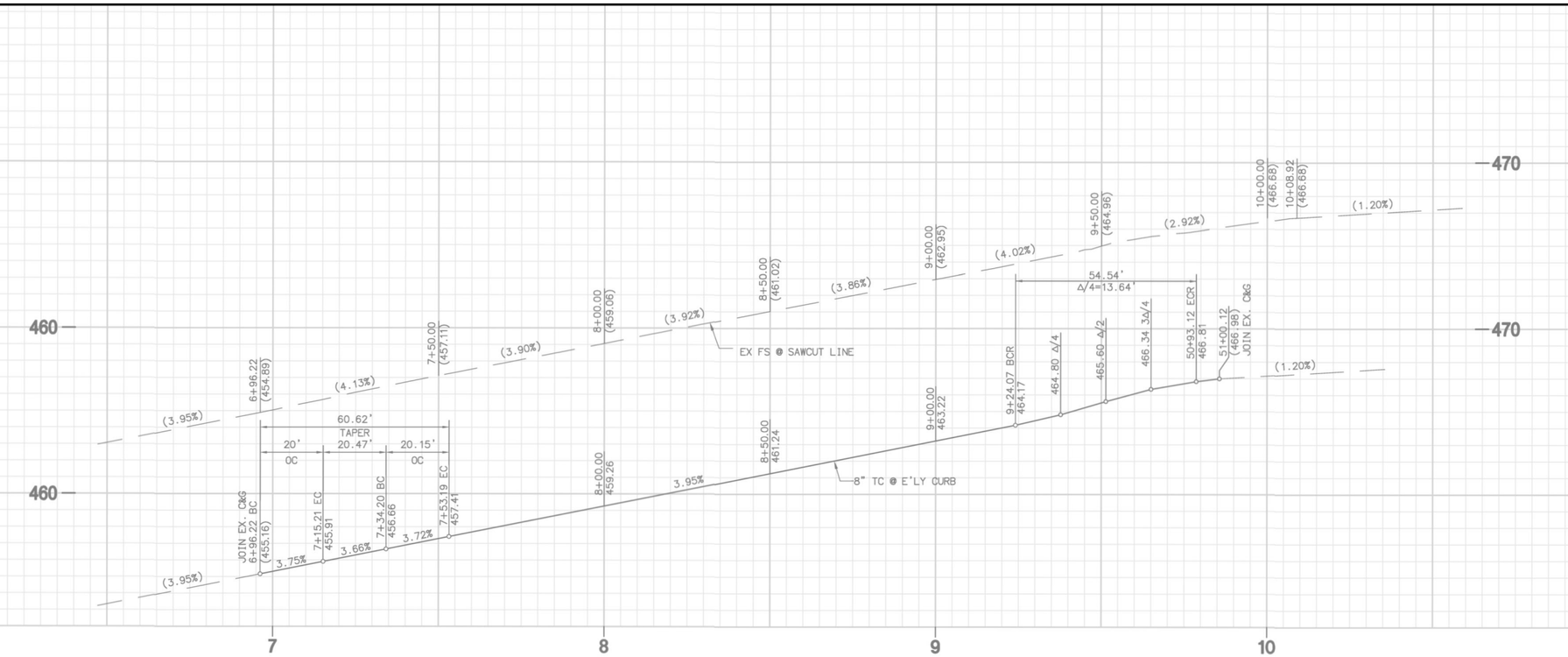
LOCATION MAP

GMU	Date: March 25, 2020	Plate 1
	Project No.: 19-182-00	

PROFILE
HORIZ: 1"=20'
VERT: 1"=4'

Geotechnical Map

GMU | Date: March 25, 2020 | Project No.: 19-182.00 | Plate 2

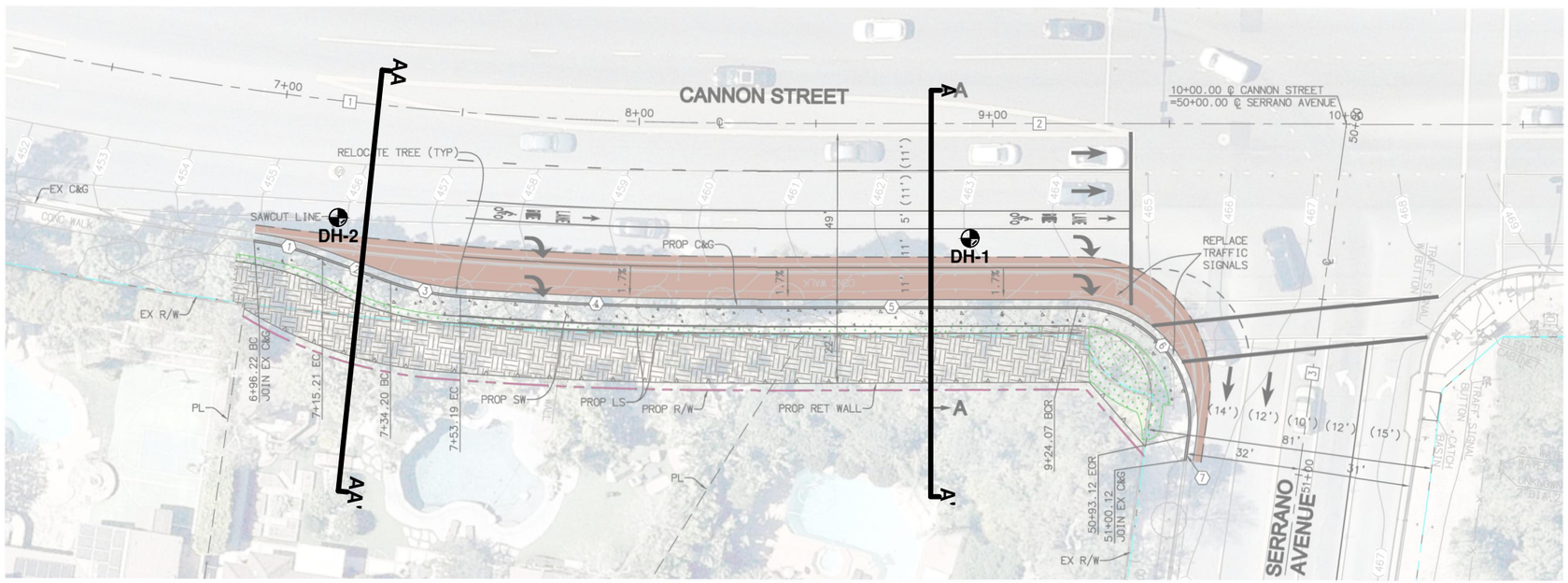


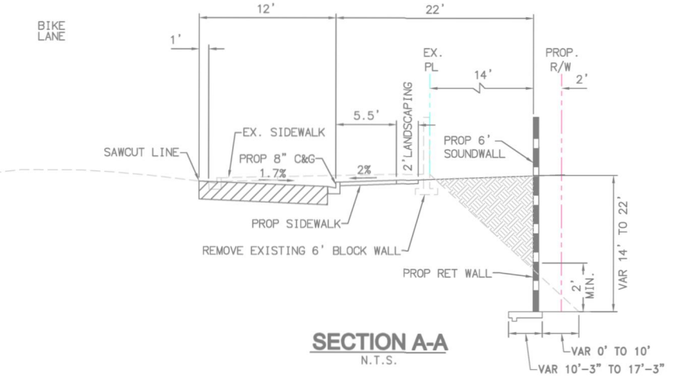
GEOTECHNICAL LEGEND

DH-4 APPROXIMATE DRILL HOLE LOCATION

A A' GEOTECHNICAL SECTION

LEGEND
- PROPOSED IMPROVEMENTS
- EXISTING R/W
- PROPOSED R/W
- EQUESTRIAN VINYL FENCE
- PROPOSED RETAINING WALL
- PROPOSED PAVEMENT
- PROPOSED LANDSCAPING
- PROPOSED HORSE TRAIL





SECTION A-A
N.T.S.

LINE/CURVE DATA TABLE

NO	BEARING/DELTA	RADIUS	LENGTH	NOTE
1	12°46'16"	89.74'	20.00'	6" CURB & GUTTER
2	N 11°57'18" E	---	20.47'	6" CURB & GUTTER
3	15°29'59"	74.50'	20.15'	6" CURB & GUTTER
4	04°11'46"	1051.75'	77.03'	6" CURB & GUTTER
5	N 07°38'59" W	---	97.64'	6" CURB & GUTTER
6	97°39'13"	32.00'	54.54'	6" CURB & GUTTER
7	N 89°59'46" W	---	7.00'	6" CURB & GUTTER

STREET ℄ DATA TABLE

NO	BEARING/DELTA	RADIUS	LENGTH	NOTE
1	12°49'06"	1000.00'	223.72'	CANNON STREET
2	N 07°38'59" W	---	173.57'	CANNON STREET
3	N 89°59'46" W	---	363.29'	SERRANO AVENUE

0 40'

1/21/20

THESE PLANS WERE PREPARED IN THE OFFICE OF:

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CITY OF ORANGE
OFFICE OF THE CITY ENGINEER

GEOMETRIC APPROVAL DRAWING
CANNON STREET & SERRANO AVENUE
INTERSECTION IMPROVEMENT PLAN

SHEET 1 OF 2 SHEETS

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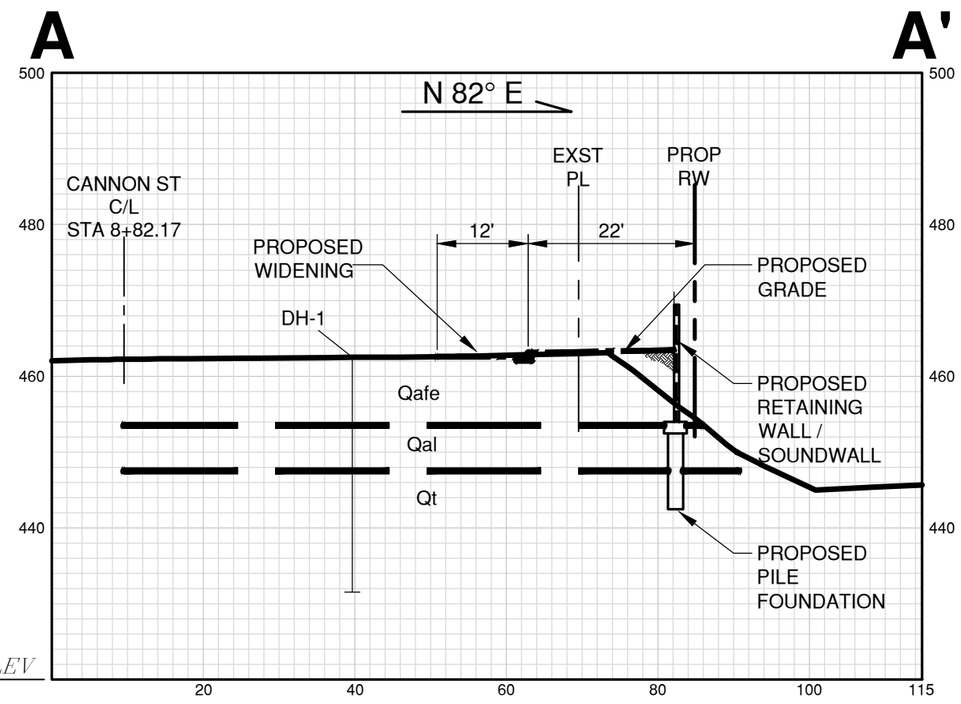

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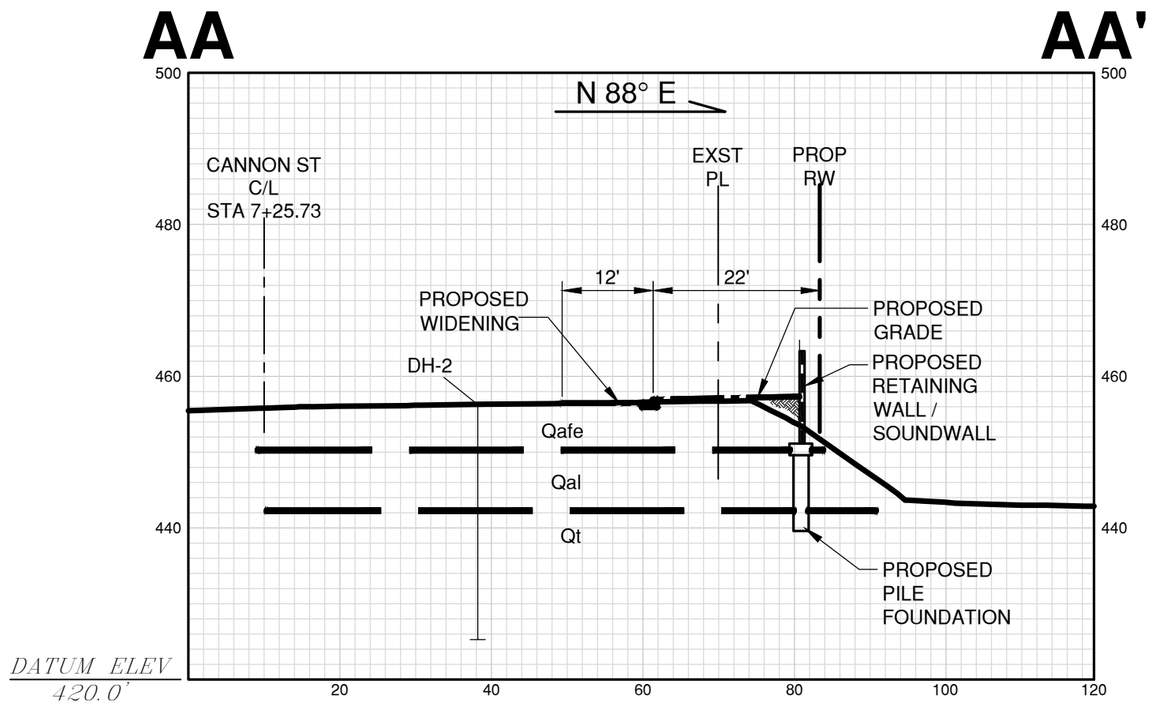


GROUP 19-182-00
SECTION AA - AA'
SCALE: 1" = 20'

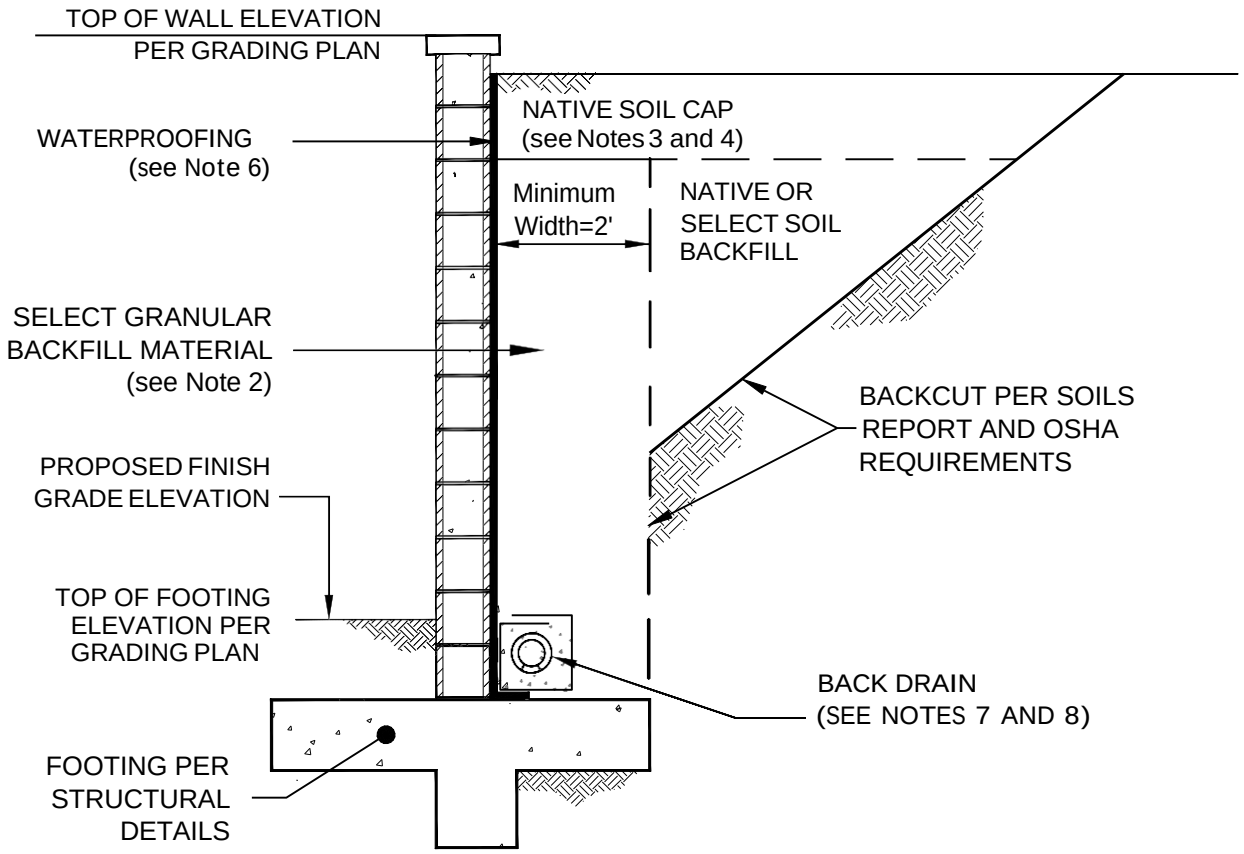
0 20'

Geotechnical Section
A - A' & AA - AA'

GMU

Date:	March 25, 2020
Project No.:	19-182-00

Plate 3



RETAINING WALL DETAIL

NOT TO SCALE

1. FINAL DETERMINATION OF THE MATERIAL TO BE USED FOR BACKFILL SHALL BE MADE BY GMU.
2. ALL SELECT BACKFILL TO WITHIN 1 TO 2 FEET OF FINAL GRADE SHOULD CONSIST OF FREE-DRAINING GRANULAR MATERIAL (I.E. SE 30 SAND, PEA GRAVEL, OR CRUSHED ROCK). CRUSHED ROCK, IF USED, SHOULD BE WRAPPED IN FILTER FABRIC (MIRAFI 140N OR EQUIVALENT) TO MINIMIZE THE POTENTIAL FOR MIGRATION OF FINES INTO THE ROCK. THE SELECT BACKFILL SHOULD BE MOISTURE CONDITIONED TO ACHIEVE OVER OPTIMUM MOISTURE CONTENT PER THE SOILS REPORT AND COMPACTED TO AT LEAST 90% RELATIVE COMPACTION AS DETERMINED BY ASTM TEST METHOD D 1557.
3. FINE-GRAINED NATIVE SOILS SHOULD BE USED TO CAP THE SELECT BACKFILL ZONE.
4. ALL NATIVE OR SELECT SOIL WALL BACKFILL SHOULD BE MOISTURE CONDITIONED AS NECESSARY TO OVER OPTIMUM MOISTURE CONTENT PER THE SOILS REPORT AND COMPACTED TO AT LEAST 95% RELATIVE COMPACTION AS DETERMINED BY ASTM TEST METHOD D 1557.
5. THE BACKSIDE OF THE WALLS SHOULD BE WATERPROOFED DOWN TO AND ACROSS THE TOP OF THE FOOTING. THE DESIGN AND SELECTION OF THE WATERPROOFING SYSTEM IS OUTSIDE OF THE PURVIEW OF GMU.
6. THE WATERPROOFING SYSTEM AND ANY DRAIN BOARDS SHOULD BE PROTECTED FROM DAMAGE BY CONSTRUCTION ACTIVITIES. THE TOP EDGE OF THE WATERPROOFING AND ANY DRAIN BOARDS SHOULD BE PROPERLY ADHERED TO THE WALL AND SEALED TO PREVENT THE POSSIBLE ACCUMULATION OF DEBRIS BETWEEN THE DRAINAGE/WATERPROOFING SYSTEM AND THE WALL.
7. THE BACKDRAIN SYSTEM SHOULD CONSIST OF 4" PERFORATED PIPE SURROUNDED BY AT LEAST ONE CUBIC FOOT OF 3/4"-1.5" OPEN GRADED GRAVEL WRAPPED IN MIRAFI 140 N FILTER FABRIC (OR EQUIVALENT). THE PERFORATED PIPE SHOULD CONSIST OF SDR-35 OR SCHEDULE 40 PVC PIPE (OR APPROVED EQUIVALENT) LAID ON AT LEAST 2" OF CRUSHED ROCK WITH THE PERFORATIONS LAID DOWN. THE BACKDRAIN GRADIENT SHOULD NOT BE LESS THAN 1% WHEN POSSIBLE. THE PERFORATED PIPE SHOULD OUTLET INTO AREA DRAINS OR OTHER SUITABLE OUTLET POINTS AT RUNS OF 200 FEET OR LESS, IF PRACTICAL. IF THE BACKDRAINS CANNOT BE OUTLETED BY GRAVITY FLOW, A SUMP PUMP SYSTEM WILL NEED TO BE DESIGNED AND CONSTRUCTED. REDUNDANT BACK-UP PUMPS OR COMPONENTS ARE RECOMMENDED. DESIGN OF THIS SYSTEM IS OUTSIDE OF THE PURVIEW OF GMU.
8. THE TIE-IN LOCATIONS FOR BACKDRAIN OUTLETS SHOULD BE SHOWN ON THE PRECISE GRADING, SITE WALL, AND/OR LANDSCAPE PLANS.

GMU	**RETAINING WALL CONSTRUCTION DETAIL**	PLATE **4**

APPENDIX A

Geotechnical Exploration Procedures and Logs

APPENDIX A

GMU GEOTECHNICAL EXPLORATION PROCEDURES AND LOGS

Our exploration at the subject site consisted of two (2) drill holes to maximum depth of 31 feet below the existing grade. The estimated locations of the explorations are shown on Plate (1) – (Geotechnical Map). Our drill holes were logged by a Certified Engineer and bulk, drive, and SPT samples of the excavated soils were collected. "Undisturbed" samples were taken using a 3.0-inch for thin walled, outside-diameter drive sampler which contains a 2.416-inch- diameter brass sample sleeve 6 inches in length. Blow counts recorded during sampling from the drive and SPT are shown on the drill hole logs. The logs of each drill hole are contained in this Appendix A, and the Legend to Logs is presented as Plate A-1 and A-2.

The geologic and engineering field descriptions and classifications that appear on these logs are prepared according to Corps of Engineers and Bureau of Reclamation standards. Major soil classifications are prepared according to the Unified Soil Classification System as modified by ASTM Standard No. 2487. Since the descriptions and classifications that appear on the Log of Drill hole are intended to be that which most accurately describe a given interval of a drill hole (frequently an interval of several feet), discrepancies do occur in the Unified Soil Classification System nomenclature between that interval and a particular sample in that interval. For example, an 8-foot-thick interval in a log may be identified as silty sand (SM) while one sample taken within the interval may have individually been identified as sandy silt (ML). This discrepancy is frequently allowed to remain to emphasize the occurrence of local textural variations in the interval.

MAJOR DIVISIONS			Group Letter	Symbol	TYPICAL NAMES
COARSE-GRAINED SOILS More Than 50% Retained On No.200 Sieve Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	GRAVELS 50% or More of Coarse Fraction Retained on No.4 Sieve	Clean Gravels	GW		Well Graded Gravels and Gravel-Sand Mixtures, Little or No Fines.
			GP		Poorly Graded Gravels and Gravel-Sand Mixtures Little or No Fines.
		Gravels With Fines	GM		Silty Gravels, Gravel-Sand-Silt Mixtures.
			GC		Clayey Gravels, Gravel-Sand-Clay Mixtures.
	SANDS More Than 50% of Coarse Fraction Passes No.4 Sieve	Clean Sands	SW		Well Graded Sands and Gravelly Sands, Little or No Fines.
			SP		Poorly Graded Sands and Gravelly Sands, Little or No Fines.
		Sands With Fines	SM		Silty Sands, Sand-Silt Mixtures.
			SC		Clayey Sands, Sand-Clay Mixtures.
FINE-GRAINED SOILS 50% or More Passe The No.200 Sieve Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	SILTS AND CLAYS Liquid Limit Less Than 50%		ML		Inorganic Silts, Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts With Slight Plasticity.
			CL		Inorganic Clays of Low To Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays.
			OL		Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid Limit 50% or Greater		MH		Inorganic Silts, Micaceous or Diatomaceous Fine Sandy or Silty Soils, Elastic Silts.
			CH		Inorganic Clays of High Plasticity, Fat Clays.
			OH		Organic Clays of Medium To High Plasticity, Organic Silts.
HIGHLY ORGANIC SOILS			PT		Peat and Other Highly Organic Soils.

The descriptive terminology of the logs is modified from current ASTM Standards to suit the purposes of this study

ADDITIONAL TESTS

DS = Direct Shear
HY = Hydrometer Test
TC = Triaxial Compression Test
UC = Unconfined Compression
CN = Consolidation Test
(T) = Time Rate
EX = Expansion Test
CP = Compaction Test
PS = Particle Size Distribution
EI = Expansion Index
SE = Sand Equivalent Test
AL = Atterberg Limits
FC = Chemical Tests
RV = Resistance Value
SG = Specific Gravity
SU = Sulfates
CH = Chlorides
MR = Minimum Resistivity
pH
(N) = Natural Undisturbed Sample
(R) = Remolded Sample
CS = Collapse Test/Swell-Settlement

GEOLOGIC NOMENCLATURE

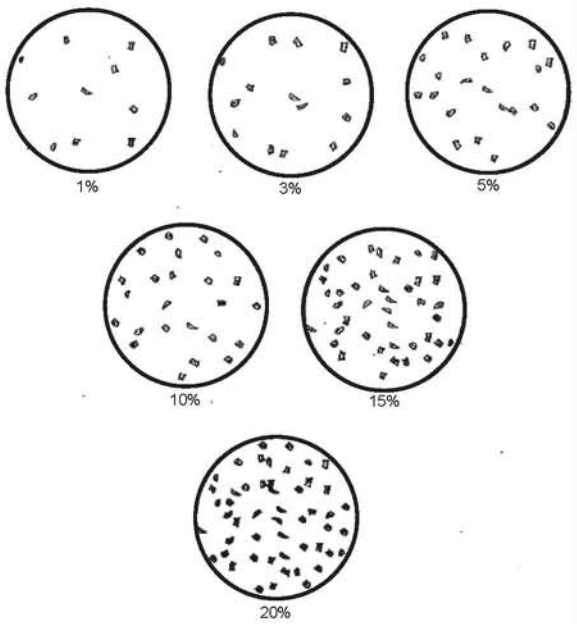
B = Bedding C = Contact J = Joint
F = Fracture Flt = Fault S = Shear
RS = Rupture Surface = Seepage
= Groundwater

SAMPLE SYMBOLS

Undisturbed Sample (California Sample)
Undisturbed Sample (Shelby Tube)
Bulk Sample
Unsuccessful Sampling Attempt
SPT Sample

5
10 Blows per 6-Inches Penetration
15

10: 10 Blows for 12-Inches Penetration
6/4": 6 Blows for 4-Inches Penetration
P: Push
(13): Uncorrected Blow Counts ("N" Values) for 12-Inches Penetration- Standard Penetration Test (SPT)



GMU

LEGEND TO LOGS

ASTM Designation: D 2487
(Based on Unified Soil Classification System)

Plate
A-1

P8-11/16/2012

SOIL DENSITY/CONSISTENCY

FINE GRAINED

Consistency	Field Test	SPT (#blows/foot)	Mod (#blows/foot)
Very Soft	Easily penetrated by thumb, exudes between fingers	<2	<3
Soft	Easily penetrated one inch by thumb, molded by fingers	2-4	3-6
Firm	Penetrated over 1/2 inch by thumb with moderate effort	4-8	6-12
Stiff	Penetrated about 1/2 inch by thumb with great effort	8-15	12-25
Very Stiff	Readily indented by thumbnail	15-30	25-50
Hard	Indented with difficulty by thumbnail	>30	>50

COARSE GRAINED

Density	Field Test	SPT (#blows/foot)	Mod (#blows/foot)
Very Loose	Easily penetrated with 0.5" rod pushed by hand	<4	<5
Loose	Easily penetrated with 0.5" rod pushed by hand	4-10	5-12
Medium Dense	Easily penetrated 1' with 0.5" rod driven by 5lb hammer	10-30	12-35
Dense	Dificult to penetrat 1' with 0.5" rod driven by 5lb hammer	31-50	35-60
Very Dense	Penetrated few inches with 0.5" rod driven by 5lb hammer	>50	>60

BEDROCK HARDNESS

Density	Field Test	SPT (#blows/foot)
Soft	Can be crushed by hand, soil like and structureless	1-30
Moderately Hard	Can be grooved with fingernails, crumbles with hammer	30-50
Hard	Can't break by hand, can be grooved with knife	50-100
Very Hard	Scratches with knife, chips with hammer blows	>100

MODIFIERS

Trace	1%
Few	1-5%
Some	5-12%
Numerous	12-20%
Abundant	>20%

GRAIN SIZE

Description		Sieve Size	Grain Size	Approximate Size
Boulders		>12"	>12"	Larger than a basketball
Cobbles		3-12"	3-12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4-3"	3/4-3"	Thumb-sized to fist-sized
	Fine	#4-3/4"	0.19-0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10-#4	0.079-0.19"	Rock-salt-sized to pea-sized
	Medium	#40-#10	0.017-0.079"	Sugar-sized to rock salt-sized
	Fine	#200-#40	0.0029-0.017"	Flour-sized to sugar-sized
Fines		passing #200	<0.0029"	Flour-sized and smaller

MOISTURE CONTENT

Dry- Very little or no moisture
Damp- Some moisture but less than optimum
Moist- Near optimum
Very Moist- Above optimum
Wet/Saturated- Contains free moisture

GMU

LEGEND TO LOGS

ASTM Designation: D 2487
(Based on Unified Soil Classification System)

Plate
A-2

Project: Cannon Street Widening
Project Location: City of Orange
Project Number: 19-182-00

Log of Drill Hole DH-1

Date(s) Drilled	**1/27/2020**	Logged By	**MTF**	Checked By	**NS**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**MR Drilling**	Total Depth of Drill Hole	**31.0 feet**
Drill Rig Type	**CME 95**	Diameter(s) of Hole, inches	**8"**	Approx. Surface Elevation, ft MSL	**462.0**
Groundwater Depth [Elevation], feet		Sampling Method(s)	**California Modified Sampler with 6-inch sleeve/SPT**	Drill Hole Backfill	**Native**
Remarks	**8" Asphalt**			Driving Method and Drop	**140 lb hammer, 30" drop**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
460	0		**ENGINEERED FILL (Qafe)**		SILTY SAND (SM); light brown, damp to moist, loose, fine to medium grained sand, trace clay				12		
	5				SANDY CLAY (CL); dark brown, moist to very moist, soft, fine to medium grained sand, mottled brown and trace white		2 3 2		14		
455											
			ALLUVIUM (Qal)		SILTY SAND (SM); light brown to yellowish brown, damp to moist, loose, fine to medium grained sand, trace clay, trace coarse grained sand, trace gravel		4 4 5		6	97	
450	10						3 5 7				
	15				CLAYEY SAND (SC); brown with trace pale red/pink, damp, medium dense, fine to coarse grained sand with some fine gravel some rounded sone fractured		5 5 6		10	98	
445							11 9 5		8		
					Becomes brown, damp to moist						

GMU

Drill Hole DH-1

Project: Cannon Street Widening
Project Location: City of Orange
Project Number: 19-182-00

Log of Drill Hole DH-1

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			TERRACE DEPOSITS (Qt)		CLAYEY SAND (SC); light yellowish brown to light red brown, damp to moist, medium dense to very dense, fine to coarse grained sand, trace fine gravel		8 10 16		4		
440											
	25						6 6 4				
435											
	30						27 50/6"		15	115	
					Total Depth = 31' No groundwater No Caving						

DH_REV3 19-182-00.GPJ GMULAB.GPJ 3/17/20

Project: Cannon Street Widening
Project Location: City of Orange
Project Number: 19-182-00

Log of Drill Hole DH-2

Date(s) Drilled	**1/27/2020**	Logged By	**MTF**	Checked By	**NS**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**MR Drilling**	Total Depth of Drill Hole	**31.0 feet**
Drill Rig Type	**CME 95**	Diameter(s) of Hole, inches	**8"**	Approx. Surface Elevation, ft MSL	**458.0**
Groundwater Depth [Elevation], feet		Sampling Method(s)	**California Modified Sampler with 6-inch sleeve/SPT**	Drill Hole Backfill	**Native**
Remarks	**8.5" Ashpalt**			Driving Method and Drop	**140 lb hammer, 30" drop**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			ENGINEERED FILL (Qafe)		SILTY SAND (SM); light yellowish brown, dry, loose, fine to coarse grained sand, numerous fine to coarse gravel				7		
455					CLAYEY SAND (SC); light brown to brown, damp to moist, loose, fine to medium grained sand, trace coarse grained sand						
	5				Becomes damp with trace pinkish coloring, some caliche		4 5 4				
			ALLUVIUM (Qal)		CLAYEY SAND (SC); brown, damp, loose to medium dense, fine-grained sand						
450											
	10						4 5 7		11	97	
445					Becomes damp to moist, medium dense		8 7 7				
			TERRACE DEPOSITS (Qt)		SILTY SAND (SM); light brown, damp, medium dense, fine to medium grained sand, trace clay						
	15						4 6 8		9	96	
440							4 6 8				

DH_REV3 19-182-00.GPJ GMULAB.GPJ 3/17/20

Project: Cannon Street Widening
Project Location: City of Orange
Project Number: 19-182-00

Log of Drill Hole DH-2

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					CLAYEY SAND (SC); light and medium brown, damp to moist, medium dense, fine to medium grained sand, trace fine gravel		6 7 8		8	97	
435											
	25				brown with trace white, moist		6 7 9				
430											
	30						8 11 12		11	105	
					Total Depth = 31' No groundwater No Caving						

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APPENDIX B

Geotechnical Laboratory Procedures and Test Results

APPENDIX B

GMU GEOTECHNICAL LABORATORY PROCEDURES AND TEST RESULTS

MOISTURE AND DENSITY

Field moisture content and in-place density were determined for each 6-inch sample sleeve of undisturbed soil material obtained from the drill holes. The field moisture content was determined in general accordance with ASTM Test Method D 2216 by obtaining one-half the moisture sample from each end of the 6-inch sleeve. The in-place dry density of the sample was determined by using the wet weight of the entire sample.

At the same time the field moisture content and in-place density were determined, the soil material at each end of the sleeve was classified according to the Unified Soil Classification System. The results of the field moisture content and in-place density determinations are presented on the right-hand column of the Log of Drill Hole and are summarized on Table B-1. The results of the visual classifications were used for general reference.

PARTICLE SIZE DISTRIBUTION

As part of the engineering classification of the materials underlying the site, samples were tested to determine the distribution of particle sizes. The distribution was determined in general accordance with ASTM Test Method D 422 using U.S. Standard Sieve Openings 3", 1.5", 3/4, 3/8, and U.S. Standard Sieve Nos. 4, 10, 20, 40, 60, 100, and 200. In addition, on some samples a standard hydrometer test was performed to determine the distribution of particle sizes passing the No. 200 sieve (i.e., silt and clay-size particles). The results of the tests are contained in Appendix B. Key distribution categories (% gravel; % sand, etc.) are contained on Table B-1.

ATTERBERG LIMITS

As part of the engineering classification of the soil material, samples of the on-site soil material were tested to determine relative plasticity. This relative plasticity is based on the Atterberg limits determined in general accordance with ASTM Test Method D 4318. The results of these tests are contained in this Appendix B and also Table B-1.

CHEMICAL TESTS

The corrosion potential of typical on-site materials under long-term contact with both metal and concrete was determined by chemical and electrical resistance tests. The soluble sulfate test for potential concrete corrosion was performed in general accordance with California Test Method 417, the minimum resistivity test for potential metal corrosion was performed in general accordance with California Test Method 643, and the concentration of soluble chlorides was determined in general accordance with California Test Method 422. The results of these tests are contained in Appendix B and also Table B-1.

COMPACTION TESTS

A bulk sample representative of the on-site materials was tested to determine the maximum dry density and optimum moisture content of the soil. These compactive characteristics were determined in general accordance with ASTM Test Method D 1557. The results of this test are contained in Appendix B and also Table B-1.

CONSOLIDATION TESTS

The one-dimensional consolidation properties of "undisturbed" samples were evaluated in general accordance with the provisions of ASTM Test Method D 2435. Sample diameter was 2.416 inches and sample height was 1.00 inch. Water was added during the test at various normal loads to evaluate the potential for hydro-collapse and to produce saturation during the remainder of the testing. Consolidation readings were taken regularly during each load increment until the change in sample height was less than approximately 0.0001 inch over a two-hour period. The graphic presentation of consolidation data is a representation of volume change in change in axial load. In addition, time rate tests were performed for a sample. The results of these tests are contained in Appendix B.

DIRECT SHEAR STRENGTH TESTS

Direct shear tests were performed on typical on-site materials. The general philosophy and procedure of the tests were in accord with ASTM Test Method D 3080 - "Direct Shear Tests for Soils Under Consolidated Drained Conditions".

The tests are single shear tests and are performed using a sample diameter of 2.416 inches and a height of 1.00 inch. The normal load is applied by a vertical dead load system. A constant rate of strain is applied to the upper one-half of the sample until failure occurs. Shear stress is monitored by a strain gauge-type precision load cell and deflection is measured with a digital dial indicator. This data is transferred electronically to data acquisition software which plots shear strength vs. deflection. The shear strength plots are then interpreted to determine either peak or ultimate shear strengths. Residual strengths were obtained through multiple shear box

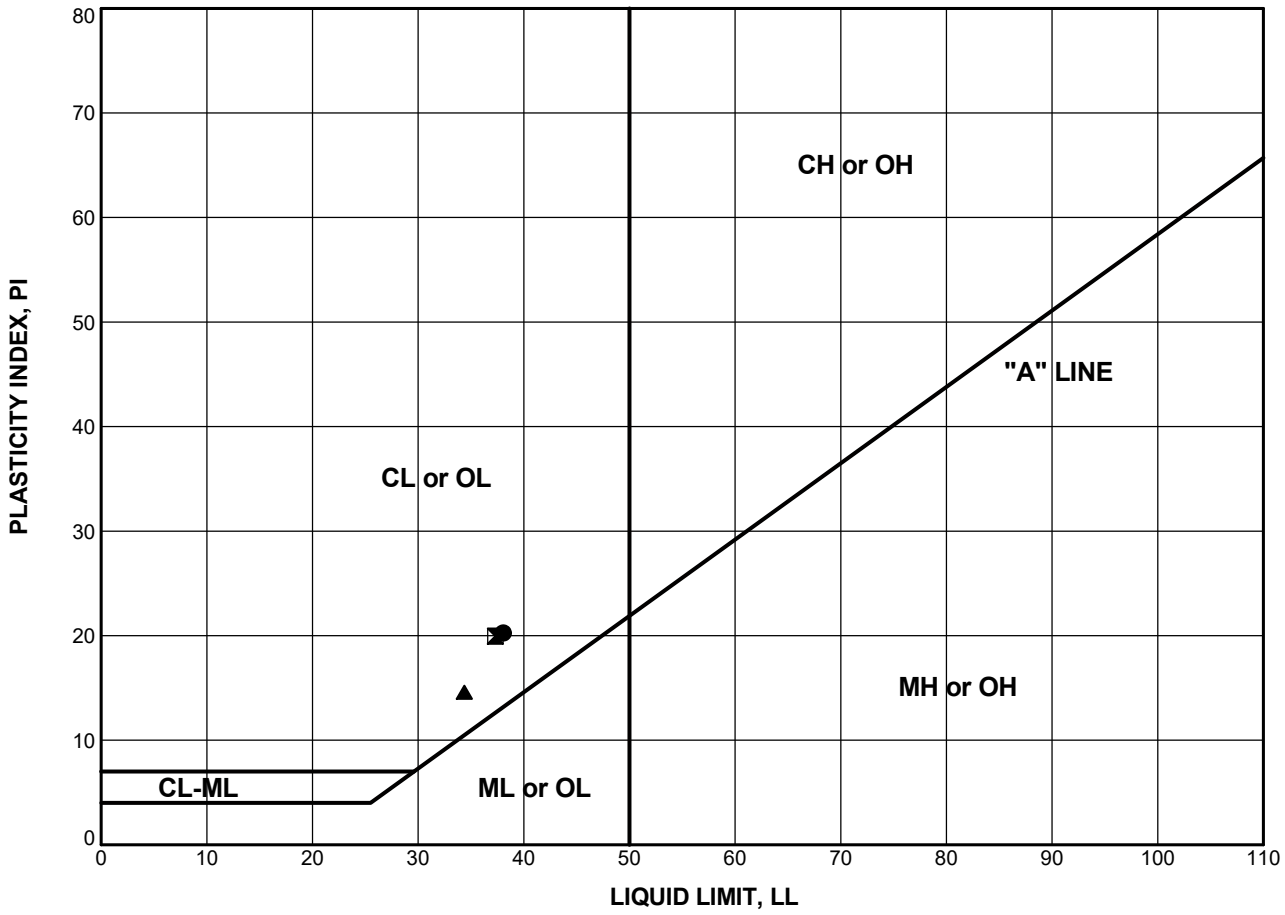
reversals. A strain rate compatible with the grain size distribution of the soils was utilized. The interpreted results of these tests are shown in Appendix B.

R-VALUE TESTS

Bulk samples representative of the underlying on-site materials were tested to measure the response of a compacted sample to a vertically applied pressure under specific conditions. The R-value of a material is determined when the material is in a state of saturation such that water will be exuded from the compacted test specimen when a 16.8 kN load (2.07 MPa) is applied. The results from these test procedures are reported in this Appendix B-1.

TABLE B-1
SUMMARY OF SOIL LABORATORY DATA

Sample Information			Geologic Unit	USCS Group Symbol	In Situ Water Content, %	In Situ Dry Unit Weight, pcf	In Situ Saturation, %	Sieve/Hydrometer				Atterberg Limits			Compaction		Expansion Index	R-Value	Chemical Test Results			
Boring Number	Depth, feet	Elevation, feet						Gravel, %	Sand, %	<#200, %	<2μ, %	LL	PL	PI	Maximum Dry Unit Weight, pcf	Optimum Water Content, %			pH	Sulfate (ppm)	Chloride (ppm)	Min. Resistivity (ohm/cm)
DH-1	0	462.0	Qafe	SM	11.7													25				
DH-1	5	457.0	Qafe	CL	13.8			2	43	55	21	38	18	20								
DH-1	10	452.0	Qal	SM	5.6	97	21															
DH-1	15	447.0	Qt	SC	9.6	98	36															
DH-1	17.5	444.5	Qt	SC	8.3			13	49	38		37	17	20								
DH-1	20	442.0	Qt	SC	4.4																	
DH-1	30	432.0	Qt	SC	14.8	115	91															
DH-2	0	458.0	Qafe	SM	6.9										133.0	7.0			8.6	130	864	1070
DH-2	10	448.0	Qal	SC	11.5	97	43															
DH-2	15	443.0	Qt	SM	9.1	96	33															
DH-2	20	438.0	Qt	SC	8.2	97	31	16	47	37		34	20	14								
DH-2	30	428.0	Qt	SC	11.1	105	52															



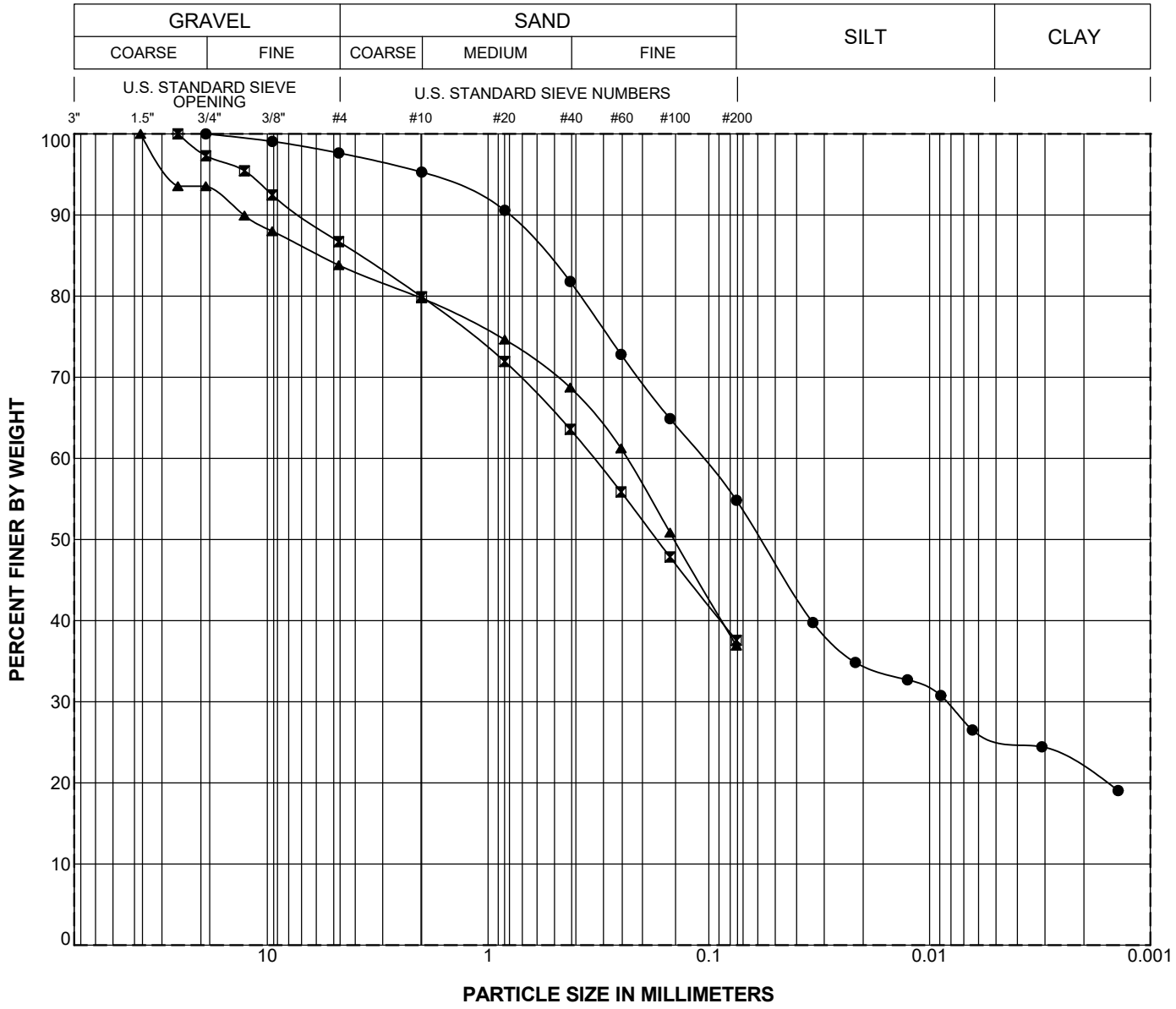
Boring Number	Depth (feet)	Geologic Unit	Test Symbol	Water Content (%)	LL	PL	PI	Classification
DH-1	5.0	Qafe	●	14	38	18	20	SANDY LEAN CLAY (CL)
DH-1	17.5	Qt	⊠	8	37	17	20	CLAYEY SAND (SC)
DH-2	20.0	Qt	▲	8	34	20	14	CLAYEY SAND (SC)

GMU_ATTERBERG_LIMITS_12 PTS 19-182-00.GPJ GM&U.GDT 3/17/20

ATTERBERG LIMITS

Project: Cannon Street Widening

Project No. 19-182-00



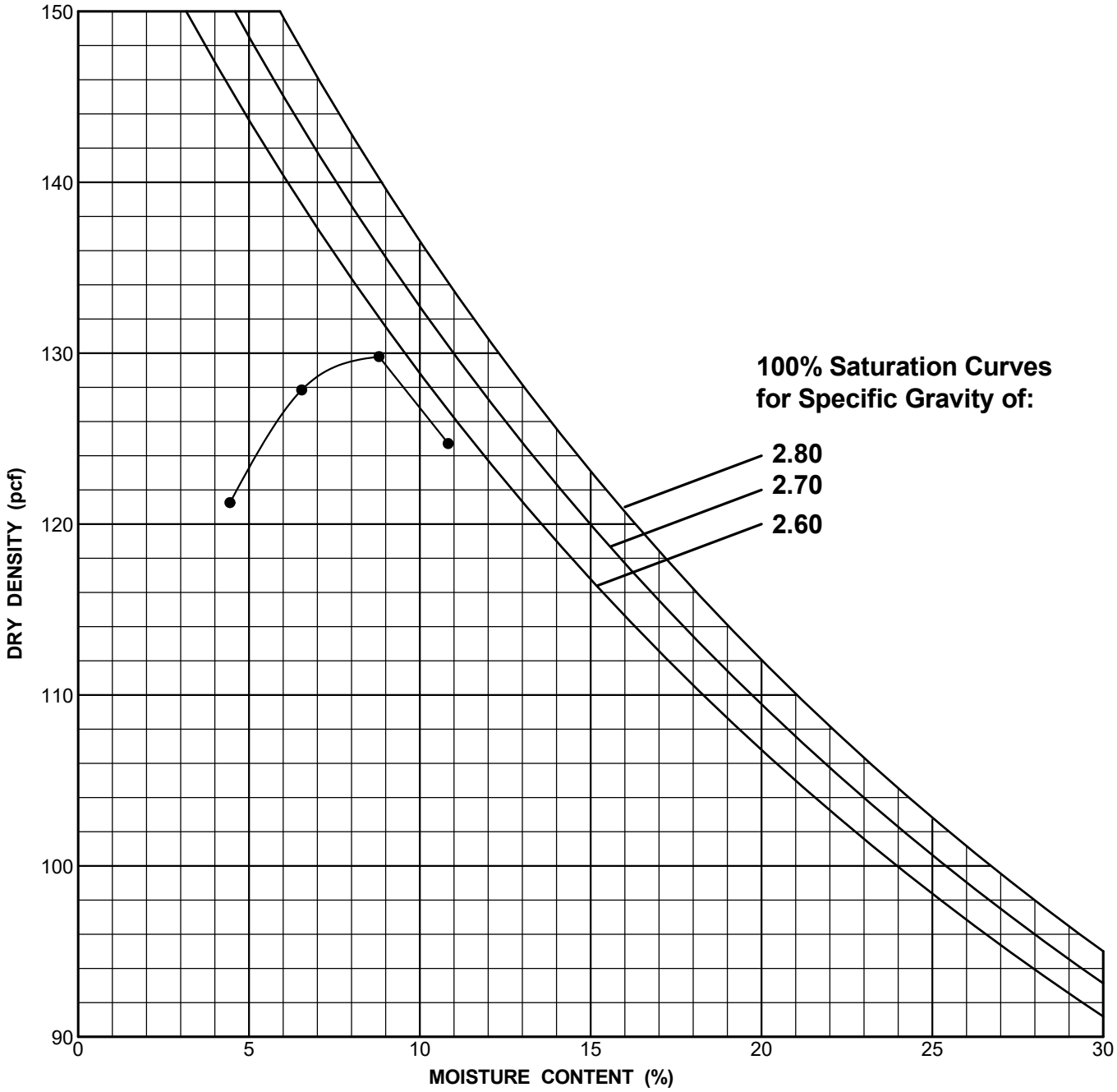
Boring Number	Depth (feet)	Geologic Unit	Symbol	LL	PI	Classification
DH-1	5.0	Qafe	●	38	20	SANDY LEAN CLAY (CL)
DH-1	17.5	Qt	⊠	37	20	CLAYEY SAND (SC)
DH-2	20.0	Qt	▲	34	14	CLAYEY SAND (SC)

GMU_GRAIN_SIZE 19-182-00.GPJ 3/17/20

PARTICLE SIZE DISTRIBUTION

Project: Cannon Street Widening

Project No. 19-182-00

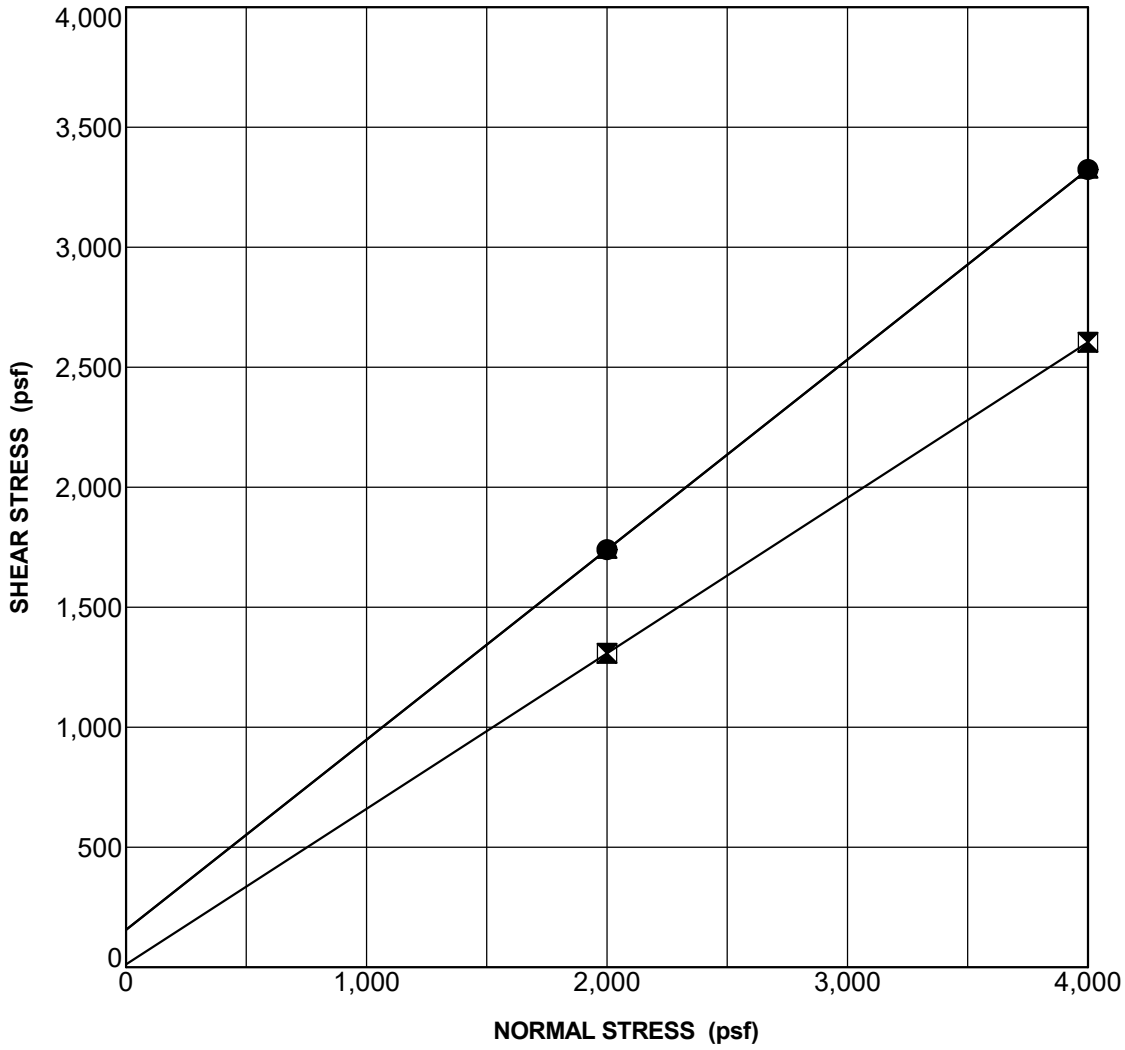


Boring Number	**DH-2**	**Maximum Dry Density**	133.0 pcf
Sample Number	**at 0 ft**	**Optimum Moisture Content**	7.0 %
Geologic Unit:	**Qafe**	**Test Method**	1557C
Description			
Liquid Limit	**Plasticity Index**	**Specific Gravity**	

COMPACTION TEST

Project: Cannon Street Widening

Project No. 19-182-00



SAMPLE AND TEST DESCRIPTION
Sample Location: DH-1 @ 30.0 ft **Geologic Unit:** Qt **Classification:** CLAYEY SAND (SC) **Strain Rate (in/min):** 0.005 **Sample Preparation:** Undisturbed **Notes:** Sample saturated prior and during shearing

STRENGTH PARAMETERS		
STRENGTH TYPE	**COHESION (psf)**	**FRICTION ANGLE (degrees)**
● Peak Strength	28	40.0
⊠ Ultimate Strength	140	31.0

SHEAR TEST DATA

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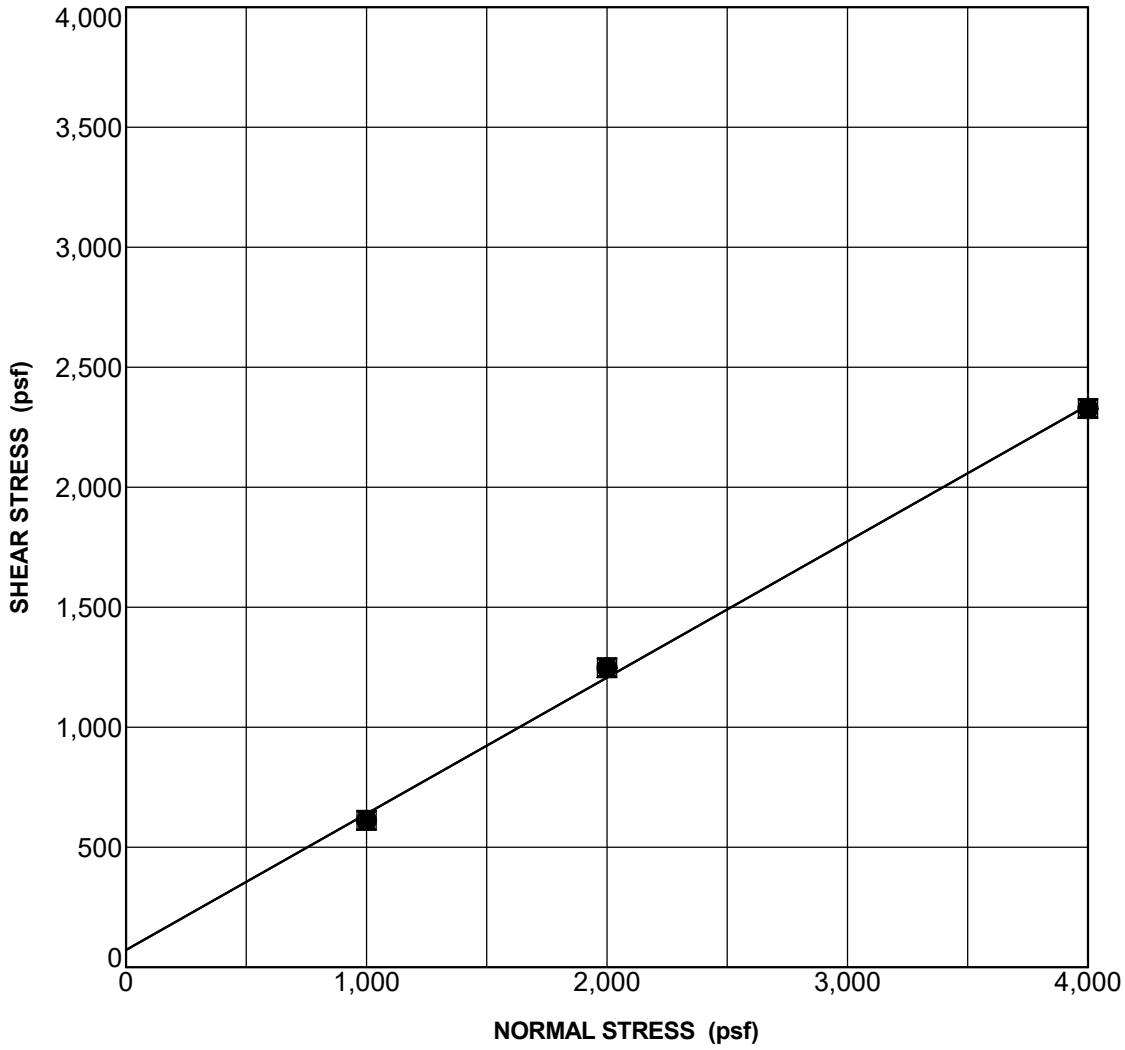
GMU



SAMPLE AND TEST DESCRIPTION
Sample Location: DH-2 @ 10.0 ft **Geologic Unit:** Qal **Classification:** CLAYEY SAND (SC) **Strain Rate (in/min):** 0.005 **Sample Preparation:** Undisturbed **Notes:** Sample saturated prior and during shearing

STRENGTH PARAMETERS		
STRENGTH TYPE	**COHESION (psf)**	**FRICTION ANGLE (degrees)**
● Peak Strength	72	29.6
⊠ Ultimate Strength	72	29.6

SHEAR TEST DATA

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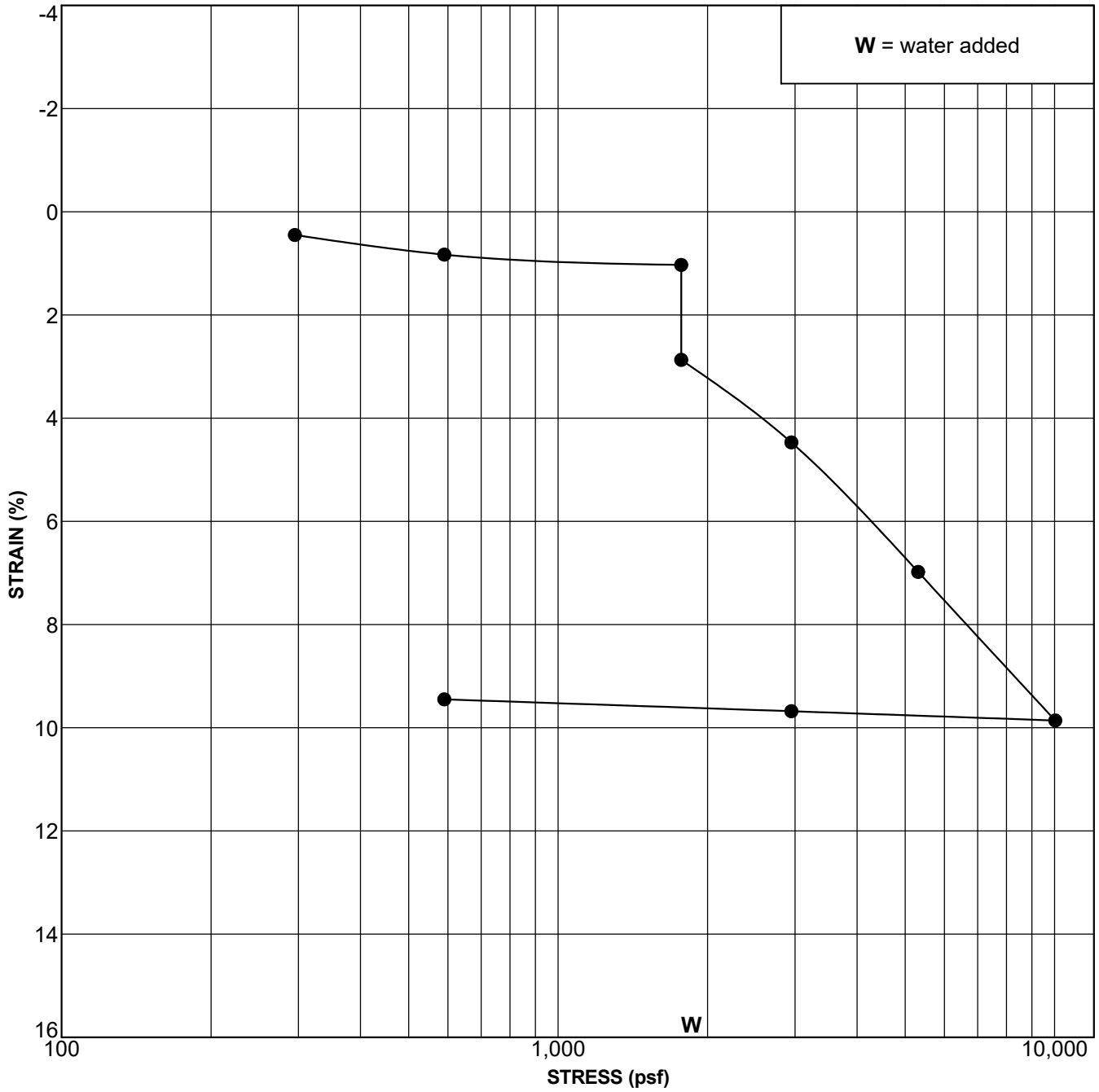
GMU



Boring Number	Depth (feet)	Geologic Unit	Symbol	In Situ or Remolded Sample	% Hydro-Collapse	Classification
DH-1	15.0	Qt	●	In Situ	1.84	CLAYEY SAND (SC)

GMU_CONSOL 19-182-00.GPJ GM&U.GDT 3/17/20

CONSOLIDATION TEST DATA

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