Appendix E

Geotechnical Investigation (Cotton, Shires and Associates, Inc. 2018)

GEOTECHNICAL INVESTIGATION

STORMWATER CAPTURE PROJECT
ORANGE MEMORIAL PARK
SOUTH SAN FRANCISCO, CALIFORNIA

Prepared for:
LOTUS WATER
215 Kearney Street
San Francisco, California 94108
June 2018

COTTON, SHIRES AND ASSOCIATES, INC.
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June 1, 2018
E5038

Robert Dusenbury
LOTUS WATER
215 Kearny Street
San Francisco, CA 94108

SUBJECT: **Geotechnical Investigation – Stormwater Capture Project**
RE: Orange Memorial Park
South San Francisco, California

Dear Mr. Dusenbury:

Cotton, Shires and Associates, Inc. (CSA) is pleased to provide Lotus Water with the following report in which we describe the findings, conclusions and recommendations of our geotechnical investigation for the proposed Storm Water Capture Project at the Orange Memorial Park, located in South San Francisco, California. This investigation was performed in accordance with our proposal to you dated October 24, 2017.

In this report, we characterize the geotechnical conditions surrounding and underlying the two alternative sites and provide conclusions and recommendations regarding geotechnical hazards, foundation type and design criteria, and site grading.

We appreciate the opportunity to have been of service to you on this project. If you have any questions regarding this report, please feel free to contact us.

Sincerely,
COTTON, SHIRES AND ASSOCIATES, INC.

David T. Schrier
Principal Geotechnical Engineer
GE 2334

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Senior Engineering Geologist
CEG 2560

AM:DTS:TS:TRH:st

GEOTECHNICAL INVESTIGATION
ORANGE MEMORIAL PARK STORM WATER CAPTURE PROJECT
South San Francisco, California

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EXECUTIVE SUMMARY

In this Executive Summary, we provide a summary of some of the most pertinent conclusions and recommendations resulting from our Geotechnical Investigation performed for Lotus Water for a storm water capture facility to be located in Orange Memorial Park in South San Francisco, California. We understand that the proposed project consists of constructing an underground capture facility either adjacent to, or below Colma Creek. In addition to the capture facility, the structure could include trash racks and collectors, diversion pipes and possibly an infiltration system. A more detailed discussion of our findings, conclusions and recommendations is presented in the main body of this technical report.

Conclusions

- The proposed construction of a buried stormwater capture system at either the North Parcel or the Ballfield is primarily constrained by liquefiable and densifiable, loose to medium dense sands.

- The site will likely be subjected to very strong seismic ground shaking within the life of the structure. The proposed stormwater capture sites are located approximately 2 miles (3.2 kilometers) northeast of the mapped main trace of the San Andreas Fault. Peak horizontal ground accelerations of up to 0.87g to 0.88g should be anticipated at the sites.

- The proposed stormwater capture sites are situated along a broad alluvial filled valley, close to the bay margin, in an area characterized by level to gentle (0 to 10 degrees inclination) natural topography.

- Groundwater was encountered at a depth of 25 feet below ground surface in the North Parcel borings and 18 feet below ground surface in the Ballfield borings. However, groundwater levels could be higher at other times and locations.

- We calculate that there is a high potential for seismically induced liquefaction/densification of portions of the subsurface materials. We calculated unmitigated potential liquefaction/densification induced ground surface settlements of up to 5-3/4 inches at the North Parcel and 9 inches at the Ballfield. We also calculated up to 1 inch and 2 inches of static load induced settlement at the North Parcel and Ballfield sites, respectively.

Recommendations

- To reduce the potential for adverse effects of differential foundation movement due to liquefaction/densification, the stormwater capture system can be supported on a layer of improved, overlapping deep soil mixed columns (DSM). Alternatively, the stormwater capture structures can be supported on deep foundations such as auger cast piles (ACP) or drilled displacement columns (DDC).

- Based on collected geotechnical data, site grading for the stormwater capture structures, including excavating, should be within the capabilities of moderate excavation equipment (i.e., dozer, backhoes, excavators and pile driving rigs). During the dry season, temporary cut slopes of 2:1 (H:V) should be satisfactory (depending on monitoring) for construction purposes. We are not anticipating that fill will be placed on the site, except to backfill around the excavation.

- The final drawings and specifications should be reviewed and approved by a representative of our firm to confirm that the recommendations of this report have been incorporated into the design of the project.

- Earthwork construction activities should be observed and tested by a representative of our firm to confirm that the recommendations of this report are incorporated into the construction of the project and to address potential unanticipated soil conditions not encountered during site investigation.

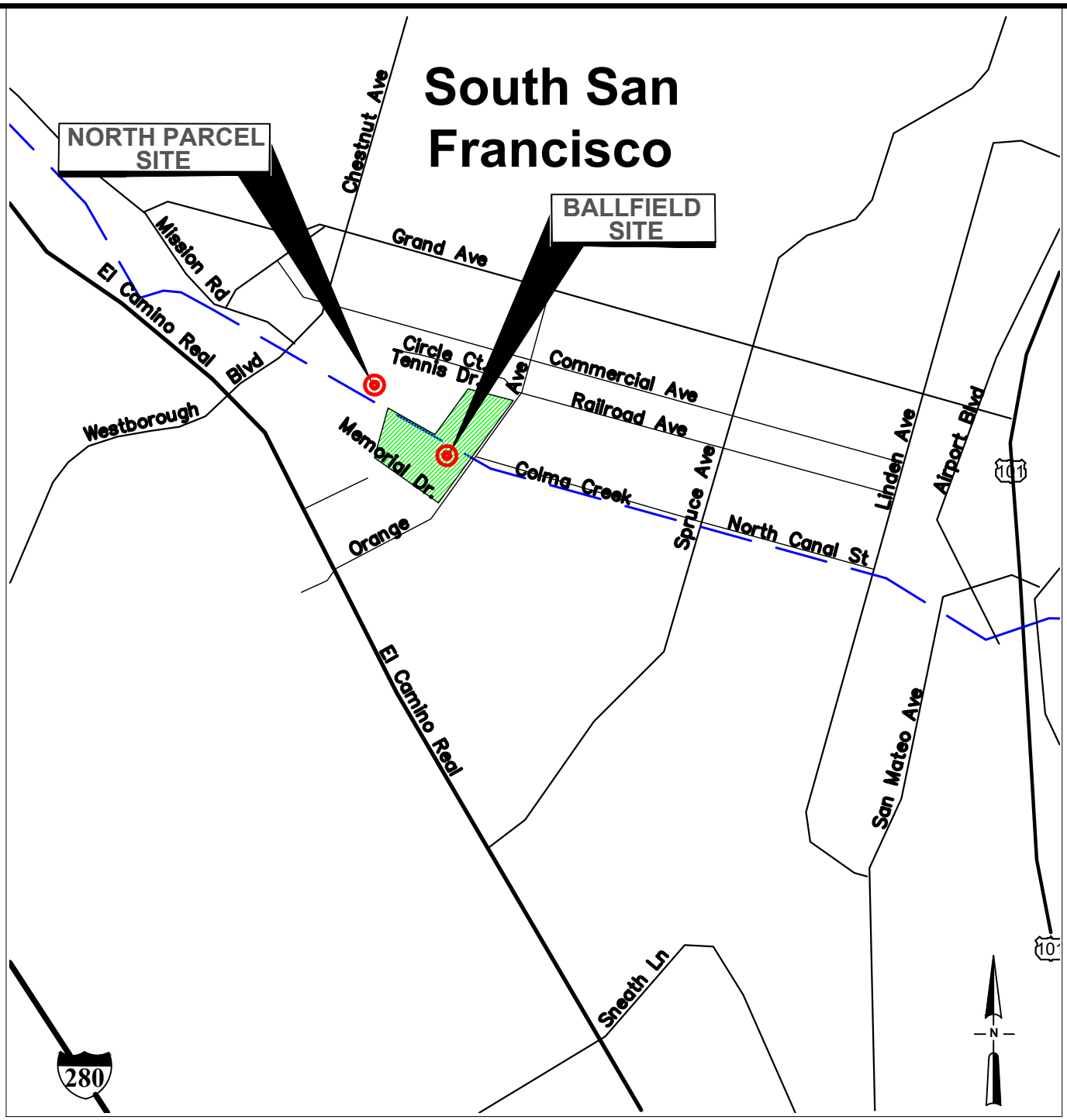
1.0 INTRODUCTION

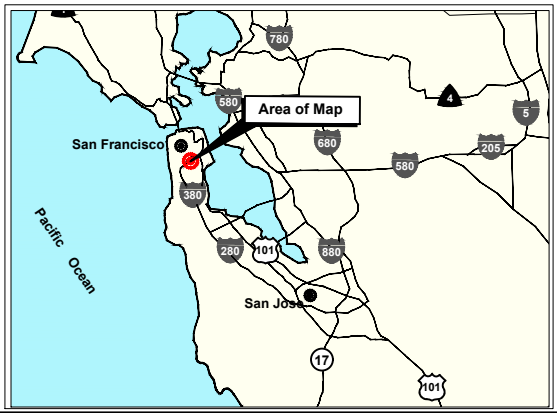
1.1 Project Description

In this report, Cotton, Shires and Associates, Inc. (CSA) presents the results of our geotechnical investigation for a stormwater capture facility to be located in Orange Memorial Park in South San Francisco, California. We understand that the proposed project is for the City of South San Francisco (City) and consists of constructing an underground stormwater capture facility either adjacent to, or below Colma Creek. In addition to the capture facility, the structure will likely include trash racks and collectors, diversion pipes and possibly an infiltration system.

We understand that presently several alternative sites are being considered including the North Parcel, the South Parcel, the Ballfield, and an instream location. We further understand that the North and South Parcels were previously occupied by greenhouses associated with a carnation growing company. CSA's scope of work was focused on investigating the subsurface conditions at the North Parcel and the Ballfield sites (See Figure 1).

We also understand that stormwater capture systems (structures) are typically buried reinforced concrete, prefabricated cells that are joined together in groups of four or more, and that individual cells are 5.5- to 9-foot tall, 8-foot wide and 16-foot long, and bear on a layer of crushed rock/aggregate (typically 12 to 21 inches thick) and isolated (sandwiched) with two layers of filter fabric (Oldcastle Precast, Storm Capture). These structures can be capped with between 0.5 feet and 5 feet of soil cover, resulting in a total depth of excavation/improvement of 7 feet to 15.75 feet. We further understand that these storm capture structures are typically pre-fabricated with either an open bottom for maximum infiltration, or a closed, slab-on-grade floor. While we have not been provided with typical loading for the capture systems, we note that Oldcastle Precast Storm Capture brochure indicates that soil bearing capacities above 1,999 psf do not require special care.





Reference: Google Maps

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SITE LOCATION MAP

ORANGE MEMORIAL PARK STORM WATER CAPTURE PROJECT

South San Francisco, California

GEO/ENG BY	SCALE	PROJECT NO.
DTS	NTS	E5038
APPROVED BY	DATE	FIGURE NO.
DTS	JUNE 2018	1

1.2 Purpose and Scope of Work

The purpose of our investigation was to develop geotechnical data and recommendations for project design. Our objectives were to: 1) evaluate surface and subsurface conditions; and 2) develop conclusions and recommendations regarding geotechnical hazards, site grading, foundation type and design criteria. The specific scope of work performed for our investigation included the following tasks:

1) Review of in-house geologic data and the previous report provided to us;
2) Attendance at the kick-off meeting;
3) Participation in conference calls;
4) Geotechnical reconnaissance;
5) Subsurface exploration;
6) Laboratory testing;
7) Geotechnical engineering and geologic analyses;
8) Formulation of conclusions and recommendations; and
9) Preparation of this report.

2.0 PHYSICAL AND GEOLOGIC SETTING

2.1 Terrain

The North Parcel and the Ballfield sites are relatively level and located at roughly elevation 27 to 28 feet and 24 to 25 feet, respectively. Natural grades in the area slope down toward Colma Creek.

2.2 Geologic Setting

The North Parcel and the Ballfield sites are located in a broad northwest-southeast trending valley close to the bay margin, and between San Bruno Mountain to the north and Skyline Ridge to the southwest. The concrete-lined Colma Creek runs down the center of the valley and borders the North Parcel to the southwest, and the Ballfield to the northeast. The sites are mapped as being underlain by alluvium (Bonilla, M. G., Preliminary Geologic Map of the San

Francisco South 7.5′ Quadrangle and Parts of the Hunters Point 7.5′ Quadrangle, California; see attached Figure 2, Regional Geologic Map).

The site is close to the transform fault boundary (the San Andreas Fault) between the Pacific and North American tectonic plates.

2.3 Seismic Setting

The alternative stormwater capture facility sites are situated in an area of high seismicity. The nearest and controlling active fault, with respect to site seismicity, is the San Andreas Fault, located approximately 2 miles (3.2 km) to the southwest (see attached San Francisco Bay Area Fault Map, Figure 3). Other active faults close to the site include the San Gregorio Fault (7.7 miles/12.4 km to the southwest) and the Hayward Fault (16.3 miles/26.2 km to the northeast).

2.3.1 Probabilistic Analysis - We performed a peak ground acceleration analysis of the site employing the USGS Seismic Design Tool, with the 2010 ASCE 7 (with March 2013 errata) Design Code. The results of our analysis indicate an appropriate Maximum Considered Earthquake Geometric Mean (MCE_G) Peak Ground Acceleration (PGA_M) of **0.87g to 0.88g**.

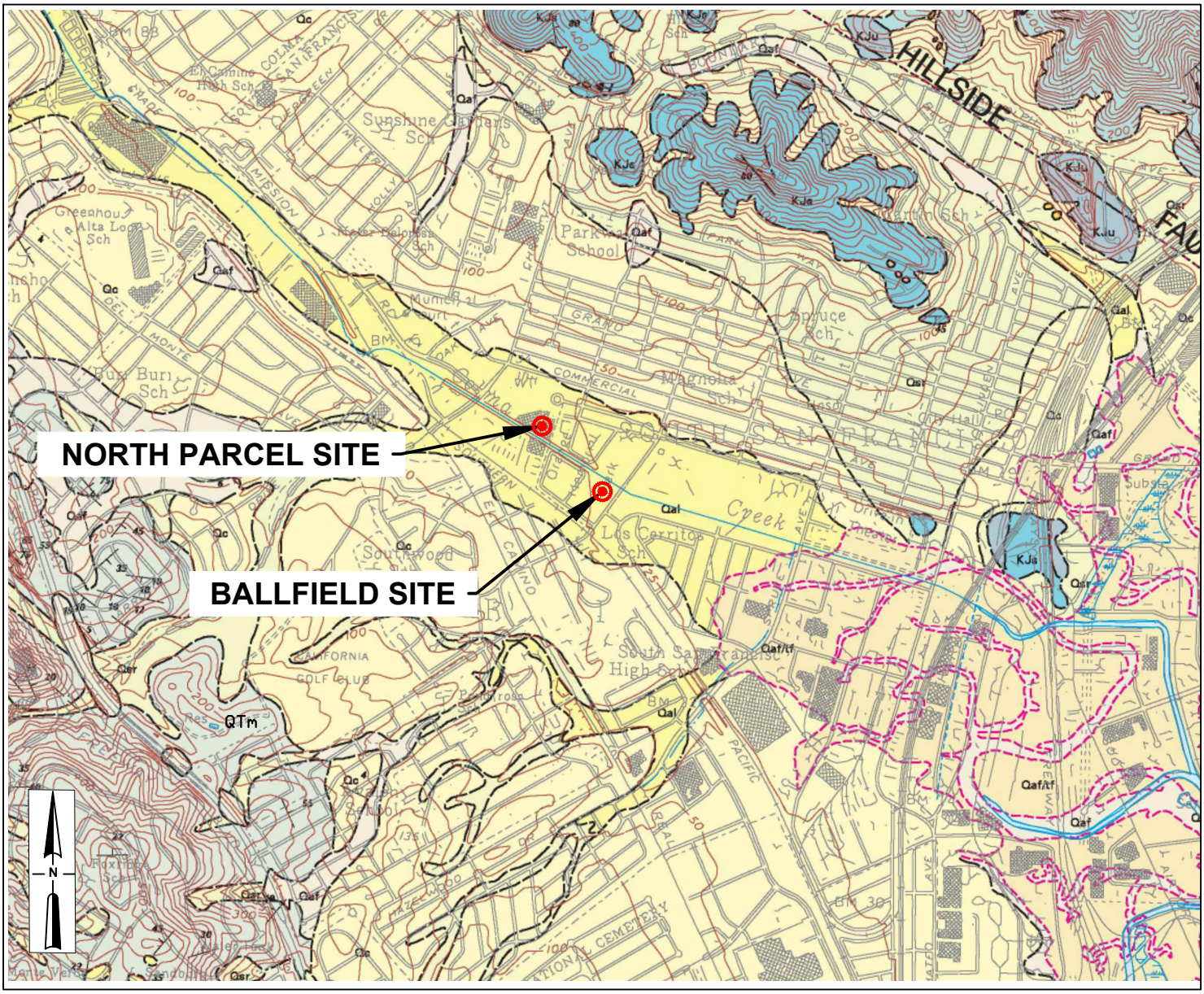
Taking into account the faults described above, the 2016 California Building Code (CBC), the ASCE 7-10 code coefficients presented in Section 5.8 of this report, and the results of the peak ground acceleration analysis, it is our opinion that the proposed storm water capture facility could experience a peak horizontal ground acceleration (PGA_M) as high as **0.87g to 0.88g**.

3.0 SITE CONDITIONS

3.1 Surface Conditions

The North Parcel is presently unoccupied by improvements and is covered with weeds. We observed several utility covers in the area, indicating possible underground utilities. We also observed mounds of fill placed adjacent to the skate park located to the southeast of the parcel.

The Ballfield is presently occupied by baseball fields.



0' 2000' 4000'

Scale 1" = 2000'

EXPLANATION

Qaf/tf	Artificial Fill, Artificial Fill over tidal flat
Ql	Landslide Deposit
Qal	Alluvium
Qsr	Slope Debris and Ravine Fill
Qc	Colma Formation
QTm	Merced Formation
KJ_{SK}	Franciscan Complex Sandstone and Shale
KJ_S	Franciscan Complex Sandstone and Shale
KJ_G	Franciscan Complex Greenstone
KJ_U	Franciscan Complex Sheared Rocks

Reference:Bonilla, M.G., 1971, Preliminary Geologic Map of the San Francisco South Quadrangle and Parts of the Hunter Point 7.5' Quadrangle, San Francisco Bay Area, California, Digital Database Prepared By Carl Wentworth, Marjorie Lucks, Heather Schoonover, Scott Graham and Thomas May, 1998

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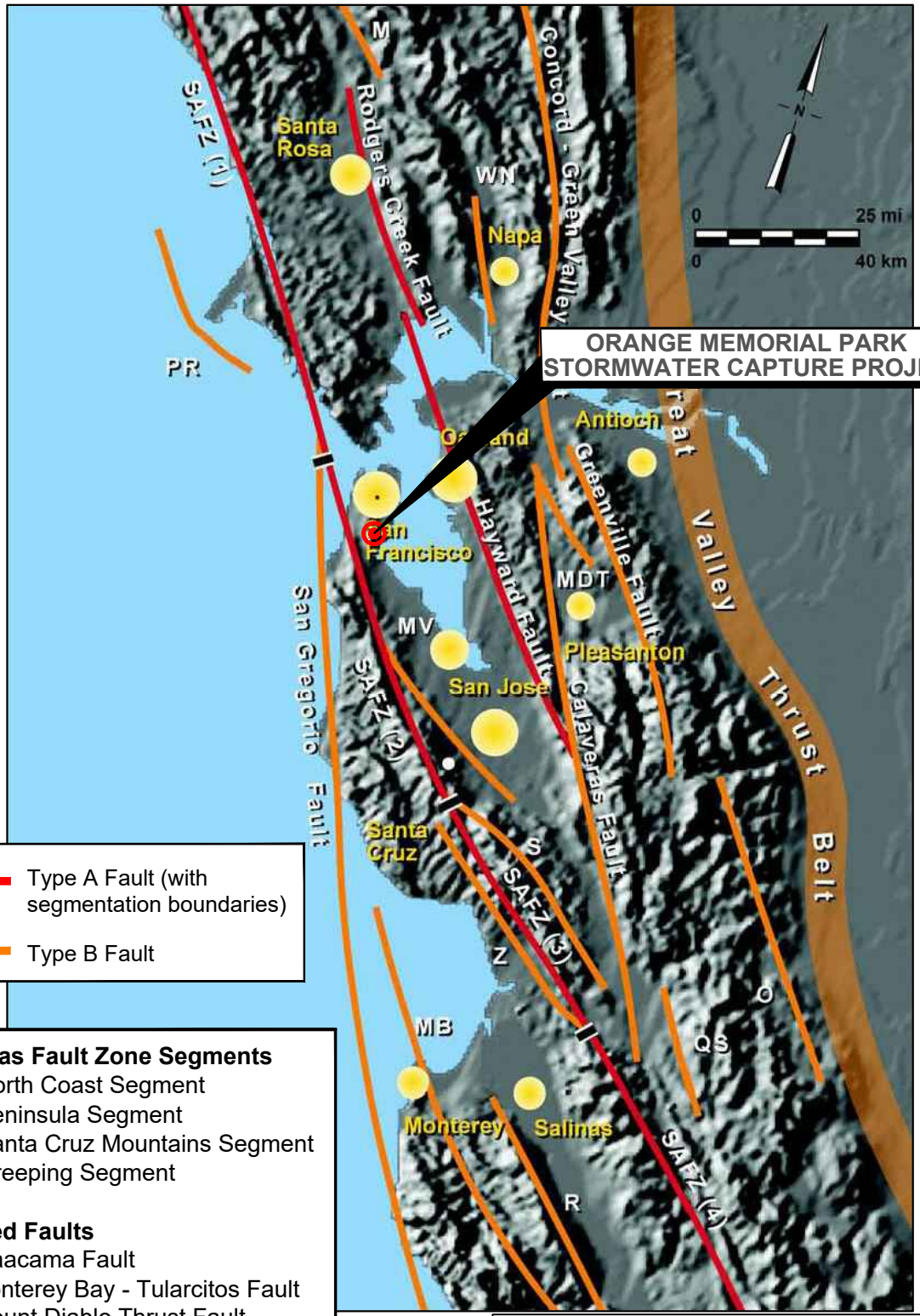
REGIONAL GEOLOGIC MAP

ORANGE MEMORIAL PARK STORMWATER CAPTURE PROJECT
South San Francisco, CALIFORNIA

GEO/ENG BY DTS	SCALE 1"=2000'	PROJECT NO. E5038
APPROVED BY DTS	DATE JUNE 2018	FIGURE NO. 2



Type A Fault (with segmentation boundaries)

Type B Fault

San Andreas Fault Zone Segments

SAFZ-1 North Coast Segment
SAFZ-2 Peninsula Segment
SAFZ-3 Santa Cruz Mountains Segment
SAFZ-4 Creeping Segment

Abbreviated Faults

M	Maacama Fault
MB	Monterey Bay - Tularcitos Fault
MDT	Mount Diablo Thrust Fault
MV	Monta Vista - Shannon Fault
O	Ortigalita Fault
PR	Point Reyes Fault
QS	Quien Sabe Fault
R	Rinconada Fault
S	Sargent - Berrocal Fault
WN	West Napa Fault
Z	Zayante - Vergeles Fault

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SAN FRANCISCO BAY AREA FAULT MAP

ORANGE MEMORIAL PARK STORMWATER CAPTURE PROJECT
South San Francisco, California

GEO/ENG BY	SCALE	PROJECT NO.
DTS	1"=25 mi	E5038
APPROVED BY	DATE	FIGURE NO.
DTS	JUNE 2018	3

The adjacent concrete-lined Colma Creek channel is about 35 to 40 feet wide, and the bottom of the channel is about 10 feet below the top of the channel wall.

3.2 Subsurface Conditions

We explored subsurface conditions at the North Parcel and the Ballfield sites between April 3 and April 5, 2018 by means of eight (four at each site) exploratory boring drilled to depths of 31.5 feet to 46.5 feet at the locations shown on Figures 4 and 5. In our borings we generally encountered alluvial sands, silts and clays. In the borings drilled at the North Parcel site, we generally encountered 15.5 to 19 feet of loose to medium dense sand and silty sand, overlying a 4- to 6.5-foot layer of stiff to very stiff clay. This clay layer was encountered in all four of the North Parcel borings. Below the clay, we encountered varying thicknesses of sands, clays and some silts to the bottom of the borings. In several of the North Parcel site borings we encountered a thin silt or clay layer at or near the ground surface (Figure 6).

In the borings drilled at Ballfield site, we generally encountered a 4.5- to 5-foot thick layer of medium stiff to stiff clayey fill overlying loose, medium dense, dense and very dense alluvial sands, and silty or clayey sands. In Borings CSA/SD-4, CSA/SD-5 and CSA/SD-7 we encountered a 4- to 5-foot thick clay layer beginning at depths of 23 feet, 25 feet, and 18 feet, respectively (Figure 7 and 8). In CSA/SD-4 we also encountered a stiff sandy clay below a depth of 40 feet.

3.2.1 Laboratory Testing - We performed laboratory tests on disturbed and relatively undisturbed soil samples obtained from our borings. Those tests included Atterberg limits, in-situ unit weight, natural moisture content, consolidation tests, and sieve analysis. Based on the results of these tests, it appears that the sandy soils in the upper 15.5 to 19 feet at the North Parcel site have low to high fines content (8% to 42%) and moderate dry unit weights (100 pcf). The laboratory test results on the underlying 4- to 6.5-foot thick clay layer indicates that this material has high plasticity (Liquid Limits = 56 to 57, Plasticity Indices = 27 to 38), low dry unit weights (89 pcf to 102 pcf), and low to moderate compression and recompression indices ($C_{c\varepsilon}$ = 0.141 and, $C_{r\varepsilon}$ = 0.033). We also performed laboratory testing on the sands, clays and silts underlaying the 4- to 6.5-foot clay layer and found that these sands had moderate to high fines content (28% to 44%) and moderate dry unit weights (109 pcf), while the clays had high sand content (37% to 47%) low plasticity (Liquid Limits = 38, Plasticity Indices = 18), and the silts had high sand content (41%), and low plasticity (Liquid Limits = 32, Plasticity Indices = 13).

NORTH PARCEL

CSA / B-3

A'

CSA / B-2

CSA / B-8

EXISTING COLMA CREEK CANAL

A

CSA / B-1

North

0 25 50 100

(feet)

Explanation

CSA/B-1 — Location of small-diameter exploratory boring

A A' — Location of engineering geologic cross section

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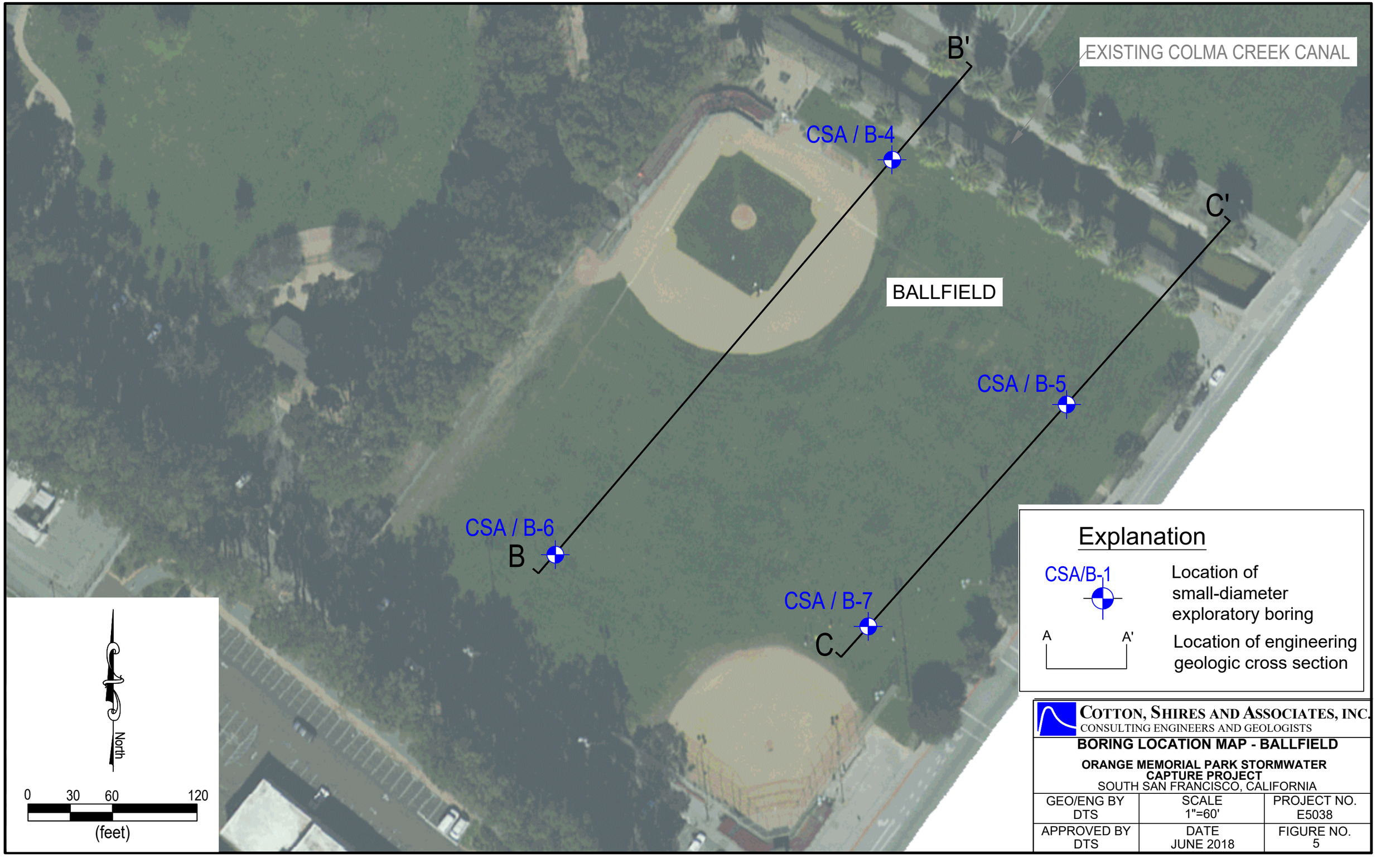
BORING LOCATION MAP - NORTH PARCEL

ORANGE MEMORIAL PARK STORMWATER CAPTURE PROJECT
SOUTH SAN FRANCISCO, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
DTS	1"=50'	E5038
APPROVED BY	DATE	FIGURE NO.
DTS	JUNE 2018	4



Explanation

CSA/B-1 — Location of small-diameter exploratory boring

A — A' — Location of engineering geologic cross section

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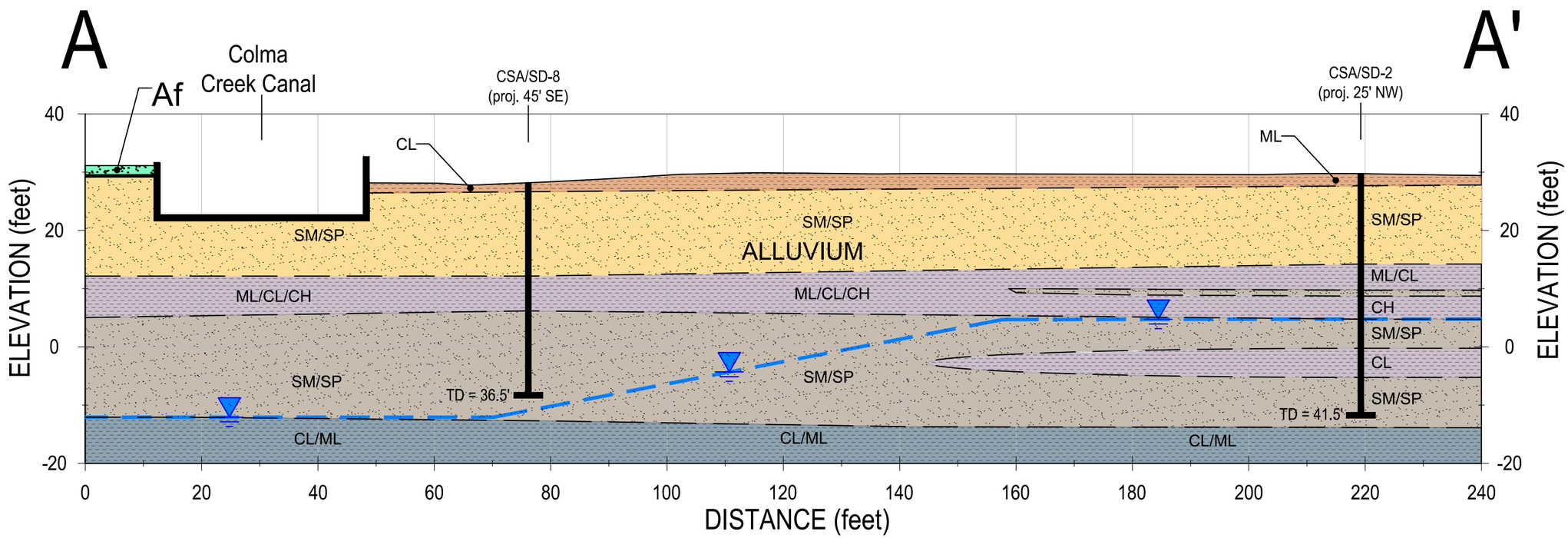
BORING LOCATION MAP - BALLFIELD

ORANGE MEMORIAL PARK STORMWATER CAPTURE PROJECT
SOUTH SAN FRANCISCO, CALIFORNIA

GEO/ENG BY DTS	SCALE 1"=60'	PROJECT NO. E5038
APPROVED BY DTS	DATE JUNE 2018	FIGURE NO. 5



EXPLANATION

Earth Materials

- Af (SM) — Fill - Silty Sand
- ML/CL — Alluvium - Near-Surface Silt and Clay
- SM/SP — Alluvium - Near-Surface Silty Sand, Sand
- ML/CL/CH — Alluvium - Deeper Silt and Clay
- SM/SP — Alluvium - Deep Silty Sand, Sand
- CL/ML — Alluvium - Deep Clay and Silt

Map Symbols

- Assumed Geologic Contact
- Groundwater
- CSA/SD-8 (proj. 45' SE), TD = 36.5' — Location of Small-Diameter Exploratory Boring

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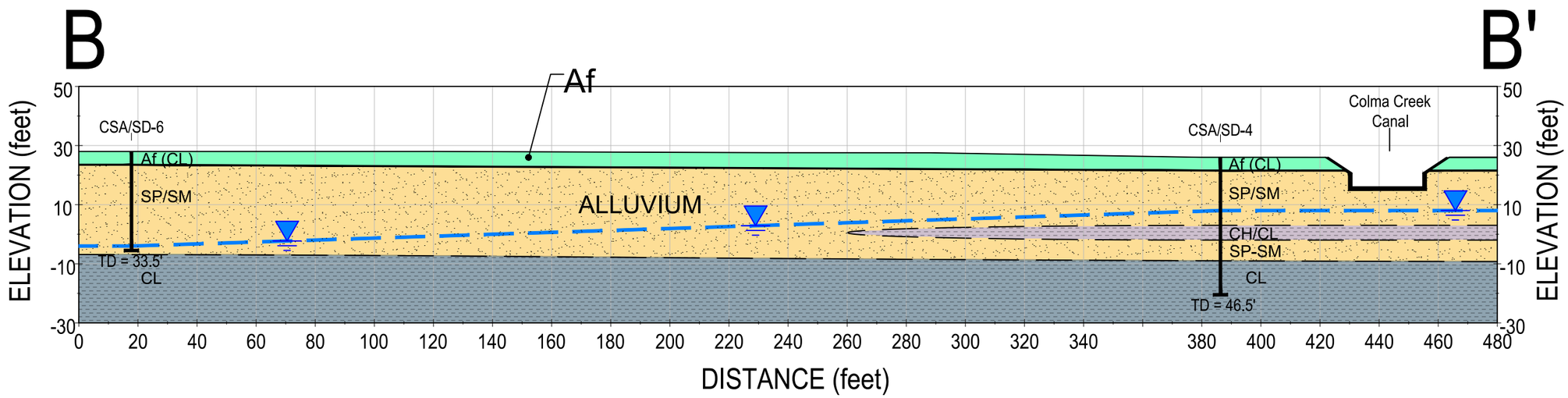
ENGINEERING GEOLOGIC CROSS SECTION A-A'
NORTH PARCEL
ORANGE MEMORIAL PARK STORMWATER CAPTURE PROJECT
SOUTH SAN FRANCISCO, CALIFORNIA

GEO/ENG BY DTS	SCALE 1"=20'	PROJECT NO. E5038
APPROVED BY DTS	DATE JUNE 2018	FIGURE NO. 6



EXPLANATION

Earth Materials

- Af (CL) — Fill - Clay
- SM/SP — Alluvium - Near-Surface Silty Sand, Sand
- CH/CL — Alluvium - Deeper Silt and Clay
- CL/ML — Alluvium - Deep Clay

Map Symbols

- ---?--- Assumed Geologic Contact
- Groundwater
- CSA/SD-6 / TD = 35.5' — Location of Small-Diameter Exploratory Boring

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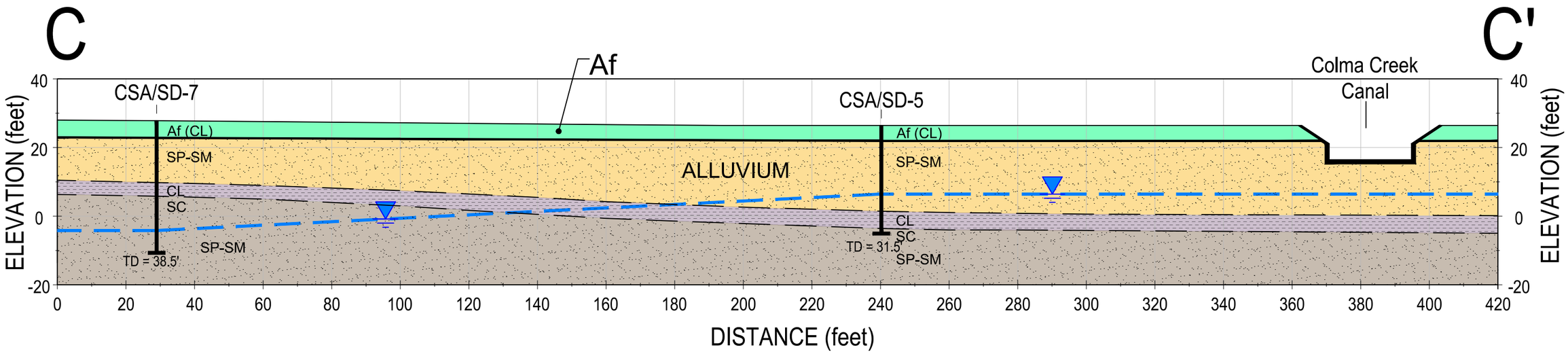
ENGINEERING GEOLOGIC CROSS SECTION B-B'
BALLFIELD
ORANGE MEMORIAL PARK STORMWATER CAPTURE PROJECT
SOUTH SAN FRANCISCO, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
DTS	1"=40'	E5038
APPROVED BY	DATE	FIGURE NO.
DTS	JUNE 2018	7



EXPLANATION

Earth Materials

- Af (CL) — Fill - Clay
- SM/SP — Alluvium - Near-Surface Silty Sand, Sand
- CH/CL — Alluvium - Deeper Silt and Clay
- SC/SM/SP — Alluvium - Deep Clayey Sand, Silty Sand, Sand

Map Symbols

- ---?--- Assumed Geologic Contact
- Groundwater
- CSA/SD-7, TD = 38.5' — Location of Small-Diameter Exploratory Boring

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ENGINEERING GEOLOGIC CROSS SECTION C-C'
BALLFIELD
ORANGE MEMORIAL PARK STORMWATER CAPTURE PROJECT
SOUTH SAN FRANCISCO, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
DTS	1"=30'	E5038
APPROVED BY	DATE	FIGURE NO.
DTS	JUNE 2018	8

Based on the consolidation test results and our analysis, it appears that the 4- to 6.5-foot thick clay layer at a depth of 15.5 to 19 feet is slightly over-consolidated with an Over Consolidation Ratio (OCR) of 1.6.

Based on the results of laboratory test results on samples taken from the Ballfield site, the near-surface clayey fill material has a low plasticity (Liquid Limits = 23, Plasticity Indices = 8) and moderate dry unit weights (107 to 108 pcf). The laboratory test results also indicate that the underlying sandy soils have moderate to high fines content (19% to 48%). Laboratory test results on the soils below the sandy layer indicate that the clays have low dry unit weight (102 pcf), moderate to high sand content (24% to 47%) and moderate to high plasticity (Liquid Limits = 34 to 56, Plasticity Indices = 18 to 35), while the sands had moderate to high fines content (30% to 45%) and low plasticity (Liquid Limits = 26, Plasticity Indices = 11).

The results of the laboratory tests performed on representative samples are presented on the boring logs in Appendix A (Field Investigation) and in Appendix B (Laboratory Testing).

A detailed description of the exploration program and our logs of the exploratory borings are presented in Appendix A.

3.3 Groundwater Conditions

Groundwater was encountered in the north Parcel site (during drilling) in the following borings at the corresponding depths:

Borings CSA/SD-2: 25 feet
Borings CSA/SD-3: 40 feet

We also encountered groundwater in our borings at the adjacent California Water Service Company at a depth of 32 feet, in 2015, and as high as 7 feet in 1997.

Groundwater was encountered in the Ballfield site (during drilling) in the following borings at the corresponding depths:

Borings CSA/SD-4: 18 feet
Borings CSA/SD-5: 20 feet

Borings CSA/SD-6: 32 feet
Borings CSA/SD-7: 32 feet

It should be understood that we were recently in a period of protracted drought and that fluctuations in groundwater levels could occur from variations in rainfall, flooding and other factors. Groundwater levels may be different at different times, climatic conditions and locations.

4.0 POTENTIAL GEOTECHNICAL HAZARDS AND BUILDING LOCATION

In the following sections, we list identified potential geotechnical hazards at the North Parcel and Ballfield sites, along with the corresponding degrees of estimated potential risk, and we provide recommendations for possible mitigation measures.

4.1 Seismic Hazards

Seismic ground shaking associated with a large earthquake on the San Andreas, San Gregorio or Hayward fault is considered to be a **high** potential hazard in the project area. Peak ground accelerations of up to **0.87g to 0.88g** should be anticipated at the site (see report Section 2.3).

No active faults have been recognized on, or mapped through, the subject property. Thus, the potential for surface faulting and ground rupture on the property is considered to be **low**. The San Andreas Fault is the closest mapped active fault to the site and is located approximately 2.0 miles to the southwest.

Other seismically-induced ground failure mechanisms include: landsliding, liquefaction, lateral spreading, lurching, and differential compaction. The potential for strong ground shaking to trigger a landslide that fails into the canal is considered to be **moderate to high** due to the relatively loose consistency of the adjacent soils, and we have no information about the canal wall design and whether they were designed to resist the landslide forces and full hydrostatic pressures. The proposed stormwater capture structures excavation will likely remove approximately 7 to 15.5 feet of the loose soil that is susceptible to mobilizing, where the structures are installed, which in turn should mitigate the high risk of landslides to the structures.

Soil liquefaction is a phenomenon in which a saturated, cohesionless or non-plastic, near-surface soil layer loses strength during cyclic loading (such as that typically generated by earthquakes). During the loss of strength, the soil develops mobility sufficient to permit both horizontal and vertical movements. Soils that are most susceptible to liquefaction are loose, saturated, fine-grained sands and non-plastic silts and clays that are generally located within 50 feet of the ground surface. Because groundwater depths of 18 feet and deeper were encountered during our subsurface investigation, it would be tempting to assume that liquefaction will only occur below that depth at the two sites; however, wetter years and/or proposed stormwater infiltration from this project could significantly raise the groundwater levels. While historic groundwater data for this area was not available, we assumed that the groundwater could rise to within 10 feet of the existing ground surface. Based on the assumed high groundwater level of 10 feet, the procedure outlined in the Soil Liquefaction During Earthquakes monograph (Idriss, Boulanger), and a site peak ground acceleration of 0.87g to 0.88g, we judge that the potential for liquefaction (below a depth of 10 feet), dry densification (above a depth of 10 feet) to be **high** at both the North Parcel and the Ballfield sites.

We determined the factors of safety against triggering liquefaction (FS_l) (and/or dry densification) by calculating the ratio of: 1) the horizontal cyclic shear stress necessary to trigger liquefaction (and/or dry densification), to 2) the average horizontal cyclic shear stress induced by the design earthquake. When this ratio is 1.3 or less (i.e., $FS_l \leq 1.3$), liquefaction (and/or dry densification) is predicted to occur or could potentially be a problem (the State of California considers a FS=1.3 as the threshold for identifying the site as having a liquefaction hazard).

In the following tables we present a summary of the results of our liquefaction and dry densification and associated settlement analysis by boring, and separated into the two alternative sites:

North Parcel

CSA/SD-1

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
0-3	5	10	0.15	0.56	16	2.8	1.04
3-5.5	5	10	0.15	0.55	16	2.8	0.84
5.5-12.5	7	12	0.12	0.53	13	3.2	2.50
						Total:	**4.38 inches**
						Total Below 10 feet:	0.75 inches

CSA/SD-2

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
2-5.5	6	12	0.17	0.55	18	2.6	1.09
5.5-9	6	11	0.11	0.54	12	3.7	1.55
9-15.5	10	17	0.22	0.50	23	2.1	1.64
						Total:	**4.28 inches**
						Total Below 10 feet:	1.45 inches

CSA/SD-3

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
6-11	11	19	0.19	0.52	21	2.3	1.38
11-19	13	22	0.23	0.45	24	1.9	1.82
34-40	7	9	0.10	0.26	12	3.1	2.23
						Total:	**5.43 inches**
						Total Below 10 feet:	4.33 inches

CSA/SD-8

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
2-8	6	11	0.16	0.54	18	2.6	1.87
8-13	10	16	0.23	0.50	24	2.0	1.20
13-18	7	10	0.11	0.41	11	3.8	2.28
22-24	12	17	0.20	0.32	23	1.9	0.45
						Total:	**5.80 inches**
						Total Below 10 feet:	3.45 inches

Based on our liquefaction/dry densification settlement calculations summarized in the above tables, we anticipate total settlements of between to 4-1/2 and 5-3/4 inches and differential settlements of up to 2-3/4 inches over 30 feet during or immediately following the design seismic event, under the current conditions at the North Parcel site. Assuming that the stormwater capture structures are installed at a depth of 10 feet (including the aggregate bearing layer), then the loose and medium dense sands above that depth would be removed, and we anticipate that the remaining liquefiable soils below 10 feet could potential settle between 3/4 inch to 4-1/2 inches with at least 2-1/4 inches of differential settlement over 30 feet.

Ballfield

CSA/SD-4

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
4.5-9	8	15	0.21	0.53	21	2.3	1.24
9-13	6	10	0.16	0.50	17	2.6	1.25
13-16	7	11	0.17	0.45	18	2.5	0.90
16-23	12	18	0.22	0.38	23	2.1	1.76
28-35	7	10	0.14	0.36	16	2.7	2.27
36-40	5	7	0.11	0.36	13	3.2	1.54
						Total:	**8.96 inches**
						Total Below 10 feet:	7.41 inches

CSA/SD-5

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
4.5-9	7	13	0.18	0.53	19	2.5	1.35
9-13	4	7	0.13	0.51	13	3.2	1.54
13-18.5	13	21	0.41	0.42	30	0.5	0.33
18.5-25	11	17	0.21	0.35	22	2.2	1.72
						Total:	**4.94 inches**
						Total Below 10 feet:	3.21 inches

CSA/SD-6

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
4.5-7.5	5	10	0.156	0.55	17	2.8	1.00
						Total:	**1.00 inches**
						Total Below 10 feet:	0.0 inches

CSA/SD-7

Depth of Liquefiable/Densifiable Materials (ft)	N_{60}	N_{160}	CRR_l	CSR_{eq}	N_{160cs}	Volumetric Strain (%)	Settlement (in)
5.0-10.0	4	7	0.12	0.53	13	3.4	2.04
10.0-18.0	6	9	0.14	0.48	16	2.9	2.78
22.0-27.0	6	8	0.13	0.32	15	3.0	1.80
						Total:	**6.62 inches**
						Total Below 10 feet:	4.58 inches

Based on our liquefaction/dry densification settlement calculations summarized in the above tables, we anticipate total settlements of between to 1 and 9 inches and differential settlements of at least 4-1/2 inches over 30 feet during or immediately following the design seismic event, under the current conditions at the Ballfield site. Assuming that the stormwater capture structures are installed to a depth of 10 feet (including the aggregate bearing layer), then the loose and medium

dense sands would be removed to that depth, and we anticipate that the remaining liquefiable soils below 10 feet could potentially settle between 0 to 7-1/2 inches with at least 3-3/4 inches of differential settlement over 30 feet.

In addition to liquefaction induced settlement, there is a **high** potential for sand boils and ejecta at both sites. Not only would sand boils and ejecta significantly increase the magnitude of differential settlement, but it could also result in a bearing failure.

If the adjacent the walls of the adjacent Colma Creek were not designed to resist full hydrostatic and seismic loading combined, then there a **high** potential that the canal walls could fail resulting in lateral spreading triggered by liquefaction which would impact the proposed stormwater capture structures, at both the North Parcel and the Ballfield sites.

In summary, the soils underlying the North Parcel and Ballfield sites are loose to medium dense and highly susceptible to liquefaction/densification, and if not mitigated, could cause significant distress to the proposed stormwater capture system. In order to mitigate the high potential for liquefaction/densification, we have considered several alternatives to either densify the potentially liquefiable soils (deep soil cement mixing), or to install deep foundations (auger cast piles, drilled displacement columns) which extend below the zone of liquefiable soils to support the stormwater capture structures. Either option will likely increase the density of the underlying soils which will reduce the infiltration capacity of the soil.

4.2 Static Settlement Behavior

For our settlement analysis, we identified three potential sources for static settlement, including immediate settlement of loose to medium dense sand, consolidation (recompression) of the roughly 6-foot thick clay layer encountered between 15 and 25 feet, and immediate compression of the clay layer. We assumed that the stormwater capture structures would be supported on a roughly 16- to 20-foot wide (two cells side-by-side) slab-on-grade floor foundation bearing on a layer of gravel (aggregate) bearing 10 feet below existing and final grade and supporting a maximum load of 2,500 psf for the dead-plus-live-load. Based on these assumptions, we calculated the following total and differential static settlement for the stormwater capture system:

North Parcel

Immediate Sand Settlement – 1/3 inch

Clay Consolidation (recompression) – 1/3 inch

Clay Immediate Compression – 1/2 inch

Combined Total and Differential Settlement: **1 inch, and 1/2 inch** (over 30 feet).

This static settlement is in addition to the previously discussed (Section 4.1) seismic induced settlement (liquefaction and densification), if not mitigated.

Ballfield

Immediate Sand Settlement – 1-1/4 inches

Clay Consolidation (recompression) – 1/4 inch

Clay Immediate Compression – 1/2 inch

Combined Total and Differential Settlement: **2 inches, and 1 inch** (over 30 feet).

This static settlement is in addition to the previously discussed (Section 4.1) seismic induced settlement (liquefaction and densification), if not mitigated.

If the soils are improved to mitigate the high potential for liquefaction/densification, or if deep foundations are installed, these static settlement magnitudes would likely be reduced as well. Please contact us if ground improvement is selected or alternative foundation dimensions and/or loading alternatives are required, or to discuss alternative settlement reduction options, if desired.

4.3 Expansive Soils

Based on the results of our laboratory testing and our experience with these earth materials, the roughly 6-foot thick clay layer encountered between 15 and 25 feet is potentially **highly** expansive. Highly expansive soils could be subjected to volume changes due to seasonal fluctuations in moisture content; however, provided that the bottom of the stormwater capture

structure is greater than 3 feet above the clay layer and that the moisture content of the remains constant (close to saturated), we don't anticipate that these expansive soils will adversely impact the structures.

4.4 Sulfate Attack on Concrete

We recommend that corrosivity testing be completed on the earth materials proposed for backfill against the stormwater capture structures to determine the potential for corrosion of metallic and concrete structures at the selected sites. If the soils are found to be potentially corrosive, then alternative backfill material can be imported.

4.5 Infiltration and Raising Groundwater Levels

We understand that one of the options being considered is to infiltrate a portion of the captured storm water into the subgrade. Due to the loose to medium dense consistency of the sands encountered between depths of about 10 feet (assumed bottom of the capture structure) and the top of the 4- to 6.5-foot thick clay layer at depths of 15 to 20 feet (North Parcel), the moderate fines content (8% to 48%), and the present depth to groundwater (18 to > 46.5 feet), we anticipate moderate rates of infiltration. While infiltration testing wasn't part of our scope, Fugro Consultants, Inc. (Fugro) performed three infiltration tests at a depth of 15 feet on the South Parcel (situated on the southern side of the canal from the North Parcel), and recorded infiltration rates of 0.3 inch/hour to 3.4 inches/hour. We anticipate that, during wetter periods, the infiltrated water will collect on the 4- to -6.5-foot thick clay layer and raise the groundwater level, which will reduce the infiltration rate.

If infiltration is to be part of the stormwater capture design, then we recommend that a comprehensive infiltration testing and monitoring program be undertaken under the direction of a hydrogeologist. Such a program will help to evaluate the effectiveness of the proposed infiltration, and potential on- and off-site impacts. Such impacts include raising the groundwater levels and increasing the extent of potentially liquefiable soils, contributing to water collecting in crawl spaces of neighboring residents (especially adjoining the Ballpark site), exacerbating expansive soil movement, triggering foundation movement and distress of shallow supported structures (especially at and adjoining the Ballpark site), and increasing the load on the canal walls. Also, high groundwater levels could result in buoyancy impacts on the stormwater capture structures and associated piping.

5.0 RECOMMENDATIONS

5.1 Site Considerations

The principal factor affecting the proposed stormwater capture system is the significant thickness of potentially liquefiable and densifiable sandy soils underlying both sites. We have provided recommendations to improve the soils (densify) or to construct deep foundations that extend below the zone of liquefaction. Either of these alternatives should mitigate the potential liquefaction induced settlement to acceptable ranges.

5.2 Soil Improvement Alternative

While there are various soil improvement options, in order to mitigate liquefaction induced settlement and the potential for bearing failure associated with liquefaction (sand boils and ejecta), we recommend that the soil beneath the stormwater capture structures be improved with deep soil mixing (DSM), also referred to as wet soil mixing. The DSM columns should overlap to uniformly treat the soil beneath the stormwater capture structures and at least 5-foot out in all directions, unless the canal wall is within 5 feet, in which the treatment should extend to the canal wall. At the North Parcel, the DSM treatment should extend to at least a depth of 35 feet below existing ground surface, or 25 feet below the bottom of the stormwater capture aggregate layer, whichever is deeper. At the Ballfield site, the DSM treatment should extend at least to a depth of 40 feet, or 30 feet below the bottom of the stormwater capture aggregate layer, whichever is deeper. At least 20% of the DSM columns should be cored and inspected to demonstrate successful soil/cement mixing. The successfully completed soil improvement should be shown by at least six evenly spaced CPT's to reduce the maximum calculated total and differential seismically induced settlement (liquefaction and densification) under the stormwater capture structure to 2 inches and 1 inch over 30 feet, respectively. In addition, static load induced settlement for the soil improved alternative should be less than 1 inch total and 1/2 inch differential over 30 feet. The successfully installed soil improvement should provide a minimum uniform dead-plus-live load bearing capacity of at least 2,500 psf, and a minimum coefficient of base friction of 0.34 across the bottom of the structure. Typically, DSM and similar soil improvement options are constructed by a design/build contractor. The prospective design/build contractor should be provided with our report and consult with us throughout the design and build process to confirm that our recommendations are being incorporated into their design and construction.

5.3 Deep Foundations Alternatives

As an alternative to mitigate liquefaction induced settlement and the potential for bearing failure associated with liquefaction (sand boils and ejecta), we recommend that the stormwater capture structure be supported by a deep foundation such as Auger Cast Piles (ACP), Drilled Displacement Piles (DDP), Auger Cast Columns (ACC) or Drilled Displacement Columns (DDC). These deep foundations should be spaced as determined by the design build contractor and the project structural engineer to support the loads of the stormcapture structures during liquefaction and resist movement. We recommend that the deep foundations extend to depths of at least 50 feet below existing ground surface or 40 feet below the bottom of the capture structure, whichever is deeper, at both the North Parcel, and the Ballfield. A successfully installed deep foundation should result in less than 1 inch total settlement and 1/2 inch differential (between piles) due to static loads, and 2 inches total and 1 differential due to seismic (liquefaction/densification) loading. Typically, auger cast piles and deep foundation options are designed and constructed by a design/build contractor. At least four of these deep foundations at each site should performance tested using dynamic pile test methods (CAPWAP with PDA or similar) to confirm the estimated pile capacity. The prospective design/build contractor should be provided with our report and consult with us throughout the design and build process to confirm that our recommendations are being incorporated into their design and construction.

5.4 Stormcapture Structure Design

The Stormcapture structure should be designed to resist at rest equivalent fluid pressure of at least 60 pounds per cubic foot (pcf) for horizontal backfill, assuming no hydrostatic pressure. If the groundwater could rise above a depth of about 10 feet (or the bottom of the structure), then the structure should be designed to resist a full hydrostatic equivalent fluid pressure lateral load of 90 pounds per cubic foot (pcf).

The lateral loads can be resisted by a coefficient of base friction of 0.34 for the soil improvement alternative, and passive resistance against the sides of the piles (design criteria to be determined by the design build contractor) for the deep foundation option.

5.5 Site Grading

Based on our field investigation, grading excavations should be within the capabilities of moderate excavation equipment (i.e., drill rigs, backhoes, excavators and dozers). Dewatering should be anticipated below depths of 25 feet or higher depending on the season at the North Parcel, and 18 feet at the Ballfield site.

5.5.1 Site Preparation - All loose material, vegetation, existing concrete foundations, concrete curbs, asphalt, debris, and other deleterious material should be stripped and removed from the areas to be occupied by the new building. This material should be disposed of in a suitable location off-site.

The site should be excavated as necessary for planned grades, we are not anticipating that fill will be placed other than to backfill around and over the stormcapture structures. The bottom of the excavation for the stormwater capture structures may be wet to saturated, and could require pumping to lower the groundwater to allow for construction to proceed. The excavation subgrade should be cleared of all loose debris and standing water prior to placing the manufacturer recommended non-woven geotextile fabric.

5.5.2. Compacted Fill – In general, the on-site materials should be suitable for re-use as compacted fill, provided they are not too wet or have plasticity index (PI) greater than 20. Imported fill should be free of organic material; it should contain no material larger than 4 inches; it should have a plasticity index (PI) of less than 16; it should be free of hazardous contamination (per State of California requirements); and it should be free of Asphaltic Concrete grindings. The fill should be placed in horizontal lifts not exceeding 8 inches in loose thickness, moisture conditioned to at least optimum moisture content, and compacted to at least 95 percent relative compaction beneath structures and 18 inches below the aggregate base rock for pavements, and 90 percent relative compaction elsewhere, all based on ASTM D-1557-12. Approximately 18 inches (Old Castle Technical Note SC-01) of manufacturer recommended aggregate (No. 56 or 57 Stone, per ASTM C33) should be placed on the geotextile. Compaction methods and equipment should be used that are suitable for compacting against the stormwater capture structures without damaging the structures or pipes. If the excavated material is too wet to use for backfilling the excavation, or if the exposed ground surface is soft and yielding, Controlled Low Strength Material (CLSM) or Controlled Density Fill (CDF) can be used instead provided it has a compressive strength of at least 100 psi.

5.5.3 Utility Trench Backfill - Planned pipelines should be placed at least 3 feet below final ground surface. Utility trenches should be backfilled with approved, on-site soil. Bedding materials for pipes should be graded and placed in accordance with the manufacturer's recommendations. The backfill should be compacted to at least 90 percent relative compaction based on based on ASTM D-1557-12. Equipment and methods should be used that are suitable for work in confined areas without damaging trench walls or conduits.

5.5.4 Temporary Cut Slope Design - We understand that the preferred excavation method is by open excavation, during the dry season, temporary cut slopes of 2:1 (H:V), should generally be satisfactory for construction purposes, provided that they are inspected and approved by our field representative at the time of construction and monitored daily during construction. However, shoring will likely be required adjacent to the canal to avoid undermining and damaging the canal. Excavation methods, shoring, bracing and safety of excavations are the responsibility of the contractor. All excavations should comply with applicable local, State and Federal safety regulations. If requested, CSA can review the Contractor's shoring calculation and provide input.

Care should be taken to ensure that other existing structures are not undermined during temporary construction excavations. We recommend that the Contractor implement a monitoring program and schedule to evaluate the safety of the excavation. The Contractor should also prepare an emergency buttressing plan, and be prepared to implement it if movement in excess of 1 inch (horizontal or vertical) is detected.

5.5.5 Pavement Subgrade Preparation - After general compaction and compaction of the utility trench backfills, pavement areas (if appropriate) should be checked for yielding areas by proof-rolling with a loaded water truck or equivalent. Any yielding areas should be excavated and replaced with compacted fill. The upper 12 inches should be moisture conditioned to at least optimum moisture content, and compacted to at least 95 percent relative compaction based on ASTM D-1557-12.

5.6 Pavement Design

Testing of the R-value of the on-site soils was outside the scope of our services; however, in the event that new pavement is planned, based on an assumed R-value of 5 (for a highly expansive soil), an assumed Traffic Index of 5.5, corresponding to relatively light loading and service

vehicle use, we recommend that the pavement section consist of a minimum of 3.5 inches thickness of asphaltic concrete underlain by a minimum of 12 inches of aggregate base rock compacted to a minimum of 95% relative compaction (ASTM D1557-12).

Asphaltic concrete should be placed and compacted in accordance with the requirements of Section 39 of the Caltrans Standard Specifications; aggregate base rock should conform to the provisions of Section 26 (Caltrans) for 3/4-inch maximum Class 2 Aggregate Base, and should be compacted to at least 95 percent relative compaction based on ASTM D-1557-12 rather than Caltrans Method 216.

5.7 Surface Drainage

We recommend that all surface drainage be permanently diverted away from the planned structures at a minimum 2% grade into an appropriate catch basin/storm drain system, or natural swale. All roof downspouts should be connected to tight line drain pipes that are directed, in turn, into an appropriate catch basin/storm drain system or natural swale.

5.8 Seismic Design

A peak ground acceleration of 0.87g to 0.88g should be anticipated for design purposes at the site. Based on our geotechnical investigation, the site location, our interpretation of the 2016 CBC documents related to Earthquake Loads and using the USGS U.S. Seismic Design Maps tool (ASCE 7-10, errata March 2013), we are providing the following parameter recommendations for the two sites:

Northern Parcel

Parameter	Value
Site Classification	D
Mapped Spectral Acc. 0.2 Sec. (g)	Ss = 2.265
Mapped Spectral Acc. 1 Sec. (g)	S_1 = 1.084
Fa – Site Coefficient	1.0
Fv – Site Coefficient	1.5
S_{MS} = FaSs	2.265
S_{M1} = FvS_1	1.626
S_{DS}=2/3 S_{MS}	1.510
S_{D1}=2/3 S_{M1}	1.084

Ballfield Site

Parameter	Value
Site Classification	D
Mapped Spectral Acc. 0.2 Sec. (g)	Ss = 2.253
Mapped Spectral Acc. 1 Sec. (g)	S_1 = 1.077
Fa – Site Coefficient	1.0
Fv – Site Coefficient	1.5
S_{MS} = FaSs	2.253
S_{M1} = FvS_1	1.616
S_{DS}=2/3 S_{MS}	1.502
S_{D1}=2/3 S_{M1}	1.077

5.9 Technical Review

Supplemental geotechnical design recommendations should be provided by our firm based on specific design needs developed by the other project design professionals. This report, and any supplemental recommendations, should be reviewed by the contractor as part of the bid process. It is strongly recommended that no construction be started nor grading undertaken until the final drawings, specifications, and calculations have been reviewed and approved in writing by a representative of **Cotton, Shires and Associates, Inc.**

5.10 Earthwork Construction Observation and Testing

All excavations including pier drilling and ground improvement should be observed by a representative of **Cotton, Shires and Associates, Inc.** prior to filling or pouring of concrete foundations. Any grading should also be observed and tested as appropriate to assure adequate stripping and compaction. Our office should be contacted with a minimum of 48 hours advance notice of construction activities requiring inspection and/or testing services and a minimum of 72 hours advance notice and provision of representative laboratory compaction curve samples for testing of fill.

6.0 INVESTIGATION LIMITATIONS

Our services consist of professional opinions and recommendations made in accordance with generally accepted engineering geology and geotechnical engineering principles and practices.

No warranty, expressed or implied, or merchantability of fitness, is made or intended in connection with our work, by the proposal for consulting or other services, or by the furnishing of oral or written reports or findings. It was not within our scope to investigate the site for environmental concerns such as contaminated soils and therefore we accept no liability associated with such materials being present.

Any recommendations and/or design criteria presented in this report are contingent upon our firm being retained to review the final drawings and specifications, to be consulted when any questions arise with regard to the recommendations contained herein, and to provide testing and inspection services for earthwork and construction operations. Unanticipated soil and geologic conditions are commonly encountered during construction which cannot be fully determined from existing exposures or by limited subsurface investigation. Such conditions may require additional expenditures during construction to obtain a properly constructed project. Some contingency fund is recommended to accommodate these possible extra costs.

This report is issued with the understanding that it is the responsibility of the owner, or of his representative, to ensure that the information and recommendations contained herein are called to the attention of the project architect and/or engineer and incorporated into the plans. Furthermore, it is also the responsibility of the owner, or of his representative, to ensure that the contractor and subcontractors carry out such recommendations in the field.

7.0 REFERENCES

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APPENDIX A

Field Investigation
Logs of Exploratory Borings

APPENDIX A
FIELD INVESTIGATION

We explored subsurface conditions at the North Parcel and Ballfield sites in South San Francisco, California on between April 3 and April 5, 2018, by means of eight small-diameter exploratory borings drilled to a depth of 31.5 to 46.5 feet using track-mounted hollow-stem auger drilling equipment. The locations of the borings are shown on Figures 4 and 5. The engineer who logged the borings visually classified the soils in accordance with ASTM D-2487. We obtained relatively undisturbed samples of the materials encountered at selected depths. These samples were obtained in stainless steel liners that were 2.5 inches in outside diameter by 6 inches long, and placed inside a 3-inch diameter modified split-barrel California Sampler for sampling. The California Sampler was driven with an automatic 140-pound hammer that was allowed to freely fall about 30 inches. We also performed Standard Penetration Tests (SPT) at selected depths. The depths of the sampling are shown on the boring logs. The number in the circle at the conclusion of the sampling interval represents the Standard Penetration Test blow count derived by multiplying the Modified California Sampler blow count by a factor of 0.68.

Descriptive logs of the borings are presented in this appendix. These logs depict our interpretation of the subsurface conditions at the dates and locations indicated, based on representative samples collected at roughly five-foot sampling intervals. It is not warranted that they are representative of subsurface conditions at other times and locations. The contacts on the logs represent the approximate boundaries between earth materials, and the transitions between these materials may be gradual.

COTTON, SHIRES AND ASSOCIATES, INC.

LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park — **Boring** CSA/SD-1

Location 22' E of PP, 28' N of channel (North Parcel) — **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 — **Date of Drilling** 04/04/2018

Ground Surface Elev. ~28 feet — **Logged By** TRH — **Hole Diameter** 8" HSA

Surface Old Farmland w/ Vegetation — **Weather** Cloudy

Depth (feet)	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
	SM	**0.0'-BOH: ALLUVIUM**							Driller: Paul Britton Helpers: Dave Start Time = 11:10
2	SM	0.0'-12.0' **Silty Sand** - Tan-brown, loose, moist to wet, fine sand	T-1 T-2	100	13.7	2 3 4	MC		
					5				
4	SM	3.0' - Fine to medium sand	SPT-1			2 2 3	SPT		
						5			
6									
8	SM	7.0' - Moist, fine sand	SPT-2			3 3 4	SPT		08:20 Sieve: 90% Sand, 8% Fines
						7			
10									
12	SP	12.0'-17.5' Sand - Tan to tan-brown, medium dense, moist to wet, fine to medium sand, trace gravel	SPT-3			7 7 8	SPT		08:34
14						15			
16									
18	CH	17.5'-24.0' Clay - Black, stiff, wet, high plasticity, rootlets	SPT-4			2 3 3	SPT		
						6			
20			T-3 T-4	89	31.1	7 7 8	MC		LL=57, PI=38 Consol
22						10			
24	CL	24.0'-29.0' Sandy Clay - Mottled blue-gray to brown, stiff, dry to moist	T-5			7 9 12	MC		Sieve: 37% Sand, 63% Fines
26						14			
28			SPT-5			2 3 2	SPT		
					5				
	CL	29.0'-31.5' Sandy Clay - Black, stiff, wet							

Project Orange Memorial Park **Date** 04/04/2018 **Boring** CSA/SD-1

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		CL	29.0'-31.5' Sandy Clay - Black, stiff, wet							12:09
32		SM	31.5'-35.5' Silty Sand - Blue-gray, dense, wet to saturated	T-6 T-7	109	19.8	8 13 18	MC		32 Zero recovery, redrove with sand trap. All samples to BOH used sand trap.
34							(21)			34 Sieve: 56% Sand, 44% Fines
36		CL	35.5'-40.5' Sandy Clay - Blue-gray, stiff, wet to saturated	SPT-6			6 3 2	SPT		36
38							(5)			38
40		CL	40.5'-45.0' Sandy Clay - Blue-gray, very stiff, wet to saturated	SPT-7			3 7 8	SPT		40 Sieve: 47% Sand, 53% Fines
42							(15)			42
44										44
46		ML	45.0'-BOH' Clayey Sandy Silt - Tan, stiff to very stiff, wet	T-8 T-9			7 15 15	MC		46 LL=32, PI=13
48			Total Depth = 46.5 feet No groundwater Encountered				(20)			Finished sampling @ 12:52 48 Finished backfill @ 13:18
50										50
52										52
54										54
56										56
58										58
60										60
62										62

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CONSULTING ENGINEERS AND GEOLOGISTS

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LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park | **Boring** CSA/SD-2

Location 215' W of fence, 170' N of channel (North Parcel) | **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 | **Date of Drilling** 04/05/2018

Ground Surface Elev. ~28 feet | **Logged By** TRH | **Hole Diameter** 8" HSA

Surface Old Farmland w/ Vegetation | **Weather** Cloudy

Depth (feet)	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
	ML	**0.0'-BOH: ALLUVIUM**							Driller: Paul Britton Helpers: Sergio + Dave Start Time = 11:20
2		0.0'-2.0' **Sandy Silt** - Dark-brown, stiff, moist	T-1 T-2	115	10.1	4 6 8	MC		
	SM	2.0'-6.0' **Silty Sand** - Tan-brown, loose, moist				(9)			
4		4.0' - Brown	SPT-1			5 3 3	SPT		
					(6)				
6	SM	6.0'-15.0' **Silty Sand** - Tan-brown, loose, moist	SPT-2			1 2 4	SPT		08:20
8						(6)			
10	SM		SPT-3			4 6 4	SPT		Sieve: 79% Sand, 21% Fines
12						(10)			08:34
14	SM	15.0'-15.5' **Silty Sand** - Tan-brown, loose, wet							
16	CL	15.5'-20.0' **Silty Clay** - Dark-brown, very stiff, wet, rootlets	SPT-4			2 3 4	SPT		Sieve: 39% Sand, 61% Fines
18						(7)			
20	SP	20.0'-21.0' **Sand** - Tan-brown, medium dense, saturated, fine to medium sand	T-3 T-4			10 11 12	MC		
22	CH	21.0'-25.0' **Clay** - Black, stiff, wet				(15)			
24									
26	SM	25.0'-30.0' **Silty Sand** - Tan-brown, medium dense, saturated, fine sand	SPT-5			6 8 12	SPT		
28						(20)			

Project Orange Memorial Park Date 04/05/2018 Boring CSA/SD-2

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
32		CL	30.0'-35.0' **Clay** - Black, stiff to very stiff, saturated	SPT-6			3 1 1	SPT		LL=38, PI=18 12:09
							(2)			Zero recovery, redrove with sand trap. All samples to BOH used sand trap.
34										
36		SM	35.0'-BOH **Silty Sand** - Blue-gray, medium dense, saturated	T-5			3 7 19	MC		
38							(17)			
40			40' - Fine to coarse sand, dense.	SPT-7			13 24 23	SPT		
42			Total Depth = 41.5 feet Groundwater - 25 feet at time of drilling				(47)			Finished sampling @ 12:40
44										Finished backfill @ 13:05
46										
48										
50										
52										
54										
56										
58										
60										
62										

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LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park | **Boring** CSA/SD-3

Location 520' W of fence, 35' N of channel (North Parcel) | **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 | **Date of Drilling** 04/05/2018

Ground Surface Elev. ~28 feet | **Logged By** TRH | **Hole Diameter** 8" HSA

Surface Old Farmland w/ Vegetation | **Weather** Cloudy

Depth (feet)	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
	SP	**0.0'-BOH: ALLUVIUM**							Driller: Paul Britton Helpers: Sergio + Dave Start Time = 09:27
		0.0'-1.5' **Sand** - Tan, loose, moist				4			
2	ML	1.5'-3.5' **Sandy Silt** - Dark-brown, stiff to very stiff, moist	T-1 T-2		8	5 7	MC		2
						4			Sieve: 55% Sand, 42% Fines
4	SM	3.5'-8.5' **Silty Sand** - Tan-brown, medium dense, moist, fine sand	SPT-1			6 8	SPT		4
6						14			6
8	SP-SM	8.5'-18.0' **Silty Sand** - Tan-brown, medium dense, moist, fine sand	SPT-2			4 6 5	SPT		8
10						11			10
12									12
		13.0' - Wet, fine to medium sand							09:41 Sieve: 91% Sand, 9% Fines
14			SPT-3			4 7 6	SPT		14
16						13			16
18	SM	18.0'-19.0' **Silty Sand** - Gray, loose, wet	SPT-4			2 3 2	SPT		18 09:47
	CL	19.0'-20.5' **Clay** - Black, stiff, wet			5				
20			T-3	91	30.1	4 7 9	MC		20
	CH	20.5'-25.0' **Clay** - Black, stiff, wet				11			
22									22
24									24
	ML	25.0'-30.0' **Sandy Silt** - Gray, medium stiff, moist to wet, rootlets	SPT-5			3 3 6	SPT		
26						9			26
28									28

Project Orange Memorial Park **Date** 04/05/2018 **Boring** CSA/SD-3

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
32		SM	30.0'-40.0' **Silty Sand** - Blue-gray, medium dense, wet	SPT-6			6 7 6	SPT		
34							(13)			
36			- loose below 35.5'	SPT-7			8 4 3	SPT		10:17
38							(7)			
40		ML	40.0'-BOH **Sandy Silt** - Blue-gray, stiff to very stiff, saturated, rootlets	T-4 T-5			5 7 7	MC		
42							(9)			
44										
46				SPT-8			5 7 5	SPT		Sieve: 41% Sand, 59% Fines
48			Total Depth = 46.5 feet Groundwater - 40 feet at time of drilling				(12)			Finished sampling @ 10:37 Finished backfill @ 11:05
50										
52										
54										
56										
58										
60										
62										

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LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park | **Boring** CSA/SD-4

Location 45' S of channel, 270' W of Orange Ave (Ballfield) | **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 | **Date of Drilling** 04/04/2018

Ground Surface Elev. ~26 feet | **Logged By** TRH | **Hole Diameter** 8" HSA

Surface Grass Sports Field | **Weather** Sunny, Clear

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		Af	**0.0'-4.5': ARTIFICIAL FILL**							Driller: Paul Britton Helpers: Dave Start Time = 08:03
		CL	0'-2.0' **Sandy Clay** - Dark brown, medium stiff to stiff, moist to wet, medium plasticity	T-1 T-2	108	13.3	4 5 7	MC		
2		CL	2.0'-4.5' **Sandy Clay** - Dark brown to tan-brown, medium stiff to stiff, moist				(8)			2
4				SPT-1			2 3 3	SPT		4 Sieve: 42% Sand/Gravel, 58% Fines
		SM	**4.5'-BOH: ALLUVIUM**				(6)			
6			4.5'-18.0' **Silty Sand** - Tan-brown, loose, dry, fine sand							6
		SM	7.0' - Dry to moist	SPT-2			3 3 5	SPT		08:20 Sieve: 70% Sand,
8							(8)			8 30% Fines
10		SM	10.0' - Tan-brown to gray	SPT-3			3 3 3	SPT		10 Sieve: 52% Sand, 48% Fines
12							(6)			12
		SM	13.5' - Dark gray, wet	SPT-4			2 3 4	SPT		08:34 Sieve: 63% Sand,
14							(7)			14 37% Fines
16										16
18		SM	18.0'-23.0' **Silty Sand** - Dark gray, medium dense, saturated	SPT-5			4 5 7	SPT		18 Sieve: 80% Sand, 19% Fines
20							(12)			20
22										22
24		CH	23.0'-24.5' **Clay** - Black, medium stiff, saturated, spongy, rootlets	SPT-6		(4)	1 2 2	SPT		24 Sieve: 24% Sand, 76% Fines LL=56, PI=35
26		CL	24.5'-28.0' **Clay** - Black, medium stiff, saturated,	T-3 T-4	102	24.1	3 4 6	MC		26 LL=34, PI=18
							(7)			
28		SM	28.0'-35.0' **Silty Sand** - Blue-gray, loose, saturated			(14)	8 10 11	MC		28 09:05 No Recovery

Project Orange Memorial Park **Date** 04/04/2018 **Boring** CSA/SD-4

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
32		SM	28.0'-35.0' **Silty Sand** - Blue-gray, loose, saturated	SPT-7			3 4 3 (7)	SPT		Only shoe recovery. Put sand trap in sampler and re-sampled. All SPTs to BOH use sand trap.
34										
36		CL	35.0'-36.0' **Sandy Clay** - Black, wet, stiff	SPT-8			2 2 3	SPT		
		SC	36.0'-40.0' **Clayey Sand** - Gray, loose, wet				(5)			
38										
40		CL	40.0'-45.0' **Sandy Clay** - Gray, stiff, moist	SPT-9			10 10 13	SPT		09:45 Sieve: 47% Sand, 53% Fines
42							(23)			
44										
46		CL	45.0'-46.0' **Sandy Clay** - Gray, stiff, moist to wet	SPT-10			8 13 12	SPT		Sieve: 26% Sand, 74% Fines
		CL	46.0'-BOH **Sandy Clay** - Olive-gray, stiff, saturated				(25)			Finished sampling @ 09:57
48			Total Depth = 46.5 feet Groundwater - 18 feet at time of drilling							Finished backfill @ 10:30
50										
52										
54										
56										
58										
60										
62										

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LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park | **Boring** CSA/SD-5

Location 140' S of channel, 80' W of Orange Ave (Ballfield) | **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 | **Date of Drilling** 04/03/2018

Ground Surface Elev. ~26 feet | **Logged By** TRH | **Hole Diameter** 8" HSA

Surface Grass Sports Field | **Weather** Sunny, Clear

Depth (feet)	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
	Af	**0.0'-4.5': ARTIFICIAL FILL**							Driller: Paul Britton
	CL	0'-4.5' **Silty Clay** - Dark brown, medium tiff to stiff, wet, low plasticity							Helpers: Sergio + Dave
			T-1			3			Start Time = 08:50
2			T-2	107	18.5	4	MC		2
						(5)			
4			T-3			2			4
			T-4			2	MC		
	SP	**4.5'-BOH: ALLUVIUM**				4			
6		4.5'-8.0' **Sand** - Tan-brown, loose, moist, fine grain							6
			T-5			3			09:04
8			T-6	99	9.4	4	MC		8
	SM	8.0'-10.0' **Silty Sand** - Tan-brown, loose, moist				(7)			
10	SM	10.0'-25.0' **Silty Sand** - Light red-brown, loose, wet, iron oxide streaks	T-7			2			10
			T-8	88	33.9	3	MC		
12						(4)			12
14									14
	SM	15.0' - Gray, fine sand, medium dense below 15.0'	SPT-1			2			09:19
16						7	SPT		16
						(13)			
18									18
20	SM	20' - Saturated	T-9			6			20
			T-10	98	25.4	8	MC		09:27
22						(11)			22
24									24
	CL	25.0'-30.0' **Sandy Silty Clay** - Dark gray, stiff, saturated, rootlets	SPT-2			1			
26						3	SPT		26
						4			
						(7)			
28									28

Project Orange Memorial Park **Date** 04/03/2018 **Boring** CSA/SD-5

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		SC	30.0'-BOH **Clayey Sand** - Light gray, dense, moist, medium sand	T-11 T-12			13 26 29	MC		09:50 Sieve: 70% Sand, 30% Fines
32			Total Depth = 31.5 feet Groundwater - 20 feet at time of drilling				(35)			32 Finished sampling @ 09:55
34										34 Finished backfill @ 10:18
36										36
38										38
40										40
42										42
44										44
46										46
48										48
50										50
52										52
54										54
56										56
58										58
60										60
62										62

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LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park — **Boring** CSA/SD-6

Location 95' N of Memorial Dr, 300' W of Orange Ave (Ballfield) — **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 — **Date of Drilling** 04/03/2018

Ground Surface Elev. ~26 feet — **Logged By** TRH — **Hole Diameter** 8" HSA

Surface Grass Sports Field — **Weather** Sunny, Clear

Depth (feet)	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		0.0'-4.5': ARTIFICIAL FILL							Driller: Paul Britton Helpers: Sergio + Dave Start Time = 12:46
2	CL	0'-4.5' **Sandy Clay** - Dark brown, medium stiff to stiff, moist	T-1 T-2			2 6 9	MC		LL=23, PI=8
						(10)			
4			T-3 T-4			3 3 4	MC		Sieve: 47% Sand, 53% Fines
	SP	**4.5'-BOH: ALLUVIUM**							
6		4.5'-7.5' **Sand** - Tan-brown, loose, dry, fine grain				(5)			
	SM	7.5'-10.0' **Silty Sand** - Tan-brown, medium dense, dry, fine grain	T-5 T-6			5 8 8	MC		12:59
8						(11)			
10	SC	10.0'-11.5' **Clayey Sand** - Dark brown, loose to medium dense, dry	T-7 T-8			7 10 16	MC		LL=38, PI=19
	SM	11.5'-25.0' **Silty Sand** - Tan-brown, medium dense, dry				(17)			
12									
14									
		15.0' - Dense below 15.0'	SPT-1			7 15 26	SPT		
16						(41)			
18									
20		20.0' - Medium dense below 20.0'	T-9 T-10			9 11 17	MC		Non-Plastic
						(19)			
22									
24									
	SP	25.0'-BOH **Sand** - Tan, dense, dry to moist	T-11 T-12			9 15 41	MC		
26						(37)			
28		28.0' - Moist to wet	SPT-2		(36)	9 15 21	SPT		13:47

Project Orange Memorial Park **Date** 04/03/2018 **Boring** CSA/SD-6

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		SP	25.0'-BOH **Sand** - Tan, dense, dry to moist							
32		SP	**32.0'** - Tan-brown, very dense, saturated, fine to medium sand	SPT-3			12 31 50	SPT		32
34			Total Depth = 33.5 feet Groundwater - 32 feet at time of drilling				(81)			34 Finished sampling @ 14:04
36										36 Finished backfill @ 14:35
38										38
40										40
42										42
44										44
46										46
48										48
50										50
52										52
54										54
56										56
58										58
60										60
62										62

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LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park — **Boring** CSA/SD-7

Location 175' N of Memorial Dr, 90' W of Orange Ave (Ballfield) — **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 — **Date of Drilling** 04/03/2018

Ground Surface Elev. ~26 feet — **Logged By** TRH — **Hole Diameter** 8" HSA

Surface Grass Sports Field — **Weather** Sunny, Clear

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
0		Af	**0.0'-5.0': ARTIFICIAL FILL**							Driller: Paul Britton Helpers: Sergio + Dave Start Time = 10:30
		CL	0'-5.0' **Sandy Silty Clay** - Brown, medium stiff to stiff, moist	T-1 T-2			3 5 8	MC		
2							(9)			
4				T-3 T-4			3 4 5	MC		10:37
6		SP	**5.0'-BOH: ALLUVIUM** 5.0'-12.0' **Sand** - Tan-brown, loose, dry, fine sand				(6)			
8			8' - Moist	SPT-1			1 2 2	SPT		10:49
10							(4)			
12		SM	12.0'-17.0' **Silty Sand** - Tan-brown, loose, dry, fine sand	SPT-2			3 3 3	SPT		10:59 Sieve: 70% Sand, 30% Fines
14							(6)			
16										
18		SM	17.0'-18.0' **Silty Sand** - Gray, loose, moist	SPT-3			3 4 3	SPT		
		CL	18.0'-22.0' **Clay** - Black, medium stiff, moist to wet, spongy				(7)			
20										
22		SC	22.0'-27.0' **Clayey Sand** - Gray, loose, wet	SPT-4			2 3 3	SPT		Sieve: 55% Sand, 45% Fines LL=26, PI=11
24							(6)			
26										
28		SP	25.0'-37.0' **Sand** - Gray, dense to very dense, wet	SPT-5			13 23 31	SPT		
							(54)			

Project Orange Memorial Park **Date** 04/03/2018 **Boring** CSA/SD-7

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		SP	25.0'-37.0' **Sand** - Gray, dense to very dense, wet							
32		SP	32.0' - Tan-brown, dense, saturated, fine to medium sand	SPT-6			9 20 28	SPT		32 11:45
34							(48)			34
36										36
38		SP-SM	37.0'-BOH **Sand with Silt** - Tan-brown, dense, saturated, fine sand	SPT-7			7 16 23	SPT		38
			Total Depth = 38.5 feet Groundwater - 32.0 feet at time of drilling				(39)			Finished sampling @ 12:05
40										40 Finished backfill @ 12:39
42										42
44										44
46										46
48										48
50										50
52										52
54										54
56										56
58										58
60										60
62										62

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LOG OF EXPLORATORY DRILLING

Project Orange Memorial Park | **Boring** CSA/SD-8

Location 335' W of fence, 32' N of channel (North Parcel) | **Project No.** E5038

Drilling Contractor/Rig Britton Exploration / CME 550 | **Date of Drilling** 04/05/2018

Ground Surface Elev. ~28 feet | **Logged By** TRH | **Hole Diameter** 8" HSA

Surface Old Farmland w/ Vegetation | **Weather** Cloudy

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		CL	**0.0'-BOH: ALLUVIUM**							Driller: Paul Britton Helpers: Sergio + Dave Start Time = 07:43
2		SM	0.0'-1.5' **Sandy Clay** - Dark-brown, stiff, moist to wet 1.5'-5.0' **Silty Sand** - Brown, loose, moist	T-1 T-2			3 4 6	MC		2
4							(7)			4
6		SM	5.0'-10.0' **Sandy Silt** - Tan-brown, loose, moist, fine sand	SPT-1			3 3 3	SPT		6 Sieve: 71% Sand, 29% Fines
8							(6)			8
10		SM	10.0'-16.0' **Silty Sand** - Tan-brown, loose, moist to wet	SPT-2			3 4 6	SPT		10 08:00
12							(10)			12
14										14
16		ML	16.0'-18.0' **Silt** - Black, stiff to very stiff, wet	SPT-3			4 2 5	SPT		08:08 16
18		CH	18.0'-22.0' **Clay** - Black, stiff to very stiff, wet, high plasticity	T-3 T-4			(7) 3 4 6	MC		18 LL=56, PI=27
20							(7)			20
22		SM	22.0'-30.0' **Silty Sand** - Blue-gray, medium dense, dry, rootlets	T-5			5 10 8	MC		22 08:27
24							(12)			24
26			25.0' - Moist	SPT-4			4 8 9	SPT		26
28							(17)			28

Project Orange Memorial Park Date 04/05/2018 Boring CSA/SD-8

Depth (feet)	Graphic Log	USCS Class.	Geotechnical Description	Sample Desig.	Dry Unit Weight(pcf)	Moisture Content (%)	SPT Blows/ft	Sample Type	Recov. (%)	Remarks
		SM	30.0'-35.0' **Silty Sand** - Gray-brown, medium dense, moist, iron oxide streaks, fine to coarse sand	SPT-5			4 7 12	SPT		08:47
32							(19)			32
34										34
36		SM	35.0'-BOH **Silty Sand** - Gray, medium dense, dry, fine sand	SPT-6			6 10 11	SPT		Sieve: 73% Sand, 28% Fines 36
			Total Depth = 36.5 feet No groundwater Encountered				(21)			Finished sampling @ 09:00
38										38 Finished backfill @ 09:20
40										40
42										42
44										44
46										46
48										48
50										50
52										52
54										54
56										56
58										58
60										60
62										62

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APPENDIX B

Laboratory Testing
Summary of Laboratory Testing
Triaxial Compression Test Results
Consolidation Test Results

APPENDIX B
LABORATORY TESTING

The laboratory analysis performed for the site consisted of limited testing of the representative soil types sampled during the field investigation to evaluate index properties of subsurface materials. The soil descriptions and the field and laboratory test results were used to assign parameters to the various materials at the site. The results of the laboratory testing program are presented in this appendix and on the boring logs.

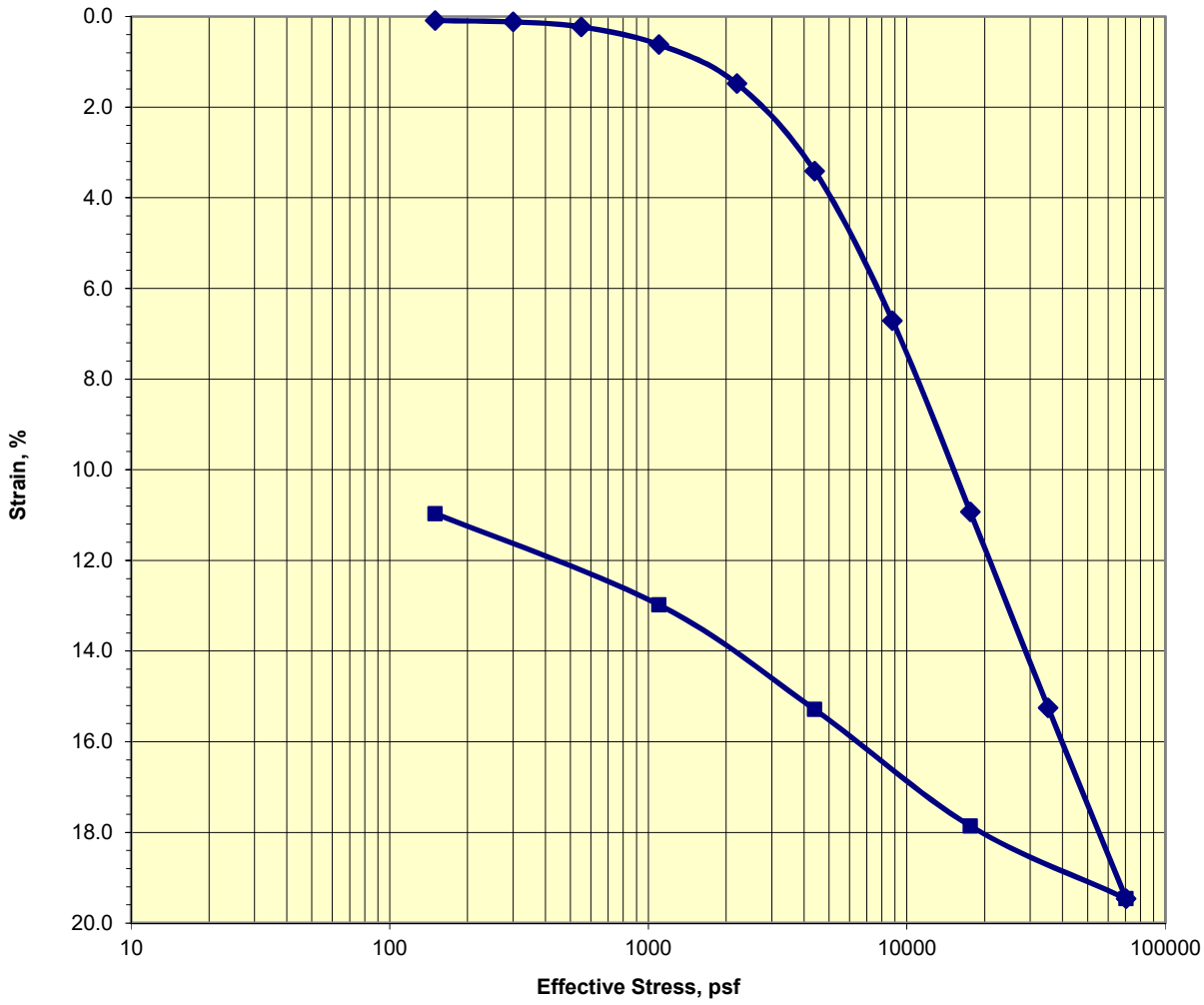
The following laboratory tests were performed as part of this investigation:

1. Detailed soil description, ASTM D2487;
2. Natural moisture content of the soil, ASTM D2216;
3. In-situ unit weight of the soil (wet and dry) ASTM D7263b;
4. Atterberg limits, ASTM D4318;
5. Unconsolidated, undrained triaxial compression test, ASTM D2850;
6. Consolidation, ASTM D2435; and
7. Percent minus the No. 200 sieve, ASTM D1140.

Consolidation Test
ASTM D2435

Job No.:	026-666	**Boring:**	B-1	**Run By:**	MD
Client:	Cotton, Shires & Associates	**Sample:**	T-4	**Reduced:**	PJ
Project:	E5038	**Depth, ft.:**	21-21.5	**Checked:**	PJ/DC
Soil Type:	Black CLAY w/ Sand			**Date:**	4/26/2018

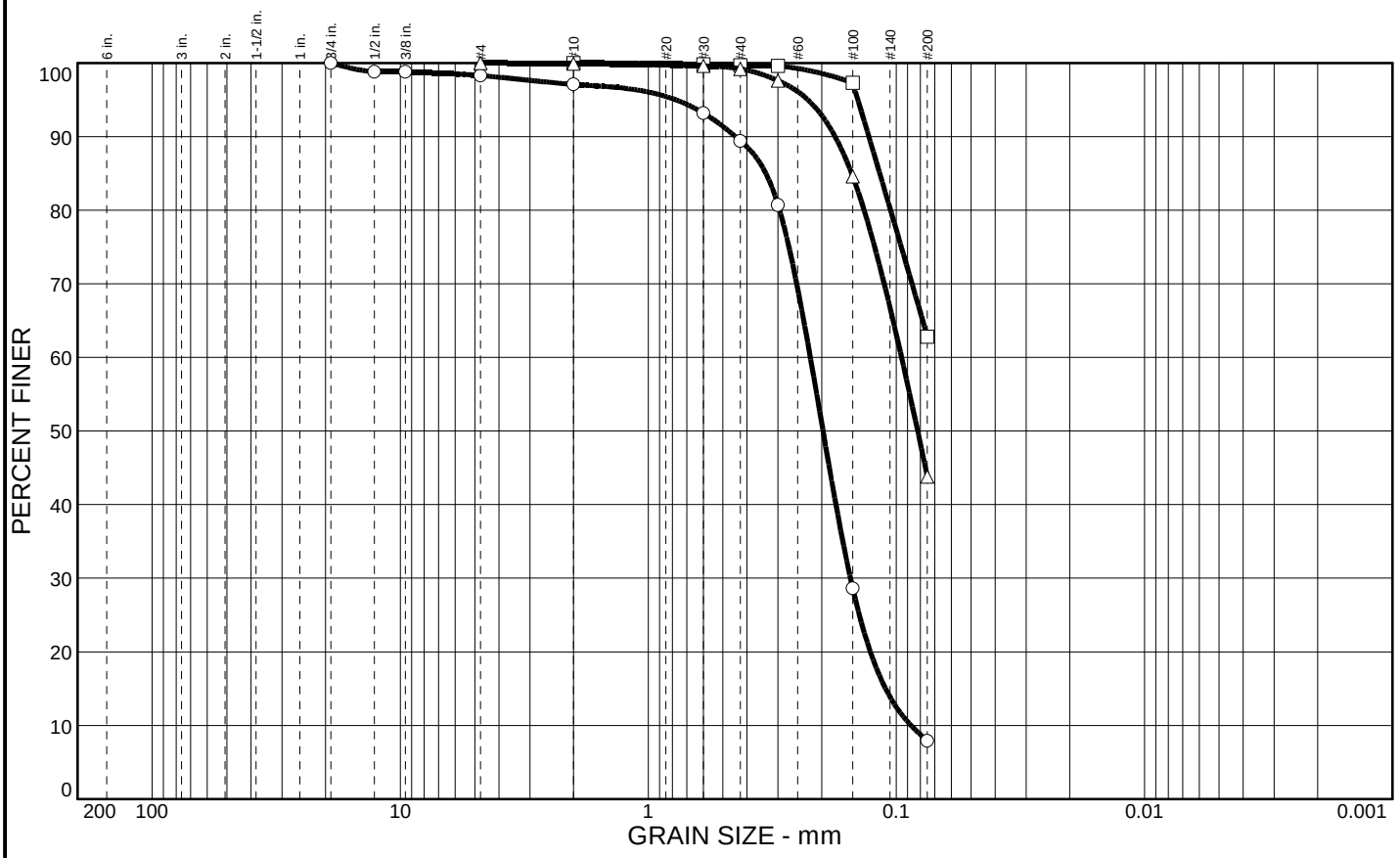
Strain-Log-P Curve



Assumed Gs 2.65	Initial	Final
Moisture %:	31.1	25.0
Dry Density, pcf:	88.8	99.5
Void Ratio:	0.863	0.663
% Saturation:	95.4	100.0

Remarks:

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		1.7	90.4	7.9					
□			37.2	62.8					
△			56.2	43.8					

SIEVE inches size	PERCENT FINER ○	□	△
3/4"	100.0		
1/2"	98.8		
3/8"	98.8		
	GRAIN SIZE		
D_{60}	0.222		0.0954
D_{30}	0.153		
D_{10}	0.0873		
	COEFFICIENTS		
C_c	1.21		
C_u	2.55		

SIEVE number size	PERCENT FINER ○	□	△
#4	98.3		100.0
#10	97.1	100.0	99.9
#30	93.2	99.8	99.6
#40	89.4	99.7	99.2
#50	80.7	99.6	97.6
#100	28.6	97.3	84.6
#200	7.9	62.8	43.8

SOIL DESCRIPTION

○ Yellowish Brown Poorly Graded SAND w/ Silt

□ Olive Gray Sandy CLAY

△ Gray Silty SAND

REMARKS:

○

□

△

○ Source: B-1 Sample No.: SPT-2 Elev./Depth: 7-8.5'

□ Source: B-1 Sample No.: T-5 Elev./Depth: 24-24.5'

△ Source: B-1 Sample No.: T-7 Elev./Depth: 33-33.5'

COOPER TESTING LABORATORY

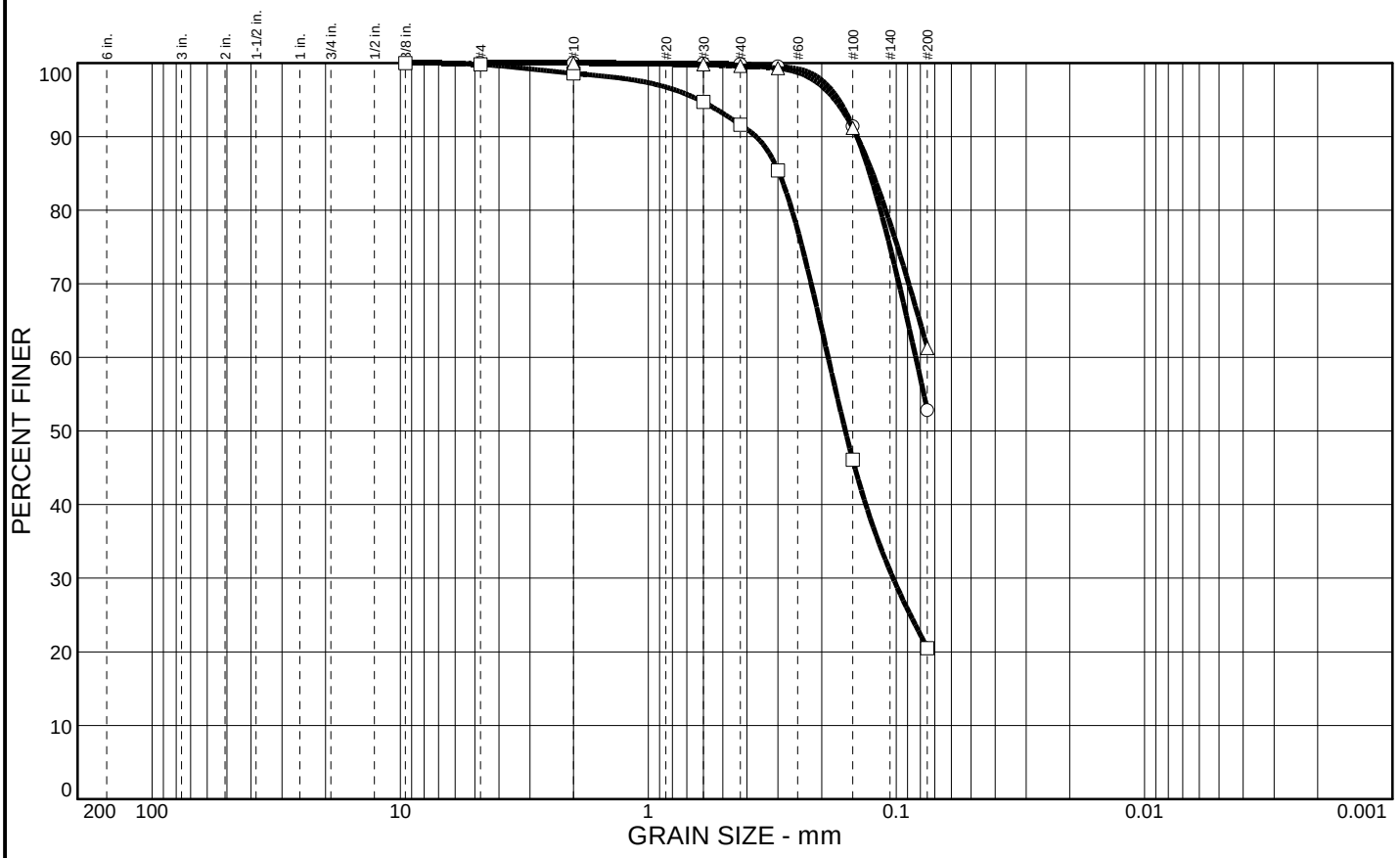
Client: Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

Project No.: 026-666

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			47.2	52.8					
□		0.2	79.3	20.5					
△			38.7	61.3					

SIEVE inches size	PERCENT FINER ○	□	△
3/8"		100.0	
GRAIN SIZE			
D_{60}	0.0836	0.188	
D_{30}		0.103	
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	99.8	
#10	100.0	98.6	100.0
#30	99.9	94.7	99.8
#40	99.8	91.6	99.6
#50	99.5	85.4	99.3
#100	91.4	46.1	91.2
#200	52.8	20.5	61.3

SOIL DESCRIPTION

○ Gray Sandy CLAY

□ Yellowish Brown Silty SAND

△ Dark Yellowish Brown Sandy CLAY

REMARKS:

○

□

△

○ Source: B-1 Sample No.: SPT-7 Elev./Depth: 40-41.5'

□ Source: B-2 Sample No.: SPT-3 Elev./Depth: 10-11.5'

△ Source: B-2 Sample No.: SPT-4 Elev./Depth: 15-16.5'

COOPER TESTING LABORATORY

Client: Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

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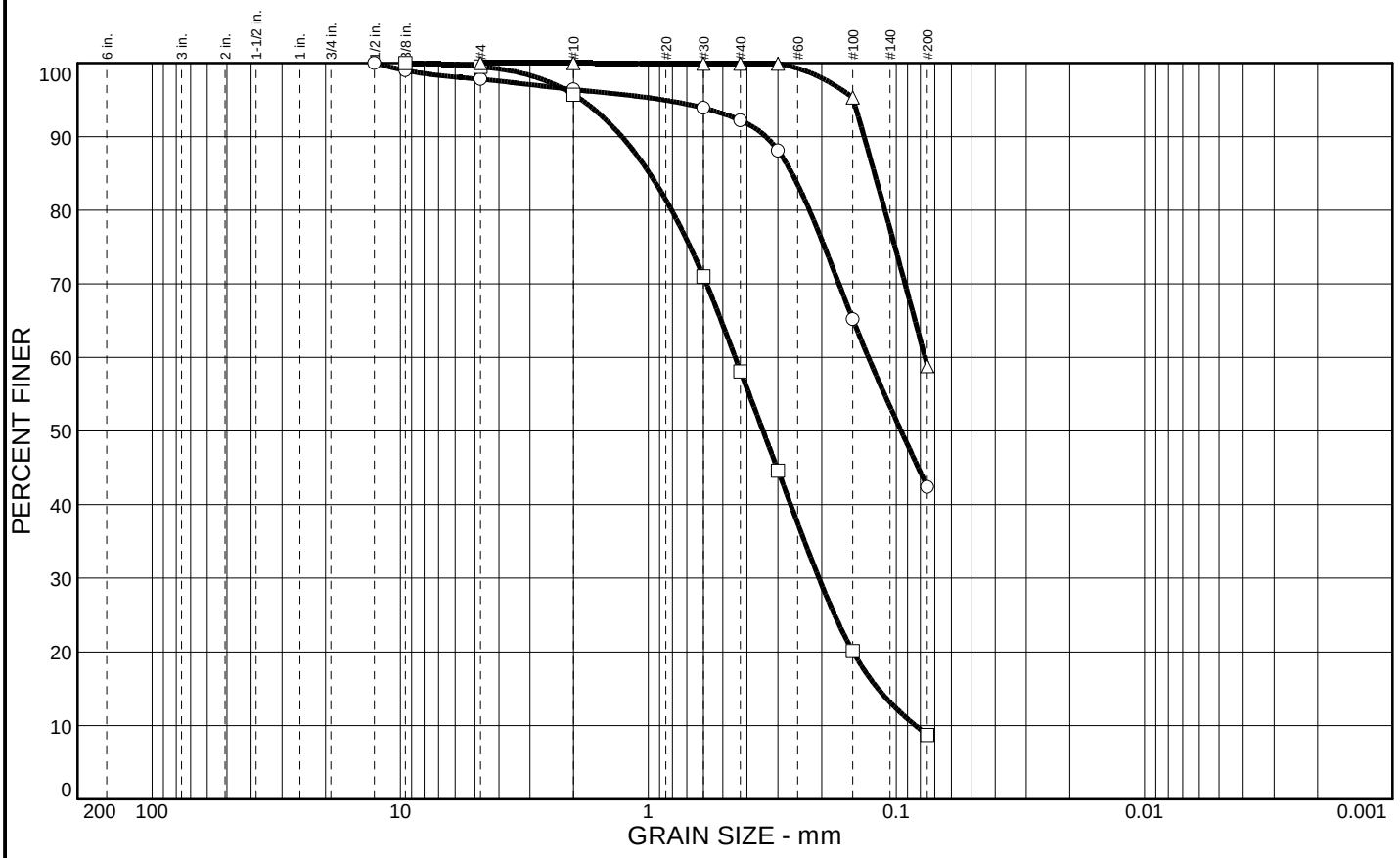
Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		2.2	55.4	42.4					
□		0.5	90.8	8.7					
△			41.2	58.8					

SIEVE inches size	PERCENT FINER ○	□	△
1/2"	100.0		
3/8"	99.0	100.0	
GRAIN SIZE			
D_{60}	0.130	0.446	0.0767
D_{30}		0.205	
D_{10}		0.0838	
COEFFICIENTS			
C_c		1.12	
C_u		5.33	

SIEVE number size	PERCENT FINER ○	□	△
#4	97.8	99.5	100.0
#10	96.4	95.7	100.0
#30	93.9	71.0	99.9
#40	92.2	58.1	99.9
#50	88.1	44.6	99.9
#100	65.2	20.1	95.3
#200	42.4	8.7	58.8

SOIL DESCRIPTION

○ Dark Olive Brown Clayey SAND

□ Dark Reddish Brown Poorly Graded SAND w/ Silt

△ Dark Gray Sandy CLAY

REMARKS:

○

□

△

○ Source: B-3 Sample No.: SPT-1 Elev./Depth: 3-4.5'

□ Source: B-3 Sample No.: SPT-3 Elev./Depth: 13-14.5'

△ Source: B-3 Sample No.: SPT-8 Elev./Depth: 45-46.5'

COOPER TESTING LABORATORY

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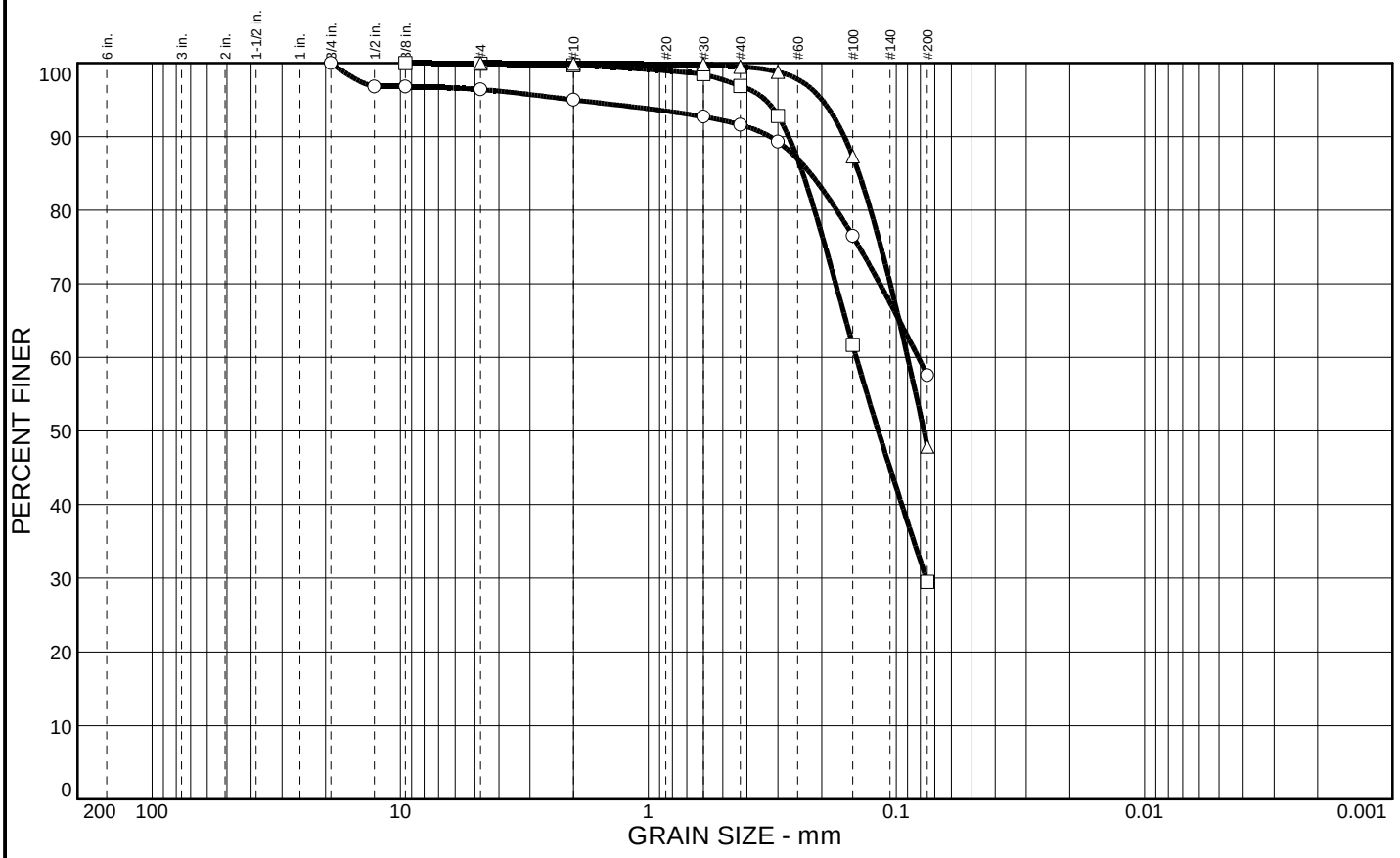
Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		3.6	38.8	57.6		ML			
□		0.1	70.4	29.5					
△			52.1	47.9					

SIEVE inches size	PERCENT FINER ○	□	△
3/4"	100.0		
1/2"	96.8		
3/8"	96.8	100.0	
	GRAIN SIZE		
D_{60}	0.0816	0.145	0.0901
D_{30}		0.0759	
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	96.4	99.9	100.0
#10	95.0	99.7	99.9
#30	92.7	98.5	99.8
#40	91.6	96.9	99.5
#50	89.3	92.8	98.8
#100	76.5	61.7	87.3
#200	57.6	29.5	47.9

SOIL DESCRIPTION

○ Olive Brown Sandy CLAY

□ Reddish Brown Silty SAND

△ Olive Brown Clayey SAND

REMARKS:

○

□

△

○ Source: B-4 Sample No.: SPT-1 Elev./Depth: 3.5-5'

□ Source: B-4 Sample No.: SPT-2 Elev./Depth: 7-8.5'

△ Source: B-4 Sample No.: SPT-3 Elev./Depth: 10-11.5'

COOPER TESTING LABORATORY

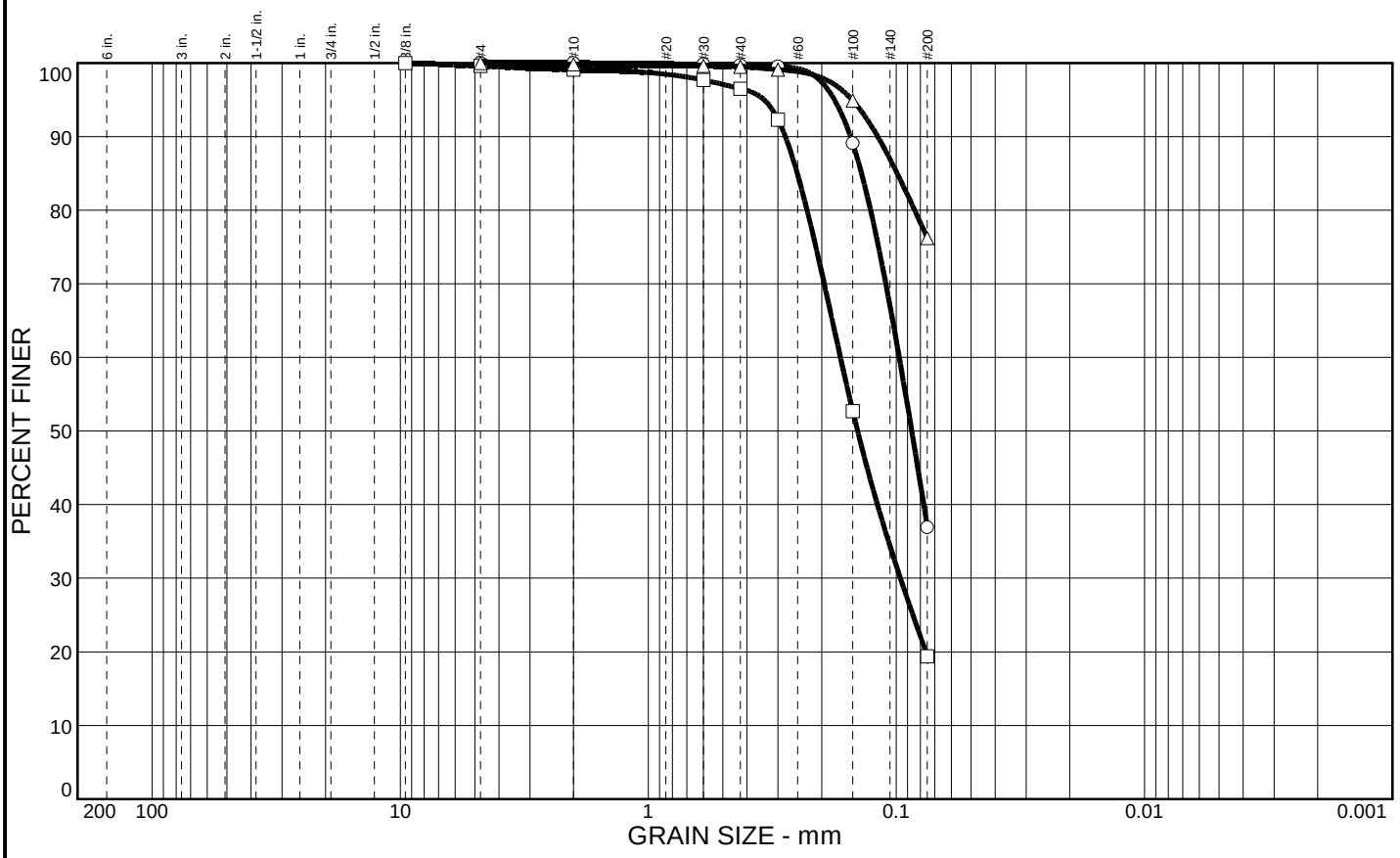
Client: Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

Project No.: 026-666

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			63.1	36.9					
□		0.4	80.2	19.4					
△			23.8	76.2		CH		21	56

SIEVE inches size	PERCENT FINER ○	□	△
3/8"		100.0	
GRAIN SIZE			
D_{60}	0.0974	0.168	
D_{30}		0.0963	
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	99.6	100.0
#10	100.0	99.1	99.8
#30	99.8	97.7	99.6
#40	99.7	96.5	99.5
#50	99.5	92.3	99.1
#100	89.1	52.7	94.9
#200	36.9	19.4	76.2

SOIL DESCRIPTION

○ Dark Olive Gray Clayey SAND

□ Very Dark Brownish Gray Clayey SAND

△ Black Fat CLAY w/ Sand

REMARKS:

○

□

△

○ Source: B-4 Sample No.: SPT-4 Elev./Depth: 13-14.5'

□ Source: B-4 Sample No.: SPT-5 Elev./Depth: 18-19.5'

△ Source: B-4 Sample No.: SPT-6 Elev./Depth: 23-24.5'

COOPER TESTING LABORATORY

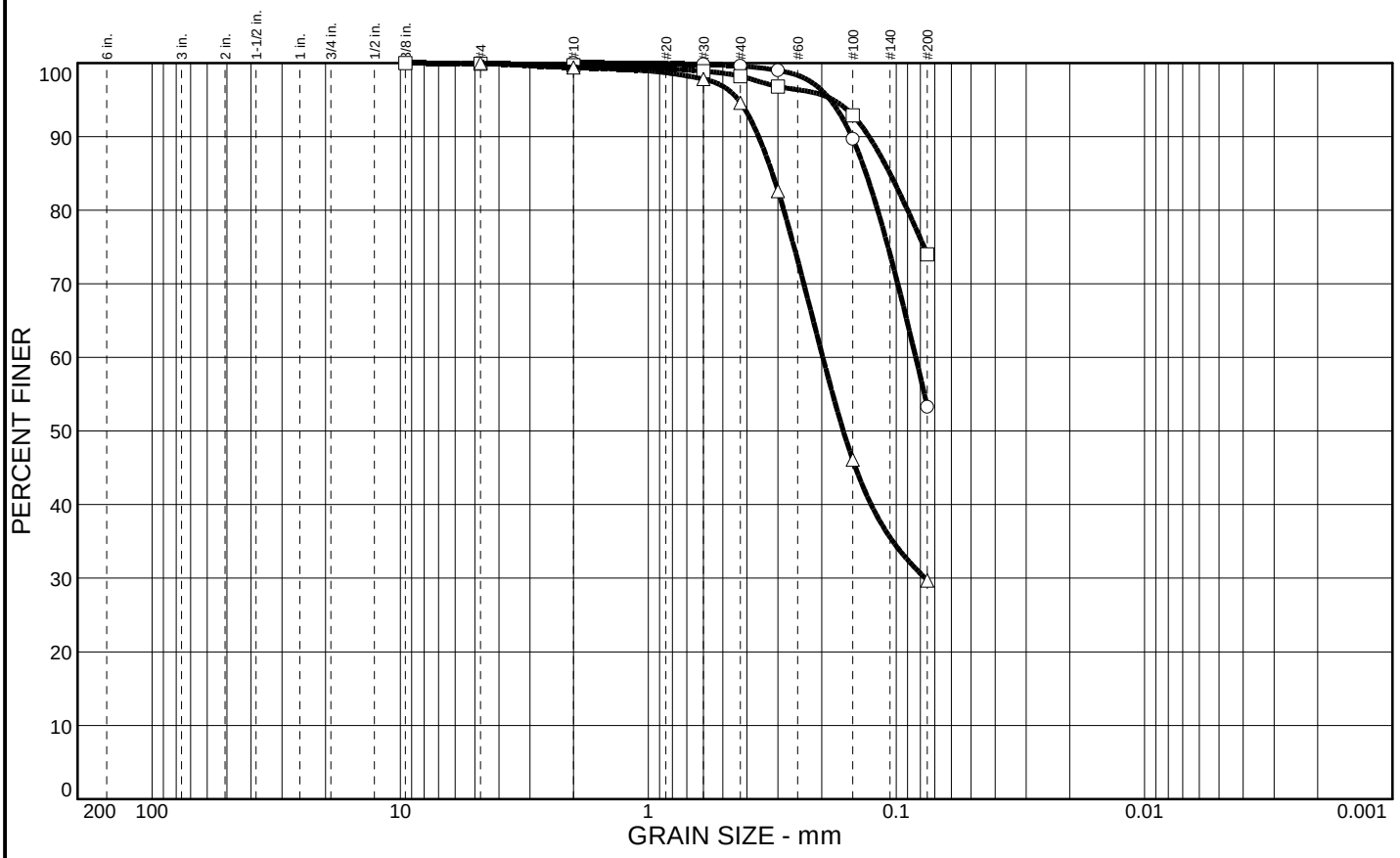
Client: Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

Project No.: 026-666

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			46.7	53.3					
□		0.1	25.9	74.0					
△			70.3	29.7					

SIEVE inches size	PERCENT FINER ○	□	△
3/8"		100.0	
GRAIN SIZE			
D_{60}	0.0836		0.198
D_{30}			0.0766
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4		99.9	100.0
#10	100.0	99.7	99.4
#30	99.8	98.9	97.8
#40	99.6	98.2	94.6
#50	99.0	96.8	82.6
#100	89.7	92.9	46.1
#200	53.3	74.0	29.7

SOIL DESCRIPTION

○ Gray Sandy CLAY

□ Dark Olive Gray CLAY w/ Sand

△ Gray Clayey SAND

REMARKS:

○

□

△

○ Source: B-4 Sample No.: SPT-9 Elev./Depth: 40-41.5'

□ Source: B-4 Sample No.: SPT-10 Elev./Depth: 45-46.5'

△ Source: B-5 Sample No.: T-11 Elev./Depth: 30-30.5'

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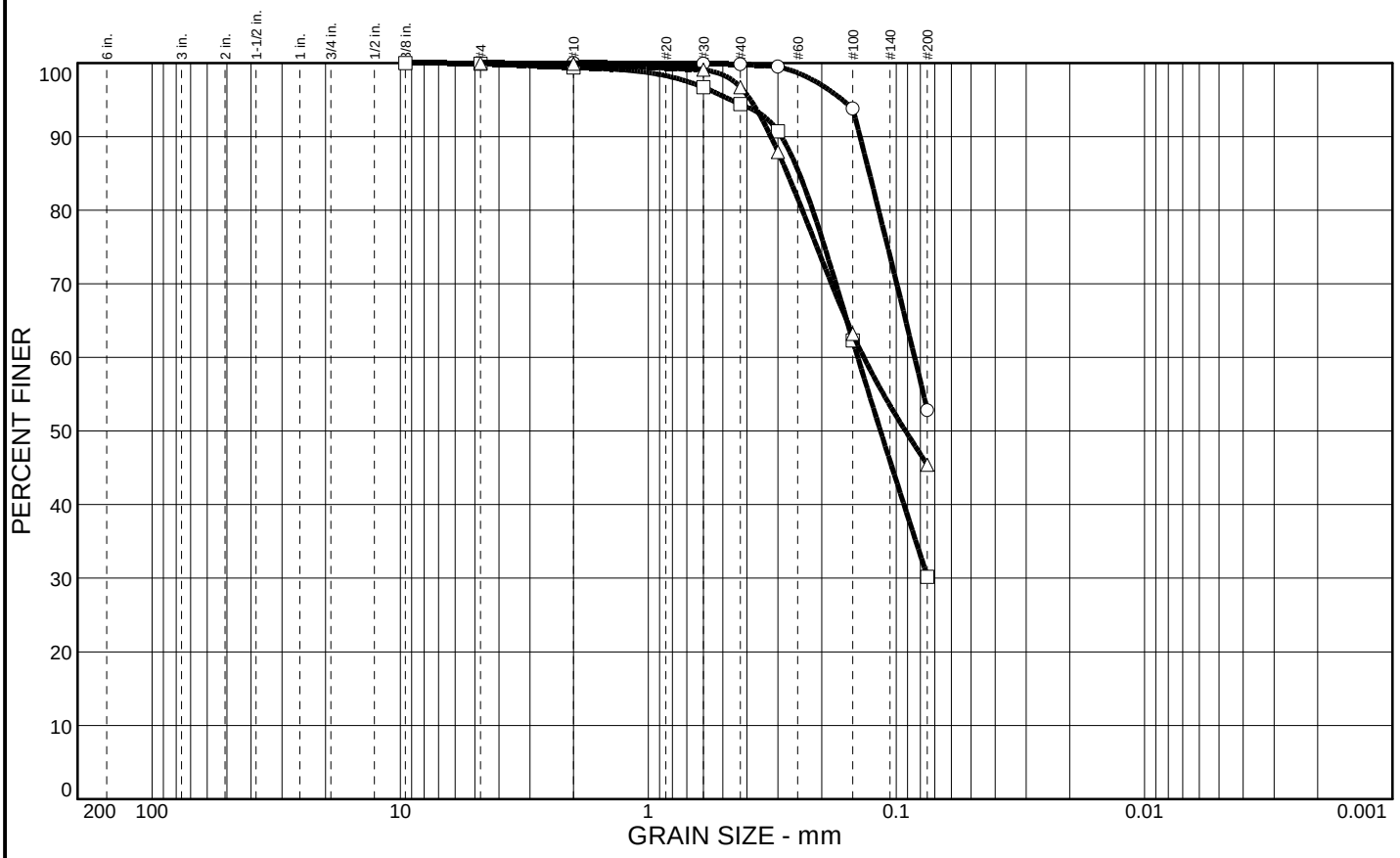
Client: Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

Project No.: 026-666

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			47.2	52.8					
□		0.1	69.7	30.2					
△			54.6	45.4		SC		15	26

SIEVE inches size	PERCENT FINER ○	□	△
3/8"		100.0	
GRAIN SIZE			
D_{60}	0.0844	0.143	0.135
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4		99.9	100.0
#10	100.0	99.4	99.9
#30	99.9	96.7	99.1
#40	99.8	94.4	96.7
#50	99.5	90.7	87.9
#100	93.8	62.3	63.2
#200	52.8	30.2	45.4

SOIL DESCRIPTION

○ Dark Olive Brown Sandy SILT

□ Dark Olive Gray Clayey SAND

△ Dark Olive Gray Lean Clayey SAND

REMARKS:

○

□

△

○ Source: B-6 Sample No.: T-4 Elev./Depth: 4.5-5'

□ Source: B-7 Sample No.: SPT-2 Elev./Depth: 12-13.5'

△ Source: B-7 Sample No.: SPT-4 Elev./Depth: 22-23.5'

COOPER TESTING LABORATORY

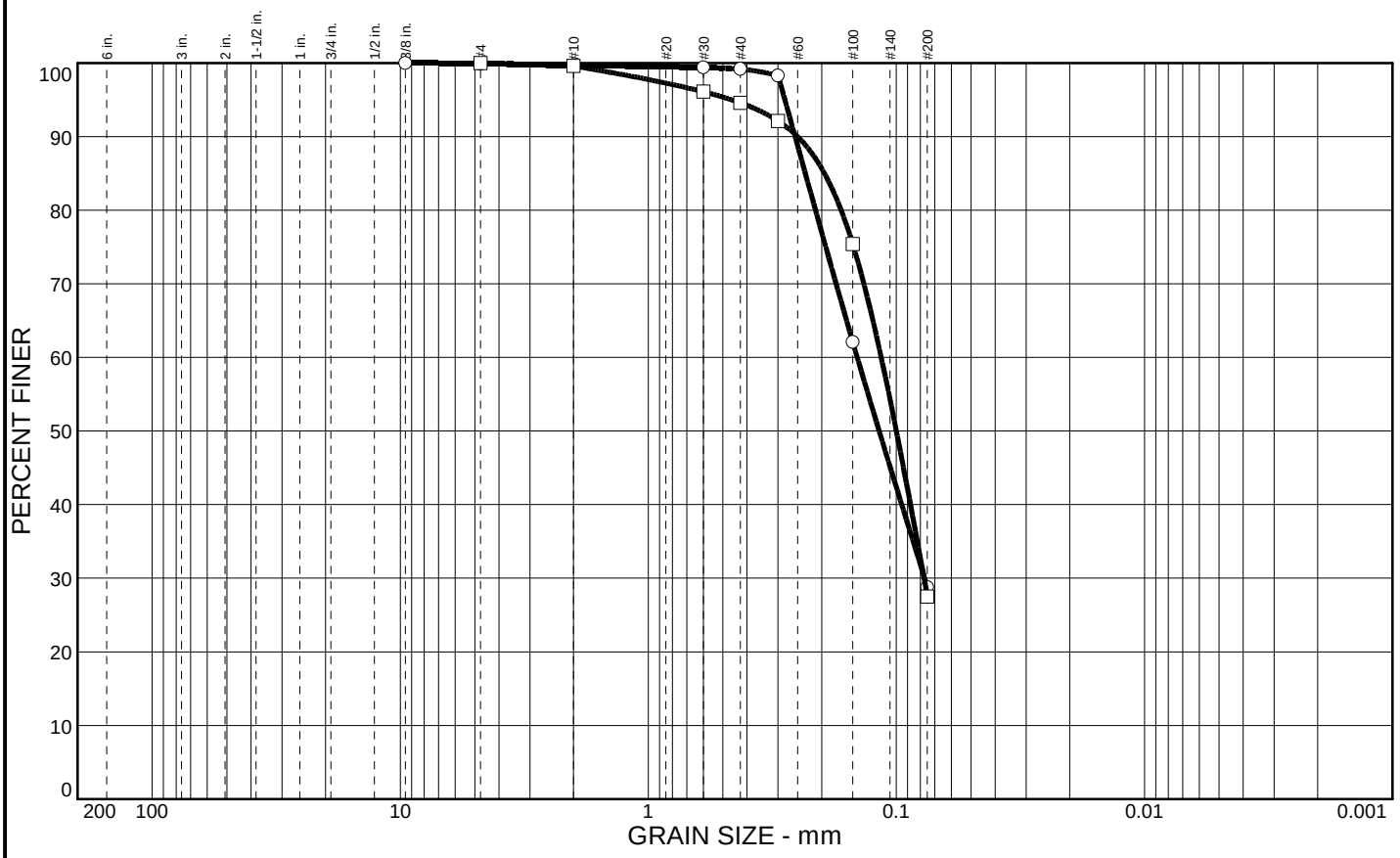
Client: Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

Project No.: 026-666

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.1	71.1	28.8					
□			72.5	27.5					

SIEVE inches size	PERCENT FINER ○	□	
3/8"	100.0		
	GRAIN SIZE		
D_{60}	0.144	0.115	
D_{30}	0.0769	0.0774	
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	
#4	99.9	100.0	
#10	99.7	99.6	
#30	99.4	96.1	
#40	99.2	94.6	
#50	98.3	92.1	
#100	62.1	75.4	
#200	28.8	27.5	

SOIL DESCRIPTION

○ Dark Reddish Brown Clayey SAND

□ Greenish Gray Silty SAND

REMARKS:

○

□

○ Source: B-8 Sample No.: SPT-1 Elev./Depth: 5-6.5'

□ Source: B-8 Sample No.: SPT-6 Elev./Depth: 35-36.5'

COOPER TESTING LABORATORY

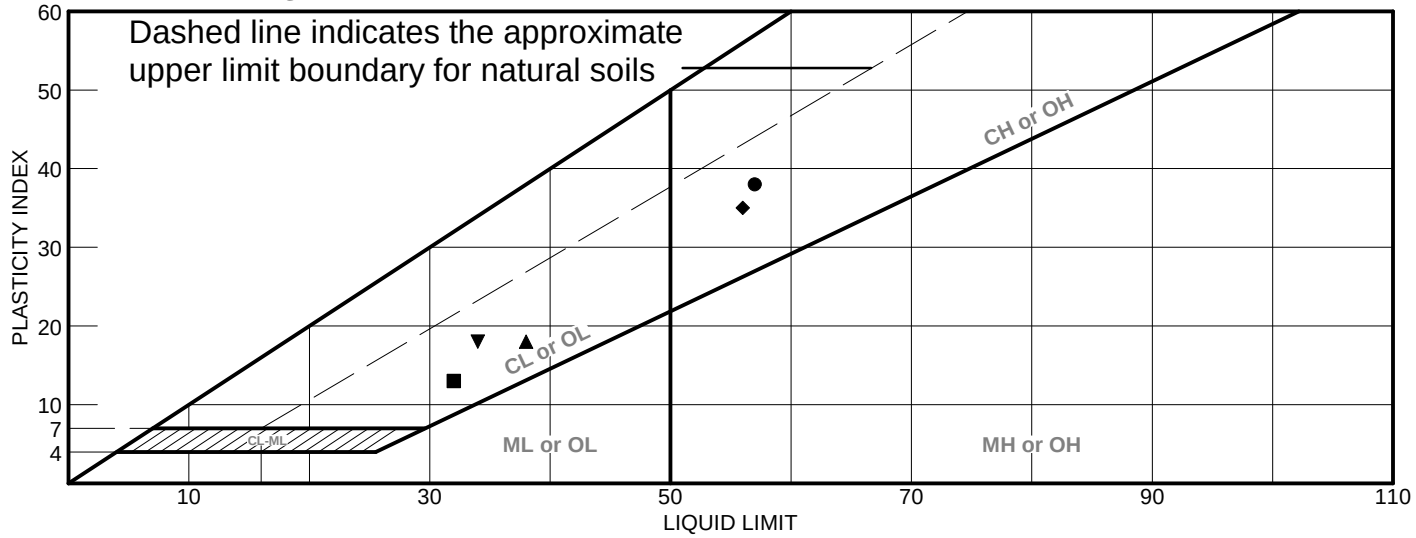
Client: Cotton, Shires & Associates

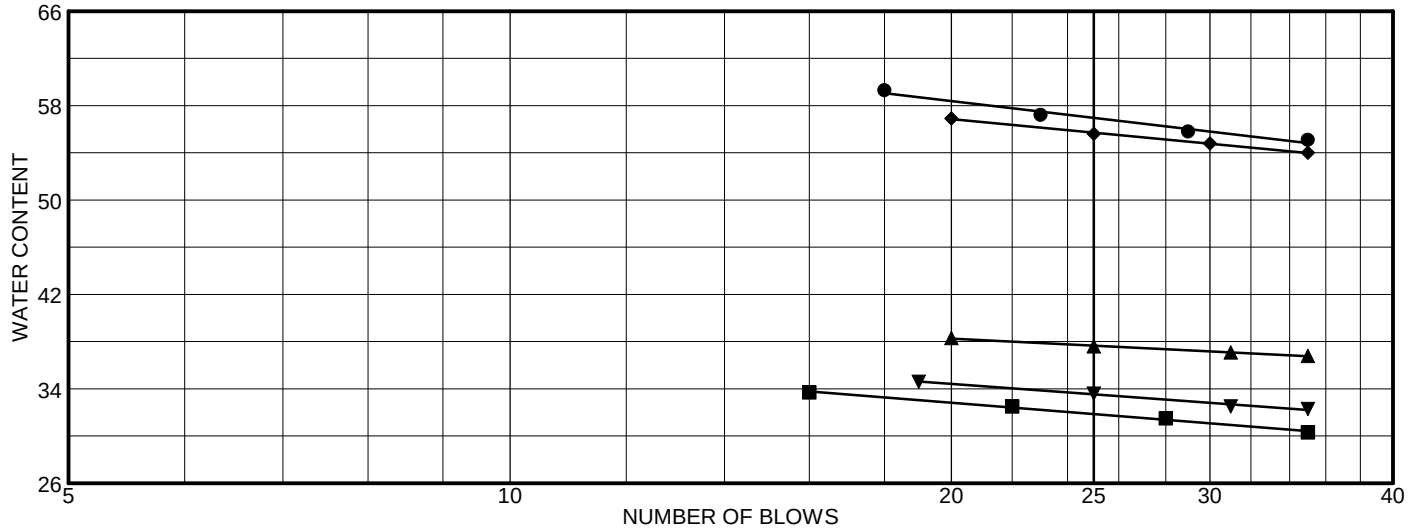
Project: Orange Memorial Park - E5038

Project No.: 026-666

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Black Fat CLAY	57	19	38			
■	Olive Gray Sandy Lean CLAY	32	19	13			
▲	Black Sandy Lean CLAY	38	20	18			
◆	Black Fat CLAY w/ Sand	56	21	35	99.5	76.2	CH
▼	Black Lean CLAY w/ Sand	34	16	18			

Project No. 026-666 **Client:** Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

●	**Source:** B-1	**Sample No.:** T-3	**Elev./Depth:** 20.5-21'
■	**Source:** B-1	**Sample No.:** T-8	**Elev./Depth:** 45.5-46'
▲	**Source:** B-2	**Sample No.:** SPT-6	**Elev./Depth:** 30-31.5'
◆	**Source:** B-4	**Sample No.:** SPT-6	**Elev./Depth:** 23-24.5'
▼	**Source:** B-4	**Sample No.:** T-4	**Elev./Depth:** 26-26.5'

Remarks:

●

■

▲

◆

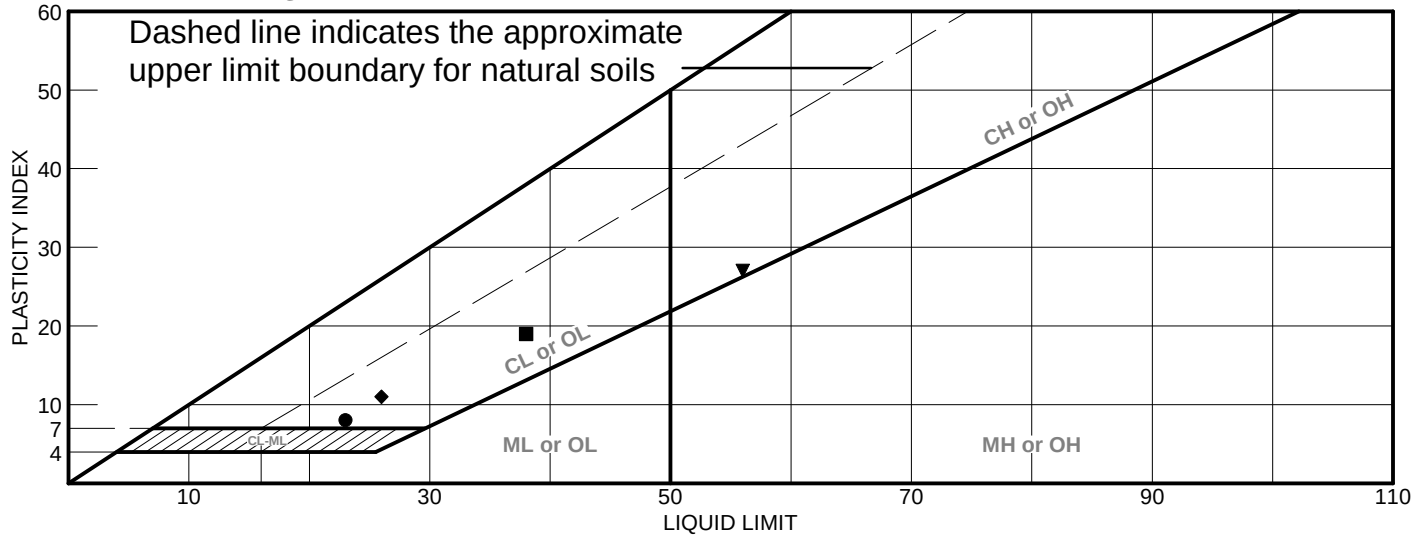
▼

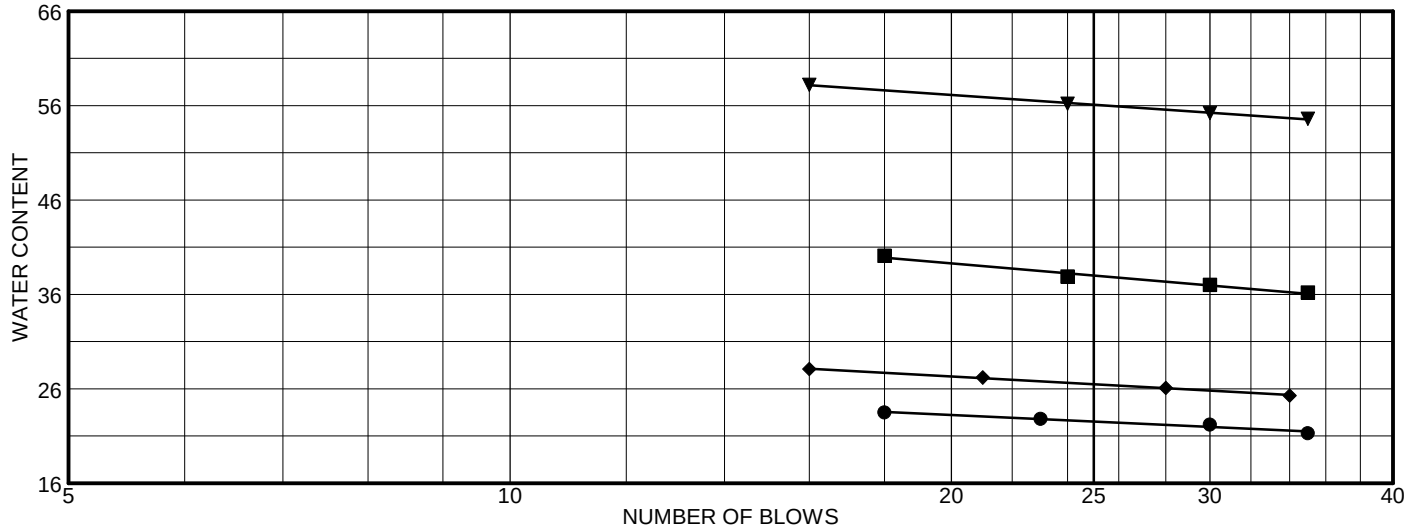
LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Dark Olive Brown Lean Clayey SAND	23	15	8			
■	Dark Reddish Brown Lean Clayey SAND	38	19	19			
▲	Gray Silty SAND		NP	NP			
◆	Dark Olive Gray Lean Clayey SAND	26	15	11	96.7	45.4	SC
▼	Black Sandy Fat CLAY	56	29	27			

Project No. 026-666 **Client:** Cotton, Shires & Associates

Project: Orange Memorial Park - E5038

●	**Source:** B-6	**Sample No.:** T-2	**Elev./Depth:** 2-2.5'
■	**Source:** B-6	**Sample No.:** T-7	**Elev./Depth:** 10-10.5'
▲	**Source:** B-6	**Sample No.:** T-10	**Elev./Depth:** 21-21.5'
◆	**Source:** B-7	**Sample No.:** SPT-4	**Elev./Depth:** 22-23.5'
▼	**Source:** B-8	**Sample No.:** T-3	**Elev./Depth:** 18-18.5'

Remarks:

●

■

▲ Could not roll out. Sample slides in bowl. Non-plastic.

◆

▼

LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

Figure