When Recorded Mail To:
American Fork City
51 East Main
American Fork UT 84003

ENT 50432:2021 PG 1 of 73
ANDREA ALLEN
UTAH COUNTY RECORDER
2021 Mar 17 10:07 am FEE 40.00 BY JR
RECORDED FOR AMERICAN FORK CITY

NOTICE OF INTEREST, BUILDING REQUIREMENTS, AND ESTABLISHMENT OF RESTRICTIVE COVENANTS

This Notice is recorded to bind the attached Geotechnical Study dated 12/11/2019 along with the site grading plan to the property generally located at 200 S. 900 W. (address), American Fork, UT 84003 and therefore mandating that all construction be in compliance with said Geotechnical Study and site grading plan per the requirements of American Fork City ordinances and standards and specification including specifically Ordinance 07-10-47, Section 6-5, Restrictive Covenant Required and 6-2-4, Liquefiable Soils. Said Sections require establishment of a restrictive covenant and notice to property owners of liquefiable soils or other unique soil conditions and construction methods associated with the property.

Exhibit A – Legal Description of Property
Exhibit B – Geotechnical Study
Exhibit C – Site Grading Plan

Dated this 14th day of January, 2021.

OWNER(S):

Jeffrey D
(Signature)

(Signature)

Jeffrey Duke
(Printed Name)

(Printed Name)

Manager
(Title)

(Title)

STATE OF UTAH)
§
COUNTY OF Utah)

On the 14th day of January, 2021, personally appeared before me Jeffrey A Duke and N/A, Owner(s) of said Property, as (individuals and/or authorized representatives of a company), and acknowledged to me that such individuals or company executed the within instrument freely of their own volition and pursuant to the articles of organization where applicable.

Notary Public - State of Utah
LISA MARIE TOMLIN
Comm. #710343
My Commission Expires
January 31, 2024

Lisa Marie Tomlin
Notary Public
My Commission Expires: 1 31·2021

Approved as to form: American Fork City Attorney

Rev. 12/4/18

EXHIBIT A

Beginning at a point on the south line of 200 South Street said point being South 89°59'22" West 2465.02 feet and North 1022.37 feet from the East Quarter Corner of Section 22 Township 5 South, Range 1 East and running

thence South 02°24'06" West 1,069.47 feet to the North line of 350 South Street;

thence North 89°28'52" West 71.77 feet along the North line of said 350 South Street;

thence Westerly 60.65 feet along the arc of a 503.00 foot radius curve to the left (center bears South 00°31'08" West and the chord bears South 87°03'53" West 60.61 feet with a central angle of 06°54'29");

thence South 83°36'38" West 33.48 feet along the North line of said 350 South Street;

thence Westerly 54.59 feet along the arc of a 447.00 foot radius curve to the right (center bears North 06°23'22" West and the long chord bears South 87°06'34" West 54.56 feet with a central angle of 06°59'51") along the North line of said 350 South Street;

thence North 89°23'31" West 139.42 feet along the North line of said 350 South Street;

thence Northwesterly 31.47 feet along the arc of a 20.00 foot radius curve to the right (center bears North 00°36'29" East and the long chord bears North 44°18'43" West 28.32 feet with a central angle of 90°09'36") along the North line of said 350 South Street to the East line of 900 West Street;

thence North 00°46'05" East 1,031.88 feet along East line of said 900 West Street;

thence Northeasterly 47.17 foot along the arc of a 30.00 feet radius curve to the right (center bears South 89°13'55" East and the chord bears North 45°48'43" East 42.46 feet with a central angle of 90°05'15") along the East line of said 900 West Street to the South line of 200 South Street;

thence South 89°08'40" East 379.83 feet along the Southeasterly line of 200 South Street to the point of beginning.

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BENCHMARK

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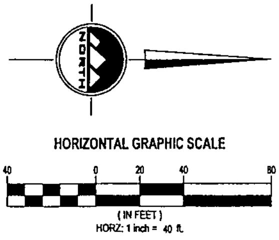
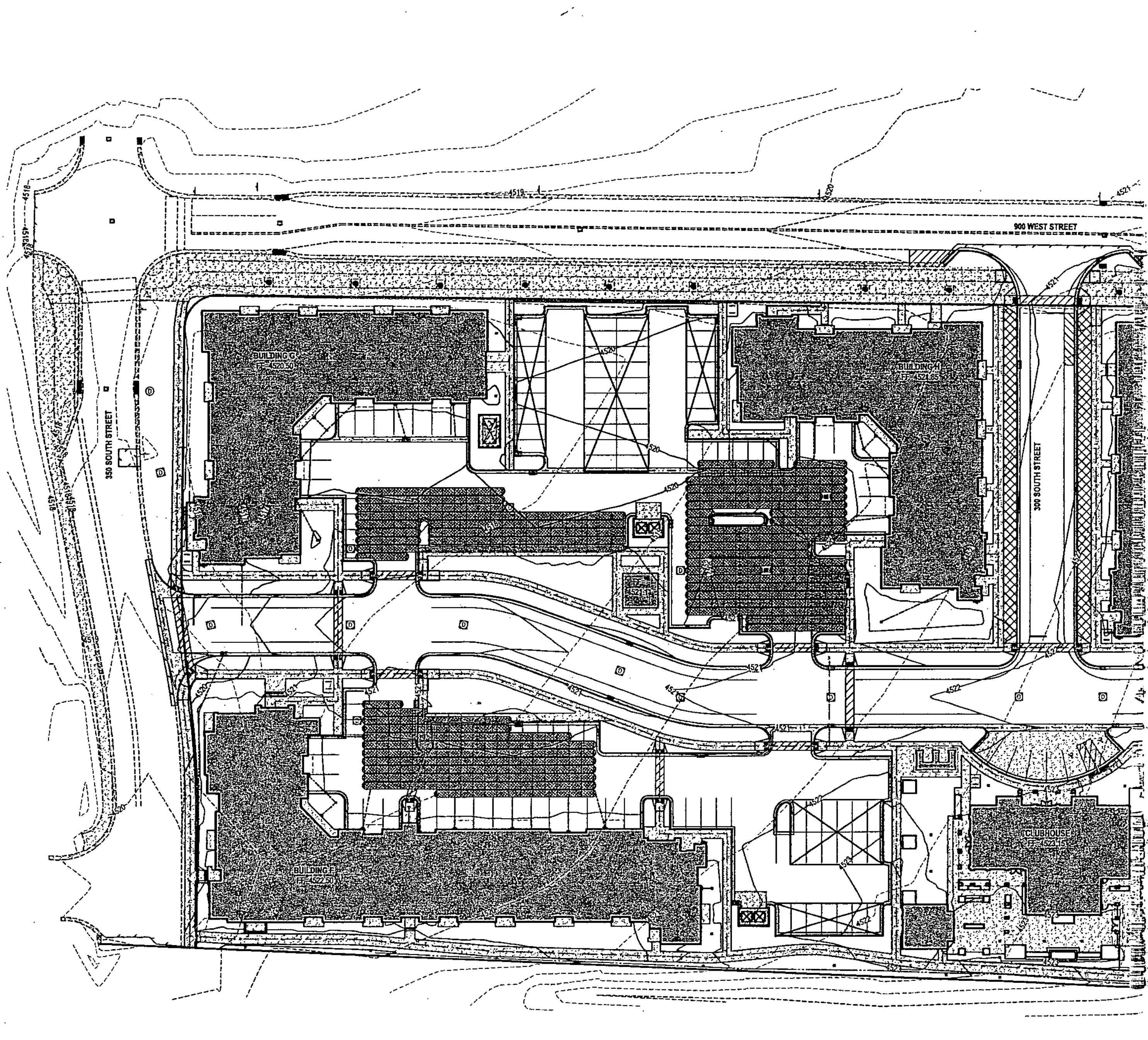
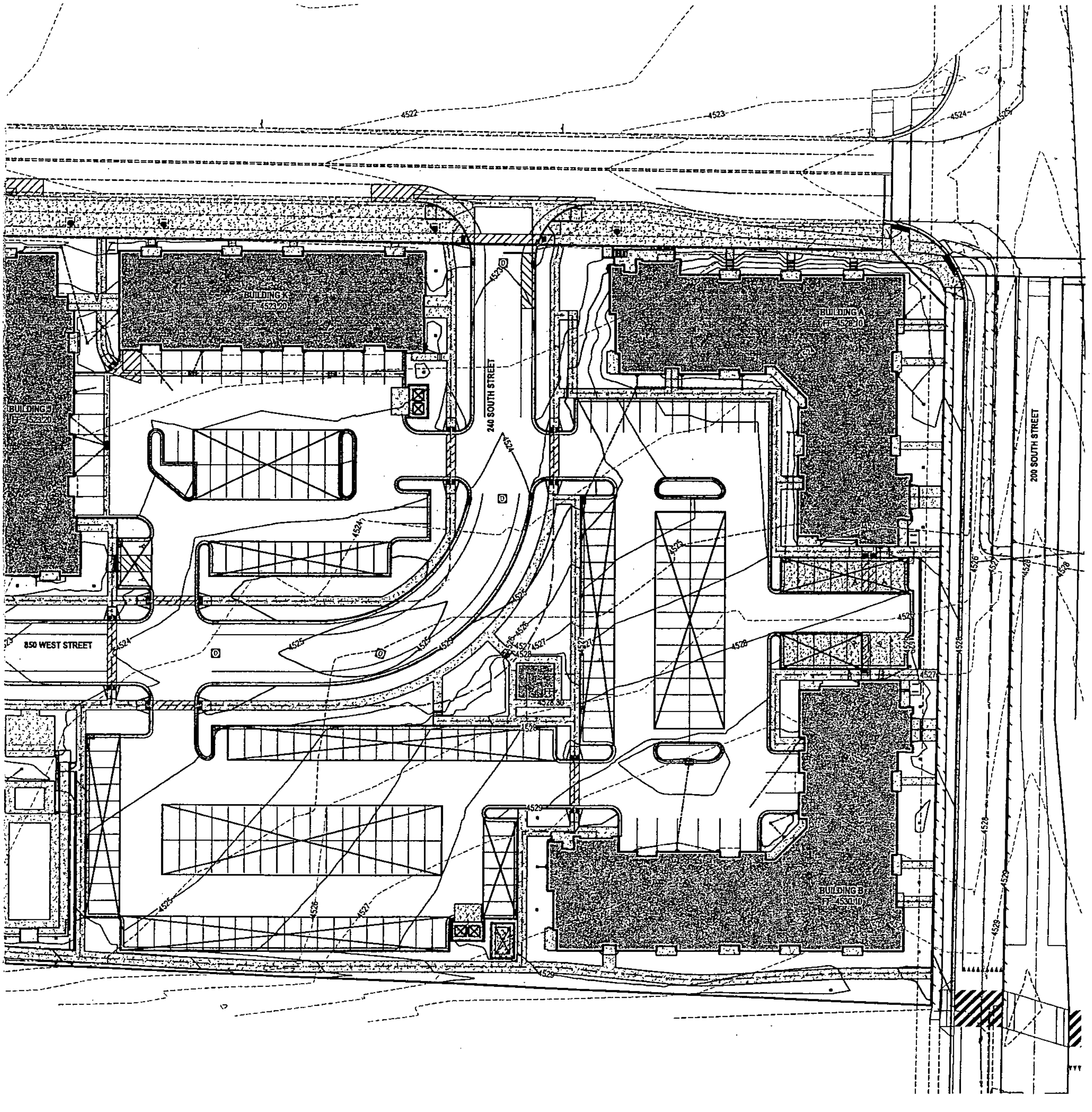
SALT LAKE BASE AND MERIDIAN
AMERICAN FORK, UTAH COUNTY, UTAH







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6740 SOUTH 1300 EAST, STE 200
SALT LAKE CITY, UTAH, 84121

CONTACT:
DUAINE RASMUSSEN
PHONE: 801-000-0000

CASTLEWOOD AMERICAN FORK APTS

900 WEST 200 SOUTH
AMERICAN FORK, UTAH

No. 7675714-2202
JARED K. FORD
9-10-2020

OVERALL GRADING PLAN

PROJECT NUMBER
8618B

PRINT DATE
9/4/20

DRAWN BY
E. FISHER

CHECKED BY
J. FORD

PROJECT MANAGER
J. FORD

C-300

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(IN FEET)
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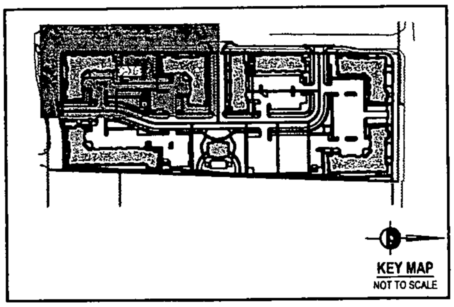

KEY MAP
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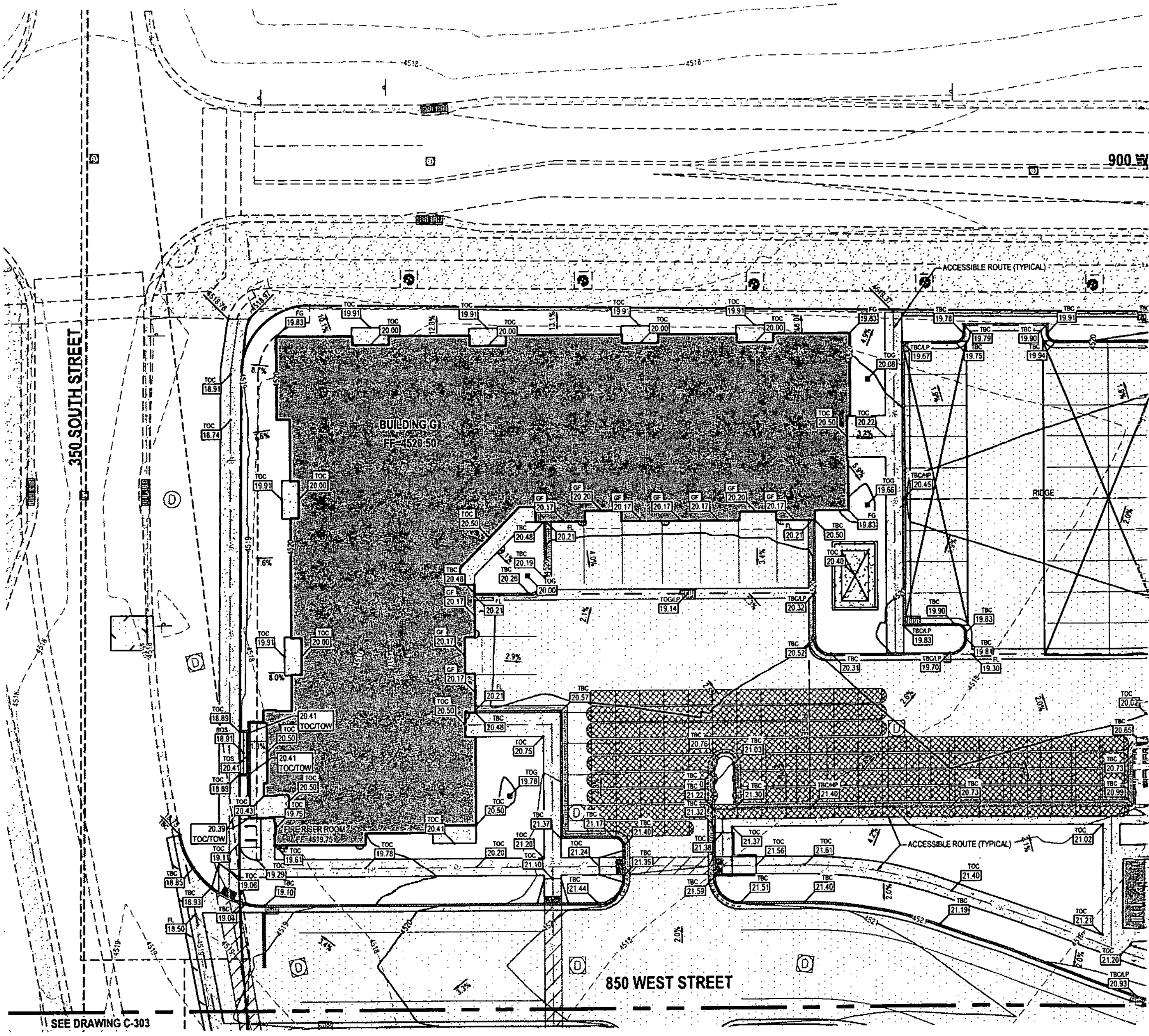

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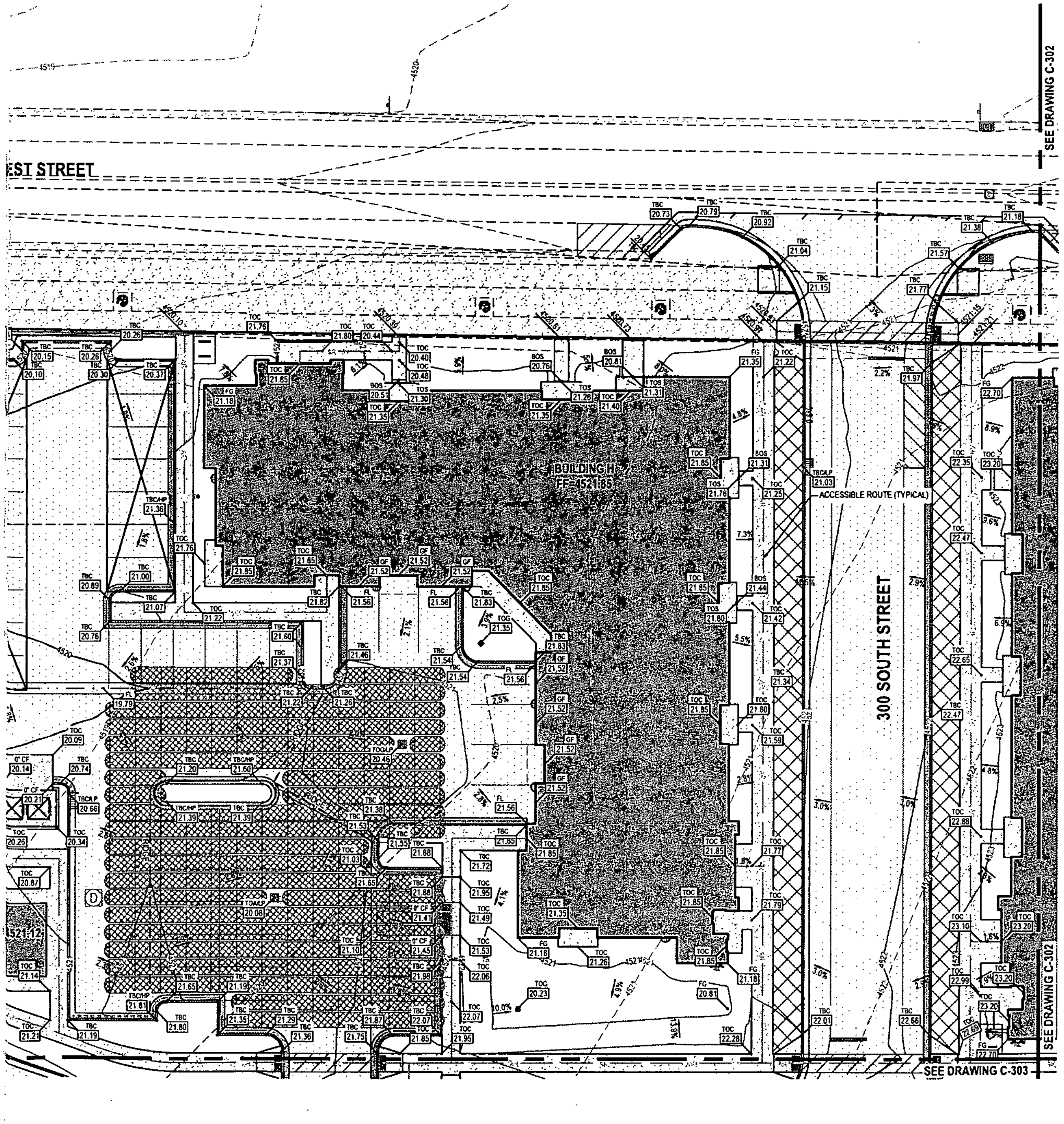

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CASTLEWOOD AMERICAN FORK APTS

900 WEST 200 SOUTH
AMERICAN FORK, UTAH

No. 7675714-2202
JARED K. FORD
9-10-2020

GRADING PLAN

PROJECT NUMBER
85188

PRINT DATE
9/4/20

DRAWN BY
E. FISHER

CHECKED BY
J. FORD

PROJECT MANAGER
J. FORD

C-301

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ENT 50432:2021 PG 7 of 73

NORTH

BENCHMARK

NORTH HALF OF SECTION 22,
TOWNSHIP 5 SOUTH, RANGE 1 EAST
SALT LAKE BASE AND MERIDIAN
AMERICAN FORK, UTAH COUNTY, UTAH

HORIZONTAL GRAPHIC SCALE

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(IN FEET)
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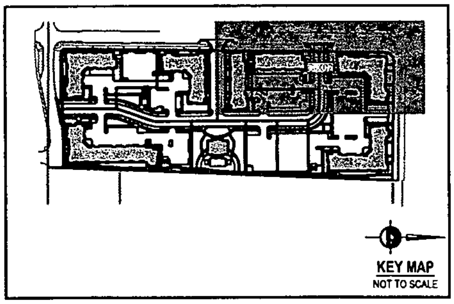

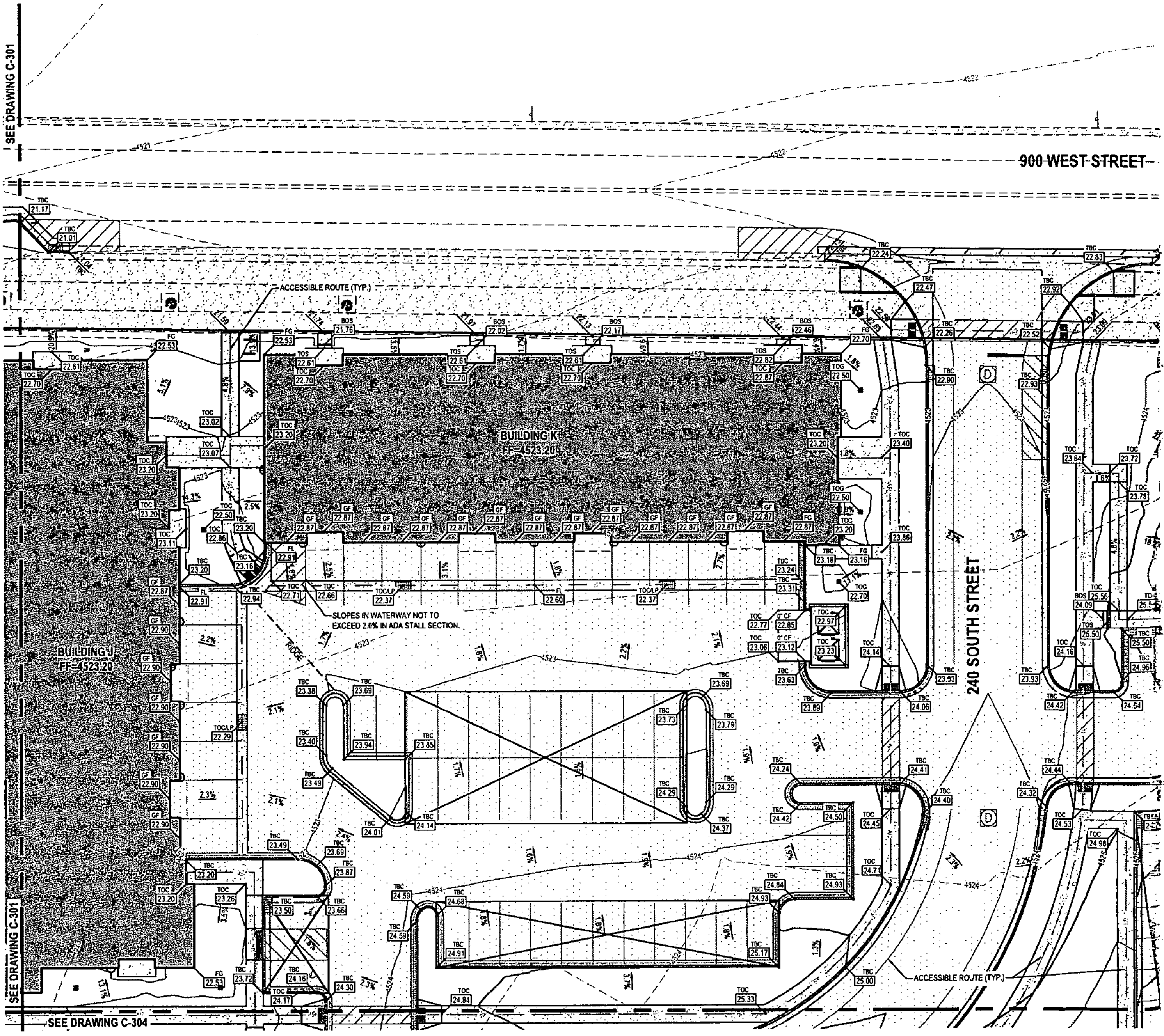

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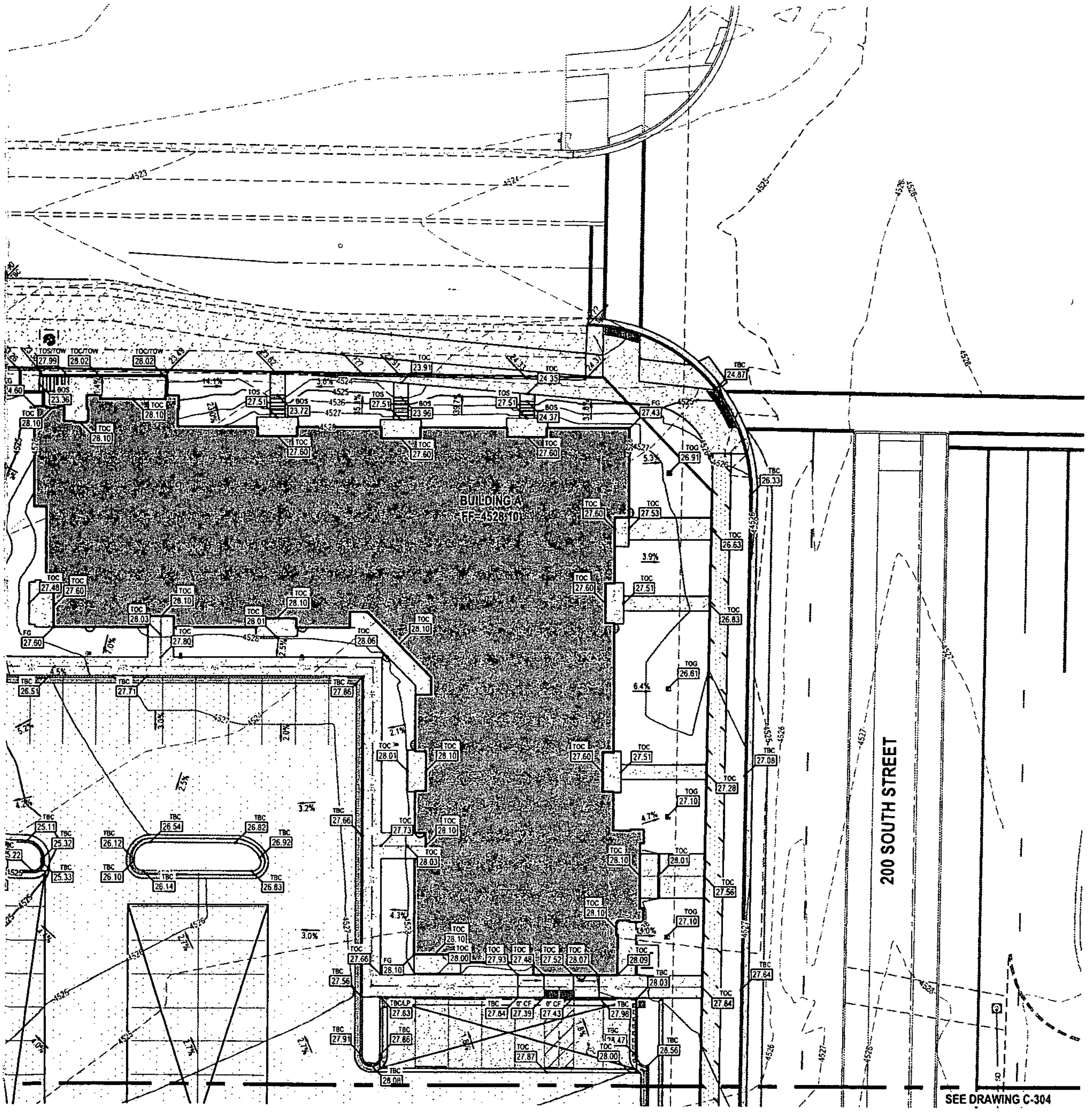

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900 WEST 200 SOUTH
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No. 7675714-2202
JARED K. FORD
9-10-2020

GRADING PLAN

PROJECT NUMBER 86188
PRINT DATE 9/4/20
DRAWN BY E. FISHER
CHECKED BY J. FORD
PROJECT MANAGER J. FORD

C-302

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BENCHMARK

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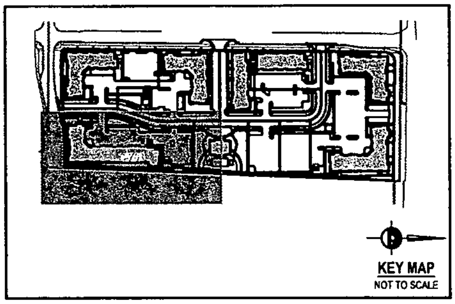
HORIZONTAL GRAPHIC SCALE



KEY MAP
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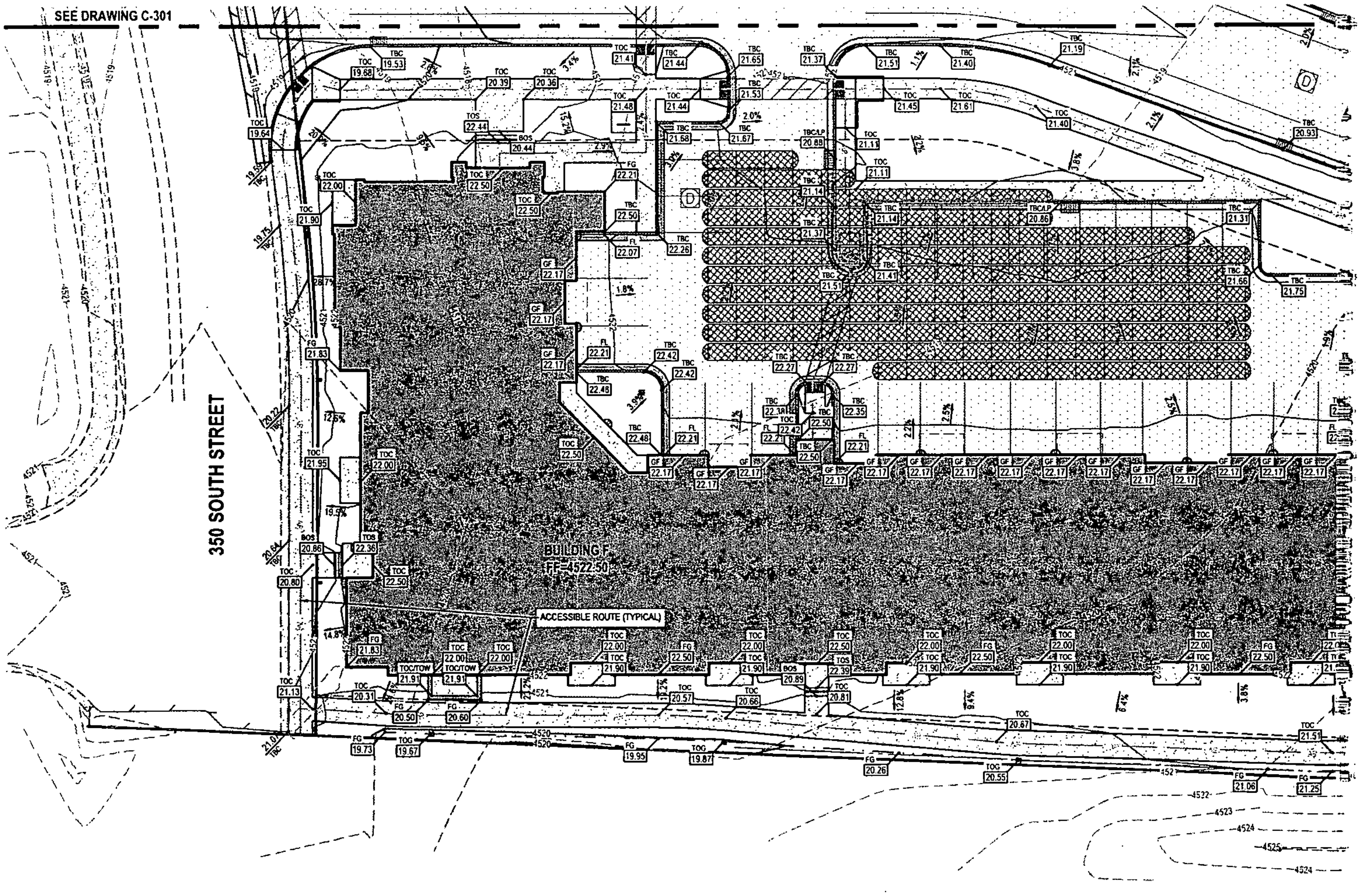

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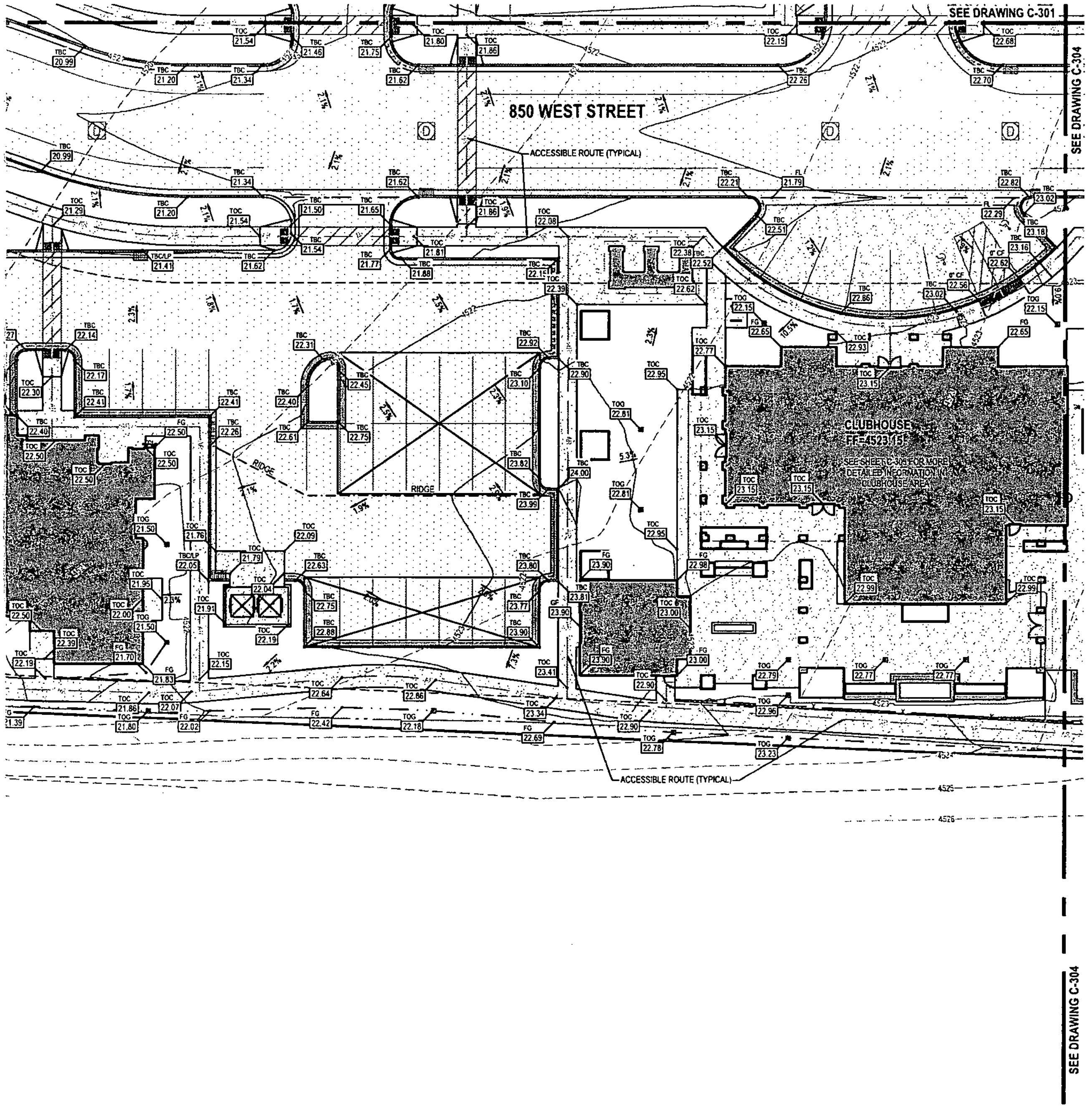

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PROJECT MANAGER	
J. FORD	

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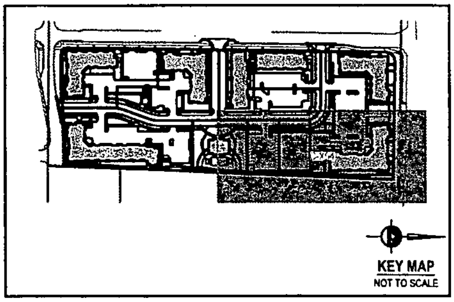

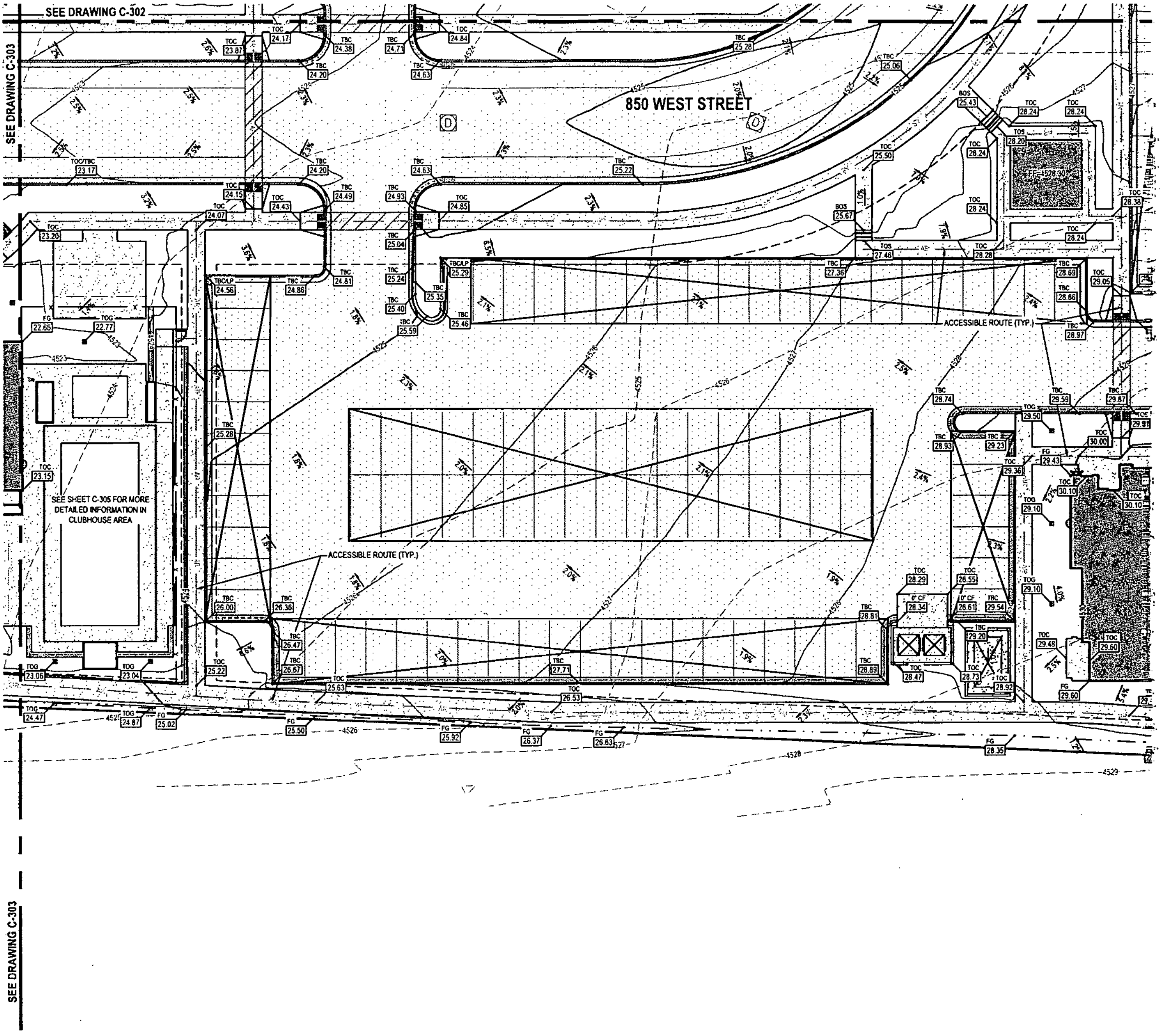

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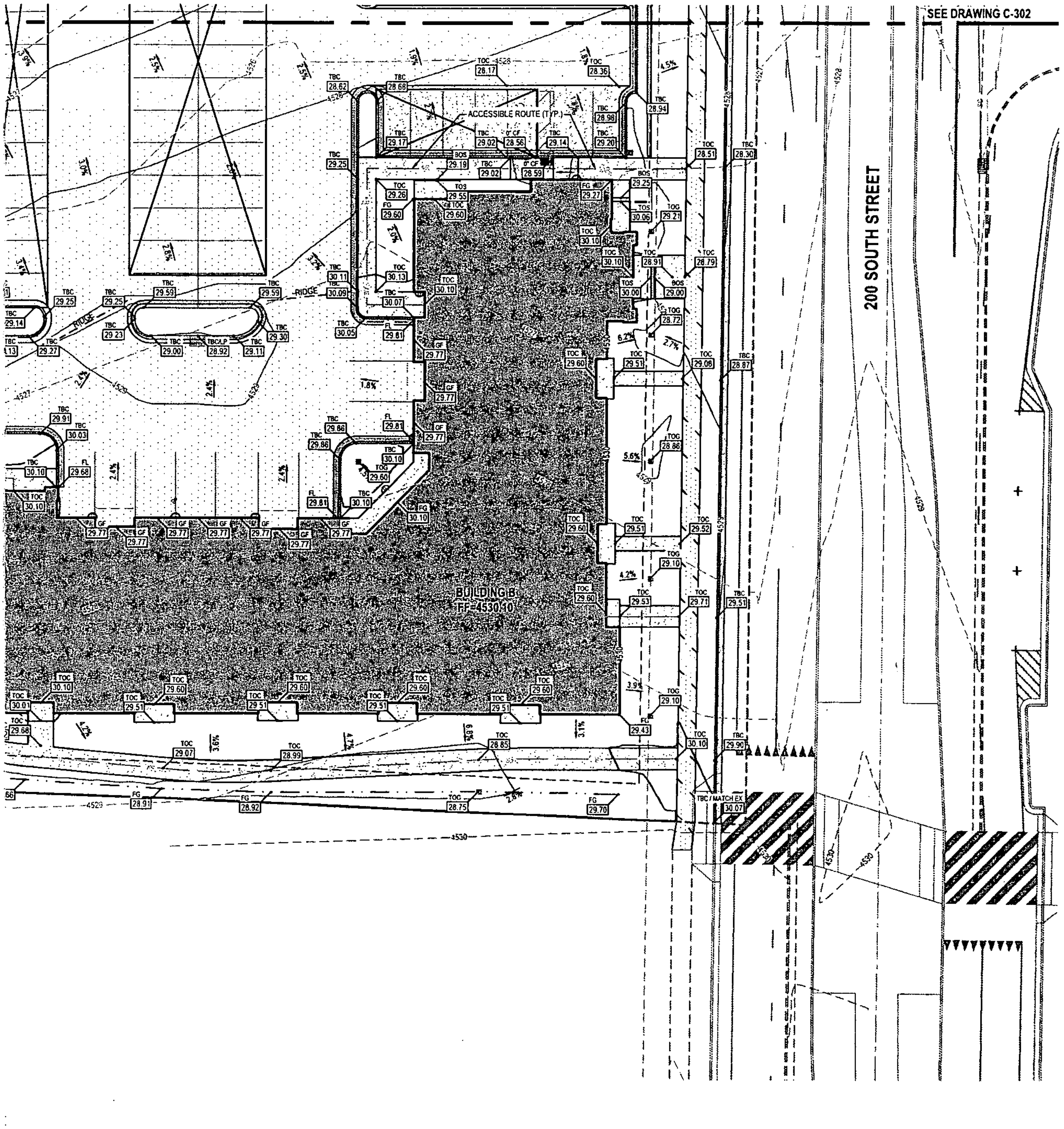
8. EXISTING UNDERGROUND UTILITIES AND IMPROVEMENTS ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED UPON RECORD INFORMATION AVAILABLE AT THE TIME OF PREPARATION OF THESE PLANS. LOCATIONS MAY NOT HAVE BEEN VERIFIED IN THE FIELD AND NO GUARANTEE IS MADE AS TO THE ACCURACY OR COMPLETENESS OF THE INFORMATION SHOWN. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO DETERMINE THE EXISTENCE AND LOCATION OF THE UTILITIES SHOWN ON THESE PLANS OR INDICATED IN THE FIELD BY LOCATING SERVICES. ANY ADDITIONAL COSTS INCURRED AS A RESULT OF THE CONTRACTOR'S FAILURE TO VERIFY THE LOCATIONS OF EXISTING UTILITIES PRIOR TO THE BEGINNING OF CONSTRUCTION IN THEIR VICINITY SHALL BE BORNE BY THE CONTRACTOR AND ASSUMED INCLUDED IN THE CONTRACT. THE CONTRACTOR IS TO VERIFY ALL CONNECTION POINTS WITH THE EXISTING UTILITIES. THE CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGE CAUSED TO THE EXISTING UTILITIES AND UTILITY STRUCTURES THAT ARE TO REMAIN. IF CONFLICTS WITH EXISTING UTILITIES OCCUR, THE CONTRACTOR SHALL NOTIFY THE ENGINEER PRIOR TO CONSTRUCTION TO DETERMINE IF ANY FIELD ADJUSTMENTS SHOULD BE MADE.
9. ALL STORM DRAIN INFRASTRUCTURE TO BE INSTALLED PER GOVERNING AGENCY OR APWA STANDARD PLANS AND SPECIFICATIONS.
10. ENSURE MINIMUM COVER OVER ALL STORM DRAIN PIPES PER MANUFACTURER'S RECOMMENDATIONS. NOTIFY ENGINEER IF MINIMUM COVER CANNOT BE ATTAINED.
11. ALL FACILITIES WITH DOWNSPOUTS/ROOF DRAINS SHALL BE CONNECTED TO THE STORM DRAIN SYSTEM. SEE PLUMBING PLANS FOR DOWNSPOUT/ROOF DRAIN LOCATIONS AND SIZES. ALL ROOF DRAINS TO HAVE MINIMUM 1% SLOPE.
12. THE CONTRACTOR SHALL ADJUST TO GRADE ALL EXISTING UTILITIES AS NEEDED PER LOCAL GOVERNING AGENCY'S STANDARDS AND SPECIFICATIONS.
13. NOTIFY ENGINEER OF ANY DISCREPANCIES IN DESIGN OR STAKING BEFORE PLACING CONCRETE, ASPHALT, OR STORM DRAIN STRUCTURES OR PIPES.
14. THE CONTRACTOR IS TO PROTECT AND PRESERVE ALL EXISTING IMPROVEMENTS, UTILITIES, AND SIGNS, ETC. UNLESS OTHERWISE NOTED ON THESE PLANS.



ENSIGN
THE STANDARD IN ENGINEERING

SALT LAKE CITY
45 W. 10000 S., Suite 500
Sandy, UT 84070
Phone: 801.255.0529

LAYTON
Phone: 801.547.1100

TOOELE
Phone: 435.843.3590

CEDAR CITY
Phone: 435.865.1453

RICHFIELD
Phone: 435.896.2983

WWW.ENSIGNENG.COM

FOR:
DUAINE RASMUSSEN
6740 SOUTH 1300 EAST, STE 200
SALT LAKE CITY, UTAH, 84121

CONTACT:
DUAINE RASMUSSEN
PHONE: 801-000-0000

CASTLEWOOD AMERICAN FORK APTS

900 WEST 200 SOUTH
AMERICAN FORK, UTAH

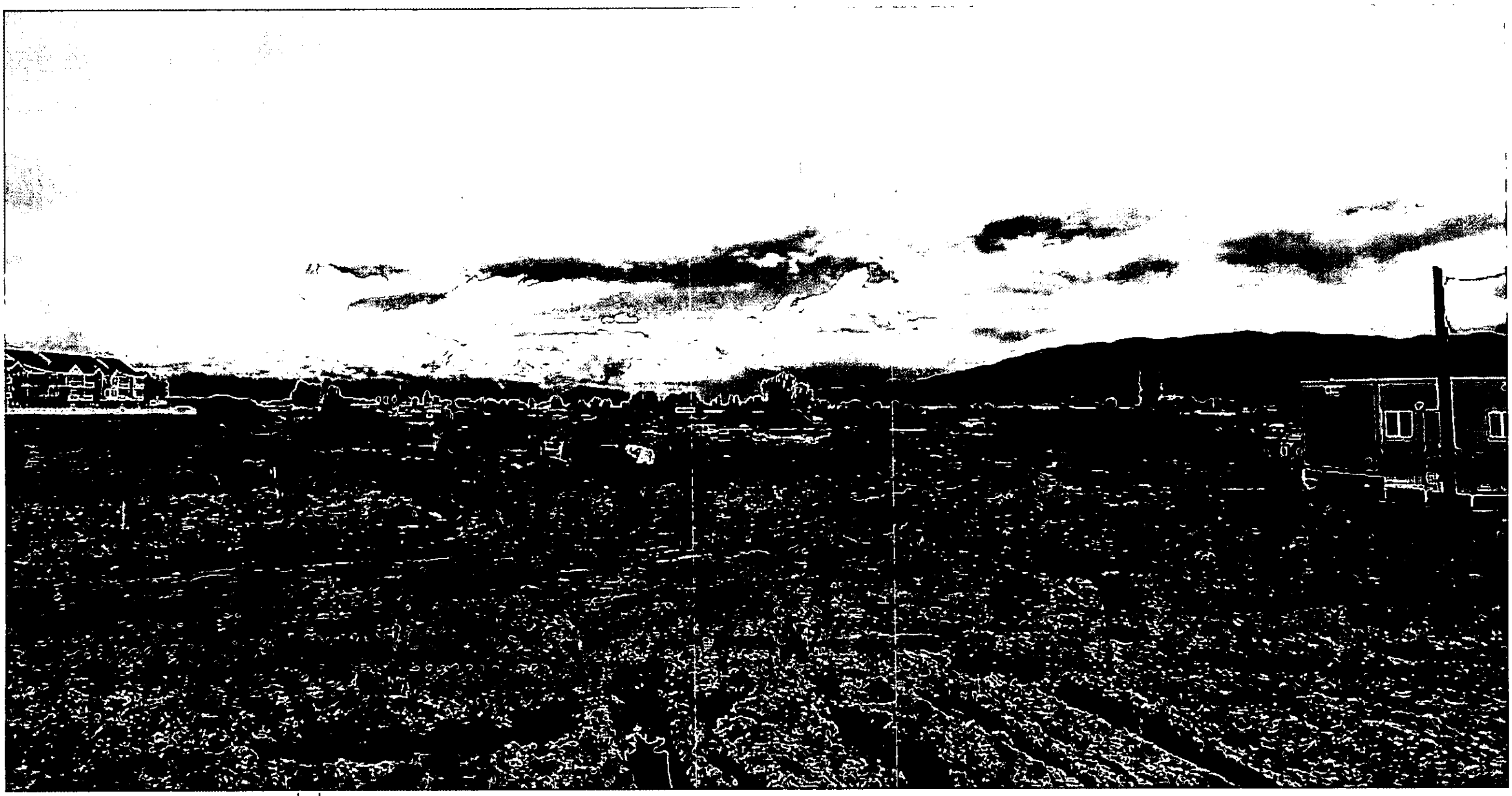
No. 7675714-2202
JARED K. FORD
9-10-2020

GRADING PLAN

PROJECT NUMBER 8618B	PRINT DATE 9/4/20
DRAWN BY E. FISHER	CHECKED BY J. FORD
PROJECT MANAGER J. FORD	

C-304

CMT ENGINEERING
LABORATORIES



ENGINEERING •GEOTECHNICAL •ENVIRONMENTAL (ESA I & II) •
MATERIALS TESTING •SPECIAL INSPECTIONS •
ORGANIC CHEMISTRY • PAVEMENT
DESIGN •GEOLOGY

GEOTECHNICAL ENGINEERING STUDY

American Fork Apartments

About 900 West 200 South
American Fork, Utah

CMT PROJECT NO. 13729

FOR:
Castlewood Development
6740 South 1300 East, Suite 200
Salt Lake City, Utah 84121

December 11, 2019

CMT ENGINEERING LABORATORIES

December 11, 2019

Mr. Russell Harris
Castlewood Development
6740 South 1300 East, Suite 200
Salt Lake City, Utah 84121

Subject: Geotechnical Engineering Study
Proposed American Fork Apartments
900 West 200 South
American Fork, Utah
CMT Project Number: 13729

Mr. Harris:

Submitted herewith is the report of our geotechnical engineering study for the subject site. This report contains the results of our findings and an engineering interpretation of the results with respect to the available project characteristics. It also contains recommendations to aid in the design and construction of the earth related phases of this project.

On November 12 and 13, 2019, a CMT Engineering Laboratories (CMT) geologist was on-site and supervised the drilling of 12 bore holes extending to depths of about 16.5 to 31.5 feet below the existing ground surface. Soil samples were obtained during the field operations and subsequently transported to our laboratory for further testing and observation.

Conventional spread and/or continuous footings may be utilized to support the proposed structures, provided the recommendations in this report are followed. A detailed discussion of design and construction criteria is presented in this report.

We appreciate the opportunity to work with you at this stage of the project. CMT offers a full range of Geotechnical Engineering, Geological, Material Testing, Special Inspection services, and Phase I and II Environmental Site Assessments. With 9 offices throughout Utah, Idaho and Arizona, our staff is capable of efficiently serving your project needs. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 492-4132.

CERTIFICATE: I hereby certify that I am a licensed professional engineer, as defined in the "Sensitive Lands Ordinance" Section of the American Fork City Ordinances. I have examined the report to which this certificate is attached and the information and conclusions contained therein are, without any reasonable reservation not stated therein, accurate and complete. The procedures and tests used in said report meet minimum applicable professional standards.

Sincerely,
CMT Engineering Laboratories

LICENSED PROFESSIONAL ENGINEER
374995
JEFFREY J.
EGBERT
12/11/19
STATE OF UTAH

Jeffrey J. Egbert, P.E., LEED A.P., M. ASCE
Senior Geotechnical Engineer

Reviewed by:

William G. Turner, P.E., M. ASCE
Senior Geotechnical Engineer

TABLE OF CONTENTS

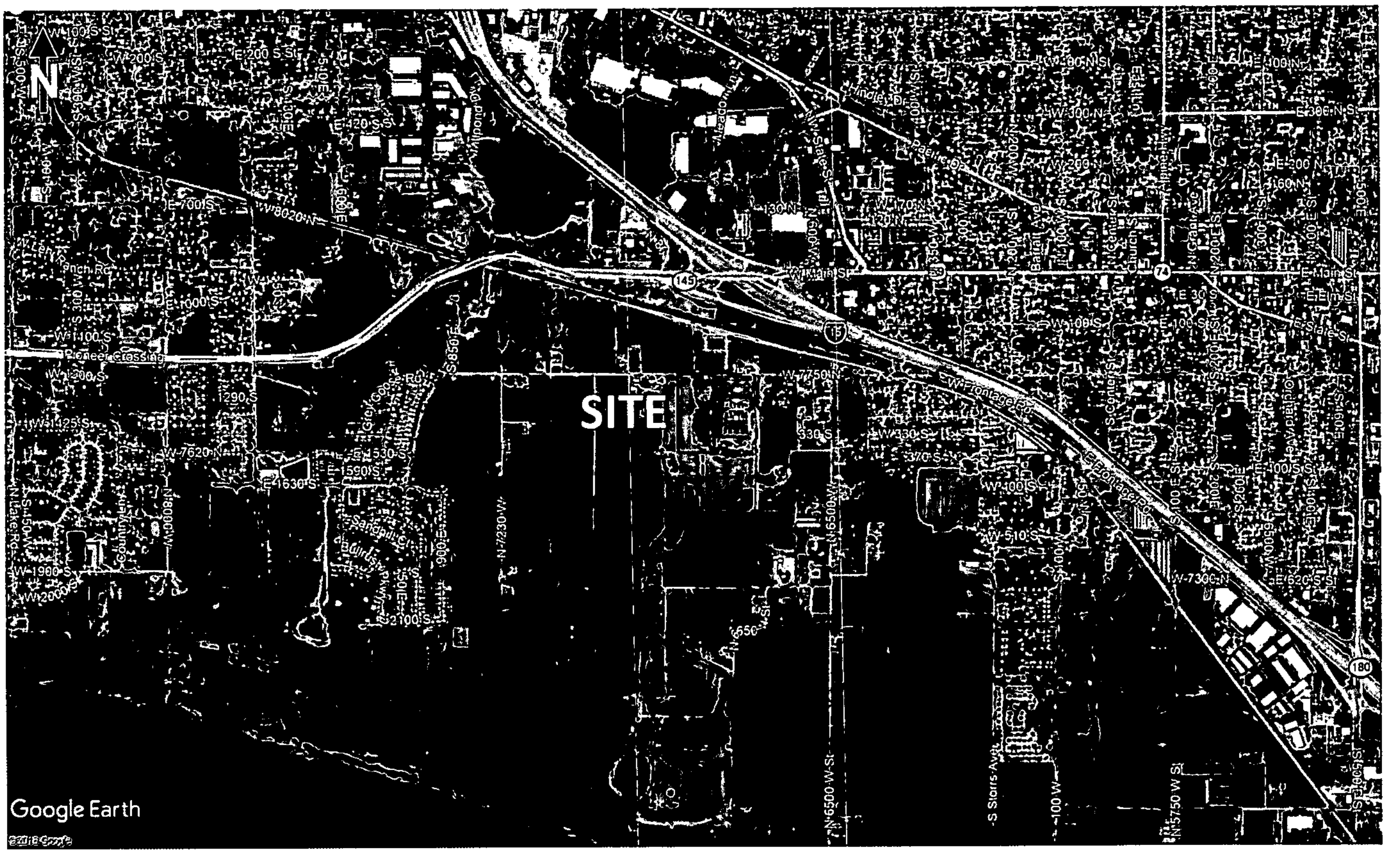
1.0 INTRODUCTION....1
  1.1 General....1
  1.2 Objectives, Scope and Authorization....1
  1.3 Description of Proposed Construction....2
  1.4 Executive Summary....2
2.0 FIELD EXPLORATION....3
3.0 LABORATORY TESTING....3
4.0 GEOLOGIC & SEISMIC CONDITIONS....4
  4.1 Geologic Setting....4
  4.2 Faulting....6
  4.3 Seismicity....7
    4.3.1 Site Class....7
    4.3.2 Ground Motions....7
    4.3.3 Liquefaction....8
  4.4 Other Geologic Hazards....9
5.0 SITE CONDITIONS....9
  5.1 Surface Conditions....9
  5.2 Subsurface Soils....9
  5.3 Groundwater....10
  5.4 Site Subsurface Variations....10
6.0 SITE PREPARATION AND GRADING....11
  6.1 General....11
  6.2 Temporary Excavations....12
  6.3 Fill Material....12
  6.4 Fill Placement and Compaction....13
  6.5 Utility Trenches....13
  6.6 Stabilization....14
7.0 FOUNDATION RECOMMENDATIONS....14
  7.1 Foundation Recommendations....15
  7.2 Installation....15
  7.3 Estimated Settlement....16
  7.4 Lateral Resistance....16
8.0 LATERAL EARTH PRESSURES....16
9.0 FLOOR SLABS....17
10.0 DRAINAGE RECOMMENDATIONS....17
11.0 PAVEMENTS....18
12.0 QUALITY CONTROL....19
  12.1 Field Observations....19
  12.2 Fill Compaction....19
  12.3 Excavations....19
  12.4 Vibration Monitoring....19
13.0 LIMITATIONS....19

APPENDIX
  Figure 1: Site Map
  Figures 2 - 13: Bore Hole Logs
  Figure 14: Key to Symbols
  Calculations (4 Pages)

1.0 INTRODUCTION

1.1 General

CMT Engineering Laboratories (CMT) was retained to conduct a geotechnical subsurface study for a proposed high density residential development. The site is situated on the south side of 200 South Street, and the east side of 900 West Street in American Fork, Utah, as shown in the **Vicinity Map** below.



VICINITY MAP

1.2 Objectives, Scope and Authorization

The objectives and scope of our study were planned in communications between Mr. Russell Harris of Castlewood Development, and Mr. Jeffrey Egbert of CMT Engineering Laboratories (CMT). In general, the objectives of this study were to define and evaluate the subsurface soil and groundwater conditions at the site, and provide appropriate foundation, earthwork, pavement and seismic recommendations to be utilized in the design and construction of the proposed development.

In accomplishing these objectives, our scope of work has included performing field exploration, which consisted of the drilling/logging/sampling of 12 bore holes, performing laboratory testing on representative samples of the subsurface soils collected in the bore holes, and conducting an office program, which consisted of correlating available data, performing engineering analyses, and preparing this summary report. This scope of work was authorized by returning a signed copy of our proposal dated October 11, 2019 and executed on October 28, 2019.

1.3 Description of Proposed Construction

We understand that the proposed construction consists of six multi-level apartment buildings, smaller clubhouse and leasing office buildings, and a swimming pool. We project that the buildings will be of conventional wood or light steel frame construction supported on concrete foundations. Maximum wall loads are projected to not exceed 12,000 pounds per linear foot and column loads to not exceed 200,000 pounds. Floor slab loads are anticipated to be relatively light, with an average uniform loading not exceeding 100 pounds per square foot. If the loading conditions are different than we have projected, please notify us so that any appropriate modifications to our conclusions and recommendations contained herein can be made.

Paved parking/drive areas will also be constructed, which we anticipate will utilize asphalt and possibly concrete pavements. Traffic is projected to consist of mostly automobiles and light trucks, a few daily medium-weight delivery trucks, a weekly garbage truck, and an occasional fire truck.

Site development will require some earthwork in the form of minor cutting and filling. A site grading plan was not available at the time of this report, but we project that maximum cuts and fills may be on the order of 3 to 4 feet. If deeper cuts or fills are planned, CMT should be notified to provide additional recommendations, if needed.

1.4 Executive Summary

The most significant geotechnical aspects regarding site development include the following:

1. An existing residence in the northeast portion of the site to be razed and removed.
2. Approximately 1.5 to 3.5 feet of fill, considered non-engineered, on the surface of a significant portion of the site, and topsoil approximately 12 inches in thickness on the remaining portions of the site. Foundations and floor slabs should not be placed on topsoil or non-engineered fill.
3. Groundwater was encountered during drilling and later measured at depths as shallow as 1.5 feet below the existing site grades. Dewatering of excavations should be anticipated.
4. Subsurface natural soils predominately consist of CLAY (CL), but also include SAND (SC, SP), and occasional GRAVEL (GC) layers, to the maximum depth explored of 31.5 feet below the existing site grades. Some of the subsurface sand layers are potentially liquefiable during a seismic event, which could result in additional differential settlement and/or lateral movement.
5. Floor slabs and more lightly loaded footings may be constructed on suitable undisturbed natural soils. More heavily loaded footings will require structural/engineered fill to limit settlements. Additional reinforcement and tying foundations together with grade beams is also recommended.

CMT must assess that topsoil, non-engineered fill, debris, disturbed or unsuitable soils have been removed and that suitable soils have been encountered prior to placing site grading fills, footings, slabs, and pavements.

In the following sections, detailed discussions pertaining to the site and subsurface descriptions, geologic/seismic setting, earthwork, foundations, lateral resistance, lateral pressure, floor slabs, and pavements are provided.

2.0 FIELD EXPLORATION

In order to define and evaluate the subsurface soil and groundwater conditions 12 bore holes were drilled at the site to depths of approximately 6.5 to 31.5 feet below the existing ground surface. Locations of the bore holes are presented on **Figure 1.**

Samples of the subsurface soils encountered in the bore holes were collected at varying depths through the hollow stem drill augers. Relatively undisturbed samples were obtained by driving a split-spoon sampler with 2.5-inch outside diameter rings/liners into the undisturbed soils below the drill augers. Disturbed samples were collected utilizing a standard split spoon sampler. This standard split spoon sampler was driven 18 inches into the soils below the drill augers using a 140 pound hammer free-falling a distance of 30 inches. The number of hammer blows needed for each 6 inch interval was recorded. The sum of the hammer blows for the final 12 inches of penetration is known as a standard penetration test and this 'blow count' was recorded on the bore hole logs. The blow count provides a reasonable approximation of the relative density of granular soils, but only a limited indication of the relative consistency of fine grained soils because the consistency of these soils is significantly influenced by the moisture content.

Soil samples were collected as described above, and were classified in the field in general accordance with ASTM[1] D-2488 based upon visual and textural examination. These field classifications were supplemented by subsequent examination and testing of select samples in our laboratory. Logs of the bore holes, including a description of the soil strata encountered, is presented on each individual Bore Hole Log, **Figures 2 through 13**, included in the Appendix. Sampling information and other pertinent data and observations are also included on the logs. In addition, a Key to Symbols defining the terms and symbols used on the logs is provided as **Figure 14** in the Appendix.

Following completion of drilling operations, 1.25-inch diameter slotted PVC pipe was installed in bore holes B-5, B-7, and B-12 to allow subsequent water level measurements.

3.0 LABORATORY TESTING

Selected samples of the subsurface soils were subjected to various laboratory tests to assess pertinent engineering properties, as follows:

1. Moisture Content, ASTM D-2216, Percent moisture representative of field conditions
2. Dry Density, ASTM D-2937, Dry unit weight representing field conditions
3. Atterberg Limits, ASTM D-4318, Plasticity and workability

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[1] American Society for Testing and Materials

4. Gradation Analysis, ASTM D-1140/C-117, Grain Size Analysis
5. One Dimension Consolidation, ASTM D-2435, Consolidation properties

To provide data necessary for our settlement analyses, a consolidation test was performed on each of 4 representative sample of the surficial clay soils encountered across the site. Based upon data obtained from the consolidation testing, the clay soils at this site are moderately over-consolidated and moderately compressible under additional loading. Detailed results of the consolidation tests are maintained within our files and can be transmitted to you, if so desired.

Laboratory test results are presented on the bore hole logs (**Figures 2 through 13**) and in the following Lab Summary Table:

LAB SUMMARY TABLE

Bore Hole	Depth (feet)	Sample Type	Soil Class	Moisture Content (%)	Dry Denstiy (pcf)	Gradation			Atterberg Limits			Collapse (-) or Expansion (+)
						Grav	Sand	Fines	LL	PL	PI	
B-1	5	Rings	CL	31.4	90.6							
	7.5	SPT	SC	23.2								
	10	SPT	SC	26.3				23				
	20	SPT	CL	48.2					46	22	24	
B-3	2.5	Rings	CL	31.0	89.2							
	15	SPT	CL	34.0					33	23	10	
B-5	5	Rings	SC	17.0		17	48	35				
	10	Rings	SC	21.9				35				
B-6	2.5	Rings	CL	24.4	100.8				29	20	9	-0.5%
	5	SPT	SC	24.7				43				
B-7	5	Rings	CL	31.2	93.4				29	19	10	-0.5%
B-8	5	Rings	CL	28.2	98.1							
	10	SPT	CL	26.9		10	37	53				
	15	Rings	CL	32.7	89.3							
B-10	2.5	Rings	CL	30.7				79				
	5	SPT	SC	26.2				43				
	10	SPT	CL	24.3				55				
	15	SPT	CL	35.2					32	23	9	
B-12	5	SPT	ML	25.5				57				
	15	SPT	CL	27.5				74				
	20	SPT	CL	44.9					36	23	13	

4.0 GEOLOGIC & SEISMIC CONDITIONS

4.1 Geologic Setting

The subject site is located in the northeast portion of Utah Valley in north-central Utah at an elevation of approximately 4,528 feet above sea level. Utah Valley is a deep, sediment-filled basin that is part of the Basin and Range Physiographic Province. The valley was formed by extensional tectonic processes during the Tertiary and Quaternary geologic time periods, and is bordered by the Wasatch Mountain Range on the east and Lake Mountain and West Mountain on the west. Utah Valley is located within the Intermountain Seismic Belt, a zone of ongoing tectonism and seismic activity extending from southwestern Montana to southwestern Utah. The active (evidence of movement in the last 10,000 years) Wasatch Fault Zone is part of the Intermountain Seismic Belt and extends from southeastern Idaho to central Utah along the western base of the Wasatch Mountain Range.

Much of northwestern Utah, including Utah Valley, was also previously covered by the Pleistocene age Lake Bonneville. Utah Lake, which currently occupies much of the western portion of the valley, is a remnant of this ancient fresh water lake. Lake Bonneville reached a high-stand elevation of between approximately 5,160 and 5,200 feet above sea level at between 18,500 and 17,400 years ago. Approximately 17,400 years ago, the lake breached its basin in southeastern Idaho and dropped by almost 300 feet relatively fast as water drained into the Snake River. Following this catastrophic release, the lake level continued to drop slowly over time, primarily driven by drier climatic conditions, until reaching the current levels of Utah Lake and the larger Great Salt Lake to the north. Shoreline terraces formed at the high-stand elevation of the lake and several subsequent lower lake levels are visible in places on the mountain slopes surrounding the valley. Much of the sediment within Utah Valley was deposited as lacustrine sediments during both the transgressive (rise) and regressive (fall) phases of Lake Bonneville and in older, pre-Bonneville lakes that previously occupied the basin.

The geology of USGS "Pelican Point, Utah" 7.5 Minute Quadrangle, which includes the location of the subject site, has been mapped by the Utah Geological Survey.[2] The surficial geology on the majority of the subject site and adjacent properties is mapped as "Lacustrine silt and clay" (Map Unit Qlmp) dated to be upper Pleistocene. On the east-central margin of the site Unit Qlmp is mapped to be overlain by "Alluvial-fan deposits, regressive (Provo) phase of Lake Bonneville" (Map Unit Qafp) dated to be upper Pleistocene. Unit Qlmp is described in the referenced mapping as "Calcareous silt (marl) and clay with minor fine sand; typically laminated or thin bedded; ostracodes locally common; deposited in quiet water in moderately deep parts of the Bonneville basin and in sheltered bays; overlies lacustrine silt and clay of the transgressive phase and grades upslope into lacustrine sand and silt (Qlsp); locally buried by loess veneer; regressive lacustrine shorelines typically poorly developed; extensive exposure within two miles (3 km) of the Utah Lake shore incised by young alluvial fans (Qafy), and small remnants south of Pelican Point. Machette (1992) reported that silt and clay of the regressive phase can be differentiated from silt and clay of the transgressive phase by the presence of conchoidal fractures in blocks of transgressive deposits and their absence in regressive deposits, but Qlmp may include some undifferentiated transgressive deposits. Exposed thickness less than 15 feet (5 m), but total thickness may exceed several tens of feet." Unit Qafp is described as "Poorly to moderately sorted, pebble to cobble gravel, locally bouldery, with a matrix of sand, silt, and minor clay; clasts typically angular, but well rounded where derived from Lake Bonneville gravel; medium to very thick bedded; deposited by debris flows, debris floods, and stream flow from American Fork as the river lost confinement beyond the American Fork delta front in the adjacent Lehi quadrangle (Biek, 2005b). The B soil horizon of paleosols developed on regressive-phase alluvial-fan deposits commonly shows an intensification of brown colors due to oxidation of iron-bearing minerals or a slight accumulation of clay, and may include a pedogenic accumulation of calcium carbonate as thin, discontinuous coatings on gravel; Machette

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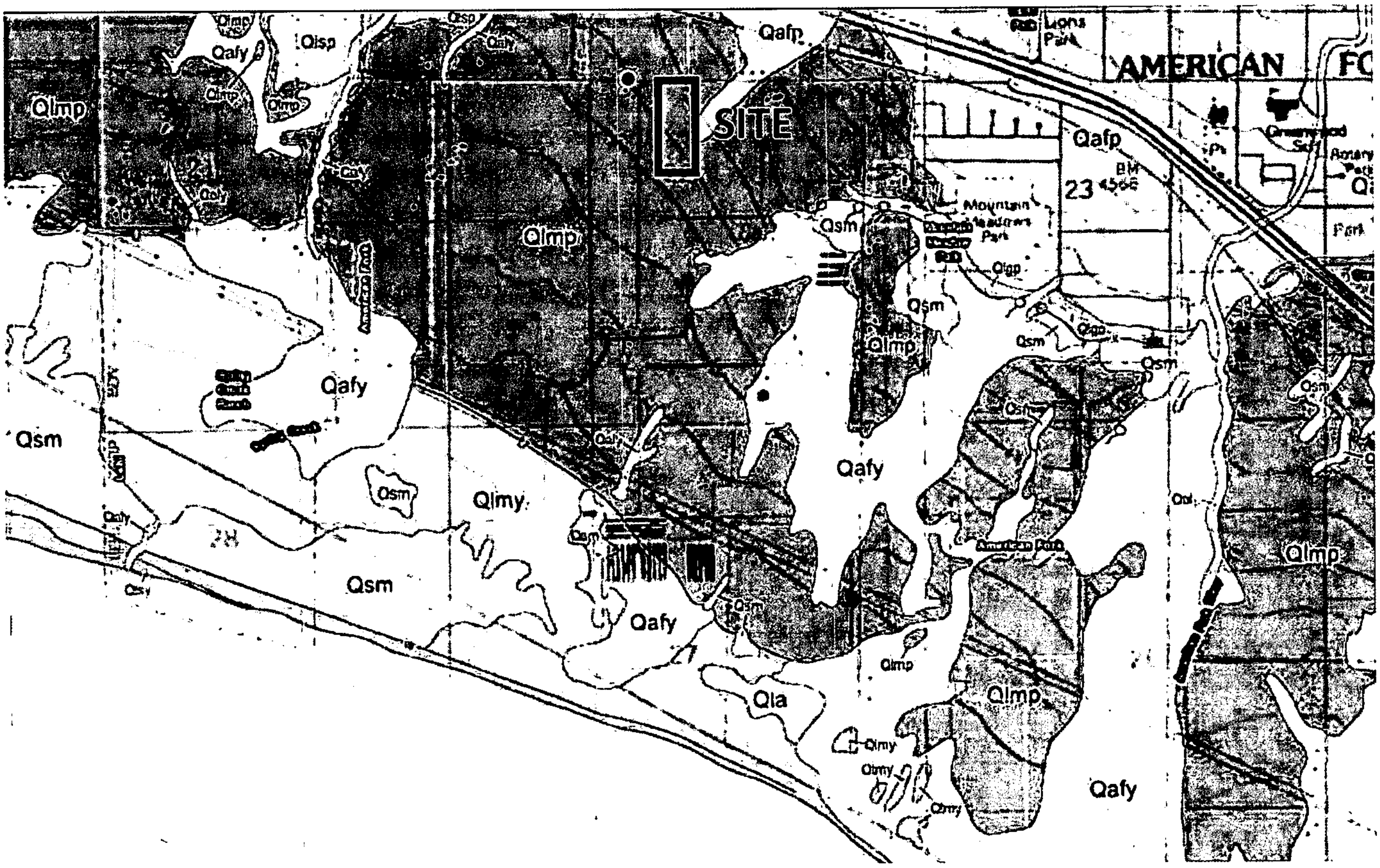
[2] Solomon, B.J., Biek, R.F., and Ritter, S.M., 2009, Geologic Map of the Pelican Point Quadrangle, Utah County, Utah; Utah Geological Survey Map 244, Scale 1:24,000.

(1992), using the terminology of Birkeland (1984), designated the soil profile of this unit and others of similar age as A/Bw/Bk(or Cox) to A/Bt(weak)/Bk(or Cox). Exposed thickness less than 30 feet (10 m)." No fill has been mapped at the location of the property on the geologic map. Refer to the **Geologic Map**, shown on the following page.



GEOLOGIC MAP

4.2 Faulting

No surface fault traces are shown on the referenced geologic map crossing or projecting toward the subject site. The nearest mapped active fault is the Provo Segment of the Wasatch Fault Zone approximately 4.7 miles to the east.

The Wasatch Fault is considered a "normal" fault because movement along the fault is typically vertical. The east side of the fault, or the mountain block, typically moves upward relative to the valley block on the west side of the fault. The fault generally dips to the west below the valleys. In an earthquake, the point where the fault initially ruptures is called the 'focus" and generally occurs about 10 miles below the surface. The point on the surface directly above the focus, the epicenter, typically out in the valley, is usually where the strongest ground shaking occurs. The Wasatch Fault is one of the longest and most active normal faults in the world.

4.3 Seismicity

4.3.1 Site Class

Utah has adopted the International Building Code (IBC) 2018, which determines the seismic hazard for a site based upon 2014 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points). For site class definitions, IBC 2018 Section 1613.2.2 refers to Chapter 20, Site Classification Procedure for Seismic Design, of ASCE[3] 7-16. Given the subsurface soils encountered in our explorations at the site, and the subsurface conditions encountered in a bore hole drilled for the Pioneer Crossing Interchange approximately 2,000 feet north of the site, which extended to a depth of 103 feet, it is our opinion the site best fits Site Class D – Stiff Soil Profile (with data), which we recommend for seismic structural design.

4.3.2 Ground Motions

The 2014 USGS mapping utilized by the IBC provides values of peak ground, short period and long period accelerations for the Site Class B/C boundary and the Maximum Considered Earthquake (MCE). This Site Class B/C boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground, short period and long period accelerations for the MCE event, and incorporates appropriate soil correction factors and any possible exceptions for a Site Class D soil profile at site grid coordinates of 40.3710 degrees north latitude and -111.8208 degrees west longitude (also see response spectrum on the following page):

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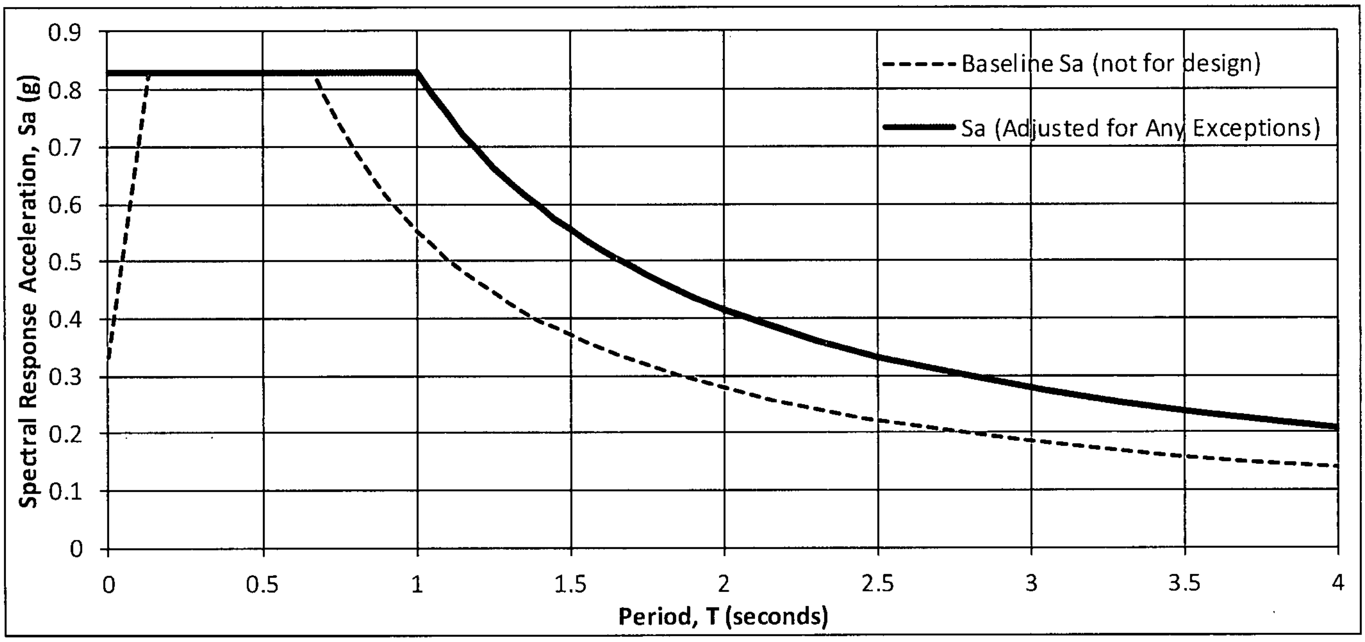
[3] American Society of Civil Engineers

SPECTRAL ACCELERATION VALUE, T	SITE CLASS B/C BOUNDARY [mapped values] (g)	SITE COEFFICIENT	SITE CLASS D* [adjusted for site class effects] (g)	MULTI-PLIER	DESIGN VALUES (g)
Peak Ground Acceleration	PGA = **0.555**	F_{pga} = 1.100	PGA_M = 0.611	1.000	PGA_M = 0.611
0.2 Seconds (Long Period Acceleration)	S_S = **1.241**	F_a = 1.004	S_{MS} = 1.245	0.667	S_{DS} = 0.830
	(exceptions, if any)	F_a = (N/A)	S_{MS} = (N/A)	0.667	S_{DS} = (N/A)
1.0 Second (Long Period Acceleration)	S_1 = **0.449**	F_v = N/A	S_{M1} = N/A	0.667	S_{D1} = N/A
	(exceptions, if any)	F_v = (1.851)	S_{M1} = (0.831)	0.667	S_{D1} = (0.554)

NOTES:

*** Site Class D With Data**

1. T_L = 8 seconds
2. Site Class: **D**
3. Have data to verify? **yes**
4. **ASCE 7-16 requires Site Specific Ground Motion Hazard Analysis (S1 ≥ 0.2), OR Can Use Exception 2**



4.3.3 Liquefaction

The site is located within an area designated by the Utah Geologic Survey[4], and in the American Fork Sensitive Lands Ordinance[5] as having "High" liquefaction potential. Liquefaction is defined as the condition when saturated, loose, sandy soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event. Clayey soils, even if saturated, will generally not liquefy during a major seismic event.

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[4] Utah Geological Survey, "Liquefaction-Potential Map for a Part of Utah County, Utah," Utah Geological Survey Public Information Series 28, August 1994. https://ugspub.nr.utah.gov/publications/public_information/pi-28.pdf

[5] American Fork City Sensitive Lands, Sensitive Lands Ordinance and Reference Materials, 2007, Proposed Liquefaction Hazards Map

We evaluated the liquefaction potential of the site using the procedures described in Youd et al[6] and Idriss & Boulanger[7], and only apply to the saturated sandy deposits. Our evaluation indicates isolated zones of the saturated sandy soils could liquefy under a major seismic event. Maximum anticipated settlement resulting from the liquefaction would be in the range of 1.0 to 2.5 inches. This amount of settlement could be accounted for in structural design to provide life safety, although some structural damage would be possible. If such liquefaction-induced settlements are not acceptable, we can provide mitigation strategies, such as soil densification methods, to treat susceptible soils. The evaluation also indicates that lateral spreading due to liquefaction could also occur with estimated movements of 0.5 to 1.0 foot.

4.4 Other Geologic Hazards

No landslide deposits or features are mapped on or adjacent to the site. The site is not located within a currently known or mapped potential debris flow, stream flooding, or rock fall hazard area.

5.0 SITE CONDITIONS

5.1 Surface Conditions

At the time the field work was performed for this study there was an existing residence in the northeast portion of the site and a foundation from an old barn. The residence had several large trees in the yard. The remainder of the site was undeveloped and parts were vegetated with grasses and weeds. Some grading had occurred on the west and south portions of the site likely during construction of 900 West Street and 350 South Street. Overall, the site is relatively flat, with a slight slope downward to the south. Based upon aerial photos dating back to 1993 that are readily available on the internet, the site was part of a cultivated field. The existing residence appears to have been constructed between 1993 and 1997. The remainder of the site appears to have been actively farmed until sometime between 2018 and 2019 when construction of 900 West began. The site is bordered on the north by 200 South Street, on the south by 350 South Street, on the east by a high density residential (townhome) development, and on the west by 900 West Street (see **Vicinity Map** in **Section 1.1** above).

5.2 Subsurface Soils

At the locations of bore holes B-1 to B-8, and B-12 (mainly the south and west sides of the site), we encountered sandy gravelly fill soils on the surface, extending to depths of about 1.5 to 2 feet below the surface, except at the location of B-12 where the fill extended about 3.5 feet below the surface. We consider the fill to be non-engineered. At the locations of bore holes B-10 and B-11, about 12 inches to clayey topsoil was noted at the

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[6] Youd, T.L.; Idriss, I.M.; Andrus, R.D.; Arango, I.; Castro, G.; Christian, J.T.; Dobry, R.; Finn, W.D.L.; Harder, L.F. Jr.; Hynes, M.E.; Ishihara, K.; Koester, J.P.; Liao, S.C.; Marcuson, W.F. III; Martin, G.R.; Mitchell, J.K.; Moriwaki, Y.; Power, M.S.; Robertson, P.K.; Seed, R.B.; and Stokoe, K.H. II; October 2001, "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils," ASCE Journal of Geotechnical and Geoenvironmental Engineering, p 817-833.

[7] Idriss, I.M. and Boulanger, R.W., December 2010, "SPT-Based Liquefaction Triggering Procedures," Department of Civil & Environmental Engineering, University of California at Davis, Report No. UCD/CGM 10/02, 259 p.

surface. Natural soils encountered beneath the fill and topsoil consisted predominately of CLAY (CL) with varying amounts of sand and/or sand seams, but also Clayey SAND (SC) layers, and an occasional Sandy SILT (ML) layer, Poorly Graded SAND (SP) layer, and Clayey GRAVEL (GC) layer, extending to the bottom of the bore holes.

The clay and silt soils were moist to wet, light brown to gray in color, and have very soft to stiff consistency based upon the SPT blow counts. In laboratory testing the clay soils also exhibited moderate over consolidation and strength characteristics with moderate compressibility characteristics.

The natural sand and gravel soils were moist to wet, brown to gray in color, and in a loose to medium dense state based upon the SPT blow counts. Some of these layers are potentially liquefiable during a seismic event as discussed in **Section 4.3.3**.

For a more descriptive interpretation of subsurface conditions, please refer to the bore hole logs, **Figures 2 through 13**, which graphically represent the subsurface conditions encountered. The lines designating the interface between soil types on the logs generally represent approximate boundaries; in situ, the transition between soil types may be gradual.

5.3 Groundwater

Groundwater was encountered in the bore holes during drilling at depths of about 1.5 to 6.0 feet below existing grades. On December 6, 2019 CMT personnel returned to the site and measured groundwater levels at depths of 2 feet 3 inches to 7 feet 10 inches below the existing site grades within slotted PVC pipes installed in bore holes B-5, B-7, and B-12. These depths to groundwater will likely affect all excavations at this site. Historic groundwater levels were not available at this site and visual indicators (i.e. oxidation) were not observed within the soil samples obtained during drilling; therefore, it is our opinion a groundwater level of 1.5 feet can be used as the historic groundwater level for this project area.

Groundwater levels can fluctuate as much as 1.5 to 2 feet seasonally. Numerous other factors such as heavy precipitation, irrigation of neighboring land, and other unforeseen factors, may also influence ground water elevations at the site. The detailed evaluation of these and other factors, which may be responsible for ground water fluctuations, is beyond the scope of this study.

5.4 Site Subsurface Variations

Based on the results of the subsurface explorations and our experience, variations in the continuity and nature of subsurface conditions should be anticipated. Due to the heterogeneous characteristics of natural soils, care should be taken in interpolating or extrapolating subsurface conditions between or beyond the exploratory locations.

6.0 SITE PREPARATION AND GRADING

6.1 General

We understand that the existing residence will be razed and removed. Removal should include floor slabs and other concrete flat work, foundations, and any existing underground utilities that will be abandoned. Resulting excavations that will be below the footprint of new structures or pavements should be backfilled with properly compacted engineered fill.

All deleterious materials should be stripped from the site prior to commencement of construction activities. This includes vegetation, topsoil, loose and disturbed soils, etc. Based upon the conditions observed at the locations of bore holes B-10 and B-11, and likely most of the eastern portion of the site, there is topsoil on the surface of the site which we estimated to be about 12 inches in thickness. When stripping and grubbing, topsoil should be distinguished by the apparent organic content and not solely by color; thus we estimate that topsoil stripping will need to include the upper 6 inches. However, given the past agricultural uses of the site, the upper 12 to 15 inches may have been disturbed during farming. Where trees are located, large roots and/or root balls likely extend deeper and must also be removed from building and pavement areas. Due to the shallow groundwater, stripping and grubbing should be kept to the minimum amount required to remove vegetation and the most significant amount of organic material.

Based upon the surface conditions observed at most of the bore hole locations, approximately 1.5 to as much as 3.5 feet of sandy gravelly soils, considered non-engineered fill (not placed in a controlled manner or tested for compaction) is present on the surface of the site. All non-engineered fill shall be removed from beneath foundation and floor slab areas. Outside of building footprints the potential for settlement of the fill below exterior concrete flatwork and pavements can be reduced, but not eliminated, with proper preparation. As the majority of the fill was found to be about 2 feet in thickness, proper preparation, after grubbing of vegetation and topsoil, shall consist of removing the upper 12 inches, scarifying the exposed surface to a minimum depth of 8 inches, moisture conditioning as needed, and re-compacting the scarified surface in place to 95% of the maximum dry density. The removed 12 inches of fill, if free or organics, debris, etc. may then be replaced in similarly compacted lifts. Prior to placing pavement materials the exposed subgrade must then be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or loose soils are encountered, they must be removed (up to a maximum depth of 2 feet) and replaced with structural fill.

The site should be examined by a CMT geotechnical engineer to assess that suitable natural soils have been exposed and any deleterious materials, loose and/or disturbed soils have been removed or prepared as described above, prior to placing site grading fills, footings, slabs, and pavements.

Fill placed over large areas to raise overall site grades can induce settlements in the underlying natural soils. If more than 3 feet of site grading fill is anticipated over the natural ground surface, we should be notified to assess potential settlements and provide additional recommendations as needed. These recommendations may include placement of the site grading fill far in advance to allow potential settlements to occur prior to construction.

6.2 Temporary Excavations

Excavations deeper than 8 feet are not anticipated at the site. Groundwater as shallow as 1.5 feet was encountered and later measured at this site. We anticipate that all excavations extending below the existing site grades could encounter groundwater and dewatering of excavations will likely be required.

The natural soils encountered at this site predominantly consisted of clay. In clayey (cohesive) soils, temporary construction excavations not exceeding 4 feet in depth may be constructed with near-vertical side slopes. Temporary excavations up to 8 feet deep, above or below groundwater, may be constructed with side slopes no steeper than one-half horizontal to one vertical (0.5H:1V).

For sandy/gravelly (cohesionless) soils, temporary construction excavations not exceeding 4 feet in depth should be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 8 feet and above groundwater, side slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult to maintain, and will require very flat side slopes and/or shoring, bracing and dewatering.

To reduce disturbance of the natural soils during excavation, we recommend that smooth edge buckets/blades be utilized.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated. All excavations should be made following OSHA safety guidelines.

6.3 Fill Material

Following are our recommendations for the various fill types we anticipate will be used at this site:

FILL MATERIAL TYPE	DESCRIPTION | RECOMMENDED SPECIFICATION
Structural Fill	Placed below structures, flatwork and pavement. Well-graded sand/gravel mixture, with maximum particle size of 4 inches, a minimum 70% passing 3/4-inch sieve, a maximum 20% passing the No. 200 sieve, and a maximum Plasticity Index of 10.
Site Grading Fill	Placed over larger areas to raise the site grade. Sandy to gravelly soil, with a maximum particle size of 6 inches, a minimum 70% passing 3/4-inch sieve, and a maximum 50% passing No. 200 sieve.
Non-Structural Fill	Placed below non-structural areas, such as landscaping. On-site soils or imported soils, with a maximum particle size of 8 inches, including silt/clay soils not containing excessive amounts of degradable/organic material (see discussion below).
Stabilization Fill	Placed to stabilize soft areas prior to placing structural fill and/or site grading fill. Coarse angular gravels and cobbles 1 inch to 8 inches in size. May also use 1.5- to 2.0-inch gravel placed on stabilization fabric, such as Mirafi RS280i, or equivalent (see **Section 6.6**).

On-site soils could be used as site grading fill and non-structural fill, but many of these soils are likely well above optimum moisture content and will be inherently more difficult to work with in proper moisture conditioning (they are very sensitive to changes in moisture content), requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year. We also recommend the site grading fill thickness using on-site soils not exceed 3 feet below structures, to minimize potential settlements.

All fill material should be approved by a CMT geotechnical engineer prior to placement.

6.4 Fill Placement and Compaction

The various types of compaction equipment available have their limitations as to the maximum lift thickness that can be compacted. For example, hand operated equipment is limited to lifts of about 4 inches and most "trench compactors" have a maximum, consistent compaction depth of about 6 inches. Large rollers, depending on soil and moisture conditions, can achieve compaction at 8 to 12 inches. The full thickness of each lift should be compacted to at least the following percentages of the maximum dry density as determined by ASTM D-1557 (or AASHTO[8] T-180) in accordance with the following recommendations:

LOCATION	TOTAL FILL THICKNESS (FEET)	MINIMUM PERCENTAGE OF MAXIMUM DRY DENSITY
Beneath an area extending at least 4 feet beyond the perimeter of structures, and below flatwork and pavement (applies to structural fill and site grading fill) extending at least 2 feet beyond the perimeter	0 to 5 5 to 8	95 98
Site grading fill outside area defined above	0 to 5 5 to 8	92 95
Utility trenches within structural areas	--	96
Roadbase and subbase	-	96
Non-structural fill	0 to 5 5 to 8	90 92

Structural fills greater than 8 feet thick are not anticipated at the site. For best compaction results, we recommend that the moisture content for structural fill/backfill be within 2% of optimum. Field density tests should be performed on each lift as necessary to verify that proper compaction is being achieved.

6.5 Utility Trenches

For the bedding zone around the utility, we recommend utilizing sand bedding fill material that meets current APWA[9] requirements.

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[8] American Association of State Highway and Transportation Officials

[9] American Public Works Association

All utility trench backfill material below structurally loaded facilities (foundations, floor slabs, flatwork, parking lots/drive areas, etc.) should be placed at the same density requirements established for structural fill in the previous section.

Most utility companies and local governments are requiring Type A-1a or A-1b (AASHTO Designation) soils (sand/gravel soils with limited fines) be used as backfill over utilities within public rights of way, and the backfill be compacted over the full depth above the bedding zone to at least 96% of the maximum dry density as determined by AASHTO T-180 (ASTM D-1557). The majority of soils at this site will not meet these specifications.

Where the utility does not underlie structurally loaded facilities and public rights of way, on-site fill and natural soils may be utilized as trench backfill above the bedding layer, provided they are properly moisture conditioned and compacted to the minimum requirements stated above in **Section 6.4**.

6.6 Stabilization

The natural clay soils at this site, which predominate near the surface, will be susceptible to rutting and pumping. The likelihood of disturbance or rutting and/or pumping of the existing natural soils is a function of the load applied to the surface, as well as the frequency of the load. Consequently, rutting and pumping can be minimized by avoiding concentrated traffic, minimizing the load applied to the surface by using lighter equipment and/or partial loads, by working in drier times of the year, or by providing a working surface for the equipment. Rubber-tired equipment particularly, because of high pressures, promotes instability in moist/wet, soft soils.

If rutting or pumping occurs, traffic should be stopped and the disturbed soils should be removed and replaced with stabilization material. Typically, a minimum of 18 inches of the disturbed soils must be removed to be effective. However, deeper removal is sometimes required.

To stabilize soft subgrade conditions (if encountered), a mixture of coarse, clean, angular gravels and cobbles and/or 1.5- to 2.0-inch clean gravel should be utilized. Often the amount of gravelly material can be reduced with the use of a geotextile fabric such as Mirafi RS280i, or equivalent. Its use will also help avoid mixing of the subgrade soils with the gravelly material. After excavating the soft/disturbed soils, the fabric should be spread across the bottom of the excavation and up the sides a minimum of 18 inches. Otherwise, it should be placed in accordance with the manufacturer's recommendation, including proper overlaps. The gravel material can then be placed over the fabric in compacted lifts as described above.

7.0 FOUNDATION RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics, the subsurface conditions observed in the field and the laboratory test data, as well as common geotechnical engineering practice.

7.1 Foundation Recommendations

Based on our geotechnical engineering analyses, the proposed structures may be supported upon conventional spread and/or continuous wall foundations placed on suitable, undisturbed natural soils or on structural fill extending to suitable natural soils (see **Section 7.3 below**). Footings may be designed using a net bearing pressure of 2,000.

The term "net bearing pressure" refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade, thus the weight of the footing and backfill to lowest adjacent final grade need not be considered. The allowable bearing pressure may be increased by 1/3 for temporary loads such as wind and seismic forces.

Due to potential lateral movements of up to 1.0 foot in the event of an earthquake which induces liquefaction in the subsurface sand layers, we also recommend tying foundations together with grade beams and additional reinforcement as determine by the design structural engineer. Or, as indicated in **Section 4.3.3**, we can provide mitigation strategies, such as soil densification methods, to treat susceptible soils.

We also recommend the following:

1. Exterior footings subject to frost should be placed at least 30 inches below final grade.
2. Interior footings not subject to frost should be placed at least 16 inches below grade.
3. Continuous footing widths should be maintained at a minimum of 18 inches.
4. Spot footings should be a minimum of 24 inches wide.

7.2 Installation

Under no circumstances shall foundations be placed on non-engineered fill, topsoil with organics, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

If unsuitable soils are encountered, they must be completely removed and replaced with properly compacted structural fill. Deep, large roots may be encountered where trees and larger bushes are located or were previously located at the site; such large roots should also be removed. Excavation bottoms should be examined by a CMT geotechnical engineer to confirm that suitable bearing soils have been exposed prior to forming for footings or placing structural fill.

All structural fill should meet the requirements for such, and should be placed and compacted in accordance with **Section 6** above. The width of structural replacement fill below footings should be equal to the width of the footing plus 1 foot for each foot of fill thickness. For instance, if the footing width is 2 feet and the structural fill depth beneath the footing is 2 feet, the fill replacement width should be 4 feet, centered beneath the footing.

The minimum thickness of structural fill below footings should be equivalent to one-third the thickness of structural fill below any other portion of the foundations. For example, if footings will cross over an area where an old basement was backfilled, and the maximum depth of structural fill used for the backfill is 6 feet, all footings for the new structure should be underlain by a minimum 2 feet of structural fill.

7.3 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that total settlements of footings founded as recommended above will not exceed 1 inch, provided more heavily loaded footings are placed on the minimum structural fill thicknesses recommended below. We project that approximately 50% of the total settlement will initially take place during construction.

FOUNDATIONS	BEARING PRESSURE	LOADING	MINIMUM THICKNESS OF REPLACEMENT STRUCTURAL FILL (feet)
Spread	2,000	Up to 100,000 pounds	0.0
Spread	2,000	100,000+ to 150,000 pounds	1.5
Spread	2,000	150,000+ to 200,000 pounds	2.0
Wall	2,000	Up to 8,000 pounds per lineal foot	0.0
Wall	2,000	8,000+ to 10,000 pounds per lineal foot	1.5
Wall	2,000	10,000+ to 12,000 pounds per lineal foot	2.0

7.4 Lateral Resistance

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.30 for natural clay soils or 0.40 for structural fill, may be utilized for design. Passive resistance provided by properly placed and compacted structural fill above the water table may be considered equivalent to a fluid with a density of 300 pcf. A combination of passive earth resistance and friction may be utilized if the friction component of the total is divided by 1.5.

8.0 LATERAL EARTH PRESSURES

We anticipate that retaining walls up to 4 feet high might be constructed at this site. The lateral earth pressure values given below are for a backfill material that will consist of drained sand/gravel soils (less than 10% passing No. 200 sieve) placed and compacted in accordance with the recommendations presented herein. If other soil types will be used as backfill, we should be notified so that appropriate modifications to these values can be provided, as needed.

The lateral pressures imposed upon subgrade facilities will depend upon the relative rigidity and movement of the backfilled structure. Following are the recommended lateral pressure values, which also assume that the soil surface behind the wall is horizontal and that the backfill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

CONDITION	EQUIVALENT FLUID PRESSURE (psf/ft)	
	STATIC	SEISMIC
Active Pressure (wall is allowed to yield, i.e. move away from the soil, with a minimum 0.001H movement/rotation at the top of the wall, where "H" is the total height of the wall)	35	55
At-Rest Pressure (wall is not allowed to yield)	55	---
Passive Pressure (wall moves into the soil)	300	500

9.0 FLOOR SLABS

Floor slabs may be established upon suitable, undisturbed, natural soils and/or on structural fill extending to suitable natural soils (same as for foundations). Under no circumstances shall floor slabs be established directly on any topsoil, non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

In order to facilitate curing of the concrete, we recommend that floor slabs be directly underlain by at least 4 inches of "free-draining" fill, such as "pea" gravel or 3/4-inch quarters to 1-inch minus, clean, gap-graded gravel. To help control normal shrinkage and stress cracking, the floor slabs should have the following features:

1. Adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints;
2. Frequent crack control joints; and
3. Non-rigid attachment of the slabs to foundation walls and bearing slabs.

10.0 DRAINAGE RECOMMENDATIONS

It is important to the long-term performance of foundations and floor slabs that water not be allowed to collect near the foundation walls and infiltrate into the underlying soils. We recommend the following:

1. All areas around each structure should be sloped to provide drainage away from the foundations. We recommend a minimum slope of 4 inches in the first 10 feet away from the structure. This slope should be maintained throughout the lifetime of the structure.

2. All roof drainage should be collected in rain gutters with downspouts designed to discharge at least 10 feet from the foundation walls or well beyond the backfill limits, whichever is greater.

3. Adequate compaction of the foundation backfill should be provided. We suggest a minimum of 90% of the maximum laboratory density as determined by ASTM D-1557. Water consolidation methods should not be used under any circumstances.

4. Landscape sprinklers should be aimed away from the foundation walls. The sprinkling systems should be designed with proper drainage and be well-maintained. Over watering should be avoided.

5. Other precautions that may become evident during construction.

11.0 PAVEMENTS

All pavement areas must be prepared as discussed above in **Section 6.1**. Under no circumstances shall pavements be established over topsoil, unprepared non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

In roadway areas, subsequent to stripping and prior to the placement of pavement materials, the exposed subgrade must be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or otherwise unsuitable soils are encountered, we recommend they be removed to a minimum of 18 inches below the subgrade level and replaced with structural fill.

We anticipate the natural near surface clay soils will exhibit poor pavement support characteristics when saturated or nearly saturated. Based on our laboratory testing experience with similar soils, our pavement design is based upon a California Bearing Ratio (CBR) of 3 for the natural clay soils.

Given the projected traffic as discussed above in **Section 1.3**, the following pavement sections are recommended for the given ESAL's (18-kip equivalent single-axle loads) per day:

MATERIAL	PAVEMENT SECTION THICKNESS (inches)					
	PARKING AREAS (3 ESAL'S per day)			DRIVE AREAS (8 ESAL'S per day)		
Asphalt	3	3	---	3	3	---
Concrete	---	--	5	---	---	6
Road-Base	8	4	5	12	5	5
Subbase	0	6	0	0	8	0
Total Thickness	11	13	10	15	16	11

Untreated base course (UTBC) should conform to city specifications, or to 1-inch-minus UDOT specifications for A–1-a/NP, and have a minimum CBR value of 70%. Material meeting our specification for structural fill can be used for subbase, as long as the fines content (percent passing No. 200 sieve) does not exceed 15%. Roadbase and subbase material should be compacted as recommended above in **Section 6.4**. Asphalt material generally should conform to APWA requirements, having a ½-inch maximum aggregate size, a 75-gyration Superpave mix containing no more than 15% of recycled asphalt (RAP) and a PG58-28 binder.

Concrete pavement should typically have a minimum 28-day strength of 3,000 psi, and should be saw-cut at appropriate intervals and at the proper time to control the locations of shrinkage cracking.

12.0 QUALITY CONTROL

We recommend that CMT be retained as part of a comprehensive quality control testing and observation program. With CMT onsite we can help facilitate implementation of our recommendations and address, in a timely manner, any subsurface conditions encountered which vary from those described in this report. Without such a program CMT cannot be responsible for application of our recommendations to subsurface conditions which may vary from those described herein. This program may include, but not necessarily be limited to, the following:

12.1 Field Observations

Observations should be completed during all phases of construction such as site preparation, foundation excavation, structural fill placement and concrete placement.

12.2 Fill Compaction

Compaction testing by CMT is required for all structural supporting fill materials. Maximum Dry Density (Modified Proctor, ASTM D-1557) tests should be requested by the contractor immediately after delivery of any fill materials. The maximum density information should then be used for field density tests on each lift as necessary to ensure that the required compaction is being achieved.

12.3 Excavations

All excavation procedures and processes should be observed by a geotechnical engineer from CMT or his representative. In addition, for the recommendations in this report to be valid, all backfill and structural fill placed in trenches and all pavements should be density tested by CMT. We recommend that freshly mixed concrete be tested by CMT in accordance with ASTM designations.

12.4 Vibration Monitoring

Construction activities, particularly site grading and fill placement, can induce vibrations in existing structures adjacent to the site. Such vibrations can cause damage to adjacent buildings, depending on the building composition and underlying soils. It can be prudent to monitor vibrations from construction activities to maintain records that vibrations did not exceed a pre-defined threshold known to potentially cause damage. CMT can provide this monitoring if desired.

13.0 LIMITATIONS

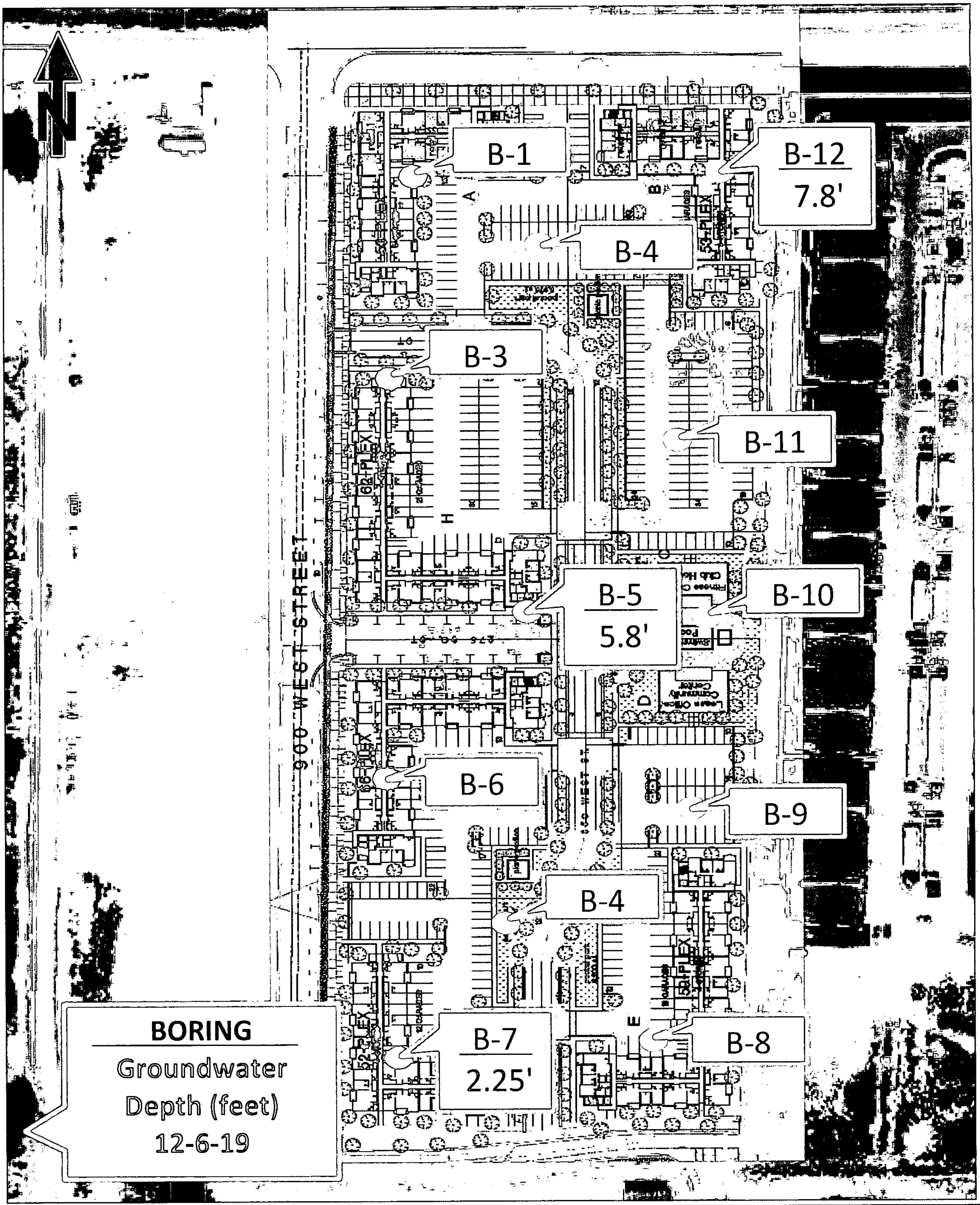
The recommendations provided herein were developed by evaluating the information obtained from the subsurface explorations and soils encountered therein. The exploration logs reflect the subsurface conditions only at the specific location at the particular time designated on the logs. Soil and ground water conditions may differ from conditions encountered at the actual exploration locations. The nature and extent of any variation in the explorations may not become evident until during the course of construction. If variations do appear, it may become necessary to re-evaluate the recommendations of this report after we have observed the variation.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 492-4132. To schedule materials testing, please call (801) 381-5141.

APPENDIX

SUPPORTING DOCUMENTATION



American Fork Apartments
900 West 200 South, American Fork, Utah

CMT ENGINEERING LABORATORIES

Site Map

Date:	11-Dec-19
Job #	13729

Figure:
1

American Fork Apartments

Bore Hole Log

B-1

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A

Total Depth: 31.5'
Water Depth: 4'

Date: 11/12/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description		Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
										Gravel %	Sand %	Fines %	LL	PL	PI
0	▩	Fill: Dark Brown Clayey Fine to Medium Gravel	moist, medium dense												
	▨	Gray CLAY (CL) with sand, very moist	soft	◤	1	1 1 1	2								
∇	▨	grades with sand layer	wet												
	▨	grades with calcified sand and clay	stiff	⧗	2	1 12 4	16	31.4	90.6						
	▨	Gray Clayey SAND (SC), wet													
8	▨		loose	◤	3	2 2 3	5	23.2				25			
	▨		medium dense	◤	4	2 5 6	11	26.3				23			
12	▨														
	▨	Gray CLAY (CL), wet													
16	▨		very soft	◤	5	0 0 0	0								
20	▨		soft	◤	6	0 0 1	1	48.2					46	22	24
24	▨														
	▨		stiff	◤	7	1 3 5	8								
28	⁘	Gray SAND (SP), occasional gravel, wet													

Remarks: Groundwater encountered during drilling at depth of 4 feet.

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 2

Figure:
2

American Fork Apartments

Bore Hole Log B-1

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 31.5'
Water Depth: 4'
Date: 11/12/19
Job #: 8/2/37

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Blows (N) Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
28	⁘	Gray SAND (SP), occasional gravel, wet grades with clay layers up to 2" thick												
	⁘	medium dense	◤	8	8 8 9	17								
32		END AT 31.5'												
36														
40														
44														
48														
52														
56														

Remarks: Groundwater encountered during drilling at depth of 4 feet.

Figure: 2

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 2 of 2

American Fork Apartments

Bore Hole Log

B-2

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 6.5'
Water Depth: 4'
Date: 11/12/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)		Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
						Total			Gravel %	Sand %	Fines %	LL	PL	PI
0	▩	Fill: Brown to Dark Brown Clayey Sand with gravel, moist												
	▨	Brown to Light Brown CLAY (CL), some sand, very moist												
	▨	soft	◣	9	0 0 1	1								
▽	▨	wet												
	▨	very soft	◣	10	0 0 0	0								
		END AT 6.5'												
8														
12														
16														
20														
24														
28														

Remarks: Groundwater encountered during drilling at depth of 4 feet.

Figure: 3

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

Bore Hole Log

B-3

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 21.5'
Water Depth: 2'
Date: 11/12/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description		Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0	▩	Fill: Dark Brown Sand with clay and gravel, moist													
▽	▨	Brown CLAY (CL), some organics	wet												
	▨		soft	⧗	11	1 2 3	5	31.0	89.2						
4	▨	organics grade out													
	▨			◣	12	0 1 0	1								
	▨	grades with sand													
8	▒	Brownish-Gray Clayey SAND (SC), wet	loose	◣	13	1 2 3	5								
	▨	Gray CLAY (CL), wet	medium stiff	◣	14	2 3 3	6								
12	▨														
16	▨		soft	◣	15	0 0 1	1	34					33	23	10
20	▨			◣	16	0 1 2	3								
		END AT 21.5'													
24															
28															

Remarks: Groundwater encountered during drilling at depth of 2 feet.

Figure: 4

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

Bore Hole Log

B-4

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 6.5'
Water Depth: (see Remarks)
Date: 11/12/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description		Sample Type	Sample #	Blows (N)		Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Total			Gravel %	Sand %	Fines %	LL	PL	PI
0	▩	Fill: Dark Brown Clayey Fine to Medium Gravel, moist													
	▨	Brown CLAY (CL), some sand, very moist													
	▨		soft	◣	17	0 2 1	3								
4	▨														
	▨			◣	18	0 1 1	2								
		END AT 6.5'													
8															
12															
16															
20															
24															
28															

Remarks: Groundwater not encountered during drilling.

Figure:
5

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

Bore Hole Log B-5

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 21.5'
Water Depth: 5', 5.8'
Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)		Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
						Total			Gravel %	Sand %	Fines %	LL	PL	PI
0	▦	Fill												
4	▨	Brown Sandy CLAY (CL), very moist medium stiff	◣	19	2 3 4	7								
▽ ▼	▨	Brown Clayey Fine to Medium SAND (SC), some cemneted nodules wet	⧗	20	6 5 8	13	17.0		17	48	35			
8	▨	loose	◣	21	1 3 4	7								
	▨		⧗	22	5 6 8	14	21.9				35			
12	▨	Gray CLAY (CL) with interbedded fine sand seams, wet												
16	▨	soft	◣	23	0 1 2	3								
20	▨	medium stiff	◣	24	0 2 3	5								
24 28		END AT 21.5'												

Remarks: Groundwater encountered during drilling at depth of 5 feet and measured on 12/6/19 at depth of 5.8 feet.
Slotted PVC pipe installed to depth of 21.5 feet to facilitate water level measurements.

Figure: 6

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

900 West 200 South, American Fork, Utah

Bore Hole Log

B-6

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 21.5'
Water Depth: 6'
Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0	▩	Fill												
	▨	Brown CLAY (CL), some sand, very moist												
	▨	medium stiff	⧗	25	2 3 4	7	24.4	101				29	20	9
4	▨	grades with alternating sand and clay layers												
	⁘	Brown Clayey Sand (SC), very moist												
▽	⁘	loose wet grades with more coarse sand	◤	26	0 0 1	1	24.7				43			
8	⁘	loose	◤	27	1 2 3	5								
	⁘	grades with less clay												
	▨	Brown CLAY (CL), wet	⧗	28	4 7 8	15								
12	▨													
	▨	grades gray												
16	▨	medium stiff	◤	29	0 2 2	4								
20	▨		◤	30	0 3 2	5								
		END AT 21.5'												
24														
28														

Remarks: Groundwater encountered during drilling at depth of 6 feet.

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

Figure:
7

American Fork Apartments

900 West 200 South, American Fork, Utah

Bore Hole Log

B-7

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 21.5'
Water Depth: 6', 2.25'
Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0	▨	Fill												
▼	▨	Brown CLAY (CL), very moist												
	▨	soft	◢	31	0 1 1	2								
4	▨													
▽	▨	grades with sand wet	⧗	32	1 1 1	2	31.2	93.4				29	19	10
8	▨	loose	◢	33	1 2 3	5								
	▨	grades with layers of clayey sand up to 2" thick												
	▨	medium stiff	◢	34	0 2 2	4								
12	▨													
16	▨	soft	◢	35	0 2 1	3								
20	▨	Gray Clayey SAND (SC), wet loose	◢	36	5 4 4	8								
		END AT 21.5'												
24														
28														

Remarks: Groundwater encountered during drilling at depth of 6 feet and measured on 12/6/19 at depth of 2.25 feet.
Slotted PVC pipe installed to depth of 21.5 feet to facilitate water level measurements.

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

Figure:
8

American Fork Apartments

Bore Hole Log

B-8

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A

Total Depth: 31.5'
Water Depth: 5.5'

Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description		Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0	▩	Fill													
	▨	Brown CLAY (CL), very moist													
	▨		very soft	◣	37	0 0 0	0								
4	▨														
▽	▨	grades sandy, some gravel	wet soft	⧗	38	0 3 3	6	28.2	98.1						
8	⁘	Brown Clayey SAND (SC), wet	loose	◣	39	2 1 2	3								
	▨	Brown CLAY (CL), wet	medium stiff	◣	40	1 2 2	4	26.9		10	37	53			
12	▨	grades gray													
16	▨			⧗	41	4 6 7	13	32.7	89.3						
	▨	grades with fine sand													
20	▨			◣	42	3 4 3	7								
24	▨														
	▨	grades with sand layers up to 1" thick	stiff	◣	43	5 6 9	15								
28	▨														

Remarks: Groundwater encountered during drilling at depth of 5.5 feet.

Figure:
9

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 2

American Fork Apartments

Bore Hole Log

B-8

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 31.5'
Water Depth: 5.5'
Date: 11/13/19
Job #: 8/2/37

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)		Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
						Total			Gravel %	Sand %	Fines %	LL	PL	PI
28	▨	Brown CLAY (CL), very moist												
	▨	Gray Clayey SAND (SC), wet												
	▨	loose	◤	44	7 4 3	7								
32		END AT 31.5'												
36														
40														
44														
48														
52														
56														

Remarks: Groundwater encountered during drilling at depth of 5.5 feet.

Figure: 9

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 2 of 2

American Fork Apartments

Bore Hole Log

B-9

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A

Total Depth: 6.5'
Water Depth: 2'

Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0	⁘	Topsoil												
	▨	Brown CLAY (CL), very moist												
▽	▨	wet												
	▨	very soft	◣	45	0 0 0	0								
4	▨													
	▨		◣	46	0 0 0	0								
		END AT 6.5'												
8														
12														
16														
20														
24														
28														

Remarks: Groundwater encountered during drilling at depth of 2 feet.

Figure:

10

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

Bore Hole Log

B-10

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A

Total Depth: 21.5'
Water Depth: 1.5'

Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0	⁘	Topsoil												
▽	▨	Brown Clay (CL) with sand wet												
	▨		⧗	47	1 2 4	6	30.7				79			
4	▨													
	▨	Brown Clayey SAND (SC), wet loose	◤	48	2 2 1	3	26.2				43			
8	▨	Gray CLAY (CL), some sand, wet	◤	49	2 2 4	6								
	▨	soft	◤	50	2 1 2	3	24.3				55			
12	▨													
16	▨		◤	51	0 0 2	2	35.2					32	23	9
20	▨	medium stiff	◤	52	0 2 3	5								
		END AT 21.5'												
24														
28														

Remarks: Groundwater encountered during drilling at depth of 1.5 feet.

Figure:
11

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

Bore Hole Log

B-11

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 6.5'
Water Depth: 4'
Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description		Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gravel %	Sand %	Fines %	LL	PL	PI
0		Topsoil													
		Brown CLAY (CL), some sand, moist													
		grades more sandy, some cemented nodules	stiff	◣	53	2 4 6	10								
∇			wet												
				◣	54	2 4 4	8								
		END AT 6.5'													
8															
12															
16															
20															
24															
28															

Remarks: Groundwater encountered during drilling at depth of 4 feet.

Figure:

12

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

Bore Hole Log

B-12

900 West 200 South, American Fork, Utah

Boring Type: Hollow-Stem Auger
Surface Elev. (approx): N/A
Total Depth: 21.5'
Water Depth: 5', 7.8'
Date: 11/13/19
Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description		Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0	▩	Fill: Brown Gravel with sand, slightly moist													
	▩			◤	55										
4	▨	Brown CLAY (CL) with sand, very moist													
▽	▥	Brown Sandy SILT (ML)	wet loose	◣	56	1 1 2	3	25.5				57			
▼ 8	●	Brown Clayey GRAVEL (GC) with sand, wet	dense	◣	57	2 8 28	36								
	●			◣	58	10 12 20	32								
12	▨	Brown CLAY (CL), wet													
	▨	grades gray with sand lenses													
16	▨		stiff	◣	59	2 4 6	10	27.5				74			
20	▨		very soft	◣	60	0 0 0	0	44.9					36	23	13
		END AT 21.5'													
24															
28															

Remarks: Groundwater encountered during drilling at depth of 5 feet and measured on 12/6/19 at depth of 7.8 feet.
Slotted PVC pipe installed to depth of 21.5 feet to facilitate water level measurements.

Figure:
13

CMT ENGINEERING LABORATORIES

Drilled By: Dirk
Logged By: Olivia R
Page: 1 of 1

American Fork Apartments

Key to Symbols

900 West 200 South, American Fork, Utah

Date: 11/12/19

Job #: 13729

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows(N)		Moisture (%)	Dry Density(pcf)	Gradation ⑩			Atterberg ⑪		
						Total			Gravel %	Sand %	Fines %	LL	PL	PI
①	②	③	④	⑤	⑥	⑦	⑧	⑨						

COLUMN DESCRIPTIONS

① **Depth (ft.):** Depth (feet) below the ground surface (including groundwater depth - see water symbol below).

② **Graphic Log:** Graphic depicting type of soil encountered (see ② below).

③ **Soil Description:** Description of soils encountered, including Unified Soil Classification Symbol (see below).

④ **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below-right.

⑤ **Sample #:** Consecutive numbering of soil samples collected during field exploration.

⑥ **Blows:** Number of blows to advance sampler in 6" increments, using a 140-lb hammer with 30" drop.

⑦ **Total Blows:** Number of blows to advance sampler the 2nd and 3rd 6" increments.

⑧ **Moisture (%):** Water content of soil sample measured in laboratory (percentage of dry weight of sample).

⑨ **Dry Density (pcf):** The dry density of a soil measured in laboratory (pounds per cubic foot).

⑩ **Gradation:** Percentages of Gravel, Sand and Fines (Silt/Clay), obtained from lab test results of soil passing the No. 4 and No. 200 sieves.

⑪ **Atterberg:** Individual descriptions of Atterberg Tests are as follows:

LL = Liquid Limit (%): Water content at which a soil changes from plastic to liquid behavior.

PL = Plastic Limit (%): Water content at which a soil changes from liquid to plastic behavior.

PI = Plasticity Index (%): Range of water content at which a soil exhibits plastic properties (= Liquid Limit - Plastic Limit).

STRATIFICATION	
Description	**Thickness**
Seam	Up to ½ inch
Lense	Up to 12 inches
Layer	Greater than 12 in.
Occasional	1 or less per foot
Frequent	More than 1 per foot

MODIFIERS
Trace
<5%
Some
5-12%
With
> 12%

MOISTURE CONTENT
Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp / moist to the touch, but no visible water.
Saturated: Visible water, usually soil below groundwater.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS SYMBOLS	②	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	GRAVELS The coarse fraction retained on No. 4 sieve.	CLEAN GRAVELS (< 5% fines)	GW	●	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	●	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (≥ 12% fines)	GM	●	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	●	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS The coarse fraction passing through No. 4 sieve.	CLEAN SANDS (< 5% fines)	SW	⁘	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	⁘	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (≥ 12% fines)	SM	⁞	Silty Sands, Sand-Silt Mixtures
			SC	▨	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	SILTS AND CLAYS Liquid Limit less than 50%		ML	▥	Inorganic Silts and 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 o f Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	▥	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	▨	Inorganic Clays of High Plasticity, Fat Clays
			OH	⁙	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	⁘	Peat, Humus, Swamp Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications (i.e. GP-GM, SC-SM, etc.).

SAMPLER SYMBOLS

▯ Block Sample

◪ Bulk/Bag Sample

⧗ Modified California Sampler 3.5" OD, 2.42" ID

⧗ D&M Sampler

▯ Rock Core

◪ Standard Penetration Split Spoon Sampler

▥ Thin Wall (Shelby Tube)

WATER SYMBOL

▽ Encountered Water Level

▼ Measured Water Level

(see Remarks on Logs)

1. The results of laboratory tests on the samples collected are shown on the logs at the respective sample depths.
2. The subsurface conditions represented on the logs are for the locations specified. Caution should be exercised if interpolating between or extrapolating beyond the exploration locations.
3. The information presented on each log is subject to the limitations, conclusions, and recommendations presented in this report.

Figure: 14

CMT ENGINEERING LABORATORIES

Company: **CMT Engineering**

Project Name: American Fork Apartments

Location: 900 W 200 S, American Fork, UT

Project #: 13729

Designer: Jeff Egbert
Date: 12/10/2019

Checked By:
Date:

Units (1=SI, 2=US):	2		**Ground Slope, S:**	0.1	% (Enter either S or W)
PGA:	0.555		**Free-Face Ratio, W:**		% (Enter either S or W)
(Modal) M_w:	7.09		**Hammer Efficiency:**	80	%
Distance:	7.6	km	**Sampler Liner:**	NL	NL = Room for liners, but no liners L = Standard Split Spoon
Vs,12:	623	ft/s	**Borehole Diameter:**	8	in
Percentile:	85		**Rod Lengths:**	5	ft

Boring No.	Top Samp. Depth (ft)	Depth to Water (ft)	Measured SPT N	γ (lb/ft^3)	Thickness (ft)	Fines (%)	D50 (mm)	$K_{(aging)}$	Soil Type	Susceptible?
B-1	7.5	4	5	113	4	25	0.215		SC	Yes
B-1	10	4	11	116	4	23	0.234		SC	Yes
B-3	7.5	2	5	113	2.5	25	0.215		SC	Yes
B-5	5	5	6	114	2.5	35	0.148		SC	Yes
B-5	7.5	5	7	114	4.5	35	0.148		SC	Yes
B-6	5	5	1	112	2.5	43	0.112		SC	Yes
B-6	7.5	5	5	113	2.5	43	0.112		SC	Yes
B-7	20	2	8	115	1.5	25	0.215		SC	Yes
B-8	7.5	5.5	3	112	2.5	25	0.215		SC	Yes
B-8	30	5.5	7	114	4.5	25	0.215		SC	Yes
B-10	5	1.5	3	112	2.5	43	0.112		SC	Yes

Deterministic Liquefaction Triggering using Youd & Idriss et al (2001)

a_{max} = 0.5550 g
M_w = 7.09

(for comparison only)

Boring No.	Samp.Depth(ft)	Depth (m)	Thick. (m)	Water (m)	γ (kN/m^3)	σ_v (kPa)	σ_v' (kPa)	Fines (%)	$(N_1)_{60}$	α	β	$(N_1)_{60,cs}$	r_d	MSF ^{Idriss}	ISF$^{Andrus+Stok}$	K_σ	$K_{(aging)}$	CSR(site)	CRR	FS_{Liq}
B-1	8	2.438	1.219	1.219	17.75	43.29	31.33	25	9.83	4.289	1.115	15.25	0.981	1.154	1.155	1.265	1.00	0.3351	0.1848	0.552
B-1	10.5	3.200	1.219	1.219	18.22	57.75	38.32	23	23.98	4.059	1.100	30.44	0.976	1.154	1.155	1.339	1.00	0.3432	0.6003	1.749
B-3	8	2.438	0.762	0.610	17.75	43.86	25.93	25	10.19	4.289	1.115	15.66	0.981	1.154	1.155	1.313	1.00	0.3950	0.1889	0.478
B-5	5.5	1.676	0.762	1.524	17.91	30.10	28.60	35	12.12	5.000	1.200	19.54	0.987	1.154	1.155	1.288	1.00	0.2521	0.2340	0.928
B-5	8	2.438	1.372	1.524	17.91	43.74	34.77	35	13.74	5.000	1.200	21.49	0.981	1.154	1.155	1.378	1.00	0.2799	0.2633	0.941
B-6	5.5	1.676	0.762	1.524	17.60	31.24	29.75	43	1.99	5.000	1.200	7.38	0.987	1.154	1.155	1.278	1.00	0.2536	0.1175	0.463
B-6	8	2.438	0.762	1.524	17.75	44.08	35.11	43	9.60	5.000	1.200	16.52	0.981	1.154	1.155	1.236	1.00	0.3115	0.1978	0.635
B-7	20.5	6.248	0.457	0.610	18.07	111.52	56.22	25	16.74	4.289	1.115	22.96	0.952	1.154	1.155	1.193	1.00	0.4947	0.2903	0.587
B-8	8	2.438	0.762	1.676	17.60	44.99	37.51	25	5.67	4.289	1.115	10.61	0.981	1.154	1.155	1.220	1.00	0.3015	0.1429	0.474
B-8	30.5	9.296	1.372	1.676	17.91	166.04	91.31	25	12.50	4.289	1.115	18.23	0.926	1.154	1.155	1.021	1.00	0.5153	0.2172	0.422
B-10	5.5	1.676	0.762	0.457	17.60	32.01	20.05	43	6.37	5.000	1.200	12.64	0.987	1.154	1.155	1.383	1.00	0.3562	0.1603	0.450
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Deterministic Liquefaction Triggering using Boulanger & Idriss (2008)

a_{max} = 0.5550 g
M_w = 7.09
Percentile = 85

Boring No.	Samp.Depth(ft)	Depth (m)	Thick. (m)	Water (m)	γ (kN/m^3)	Fines (%)	$(N_1)_{60}$	$(N_1)_{60,cs}$	σ_v (kPa)	σ_v' (kPa)	α	β	r_d	MSF	C_σ	K_σ	$K_{(aging)}$	CSR(site)	CRR	FS_{Liq}
B-1	8	2.438	1.219	1.219	17.75	25	11.47	16.54	43.29	31.33	-0.101	0.012	0.982	1.114	0.097	1.114	1.00	0.3943	0.1981	0.502
B-1	10.5	3.200	1.219	1.219	18.22	23	25.32	30.20	57.75	38.32	-0.146	0.017	0.973	1.114	0.165	1.160	1.00	0.4092	0.5815	1.421
B-3	8	2.438	0.762	0.610	17.75	25	11.47	16.54	43.86	25.93	-0.101	0.012	0.982	1.114	0.097	1.133	1.00	0.4750	0.1981	0.417
B-5	5.5	1.676	0.762	1.524	17.91	35	13.88	19.39	30.10	28.60	-0.060	0.007	0.991	1.114	0.106	1.135	1.00	0.2975	0.2319	0.780
B-5	8	2.438	1.372	1.524	17.91	35	16.04	21.55	43.74	34.77	-0.101	0.012	0.982	1.114	0.115	1.123	1.00	0.3562	0.2643	0.742
B-6	5.5	1.676	0.762	1.524	17.60	43	2.29	7.89	31.24	29.75	-0.060	0.007	0.991	1.114	0.066	1.081	1.00	0.3115	0.1213	0.389
B-6	8	2.438	0.762	1.524	17.75	43	11.47	17.07	44.08	35.11	-0.101	0.012	0.982	1.114	0.097	1.103	1.00	0.3619	0.2038	0.563
B-7	20.5	6.248	0.457	0.610	18.07	25	17.54	22.61	111.52	56.22	-0.360	0.041	0.930	1.114	0.122	1.072	1.00	0.5576	0.2834	0.508
B-8	8	2.438	0.762	1.676	17.60	25	6.88	11.95	44.99	37.51	-0.101	0.012	0.982	1.114	0.082	1.081	1.00	0.3527	0.1543	0.437
B-8	30.5	9.296	1.372	1.676	17.91	25	12.59	17.66	166.04	91.31	-0.618	0.069	0.881	1.114	0.102	1.011	1.00	0.5130	0.2106	0.410
B-10	5.5	1.676	0.762	0.457	17.60	43	6.88	12.48	32.01	20.05	-0.060	0.007	0.991	1.114	0.082	1.133	1.00	0.4521	0.1589	0.351
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Company: CMT Engineering	**Project:** American Fork Apartments	
Location: 900 W 200 S, American Fork, UT	**Designer:** Jeff Egbert	**Checked by:**
Project #: 13729	**Date:** 12/10/2019	**Date:**

Results of Deterministic Liquefaction Initiation and Settlement:

Boring No.	Top Samp Depth(ft)	Youd and Idriss (2001) - See Note 1			Idriss & Boulanger(2008,2012)-See Note 2			Cetin et al. (2004, 2009) - See Note 3		
		$(N_1)_{60,cs}$	$FS_{Liq.}$	∑S (in)	$(N_1)_{60,cs}$	$FS_{Liq.}$	∑S (in)	$(N_1)_{60,cs}$	$FS_{Liq.}$	∑S (in)
B-1	7.5	15.3	0.6	0.9	16.5	0.5	1.2	12.9	0.4	1.6
B-1	10	30.4	1.7	0.0	30.2	1.4	0.0	31.2	1.3	0.0
B-3	7.5	15.7	0.5	0.6	16.5	0.4	0.7	12.9	0.4	1.0
B-5	5	19.5	0.9	0.9	19.4	0.8	1.7	16.4	0.7	2.0
B-5	7.5	21.5	0.9	0.6	21.5	0.7	1.0	19.0	0.7	1.2
B-6	5	7.4	0.5	1.4	7.9	0.4	1.9	4.5	0.3	2.5
B-6	7.5	16.5	0.6	0.5	17.1	0.6	0.7	14.0	0.5	0.9
B-7	20	23.0	0.6	0.2	22.6	0.5	0.3	21.2	0.4	0.5
B-8	7.5	10.6	0.5	1.7	12.0	0.4	2.2	8.4	0.3	3.1
B-8	30	18.2	0.4	0.9	17.7	0.4	1.0	14.9	0.3	1.4
B-10	5	12.6	0.5	0.7	12.5	0.4	0.9	9.2	0.3	1.2
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
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#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

NOTES:

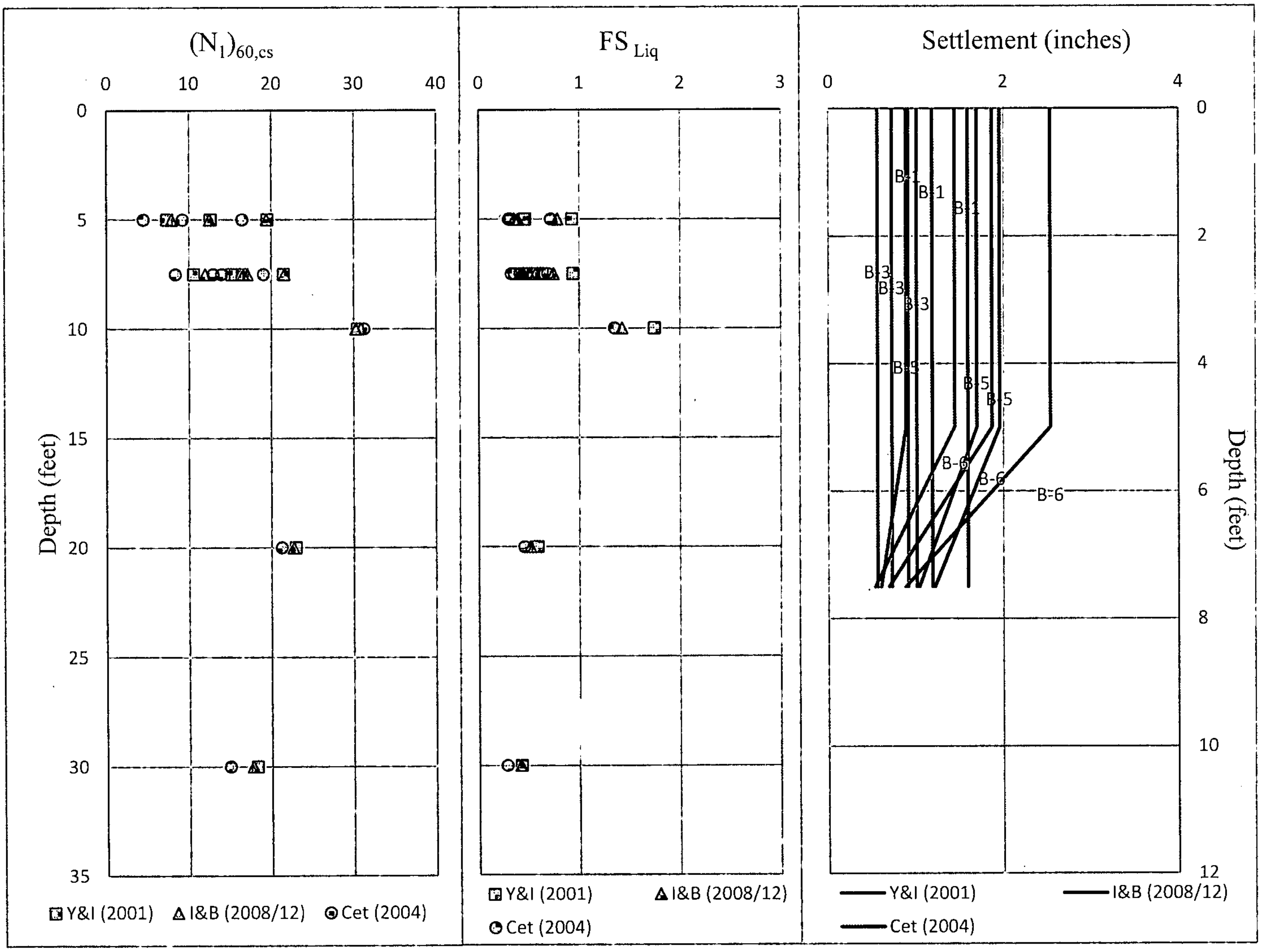
1. Youd & Idriss et al (2001); Tokimatsu & Seed (1987)
2. Idriss & Boulanger (2008, 2012); Ishihara & Yoshimine (1992)
3. Cetin et al. (2004, 2009)

American Fork Apartments

Company: CMT Engineering	**Project:** American Fork Apartments	
Location: 900 W 200 S, American Fork, UT	**Designer:** Jeff Egbert	**Checked by:**
Project #: 13729	**Date:** 12/10/2019	**Date:**

Summary of Deterministic Liquefaction Settlement and Lateral Spreading:

Boring No.	Deterministic Settlement			T_{15} (m)	F_{15} (%)	$D50_{15}$ (mm)	Lat.Spread. Dh (ft)
	Y&S(1987)	I&Y(1992)	Cetin(2009)				
B-1	0.91	1.18	1.59	0.00	25.00	0.22	0.00
B-3	0.56	0.72	1.01	0.00	25.00	0.22	0.00
B-5	0.89	1.69	1.95	0.00	35.00	0.15	0.00
B-6	1.44	1.87	2.53	0.76	43.00	0.11	0.47
B-7	0.25	0.34	0.45	0.00	0.00	0.00	0.00
B-8	1.67	2.23	3.14	0.76	25.00	0.22	0.87
B-10	0.66	0.88	1.21	0.76	43.00	0.11	0.47



CMT ENGINEERING LABORATORIES

February 21, 2020

Castlewood Development
Attn: Russell Harris
6900 South 900 East, Suite 130
Salt Lake City, Utah 84047

Re: Geotechnical Report Review Response
American Fork Apartments
American Fork, Utah
CMT Job No. 13729

Mr. Harris;

The purpose of this letter is to address review comments of the geotechnical report[1] CMT performed for the project site. The review was provided by Taylor Geotechnical (Project #20009, February 13, 2020). This letter will serve as an addendum to the referenced report.

Comment No. 2: "CMT completed a site specific liquefaction analysis based on borings that extended to a maximum depth of 31.5 feet. In accordance with Chapter 4, Procedure to Develop Real Property, section 4-2-2 Soils Investigation, sub-item 10, which states: "The report must be in accordance with the guidelines and recommendations of the "American Fork Sensitive Lands Geologic Hazards Study," Chapter 5 titled "Conclusion and Recommendations" prepared by RB&G Engineering, Inc. dated December 2006." In the RB&G document, it specifies the minimum depth of borings for liquefaction analysis is 40 feet. Therefore, TG recommends the City of American Fork request CMT to complete the subsurface investigation and accompanying liquefaction analysis in accordance with the American Fork City Sensitive Lands Ordinance.

Response: As part of a previous geotechnical investigation[2] CMT performed for the development immediately east of the project site (Meadows at American Fork) in 2016 a borehole was extended to a depth of 41.5 feet below the surface. A log of the bore hole (B-5) is attached. The hole was located in the approximate center of the adjacent site approximately 300 feet east of the east boundary of the subject site. As indicated on the B-5 log, a similar soil profile to the subsurface conditions encountered at the subject site was found, namely predominately clay layers, with interbedded layers of sand and gravel. The geotechnical report for adjacent property found similar liquefaction potential and estimated potential differential settlements.

Comment No. 3: "TG recommends the City of American Fork request CMT to provide calculations that substantiate their recommended allowable bearing capacity, estimated settlement, lateral resistance, and lateral loading recommendations. Variable used in their calculations should be substantiated."

Response: See attached data sheets. Soil strength parameters used in the calculations (friction angle of 30 degrees for native clay soils and of 34 degrees for structural fill) were based upon correlations with Bureau of Reclamation Design Standards No. 13 Embankment Dams, Table 5.

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[1] Geotechnical Engineering Study, American Fork Apartments, About 900 West 200 South, American Fork, Utah, Project No. 13729, December 11, 2019

[2] Geotechnical Engineering Study, 18 Acre Townhome Development, 6600 West 7750 North, Utah County, Utah, Project No. 8477, April 27, 2016

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 492-4132. To schedule materials testing please call (801) 381-5141.

Respectfully submitted,
CMT Engineering Laboratories

LICENSED PROFESSIONAL ENGINEER
\# 374995
JEFFREY J.
EGBERT
2/21/20
STATE OF UTAH

Jeffrey J. Egbert, P.E., LEED A.P., M. ASCE
Senior Geotechnical Engineer

18 Ac. Townhome Development

6600 W 7750 N, Utah County, Utah

Bore Hole Log

B-5

Boring Type: Hollow Stem
Surface Elev. (approx):

Total Depth: 41.5 Feet
Water Level: 6.5

Date: 4-12-2016
Job #: 8477

Depth (ft.)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N) Blows/6"	Blows (N) Total Final 12"	Moisture (%)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI	Dry Density
0		TOPSOIL: Approximately 6 inches												
		Dark brown/gray CLAY (CL) w/ roots												
3														
		moist		21			32				34	15	19	86.0
					2									
		very moist and medium stiff		22	2									
6					3	5								
		Dark brown Clayey GRAVEL (GC) w/ sand												
					5									
		wet and medium dense		23	9									
9					12	21								
					12									
		wet and dense		24	20									
					15	35								
12														
		Gray SAND (SP-SC) w/ gravel and clay												
15					6									
		moist and loose		25	4									
		Dark gray CLAY (CL)			3	7								
18														
					1									
		very moist and soft		26	1		45.1				38	25	13	
21					1	2								

Remarks: Ground water at 6.5'

CMT ENGINEERING LABORATORIES

Drilling By: Great Basin
Logged By: N. Pack

Figure:
7

18 Ac. Townhome Development

6600 W 7750 N, Utah County, Utah

Bore Hole Log

B-5

Boring Type: Hollow Stem
Surface Elev. (approx):

Total Depth: 41.5 Feet
Water Level: 6.5

Date: 4-12-2016
Job #: 8477

Depth (ft.)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)		Moisture (%)	Gradation			Atterberg			Dry Density
					Blows/6"	Total Final 12"		Gravel %	Sand %	Fines %	LL	PL	PI	
24														
		very moist and medium stiff		27	3 2 3	5								
27														
30		moist and stiff		28	2 4 6	10								
33														
36		moist and very stiff		29	3 6 12	18								
		Gray SAND (SP) w/ round gravel												
39														
		wet and dense		30	7 13 19	32								
42		End at 41.5 Feet												

Remarks: Ground water at 6.5'

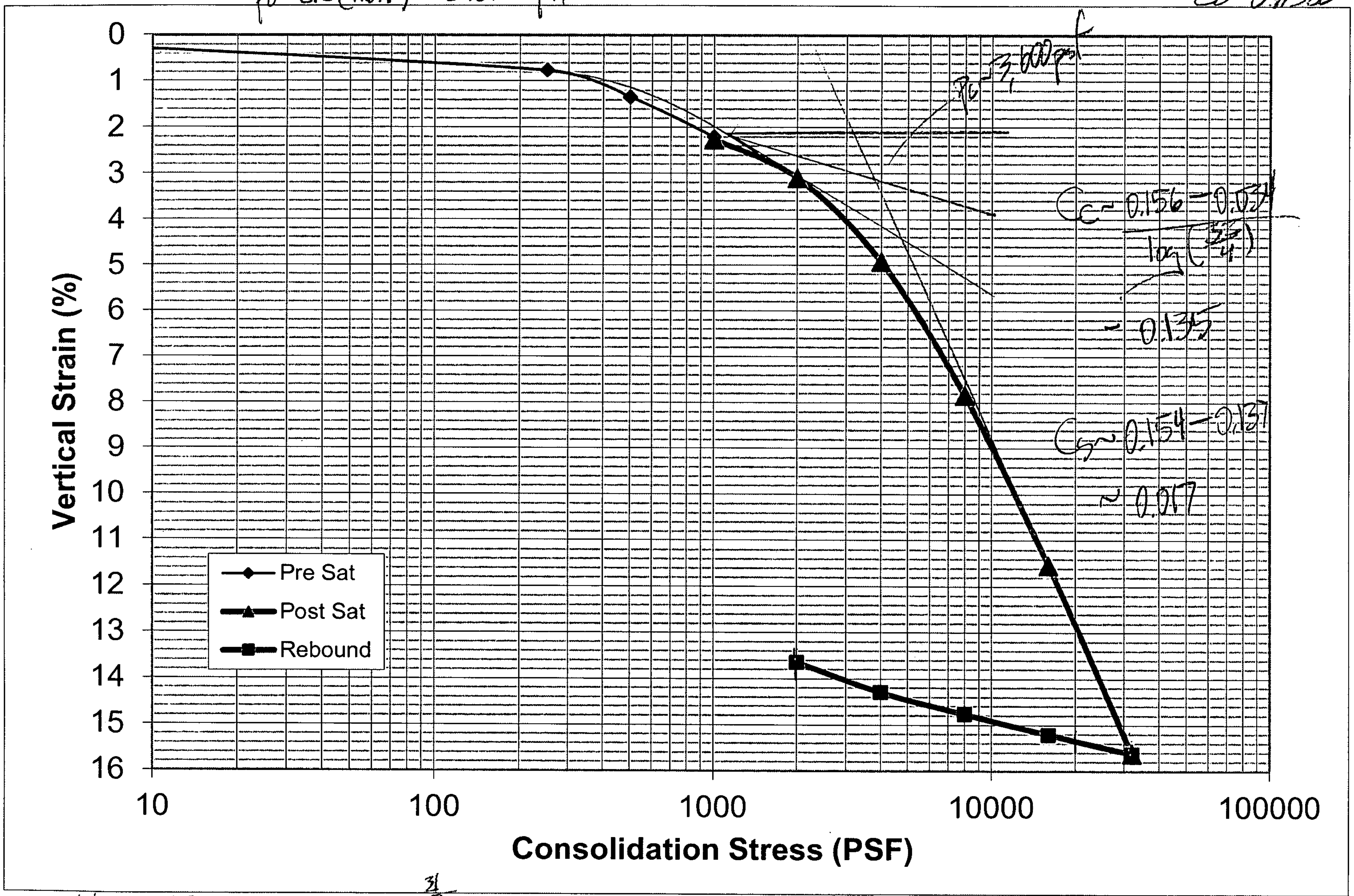
CMT ENGINEERING LABORATORIES

Drilling By: Great Basin
Logged By: N. Pack

Figure:
7

#13729 TH-3 @ 2.5'
γ = 116.9 γd = 89.2, w = 31.0
Co = 0.4530

Po ~ 2.5(116.9) = 292.25 psf



$C_c \sim \frac{0.156 - 0.034}{\log\left(\frac{32}{4}\right)}$

~ 0.135

$C_s \sim 0.154 - 0.137$

~ 0.017

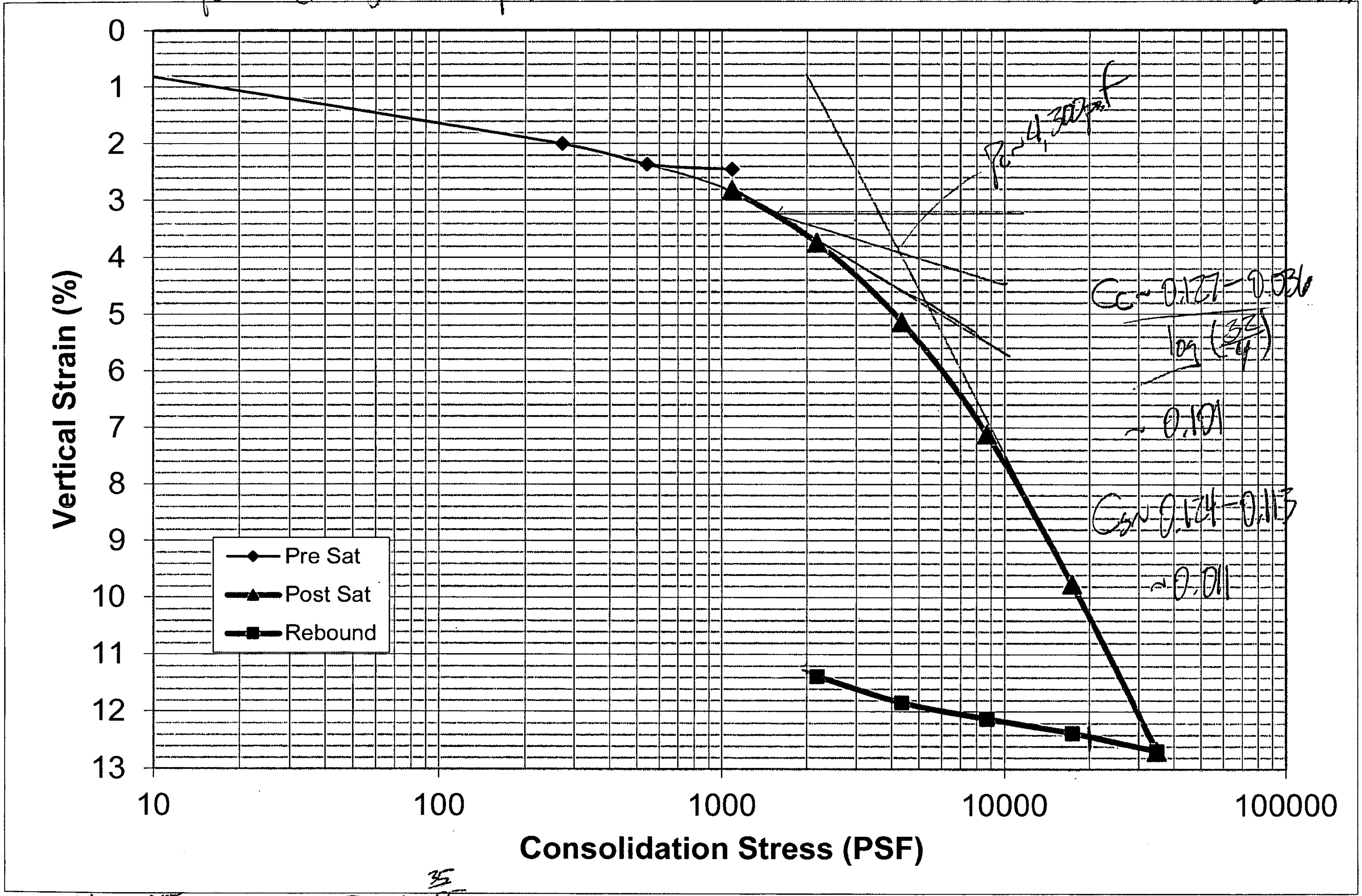
1 log ~ 55 MM

$P_c \sim 10^{\frac{31}{55}}$

~ 3.6

#13729 B6 @ 2.5'
γ = 125.3 γ_d = 100.9 w = 24.4
e_o = 0.3973

$P_o \sim 2.5(125.3) = 313.25$ psf

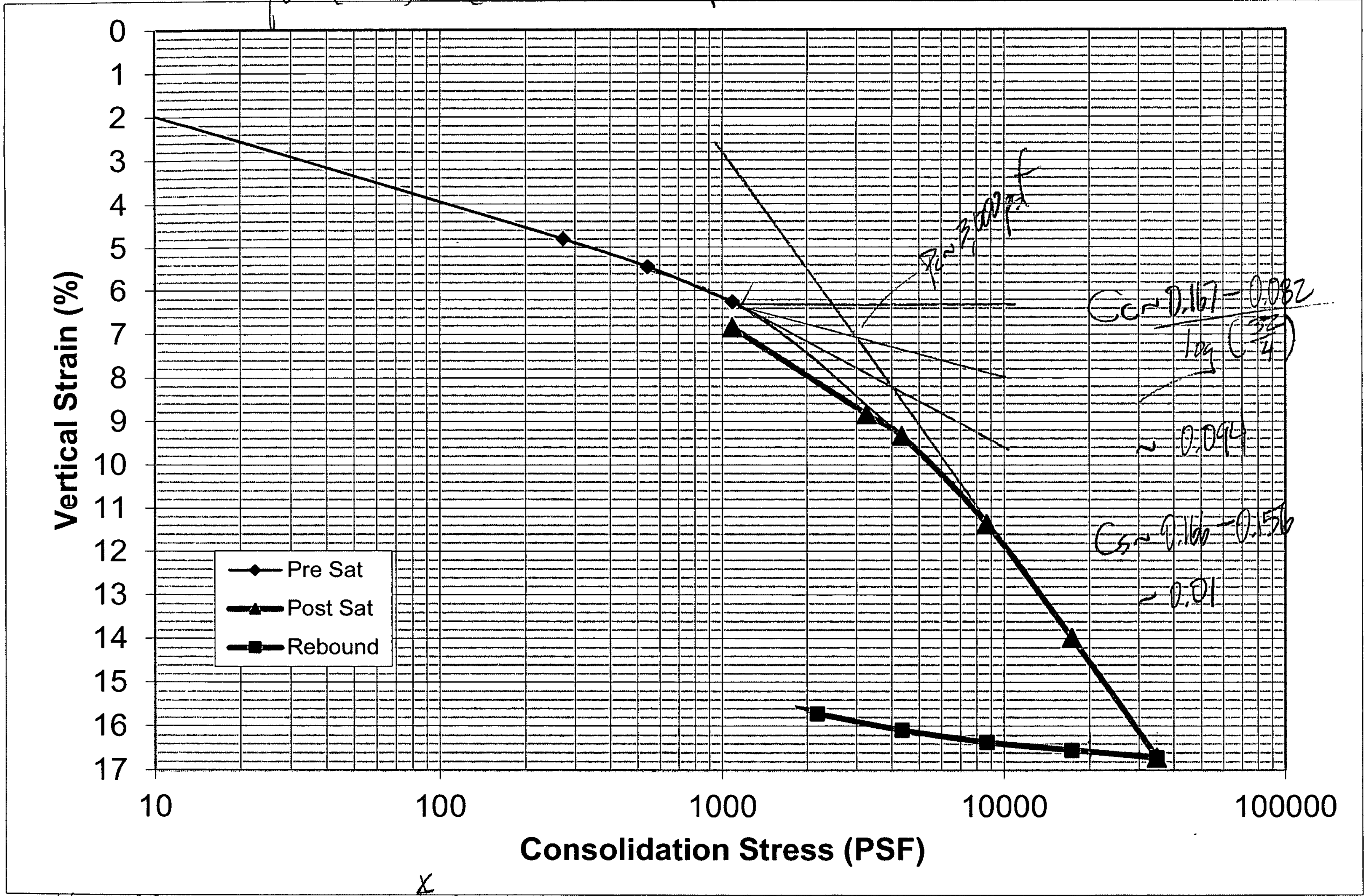


1 log ~ 55 MM

$P_c \sim 10^{\frac{35}{55}}$
~ 4.3

#13729 B-7 @ 5'
γ=122.6 γ_d=93.4, w: 31.2
e_o = 0.3986

$\sigma_o \sim 2(1226) + 3(122.6 - 62.4) = 425.8$ psf



$\sigma_c \sim 3200$ psf

$C_c \sim \frac{0.167 - 0.082}{\log\left(\frac{32}{4}\right)}$

~ 0.094

$C_s \sim 0.166 - 0.156$

~ 0.01

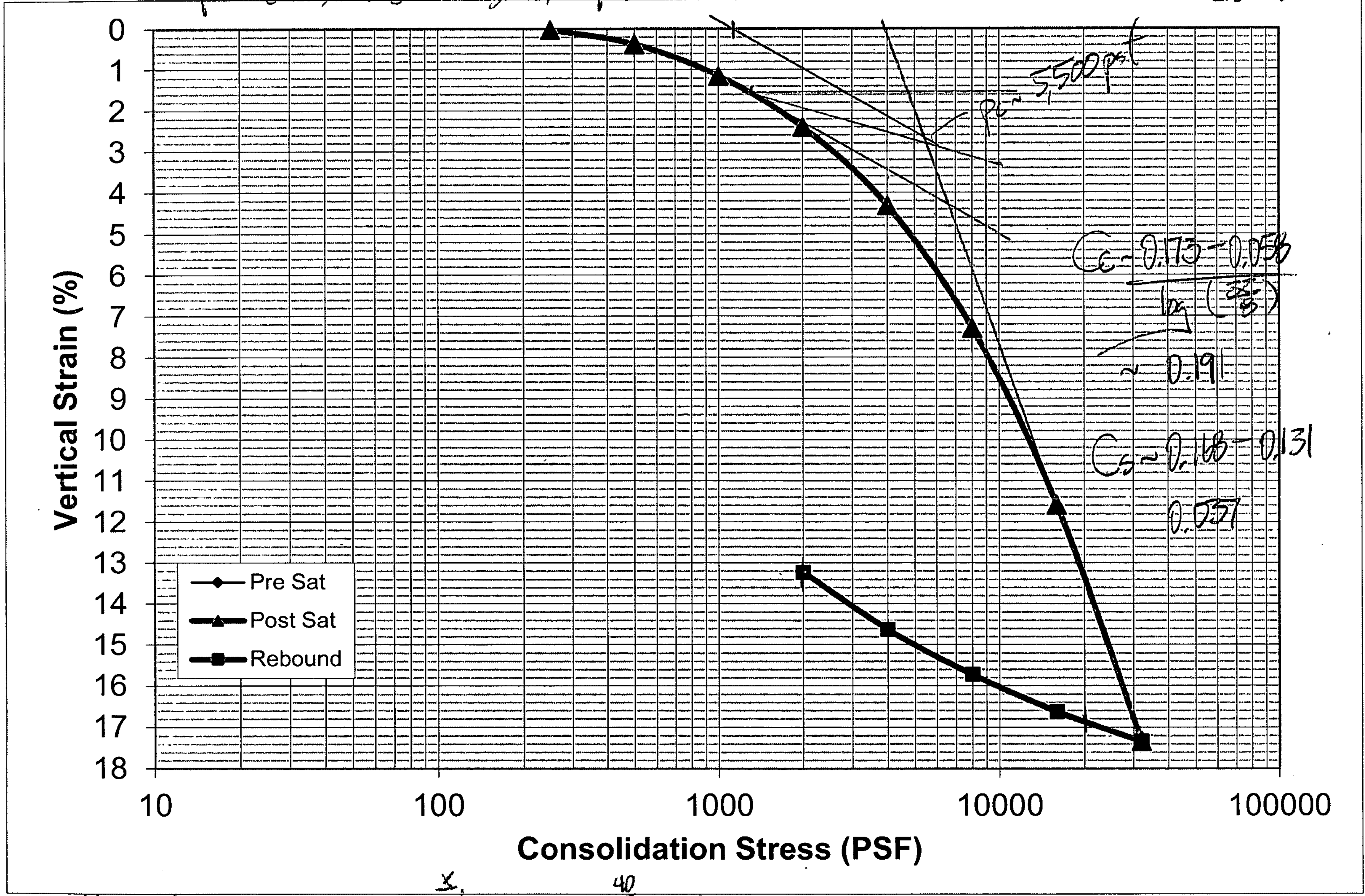
1 log ~ 55MM

$\sigma_o \sim 4.258 \approx 10^{\frac{x}{55}}$

$x = 34.6$

#13729 B-8@15'
γ: 118.6 γd = 89.3 w = 32.7
eo' = 0.39552

Po~ 5(118.6) + 10(118.6-62.4) = 1,155 psf



$$C_c \sim \frac{0.173 - 0.058}{\log\left(\frac{32}{8}\right)}$$

~ 0.191

$C_s \sim 0.188 - 0.131$

0.057

1 log ~ 54 mm

$P_o \sim 1{,}155 = 10^{\frac{x}{54}}$

$x = 3$

$P_c \sim 10^{\frac{40}{54}}$

~ 5,500 psf

CMT ENGINEERING LABORATORIES

Project #:	13729
Project Name:	AF Apartments
Address:	900 W 200 S, American Fork, UT

Footing Depth, D (ft)	2.5
Depth to Water (ft)	2.5
Bearing Capacity, P (psf)	2000

Spot Load (k)	150
Strip Load (klf)	10

	Strip	**Spread**
Footing Width, B	5	8.7
Footing Length, L	25	8.7

Soil Parameters Type	Cc	Cs	pc	e°	**Unit Weight, γ (pcf)**	**Bottom of Layer (from BOF)**
Structural Fill	---	---	---	---	---	4
CL1	0.135	0.017	3000	0.4152	116.9	5
CL2	0.094	0.01	5300	0.3496	122.6	15
CL3	0.191	0.037	7700	0.39552	118.6	25

Total Settlement Strip Footing **0.85"**

Total Settlement Spread Footing **0.81"**

Settelement (S) Calculations

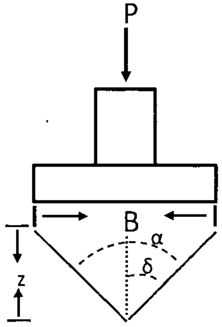
							Strip Footing			Spread Footing		
z=BBOF	Pc	Cs	Cc	e°	(Cs*H)/(1+e°)	(Cc*H)/(1+e	po+Δp	S (ft)	S (in)	po+Δp	S (ft)	S (in)
1	2000	0	0	0.720	0.00872093	0.0697674	2476.62	0.009762	0.117145	2840	0.01391	0.166925
2	2000	0	0	0.720	0.00872093	0.0697674	2059.63	0.00367	0.044041	2960	0.014659	0.175903
3	2000	0	0	0.720	0.00872093	0.0697674	1871.637	0.002083	0.02499	2436.346	0.008313	0.099762
4	2000	0	0	0.720	0.00872093	0.0697674	1811.502	0.00156	0.018718	2156.433	0.004217	0.050598
5	2000	0	0	0.720	0.00872093	0.0697674	1816.186	0.001209	0.014503	2013.591	0.001779	0.021347
6	2000	0	0	0.720	0.00872093	0.0697674	1856.745	0.000963	0.011552	1959.236	0.001166	0.013994
7	2000	0	0	0.720	0.00872093	0.0697674	1918.922	0.000784	0.009412	1960.327	0.000865	0.010382
8	2000	0	0	0.720	0.00872093	0.0697674	1995.04	0.000651	0.007811	1996.662	0.000654	0.007848
9	2000	0	0	0.720	0.00872093	0.0697674	2080.639	0.001597	0.019161	2056.024	0.001236	0.014834

Overburden Pressure Calculations

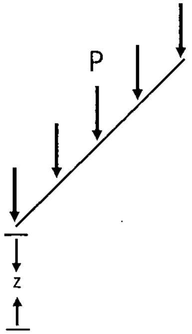
z= (Below BOF)	Soil Unit Weight (ɣ)	Below Water Table?	Effective Unit Weight (ɣ') = ɣ-ɣ$_w$ (if below WT)	Existing Effective Stress (psf) = ɣ' * z
1	116.9	y	54.5	190.75
2	116.9	y	54.5	245.25
3	122.6	y	60.2	305.45
4	122.6	y	60.2	365.65
5	122.6	y	60.2	425.85
6	122.6	y	60.2	486.05
7	122.6	y	60.2	546.25
8	122.6	y	60.2	606.45
9	122.6	y	60.2	666.65
10	122.6	y	60.2	726.85
11	122.6	y	60.2	787.05
12	122.6	y	60.2	847.25
13	122.6	y	60.2	907.45
14	122.6	y	60.2	967.65
15	122.6	y	60.2	1027.85
16	118.6	y	56.2	1084.05
17	118.6	y	56.2	1140.25
18	118.6	y	56.2	1196.45
19	118.6	y	56.2	1252.65
20	118.6	y	56.2	1308.85
21	118.6	y	56.2	1365.05
22	118.6	y	56.2	1421.25
23	118.6	y	56.2	1477.45
24	118.6	y	56.2	1533.65
25	118.6	y	56.2	1589.85
26		y	#VALUE!	#VALUE!
27		y	#VALUE!	#VALUE!
28		y	#VALUE!	#VALUE!
29		y	#VALUE!	#VALUE!
30		y	#VALUE!	#VALUE!
31		y	#VALUE!	#VALUE!
32		y	#VALUE!	#VALUE!
33		y	#VALUE!	#VALUE!
34		y	#VALUE!	#VALUE!
35		y	#VALUE!	#VALUE!
36		y	#VALUE!	#VALUE!
37		y	#VALUE!	#VALUE!
38		y	#VALUE!	#VALUE!
39		y	#VALUE!	#VALUE!
40		y	#VALUE!	#VALUE!

Strip Footing Stress Increase Calculations

$$\Delta p = \frac{P}{\pi}[\alpha + (\sin \alpha) * \cos(\alpha + 2(-\delta))]$$



$$\Delta p = \frac{2Pz^2}{\pi(z^2)^2}$$



$$\Delta p = P\frac{B+z}{B}$$

Boussinesq's Solution for Stress Increase Below Center of a Strip Footing						Stress Below a Line Load		2:1 Method Stress Increase		Average
Depth, z	δ (radians)	2δ=α	sin(α)	cos(α+2(-δ))	**Δp=**	z=	**Δp =**	z=	**Δp =**	
1	1.19028995	2.38058	0.6897	1	1955	1	1273	1	1603	1610
2	0.89605538	1.792111	0.9756	1	1762	2	637	2	1323	1240
3	0.69473828	1.389477	0.9836	1	1511	3	424	3	1116	1017
4	0.55859932	1.117199	0.8989	1	1283	4	318	4	958	853
5	0.46364761	0.927295	0.8	1	1100	5	255	5	833	729
6	0.39479112	0.789582	0.7101	1	955	6	212	6	733	633
7	0.34302394	0.686048	0.6335	1	840	7	182	7	651	558
8	0.30288487	0.60577	0.5694	1	748	8	159	8	583	497
9	0.27094685	0.541894	0.5158	1	673	9	141	9	525	447
10	0.24497866	0.489957	0.4706	1	612	10	127	10	476	405
11	0.2234766	0.446953	0.4322	1	560	11	116	11	434	370
12	0.20539539	0.410791	0.3993	1	516	12	106	12	397	340
13	0.18998829	0.379977	0.3709	1	478	13	98	13	365	314
14	0.17670886	0.353418	0.3461	1	445	14	91	14	337	291
15	0.16514868	0.330297	0.3243	1	417	15	85	15	313	271
16	0.15499674	0.309993	0.3051	1	392	16	80	16	290	254
17	0.14601226	0.292025	0.2879	1	369	17	75	17	271	238
18	0.13800602	0.276012	0.2725	1	349	18	71	18	253	224
19	0.1308274	0.261655	0.2587	1	331	19	67	19	237	212
20	0.12435499	0.24871	0.2462	1	315	20	64	20	222	200
21	0.11848996	0.23698	0.2348	1	300	21	61	21	209	190
22	0.11315098	0.226302	0.2244	1	287	22	58	22	197	181
23	0.10827059	0.216541	0.2149	1	275	23	55	23	186	172
24	0.10379234	0.207585	0.2061	1	263	24	53	24	176	164
25	0.09966865	0.199337	0.198	1	253	25	51	25	167	157
26	0.09585915	0.191718	0.1905	1	243	26	49	26	158	150
27	0.09232933	0.184659	0.1836	1	234	27	47	27	150	144
28	0.08904958	0.178099	0.1772	1	226	28	45	28	143	138
29	0.08599429	0.171989	0.1711	1	218	29	44	29	136	133
30	0.08314123	0.166282	0.1655	1	211	30	42	30	130	128
31	0.08047101	0.160942	0.1602	1	204	31	41	31	124	123
32	0.07796663	0.155933	0.1553	1	198	32	40	32	119	119
33	0.07561314	0.151226	0.1507	1	192	33	39	33	113	115
34	0.07339733	0.146795	0.1463	1	187	34	37	34	109	111
35	0.07130746	0.142615	0.1421	1	181	35	36	35	104	107
36	0.06933313	0.138666	0.1382	1	176	36	35	36	100	104
37	0.06746502	0.13493	0.1345	1	172	37	34	37	96	101
38	0.0656948	0.13139	0.131	1	167	38	34	38	92	98
39	0.06401498	0.12803	0.1277	1	163	39	33	39	89	95
40	0.06241881	0.124838	0.1245	1	159	40	32	40	85	92
41	0.06090021	0.1218	0.1215	1	155	41	31	41	82	89
42	0.05945366	0.118907	0.1186	1	151	42	30	42	79	87
43	0.05807416	0.116148	0.1159	1	148	43	30	43	77	85
44	0.05675716	0.113514	0.1133	1	144	44	29	44	74	82
45	0.05549851	0.110997	0.1108	1	141	45	28	45	71	80
46	0.05429441	0.108589	0.1084	1	138	46	28	46	69	78
47	0.05314141	0.106283	0.1061	1	135	47	27	47	67	76
48	0.05203631	0.104073	0.1039	1	132	48	27	48	65	75
49	0.05097621	0.101952	0.1018	1	130	49	26	49	63	73
50	0.0499584	0.099917	0.0998	1	127	50	25	50	61	71

Spread Footing Stress Increase Calculations
Boussinesq's Solution Rectangular Footing

$m_1 = \frac{L}{B} = 1$

$m_1^2 = 1$

$\frac{2}{\pi} = 0.636619772$

$$\Delta p = P * \frac{2}{\pi}\left[\frac{m_1 * n_1}{\sqrt{1 + m_1^2 + n_1^2}} * \frac{1 + m_1^2 + 2n_1^2}{(1 + n_1^2) * (m_1^2 + n_1^2)}\right] + \sin^{-1}\left(\frac{m_1}{\sqrt{m_1^2 + n_1^2} * \sqrt{1 + n_1^2}}\right)$$

Depth, z	$b = \frac{B}{2}$	$n_1 = \frac{z}{b}$	n_1^2	$\frac{m_1 * n_1}{\sqrt{1 + m_1^2 + n_1^2}}$	$\frac{1 + m_1^2 + 2n_1^2}{(1 + n_1^2) * (m_1^2 + n_1^2)}$	$\sin^{-1}\left(\frac{m_1}{\sqrt{m_1^2 + n_1^2} * \sqrt{1 + n_1^2}}\right)$	$\frac{2}{\pi}\left[\frac{m_1 * n_1}{\sqrt{1 + m_1^2 + n_1^2}} * \frac{1 + m_1^2 + 2n_1^2}{(1 + n_1^2) * (m_1^2 + n_1^2)}\right] + \sin^{-1}\left(\frac{m_1}{\sqrt{m_1^2 + n_1^2} * \sqrt{1 + n_1^2}}\right)$	Δp=
1	4.330127	0.23094	0.053333	0.161164593	1.898734177	1.251215169	1	2000
2	4.330127	0.46188	0.213333	0.31046021	1.648351648	0.968745373	1	2000
3	4.330127	0.69282	0.48	0.439941345	1.351351351	0.741880862	1.120361077	2240.722
4	4.330127	0.92376	0.853333	0.546868742	1.079136691	0.569924336	0.945623027	1891.246
5	4.330127	1.154701	1.333333	0.632455532	0.857142857	0.442911044	0.788025641	1576.051
6	4.330127	1.385641	1.92	0.699854212	0.684931507	0.3495401	0.654705188	1309.41
7	4.330127	1.616581	2.613333	0.752644663	0.553505535	0.280413236	0.545624568	1091.249
8	4.330127	1.847521	3.413333	0.794066667	0.453172205	0.228571186	0.457658138	915.3163
9	4.330127	2.078461	4.32	0.826767382	0.37593985	0.189094818	0.386965668	773.9313
10	4.330127	2.309401	5.333333	0.852802865	0.315789474	0.158558281	0.330003912	660.0078
11	4.330127	2.540341	6.453333	0.873731618	0.268336315	0.134573982	0.283831985	567.664
12	4.330127	2.771281	7.68	0.890723543	0.230414747	0.11546376	0.246120954	492.2419
13	4.330127	3.002221	9.013333	0.904655701	0.199733688	0.100033595	0.215064562	430.1291
14	4.330127	3.233162	10.45333	0.916187987	0.174621653	0.08742214	0.189272557	378.5451
15	4.330127	3.464102	12	0.9258201	0.153846154	0.076999141	0.167675353	335.3507
16	4.330127	3.695042	13.65333	0.933933449	0.136487716	0.068296941	0.149447145	298.8943
17	4.330127	3.925982	15.41333	0.940821706	0.121852153	0.060963832	0.133946655	267.8933
18	4.330127	4.156922	17.28	0.946713029	0.10940919	0.054731917	0.120672424	241.3448
19	4.330127	4.387862	19.25333	0.951786275	0.098749177	0.049394672	0.109229362	218.4587
20	4.330127	4.618802	21.33333	0.956182887	0.089552239	0.044791095	0.099303775	198.6076
21	4.330127	4.849742	23.52	0.960015674	0.081566069	0.040794348	0.090644671	181.2893
22	4.330127	5.080682	25.81333	0.963375338	0.074589756	0.037303529	0.083049709	166.0994
23	4.330127	5.311622	28.21333	0.966335377	0.06846189	0.034237633	0.07635458	152.7092
24	4.330127	5.542563	30.72	0.968955781	0.063051702	0.031531076	0.070424922	140.8498
25	4.330127	5.773503	33.33333	0.971285862	0.058252427	0.029130333	0.065150127	130.3003
26	4.330127	6.004443	36.05333	0.973366419	0.05397625	0.026991402	0.060438558	120.8771
27	4.330127	6.235383	38.88	0.975231419	0.050150451	0.025077854	0.056213842	112.4277
28	4.330127	6.466323	41.81333	0.976909308	0.046714419	0.023359334	0.052411955	104.8239
29	4.330127	6.697263	44.85333	0.97842404	0.043617331	0.021810394	0.048978936	97.95787
30	4.330127	6.928203	48	0.979795897	0.040816327	0.02040958	0.045869068	91.73814
31	4.330127	7.159143	51.25333	0.981042132	0.03827507	0.019138703	0.04304343	86.08686
32	4.330127	7.390083	54.61333	0.982177496	0.035962599	0.017982269	0.040468733	80.93747
33	4.330127	7.621024	58.08	0.983214652	0.033852404	0.01692701	0.038116377	76.23275
34	4.330127	7.851964	61.65333	0.984164522	0.031921685	0.01596152	0.035961688	71.92338
35	4.330127	8.082904	65.33333	0.985036563	0.030150754	0.015075948	0.033983297	67.96659
36	4.330127	8.313844	69.12	0.98583899	0.028522533	0.01426175	0.032162622	64.32524
37	4.330127	8.544784	73.01333	0.986578975	0.027022158	0.01351149	0.030483451	60.9669
38	4.330127	8.775724	77.01333	0.98726279	0.025636643	0.012818673	0.028931585	57.86317
39	4.330127	9.006664	81.12	0.987895947	0.024354603	0.012177602	0.027494556	54.98911

Settelement (S) Calculations

							Strip Footing			Spread Footing		
z=BBOF	Pc	Cs	Cc	e°	(Cs*H)/(1+e°)	(Cc*H)/(1+e°)	po+Δp	S (ft)	S (in)	po+Δp	S (ft)	S (in)
1	3000	0.017	0.135	0.4152	0.012012436	0.095392877	2145	0.012625407	0	2191	0.012735	0
2	3000	0.017	0.135	0.4152	0.012012436	0.095392877	2007	0.010967226	0.131606716	2245	0.011552	0.138622
3	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1816	0.005736692	0.068840302	2546	0.006824	0.081886
4	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1649	0.00484727	0.058167238	2257	0.005857	0.070283
5	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1525	0.004106031	0.049272372	2002	0.004981	0.059768
6	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1441	0.003496652	0.041959819	1795	0.004205	0.050459
7	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1386	0.002996908	0.035962896	1637	0.003533	0.042394
8	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1355	0.00258603	0.031032364	1522	0.002961	0.035526
9	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1340	0.002246578	0.026958931	1441	0.00248	0.029755
10	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1338	0.001964476	0.02357371	1387	0.002079	0.024948
11	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1347	0.001728544	0.020742534	1355	0.001748	0.02097
12	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1363	0.001529947	0.018359364	1339	0.001474	0.017688
13	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1385	0.0013617	0.016340403	1338	0.001248	0.014982
14	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1413	0.001218272	0.014619262	1346	0.001062	0.01275
15	5300	0.01	0.094	0.3496	0.007409603	0.069650267	1445	0.001095261	0.01314313	1363	0.000909	0.010904
16	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1476	0.003550662	0.042607942	1383	0.002804	0.033647
17	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1509	0.003229722	0.038756666	1408	0.00243	0.029158
18	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1546	0.002948783	0.035385397	1438	0.002116	0.02539
19	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1584	0.002701701	0.03242041	1471	0.001851	0.022212
20	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1624	0.002483426	0.029801107	1507	0.001627	0.019521
21	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1665	0.002289784	0.027477412	1546	0.001436	0.01723
22	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1708	0.002117311	0.025407727	1587	0.001273	0.015272
23	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1752	0.00196311	0.023557315	1630	0.001133	0.013591
24	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1797	0.001824752	0.021897029	1674	0.001012	0.012141
25	7700	0.037	0.191	0.39552	0.026513414	0.136866544	1843	0.001700191	0.020402289	1720	0.000907	0.010884
26					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
27					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
28					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
29					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
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31					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
32					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
33					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
34					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
35					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
36					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
37					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
38					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
39					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
40					#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
									0.85			0.81

Meyerhof (1963) General Bearing Capacity Equation

$$q_{all} = (cN_cF_{cs}F_{cd}F_{ci} + qN_qF_{qs}F_{qd}F_{qi} + 0.5\gamma BN_\gamma F_{\gamma s}F_{\gamma d}F_{\gamma i})/FS$$

where: c = cohesion
q = effective stress at the level of the bottom of the foundation
γ = unit weight of soil
B = width of foundation (= diameter for circular foundation)
Fcs, Fqs, Fγs = shape factors
Fcd, Fqd, Fγd = depth factors
Fci, Fqi, Fγi = load inclination factors
Nc, Nq, Nγ = bearing capacity factors

Friction Angle, ϕ = 30 degrees
Cohesion, c = 0 psf
Effective Unit Weight, γ = 125 pcf
Longest Wall Footing Length, L = 25 ft
Load Inclination (from veritcal), β = 0 degrees
Factor of Safety, FS = 3

Nq = 18.40 $= e^{\pi \tan \emptyset} tan^2\left(45 + \frac{\emptyset}{2}\right)$
Nc = 30.14 $= \left(N_q - 1\right)\cot \emptyset$
Nγ = 22.40 $= 2\left(N_q + 1\right)\tan \emptyset$

Summary Tables

Wall Footing Allowable Bearing Capacity, q_{all} (ksf)

Footing Depth, D (ft)	Structural Fill Depth, z (ft)	Footing Width, B (ft)								
		1.67	2	2.5	3	3.5	4	4.5	5	5.5
2.5	0	3.01	2.98	3.06	2.99	2.94	2.91	2.89	2.88	2.87
4	0	4.72	4.69	4.64	4.60	4.57	4.75	4.69	4.64	4.61
6	0	7.02	7.00	6.97	6.94	6.91	6.89	6.87	6.86	6.85
8	0	9.33	9.32	9.31	9.30	9.29	9.28	9.27	9.27	9.27
2.5	1.5	5.71	5.21	4.90	4.48	4.20	4.00	3.85	3.74	3.65
4	1.5	8.96	8.20	7.42	6.90	6.53	6.54	6.25	6.03	5.86
6	1.5	13.33	12.25	11.15	10.40	9.87	9.47	9.16	8.92	8.72
8	1.5	17.72	16.32	14.90	13.95	13.27	12.76	12.36	12.05	11.80

Square Footing Allowable Bearing Capacity, q_{all} (ksf)

Footing Depth, D (ft)	Structural Fill Depth, z (ft)	Footing Width, B (ft)								
		2.5	3	3.5	4	4.5	5	5.5	6	6.5
2.5	0	4.18	4.03	3.93	3.85	3.79	3.74	3.70	3.67	3.64
4	0	6.53	6.41	6.31	6.51	6.36	6.23	6.13	6.05	5.98
6	0	10.00	9.86	9.72	9.59	9.48	9.37	9.27	9.63	9.47
8	0	13.50	13.34	13.19	13.05	12.91	12.78	12.66	12.54	12.44
2.5	1.5	10.69	9.07	8.01	7.28	6.73	6.32	5.99	5.73	5.51
4	1.5	16.72	14.43	12.87	12.32	11.30	10.54	9.93	9.45	9.05
6	1.5	25.60	22.17	19.84	18.14	16.85	15.84	15.02	15.05	14.34
8	1.5	34.55	30.02	26.92	24.67	22.95	21.60	20.51	19.60	18.84

Summary Tables of Shape, Depth, and Inclination Factors

Wall Footings

Fotting Width, B =	1.67	2	2.5	3	3.5	4	4.5	5	5.5
Fcs =	1.04	1.05	1.06	1.07	1.09	1.10	1.11	1.12	1.13
Fqs =	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.12	1.13
F γs =	0.97	0.97	0.96	0.95	0.94	0.94	0.93	0.92	0.91
Footing Depth, Df =	2.5								
Fcd =	1.39	1.36	1.40	1.33	1.29	1.25	1.22	1.20	1.18
Fqd =	1.28	1.26	1.29	1.24	1.21	1.18	1.16	1.14	1.13
F γd =	1	1	1	1	1	1	1	1	1
Footing Depth, Df =	4								
Fcd =	1.47	1.44	1.40	1.37	1.34	1.40	1.36	1.32	1.29
Fqd =	1.34	1.32	1.29	1.27	1.25	1.29	1.26	1.23	1.21
F γd =	1	1	1	1	1	1	1	1	1
Footing Depth, Df =	6								
Fcd =	1.52	1.50	1.47	1.44	1.42	1.39	1.37	1.35	1.33
Fqd =	1.38	1.36	1.34	1.32	1.30	1.28	1.27	1.25	1.24
F γd =	1	1	1	1	1	1	1	1	1
Footing Depth, Df =	8								
Fcd =	1.55	1.53	1.51	1.48	1.46	1.44	1.42	1.40	1.39
Fqd =	1.39	1.38	1.37	1.35	1.33	1.32	1.31	1.29	1.28
F γd =	1	1	1	1	1	1	1	1	1

Column Footings

Fotting Width, B =	2.5	3	3.5	4	4.5	5	5.5	6	6.5
Fcs =	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
Fqs =	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58
F γs =	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Footing Depth, Df =	2.5								
Fcd =	1.40	1.33	1.29	1.25	1.22	1.20	1.18	1.17	1.15
Fqd =	1.29	1.24	1.21	1.18	1.16	1.14	1.13	1.12	1.11
F γd =	1	1	1	1	1	1	1	1	1
Footing Depth, Df =	4								
Fcd =	1.40	1.37	1.34	1.40	1.36	1.32	1.29	1.27	1.25
Fqd =	1.29	1.27	1.25	1.29	1.26	1.23	1.21	1.19	1.18
F γd =	1	1	1	1	1	1	1	1	1
Footing Depth, Df =	6								
Fcd =	1.47	1.44	1.42	1.39	1.37	1.35	1.33	1.40	1.37
Fqd =	1.34	1.32	1.30	1.28	1.27	1.25	1.24	1.29	1.27
F γd =	1	1	1	1	1	1	1	1	1
Footing Depth, Df =	8								
Fcd =	1.51	1.48	1.46	1.44	1.42	1.40	1.39	1.37	1.36
Fqd =	1.37	1.35	1.33	1.32	1.31	1.29	1.28	1.27	1.26
F γd =	1	1	1	1	1	1	1	1	1

All Footings

Fci = Fqi =	1
F γi =	1

Lateral Earth Pressure Coefficients
Project: American Fork Apartments
Job No. 13729

CMT ENGINEERING LABORATORIES

Soil Unit Weight	135	γ, pcf
Soil Friction Angle	34	Ø, degrees
Soil Cohesion	0	psf
Friction Between Wall and Soil	17	(δ, Typically 0.5Ø)
Backfill Slope Angle	0	α, degrees
Wall Back Incline	90	β, degrees
Surcharge Load		psf
Height of the Wall		ft
Earthquake Acceleration, k_h	0.25	%, 2/3 MCE
Earthquake Acceleration, k_v	0	
	14.04	$\Theta' = tan^{-1}\left[\frac{k_h}{1-k_v}\right]$

At Rest Coefficient, Ko		Ko	Equivalent Fluid, psf $(K_o * \gamma)$	Pa
Jaky, 1944	$(1 - sin\,\phi)$	0.44	60	
Brooker and Ireland, 1965	$(0.95 - sin\,\phi)$	0.39	53	

Active Coefficient, Ka		Ka	Equivalent Fluid, psf $(K_a * \gamma)$	
Rankine (level backfill)	$tan^2\left(45 - \frac{\phi}{2}\right)$	0.28	38	
Rankine (inclined backfill)	$cos\,\alpha \frac{cos\,\alpha - \sqrt{cos^2\alpha - cos^2\phi}}{cos\,\alpha + \sqrt{cos^2\alpha - cos^2\phi}}$	0.28	38	
Coulomb Static	$\frac{sin^2(\beta+\phi)}{sin^2\beta\,sin(\beta-\alpha)\left[1+\sqrt{\frac{sin(\phi+\delta)\,sin(\phi-\alpha)}{sin(\beta-\delta)\,sin(\alpha+\beta)}}\right]^2}$	0.26	35	0
Mononabe-Okabe, Seismic, Das Text	$\frac{sin^2(\phi+\beta-\Theta')}{cos\Theta' sin^2\beta sin(\beta-\Theta'-\delta)\left[1+\sqrt{\frac{sin(\phi+\delta)\,sin(\phi-\Theta'-\alpha)}{sin(\beta-\delta-\Theta')sin(\alpha+\beta)}}\right]^2}$	0.44	59	
Mononabe-Okabe, Seismic, SEA Paper	$\frac{cos^2(\phi-\Theta'-\beta)}{cos\Theta' cos^2\beta sin(\delta+\beta+\Theta')\left[1+\sqrt{\frac{sin(\phi+\delta)\,sin(\phi-\Theta'-\alpha)}{sin(\delta+\beta+\Theta')sin(\alpha-\beta)}}\right]^2}$	0.50	67	

Passive Coefficients, Kp		Kp	Equivalent Fluid, psf $(K_p * \gamma)$	
Rankine (level backfill)	$tan^2\left(45 + \frac{\phi}{2}\right)$	3.54	478	
Rankine (inclined backfill)	$cos\,\alpha \frac{cos\,\alpha + \sqrt{cos^2\alpha - cos^2\phi}}{cos\,\alpha - \sqrt{cos^2\alpha - cos^2\phi}}$	3.54	478	
Coulomb	$\frac{sin^2(\beta+\phi)}{sin^2\beta\,sin(\beta-\alpha)\left[1+\sqrt{\frac{sin(\phi+\delta)\,sin(\phi-\alpha)}{sin(\beta-\delta)\,sin(\alpha+\beta)}}\right]^2}$	6.77	914	0

Ultimate Coefficient of Friction	0.67
Allowable Coefficient of Friction	0.45

Table 5. Stress-Strain and Strength Parameters for Soils Tested under Drained Conditions

Soil	Group	Soil Description	References	Grain Size (mm)			LL	PI	Compaction					Init. Void Ratio	Relative Density	Degree of Saturation	Rating	Particle Shape	Stress Range (TSF)	Number of Tests	C (TSF)	Friction Angle	K	n	R_f	K_b	m
				D_{60}	D_{30}	D_{10}			Type	Max. Dry Unit Wt. (pcf)	Opt. w/c	Dry Unit Wt. (pcf)	w/c														
GW	GW-1	Conglomerate Rockfill (Netzahu. Dam)	Marsal et al (38)	47.	7.5	0.9						118.9		0.380	70		**	Sub-angular	1.9- 25.5	3	0.00	50 (10)	540	0.43	0.64	135	-0.34
GW	GW-2	Granitic Gneiss Rockfill (Mica Dam)	Casagrande (10) / Marsal (39)	78.	24.	4.						123.7		0.320	95		**	Sub-angular	5.1- 25.6	3	0.00	44 (9)	210	0.51	0.64	100	-0.34
GW	GW-3	Quartzite Rockfill (Furnas Dam Shell)	Casagrande (10)	10.	-	-											***	Sub-rounded	4.1- 36.9	4	0.00	49 (6)	560	0.48	0.65	330	-0.33
GW	GW-4	Quartzite Rockfill (Furnas Dam Transit.)	Casagrande (10)	25.													***	Sub-rounded	4.1- 36.9	4	0.00	53 (7)	950	0.52	0.59	470	0.62
GW	GW-5	Furnas Dam Transition	Casagrande (10)	10.													***	Sub-rounded	4.1- 36.9	4	0.00	50 (7)	890	0.57	0.51	360	0.57
GW	GW-6	Pinzandapan Gravel	Marsal et al (38)	21.	2.7	0.25						132.1		0.340	65		**	Sub-rounded	0.4- 26.5	6	0.00	51 (9)	690	0.45	0.59	170	0.22
GW	GW-7	Diorite Rockfill (El Infiernillo Dam)	Marsal et al (38)	93.	42.	17.						105.7		0.560	50		**	Angular	0.4- 17.0	7	0.00	46 (9)	340	0.28	0.71	52	0.18
GP	GP-2	Sandy Gravel (Mica Dam Shell)	Casagrande (10)	22.	1.2	0.23									50		**	Sub-angular	7.2- 32.5	3	0.00	41 (3)	420	0.50	0.78	125	0.46
GP	GP-3	Basalt Rockfill	Casagrande (10) / Marsal (39)	19.	3.6	1.						133.8		0.300	95		***	Angular	5.1- 25.6	3	0.00	52 (10)	450	0.37	0.61	265	0.18
GP	GP-6	Silty Sandy Gravel (Oroville Dam)	Hall & Gordon (25)	18.	4.8	0.4	21	3				148.0		0.210	100		***	Rounded	9.0- 46.8	4	0.00	53 (8)	1300	0.40	0.72	900	0.22
GP	GP-7	Amphibolite Gravel (Oroville Dam Shell)	Marachi (37)	13.2	4.6	0.38						152.0		0.200	100		***	Rounded	2.2- 28.6	4	0.00	51 (6)	1780	0.39	0.67	1300	0.16
GP	GP-11	Crushed Basaltic Rock (Round Butte Dam)	Shannon & Wilson (41)	15.	12.	6.				91.6		99.0	3.20		99		**	Angular	2.0- 14.1	3	0.00	51 (14)	410	0.21	0.71	195	0.00
GP	GP-13	Sandy Gravel (Rowallan Dam)	Boughton (5)	10.	3.	0.8						135.0		0.233	100		***	Rounded	1.8- 10.8	4	0.00	58 (10)	2500	0.21	0.75	1400	0.00
GC	GC-1	Clay Gravel (New Hogan Dam Core)	Bird (3)	12.	0.6	-	51	30		113.0	10.8	107.0	10.80			51	**		1.1- 4.3	3	0.28	19	99	0.70	0.88	45	0.00
SW	SW-1	Argillite Rockfill (Pyramid Dam Shell)	Marachi (37)	4.1	1.8	0.6						111.8		0.460	100		*	Angular	2.2- 46.8	4	0.00	53 (9)	1600	0.08	0.72	800	0.00
SW	SW-2	Crushed Olivine Basalt	Marachi (37)	4.1	1.8	0.6						125.4		0.430	100		*	Angular	2.2- 46.8	4	0.00	56 (10)	1000	0.22	0.70	390	0.14
SW	SW-3	Silty Sand, Some Gravel (Round Butte Dam)	Shannon & Wilson (41)	1.7	0.09	0.009	NP	NP	16,450	120.0	13.2	108.7	13.50				*	Sub-rounded	2.0- 14.0	3	0.00	38 (3)	260	0.50	0.76	100	0.50
SW	SW-6	Venato Sandstone (0.5 in. max. size)	Becker, Chan & Seed (2)	0.17	0.07	0.025	NP	NP		118.3		117.5		0.470	93		**	Angular	2.2- 28.6	4	0.00	43 (4)	330	0.46	0.61	110	0.46
SP	SP-3	Glacial Outwash Sand	Hirschfeld & Poulos (26)	0.03	0.4	0.14						112.3		0.500	80		***	Sub-rounded	1.0- 41.1	6	0.00	44 (4)	190	0.70	0.57	190	0.35
SP	SP-4A	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						89.5		0.870	38		*	Rounded	1.0- 41.1	8	0.00	35 (2)	430	0.27	0.84	230	0.02
SP	SP-4B	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						94.0		0.780	60		*	Rounded	1.0- 13.0	4	0.00	37 (2)	410	0.69	0.90	260	0.15
SP	SP-4C	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						97.8		0.710	78		*	Rounded	1.0- 41.1	8	0.00	41 (5)	1100	0.38	0.85	900	0.00
SP	SP-4D	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						103.9		0.810	100		*	Rounded	3.0- 41.1	8	0.00	45 (7)	1200	0.48	0.85	1500	0.00
SP	SP-5A	Ham River Sand	Bishop (4)	0.25	0.17	0.15								0.820	Loose		**	Rounded	7.2-287.9	4	0.00	31 (2)	890	0.26	0.78	360	0.11
SP	SP-5B	Ham River Sand	Bishop (4)	0.25	0.17	0.15								0.840	Dense		**	Rounded	7.2- 71.3	3	0.00	47 (9)	1100	0.57	0.88	2250	0.00
SP	SP-7A	Poorly Graded Sand (Port Allen Lock)	Sherman & Trahan (44)	0.2	0.17	0.12	NP	NP		100.0	13.0	95.5		0.730	49		***	Rounded	0.9- 3.9	3	0.00	39 (0)	410	0.65	0.84		
SP	SP-7B	Poorly Graded Sand (Port Allen Lock)	Sherman & Trahan (44)	0.2	0.17	0.12	NP	NP		100.0	13.0	100.0		0.650	73		***	Rounded	0.9- 3.9	3	0.00	40 (1)	400	0.49	0.77		
SP	SP-7C	Poorly Graded Sand (Port Allen Lock)	Sherman & Trahan (44)	0.2	0.17	0.12	NP	NP		100.0	13.0	105.1		0.570	98		**	Rounded	0.9- 3.9	3	0.00	44 (3)	750	0.77	0.83		
SP	SP-12	Coarse to Fine Sand (Round Butte Dam)	Shannon & Wilson (41)	minus No. 4 sieve			NP	NP				74.8		1.220	70		**	Angular	2.0- 14.0	3	0.00	39 (6)	280	0.37	0.71	95	0.21
SP	SP-13	Pumiceous Sand (Round Butte Dam)	Shannon & Wilson (41)	0.85	0.41	0.24				87.4		84.2	18.00		77		*	Angular	2.0- 14.1	3	0.00	48 (10)	340	0.45	0.70	230	0.06
SP	SP-14	Pumiceous Sand (Round Butte Dam)	Shannon & Wilson (41)	1.0	0.5	0.24				80.7		76.9	26.00		71		*	Angular	2.0- 14.1	3	0.00	49 (12)	650	0.38	0.77	380	0.05
SP	SP-16A	Fine Silica Sand (Loose)	Duncan & Chang (22)	0.27	0.2	0.165								0.650	38		***	Rounded	1.0- 5.1	3	0.00	30 (0)	280	0.65	0.93	110	0.65
SP	SP-16B	Fine Silica Sand (Dense)	Duncan & Chang (22)	0.27	0.2	0.165								0.540	100		***	Rounded	1.0- 5.1	3	0.00	37 (0)	1400	0.74	0.90	1080	0.15
SP	SP-17A	Monterey No. 0 Sand (Cylind. specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.780	27		***	Rounded	0.3- 1.2	3	0.00	35 (0)	920	0.79	0.98	465	0.32
SP	SP-17B	Monterey No. 0 Sand (Cubical specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.780	27		**	Rounded	0.3- 1.2	3	0.00	39 (0)	510	0.61	0.97	370	0.22
SP	SP-17C	Monterey No. 0 Sand (Cylind. specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.570	98		***	Rounded	0.3- 1.2	3	0.00	45 (3)	3200	0.78	0.92	1400	0.45
SP	SP-17D	Monterey No. 0 Sand (Cubical specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.570	98		**	Rounded	0.3- 1.2	3	0.00	47 (5)	1500	0.76	0.91	1100	0.52
SP	SP-18	Basaltic Sand (Round Butte Dam)	Shannon & Wilson (42)	3.	9.	0.13				120.1	9.5	120.0	9.50				**	Angular	2.0- 14.0	3	0.00	39 (13)	1800	0.08	0.63	750	0.00
SM	SM-4	Silty Sand (Chatfield Dam)	COE, Omaha District (19)	0.82	0.16	0.026	20	0	Std. AASHO	123.0	9.5	116.7	9.40				**	Sub-rounded	6.0- 10.0	3	0.00	37 (0)	100	1.07	0.62		
SM	SM-5	Silty Gravelly Sand (Chatfield Dam)	COE, Omaha District (19)	1.15	0.28	0.05	NP	NP	Std. AASHO	132.0	8.1	124.5	7.53				*	Sub-rounded	6.0- 10.0	3	0.00	41 (0)	530	0.51	0.82	640	0.00
SM	SM-6	Silty Sand w/Pebbles (Round Butte Dam)	Shannon & Wilson (41)	0.31	0.1	0.04	NP	NP	16,450	110.6	17.5	108.1	17.50				***	Angular	2.0- 14.0	3	0.00	48 (8)	700	0.35	0.75		
SM	SM-9	Silty Sand w/Pumice (Round Butte Dam)	Shannon & Wilson (41)	0.15	0.054	0.013	NP	NP	16,450	91.7	19.5	88.4	19.00				**	Angular	2.0- 13.7	3	0.00	43 (8)	670	0.25	0.72	500	0.00
SM	SM-13	Silty Sand (Round Butte Dam)	Shannon & Wilson (43)	0.27	0.027	0.0022				105.6	16.4	104.5	15.00				*	Sub-angular	2.0- 14.1	3	0.00	36 (5)	530	0.28	0.74	470	0.00
SM	SM-16	Silty Sand & Gravel (Round Butte Dam)	Shannon & Wilson (42)	0.45	0.052	0.012				109.3	12.9	109.0	12.00				**	Sub-angular	2.0- 14.0	3	0.00	36 (11)	800	0.20	0.67	600	0.00
SM-SC	SM-SC-1A	Silty Clayey Sand (Mica Dam Core)	Casagrande (10) / Insley & Hillis (27)	0.34	0.03	0.002	21	4	Std. AASHO	136.0	9.8	131.1	7.70				**		3.6- 32.4	6	0.31	33	700	0.37	0.80	280	0.19
SM-SC	SM-SC-1B	Silty Clayey Sand (Mica Dam Core)	Casagrande (10) / Insley & Hillis (27)	0.34	0.03	0.002	21	4	Std. AASHO	136.0	9.8	134.0	9.70				***		3.6- 18.0	4	0.85	34	425	0.58	0.70	205	0.44
SM-SC	SM-SC-1C	Silty Clayey Sand (Mica Dam Core)	Casagrande (10) / Insley & Hillis (27)	0.34	0.03	0.0002	21	4	Std. AASHO	136.0	9.8	128.2	11.90				***		3.6- 32.4	6	0.40	34	160	0.81	0.83	65	0.81
ML	ML-1	Cannonsville Silt (Undisturbed)	Hirschfeld & Poulos (26)	0.033	0.018	0.005						108.0		0.570			*		1.5- 7.4	4	0.00	45 (6)	200	1.07	0.57	200	0.89
ML	ML-4	Sandy Silty w/Pumice (Round Butte Dam)	Shannon & Wilson (41)	0.078	0.032	0.0064	NP	NP	16,450	97.0	19.0	92.8	17.70				*		2.0- 13.9	2	0.00	42 (7)	500	0.45	0.82	400	0.00
ML	ML-5	Sandy Silty w/Pumice (Round Butte Dam)	Shannon & Wilson (41)	0.1	0.026	0.0052	NP	NP	16,450	102.5	16.5	99.2	17.00				**		2.0- 13.9	3	0.00	38 (1)	530	0.35	0.71	520	0.23
CL	CL-29C	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	116.2	15.2	111.2	13.10			69	**		1.0- 8.2	4	0.17	30	550	-0.05	0.82		
CL	CL-29D	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	116.2	15.2	116.2	13.30			79	**		1.0- 8.2	4	0.59	29	690	0.10	0.71		
CL	CL-30E	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	112.8	16.7	115.1	15.20			88	**		1.0- 8.2	4	0.51	33	150	0.62	0.61	360	0.00
CL	CL-30F	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	112.8	16.7	110.0	17.40			88	**		1.0- 4.0	4	0.39	30	160	0.50	0.63	210	0.00
CL	CL-34E	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (7)	0.037	0.008	-	34	19	Harvard	105.6	19.8	106.3	19.00			87	*		0.5- 8.0	5	0.28	31	130	0.59	0.72	45	0.59