ENTECH
ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
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April 12, 2019

Tech Contractors
3575 Kenyon Street, Suite 200
San Diego, California 92110

Approved
by Elizabeth Nijkamp
El Paso County Planning and Community Development
on behalf of Jennifer Irvine, County Engineer, ECM Administrator
04/23/2019 9:45:03 AM

Attn: Jeff Scheble

Re: Pavement Recommendations – Partial
Windingwalk, Filing 1, Phase 3
El Paso County File No. SF 18-002
El Paso County, Colorado

Dear Mr. Scheble:

As requested, Entech Engineering, Inc. has obtained samples of the subgrade soils from sections of the roadways in the Windingwalk Subdivision, Filing 1, Phase 3, in El Paso County, Colorado. Laboratory testing to determine the pavement support characteristics of the soils was performed. This letter presents the results of the laboratory testing and pavement recommendations for the roadways.

Project Description

The project lies north and west of the initial phases of the development. The extent of the roadway construction is shown in Figure 1.

The roadways in this project consist of four roadways: Fairway Glen Drive, and portions of Windingwalk Drive, Windingpark Drive, and Hiddenwalk Way. The site layout and the locations of the test borings, drilled at approximate 500-foot intervals, are shown on the Test Boring Location Plan, Figure 1.

Subgrade Conditions

Nine exploratory test borings (Test Boring Nos. 10 thru 18) were drilled in the roadways to depths of approximately 5 to 10 feet. Test Boring Nos. 1 thru 9 were previously reported under a separate cover (Entech Job No. 190128). The Boring Logs are presented in Appendix A. Sieve Analysis and Atterberg Limit testing were performed on soil samples obtained from the test borings for the purpose of classification. Sieve analyses performed indicated the percent passing the No. 200 sieve for the roadway subgrade soils ranged from approximately 14 to 27 percent. Atterberg Limit Tests performed on the samples resulted in Liquid Limits ranging from 24 to 35 and no value and Plastic Indexes of 9 to 20 and non-plastic. One general soil type was encountered at the subgrade depth (Soil Type 1A). Soil Type 1A consisted of silty sand fill and clayey sand fill which classified as A-1-b, A-2-4, and A-2-6 soils based on the AASHTO classification system. Type 1A soils encountered in this portion of the subdivision phasing typically have good pavement support characteristics. Sulfate testing of the subgrade indicated that the soils exhibit a negligible potential for sulfate attack. Groundwater was not encountered in the test borings.

Swell testing was conducted on Soil Type 1A which showed swells ranging between 0.1 and 0.4 percent, indicating low expansion potentials. One sample showed a consolidation of 0.1 percent, indicating a low consolidation potential. These limits are below the level in which mitigation is required (2.0 percent). Laboratory test results are presented in Appendix B and are summarized on Table 1.

California Bearing Ratio (CBR) testing was performed on a sample of Soil Type 1A to determine the support characteristic of the subgrade soils for the roadway sections. The results of the CBR testing, are presented in Appendix B and summarized as follows:

CBR Test Results
Soil Type 1A – Silty Sand Fill
R @ 90% = 37.0
R @ 95% = 75.0
Use R = 40.0 for design

Classification Testing

Liquid Limit	NV
Plasticity Index	NP
Percent Passing 200	23.8
AASHTO Classification	A-2-4
Group Index	0
Unified Soils Classification	SM

Pavement Design

The CBR testing was used to determine pavement sections for this site. The pavement sections were determined utilizing the El Paso County "Pavement Design Criteria and Report". The following classifications and ESAL values were used for this portion of the filing. Fairway Glen Drive classifies as a local low volume road, north of the intersection of Windingwalk Drive, which use an 18K ESAL value of 36,500 for design. The southern portion of Fairway Glen Drive, Windingwalk Drive, Windingpark Drive, and Hiddenwalk Way classify as an urban local road which uses an 18K ESAL value of 292,000 for design. Pavement alternatives for asphalt over aggregate basecourse and cement stabilized subgrade sections are provided. Design parameters used in the pavement analysis are as follows:

Reliability (Local Roads)	80%
Serviceability Index Local Low Volume, Local Roads	2.0
"R" Value Subgrade – ST 1A	40.0
Resilient Modulus	9,497 psi
Structural Coefficients:	
Hot Bituminous Pavement	0.44
Aggregate Base Course	0.11
Cement Stabilized Subgrade	0.12

Pavement calculations are attached in Appendix C. Pavement sections recommended for this phase of the filing are summarized as follows:

Pavement Sections – Soil Type 1A

Local Low Volume – ESAL = 36,500 – Fairway Glen Drive (north of Windingwalk Drive)

Alternative	Asphalt (in)	Base Course (in)	Cement Stabilized Subgrade (in.)
1. Asphalt Over Base Course	3.0*	4.0*	--
2. Cement Stabilized Subgrade	4.0*	--	10.0*

Urban Local – ESAL = 292,000 – Fairway Glen Drive (south of Windingwalk Drive), Windingwalk Drive, Windingpark Drive, and Hiddenwalk Way

Alternative	Asphalt (in)	Base Course (in)	Cement Stabilized Subgrade (in.)
1. Asphalt Over Base Course	3.5	8.0*	--
2. Cement Stabilized Subgrade	4.0*	--	10.0*

[1] Full depth sections are only allowed over chemically treated or suitable subgrade.
* Minimum sections required by the El Paso County Pavement Design Criteria and Report.

Mitigation

El Paso County criteria requires mitigation of expansive soils for roadway subgrade that have a swell of 2 percent or greater with a 150 pound per square foot surcharge. Five samples at subgrade depth were tested that resulted in volume changes ranging between -0.1 to 0.4 percent. Due to the testing mitigation for expansive soils will not be required.

Roadway Construction - Full Depth Asphalt and Asphalt on Aggregate Base Course Alternatives

Prior to placement of the asphalt, the subgrade should be proofrolled and compacted to a minimum of 95 percent of its maximum Standard Proctor Dry Density, ASTM D-698 at -1 to +2 percent of optimum moisture content or 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ±2 percent of optimum moisture content. Any loose or soft areas should be removed and replaced with suitable materials. Base course materials should be compacted to a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

Roadway Construction – Cement Stabilized Subgrade Alternative

Prior to placement of the asphalt, the subgrade shall be stabilized by addition of cement to a depth of at least 10 inches. The depth of the required cement stabilized subgrade is shown in the previous table. The amount of cement applied shall be 2.0 percent (by weight) of the subgrade's maximum dry density as determined by the Standard Proctor Test (ASTM D-698) based on laboratory cement stabilization testing. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over a 10-inch depth such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 10 inches of subgrade should be thoroughly moisture conditioned to the soil's optimum water content or as much as 2 percent more than the optimum water content as necessary to provide a compactable soil condition. Densification of the cement-stabilized subgrade should be completed to obtain a compaction of at least 95 percent of the subgrade maximum dry density as determined by the Standard Proctor Test (ASTM D-698). Satisfactory compaction of the subgrade shall occur within 90 minutes from the time of mixing the cement into the subgrade.

The following conditions shall be observed as part of the subgrade stabilization:

- Type I/II cement as supplied, a local supplier shall be used. All cement used for stabilization should come from the same source. If cement sources are changed a new laboratory mix design should be completed.

- Moisture conditioning of the subgrade and/or mixing of the cement into the subgrade shall not occur when soil temperatures are below 40° F. Cement treated subgrades should be maintained at a temperature of 40° F or greater until the subgrade has been compacted as required.

- Cement placement, cement mixing and compaction of the cement treated subgrade should be observed by a Soils Engineer. The Soils Engineer should complete in situ compaction tests and construct representative compacted specimens of the treated subgrade material for subsequent laboratory quality assurance testing.

- Microfracturing of the stabilized subgrade is recommended.

If significant grading is performed, the soils at subgrade may change. Modification to the pavement sections should be evaluated after site grading is completed.

In addition to the above guidance, the asphalt, cement, subgrade conditions, compaction of materials and roadway construction methods shall meet the El Paso County specifications.

We trust that this has provided you with the information you required. If you have any questions or need additional information, please do not hesitate to contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.

COLORADO REGISTERED
STANLEY CLARE CULP
36723
4/12/19
PROFESSIONAL ENGINEER

Stan C. Culp, P.E.
Senior Engineer

Reviewed by:

Joseph C. Goode, Jr., P.E.
President

SCC/sc

Encl.

Entech Job No. 190128
AAprojects/2019/190128/190128 pr_ph3

TABLE

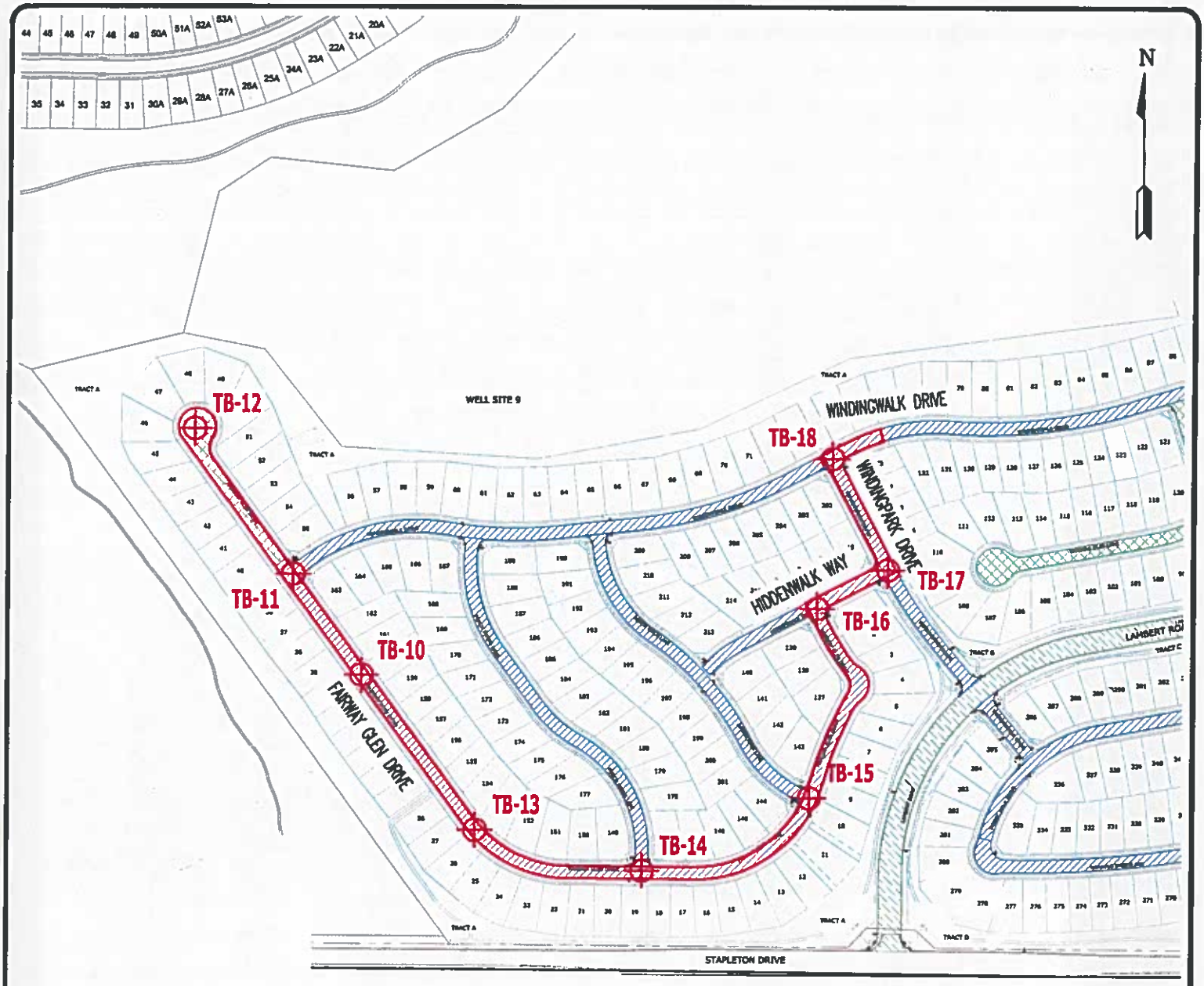
TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT TECH CONTRACTORS
PROJECT WINDING WALK, PHASE 3
JOB NO. 190128

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	SULFATE (WT %)	AASHTO CLASS.	SWELL/ CONSOL (%)	UNIFIED CLASSIFICATION	SOIL DESCRIPTION
1A, CBR	11	0-3			23.8	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1A	10	1-2			21.9	NV	NP	<0.01	A-1-b		SM	FILL, SAND, SILTY
1A	11	1-2			20.6	NV	NP		A-1-b		SM	FILL, SAND, SILTY
1A	12	1-2	6.6	107.8	16.3	27	14		A-2-6	0.1	SC	FILL, SAND, CLAYEY
1A	13	1-2	8.9	12.06	20.5	35	20		A-2-6	0.2	SC	FILL, SAND, CLAYEY
1A	15	1-2			29.6	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1A	16	1-2	8.8	112.5	24.0	33	19		A-2-6	0.4	SC	FILL, SAND, CLAYEY
1A	14	1-2	7.9	105.0	13.7	24	9		A-2-4	-0.1	SC	FILL, SAND, CLAYEY
1A	17	1-2			26.7	33	19	<0.01	A-2-6		SC	FILL, SAND, CLAYEY
1A	18	1-2	9.2	108.8	19.1	34	20	<0.01	A-2-6	0.1	SC	FILL, SAND, CLAYEY

FIGURE



SOIL TYPE 1A

NOTES:

UNMARKED : URBAN LOCAL LOW VOLUME – (36,500) – 3.0" ASPHALT OVER 4.0" BASE COURSE, OR 4.0" ASPHALT OVER 10.0" OF CEMENT-TREATED SUBGRADE.

UNMARKED : URBAN LOCAL – (292,000) – 3.5" ASPHALT OVER 8.0" BASE COURSE, OR 4.0" ASPHALT OVER 10.0" OF CEMENT-TREATED SUBGRADE.

⊕ TB-11- APPROXIMATE TEST BORING LOCATION AND NUMBER

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TEST BORING LOCATION PLAN
WINDINGWALK, F1, PHASE 3
EL PASO COUNTY, CO
FOR: TECH CONTRACTORS

DRAWN BY:	DATE DRAWN:	DESIGNED BY:	CHECKED:
SCC	03/26/19	SC	SC

JOB NO.: 190128

FIG. NO.: 1

APPENDIX A: Test Boring Logs

TEST BORING NO. 10
DATE DRILLED 3/6/2019
Job # 190128

REMARKS

DRY TO 5', 3/6/19

FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, LOOSE TO MEDIUM DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			9	7.2	1A
5			16	6.2	1A
10					
15					
20					

TEST BORING NO. 11
DATE DRILLED 3/6/2019
CLIENT TECH CONTRACTORS
LOCATION WINDING WALK, PHASE 3

REMARKS

DRY TO 10', 3/6/19

FILL 0-10', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, VERY LOOSE TO MEDIUM DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			4	8.5	1A
5			3	8.5	1A
10			27	9.4	1A
15					
20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: A- 1

TEST BORING NO. 12
DATE DRILLED 3/6/2019
Job # 190128

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 3/6/19						
FILL 0-5', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				25	5.9	1A
	5			27	5.9	1A
	10					
	15					
	20					

TEST BORING NO. 13
DATE DRILLED 3/6/2019
CLIENT TECH CONTRACTORS
LOCATION WINDING WALK, PHASE 3

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 3/6/19						
FILL 0-4', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				20	9.2	1A
SAND, CLAYEY, FINE TO COARSE GRAINED, LIGHT BROWN, DENSE, MOIST	5			30	8.3	1
	10					
	15					
	20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: A- 2

TEST BORING NO. 14
DATE DRILLED 3/6/2019
Job # 190128

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 10', 3/6/19						
FILL 0-9', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				19	6.5	1A
	5			20	9.1	1A
SAND, CLAYEY, FINE GRAINED, TAN, MEDIUM DENSE, MOIST	10			23	17.0	1
	15					
	20					

TEST BORING NO. 15
DATE DRILLED 3/6/2019
CLIENT TECH CONTRACTORS
LOCATION WINDING WALK, PHASE 3

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 3/6/19						
FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, LOOSE TO MEDIUM DENSE, MOIST				5	10.3	1A
	5			21	16.4	1A
	10					
	15					
	20					

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TEST BORING LOG

DRAWN	DATE	CHECKED	DATE
		SCC	4/4/19

JOB NO. 190128
FIG NO. A- 3

TEST BORING NO. 16
DATE DRILLED 3/6/2019
Job # 190128

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 3/6/19						
FILL 0-5', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				17	9.6	1A
	5			16	10.4	1A
	10					
	15					
	20					

TEST BORING NO. 17
DATE DRILLED 3/6/2019
CLIENT TECH CONTRACTORS
LOCATION WINDING WALK, PHASE 3

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 10', 3/6/19						
FILL 0-4', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				15	11.1	1A
WEATHERED TO FORMATIONAL SANDSTONE, CLAYEY, FINE TO COARSE GRAINED, BROWN, DENSE TO VERY DENSE, MOIST	5			40	9.6	4
	10			50 / 11"	10.6	4
	15					
	20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: A- 4

TEST BORING NO. 18
DATE DRILLED 3/6/2019
Job # 190128

TEST BORING NO.
DATE DRILLED
CLIENT TECH CONTRACTORS
LOCATION WINDING WALK, PHASE 3

REMARKS

DRY TO 5', 3/6/19

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			7	9.0	1A
5			7	9.7	1A
10					
15					
20					

FILL 0-5', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, LOOSE, MOIST

REMARKS

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5					
10					
15					
20					

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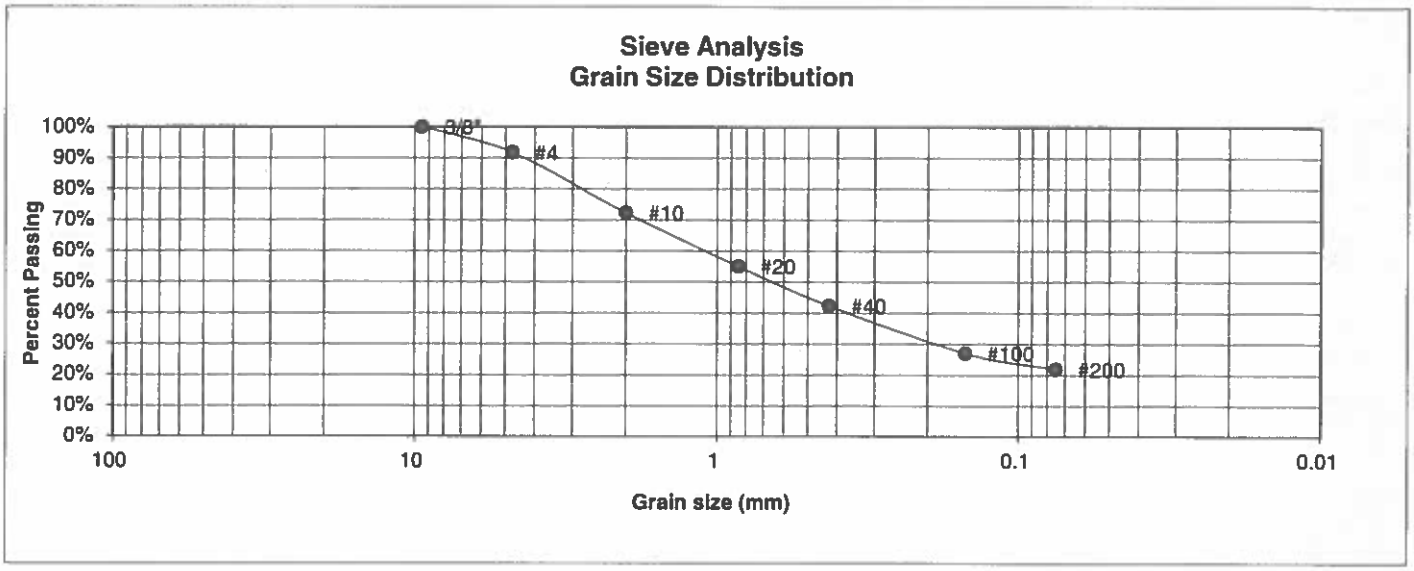
TEST BORING LOG

DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: A- 5

APPENDIX B: Laboratory Test Results

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	10	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	91.8%
10	72.3%
20	55.1%
40	42.3%
100	27.1%
200	21.9%

Atterberg Limits	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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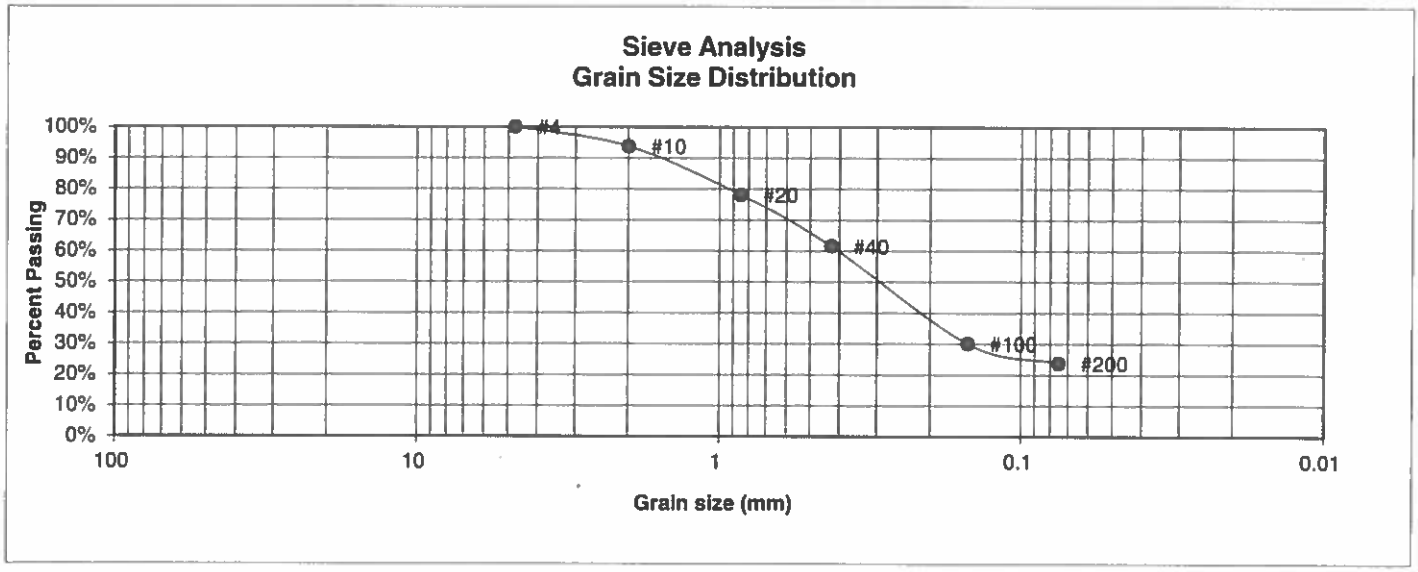
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-1

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A, CBR	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	11	JOB NO.	190128
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	93.8%
20	78.1%
40	61.6%
100	30.1%
200	23.8%

Atterberg Limits	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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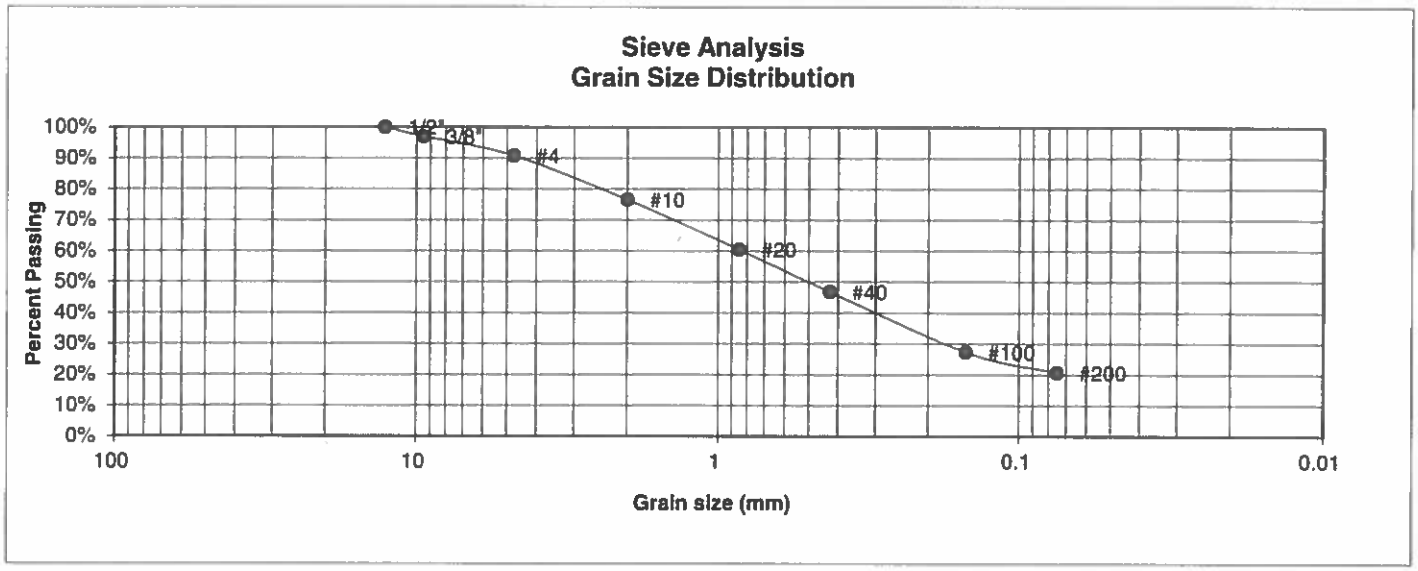
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/8/19

JOB NO.: 190128
FIG NO.: B-2

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	11	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	97.0%
4	90.8%
10	76.5%
20	60.5%
40	46.8%
100	27.3%
200	20.6%

Atterberg Limits	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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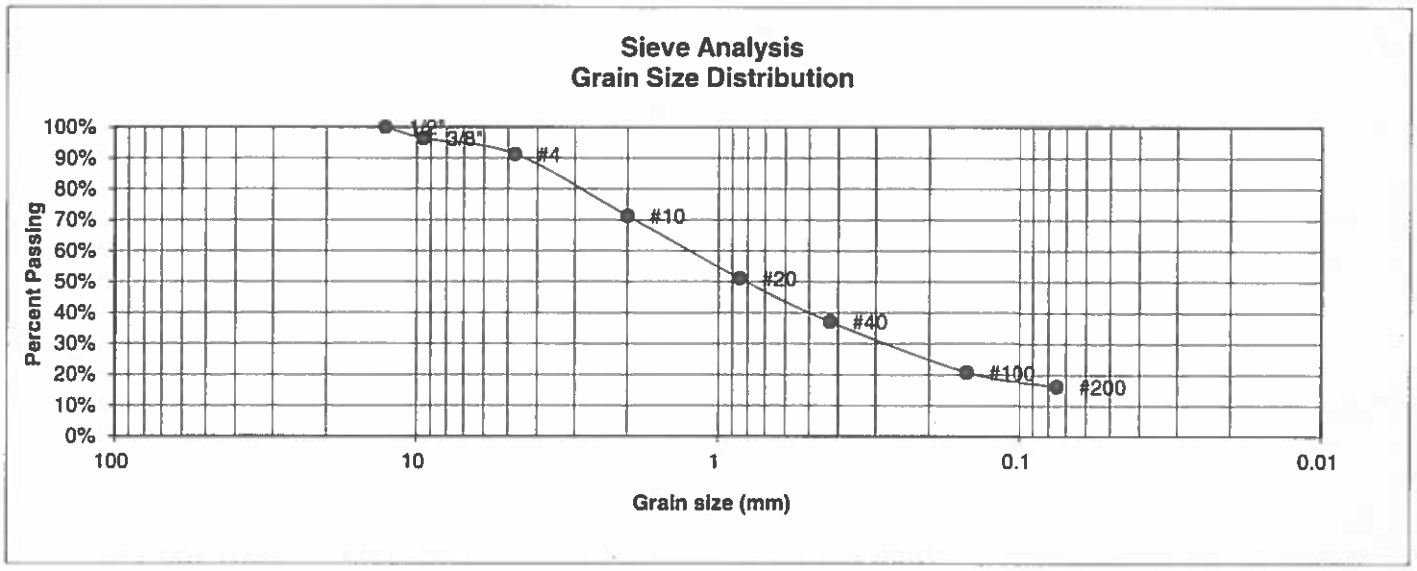
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: B-3

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	12	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	96.4%
4	91.2%
10	71.3%
20	51.1%
40	37.1%
100	20.8%
200	16.3%

Atterberg Limits	
Plastic Limit	13
Liquid Limit	27
Plastic Index	14

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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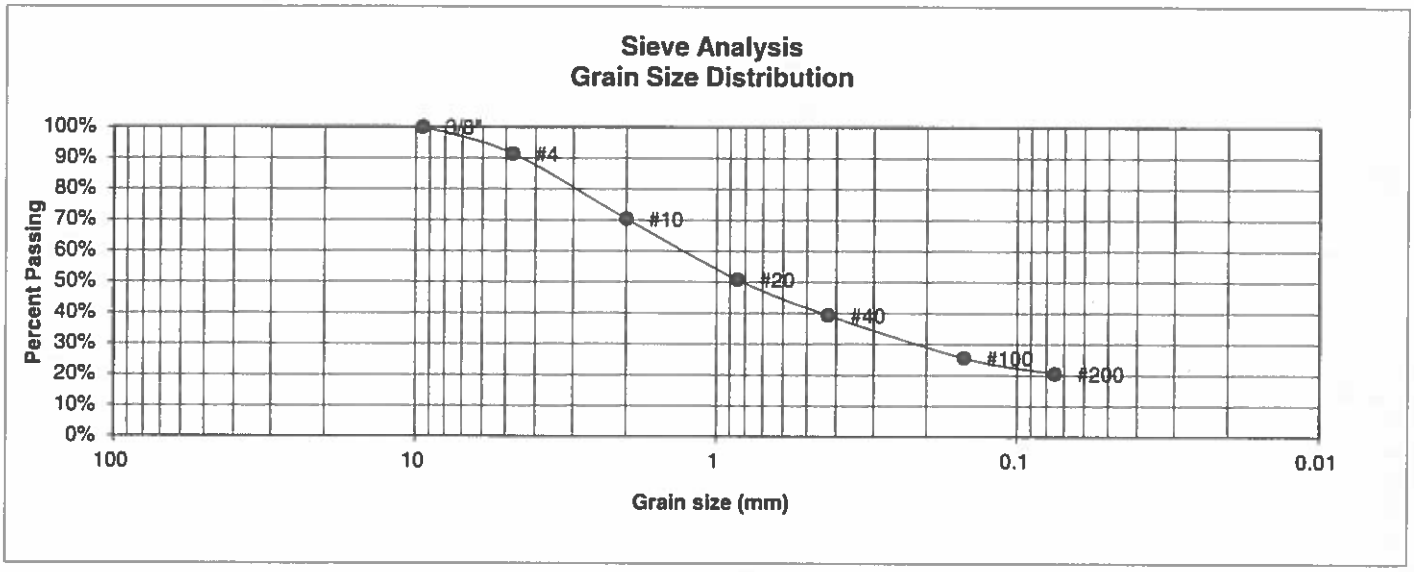
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: B-4

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	13	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	1



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	91.4%
10	70.4%
20	50.8%
40	39.3%
100	25.6%
200	20.5%

Atterberg Limits	
Plastic Limit	15
Liquid Limit	35
Plastic Index	20

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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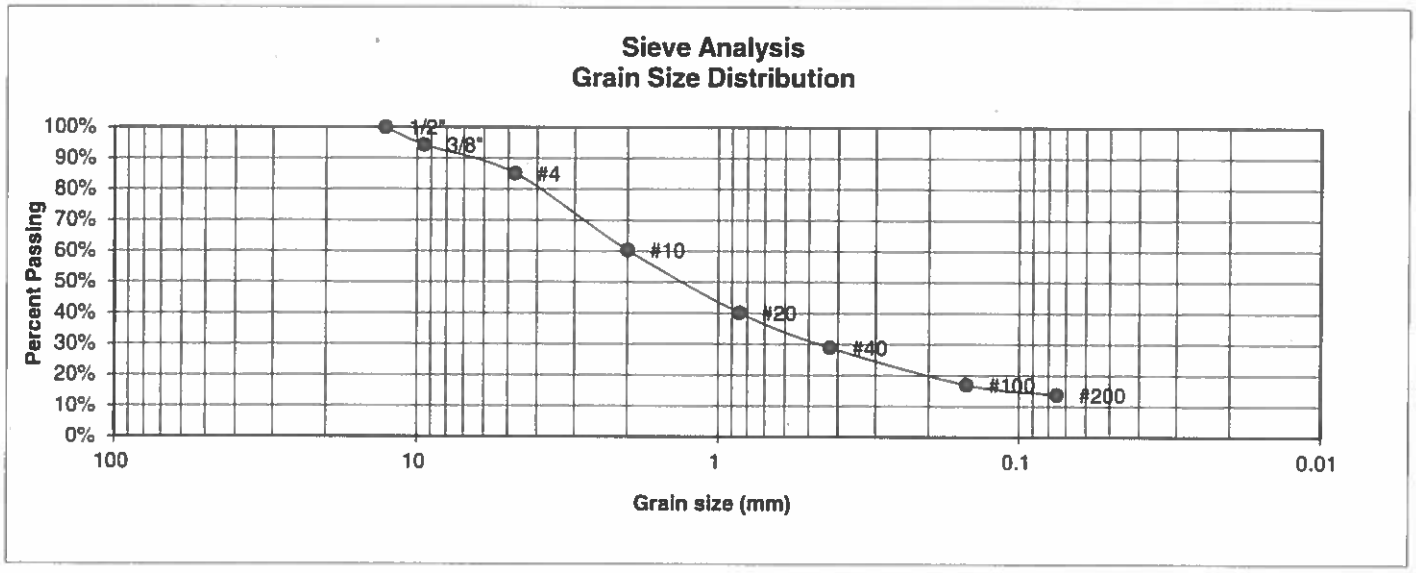
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-5

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	14	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	94.3%
4	85.1%
10	60.4%
20	40.2%
40	28.9%
100	17.0%
200	13.7%

Atterberg Limits	
Plastic Limit	15
Liquid Limit	24
Plastic Index	9

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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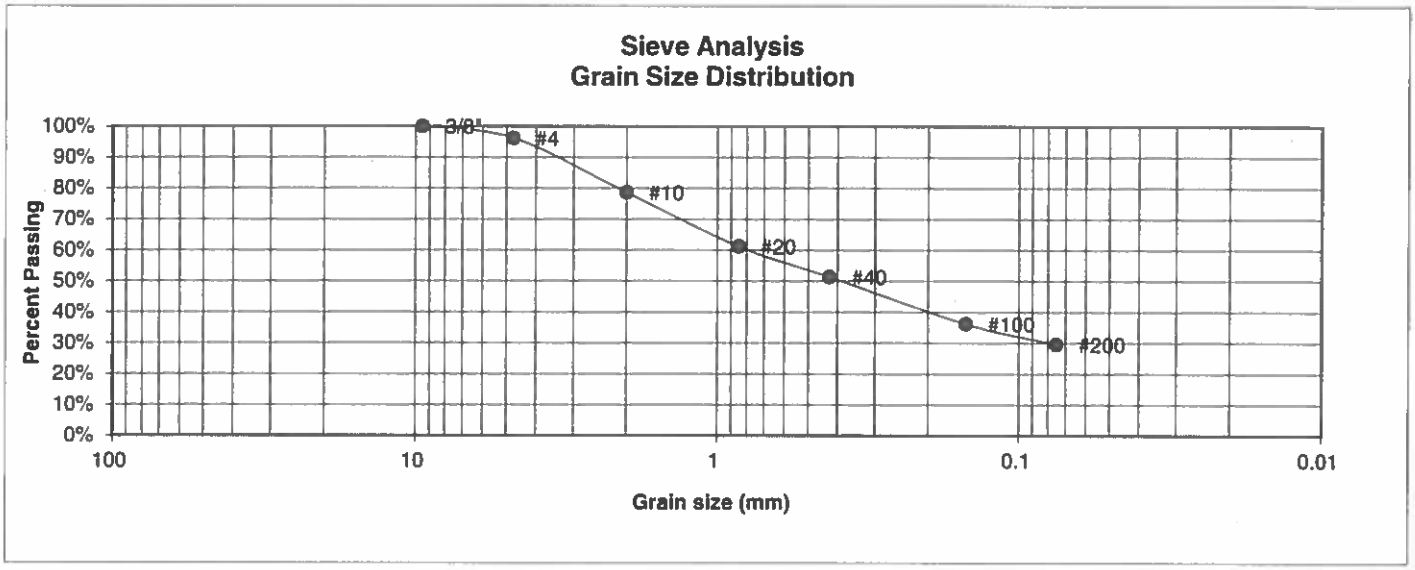
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: B-6

UNIFIED CLASSIFICATION	SM	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	15	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.2%
10	78.7%
20	61.2%
40	51.3%
100	36.2%
200	29.6%

Atterberg Limits	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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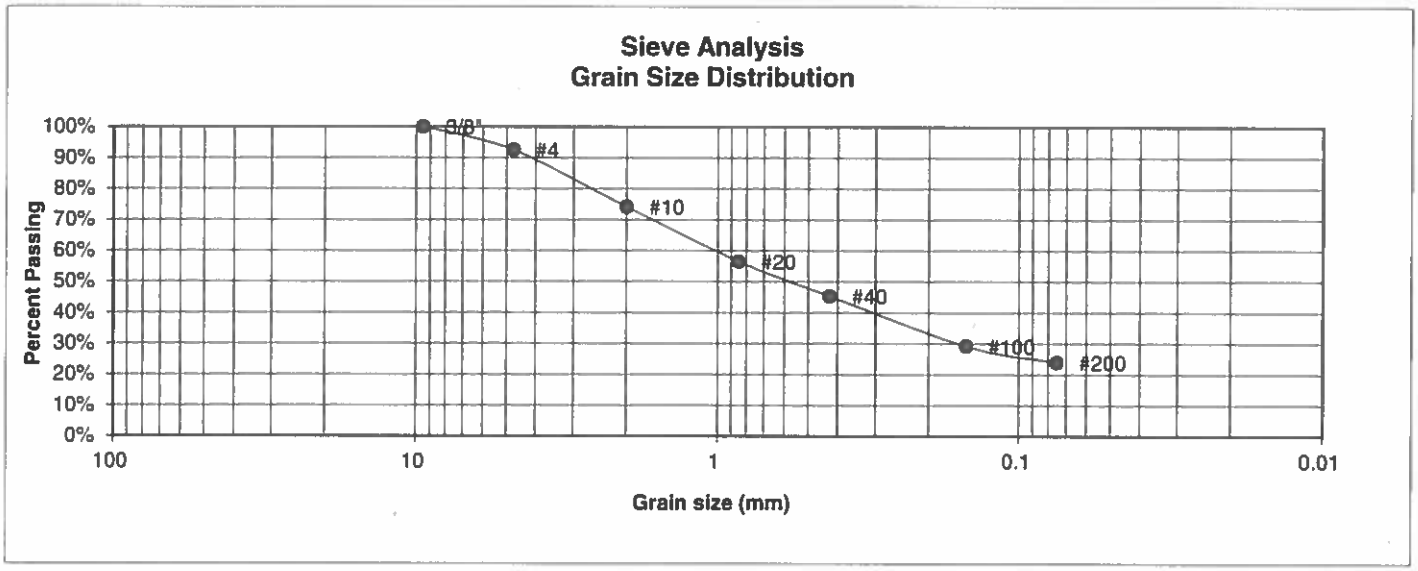
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-7

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	16	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	1



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	92.5%
10	74.2%
20	56.6%
40	45.4%
100	29.2%
200	24.0%

Atterberg Limits	
Plastic Limit	14
Liquid Limit	33
Plastic Index	19

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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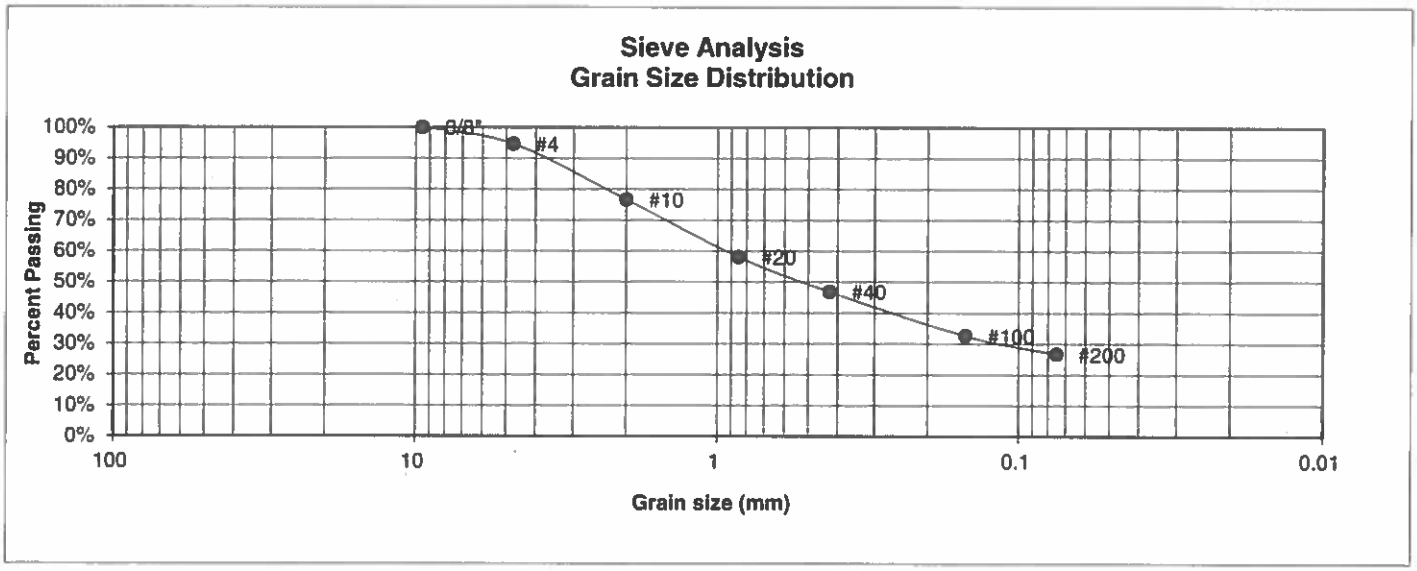
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: B-8

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	17	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	1



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	94.6%
10	76.7%
20	58.1%
40	46.9%
100	32.6%
200	26.7%

Atterberg Limits	
Plastic Limit	14
Liquid Limit	33
Plastic Index	19

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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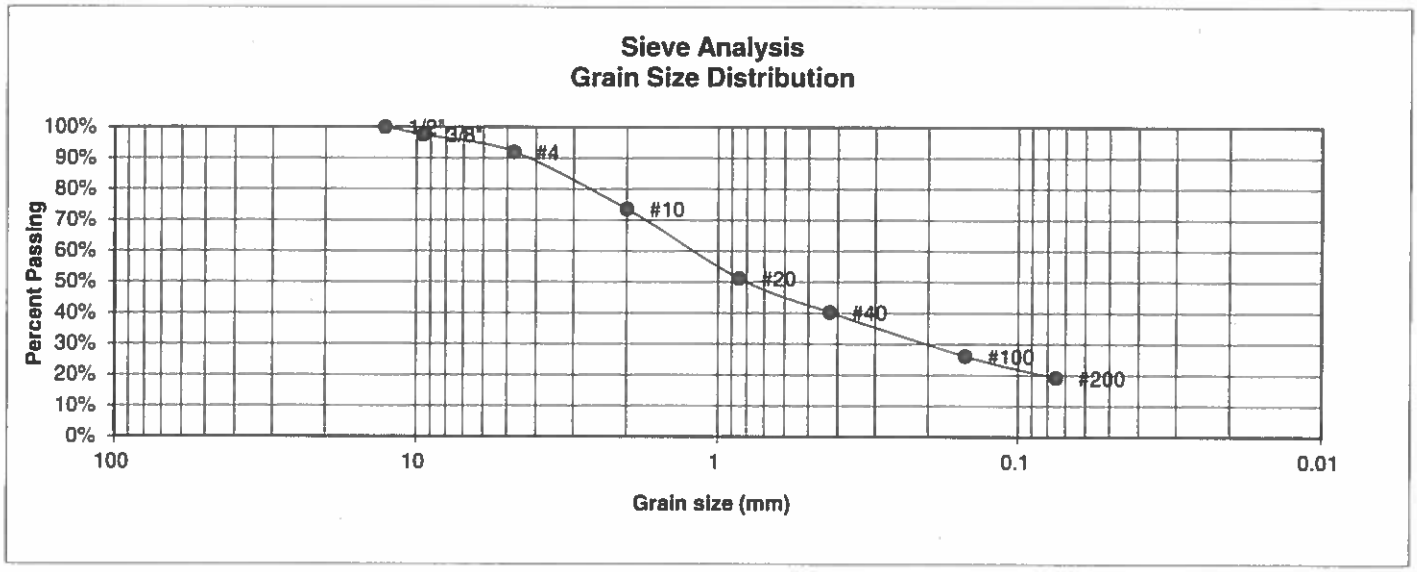
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-9

UNIFIED CLASSIFICATION	SC	CLIENT	TECH CONTRACTORS
SOIL TYPE #	1A	PROJECT	WINDING WALK, PHASE 3
TEST BORING #	18	JOB NO.	190128
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	97.6%
4	91.9%
10	73.6%
20	51.2%
40	40.3%
100	26.1%
200	19.1%

Atterberg Limits	
Plastic Limit	14
Liquid Limit	34
Plastic Index	20

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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LABORATORY TEST RESULTS

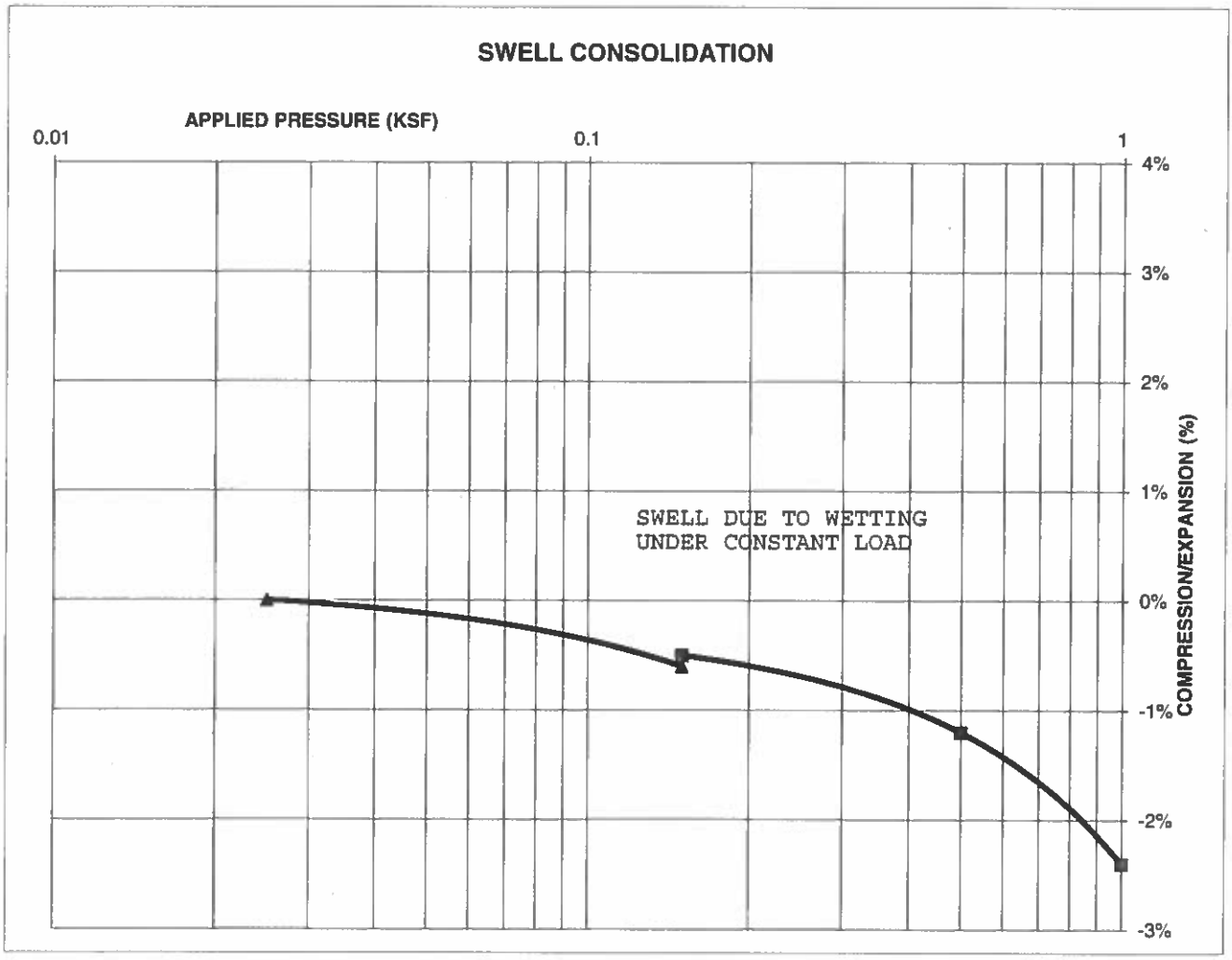
DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: B-10

CONSOLIDATION TEST RESULTS

TEST BORING #	12	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1A
NATURAL UNIT DRY WEIGHT (PCF)			108
NATURAL MOISTURE CONTENT			6.6%
SWELL/CONSOLIDATION (%)			0.1%

JOB NO. 190128
CLIENT TECH CONTRACTORS
PROJECT WINDING WALK, PHASE 3



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SWELL CONSOLIDATION
TEST RESULTS

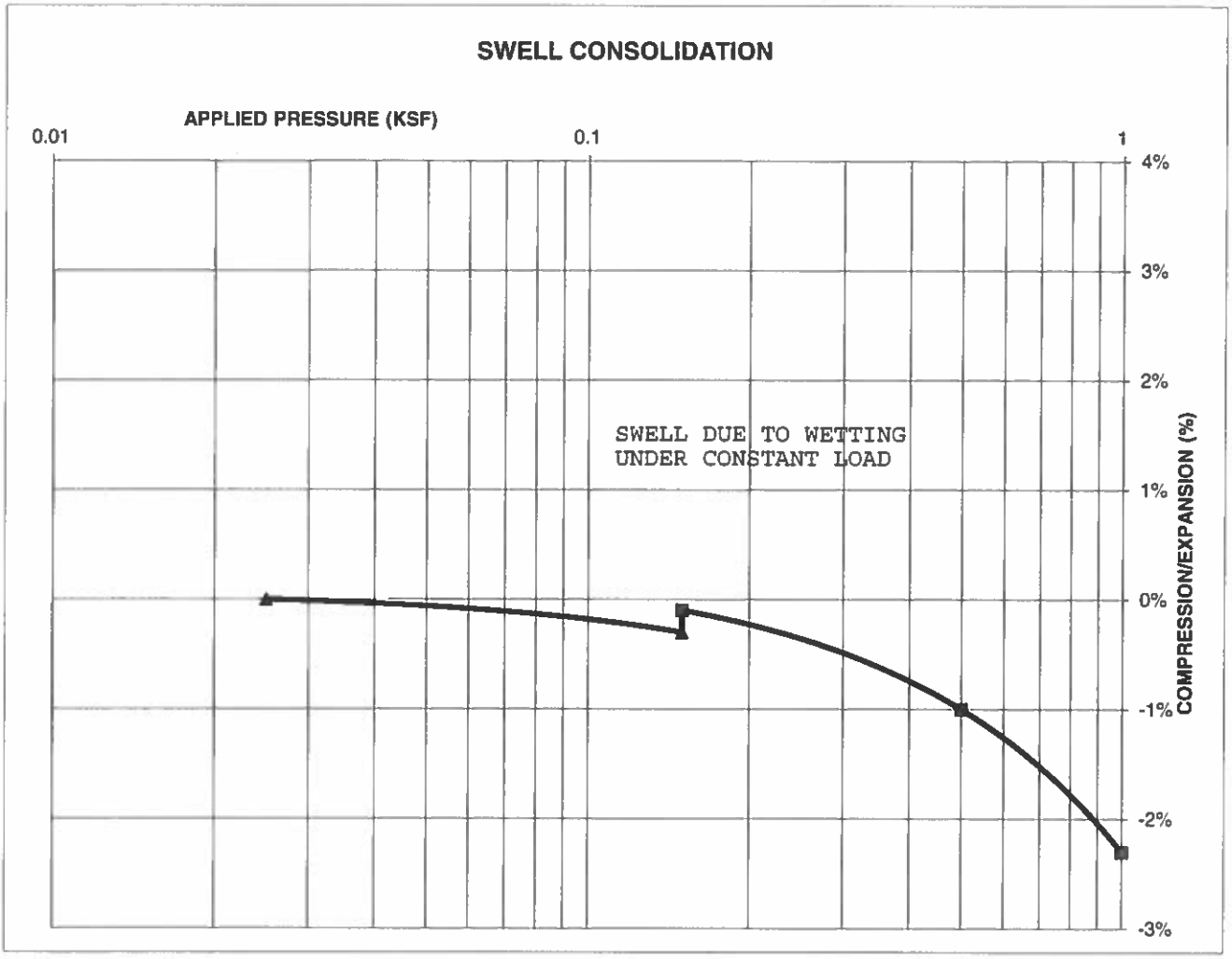
DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-11

CONSOLIDATION TEST RESULTS

TEST BORING #	13	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1A
NATURAL UNIT DRY WEIGHT (PCF)			121
NATURAL MOISTURE CONTENT			8.9%
SWELL/CONSOLIDATION (%)			0.2%

JOB NO. 190128
CLIENT TECH CONTRACTORS
PROJECT WINDING WALK, PHASE 3



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SWELL CONSOLIDATION
TEST RESULTS

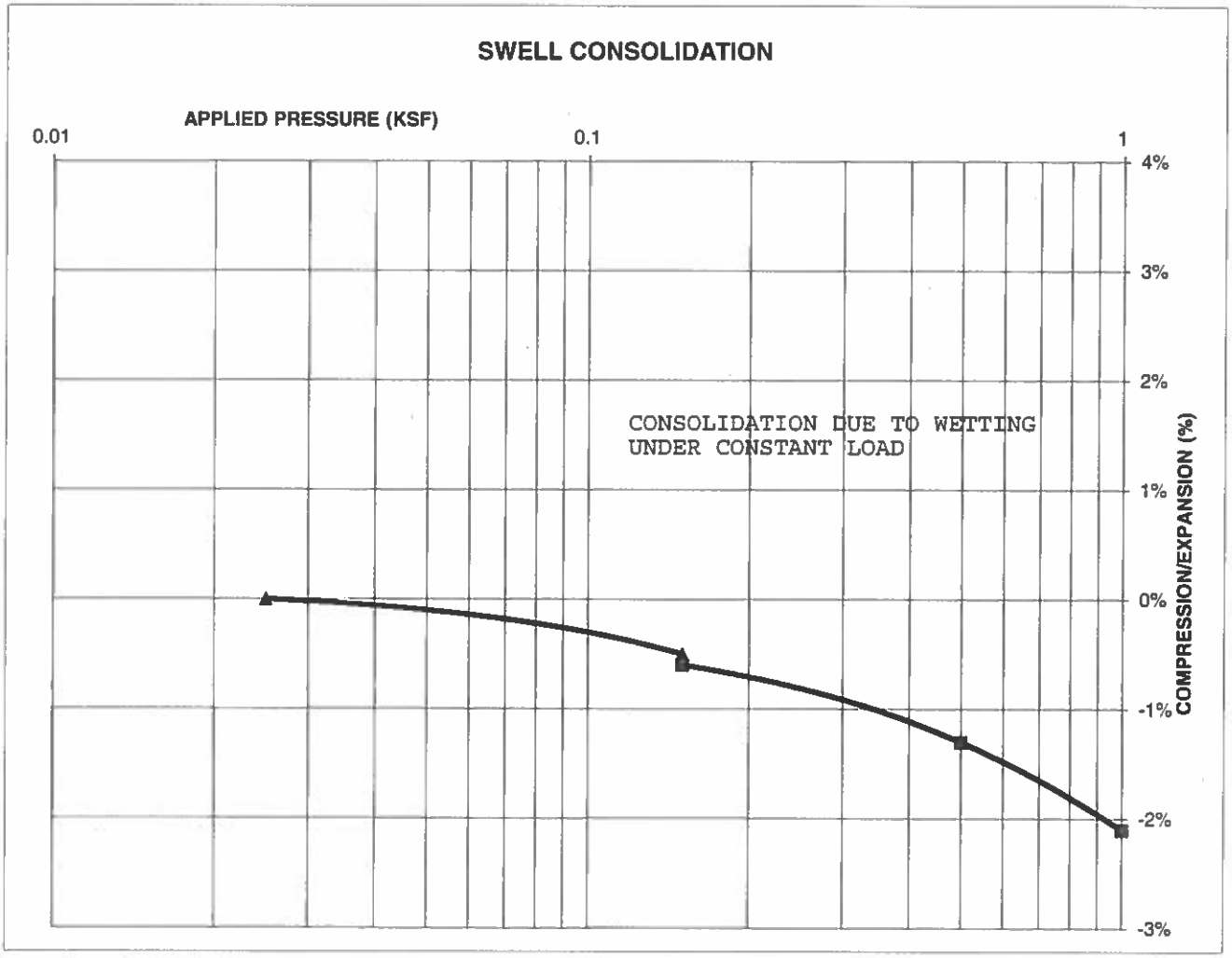
DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: B-12

CONSOLIDATION TEST RESULTS

TEST BORING #	14	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1A
NATURAL UNIT DRY WEIGHT (PCF)			105
NATURAL MOISTURE CONTENT			7.9%
SWELL/CONSOLIDATION (%)			-0.1%

JOB NO. 190128
CLIENT TECH CONTRACTORS
PROJECT WINDING WALK, PHASE 3



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SWELL CONSOLIDATION
TEST RESULTS

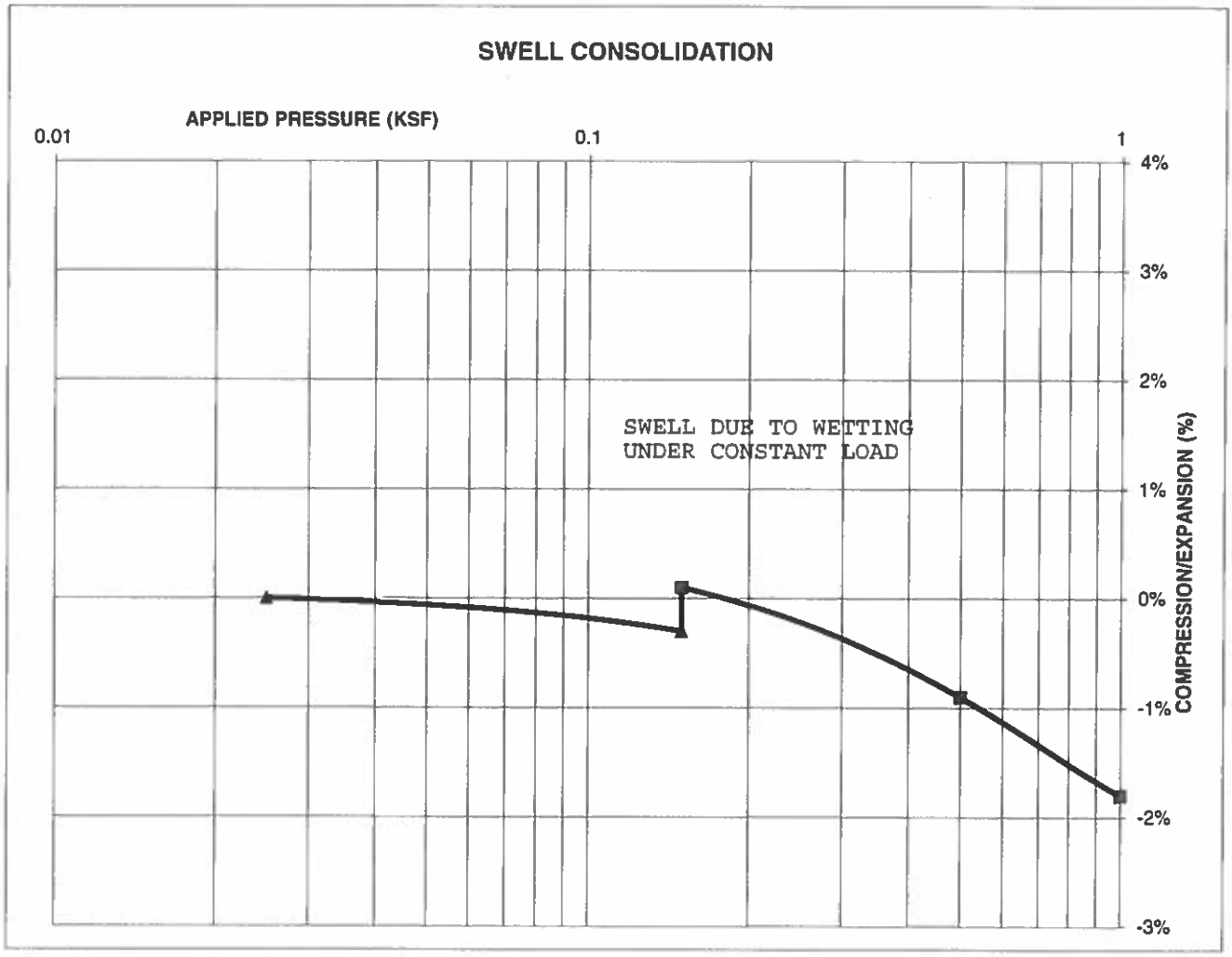
DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-13

CONSOLIDATION TEST RESULTS

TEST BORING #	16	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1A
NATURAL UNIT DRY WEIGHT (PCF)			113
NATURAL MOISTURE CONTENT			8.8%
SWELL/CONSOLIDATION (%)			0.4%

JOB NO. 190128
CLIENT TECH CONTRACTORS
PROJECT WINDING WALK, PHASE 3



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SWELL CONSOLIDATION
TEST RESULTS

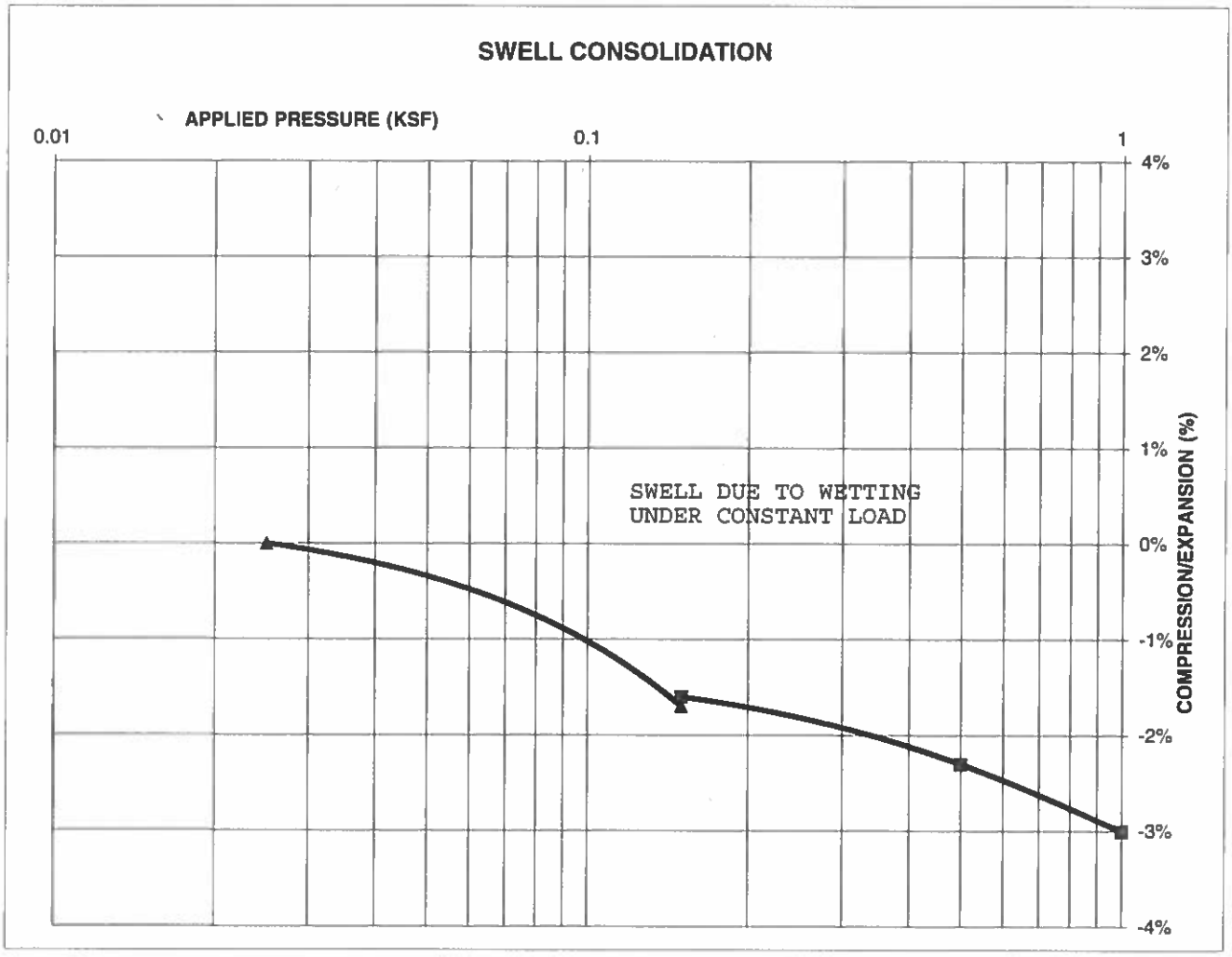
DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-14

CONSOLIDATION TEST RESULTS

TEST BORING #	18	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1A
NATURAL UNIT DRY WEIGHT (PCF)			109
NATURAL MOISTURE CONTENT			9.2%
SWELL/CONSOLIDATION (%)			0.1%

JOB NO. 190128
CLIENT TECH CONTRACTORS
PROJECT WINDING WALK, PHASE 3



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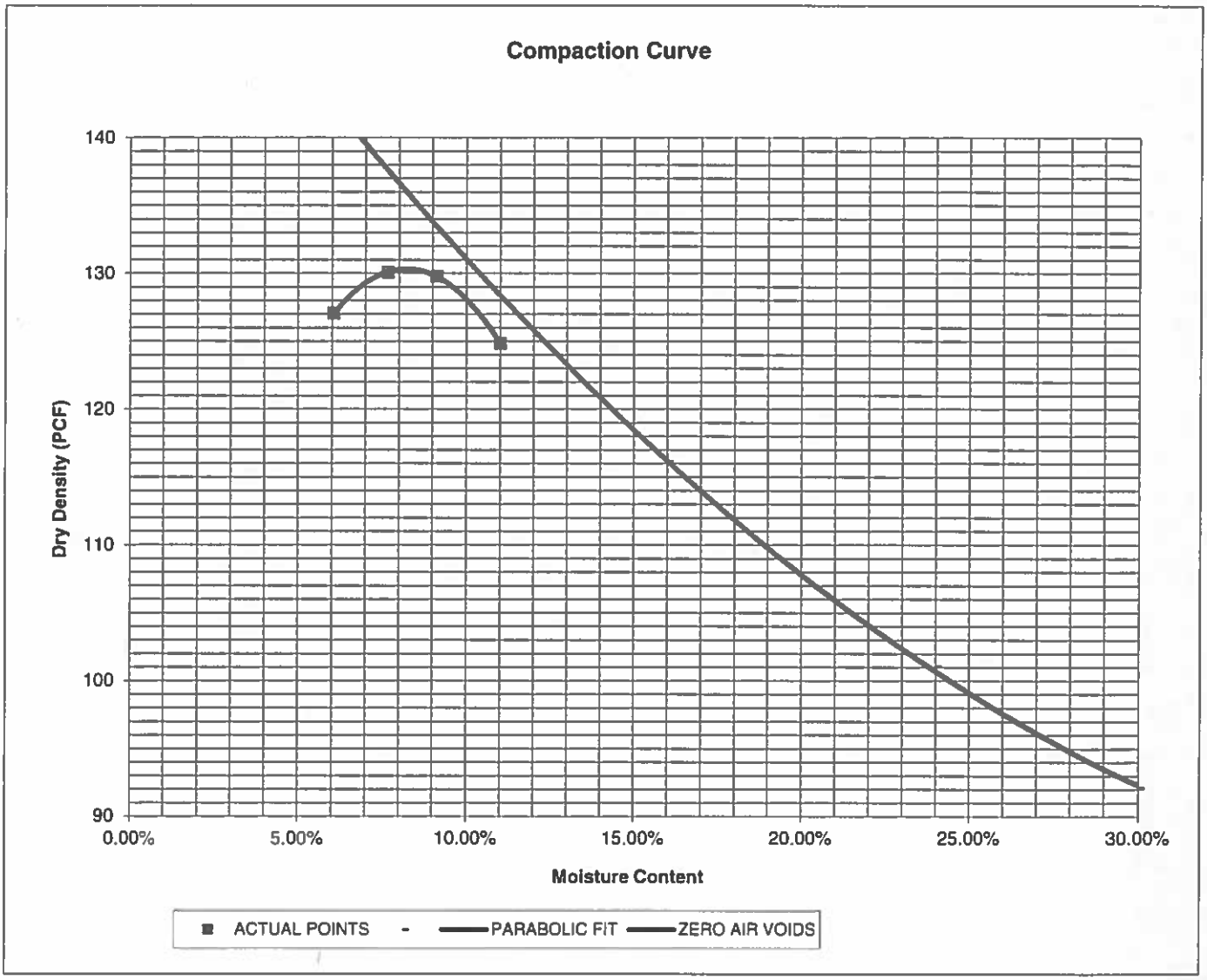
SWELL CONSOLIDATION
TEST RESULTS

DRAWN:	DATE:	CHECKED: SLC	DATE: 9/4/19

JOB NO.: 190128
FIG NO.: B-15

PROJECT	WINDING WALK, PHASE 3	CLIENT	TECH CONTRACTORS
SAMPLE LOCATION	TB-11 @ 0-3'	JOB NO.	190128
SOIL DESCRIPTION	SAND, SILTY, BROWN	DATE	02/05/19

IDENTIFICATION	SC	COMPACTION TEST #	1
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	130.3	OPTIMUM MOISTURE	8.2%



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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128

FIG NO.: B-16

CBR TEST LOAD DATA

JOB NO: 190128
CLIENT: TECH CONTRACTORS
PROJECT: WINDING WALK, PHASE 3
SOIL TYPE: 1A

PISTON DIAMETER (cm)	PISTON AREA (in²)
4.958	2.99250919

PENETRATION DEPTH (INCHES)	*10 BLOWS* MOLD # 15 LOAD(LBS) (LBS)	STRESS (PSI)	*25 BLOWS* MOLD # 5 LOAD(LBS) (LBS)	STRESS (PSI)	*56 BLOWS* MOLD # 12 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	178	59.48	318	106.27	288	96.24
0.050	369	123.31	734	245.28	705	235.59
0.075	477	159.40	1004	335.50	1086	362.91
0.100	707	236.26	1315	439.43	1698	567.42
0.125	890	297.41	1791	598.49	2341	782.29
0.150	1135	379.28	2314	773.26	2910	972.43
0.175	1346	449.79	2635	880.53	3395	1134.50
0.200	1533	512.28	2968	991.81	4079	1363.07
0.300	2034	679.70	4321	1443.94	6000	2005.01
0.400	2268	757.89	4847	1619.71		
0.500	2417	807.68	5023	1678.52		

FINAL MOISTURE CONTENT

	MOLD # 15	MOLD # 5	MOLD # 12
CAN #	307	306	310
WT. CAN	6.75	6.74	6.88
WT. CAN+WET	225.17	339.89	368.96
WT. CAN+DRY	205.71	312.49	342.49
WT. H20	19.46	27.4	26.47
WT. DRY SOIL	198.96	305.75	335.61
MOISTURE CONTENT	9.78%	8.96%	7.89%
WET DENSITY (PCF)	129.7	134.5	139.0
DRY DENSITY (PCF)	119.8	124.3	128.4
BEARING RATIO	23.63	43.94	56.74

90% OF DRY DENSITY	117.3
95% OF DRY DENSITY	123.8

BEARING RATIO AT 90% OF MAX	12.01	~ R VALUE	37
BEARING RATIO AT 95% OF MAX	41.54	~ R VALUE	75

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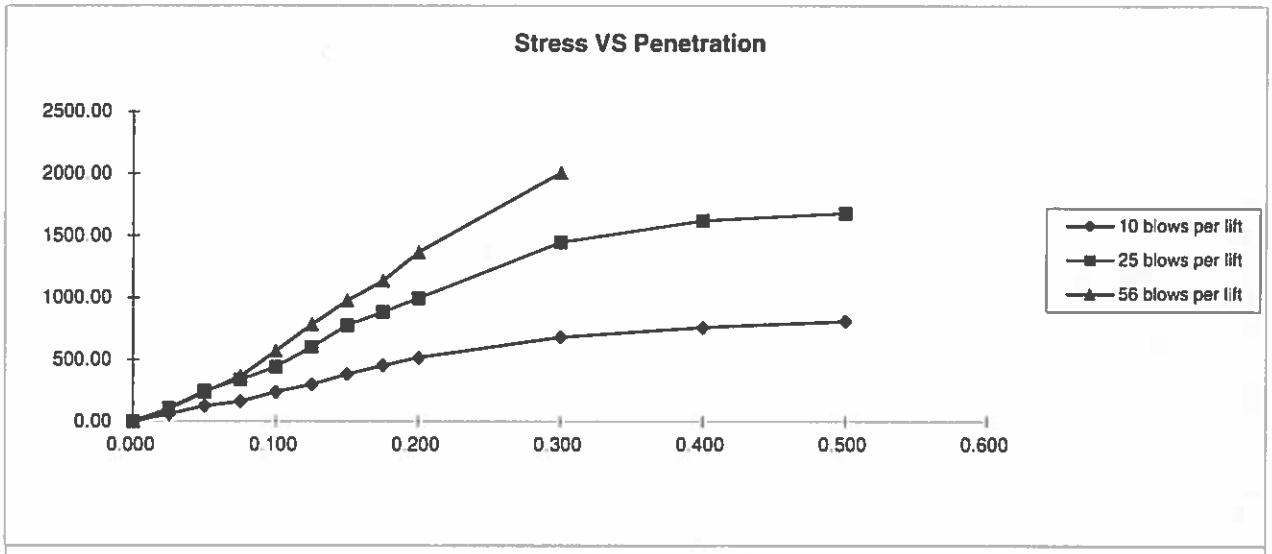
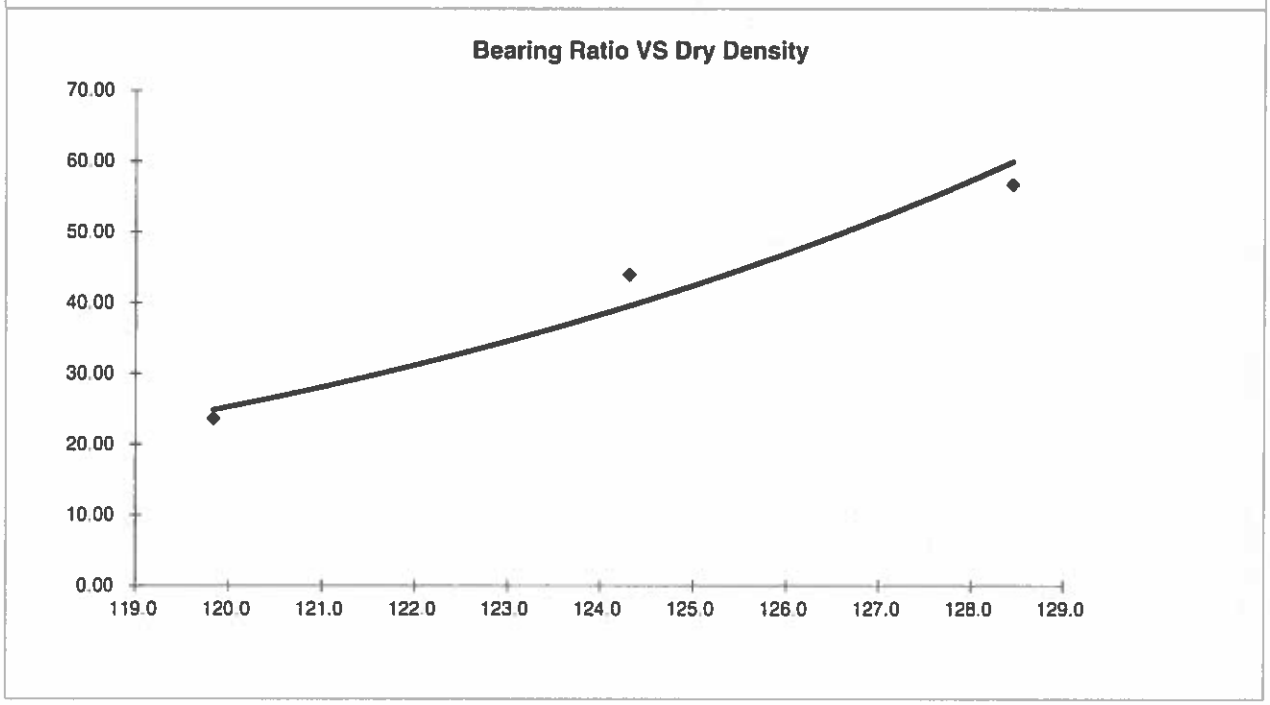
CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
		SCC	4/4/19

JOB NO.: 190128
FIG NO.: B-17





BEARING RATIO AT 90% OF MAX	12.01	~ R VALUE	37.00
BEARING RATIO AT 95% OF MAX	41.54	~ R VALUE	75.00

JOB NO: 190128
SOIL TYPE: 1A

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CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:
		SLC	4/4/19

JOB NO.: 190128
FIG NO.: B-18

CLIENT	TECH CONTRACTORS	JOB NO.	190128
PROJECT	WINDING WALK, PHASE 3	DATE	2/25/2019
LOCATION	WINDING WALK, PHASE 3	TEST BY	BL

BORING NUMBER	DEPTH, (ft)	SOIL TYPE NUMBER	UNIFIED CLASSIFICATION	WATER SOLUBLE SULFATE, (wt%)
TB-10	1-2	1A	SM	<0.01
TB-17	1-2	1A	SM	<0.01
TB-18	1-2	1A	SC	<0.01

QC BLANK PASS

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LABORATORY TEST
SULFATE RESULTS

DRAWN:	DATE:	CHECKED: SCC	DATE: 4/4/19

JOB NO.: 190128
FIG NO.: B-19

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA WINDINGWALK, F1, PH 3 - (LOCAL LOW-VOLUME 36.5K)

SOIL TYPE 1A, CBR # 1A

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	40
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	9497

Weighted Structural Number (WSN): → WSN = 1.67

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10}W_{18} = Z_R * S_O + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10}M_R - 8.07$$

Left	Right	Difference
4.56	4.55	0.0

Job No. 190128
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA WINDINGWALK, F1, PH 3 - (LOCAL LOW-VOLUME 36.5K)

SOIL TYPE 1A, CBR # 1A

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	40
Weighted Structural Number (WSN):	WSN =	1.67

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Aggregate Base Course

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1 =$ 3.8 inches of Full Depth Asphalt
Use 4.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = [3] inches
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 3.2 inches of Aggregate
Base Course, use 4.0 inches

RECOMMENDED ALTERNATIVES

1. 3.0 inches of Asphalt + 4.0 inches of Aggregate Base Course, or
2. 4.0 inches of Asphalt

Job No. 190128
Fig. No. C-2

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA: WINDINGWALK, F1, PH 3 - LOCAL LOW VOLUME 36.5K

SOIL TYPE 1A, CBR #1A

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	40
Weighted Structural Number (WSN):	WSN =	1.67

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Treated Subgrade.

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Treated Subgrade (inches)

FOR FULL DEPTH ASPHALT SECTION - (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1$ = 3.8 inches of Full Depth Asphalt
Use 5.0 inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches USE 4 INCH MINIMUM.
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -0.8 inches
Use 10.0 inches of Cement Treated Subgrade.

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10 inches of Cement Treated Subgrade.
2. 5.0 inches of Full Depth Asphalt

Job No. 190128
Fig. No. C-3

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA WINDINGWALK, F1, PH 2 - URBAN LOCAL ROAD - 292K

SOIL TYPE 1A, CBR # 1A

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	292,000
Hveem Stabilometer (R Value) Results:	R =	40
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	9497

Weighted Structural Number (WSN): → WSN = 2.37

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10}W_{18} = Z_R * S_O + 9.36*\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32*\log_{10}M_R - 8.07$$

Left	Right	Difference
5.47	5.47	0.0

Job No. 190128
Fig. No. C-4

DESIGN CALCULATIONS

DESIGN DATA WINDINGWALK, F1, PH 2 - URBAN LOCAL ROAD - 292K

SOIL TYPE 1A, CBR # 1A

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	292,000
Hveem Stabilometer (R Value) Results:	R =	40
Weighted Structural Number (WSN):	WSN =	2.37

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Aggregate Base Course

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1 =$ 5.4 inches of Full Depth Asphalt
Use 5.5 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = $\boxed{3.5}$ inches
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 7.6 inches of Aggregate
Base Course, use 8.0 inches

RECOMMENDED ALTERNATIVES

1. 3.5 inches of Asphalt + 8.0 inches of Aggregate Base Course, or
2. 5.5 inches of Asphalt

Job No. 190128
Fig. No. C-5

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA: WINDINGWALK, F1, PH 3 -URBAN LOCAL ROAD - 292K

SOIL TYPE 1A, CBR # 1A

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	292,000
Hveem Stabilometer (R Value) Results:	R =	40
Weighted Structural Number (WSN):	WSN =	2.37

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Treated Subgrade.

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Treated Subgrade (inches)

FOR FULL DEPTH ASPHALT SECTION - (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1 =$ 5.4 inches of Full Depth Asphalt
Use 5.5 inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches USE 4 INCH MINIMUM.
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 5.1 inches
Use 10.0 inches of Cement Treated Subgrade.

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10 inches of Cement Treated Subgrade.
2. 5.5 inches of Full Depth Asphalt

Job No. 190128
Fig. No. C-6