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PAVEMENT DESIGN REPORT
WALDEN PRESERVE 2 – FILING NO. 5
EL PASO, COLORADO

Prepared for:
M.A. Infrastructure
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Attn: Matt Dunston

November 1, 2023

Respectfully Submitted,

ENTECH ENGINEERING, INC.

Daniel P. Stegman
Geotechnical Engineering Staff

Reviewed by:

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Entech Job No. 230684

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1 Introduction

Entech Engineering, Inc. (Entech) completed a subsurface investigation for the pavement design for roadways in the Walden Preserve 2 subdivision, Filing No. 5 in northern El Paso County, Colorado (refer to Figure 1). This report describes the subsurface investigation conducted for the proposed roadway improvements and provides pavement section alternatives and construction recommendations. Entech participated in this project as a subconsultant to M.A. Infrastructure. The contents of this report, including the pavement design recommendations, are subject to the limitations and assumptions presented in Section 7.

2 Project Description

The proposed roadways to be constructed include a section of Pinehurst Drive along with 3 cul-de-sacs designated Emerson Cliff Court, cul-de-sac B, and cul-de-sac C. At the time of our subsurface exploration program, the existing roadways had been rough graded and utilities, curbs and gutters were installed. Surrounding properties include vacant land and land being developed for future residential lots. Based on the development plans, the cul-de-sacs are designated as rural local roadways and Pinehurst Drive is designated as a rural minor collector.

3 Subsurface Explorations and Laboratory Testing

3.1 Subsurface Exploration Program

Subsurface conditions at the project site were explored by ten test borings, designated TB-1 through TB-10, drilled on September 25, 2023. The locations of the test borings are shown on the Site and Exploration Plan (Figure 2). The borings were drilled to depths of 5 to 10 feet below the existing ground surface (bgs). The drilling was performed using a truck-mounted, continuous flight auger drill rig supplied and operated by Entech. Descriptive boring logs providing the lithologies of the subsurface conditions encountered during drilling are presented in Appendix A. Groundwater levels were measured in each of the open boreholes at the conclusion of drilling.

Soil and bedrock samples were obtained from the borings utilizing the Standard Penetration Test (ASTM D1586) using a split-barrel California sampler. Results of the Standard Penetration Test (SPT) are included on the boring logs in terms of N-values expressed in blows per foot (bpf). Soil and bedrock samples recovered from the borings were visually classified and recorded on the boring logs. The soil classifications were later verified utilizing laboratory testing and grouped by

soil type. The soil type numbers are included on the boring logs. It should be understood that the soil descriptions shown on the boring logs may vary between boring locations and sample depths. It should also be noted that the lines of stratigraphic separation shown on the boring logs represent approximate boundaries between soil types and the actual stratigraphic transitions may be more gradual or variable with location.

3.2 Geotechnical Index and Engineering Property Testing

Water content testing (ASTM D2216) was performed on the samples recovered from the borings, and the results are shown on the boring logs. Grain-Size Analysis (ASTM D422) and Atterberg Limits testing (ASTM D4318) were performed on selected samples to assist in classifying the materials encountered in the borings. Swell/Consolidation testing (ASTM D 4546) was performed to determine the expansive/compressive characteristics.

For pavement design, a modified proctor (ASTM D1557) and California Bearing Ratio (CBR) test (ASTM D1883) were completed. Soluble sulfate testing was performed on select soil samples to evaluate the potential for below grade degradation of concrete due to sulfate attack. The laboratory testing results are presented in Appendix B and summarized in Table B-1.

Strength testing was performed on two sets of soil/cement composite samples. Testing was performed on soil samples prepared with 2% and 4% Portland Cement Type 1/2. A compression strength of 160 pounds per square inch (psi) is recommended for cement stabilized subgrade. The 7-day average strength value of the 2% mix was 231 psi. The 7-day average strength value of the 4% mix was 287 psi. A 2% mix is recommended based on the laboratory test results. A summary of the testing results is attached in Appendix B, Table B-2.

4 Subgrade Conditions

Three primary soil types and one bedrock type were encountered in the test borings drilled for the subsurface investigation. Each soil type was classified in accordance with the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system using the laboratory testing results and the observations made during drilling.

4.1 Subsurface Conditions

Subsurface conditions along the proposed roadways consisted of loose to medium dense silty sand fill and clayey-silty sand fill (Soil Type 1), medium dense clayey-silty sand and sandy clay fill (Soil Type 2), and native silty sand (Soil Type 3). Very weak sandstone was encountered at a depth of 5 feet bgs in TB-6. When classified as a soil, the sandstone classified as very dense, moderately weathered silty sand (Soil Type 4). Soil types and corresponding AASHTO soil classifications are listed as follows.

- Soil Type 1: A-2-4
- Soil Type 2: A-6
- Soil Type 3: A-2-4
- Soil Type 4: A-2-4

Laboratory test results are presented in Appendix B and are summarized in Table B-1.

4.2 Groundwater

Groundwater was not encountered in the test borings. Groundwater fluctuations are possible and will depend on seasonal variations, local precipitation, runoff, and other factors. We do not anticipate groundwater to affect the proposed roadway construction.

5 Pavement Design Recommendations

Pavement design recommendations were made in accordance with the El Paso County Engineering Criteria Manual.

5.1 Subgrade Conditions

California Bearing Ratio (CBR) testing was performed on a representative sample of the subgrade silty sand fill (Soil Type 1) from TB-6 to determine the support characteristic of the subgrade soils for the roadway section. The results of the CBR testing are presented in Appendix B and summarized in Exhibit 1.

Exhibit 1: Subsurface Laboratory Testing Summary

Design Parameter	Value
Soil Type	1 – Silty Sand Fill
CBR at 95%	28.71
Design CBR	10
Liquid Limit	NV
Plasticity Index	NP
Percent Passing 200	17.9
AASHTO Classification	A-2-4
Unified Soils Classification	SM

5.2 Swell Mitigation

El Paso County regulations require swell mitigation of expansive soils criteria for soils with swell testing results greater than 2% under a 150 pounds per square foot (psf) surcharge. Localized areas of high clay contents (Soil Type 2, AASHTO A-6) were encountered in TB-3 and TB-5. Swell testing on Soil Type 2 resulted in volume changes of 0.5 and 0.6%. Based on the test results and the classification of the soils, mitigation for expansive soils is not required. Overexcavation of cohesive soils is recommended to provide proper subgrade support as discussed in Section 6.1.1.

5.3 Traffic Loading

Traffic data for the proposed roadways in the filing were provided in the Traffic Impact Study by LSC Transportation Consultants Inc. dated March 1, 2022, LSC # S214070. The cul-de-sacs were classified as rural local roadways and Pinehurst Drive was classified as a rural minor collector. The El Paso County Engineering Criteria Manual provides default 18-kip equivalent single axle loading (ESAL) based street classifications. For design, a default ESAL value of 36,500 was used for the rural local cul-de-sacs and 109,500 was used for the rural minor collector section of Pinehurst Circle.

5.4 Pavement Design

The pavement sections were determined utilizing the El Paso County Engineering Criteria Manual, the CBR testing, and default ESAL values. Design parameters used in the pavement analysis are presented in Exhibit 2.

Exhibit 2: Pavement Design Parameters

Design Parameter	Value
Reliability	
Rural Local	75%
Rural Minor Collector	80%
Standard Deviation	0.45
Serviceability Loss (Δ psi)	2.0
Design CBR	10.0
Resilient Modulus	15,000 psi
Structural Coefficients	
Hot Mix Asphalt	0.44
Cement Treated Subgrade	0.11

Pavement sections recommended for roads are summarized in Exhibit 3. The pavement design calculations are presented in Appendix C.

Exhibit 3: Recommended Pavement Sections

Pavement Area	Roadway Designation	Design ESAL	Alternative [1]
Cul-de-Sacs [2]	Rural Local	36,500	1. 4.0 inches HMA over 8.0 inches CTS
			2. 3.0 inches HMA over 4.0 inches ABC
Pinehurst Circle	Rural Minor Collector	109,500	1. 4.0 inches HMA over 8.0 inches CTS
			2. 3.0 inches HMA over 6.0 inches ABC

ABC = Aggregate Base Course; CTS = cement treated subgrade; ESAL = equivalent single axle loads; HMA = Hot Mix Asphalt

Notes:

1. All pavement alternatives meet the minimum sections required per El Paso County Pavement Design Criteria.
2. Roadways include: Emerson Cliff Court, Cul-de-Sac B, and Cul-de-Sac C.

6 Construction Recommendations

Pavement design recommendations provided herein are contingent on good construction practices, and poor construction techniques may result in poor performance. Our analyses assumed that this project will be constructed according to the El Paso County Engineering Criteria Manual and the Pikes Peak Region Asphalt Paving Specifications.

6.1 Earthwork Recommendations for Pavement Subgrade

Proper subgrade preparation is required for adequate pavement performance. Paving areas should be cleared of all deleterious materials including but not limited to: existing pavements,

utility poles, and fence poles. Surface vegetation, if any, should be removed by stripping, with the depth to be field determined.

6.1.1 Overexcavation

Where encountered, cohesive soils (Soil Type 2) should be removed to a depth 18-inches and replaced with granular fill (Section 6.1.4) to provide uniform subgrade support. The extents of any cohesive material overexcavation should be field determined.

6.1.2 Subgrade Preparation – ABC Alternatives

If pavement section alternatives are selected utilizing ABC, the final subgrade surface should be scarified to a depth of 12 inches, moisture conditioned within +/-2% over the optimum water content, and recompacted to 95% of its maximum Modified Proctor dry density, ASTM D1557.

Any A-6 material identified during scarification should be removed to a depth of 18-inches and be replaced with granular fill as discussed in Section 6.1.1.

The compacted surface below pavements should be proof-rolled with a fully loaded, tandem-axle, 10-yard dump truck or equivalent. Any areas that are delineated to be soft, loose, or yielding during proof-rolling should be removed and reconditioned or replaced.

6.1.3 Cement-treated Subgrade Preparation

For pavement section alternatives utilizing cement treated subgrade (CTS), the subgrade shall be stabilized prior to placement of the asphalt by the addition of cement to a depth of at least 8 inches. The amount of cement applied shall be a minimum of 2% (by weight) of the subgrade's maximum dry density as determined by the Modified Proctor Test (ASTM D1557) for granular soils or by the Standard Proctor Test (ASTM D698) for cohesive soils. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over an 8-inch depth, as specified, such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 8 inches of subgrade should be thoroughly moisture conditioned to the soil's optimum water content or as much as 2% 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% of the subgrade maximum dry density as determined by the Modified Proctor Test (ASTM D1557) or by the Standard Proctor Test (ASTM D698). 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 of Type 1L 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 degrees F. Cement-treated subgrades should be maintained at a temperature of 40 degrees 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 qualified geotechnical engineer. The geotechnical engineer should complete in-situ compaction tests and construct representative compacted specimens of the treated subgrade material for subsequent laboratory quality assurance testing.

Pending the results of the field density testing, microfracturing of the stabilized subgrade may be required. Soil strengths in excess of 275 psi require microfracturing.

6.1.4 Fill Placement and Compaction

Granular fill placed as part of the pavement subgrade shall consist of non-expansive, granular soil, free of organic matter, unsuitable materials, debris, and cobbles greater than 3 inches in diameter. Additionally, any granular fill placed as part of the roadway subgrade should have a minimum CBR of 10. All granular fill placed within the pavement subgrade should be compacted to a minimum of 95% of its maximum Modified Proctor Dry Density (ASTM D1557) at +/-2% of optimum moisture content. Fill material should be placed in horizontal lifts such that each finished lift has a compacted thickness of 6 inches or less. Entech should approve any imported fill to be used within the pavement subgrade area prior to delivery to the site.

6.2 Concrete Degradation Due to Sulfate Attack

Sulfate solubility testing was conducted on several samples recovered from the test borings to evaluate the potential for sulfate attack on concrete. The test results indicated less than 0.01% to 0.04% soluble sulfate (by weight). The test results indicate the sulfate component of the in-place soils presents a negligible exposure threat to concrete placed below the site grade.

Type I/II or Type 1L cement is recommended for concrete on the site. To further avoid concrete degradation during construction, it is recommended that concrete not be placed on frozen or wet

ground. Care should be taken to prevent the accumulation or ponding of water in the foundation excavation prior to the placement of concrete. If standing water is present in the foundation excavation, it should be removed by ditching to sumps and pumping the water away from the foundation area prior to concrete placement. If concrete is placed during periods of cold temperatures, the concrete must be kept from freezing. This may require covering the concrete with insulated blankets and adding heat to prohibit freezing.

6.3 Aggregate Base Course

ABC materials shall conform to the El Paso County Standard Specifications, Table D-6, Aggregate Base Course Materials. ABC materials should be compacted to a minimum of 95% of its maximum Modified Proctor Dry Density (ASTM D1557) at +/-2% of optimum moisture content.

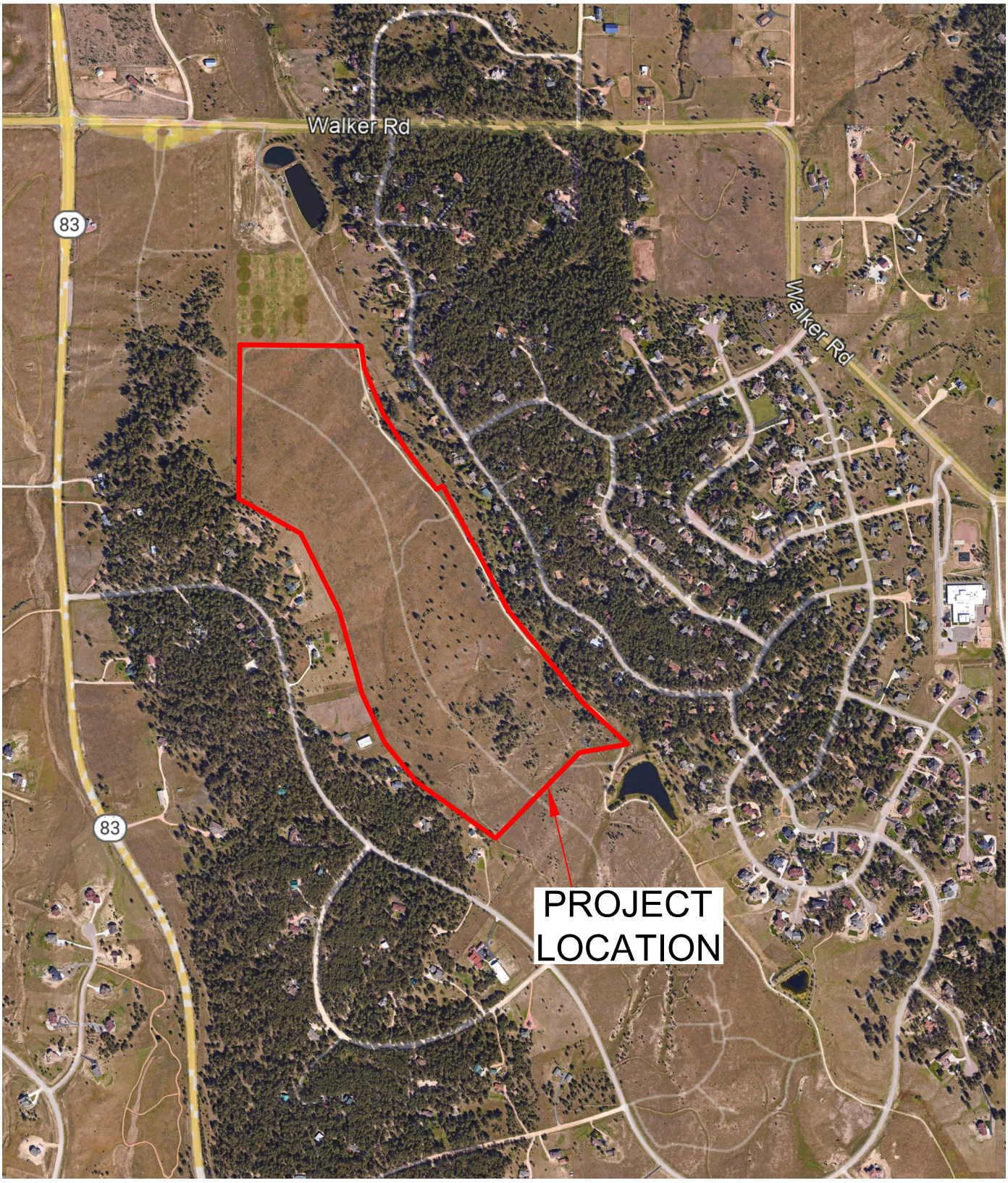
6.4 Construction Observation

Subgrade preparation for pavement structures should be observed by Entech in order to verify that (1) no anomalies are present, (2) materials similar to those described in this report have been encountered or placed, and (3) no soft spots, expansive or organic soil, or debris are present in the pavement subgrade prior to paving.

7 Closure

The subsurface investigation, geotechnical evaluation, and recommendations presented in this report are intended for use by M.A. Infrastructure with application to the Walden Preserve 2, Filing No. 5 roadways paving project in in El Paso County, Colorado. In conducting the subsurface investigation, laboratory testing, engineering evaluation, and reporting, Entech Engineering, Inc. endeavored to work in accordance with generally accepted professional geotechnical and geologic practices and principles consistent with the level of care and skill ordinarily exercised by members of the geotechnical profession currently practicing in the same locality and under similar conditions. No other warranty, expressed or implied, is made. During final design and/or construction, if conditions are encountered which appear different from those described in this report, Entech Engineering, Inc. requests to be notified so that the evaluation and recommendations presented herein can be reviewed and modified as appropriate.

If there are any questions regarding the information provided herein, or if Entech Engineering, Inc. can be of further assistance, please do not hesitate to contact us.



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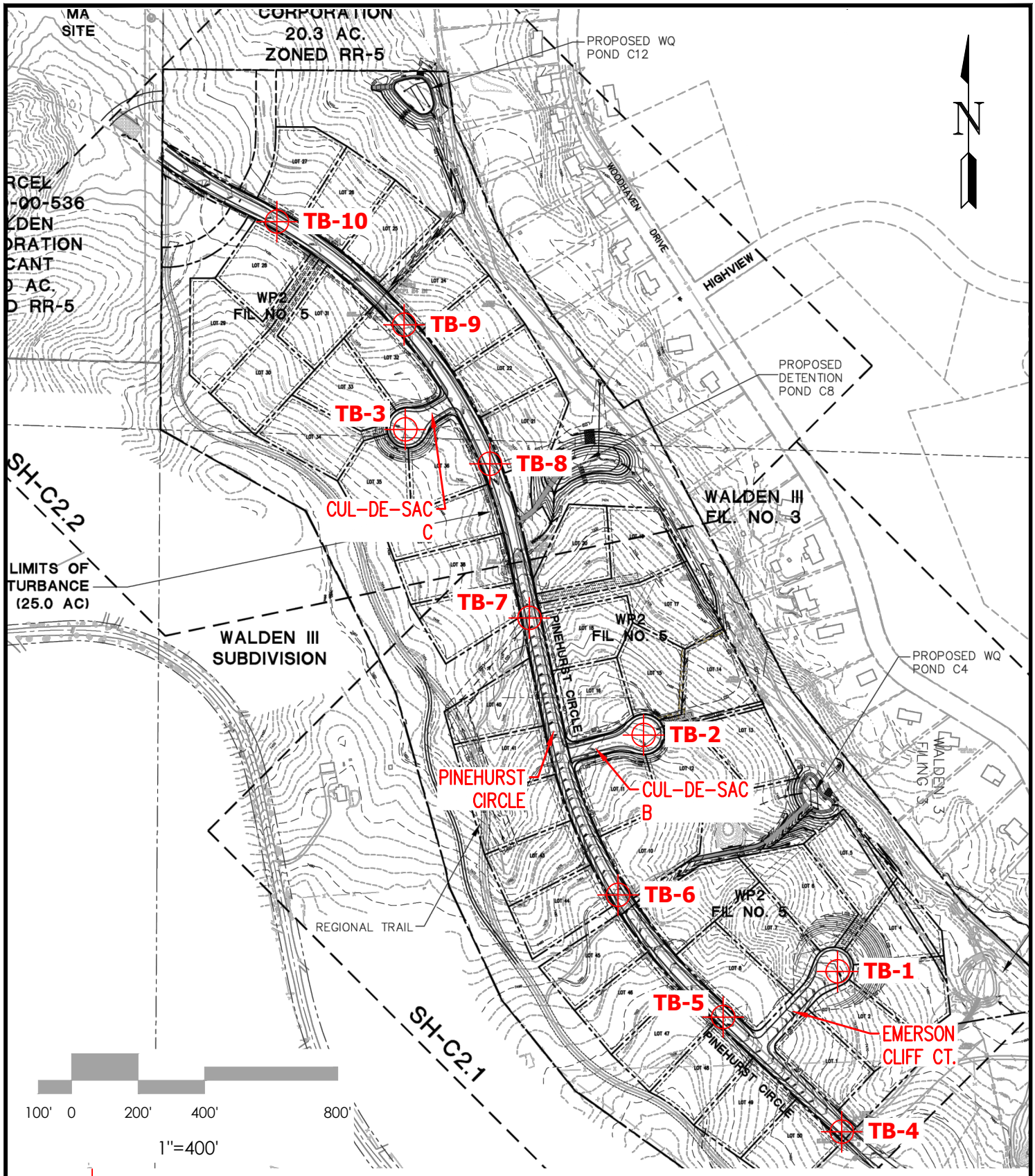
VICINITY MAP

WALDEN PRESERVE 2, FILING NO. 5
MA INFRASTRUCTURE

JOB NO.
230684

FIG. 1



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VICINITY MAP

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MA INFRASTRUCTURE

JOB NO. 230684

FIG. 2

APPENDIX A: Test Boring Logs

TEST BORING 1
DATE DRILLED 9/25/2023

REMARKS

DRY TO 5', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			8	3.8	3	SAND, SILTY, LIGHT BROWN, LOOSE to MEDIUM DENSE, MOIST
5			10	4.8	3	
10						
15						
20						

TEST BORING 2
DATE DRILLED 9/25/2023

REMARKS

DRY TO 5', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			13	8.7	1	FILL 0-4', SAND, SILTY, LIGHT BROWN, MEDIUM DENSE, MOIST
5			20	7.7	3	SAND, SILTY, TAN, MEDIUM DENSE, MOIST
10						
15						
20						

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TEST BORING LOGS

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JOB NO. 230684

FIG. A-1

TEST BORING 3
DATE DRILLED 9/25/2023

REMARKS

DRY TO 5', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			13	13.9	2
5			7	16.7	2
10					
15					
20					

FILL 0-5', CLAY, SANDY, BROWN, STIFF to MEDIUM STIFF, MOIST

TEST BORING 4
DATE DRILLED 9/25/2023

REMARKS

DRY TO 10', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			17	8.6	1
5			9	14.0	1
10			13	12.3	1
15					
20					

FILL 0-10', SAND, SILTY, TAN, MEDIUM DENSE to LOOSE, MOIST

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TEST BORING LOGS

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FIG. A-2

TEST BORING 5
DATE DRILLED 9/25/2023

REMARKS

DRY TO 5', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			20	7.9	2
5			20	6.9	2
10					
15					
20					

FILL 0-5', SAND, CLAYEY-SILTY, LIGHT BROWN, MEDIUM DENSE, MOIST

TEST BORING 6
DATE DRILLED 9/25/2023

REMARKS

DRY TO 10', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			26	5.9	1
5			33	4.9	1
10			50/11"	5.8	4
15					
20					

FILL 0-5', SAND, SILTY, LIGHT BROWN, MEDIUM DENSE to DENSE, MOIST

SANDSTONE, VERY WEAK, TAN, MODERATELY WEATHERED (SAND, SILTY, VERY DENSE, MOIST)

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TEST BORING LOGS

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FIG. A-3

TEST BORING 7
DATE DRILLED 9/25/2023

REMARKS

DRY TO 5', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-5', SAND, SILTY, LIGHT BROWN, MEDIUM DENSE, MOIST			17	14.6	1
5			17	7.0	1
10					
15					
20					

TEST BORING 8
DATE DRILLED 9/25/2023

REMARKS

DRY TO 10', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-9', SAND, SILTY, BROWN, MEDIUM DENSE, MOIST			11	17.6	1
5			12	5.3	1
10 SAND, SILTY, TAN, MEDIUM DENSE, MOIST			19	5.1	3
15					
20					

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TEST BORING LOGS

WALDEN PRESERVE 2, FILING NO. 5
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FIG. A-4

TEST BORING 9
DATE DRILLED 9/25/2023

REMARKS

DRY TO 5', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			13	6.2	1	FILL 0-5', SAND, SILTY, LIGHT BROWN, MEDIUM DENSE, MOIST
5			10	8.3	1	
10						
15						
20						

TEST BORING 10
DATE DRILLED 9/25/2023

REMARKS

DRY TO 5', 9/25/23

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
			15	11.1	1	FILL 0-4', SAND, CLAYEY-SILTY, BROWN, MEDIUM DENSE, MOIST
5			4	7.4	3	SAND, SILTY, TAN, LOOSE, MOIST
10						
15						
20						

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TEST BORING LOGS

WALDEN PRESERVE 2, FILING NO. 5
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FIG. A-5

APPENDIX B: Laboratory Test Results

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SULFATE (WT %)	SWELL/ CONSOL (%)	AASHTO CLASS.	USCS	SOIL DESCRIPTION
1, CBR	6	0-3			17.9	NV	NP	NP			A-2-4	SM	FILL, SAND, SILTY
1	4	1-2			34.5	NV	NP	NP			A-2-4	SM	FILL, SAND, SILTY
1	6	1-2			35.8	NV	NP	NP			A-2-4	SM	FILL, SAND, SILTY
1	9	1-2			16.6	NV	NP	NP	0.04		A-2-4	SM	FILL, SAND, SILTY
1	10	1-2			34.5	22	16	6			A-2-4	SC-SM	FILL, SAND, CLAYEY-SILTY
1	7	1-2			27.1	NV	NP	NP			A-2-4	SM	FILL, SAND, SILTY
1	8	1-2			19.6	NV	NP	NP			A-2-4	SM	FILL, SAND, SILTY
1	2	1-2			19.8	NV	NP	NP			A-2-4	SM	FILL, SAND, SILTY
2	3	1-2	13.8	115.2	59.7	31	16	15		0.5	A-6	CL	FILL, CLAY, SANDY
2	5	1-2	9.1	122.9	47.6	25	19	6	<0.01	0.6	A-6	SC-SM	FILL, SAND, CLAYEY-SILTY
3	1	1-2			26.1	NV	NP	NP			A-2-4	SM	SAND, SILTY

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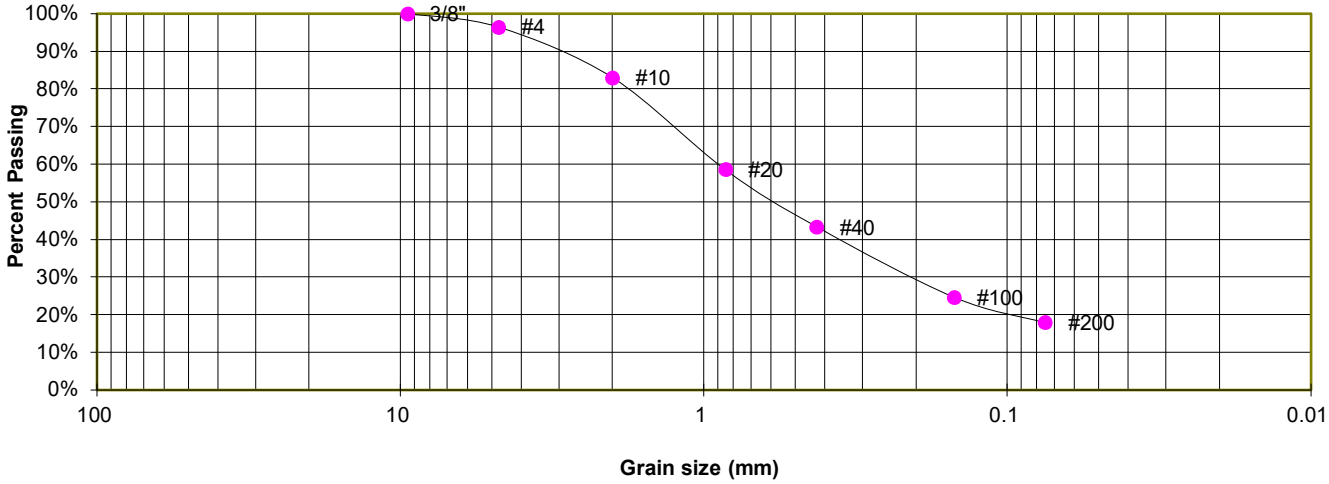
TABLE B-2
SUMMARY OF CTS TEST RESULTS

FIELD SAMPLE ID: SAND, SILTY
SOIL ADDITIVE: TYPE I/II CEMENT
CURING METHOD: 100° HUMIDIFIED OVEN

ADDITIVE %	*WATER %*	*DENSITY (dry)*	*AGE (days)*	*STRENGTH (psi)*
2	9.1	119.5	7	232
2	9.1	119.3	7	221
2	9.1	119.6	7	240
			AVERAGE:	**231**
4	9.1	119.8	7	291
4	9.1	119.1	7	298
4	9.1	119.3	7	271
			AVERAGE:	**287**

TEST BORING	6	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	0-3	SOIL TYPE	1, CBR



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.5%
10	83.0%
20	58.6%
40	43.3%
100	24.7%
200	17.9%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

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LABORATORY TEST RESULTS

WALDEN PRESERVE 2, FILING NO. 5
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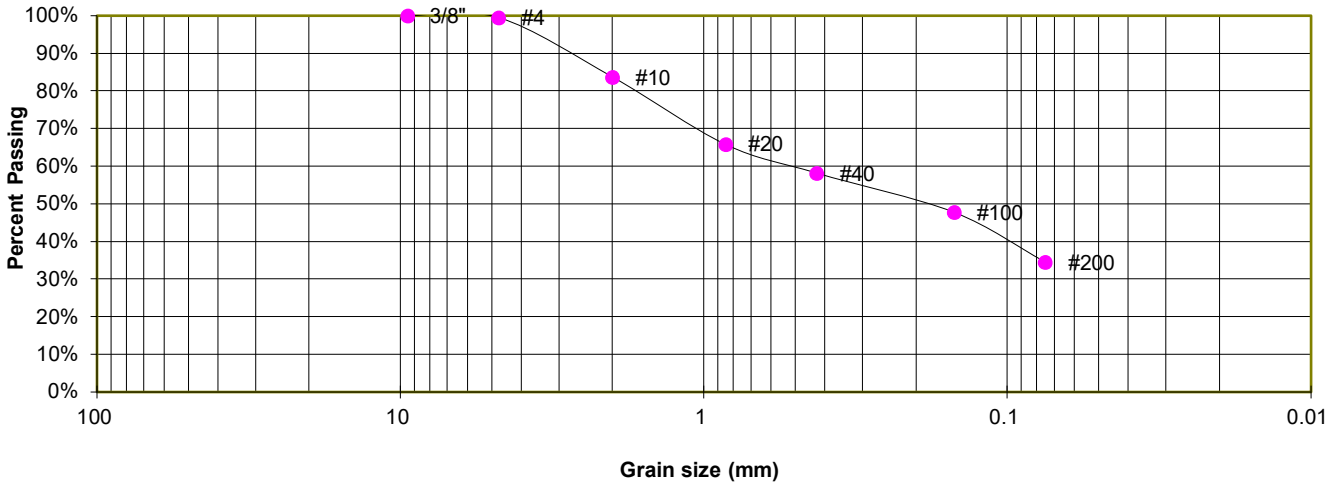
FIG. B-1

TEST BORING 4	SOIL DESCRIPTION FILL, SAND, SILTY
DEPTH (FT) 1-2	SOIL TYPE 1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.5%
10	83.7%
20	65.9%
40	58.2%
100	47.8%
200	34.5%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

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LABORATORY TEST RESULTS

WALDEN PRESERVE 2, FILING NO. 5
MA INFRASTRUCTURE

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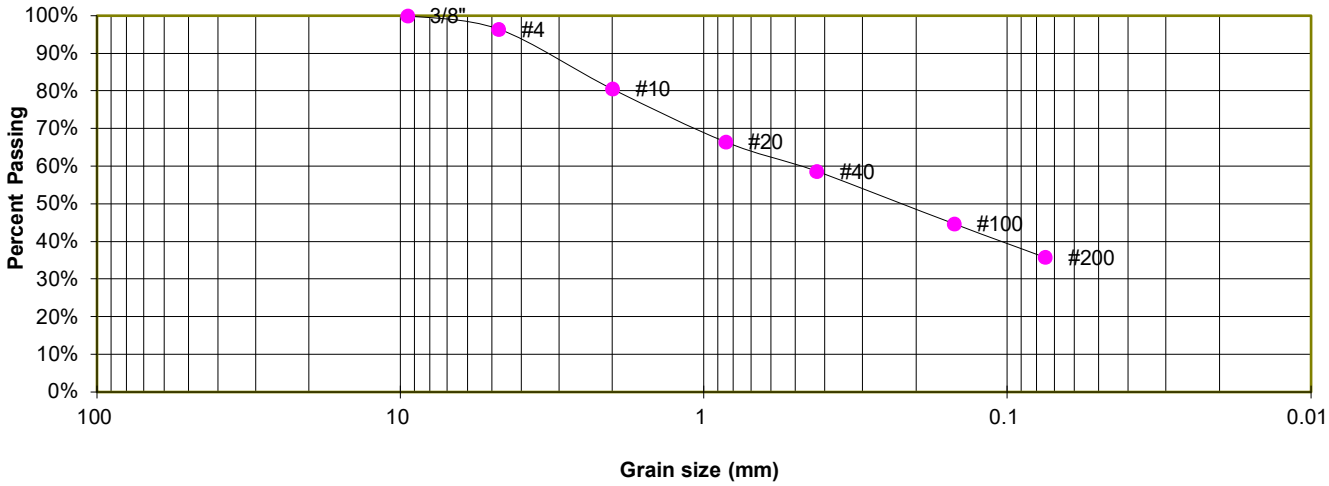
FIG. B-2

TEST BORING	6	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.4%
10	80.5%
20	66.5%
40	58.7%
100	44.7%
200	35.8%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

ENTECH ENGINEERING, INC.

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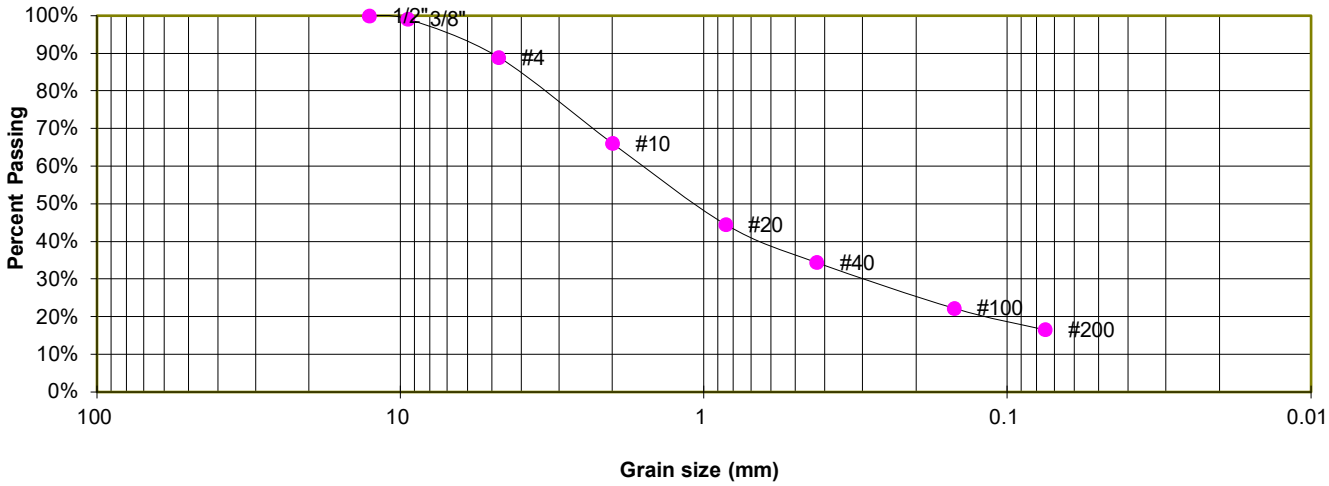
FIG. B-3

TEST BORING	9	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	99.2%
4	89.0%
10	66.1%
20	44.6%
40	34.5%
100	22.3%
200	16.6%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

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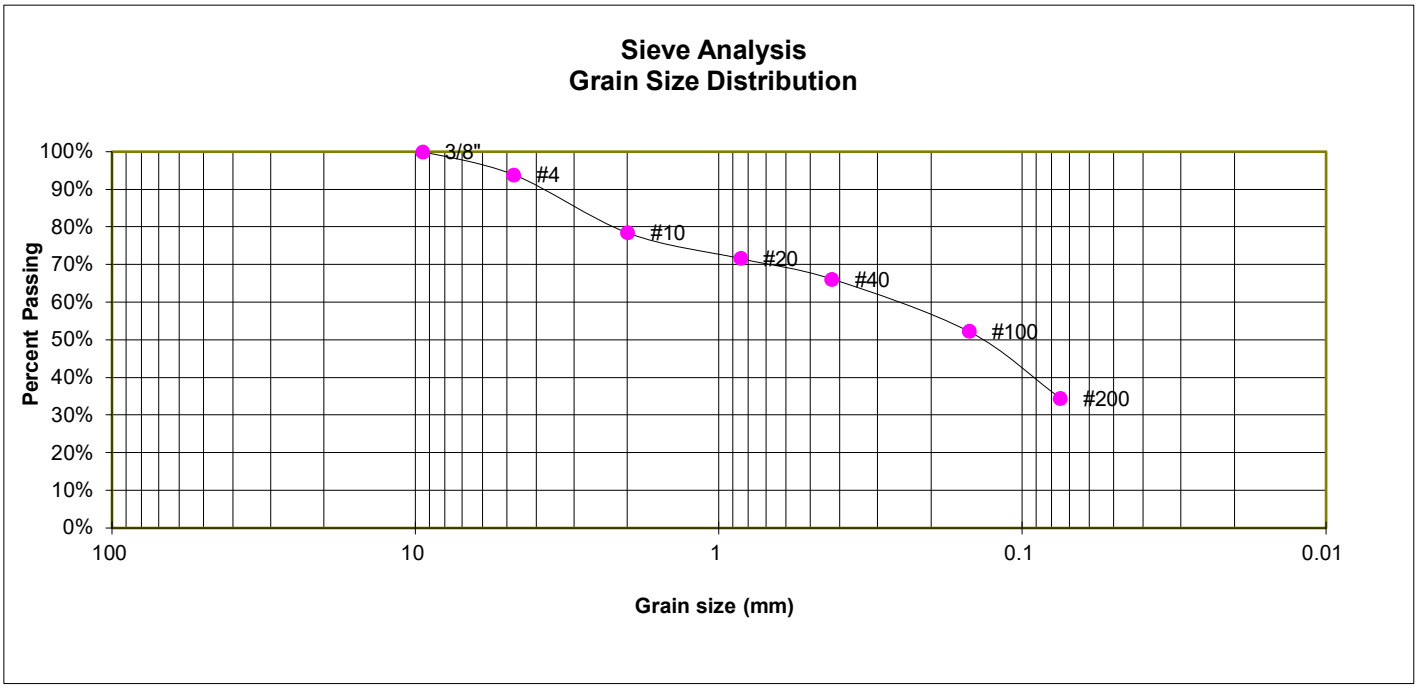
FIG. B-4

TEST BORING	10	SOIL DESCRIPTION	FILL, SAND, CLAYEY-SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	93.9%
10	78.5%
20	71.7%
40	66.2%
100	52.3%
200	34.5%

ATTERBERG LIMITS

Plastic Limit	16
Liquid Limit	22
Plastic Index	6

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC-SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

ENTECH ENGINEERING, INC.

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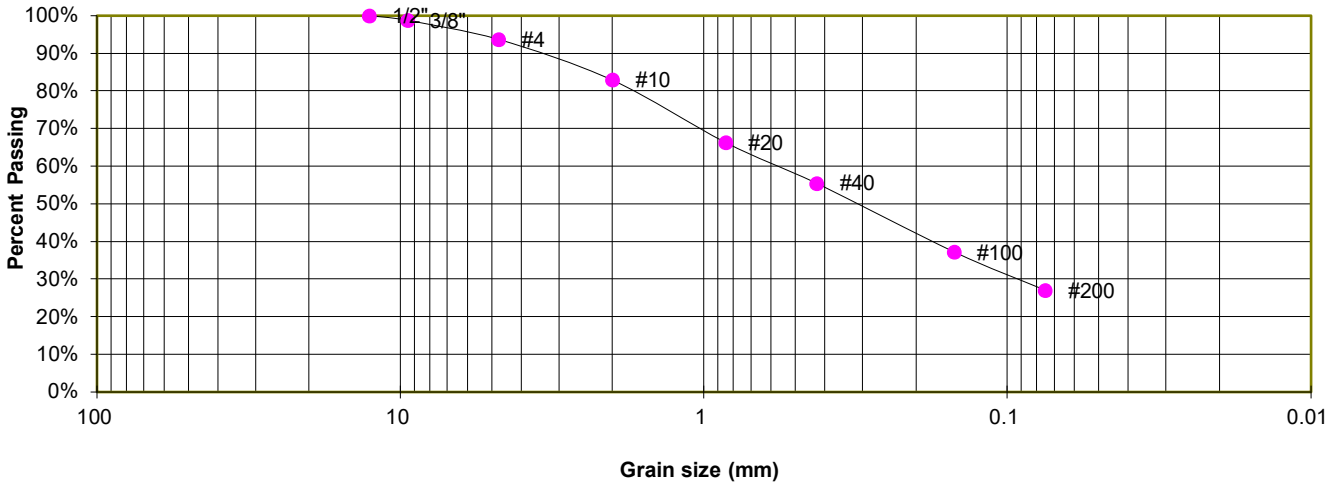
FIG. B-5

TEST BORING	7	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.8%
4	93.7%
10	82.9%
20	66.4%
40	55.5%
100	37.3%
200	27.1%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

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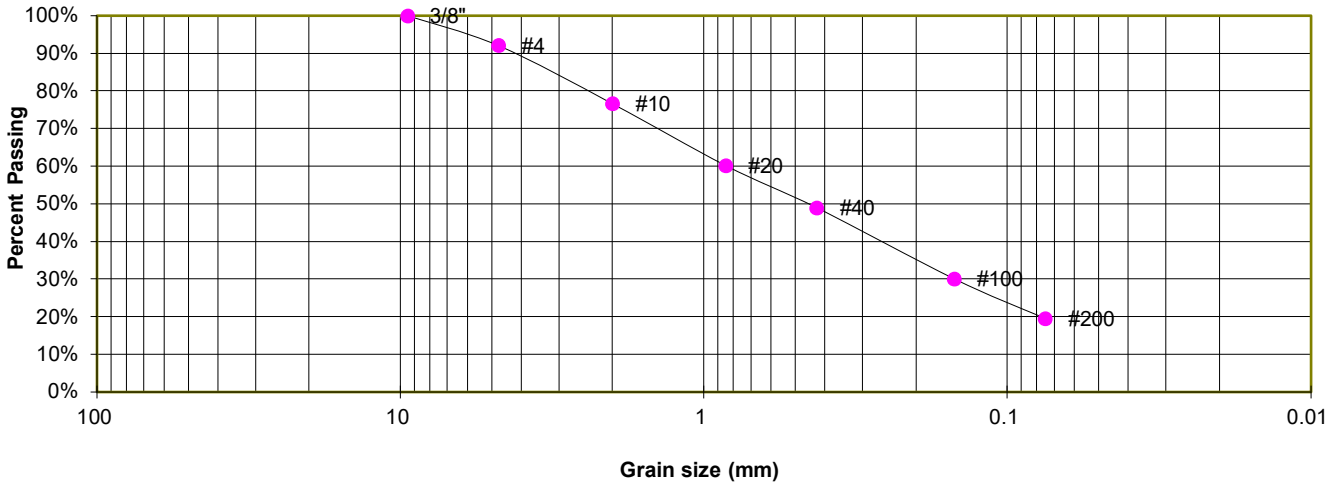
FIG. B-6

TEST BORING	8	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	92.1%
10	76.7%
20	60.2%
40	49.0%
100	30.1%
200	19.6%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

ENTECH ENGINEERING, INC.

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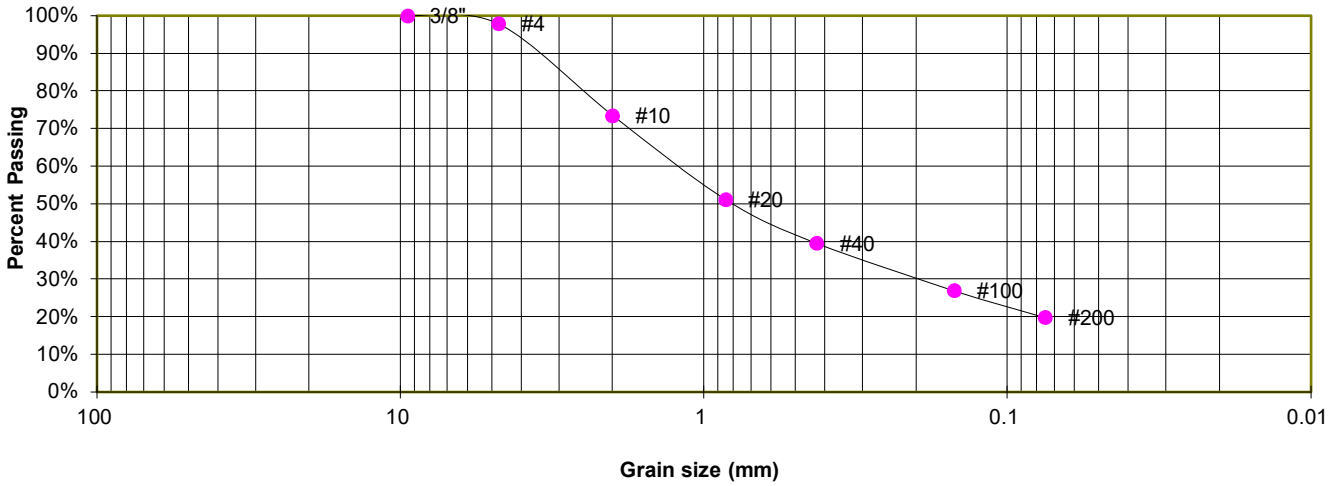
FIG. B-7

TEST BORING	2	SOIL DESCRIPTION	FILL, SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.9%
10	73.5%
20	51.2%
40	39.6%
100	27.0%
200	19.8%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

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LABORATORY TEST RESULTS

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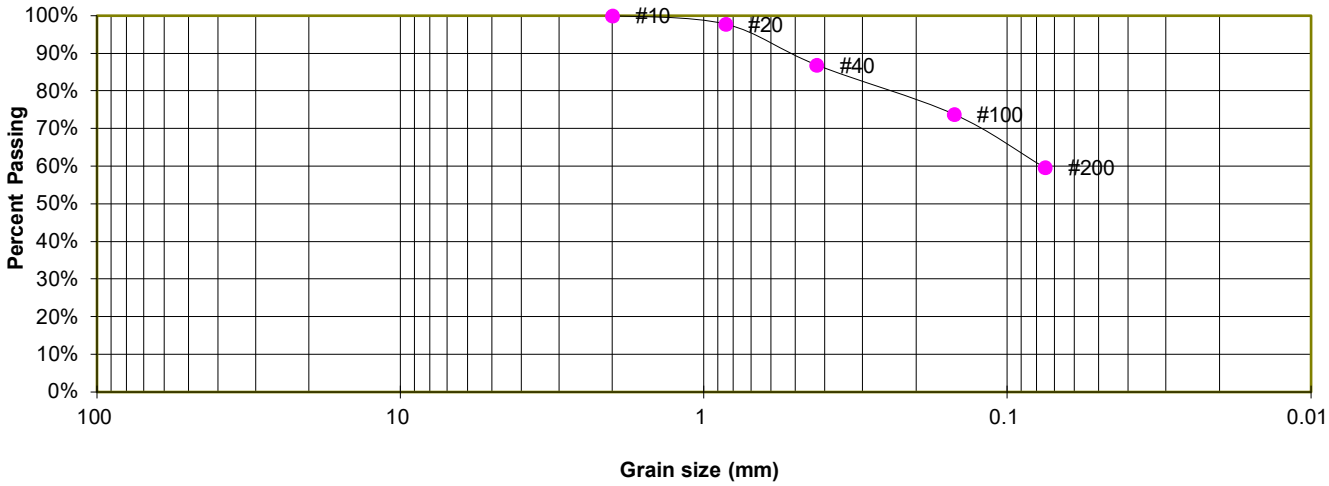
FIG. B-8

TEST BORING	3	SOIL DESCRIPTION	FILL, CLAY, SANDY
DEPTH (FT)	1-2	SOIL TYPE	2



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	100.0%
20	97.8%
40	86.9%
100	73.8%
200	59.7%

ATTERBERG LIMITS

Plastic Limit	16
Liquid Limit	31
Plastic Index	15

SOIL CLASSIFICATION

USCS CLASSIFICATION:	CL
AASHTO CLASSIFICATION:	A-6
AASHTO GROUP INDEX:	6

ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

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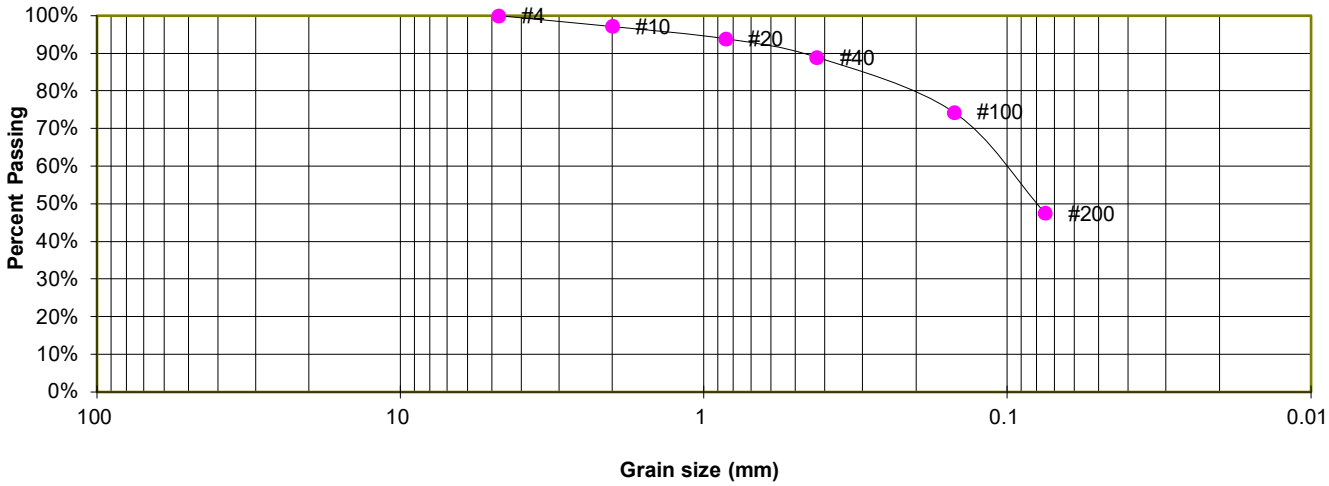
FIG. B-9

TEST BORING	5	SOIL DESCRIPTION	FILL, SAND, CLAYEY-SILTY
DEPTH (FT)	1-2	SOIL TYPE	2



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	97.2%
20	93.9%
40	89.0%
100	74.4%
200	47.6%

ATTERBERG LIMITS

Plastic Limit	19
Liquid Limit	25
Plastic Index	6

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC-SM
AASHTO CLASSIFICATION:	A-6
AASHTO GROUP INDEX:	0

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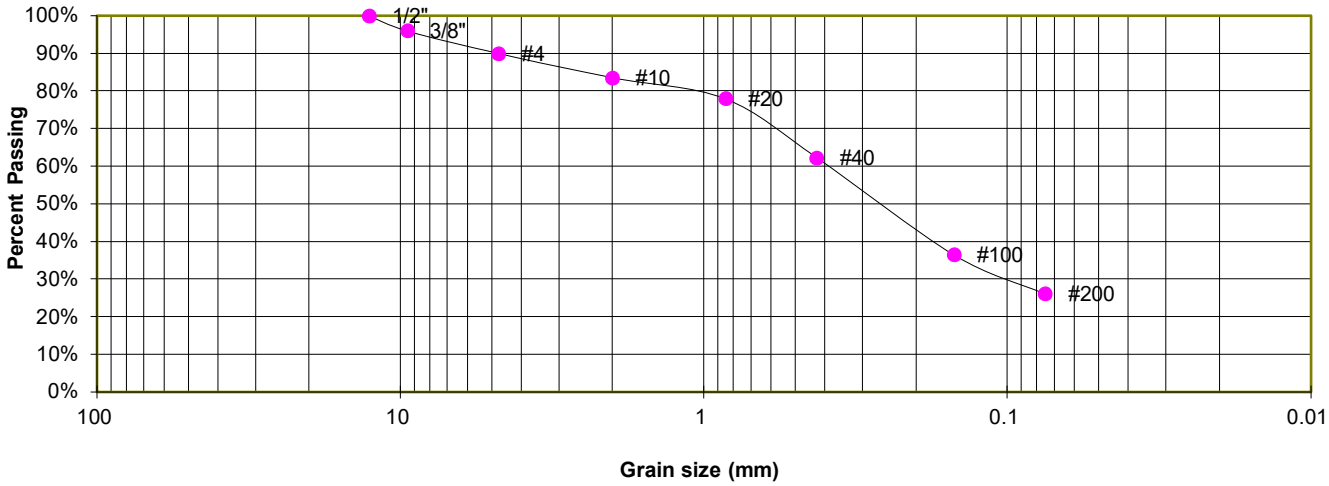
FIG. B-10

TEST BORING	1	SOIL DESCRIPTION	SAND, SILTY
DEPTH (FT)	1-2	SOIL TYPE	3



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	96.0%
4	89.9%
10	83.5%
20	78.0%
40	62.3%
100	36.5%
200	26.1%

ATTERBERG LIMITS

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SM
AASHTO CLASSIFICATION:	A-2-4
AASHTO GROUP INDEX:	0

ENTECH ENGINEERING, INC.

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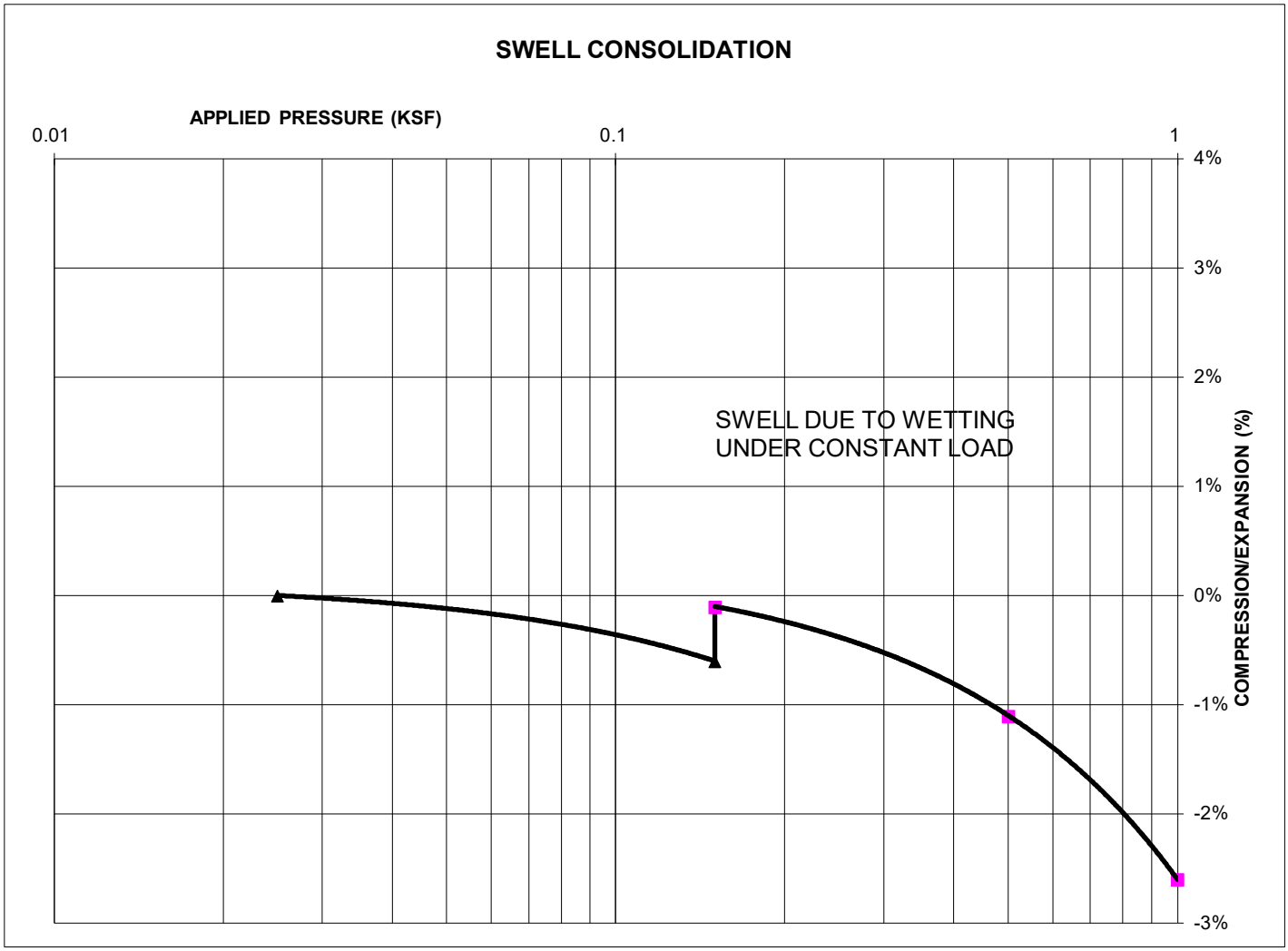
FIG. B-11

TEST BORING	3	SOIL DESCRIPTION	FILL, CLAY, SANDY
DEPTH (FT)	1-2	SOIL TYPE	2



SWELL/CONSOLIDATION TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF): 115
NATURAL MOISTURE CONTENT: 13.8%
SWELL/CONSOLIDATION (%): 0.5%

ENTECH ENGINEERING, INC.

SWELL/CONSOLIDATION TEST RESULTS

WALDEN PRESERVE 2, FILING NO. 5
MA INFRASTRUCTURE

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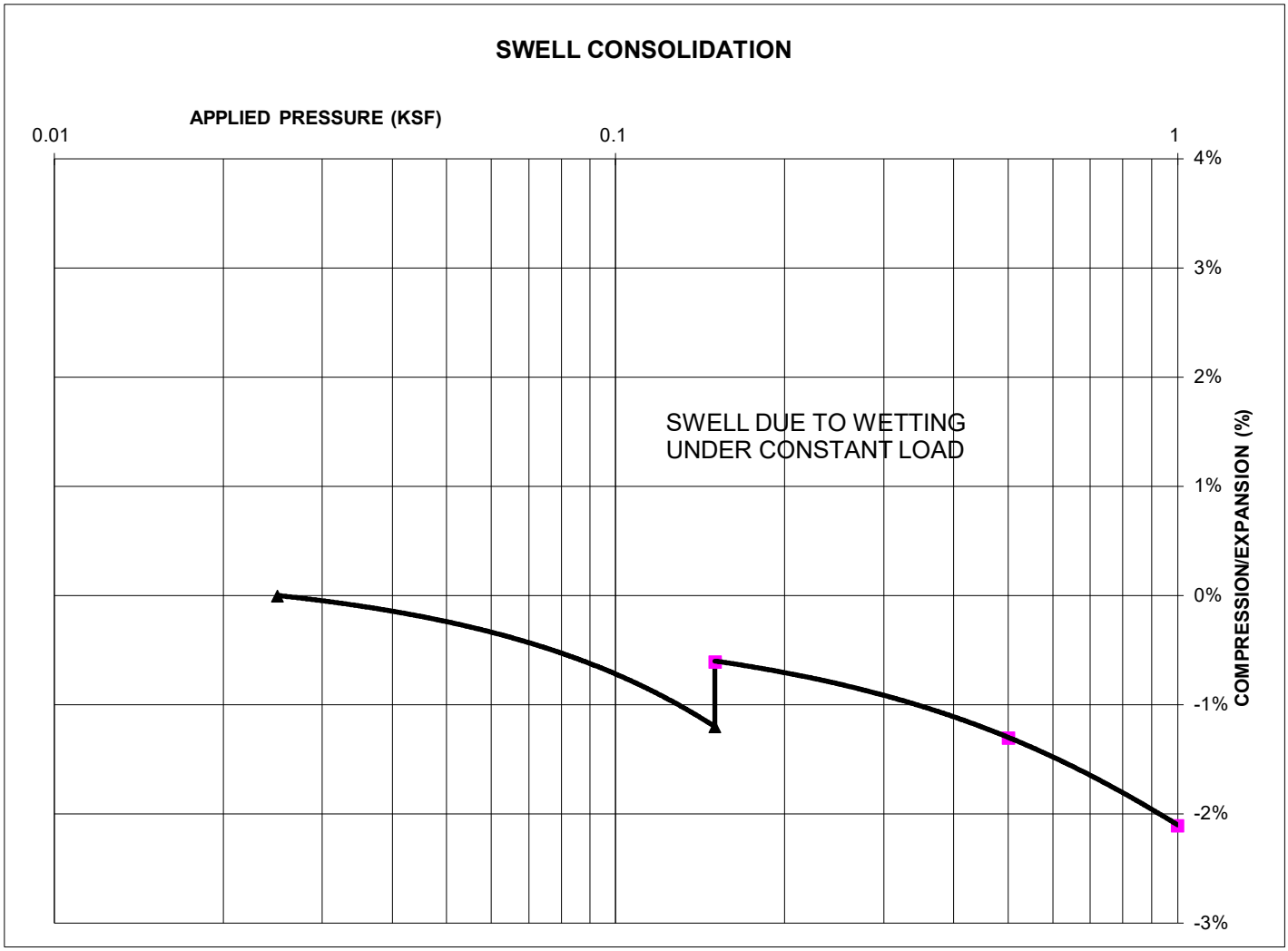
FIG. B-12

TEST BORING	5	SOIL DESCRIPTION	FILL, SAND, CLAYEY-SILTY
DEPTH (FT)	1-2	SOIL TYPE	2



SWELL/CONSOLIDATION TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF):	123
NATURAL MOISTURE CONTENT:	9.1%
SWELL/CONSOLIDATION (%):	0.6%

ENTECH ENGINEERING, INC.

SWELL/CONSOLIDATION TEST RESULTS

WALDEN PRESERVE 2, FILING NO. 5
MA INFRASTRUCTURE

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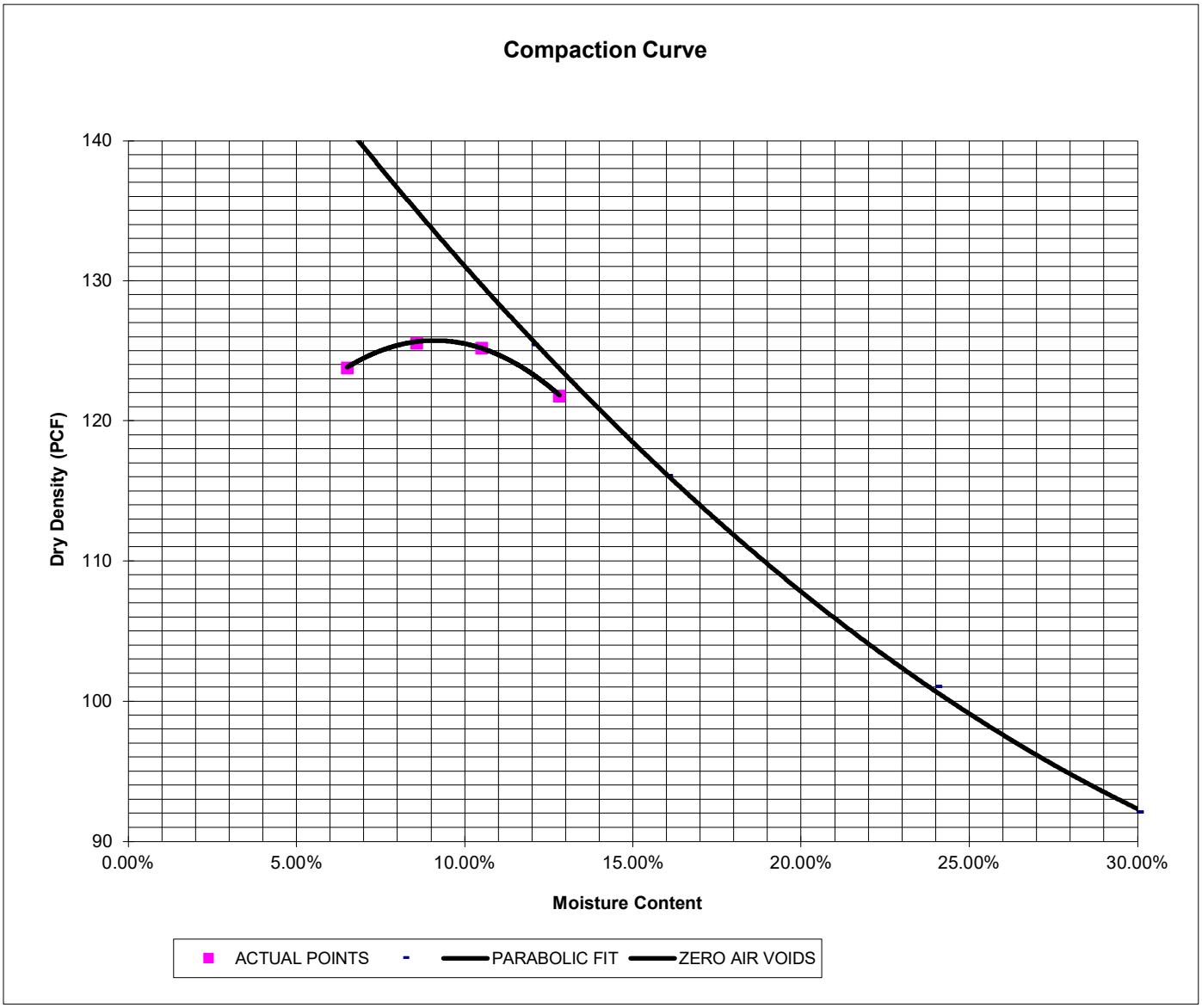
FIG. B-13

SAMPLE LOCATION TB-6 @ 0-3'	SOIL DESCRIPTION FILL, SAND, SILTY, BROWN
	SOIL TYPE 1

PROCTOR DATA

IDENTIFICATION:	SM
PROCTOR TEST #:	1
TEST BY:	BL
TEST DESIGNATION:	ASTM-1557-A
MAXIMUM DRY DENSITY (PCF):	125.8
OPTIMUM MOISTURE:	9.1



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LABORATORY TEST RESULTS

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FIG. B-14

SAMPLE LOCATION TB-6 @ 0-3'	SOIL DESCRIPTION FILL, SAND, SILTY, BROWN
DEPTH (FT) 0	SOIL TYPE 1

CBR TEST LOAD DATA

Piston Diameter (cm): 4.958
Piston Area (in^2): 2.993

Penetration Depth (inches)	*10 BLOWS* Mold # 1 Load (lbs)	Stress (psi)	*25 BLOWS* Mold # 2 Load (lbs)	Stress (psi)	*56 BLOWS* Mold # 3 Load (lbs)	Stress (psi)
0.000	0	0.00	0	0.00	0	0.00
0.025	180	60.15	224	74.85	880	294.07
0.050	325	108.60	490	163.74	1085	362.57
0.075	385	128.65	638	213.20	1201	401.34
0.100	440	147.03	881	294.40	1352	451.79
0.125	498	166.42	1266	423.06	1580	527.99
0.150	545	182.12	1529	510.94	1770	591.48
0.175	574	191.81	1703	569.09	2040	681.70
0.200	624	208.52	1926	643.61	2347	784.29
0.300	770	257.31	2690	898.91	3477	1161.90
0.400	889	297.08	3157	1054.97	4520	1510.44
0.500	1025	342.52	3764	1257.81	5556	1856.64

MOISTURE AND DENSITY DATA

	Mold # 1	Mold # 2	Mold # 3
Can #	342	343	345
Wt. Can	8.54	8.67	8.58
Wt. Can+Wet	234.13	211.11	224.11
Wt. Can+Dry	211.19	193.53	204.87
Wt. H20	22.94	17.58	19.24
Wt. Dry Soil	202.65	184.86	196.29
Moisture Content	11.32%	9.51%	9.80%
Wet Density (PCF)	123.5	130.7	139.2
Dry Density (PCF)	113.2	119.8	127.6
% Compaction	90%	95%	101%
CBR	14.70	29.44	45.18

PROCTOR DATA

Maximum Dry Density (pcf)	125.8
Optimum Moisture	9.1
90% of Max. Dry Density (pcf)	113.2
95% of Max. Dry Density (pcf)	119.5

CBR at 90% of Max. Density = 14.83	~ R VALUE 45
CBR at 95% of Max. Density = 28.71	~ R VALUE 73

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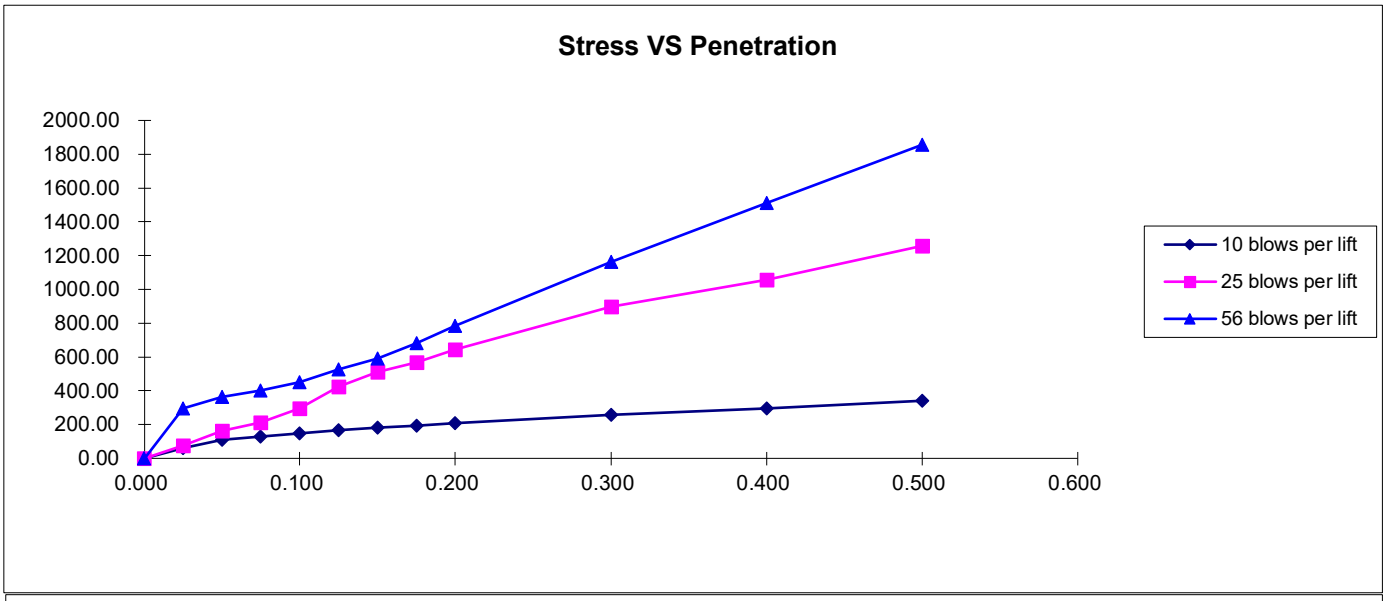
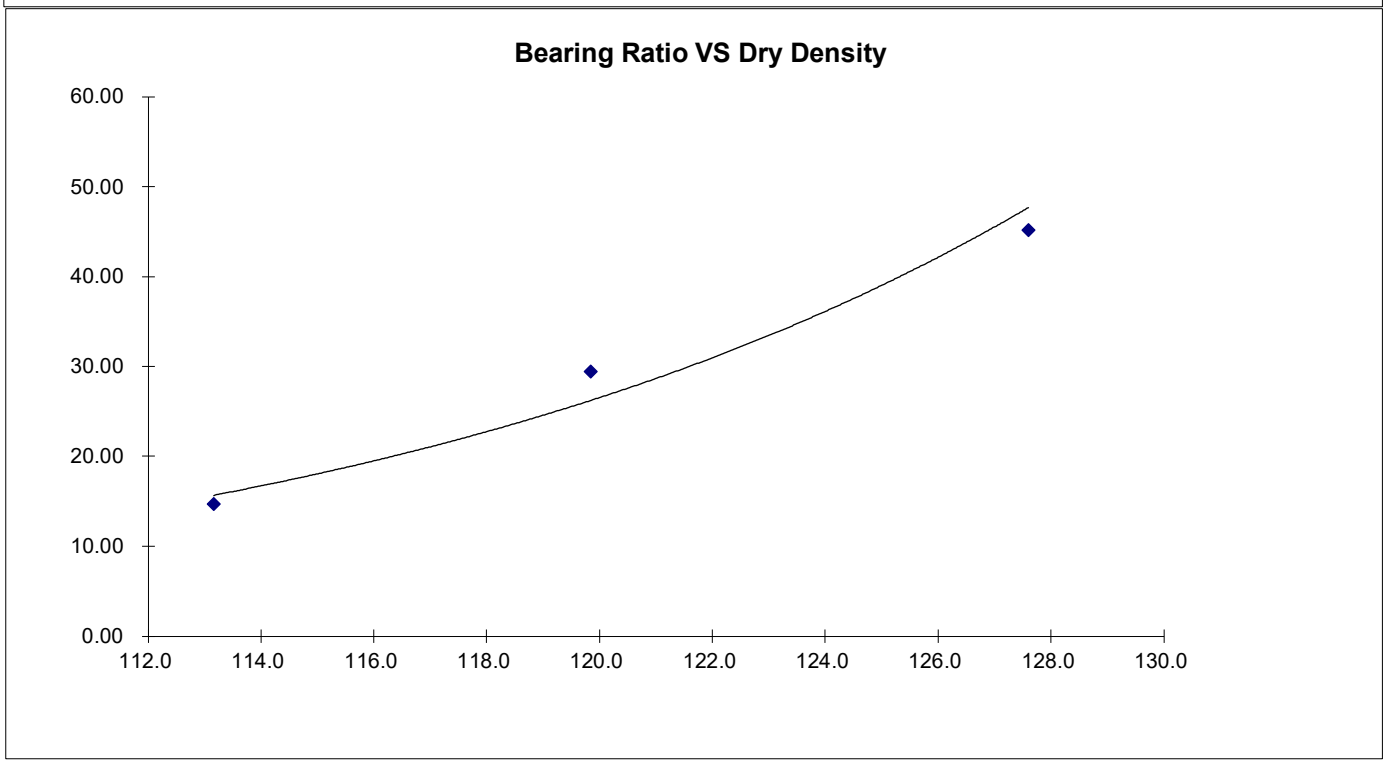
FIG. B-15

SAMPLE LOCATION TB-6 @ 0-3'	SOIL DESCRIPTION FILL, SAND, SILTY, BROWN
DEPTH (FT) 0	SOIL TYPE 0





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LABORATORY TEST RESULTS

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FIG. B-16

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

PROJECT DATA

Project Location Walden Preserve No.2, Filing No. 5

Job Number: 230684

DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Design CBR	CBR =	10
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	75
Reliability (z-statistic)	Z_R =	-0.67
Soil Resilient Modulus	M_R =	15,000 psi

Required Structural Number (SN): → SN = 1.34

DESIGN EQUATIONS

Resilient Modulus

If using CBR:

M_R = (CBR) x 1,500

If using R-Value:

$M_R = 10^{[(S_i + 18.72) / 6.24]}$ where: S_1 = [(R-value - 5) / 11.29] + 3

Required Structural Number

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

Pavement Section Thickness

$SN^* = C_1D_1 + C_2D_2$ where:

C_1 = Strength Coefficient - HMA

C_2 = Strength Coefficient - CTS

D_1 = Depth of HMA (inches)

D_2 = Depth of CTS (inches)

RECOMMENED THICKNESSES

Layer	Material	Structural Layer	Thickness (D^*_i)	SN^*_i	SN
1	HMA	C_1 = 0.44	4.0 inches	1.760	-
2	CTS	C_2 = 0.11	8.0 inches	0.880	
			SN* =	2.640	1.34

Pavement SN > Required SN, Design is Acceptable

FIG. C-1

FLEXIBLE PAVEMENT DESIGN

PROJECT DATA

Project Location Walden Preserve No.2, Filing No. 5

Job Number: 230684

DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	109,500
Design CBR	CBR =	10
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	15,000 psi

Required Structural Number (SN): → SN = 1.68

DESIGN EQUATIONS

Resilient Modulus

If using CBR:

M_R = (CBR) x 1,500

If using R-Value:

$M_R = 10^{[(S_i + 18.72) / 6.24]}$ where: S_1 = [(R-value - 5) / 11.29] + 3

Required Structural Number

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

Pavement Section Thickness

$SN^* = C_1D_1 + C_2D_2$ where:

C_1 = Strength Coefficient - HMA

C_2 = Strength Coefficient - CTS

D_1 = Depth of HMA (inches)

D_2 = Depth of CTS (inches)

RECOMMENED THICKNESSES

Layer	Material	Structural Layer	Thickness (D^*_i)	SN^*_i	SN
1	HMA	C_1 = 0.44	4.0 inches	1.760	-
2	CTS	C_2 = 0.11	8.0 inches	0.880	
			SN* =	2.640	1.68

Pavement SN > Required SN, Design is Acceptable

FIG. C-2

FLEXIBLE PAVEMENT DESIGN

PROJECT DATA

Project Location Walden Preserve No.2, Filing No. 5

Job Number: 230684

DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	109,500
Design CBR	CBR =	10
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	15,000 psi

Required Structural Number (SN): → SN = 1.68

DESIGN EQUATIONS

Resilient Modulus

If using CBR:

M_R = (CBR) x 1,500

If using R-Value:

$M_R = 10^{[(S_i + 18.72) / 6.24]}$ where: S_1 = [(R-value - 5) / 11.29] + 3

Required Structural Number

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

Pavement Section Thickness

$SN^* = C_1D_1 + C_2D_2$ where:

C_1 = Strength Coefficient - HMA

C_2 = Strength Coefficient - ABC

D_1 = Depth of HMA (inches)

D_2 = Depth of ABC (inches)

RECOMMENED THICKNESSES

Layer	Material	Structural Layer	Thickness (D^*_i)	SN^*_i	SN
1	HMA	C_1 = 0.44	3.0 inches	1.320	-
2	ABC	C_2 = 0.11	6.0 inches	0.660	
			SN* =	1.980	1.68

Pavement SN > Required SN, Design is Acceptable

FIG. C-3

FLEXIBLE PAVEMENT DESIGN

PROJECT DATA

Project Location Walden Preserve No.2, Filing No. 5

Job Number: 230684

DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Design CBR	CBR =	10
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	75
Reliability (z-statistic)	Z_R =	-0.67
Soil Resilient Modulus	M_R =	15,000 psi

Required Structural Number (SN): → SN = 1.34

DESIGN EQUATIONS

Resilient Modulus

If using CBR: M_R = (CBR) x 1,500

If using R-Value: $M_R = 10^{[(S_i + 18.72) / 6.24]}$ where: S_1 = [(R-value - 5) / 11.29] + 3

Required Structural Number

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

Pavement Section Thickness

$SN^* = C_1D_1 + C_2D_2$ where: C_1 = Strength Coefficient - HMA

C_2 = Strength Coefficient - ABC

D_1 = Depth of HMA (inches)

D_2 = Depth of ABC (inches)

RECOMMENED THICKNESSES

Layer	Material	Structural Layer	Thickness (D^*_i)	SN^*_i	SN
1	HMA	C_1 = 0.44	3.0 inches	1.320	-
2	ABC	C_2 = 0.11	4.0 inches	0.440	
			SN* =	1.760	1.34

Pavement SN > Required SN, Design is Acceptable

FIG. C-4