



**ENTECH**  
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**PAVEMENT DESIGN REPORT  
TRAILS AT ASPEN RIDGE, FILING NO. 3 Phase 2  
RAINY CREEK TRAIL, TRIPLE TREE STREET, TURKEY FLAT LANE  
EI PASO COUNTY, COLORADO**

Prepared for:  
**COLA, LLC**  
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Attn: Richard A. Van Seenus

September 26, 2024

Respectfully Submitted,

ENTECH ENGINEERING, INC.


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Joseph C. Goode Jr, P.E.  
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ZCG/JCG

Entech Job No. 240367

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## **1 Introduction**

Entech Engineering, Inc. (Entech) completed a subsurface investigation for the pavement design for Rainy Creek Trail, Triple Tree Street, and Turkey Flat Lane in the Trails at Aspen Ridge subdivision in El Paso County, Colorado. This report describes the subsurface investigation conducted for the proposed roadway and construction recommendations. Entech participated in this project as a consultant to COLA, LLC. 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 improvements include Rainy Creek Trail, Triple Tree Street, and Turkey Flat Lane within the Trails at Aspen Ridge subdivision (Figure 1). At the time of our subsurface exploration program, the proposed roadways had been rough-graded. The proposed roadway will travel between surrounding properties comprised of vacant land and land being developed for future residential lots. Based on the development plans, Rainy Creek Trail, Triple Tree Street, and Turkey Flat Lane are designated as local roadways.

## **3 Subsurface Explorations and Laboratory Testing**

### **3.1 Subsurface Exploration Program**

Subsurface conditions at the project site were explored by 7 test borings, designated TB-1 through TB-7, drilled on August 1, 2024. 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.

For pavement design, a Standard Proctor (ASTM D698), a Modified Proctor (ASTM D1557), and a 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.

## **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 roadway consisted of medium stiff to stiff slightly sandy clay fill to clay with sand fill (CL, Soil Type 1), loose slightly silty sand fill (SM, Soil Type 2), hard slightly sandy native clay (CL, Soil Type 3), and claystone or hard slightly sandy clay (CL, Soil Type 4)) when classified as a soil. Soil types and corresponding AASHTO soil classifications are listed as follows:

- Soil Type 1: A-7-6
- Soil Type 2: A-1-b
- Soil Type 3: A-7-6
- Soil Type 4: A-7-6

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 likely and will depend on seasonal variations, local precipitation, runoff, and other factors. We do not anticipate groundwater to affect the proposed 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 one representative samples of the subgrade silty sand fill (Soil Type 1) from TB-1 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	Clay, Slightly Sandy
CBR at 95%	1.98
Design CBR	2.0
Liquid Limit	47
Plasticity Index	22
Percent Passing 200	87.3
AASHTO Classification	A-7-6
Group Index	0
Unified Soils Classification	CL

#### 5.2 Swell Mitigation

El Paso County recommendations require swell mitigation of expansive soils criteria for roadway subgrade with swell testing results greater than 2% under a 150 pounds per square foot (psf) surcharge. Based on the swell testing completed and given the classification of the soils, mitigation for expansive soils is not required on this site.

### 5.3 Traffic Loading

Traffic data is not available for Rainy Creek Trail, Triple Tree Street, and Turkey Flat Lane; however, the roadways are classified as local roadways based on the current development plans. *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 292,000 was used for the local roadway designation.

### 5.4 Pavement Design

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

**Exhibit 2: Pavement Design Parameters**

Design Parameter	Values
Reliability	80%
Standard Deviation	0.44
Serviceability Loss ( $\Delta$ psi)	2.0
Design CBR	2.0
Resilient Modulus - Soil Type 1	3,000 psi
Structural Coefficients	
Hot Mix Asphalt	0.44
Aggregate Base Course	0.11

Pavement sections recommended for Rainy Creek Trail, Triple Tree Street, and Turkey Flat Lane 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	Pavement Alternatives <sup>1</sup>
Rainy Creek Trail, Triple Tree Street, and Turkey Flat Lane	Local Roadway	292,000	1. 6.0 inches HMA over 10 inches ABC 2. 5.0 inches HMA over 12.5 inches ABC

*ABC = Aggregate Base Course; ESAL = equivalent single axle loads; HMA = Hot Mix Asphalt*

**Notes:**

1. All pavement alternatives meet the minimum sections required per *El Paso County Engineering Criteria Manual*.

## 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 Subgrade Preparation – Aggregate Base Course Alternatives

If pavement section alternatives are selected utilizing aggregate base course (ABC), the final subgrade surface should be scarified to a depth of 12 inches, moisture conditioned within +/- 2% of the optimum water content, and recompact to 95% of the Standard Proctor (ASTM 698) maximum dry density. 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.

#### 6.1.2 Fill Placement and Compaction

Granular fill placed as part of the pavement subgrade shall consist of nonexpansive, 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 the Modified Proctor (ASTM D1557) maximum dry density 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 Aggregate Base Course

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

### **6.3 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 0.32% soluble sulfate (by weight). The test results indicate the sulfate component of the in-place soils presents a low 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.

### **6.4 Construction Observation**

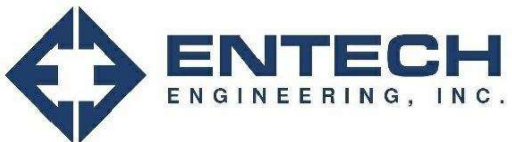
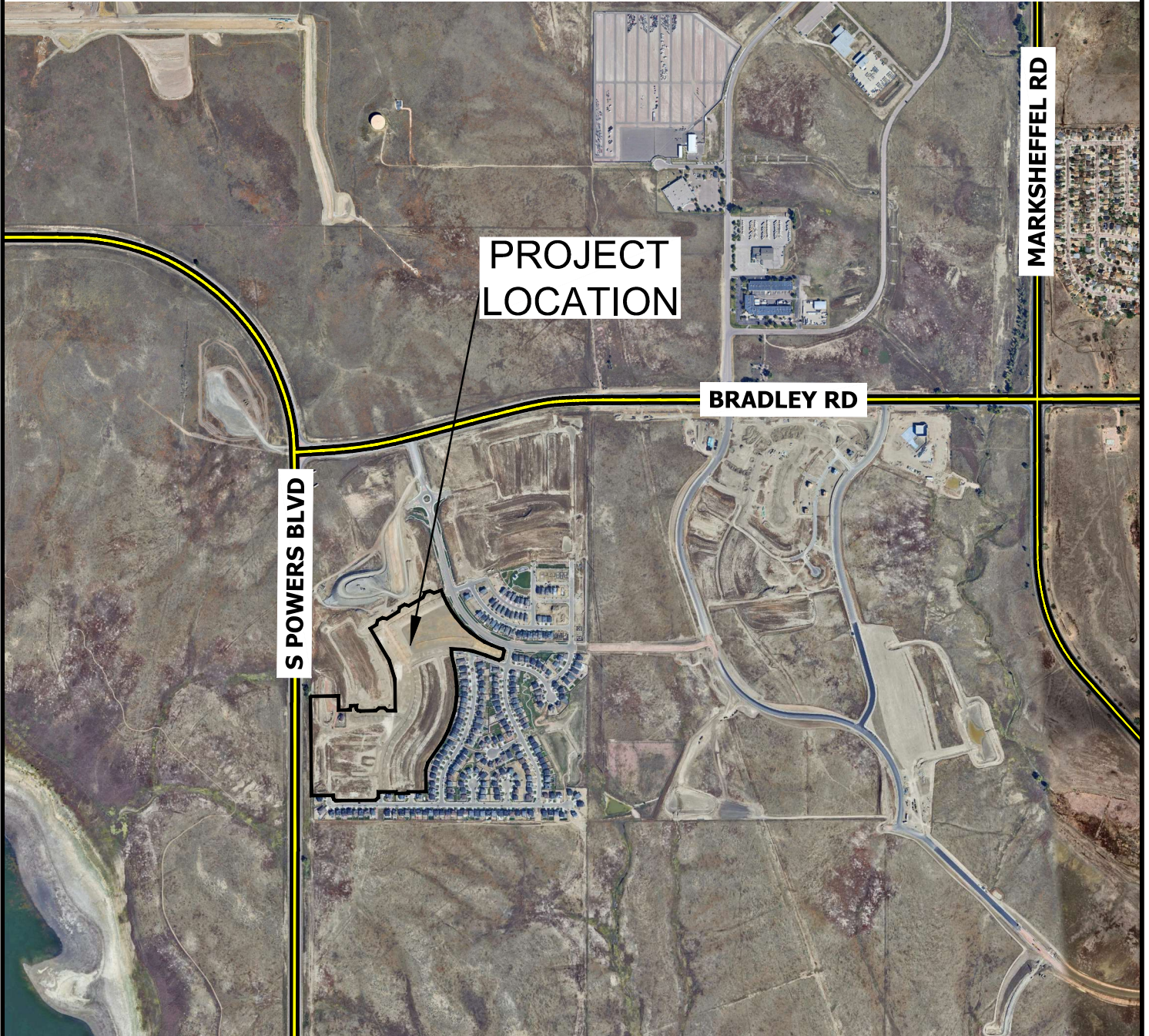
Subgrade preparation for pavement structures should be observed by Entech in order to verify that (1) no anomalies are present, (2) materials similar to those described in this report have been encountered or placed, and (3) no soft spots, expansive or organic soil, or debris are present in the pavement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



## 7 Closure

The subsurface investigation, geotechnical evaluation, and recommendations presented in this report are intended for use by COLA, LLC with application to Trails at Aspen Ridge, Filing No. 3 Phase 2 roadways paving project 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 that 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.

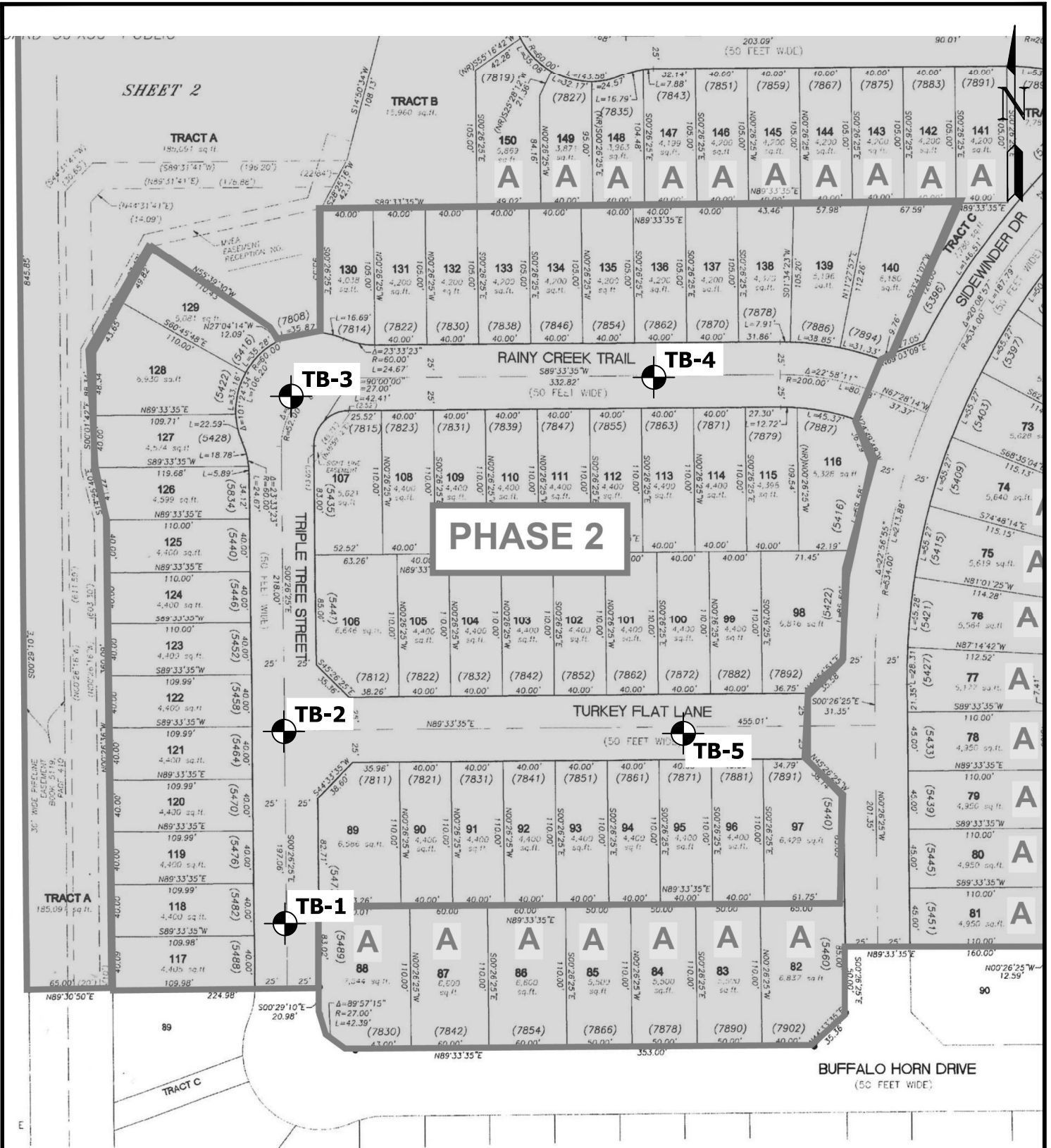
If there are any questions regarding the information provided herein, or if Entech Engineering, Inc. can be of further assistance, please do not hesitate to contact us.



**VICINITY MAP**  
TRAILS @ ASPEN RIDGE F3  
COLA

JOB NO.  
240367

**FIG. 1**



 **TB- APPROXIMATE TEST BORING LOCATION AND NUMBER**



**SITE AND EXPLORATION MAP**  
TRAILS @ ASPEN RIDGE F3  
COLA

JOB NO.  
240367  
**FIG. 2**



## **APPENDIX A: Test Boring Logs**

TEST BORING 3  
 DATE DRILLED 8/1/2024

TEST BORING 4  
 DATE DRILLED 8/1/2024

REMARKS

REMARKS

DRY TO 10', 8/1/24

FILL 0-7', CLAY, SLIGHTLY SANDY,  
 BROWN, VERY STIFF to HARD,  
 MOIST

CLAY, SLIGHTLY SANDY, OLIVE,  
 HARD, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-7	[Symbol]		18	16.7	1
5	[Symbol]		35	12.4	1
10	[Symbol]		38	12.0	3

DRY TO 5', 8/1/24

FILL 0-3', CLAY, WITH SAND,  
 BROWN, MEDIUM STIFF, MOIST

CLAYSTONE, VERY WEAK, OLIVE,  
 HIGHLY WEATHERED (CLAY,  
 SLIGHTLY SANDY, HARD, MOIST)

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-3	[Symbol]		7	10.1	1
5	[Symbol]		50 11"	13.6	4



**TEST BORING LOGS**  
 TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364  
**FIG. A-2**

TEST BORING 5  
 DATE DRILLED 8/1/2024

TEST BORING 6  
 DATE DRILLED 8/1/2024

REMARKS

REMARKS

DRY TO 10', 8/1/24

FILL 0-10', CLAY, SLIGHTLY SANDY,  
 OLIVE, STIFF to VERY STIFF,  
 MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-5	[Symbol]		13	15.6	1
5-10	[Symbol]		20	14.8	1
10-15	[Symbol]		22	13.2	1

DRY TO 5', 8/1/24

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

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-5	[Symbol]		10	18.6	1
5-10	[Symbol]		7	15.4	1



**TEST BORING LOGS**  
 TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364



**FIG. A-3**

TEST BORING 7  
 DATE DRILLED 8/1/2024

REMARKS

DRY TO 3', 8/1/24

FILL 0-3', CLAY, SLIGHTLY SANDY,  
 GRAY, HARD, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-3			43	19.2	1
5					
10					
15					
20					



**TEST BORING LOGS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

**FIG. A-4**



## **APPENDIX B: Laboratory Test Results**



**TABLE B-1  
SUMMARY OF LABORATORY TEST RESULTS**

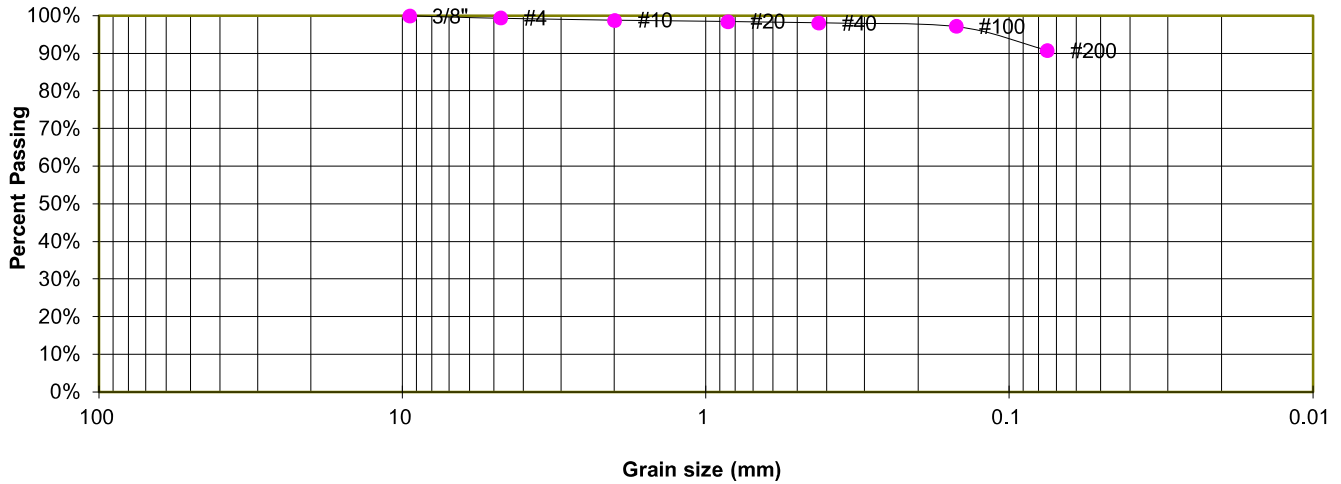


SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SULFATE (WT %)	SWELL/ COLLAPSE (%)	AASHTO CLASS. (GROUP INDEX)	USCS	SOIL DESCRIPTION
1, CBR	5	0-3			90.8	49	27	22			A-7-6 (23)	CL	FILL, CLAY, SLIGHTLY SANDY
1	4	0-3			85.6	45	26	19			A-7-6 (18)	CL	FILL, CLAY, SLIGHTLY SANDY
1	2	0-3			87.3	47	25	22			A-7-6 (21)	CL	FILL, CLAY, SLIGHTLY SANDY
1	1	1-2	18.3	96.2	92.3	49	27	22	0.30	1.0	A-7-6 (23)	CL	FILL, CLAY, SLIGHTLY SANDY
1	2	1-2	22.4	97.4	87.4	49	25	24		1.4	A-7-6 (23)	CL	FILL, CLAY, SLIGHTLY SANDY
1	3	1-2	16.3	103.3	95.5	51	23	28		0.6	A-7-6 (30)	CH	FILL, CLAY, SLIGHTLY SANDY
1	4	1-2	10.1	91.7	83.7	46	26	20	0.32	-0.2	A-7-6 (18)	CL	FILL, CLAY, WITH SAND
1	5	1-2	15.6	96.4	93.0	47	25	22		0.8	A-7-6 (23)	CL	FILL, CLAY, SLIGHTLY SANDY
1	6	1-2	18.6	98.6	88.8	42	24	18		-0.9	A-7-6 (18)	CL	FILL, CLAY, SLIGHTLY SANDY
1	7	1-2	19.2	110.3	91.2	42	24	18		1.9	A-7-6 (18)	CL	FILL, CLAY, SLIGHTLY SANDY
2	1	5			2.2	NV	NP	NP	<0.01		A-1-b (0)	SW	FILL, SAND, SLIGHTLY SILTY
3	3	10	13.3	98.8	85.4	50	25	25	0.02	2.3	A-7-6 (23)	CH	CLAY, SLIGHTLY SANDY
4	4	5	13.6	95.0	90.3	44	23	21	0.29	0.4	A-7-6 (21)	CL	CLAYSTONE (CLAY, SL. SANDY)

TEST BORING 5  
 DEPTH (FT) 0-3

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1, CBR

**Sieve Analysis  
 Grain Size Distribution**



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.4%
10	98.9%
20	98.5%
40	98.1%
100	97.2%
200	90.8%

**ATTERBERG LIMITS**

Plastic Limit	27
Liquid Limit	49
Plastic Index	22

**SOIL CLASSIFICATION**

USCS CLASSIFICATION:	CL
AASHTO CLASSIFICATION:	A-7-6
AASHTO GROUP INDEX:	23



**LABORATORY TEST RESULTS**

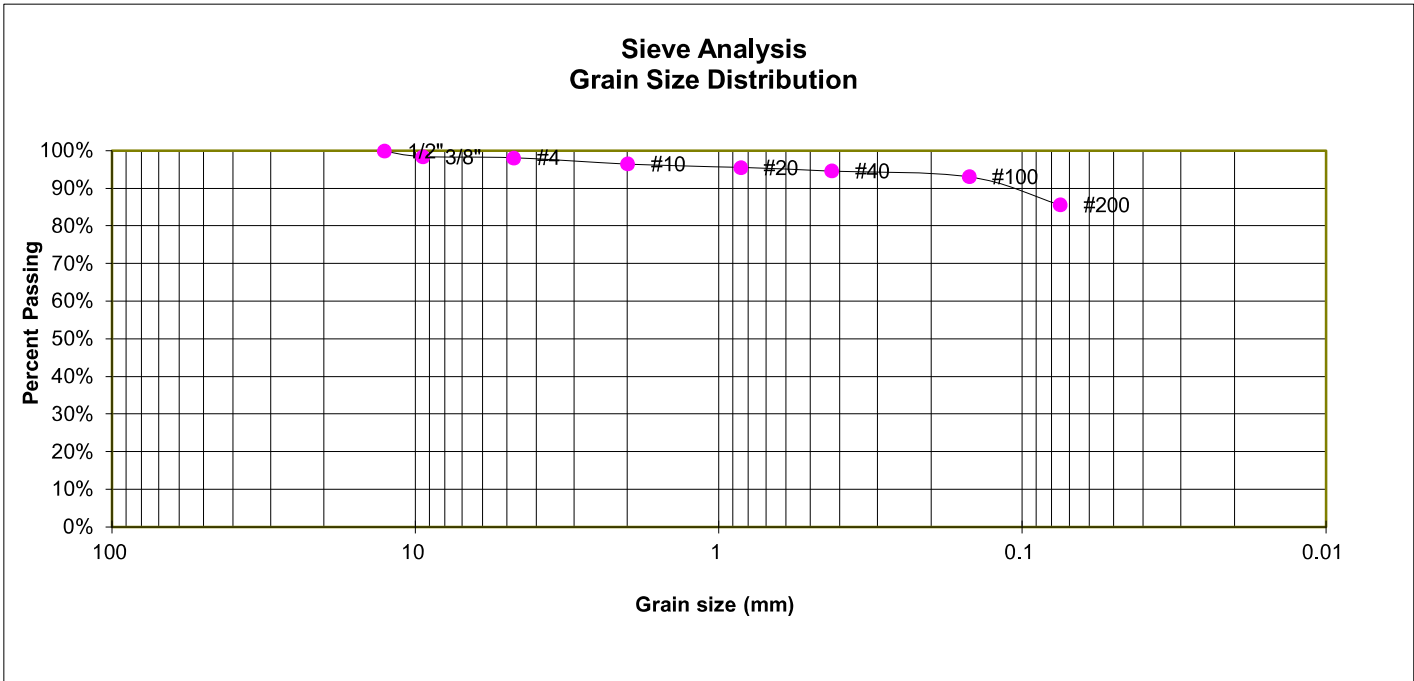
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**FIG. B-1**

TEST BORING 4  
 DEPTH (FT) 0-3

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	98.4%
4	98.2%
10	96.6%
20	95.6%
40	94.7%
100	93.1%
200	85.6%

**ATTERBERG LIMITS**

Plastic Limit	26
Liquid Limit	45
Plastic Index	19

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 18



**LABORATORY TEST RESULTS**

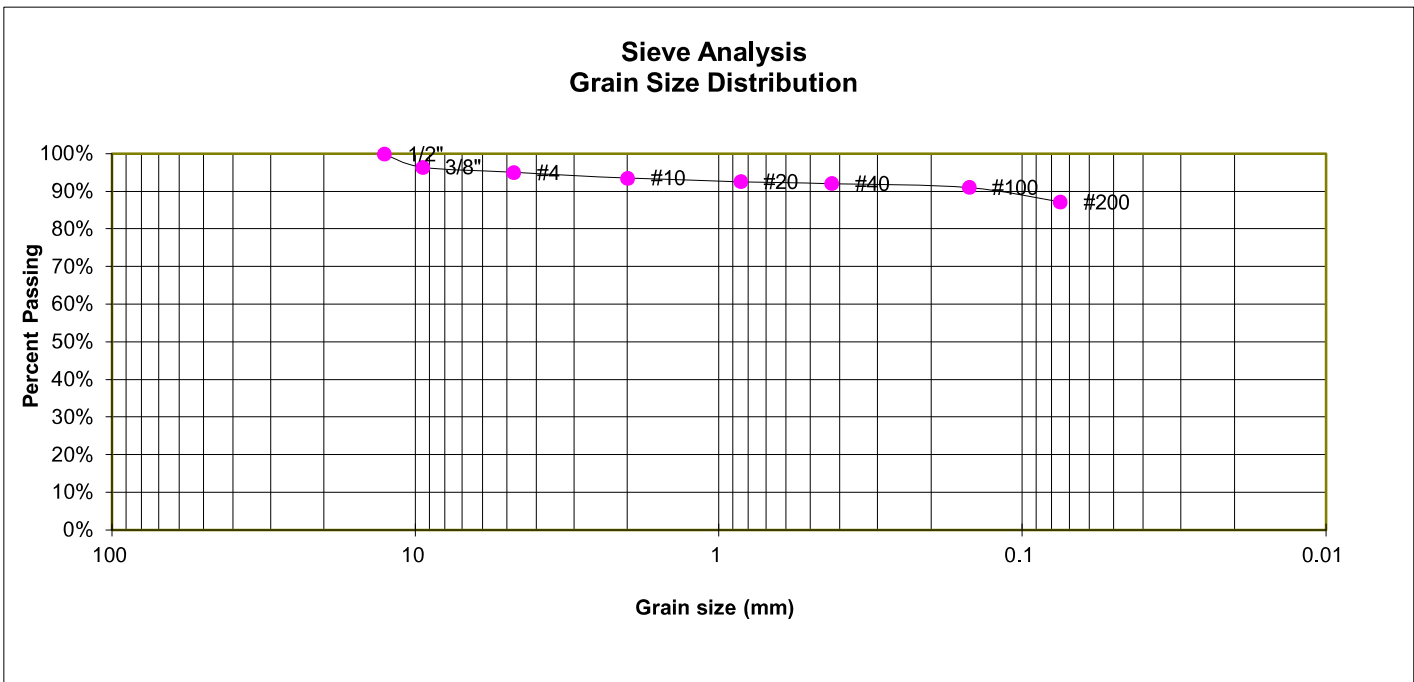
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 240364

**FIG. B-2**

TEST BORING 2  
 DEPTH (FT) 0-3

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	96.5%
4	95.1%
10	93.6%
20	92.6%
40	92.1%
100	91.0%
200	87.3%

**ATTERBERG LIMITS**

Plastic Limit	25
Liquid Limit	47
Plastic Index	22

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 21



**LABORATORY TEST RESULTS**

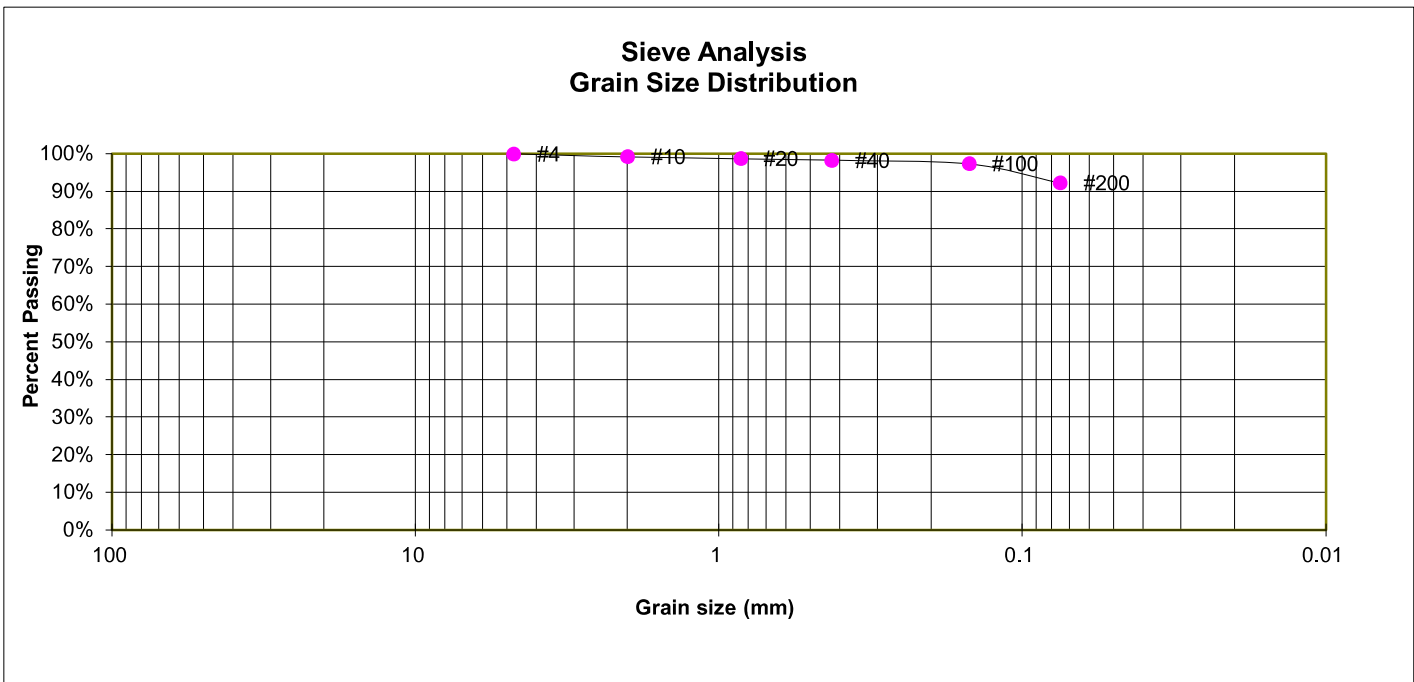
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 240364

**FIG. B-3**

TEST BORING 1  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.2%
20	98.7%
40	98.3%
100	97.4%
200	92.3%

**ATTERBERG LIMITS**

Plastic Limit	27
Liquid Limit	49
Plastic Index	22

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 23



**LABORATORY TEST RESULTS**

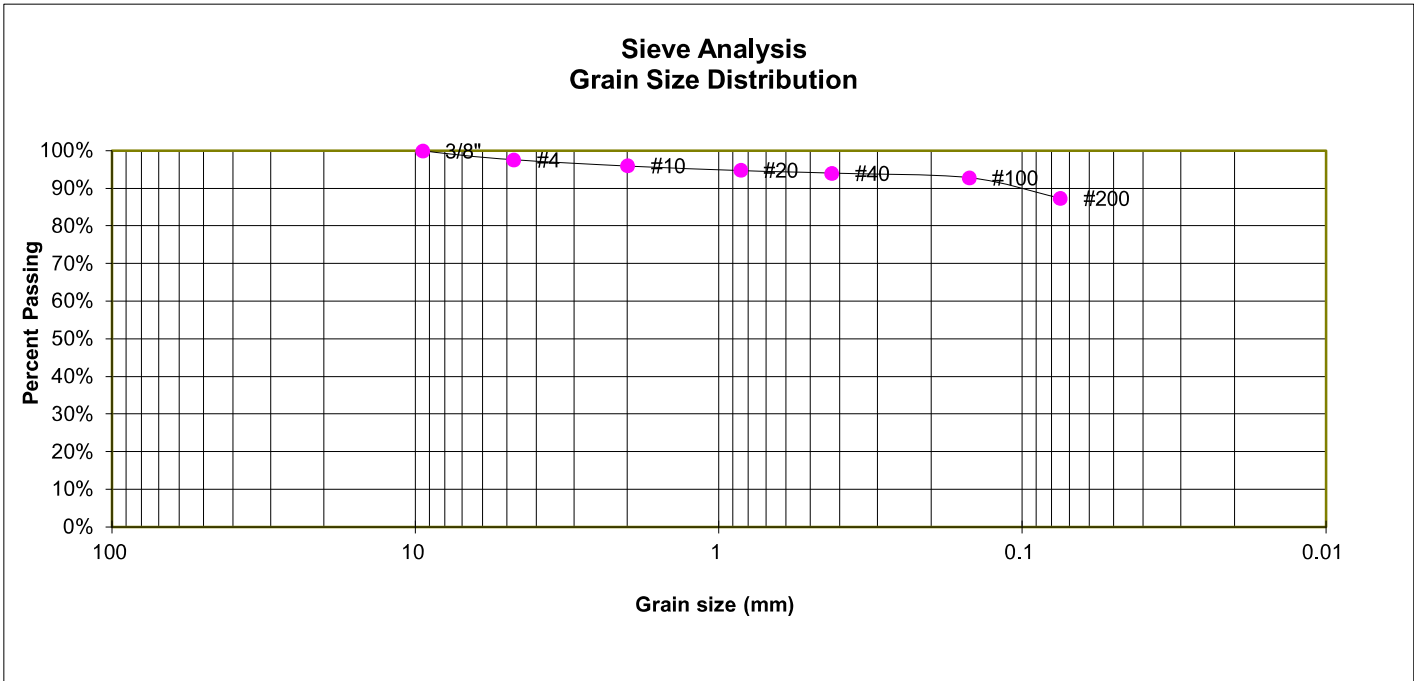
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**FIG. B-4**

TEST BORING 2  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.6%
10	96.0%
20	94.8%
40	94.1%
100	92.9%
200	87.4%

**ATTERBERG LIMITS**

Plastic Limit	25
Liquid Limit	49
Plastic Index	24

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 23



**LABORATORY TEST RESULTS**

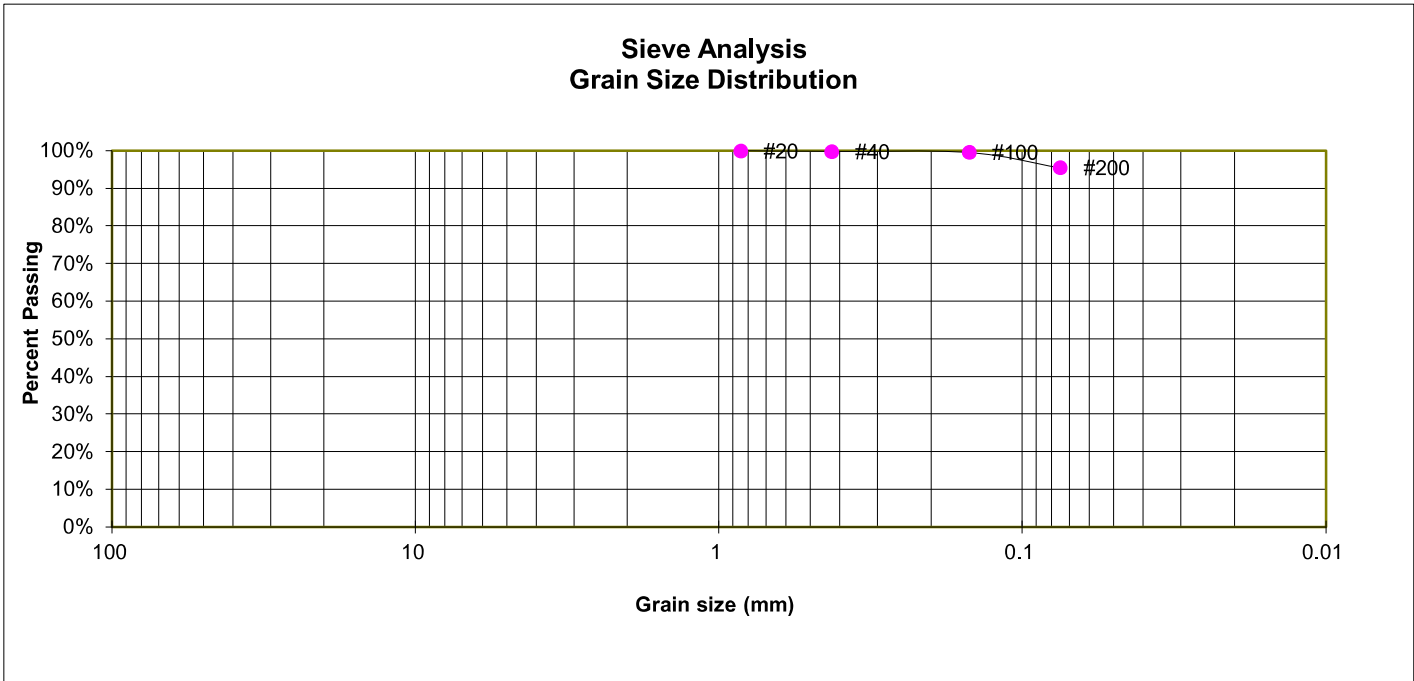
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 240364

**FIG. B-5**

TEST BORING 3  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	
20	100.0%
40	99.8%
100	99.6%
200	95.5%

**ATTERBERG LIMITS**

Plastic Limit	23
Liquid Limit	51
Plastic Index	28

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CH  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 30



**LABORATORY TEST RESULTS**

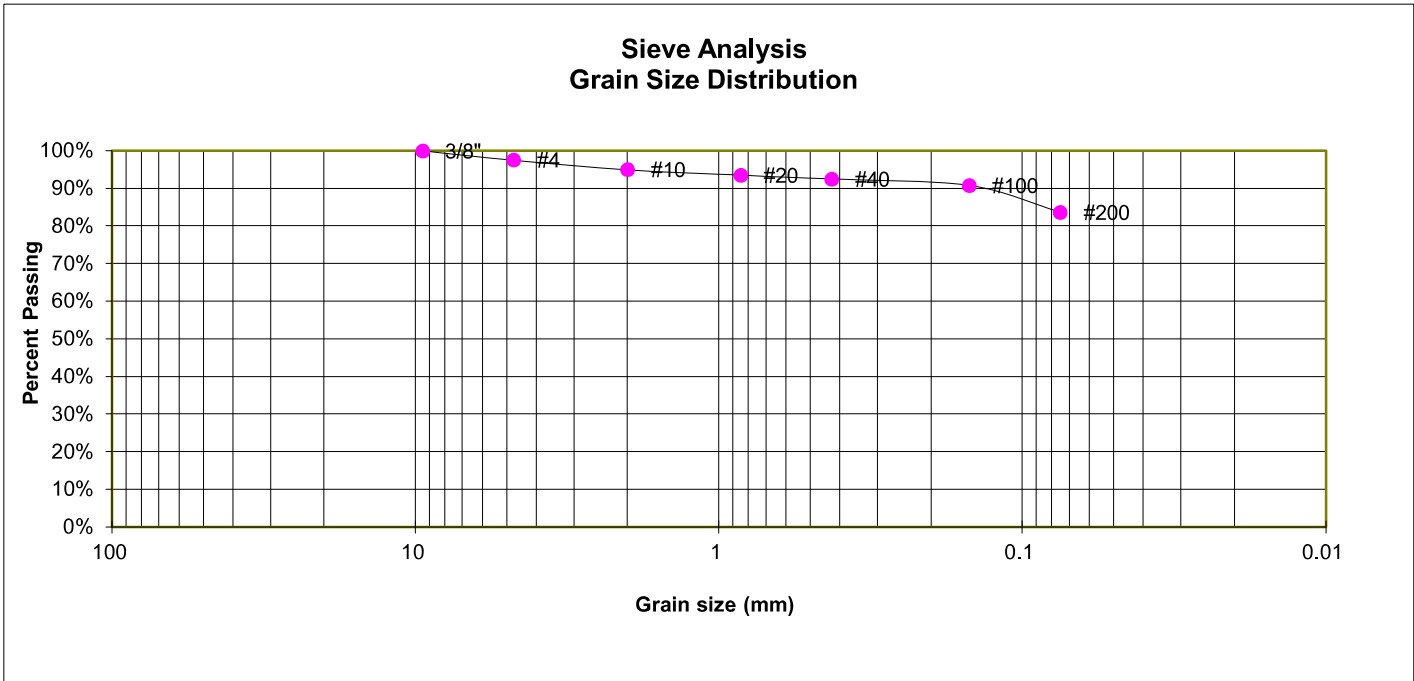
TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

**FIG. B-6**

TEST BORING 4  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, WITH SAND  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.5%
10	95.0%
20	93.5%
40	92.5%
100	90.8%
200	83.7%

**ATTERBERG LIMITS**

Plastic Limit	26
Liquid Limit	46
Plastic Index	20

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 18



**LABORATORY TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

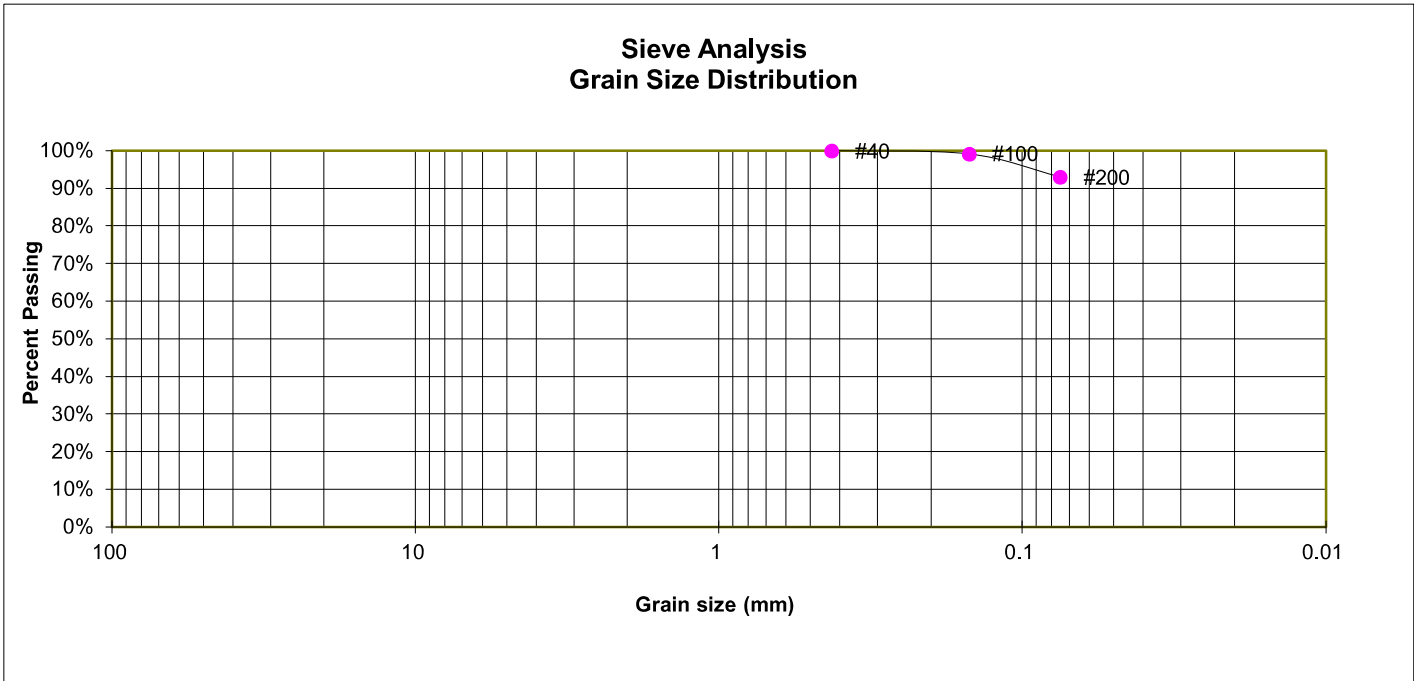
JOB NO.  
 240364

**FIG. B-7**



TEST BORING 5  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	
20	
40	100.0%
100	99.2%
200	93.0%

**ATTERBERG LIMITS**

Plastic Limit	25
Liquid Limit	47
Plastic Index	22

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 23



**LABORATORY TEST RESULTS**

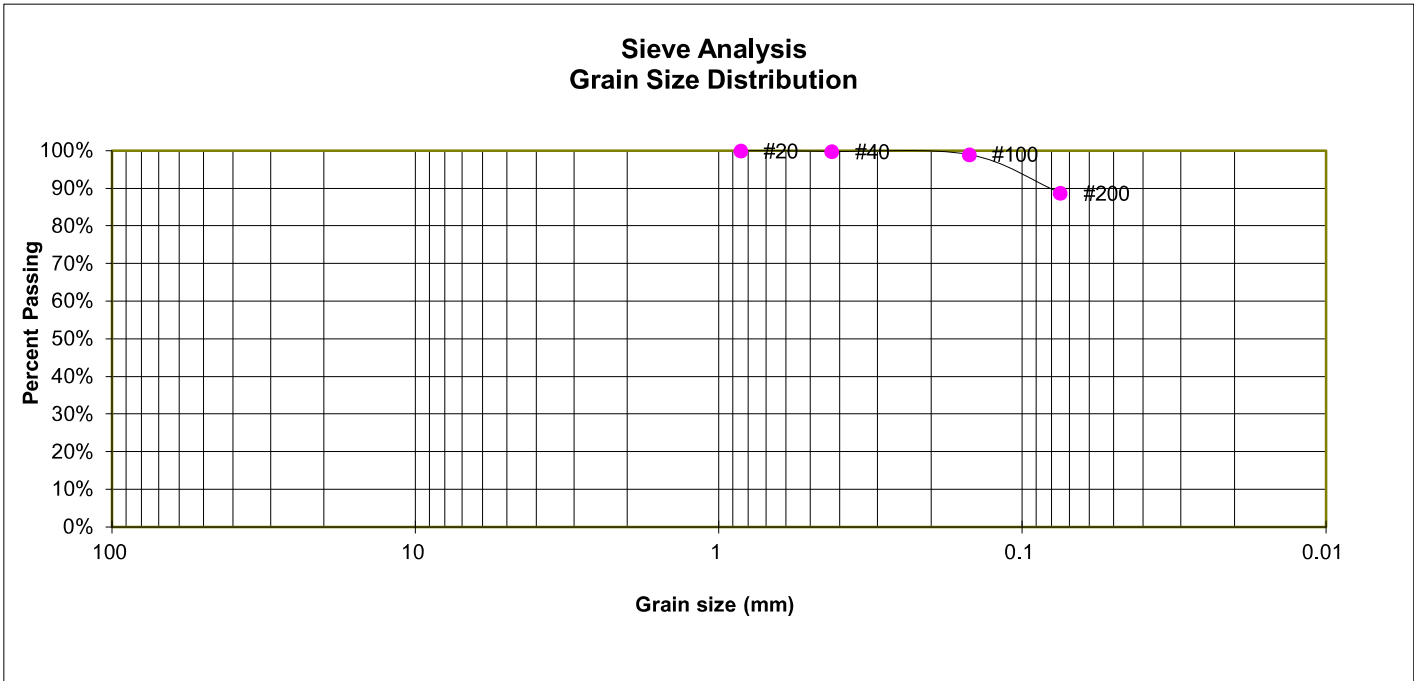
TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

**FIG. B-8**

TEST BORING 6  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	
20	100.0%
40	99.8%
100	99.0%
200	88.8%

**ATTERBERG LIMITS**

Plastic Limit	24
Liquid Limit	42
Plastic Index	18

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 18



**LABORATORY TEST RESULTS**

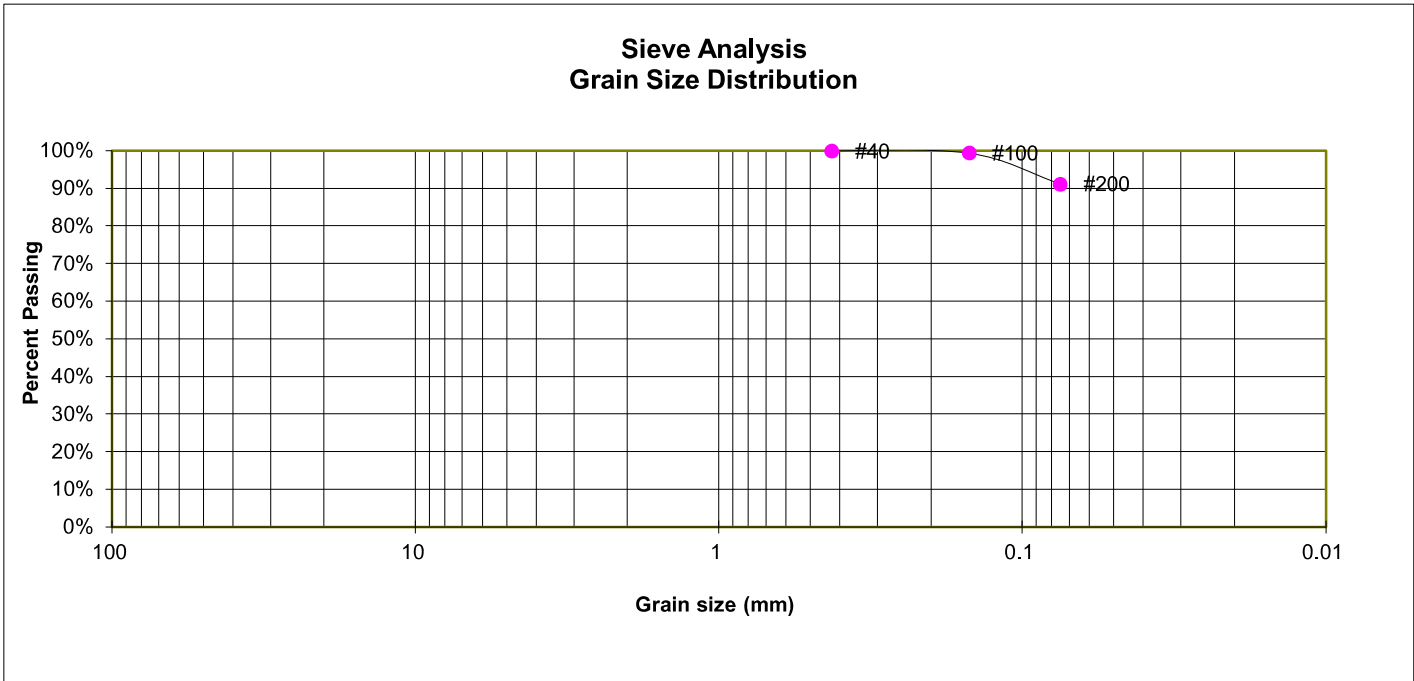
TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

**FIG. B-9**

TEST BORING 7  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	
20	
40	100.0%
100	99.5%
200	91.2%

**ATTERBERG LIMITS**

Plastic Limit	24
Liquid Limit	42
Plastic Index	18

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CL  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 18



**LABORATORY TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

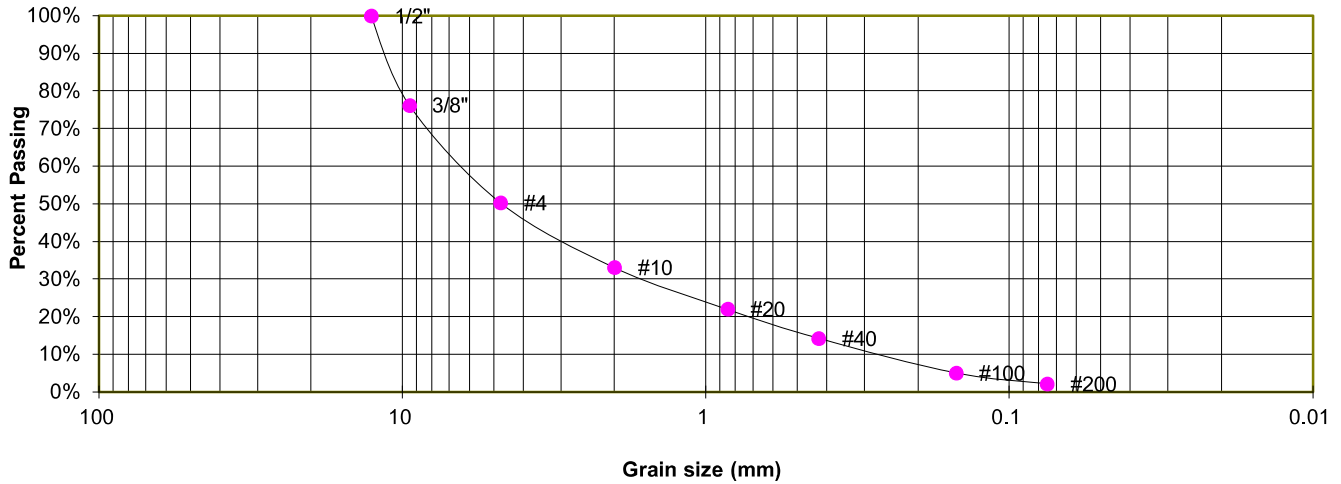
JOB NO.  
 240364

**FIG. B-10**

TEST BORING 1  
 DEPTH (FT) 5

SOIL DESCRIPTION FILL, SAND, SLIGHTLY SILTY  
 SOIL TYPE 2

**Sieve Analysis  
 Grain Size Distribution**



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	76.2%
4	50.3%
10	33.1%
20	22.0%
40	14.3%
100	5.1%
200	2.2%

**ATTERBERG LIMITS**

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: SW  
 AASHTO CLASSIFICATION: A-1-b  
 AASHTO GROUP INDEX: 0



**LABORATORY TEST RESULTS**

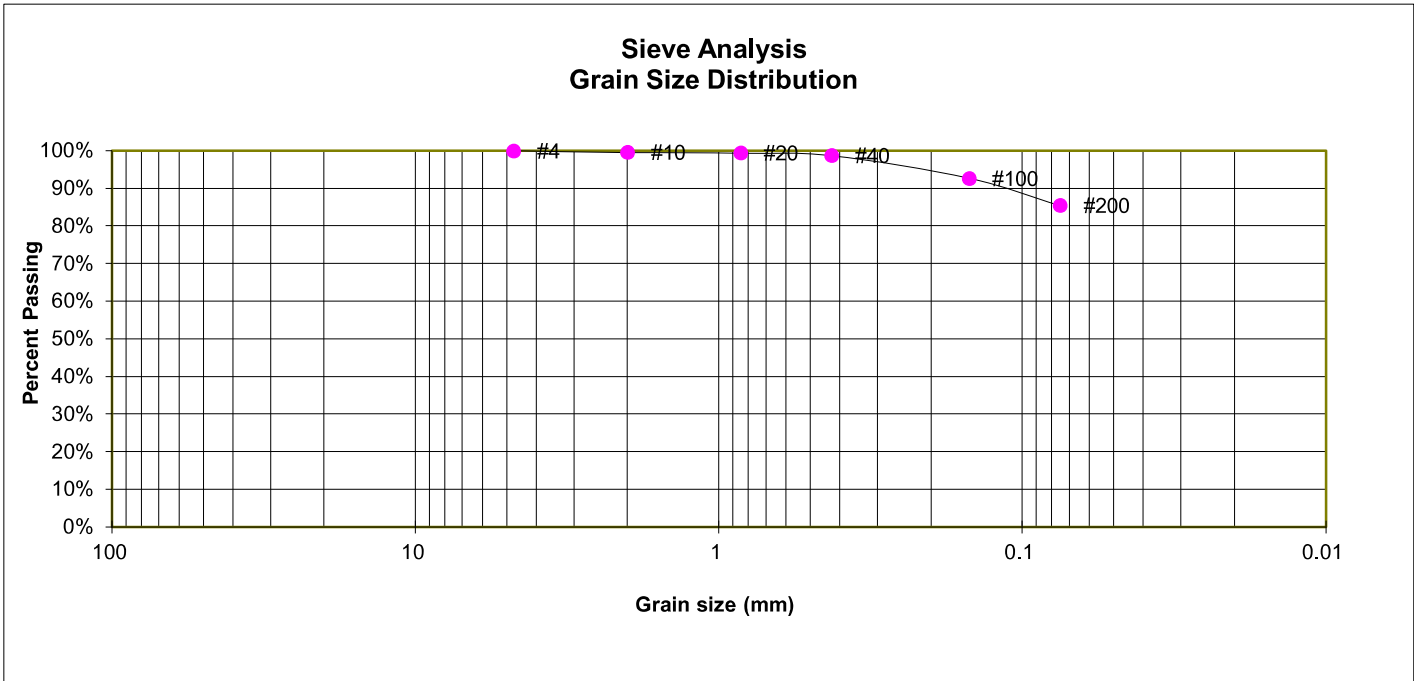
TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

**FIG. B-11**

TEST BORING 3  
 DEPTH (FT) 10

SOIL DESCRIPTION CLAY, SLIGHTLY SANDY  
 SOIL TYPE 3



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.6%
20	99.4%
40	98.7%
100	92.7%
200	85.4%

**ATTERBERG LIMITS**

Plastic Limit	25
Liquid Limit	50
Plastic Index	25

**SOIL CLASSIFICATION**

USCS CLASSIFICATION: CH  
 AASHTO CLASSIFICATION: A-7-6  
 AASHTO GROUP INDEX: 23



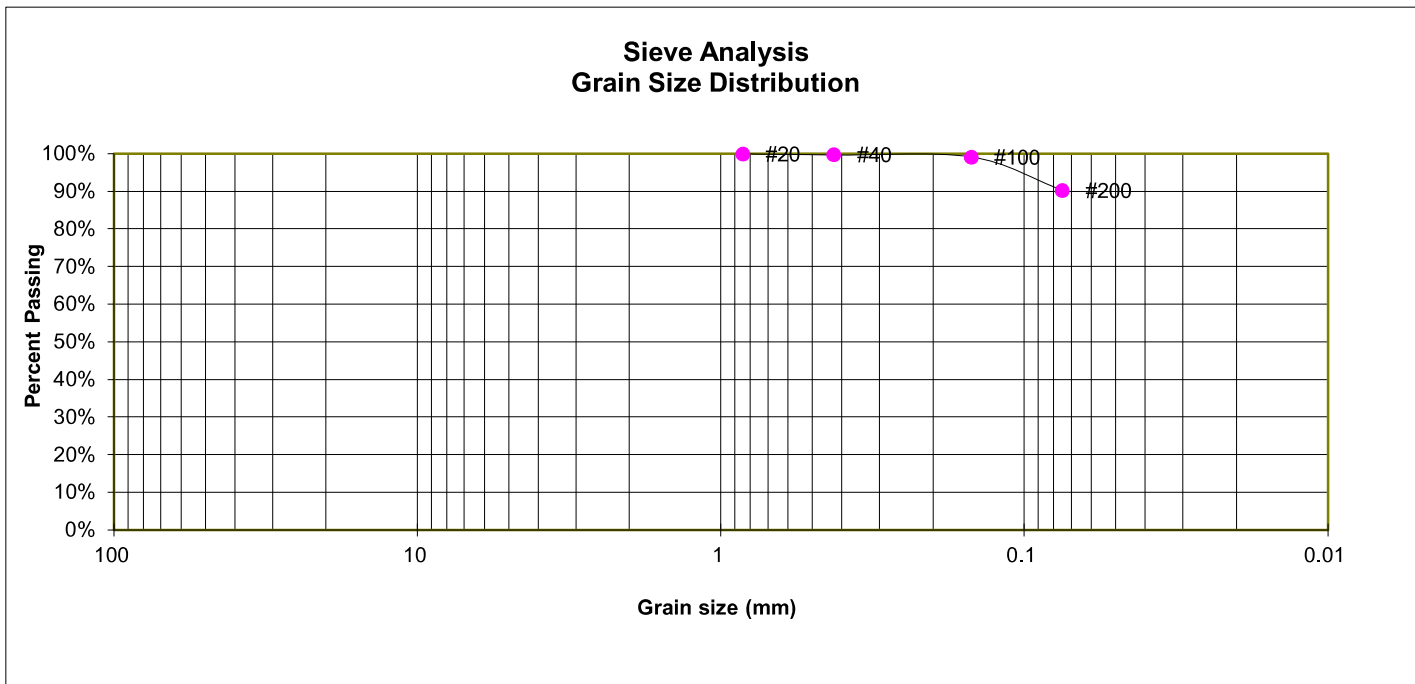
**LABORATORY TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

**FIG. B-12**

<u>TEST BORING</u>	4	<u>SOIL DESCRIPTION</u>	CLAYSTONE (CLAY, SL. SANDY)
<u>DEPTH (FT)</u>	5	<u>SOIL TYPE</u>	4



**GRAIN SIZE ANALYSIS**

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	
20	100.0%
40	99.8%
100	99.2%
200	90.3%

**ATTERBERG LIMITS**

Plastic Limit	23
Liquid Limit	44
Plastic Index	21

**SOIL CLASSIFICATION**

USCS CLASSIFICATION:	CL
AASHTO CLASSIFICATION:	A-7-6
AASHTO GROUP INDEX:	21



**LABORATORY TEST RESULTS**

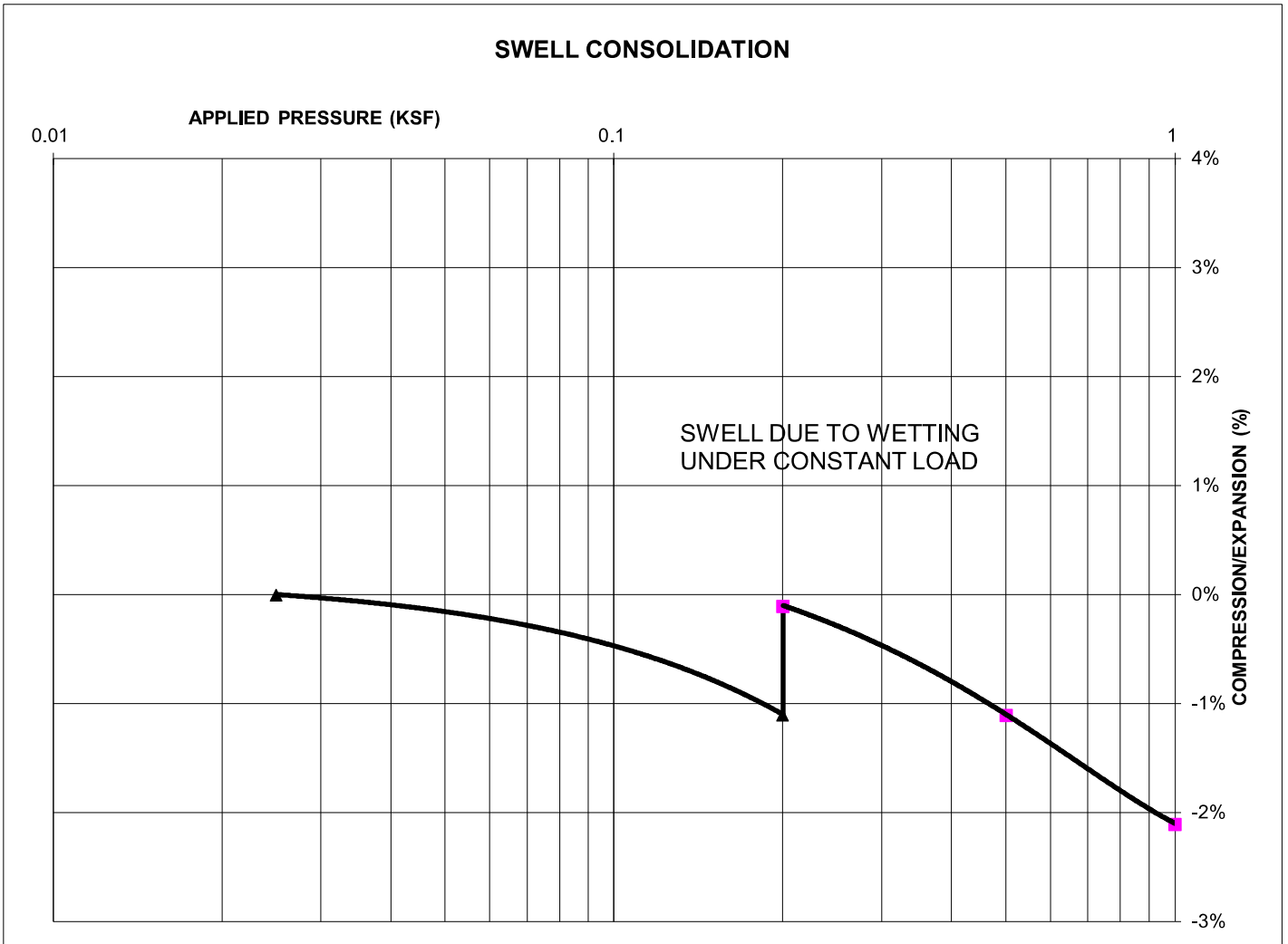
TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-13**

TEST BORING 1  
 DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
 SOIL TYPE 1



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 96  
 NATURAL MOISTURE CONTENT: 18.3%  
 SWELL/COLLAPSE (%): 1.0%



**SWELL TEST RESULTS**

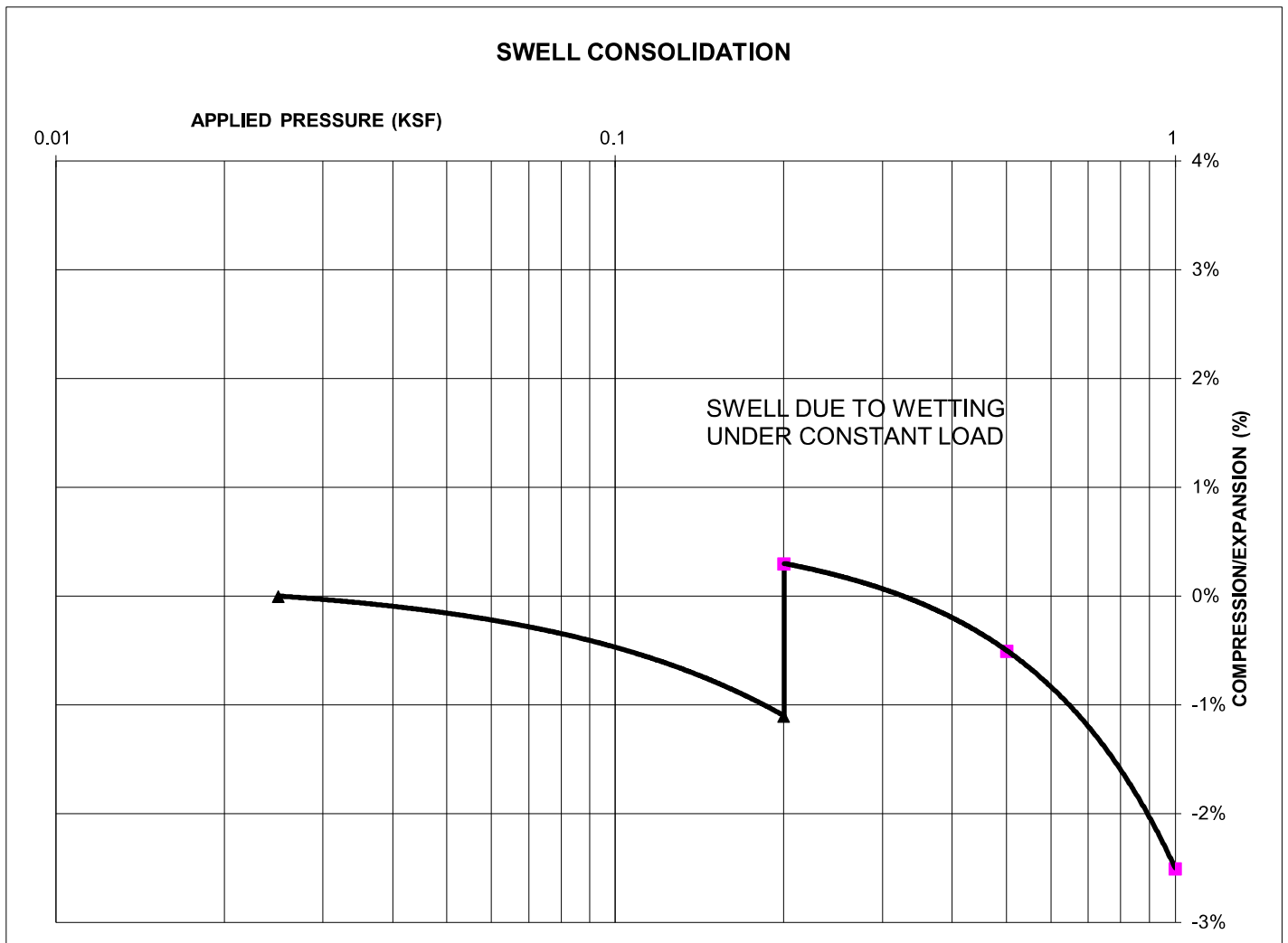
TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

**FIG. B-14**

TEST BORING 2  
DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 97  
NATURAL MOISTURE CONTENT: 22.4%  
SWELL/COLLAPSE (%): 1.4%



**SWELL TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-15**



TEST BORING 3  
DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 103  
NATURAL MOISTURE CONTENT: 16.3%  
SWELL/COLLAPSE (%): 0.6%



**SWELL TEST RESULTS**

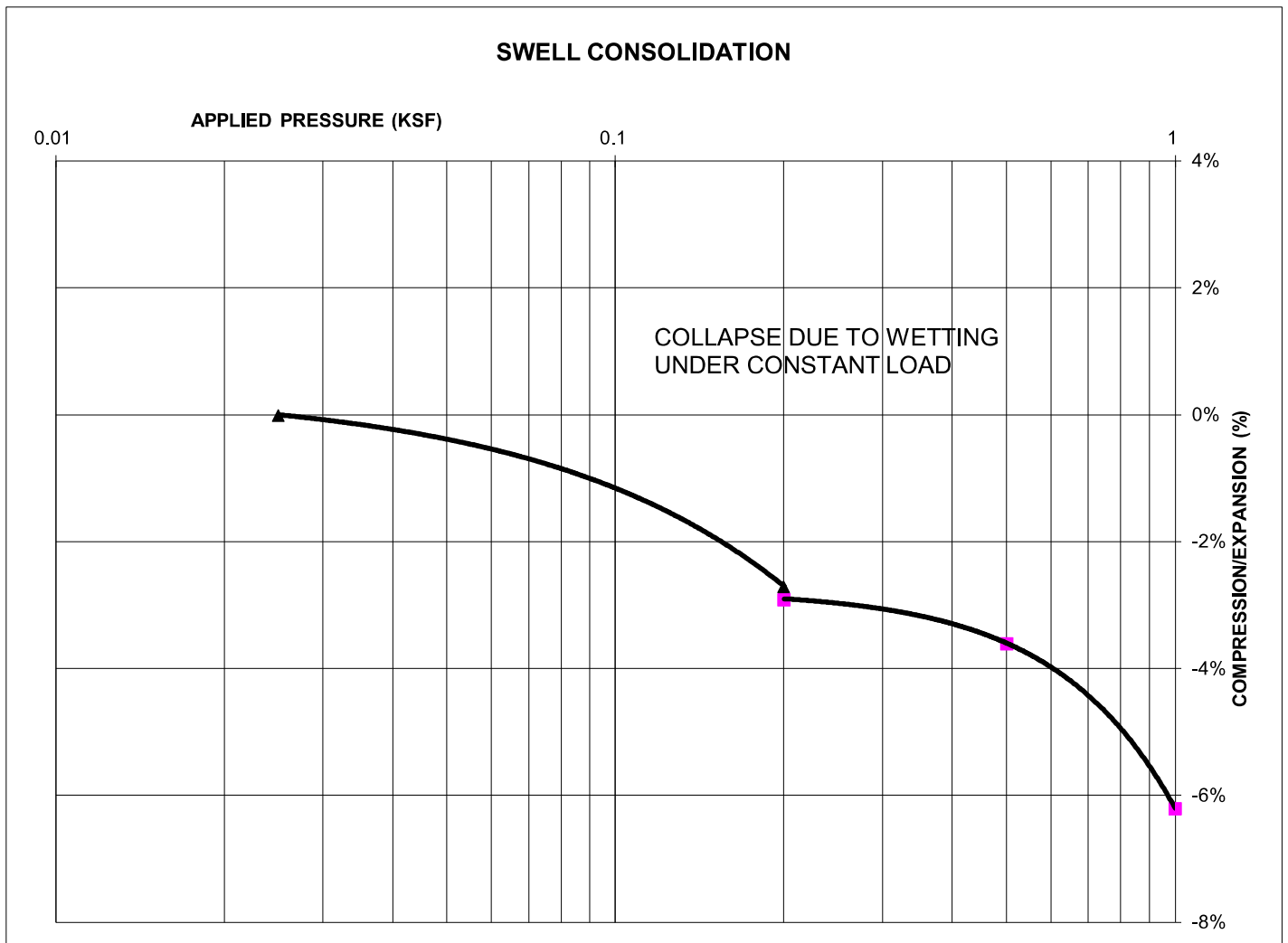
TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-16**

TEST BORING 4  
DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 92  
NATURAL MOISTURE CONTENT: 10.1%  
SWELL/COLLAPSE (%): -0.2%



**SWELL TEST RESULTS**

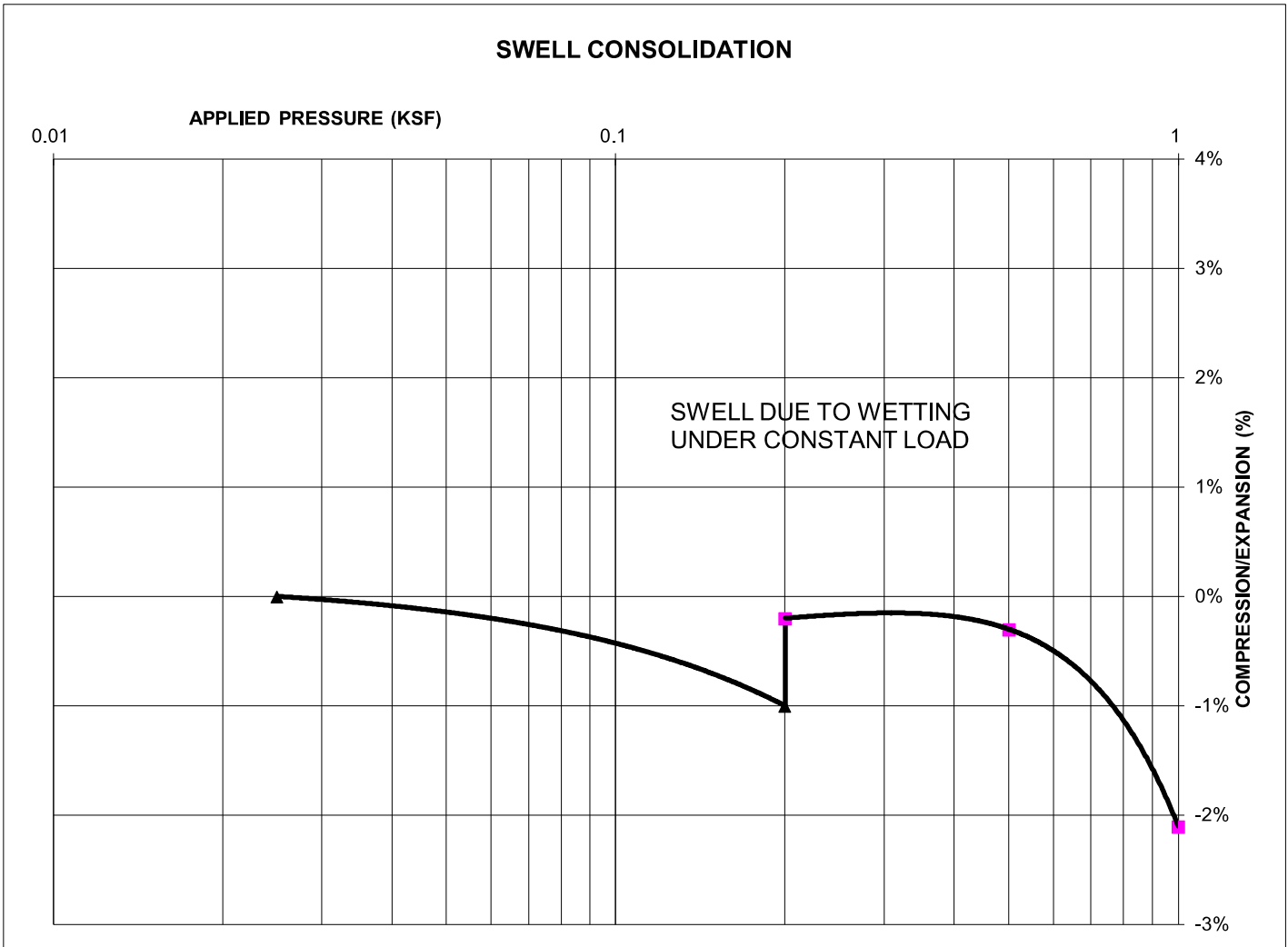
TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-17**

TEST BORING 5  
DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 96  
NATURAL MOISTURE CONTENT: 15.6%  
SWELL/COLLAPSE (%): 0.8%



**SWELL TEST RESULTS**

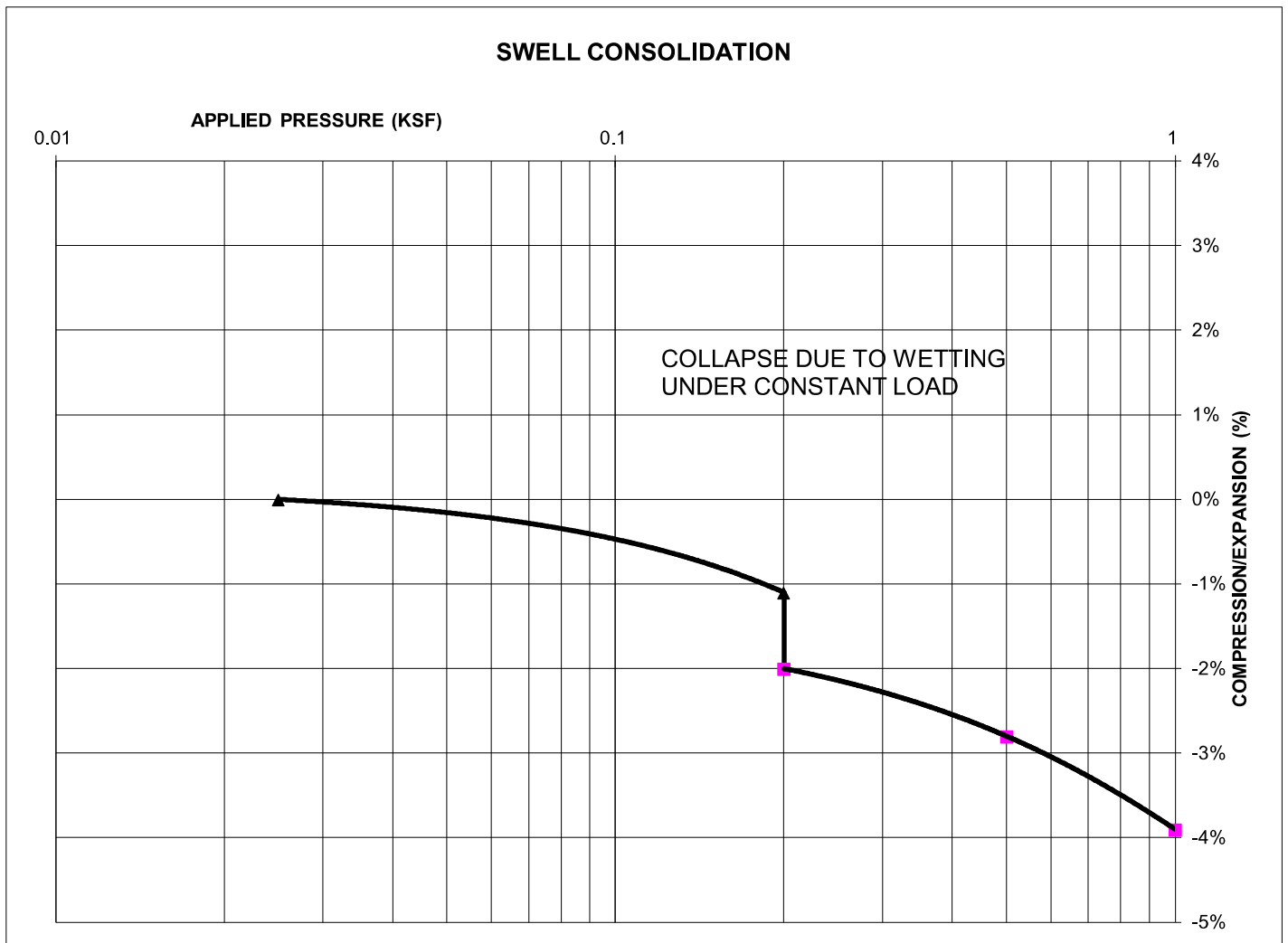
TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-18**

TEST BORING 6  
DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 99  
NATURAL MOISTURE CONTENT: 18.6%  
SWELL/COLLAPSE (%): -0.9%



**SWELL TEST RESULTS**

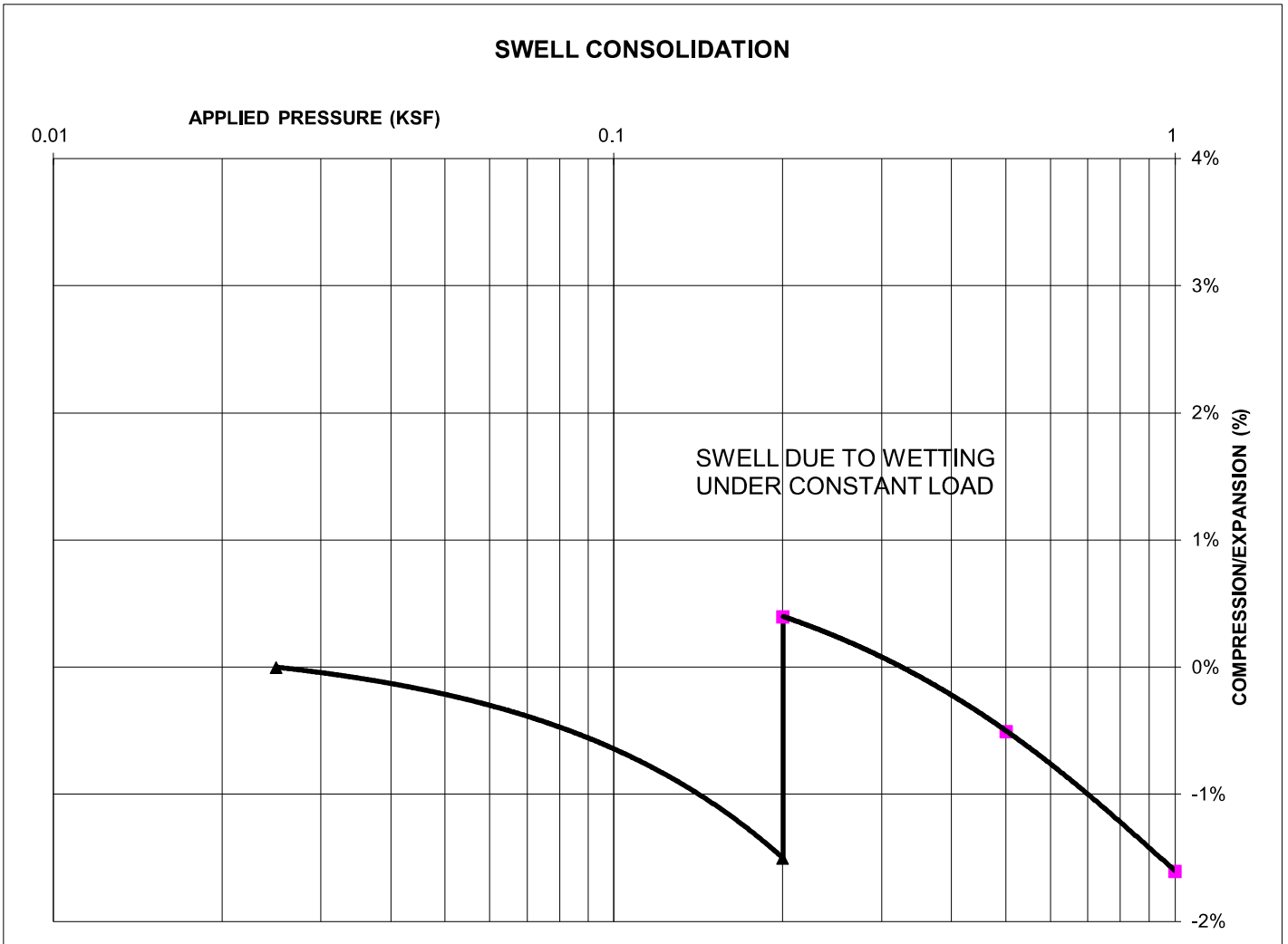
TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-19**

TEST BORING 7  
DEPTH (FT) 1-2

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 110  
NATURAL MOISTURE CONTENT: 19.2%  
SWELL/COLLAPSE (%): 1.9%



**SWELL TEST RESULTS**

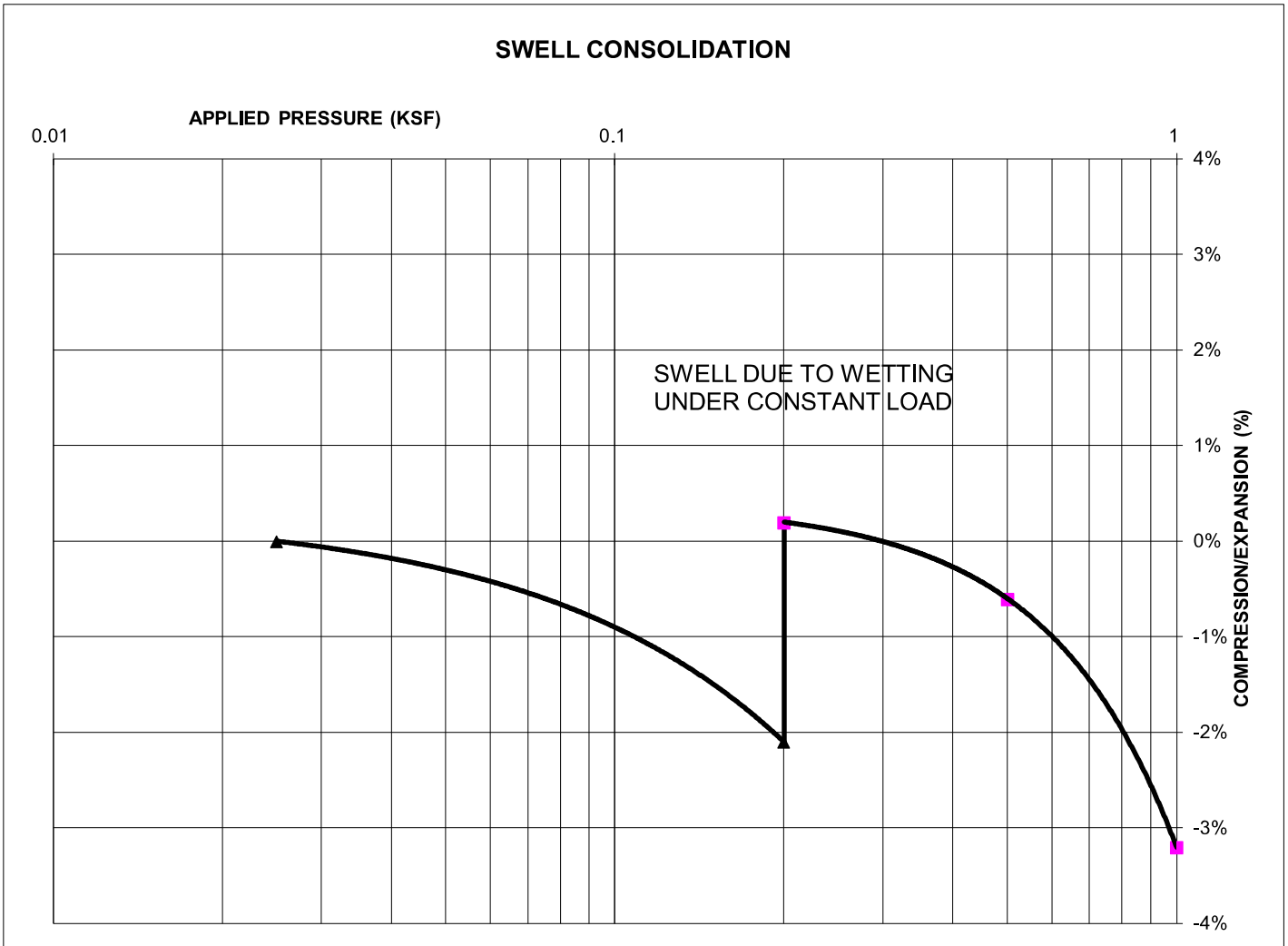
TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-20**

TEST BORING 3  
DEPTH (FT) 10

SOIL DESCRIPTION CLAY, SLIGHTLY SANDY  
SOIL TYPE 3



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 99  
NATURAL MOISTURE CONTENT: 13.3%  
SWELL/COLLAPSE (%): 2.3%



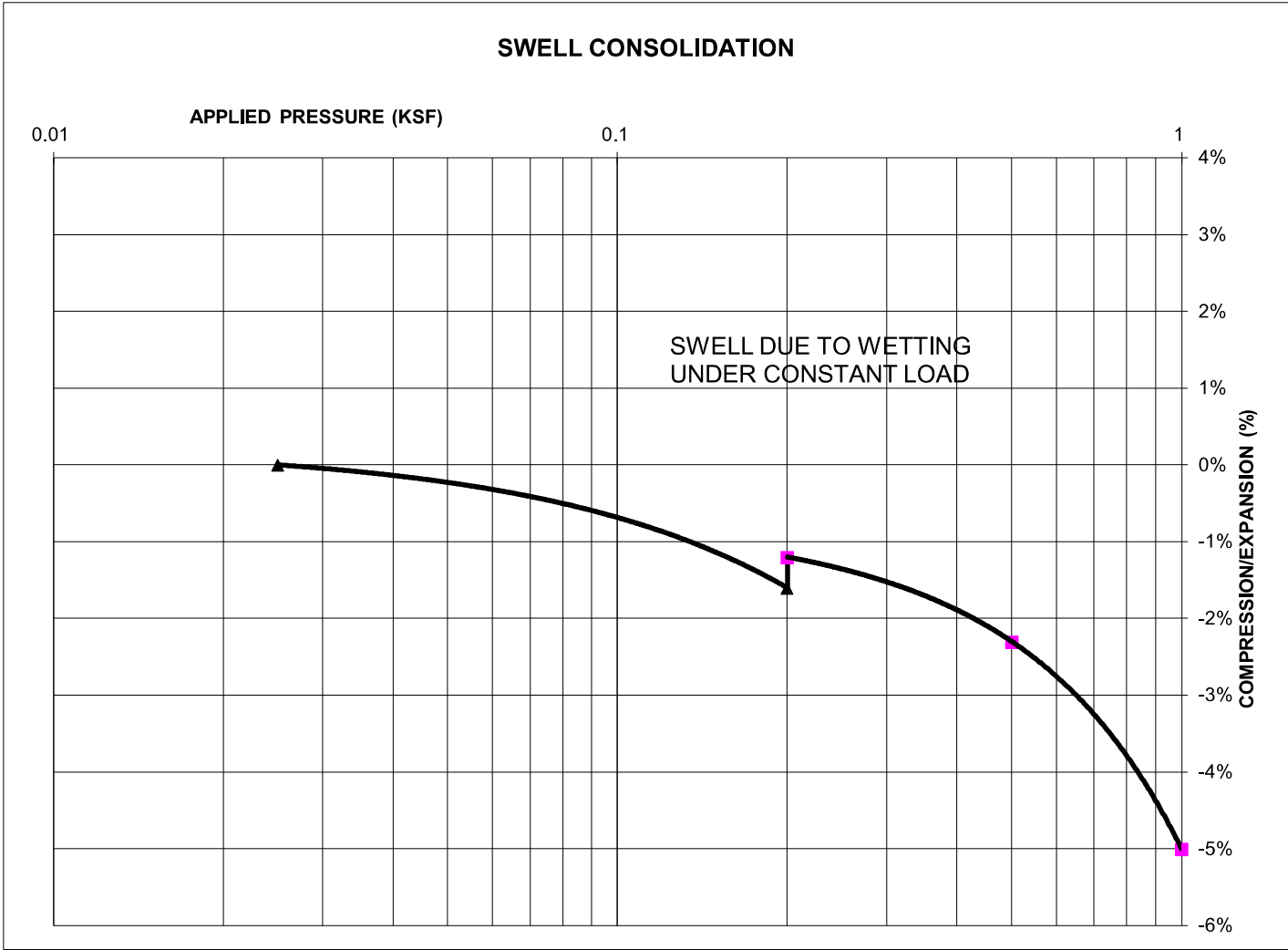
**SWELL TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-21**

TEST BORING	4	SOIL DESCRIPTION	CLAYSTONE (CLAY, SLIGHTLY SANDY)
DEPTH (FT)	5	SOIL TYPE	4



**SWELL/COLLAPSE TEST RESULTS**

NATURAL UNIT DRY WEIGHT (PCF): 95  
 NATURAL MOISTURE CONTENT: 13.6%  
 SWELL/COLLAPSE (%): 0.4%



**SWELL TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
 COLA, LLC

JOB NO.  
 240364

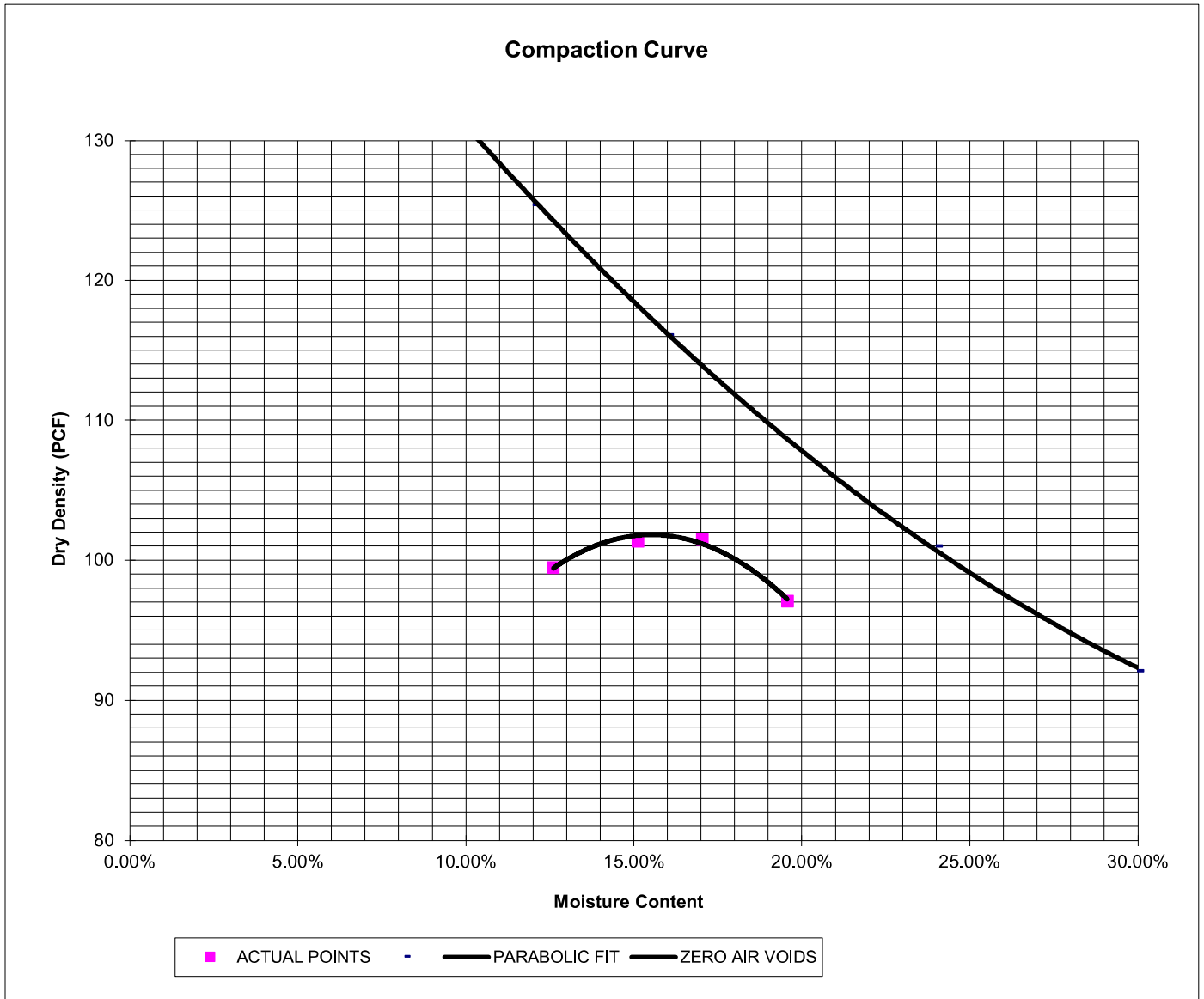
**FIG. B-22**

SAMPLE LOCATION TB-2 @ 0-3'

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1

**PROCTOR DATA**

IDENTIFICATION: CL  
PROCTOR TEST #: 1  
TEST BY: PH  
TEST DESIGNATION: ASTM-698-A  
MAXIMUM DRY DENSITY (PCF): 101.9  
OPTIMUM MOISTURE: 15.4



**LABORATORY TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

**FIG. B-23**



SAMPLE LOCATION TB-2 @ 0-3'

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1

**CBR TEST LOAD DATA**

Piston Diameter (cm): 4.958

Piston Area (in<sup>2</sup>): 2.993

Penetration Depth (inches)	10 BLOWS Mold # 1		25 BLOWS Mold # 2		56 BLOWS Mold # 3	
	Load (lbs)	Stress (psi)	Load (lbs)	Stress (psi)	Load (lbs)	Stress (psi)
0.000	0	0.00	0	0.00	0	0.00
0.025	31	10.36	41	13.70	43	14.37
0.050	35	11.70	50	16.71	53	17.71
0.075	37	12.36	53	17.71	59	19.72
0.100	40	13.37	56	18.71	64	21.39
0.125	41	13.70	61	20.38	71	23.73
0.150	43	14.37	68	22.72	76	25.40
0.175	46	15.37	74	24.73	81	27.07
0.200	48	16.04	78	26.07	82	27.40
0.300	50	16.71	81	27.07	91	30.41
0.400	51	17.04	88	29.41	103	34.42
0.500	53	17.71	93	31.08	113	37.76

**MOISTURE AND DENSITY DATA**

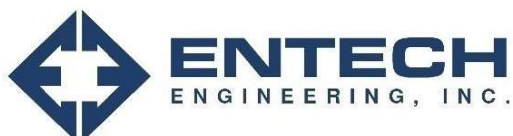
	Mold # 1	Mold # 2	Mold # 3
Can #	350	341	343
Wt. Can	8.03	8.51	8.55
Wt. Can+Wet	134.79	147.88	162.33
Wt. Can+Dry	107.19	118.75	130.81
Wt. H2O	27.6	29.13	31.52
Wt. Dry Soil	99.16	110.24	122.26
Moisture Content	27.83%	26.42%	25.78%
Wet Density (PCF)	103.3	108.9	115.7
Dry Density (PCF)	89.5	94.4	100.3
% Compaction	88%	93%	98%
CBR	1.34	1.87	2.14

**PROCTOR DATA**

Maximum Dry Density (pcf)	101.9
Optimum Moisture	15.4
90% of Max. Dry Density (pcf)	91.7
95% of Max. Dry Density (pcf)	96.8

CBR at 90% of Max. Density = 1.58 ~ R VALUE 1

CBR at 95% of Max. Density = 1.98 ~ R VALUE 1



**LABORATORY TEST RESULTS**

TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

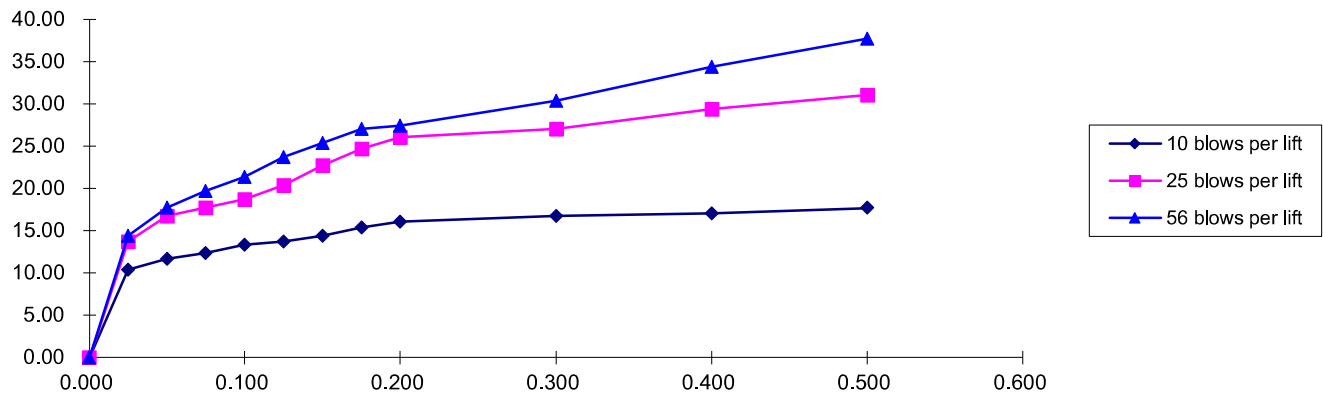
JOB NO.  
240364

**FIG. B-24**

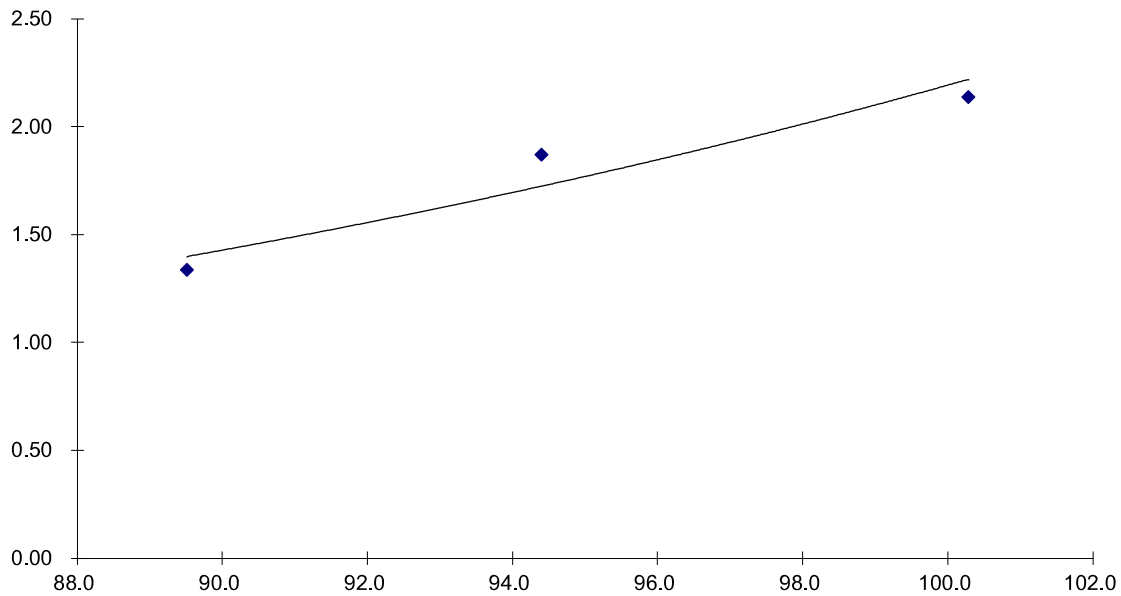
SAMPLE LOCATION TB-2 @ 0-3'

SOIL DESCRIPTION FILL, CLAY, SLIGHTLY SANDY  
SOIL TYPE 1

Stress VS Penetration



Bearing Ratio VS Dry Density



LABORATORY TEST RESULTS

TRAILS AT ASPEN RIDGE, FILING NO. 3  
COLA, LLC

JOB NO.  
240364

FIG. B-25



## **APPENDIX C: Pavement Design Calculations**

## FLEXIBLE PAVEMENT DESIGN

### PROJECT DATA

Project Location: Trails at Aspen Ridge, Filing No. 3, Soil Type 1  
 Job Number: 2340367

### DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL ( $W_{18}$ ) =	292,000
Design CBR	CBR =	2
Standard Deviation	$S_o$ =	0.44
Loss in Serviceability	$\Delta\psi$ =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	$Z_R$ =	-0.84
Soil Resilient Modulus	$M_R$ =	3,000 psi

Required Structural Number (SN): ➔ SN = 3.60

### DESIGN EQUATIONS

#### Resilient Modulus

If using CBR:

$$M_R = (\text{CBR}) \times 1,500$$

If using R-Value:

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

#### Required Structural Number

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

#### Pavement Section Thickness

$$SN^* = C_1 D_1 + C_2 D_2 \quad \text{where:}$$

- $C_1$  = Strength Coefficient - HMA
- $C_2$  = Strength Coefficient - ABC
- $D_1$  = Depth of HMA (inches)
- $D_2$  = Depth of ABC (inches)

### RECOMMENDED THICKNESSES

Layer	Material	Structural Layer	Thickness ( $D^*_i$ )	$SN^*_i$	SN
1	HMA	$C_1 = 0.44$	5.5 inches	2.420	-
2	ABC	$C_2 = 0.11$	12.0 inches	1.320	
				$SN^* = 3.740$	3.60

Pavement SN > Required SN, Design is Acceptable

FIG. C-1

## FLEXIBLE PAVEMENT DESIGN

### PROJECT DATA

Project Location: Trails at Aspen Ridge, Filing No. 3, Soil Type 1  
 Job Number: 2340367

### DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL ( $W_{18}$ ) =	292,000
Design CBR	CBR =	2
Standard Deviation	$S_o$ =	0.44
Loss in Serviceability	$\Delta\text{psi}$ =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	$Z_R$ =	-0.84
Soil Resilient Modulus	$M_R$ =	3,000 psi

Required Structural Number (SN): ➔ SN = 3.60

### DESIGN EQUATIONS

#### Resilient Modulus

If using CBR:

$$M_R = (\text{CBR}) \times 1,500$$

If using R-Value:

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

#### Required Structural Number

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

#### Pavement Section Thickness

$\text{SN}^* = C_1 D_1 + C_2 D_2$  where:

- $C_1$  = Strength Coefficient - HMA
- $C_2$  = Strength Coefficient - ABC
- $D_1$  = Depth of HMA (inches)
- $D_2$  = Depth of ABC (inches)

### RECOMMENDED THICKNESSES

Layer	Material	Structural Layer	Thickness ( $D^*_i$ )	$\text{SN}^*_i$	SN
1	HMA	$C_1 = 0.44$	6.0 inches	2.640	-
2	ABC	$C_2 = 0.11$	10.0 inches	1.100	
				<b><math>\text{SN}^* = 3.740</math></b>	<b>3.60</b>

Pavement SN > Required SN, Design is Acceptable

FIG. C-2