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GEOTECHNICAL AND PAVEMENT DESIGN REPORT
2725 AKERS DRIVE – ADDITION AND RETAINING WALLS
COLORADO SPRINGS, COLORADO

Prepared for:
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Attn: Nick Sallecchia

January 27, 2025

Respectfully Submitted,

ENTECH ENGINEERING, INC.

Zachary C. Gutierrez, E.I.T.
Geotechnical Engineering Staff

Reviewed by:

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Digitally signed by Joseph C Goode III
Date: 01/27/25

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1 Introduction

Entech Engineering Inc. (Entech) completed this geotechnical and pavement design report for a new building addition, retaining walls, and associated site improvements in Colorado Springs, Colorado. This report describes the subsurface exploration program conducted for the planned commercial addition and provides recommendations for foundation design, retaining walls, pavement sections, and construction. Our services were completed for Landscape Endeavors, Inc. in accordance with our geotechnical service agreements dated November 26, 2024. The contents of this report, including the geotechnical evaluation and recommendations, are subject to the limitations and assumptions presented in Section 8.

2 Project and Site Description

We understand that the project will consist of the construction of a new 7,100-square-foot addition, three retaining walls, and associated site improvements at the existing commercial property located at 2725 Akers Drive in Colorado Springs, Colorado. Retaining walls are proposed along the northern, southern, and western edges of the site. The location of the project site is shown on the Vicinity Map (Figure 1).

At the time of drilling, the property was an occupied commercial property with an existing warehouse located centrally on the property with variable grades across the site. Vegetation was absent due to the previous asphalt recovery processes conducted on the site. The site is surrounded by commercial properties with a residential neighborhood to the west across Akers Drive. Building loads are expected to be light to moderate.

3 Subsurface Explorations and Laboratory Testing

3.1 Subsurface Exploration Program

Subsurface conditions at the project site were explored by nine test borings, designated TB-1 through TB-9, drilled on December 13 and 16, 2024 at the approximate locations shown on the Site and Exploration Plan (Figure 2). Two borings (TB-1 and TB-2) were drilled in the addition footprint and five (TB-3 through TB-7) were drilled for the three retaining walls. Two additional borings (TB-8 and TB-9) were drilled in the parking lot and drive lanes to provide pavement design recommendations. The borings in the building footprint and at the proposed retaining wall locations were drilled to depths of 20 feet below the existing ground surface (bgs), and the borings in the parking and drive areas were drilled to depths of 10 feet 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, and subsequent to, 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 and bedrock classifications were later verified utilizing laboratory testing and grouped by soil type. The soil and bedrock type numbers are included on the boring logs. It should be understood that soil and bedrock descriptions shown on the boring logs may vary between boring location and sample depths. It should also be noted that the lines of stratigraphic separation shown on the boring logs represent approximate boundaries between soil and bedrock types, and the actual stratigraphic transitions may be more gradual or variable with location.

3.2 Laboratory 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. One-dimensional swell/collapse testing (ASTM D4546) was performed to evaluate the expansive characteristics and collapse potential characteristics. Soluble sulfate testing was performed on select soil samples to evaluate the potential for below-grade degradation of concrete due to sulfate attack.

For pavement design, a Standard Proctor (ASTM D698) and California Bearing Ratio (CBR) test (ASTM D1883) were completed on a bulk sample from the roadway subgrade. The Laboratory Testing Results are presented in Appendix B and summarized in Table B-1.

4 Subsurface Conditions

Two primary soil types 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 Soil and Bedrock

Soil Type 1 classified as clayey sand or silty sand (SM, SC). The medium dense sand was encountered in all test borings at ground surface to 9 feet bgs and extended to depths of 9 feet bgs or to the termination depth of the boring at 10 or 20 feet. One-dimensional swell or collapse testing on a sample of the sands resulted in volume changes of -1.8% to 0.6% indicating low to moderate expansion and collapse potential.

Pavement subgrade soils generally consisted of Soil Type 1 which classified as AASHTO A-6.

Soil Type 1A classified as clayey sand fill (SC). The sand fill was encountered in the majority of test borings at ground surface and extended to depths of 1.5 to 2 feet bgs. The on-site sands are expected to have a low potential for expansion or collapse.

Soil Type 2 classified as native sandy clay (CL). The stiff native clay was encountered in TB-4 at the existing ground surface and extended to a depth of 9 feet bgs and was encountered in TB-6 at 9 feet bgs and extended to the termination depth of the boring at 20 feet bgs. The encountered clay is expected to have low to moderate expansion potential.

4.2 Groundwater

Groundwater was encountered in test borings TB-1 and TB-3 during our subsurface exploration program at 19.5 and 19 feet bgs, respectively. It should be noted that groundwater levels could change due to seasonal variations, changes in land runoff characteristics, and future development of nearby areas.

5 Geotechnical Evaluation and Recommendations

The following discussion is based on the subsurface conditions encountered in the borings drilled on the planned lot for construction. If subsurface conditions different from those described herein are encountered during construction, or if the project elements change from those described, Entech should be notified so that the evaluation and recommendations presented can be reviewed and revised if necessary.

As discussed in Section 2, we understand that the site will be developed with a new commercial addition, retaining walls, and associated site improvements. The proposed structure is expected to have a shallow foundation system. Anticipated subsurface conditions at footing grade are expected to consist of native granular soil or recompacted onsite granular material and are suitable for support of shallow foundations.

5.1 Shallow Foundations

For shallow foundation design, continuous spread footings are recommended to have a minimum width of 16 inches, and individual column footings for main support beams should have minimum plan dimensions of 24 inches on each side in order to avoid punching failure into the supporting subgrade soils. Subgrades should be prepared as discussed in Section 7.1.1. Refer to Exhibit 1 for the recommended allowable bearing capacity values. Shallow foundations shall not be placed on soils with differential bearing capacities, loose granular soil, or uncontrolled fill. Undocumented, uncontrolled fill was encountered throughout the site to depths of up to 2 feet. We anticipate that this fill will be penetrated by the proposed shallow foundations. If grades on the site are raised, the undocumented fill material should be overexcavated and recompacted below foundation components and slabs on grade.

Foundation walls should be designed to resist lateral pressures generated by the soils used for wall backfill. Recommended active equivalent fluid density parameters for the on-site granular soils are provided in Exhibit 1. Clay/silt soils (more than 50% passing the No. 200 sieve) are not recommended for backfill against the walls. It should be noted that this value applies to level backfill conditions. If sloping backfill conditions exist, pressures will increase substantially depending on the conditions adjacent to the walls. Surcharge loading should also be considered in wall designs. Equivalent fluid pressures for sloping conditions should be determined on an individual basis. Exterior footings should extend a minimum of 30 inches below the adjacent exterior site grade for frost protection.

Exhibit 1: Foundation Design Parameters

Design Parameter	Value
Allowable Bearing Capacity [1]	
Medium Dense Native Sand or Granular Fill	2,200 psf
Lateral Earth Pressure Equivalent Fluid Density [2]	
Active Conditions – On-Site Granular Backfill	45 pcf

pcf = pounds per cubic foot; psf = pounds per square foot

Notes:
1. Assumes a minimum embedment of 30 inches for frost protection.
2. Assumes level backfill conditions.

Actual bearing capacities will be verified at the time of the open excavation observation (Section 7.9).

5.2 On-Grade Floor Slabs

On-grade floor slabs for the planned structure should be supported on native, medium dense sand or 2 feet of moisture-conditioned and recompacted site or imported granular soils prepared in accordance with Section 7.1.1, and any loose soils or uncontrolled fill encountered will require removal.

Grade-supported floor slabs should be separated from other building structural components and utility penetrations to allow for possible future vertical movement. Interior partition walls should be constructed in such a manner so as not to transfer slab movement into the overlying floor(s) and/or roof members, should slab movement occur. Control joints in grade-supported slabs are recommended at 10- to 15-foot perpendicular spacings to control cracking. If slab movement cannot be tolerated, a structural floor system should be used.

5.3 Design Parameters for Retaining Walls

Based on the material encountered in the test borings, the proposed retaining walls can be supported on a gravel leveling pad (for segmental walls) or a shallow concrete footing (for cast-in-place concrete walls), bearing on native medium dense granular fill. A bearing capacity for the site granular material is presented in Exhibit 2. Any loose or uncontrolled fill material encountered in the wall subgrade should be removed completely and recompacted under controlled conditions. Any fill material should be placed in finished lifts no thicker than 6 inches, compacted to at least

95% of the Modified Proctor (ASTM D1557) maximum dry density at a moisture content conducive to compaction, usually within +/- 2% of optimum.

Retaining walls should be designed to resist lateral earth pressures generated by the soils used for wall backfill. Equivalent hydrostatic fluid pressures are also provided in Exhibit 2 for the approved site soils. It should be noted that this value applies to level backfill conditions. Pressures will increase substantially depending on the conditions adjacent to the wall. Surcharge loading should be considered in wall design. The following values are recommended for use in the design of the retaining wall associated with this project:

Exhibit 2: Retaining Wall Design Recommendations

Design Parameter (On-site granular soil)	Value
Equivalent Fluid Pressure (active case), pcf	45
Equivalent Fluid Pressure (passive case), pcf	300
Equivalent Fluid Pressure (at rest), pcf	65
Soil Density, pcf	120
Angle of Internal Friction, degrees	28
Coefficient of Sliding (Concrete & Sand)	0.35
Soil Bearing Capacity	2,200 psf

The wall should include a subsurface drain installed according to the design drawings in order to avoid accumulation of hydrostatic pressures on the wall.

5.4 Seismic Site Classification

Based on the subsurface conditions encountered at the site, and in accordance with Section 1613 of the 2021 *International Building Code* (IBC), the site meets the conditions of a Site Class D.

5.5 Surface and Subsurface Drainage

Positive surface drainage is recommended around the building's perimeter to minimize infiltration of surface water into the supporting foundation soils. A minimum ground surface slope of 5% in the first 10 feet adjacent to exterior foundation walls is recommended for unpaved areas. For paved areas and other impervious surfaces, a minimum slope of 2% is adequate. All roof drains and gutter downspouts should be extended to discharge well beyond the building's foundation backfill zone or be connected to a storm sewer system.

To help minimize infiltration of water into the foundation zone, vegetative plantings placed close to foundation walls should be limited to those species having low watering requirements, and irrigated grass should not be located within 5 feet of the foundation. Sprinklers are not recommended to discharge water within 5 feet of foundations. Irrigation near foundations should be limited to the minimum amount sufficient to maintain vegetation. The application of more irrigation water than necessary can increase the potential for slab and foundation movement.

Perimeter drains are recommended for usable space below grade (areas where the interior slab or bottom of the crawl space is below the exterior grade). A typical perimeter drain detail is shown in Figure 3.

6 Pavement Design Recommendations

Pavement design recommendations were made in accordance with the *City of Colorado Springs Pavement Design Criteria Manual.*

6.1 Pavement Subgrade Conditions

Two test borings (TB-8 and TB-9) were drilled to depths of approximately 10 feet below the existing subgrade surface in the parking lot and drive lanes. The soils at the roadway subgrade depth consisted of silty sand and clayey sand. The sands classified as A-6 using the AASHTO classification system.

California Bearing Ratio (CBR) testing was performed on a representative bulk sample of the clayey sand (Soil Type 1) from TB-8 to determine the support characteristics of the subgrade soils for the pavement sections. The results of the CBR testing are presented in Appendix B and summarized in Exhibit 2.

Exhibit 2: Pavement Subgrade Laboratory Summary

Design Parameter	Value
Soil Type	1-Clayey Sand
CBR at 95%	4.7
Design CBR	4.7
Liquid Limit	31
Plasticity Index	10
Percent Passing 200	43.5
AASHTO Classification	A-6
Group Index	1
Unified Soils Classification	SC

6.2 Swell Mitigation

The City of Colorado Springs requires swell mitigation of expansive soils criteria for soils with swell testing results greater than 4% under a 200 pounds per square foot (psf) surcharge. Based on the swell testing and classification of the subgrade soils, mitigation for expansive soils is not required on this site.

6.3 Traffic Loading

Traffic data is not available for the parking lot and access road. Based on the Colorado Asphalt Pavement Association (CAPA) *Guideline for the Design and Construction of Asphalt Parking Lots in Colorado* (2006), an 18-kip equivalent single axle loading (ESAL) of 50,000 is appropriate for moderate traffic levels which includes passenger cars and light trucks.

6.4 Pavement Designs

The recommended pavement sections were determined utilizing the *City of Colorado Springs Pavement Design 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	85%
Standard Deviation	0.44
Serviceability Loss (Δ psi)	2.5
Design CBR	4.7
Resilient Modulus - Soil Type 1	7,050 psi
Structural Coefficients	
Hot Mix Asphalt	0.44
Aggregate Base Course	0.12
Recycled Concrete Base	0.12

Pavement sections are presented below in Exhibit 4. Any additional grading may result in subgrade soils with different support characteristics. The following pavement sections should be re-evaluated if additional grading is performed.

Exhibit 4: Recommended Pavement Sections

Pavement Area	Design ESAL	Alternative[1]
Parking Areas and Drive Lanes	50,000	1. 4.0 inches HMA over 4.0 inches ABC/RCB

ABC = Aggregate Base Course; ESAL = Equivalent Single Axle Loads; HMA = Hot Mix Asphalt; RCB = Recycled Concrete Base

Notes:

1. All pavement alternatives meet the minimum sections required per the *City of Colorado Springs Pavement Design Criteria Manual.*
2. Full-depth sections are not allowed within the City of Colorado Springs.

7 Construction Recommendations

7.1 Earthwork Recommendations for Structures

7.1.1 Subgrade Preparation

We anticipate that the shallow foundations will penetrate the undocumented fill encountered throughout the site. We recommend that the undocumented fill be overexcavated and recompacted in place in the slab-on-grade areas or in areas where grades are raised and the bottom of shallow foundations do not penetrate the undocumented fill.

Where applicable, undocumented fill should be fully penetrated (anticipated depth of 2 feet) to expose a dense and unyielding native subgrade. Once suitable materials are encountered, the subgrade should be scarified to a depth of 6 inches and then recompacted to 95% of the Modified Proctor (ASTM D1557) maximum dry density within +/- 2% of the optimum moisture content. The overexcavated material can then be replaced in 6-inch lifts and recompacted to the same specifications as described above. The suitability of subgrades and/or overexcavation depth should be determined during the excavation observation.

Foundations and on-grade floor slabs may be placed on controlled, well-compacted, site or imported granular fill. All soil beneath the foundation and slabs should be free of organics, debris, and cobbles larger than 3 inches in diameter.

7.1.2 Granular Fill

Granular fill placed beneath foundation components and floor slabs shall consist of nonexpansive, granular soil, free of organic matter, unsuitable materials, debris, and cobbles greater than 3 inches in diameter. On-site granular soils may be used as granular fill. Entech should approve any imported granular or structural fill to be used within the foundation area prior to delivery to the site.

7.1.3 Fill Placement and Compaction

All granular fill placed within the foundation area 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 as determined by ASTM D1557. Mechanical methods can be used for placement and compaction of fill; however, heavy equipment should be kept at a distance from foundation walls and below slab infrastructure to avoid overstressing. No water flooding techniques of any type should be used for compaction or placement of foundation or floor slab fill material.

Fill placement and compaction beneath and around foundations should be observed and tested by Entech during construction. Density tests should be performed frequently to verify compaction with the first density test performed at the overexcavated subgrade elevation and with additional testing once each 12 to 18 inches of granular fill has been placed.

7.2 Pavements

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 *Colorado Springs Engineering Criteria Manual* and the *Pike Peak Regional Asphalt Paving Specifications*.

7.2.1 Pavement Subgrade Preparation

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 should be removed by stripping, with the depth to be field determined.

The final subgrade surface should be scarified to a depth of 12 inches and then recompacted to a minimum of 95% of the Modified Proctor (ASTM D1557) maximum dry density at +/- 2% of optimum moisture content. 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.

We do not anticipate issues with the subgrade in regard to shallow water, frost-susceptible soils, groundwater or drainage conditions, or cold weather construction.

7.2.2 Aggregate Base Course and Recycled Concrete Base

ABC or RCB materials shall conform to the *Colorado Springs Standard Specifications Manual*, Section 300 Aggregate Base Course. ABC or RCB materials should be compacted to a minimum of 95% of the Modified Proctor (ASTM D1557) maximum dry density within +/-2% of optimum moisture content.

7.3 Excavation Potential

Excavation of the upper granular soils should be feasible with rubber-tired equipment.

7.4 Excavation Stability

Excavation sidewalls must be properly sloped, benched, and/or otherwise supported in order to maintain stable conditions. All excavation openings and work completed therein shall conform to OSHA Standards as put forward in CFR 29, Part 1926.650-652, (Subpart P).

7.5 Utility Trench Backfill

Trench backfill placement should be performed in accordance with Colorado Springs specifications. All excavation and excavation shoring/bracing should be performed in accordance with OSHA guidelines.

Fill placement and compaction in utility trenches should be observed and tested by Entech during construction. Fill should be placed in horizontal lifts having a compacted thickness of 6 inches or less and at a water content conducive to adequate compaction, within +/-2% of optimum water content. No water flooding techniques of any type should be used for compaction or placement of utility trench fill.

7.6 General Backfill

Any areas to receive general grading fill should have all topsoil, organic material, and debris removed. Fill must be properly benched into existing slopes in order to be adequately compacted. The fill-receiving surface should be scarified to a depth of 12 inches and then recompacted to a minimum of 95% of the Modified Proctor (ASTM D1557) maximum dry density at +/-2% of optimum moisture content or the Standard Proctor (ASTM D698) for cohesive soils before the addition of new fill. Fill should be placed in thin lifts not to exceed 6 inches in thickness. Fill material should be free of vegetation and other unsuitable material and should not contain cobbles or fragments larger than 3 inches. Topsoil and strippings should be segregated from all other fill sources on the site. Fill placement and compaction beneath and around foundations, in utility trenches, or beneath roadways or other structural features of the project should be observed and tested by Entech during construction.

7.7 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 placed below surface grade. The test results indicated less than 0.01 and 0.00% 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 1L or Type II 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.

7.8 Winter Construction

In the event construction of the planned facility occurs during winter, foundations and subgrades should be protected from freezing conditions. Concrete should not be placed on frozen soil and once concrete has been placed, it should not be allowed to freeze. Similarly, once exposed, the foundation subgrade should not be allowed to freeze. During site grading and subgrade preparation, care should be taken to eliminate the burial of snow, ice, or frozen material within the planned construction area.

7.9 Foundation Excavation and Construction Observation

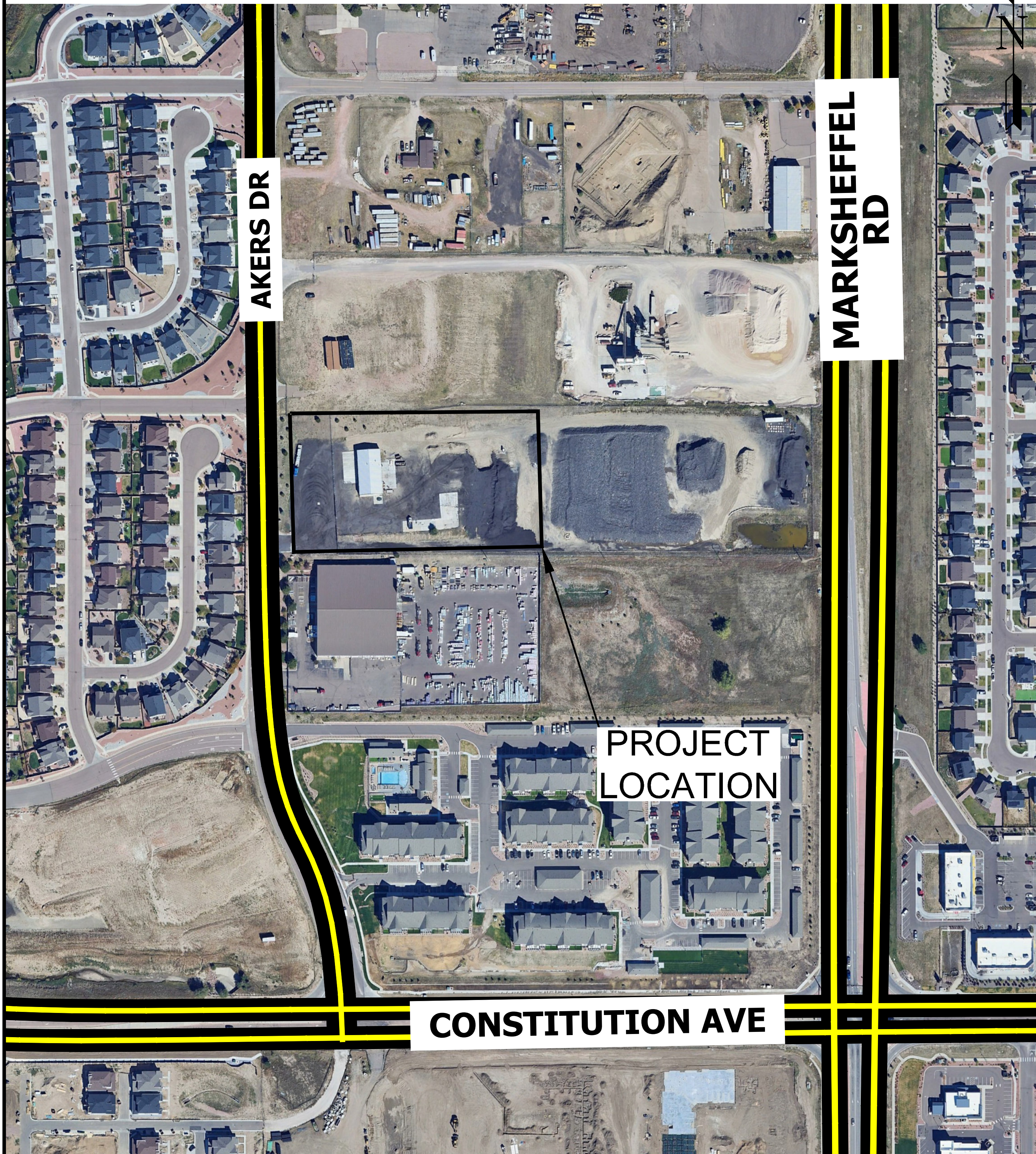
Subgrade preparation for building foundations should be observed by Entech prior to construction of the footings and floor slabs in order to verify that (1) no anomalies are present, (2) materials similar to those described in this report have been encountered or placed, and (3) no soft spots, expansive or organic soil, or debris are present in the foundation area prior to concrete placement or backfilling. Entech should make final recommendations for overexcavation, if required, and foundation drainage at the time of excavation observation, if necessary.

In addition, Entech should observe and document placement and compaction of utility bedding and trench backfill.

8 Closure

The subsurface investigation, geotechnical evaluation, and recommendations presented in this report are intended for use by Landscape Endeavors, Inc. with application to the planned new addition, retaining walls, and associated site improvements located in Colorado Springs, 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.



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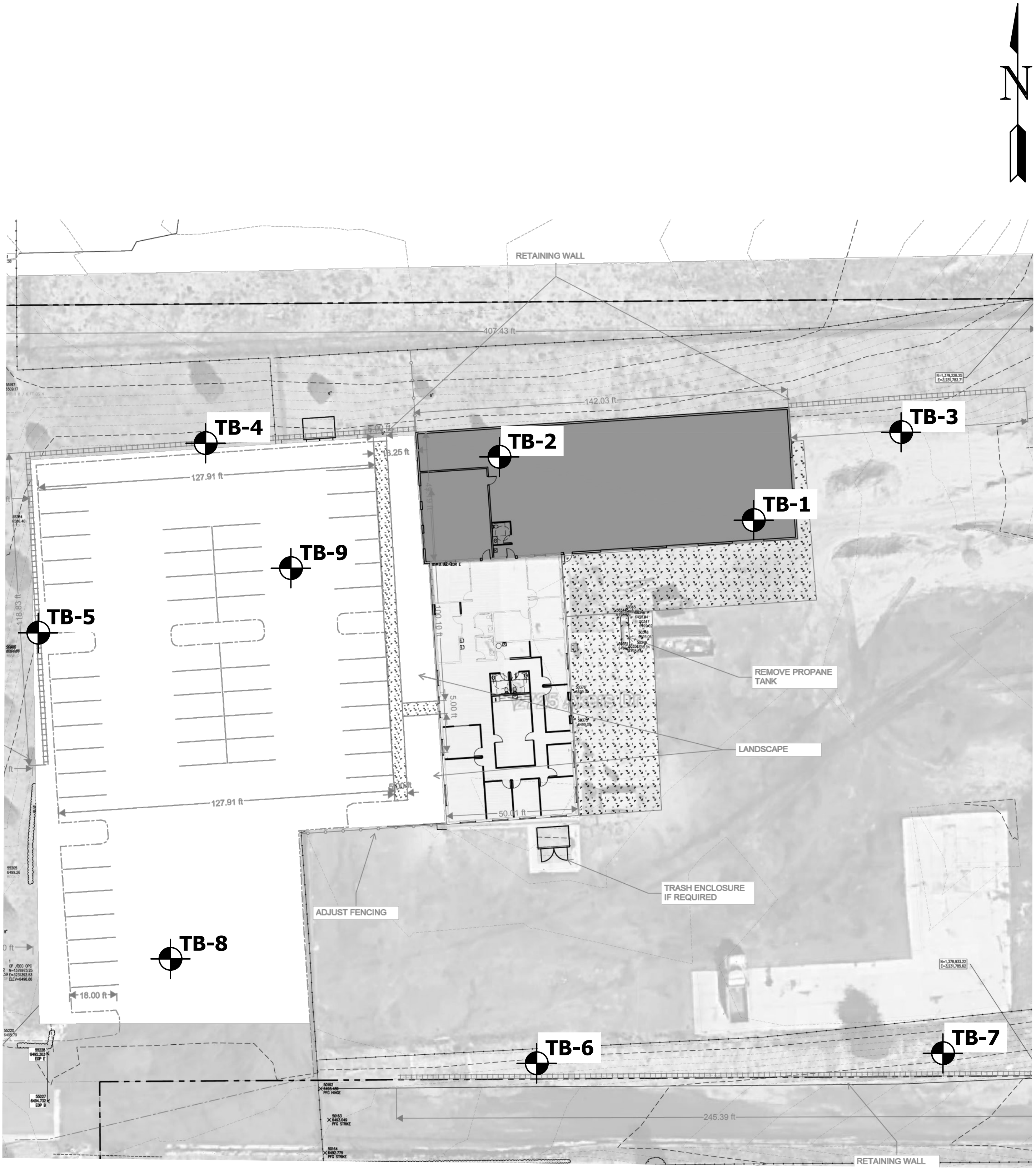
VICINITY MAP

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

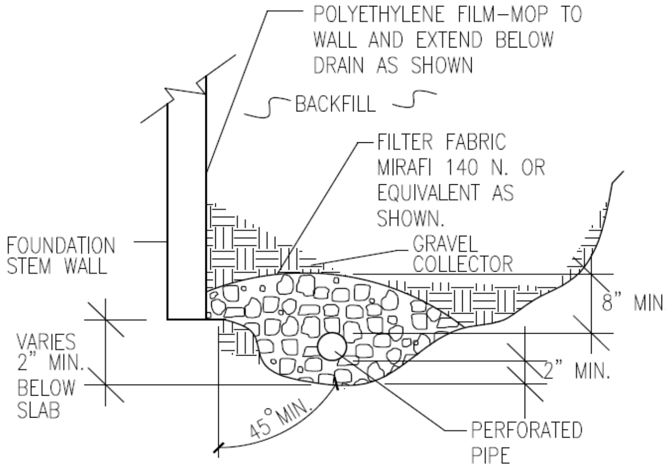
JOB NO.
242065

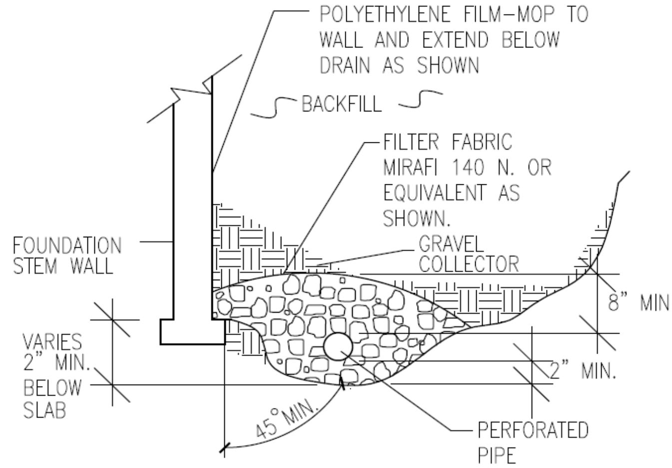
FIG. 1



TB- APPROXIMATE TEST BORING LOCATION AND NUMBER

ENTECH ENGINEERING, INC.	SITE AND EXPLORATION PLAN 2725 AKERS DRIVE LANDSCAPE ENDEAVORS, INC.	JOB NO. 242065 FIG. 2





NOTES:

–GRAVEL SIZE IS RELATED TO DIAMETER OF PIPE PERFORATIONS–85% GRAVEL GREATER THAN 2x PERFORATION DIAMETER.

–PIPE DIAMETER DEPENDS UPON EXPECTED SEEPAGE. 4–INCH DIAMETER IS MOST OFTEN USED.

–ALL PIPE SHALL BE PERFORATED PLASTIC. THE DISCHARGE PORTION OF THE PIPE SHOULD BE NON–PERFORATED PIPE.

–FLEXIBLE PIPE MAY BE USED UP TO 8 FEET IN DEPTH, IF SUCH PIPE IS DESIGNED TO WITHSTAND THE PRESSURES. RIGID PLASTIC PIPE WOULD OTHERWISE BE REQUIRED.

–MINIMUM GRADE FOR DRAIN PIPE TO BE 1% OR 3 INCHES OF FALL IN 25 FEET.

–DRAIN TO BE PROVIDED WITH A FREE GRAVITY OUTFALL, IF POSSIBLE. A SUMP AND PUMP MAY BE USED IF GRAVITY OUT FALL IS NOT AVAILABLE.

ENTECH ENGINEERING, INC.	**PERIMETER DRAIN DETAIL** 2725 AKERS DRIVE LANDSCAPE ENDEAVORS, INC.	JOB NO. 242065 **FIG. 3**

APPENDIX A: Test Boring Logs

TEST BORING 1
DATE DRILLED 12/13/2024
REMARKS
WATER @ 19.5', 12/17/24

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-2', SAND, CLAYEY, BROWN						1A
SAND, SILTY, BROWN to LIGHT BROWN, MEDIUM DENSE, MOIST				13	18.5	1
	5			11	10.7	1
SAND, CLAYEY, LIGHT BROWN, MEDIUM DENSE, MOIST	10			16	18.2	1
	15			16	10.4	1
	20			24	17.7	1

TEST BORING 2
DATE DRILLED 12/13/2024
REMARKS
DRY TO 20', 12/17/24

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
SAND, CLAYEY, LIGHT BROWN, MEDIUM DENSE, MOIST				12	19.6	1
	5			12	15.2	1
	10			16	9.4	1
	15			16	9.4	1
	20			19	9.4	1

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TEST BORING LOGS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO. 242065

FIG. A-1

TEST BORING 3
DATE DRILLED 12/13/2024
REMARKS
WATER @ 19', 12/13/24

Description	Depth (ft)	Blows per foot	Watercontent %	Soil Type
SAND, CLAYEY, BROWN to LIGHT BROWN, MEDIUM DENSE, MOIST				
	2.5	11	12.0	1
	5	13	12.0	1
	10	16	13.3	1
	15	18	10.3	1
	20	19	13.4	1

TEST BORING 4
DATE DRILLED 12/13/2024
REMARKS
DRY TO 20', 12/17/24

Description	Depth (ft)	Blows per foot	Watercontent %	Soil Type
CLAY, SANDY, BROWN, STIFF, MOIST				
	2.5	8	10.1	2
	5	13	13.6	2
SAND, CLAYEY, BROWN to LIGHT BROWN, MEDIUM DENSE, MOIST	10	15	10.0	1
	15	21	8.5	1
	20	20	12.2	1

ENTECH ENGINEERING, INC.

TEST BORING LOGS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO. 242065

FIG. A-2

TEST BORING 5
DATE DRILLED 12/16/2024
REMARKS
DRY TO 19.5', 12/17/24

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-1.5', SAND, CLAYEY, BROWN					1A
SAND, CLAYEY, BROWN to LIGHT BROWN, MEDIUM DENSE, MOIST		■	13	19.2	1
	5	■	18	16.4	1
	10	■	11	12.4	1
	15	■	15	13.0	1
	20	■	21	8.7	1

TEST BORING 6
DATE DRILLED 12/16/2024
REMARKS
DRY TO 20', 12/17/24

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-2', SAND, CLAYEY, BROWN					1A
SAND, CLAYEY, BROWN to LIGHT BROWN, MEDIUM DENSE, MOIST		■	10	15.8	1
	5	■	11	18.5	1
CLAY, SANDY, LIGHT BROWN, STIFF, MOIST	10	■	12	15.8	2
	15	■	11	15.4	2
	20	■	14	13.0	2

ENTECH ENGINEERING, INC.

TEST BORING LOGS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. A-3

TEST BORING 7
DATE DRILLED 12/16/2024
REMARKS

DRY TO 19.5', 12/17/24

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-1.5', SAND, CLAYEY, BROWN						1A
SAND, CLAYEY, BROWN to LIGHT BROWN, MEDIUM DENSE, MOIST				10	9.6	1
	5			12	10.6	1
	10			18	10.4	1
	15			16	7.2	1
	20			14	10.0	1

TEST BORING 8
DATE DRILLED 12/16/2024
REMARKS

DRY TO 10', 9/16/24

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-1.5', SAND, CLAYEY, BROWN						1A
SAND, CLAYEY, BROWN to LIGHT BROWN, MEDIUM DENSE, MOIST				11	11.8	1
	5			11	13.0	1
	10			9	18.6	1
	15					
	20					

ENTECH ENGINEERING, INC.

TEST BORING LOGS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. A-4

TEST BORING 9
DATE DRILLED 12/16/2024

REMARKS

DRY TO 10', 9/16/24

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
SAND, CLAYEY, BLACK, MEDIUM DENSE, MOIST				19	14.9	1
	5			11	12.4	1
	10			14	15.3	1
	15					
	20					

ENTECH ENGINEERING, INC.

TEST BORING LOGS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. A-5

ENTECH ENGINEERING, INC.

APPENDIX B: Laboratory Test Results

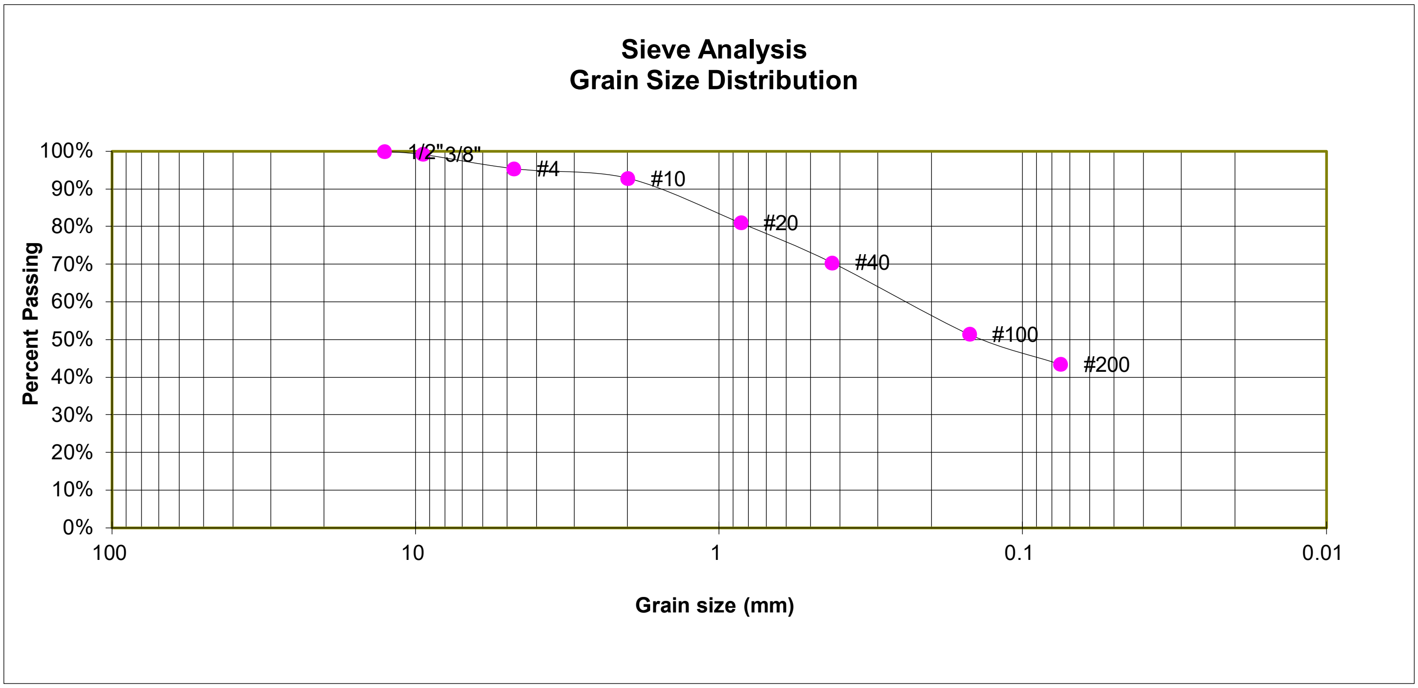
TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS

ENTECH ENGINEERING, INC.

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX	SULFATE (WT %)	FHA SWELL (PSF)	SWELL/ COLLAPSE (%)	AASHTO CLASS. (GROUP INDEX)	USCS	SOIL DESCRIPTION
1, CBR	8	1-3	12.6		43.5	31	21	10				A-6 (1)	SC	SAND, CLAYEY
1	1	5	11.3		29.4	NV	NP	NP	0.00			A-2-4 (0)	SM	SAND, SILTY
1	2	2-3	17.5	93.2	45.2	32	24	8	<0.01		-1.8	A-4 (1)	SC	SAND, CLAYEY
1	3	10	10.9		39.8								SC	SAND, CLAYEY
1	5	5	14.7	103.4	46.5						-0.4		SC	SAND, CLAYEY
1	7	2-3	12.9	90.8	32.1						-0.4		SC	SAND, CLAYEY
1	8	1-2	14.5	102.3	35.6	28	21	7	<0.01		0.8	A-4 (0)	SC	SAND, CLAYEY
1	9	1-2	19.5	109.6	42.4	33	22	11			0.6	A-6 (1)	SC	SAND, CLAYEY
1	1	2-3	14.8	108.9							-0.1		SC	SAND, CLAYEY
2	4	5	11.7		54.9								CL	CLAY, SANDY
2	6	10	14.1		54.5					450			CL	CLAY, SANDY

Project: 2725 Akers Drive
Client: Bucher Design Studio
Job No: 242065

TEST BORING	8	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	1-3	SOIL TYPE	1, CBR



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	99.3%
4	95.4%
10	92.8%
20	81.1%
40	70.5%
100	51.4%
200	43.5%

ATTERBERG LIMITS

Plastic Limit	21
Liquid Limit	31
Plastic Index	10

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-6
AASHTO GROUP INDEX:	1

ENTECH ENGINEERING, INC.

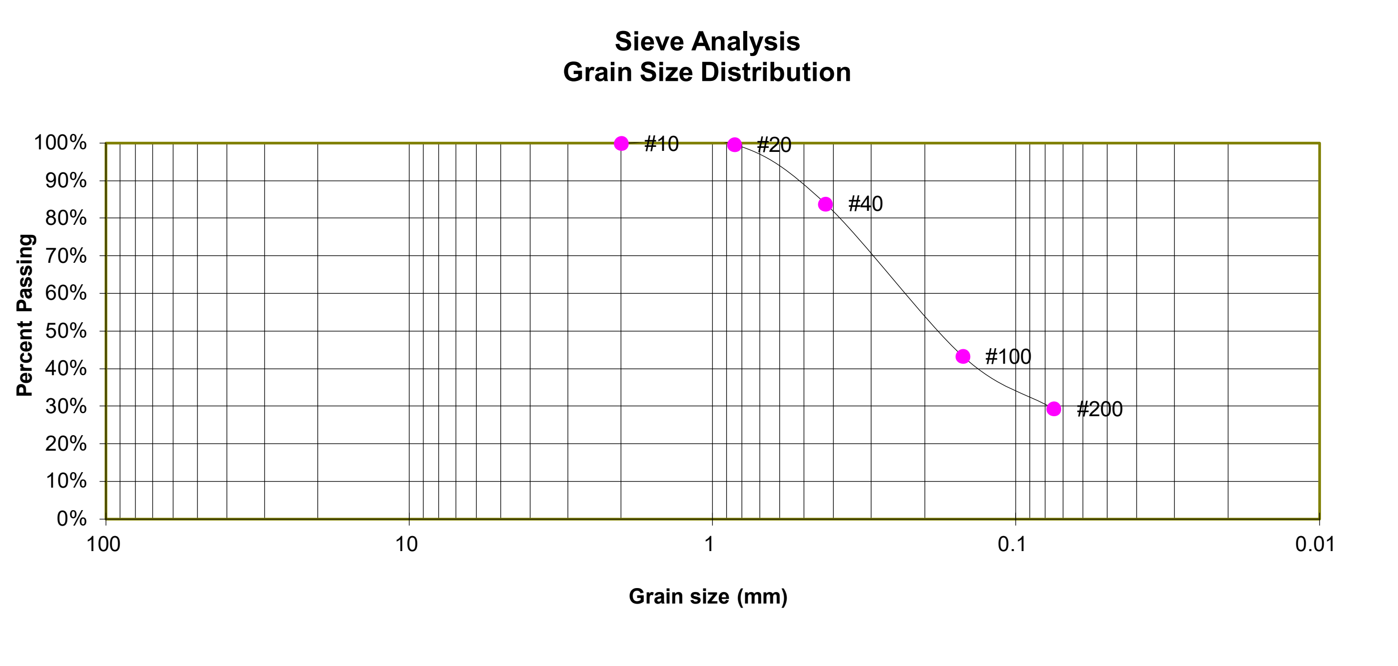
LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-1

TEST BORING	1	SOIL DESCRIPTION	SAND, SILTY
DEPTH (FT)	5	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	100.0%
20	99.6%
40	83.9%
100	43.4%
200	29.4%

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.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
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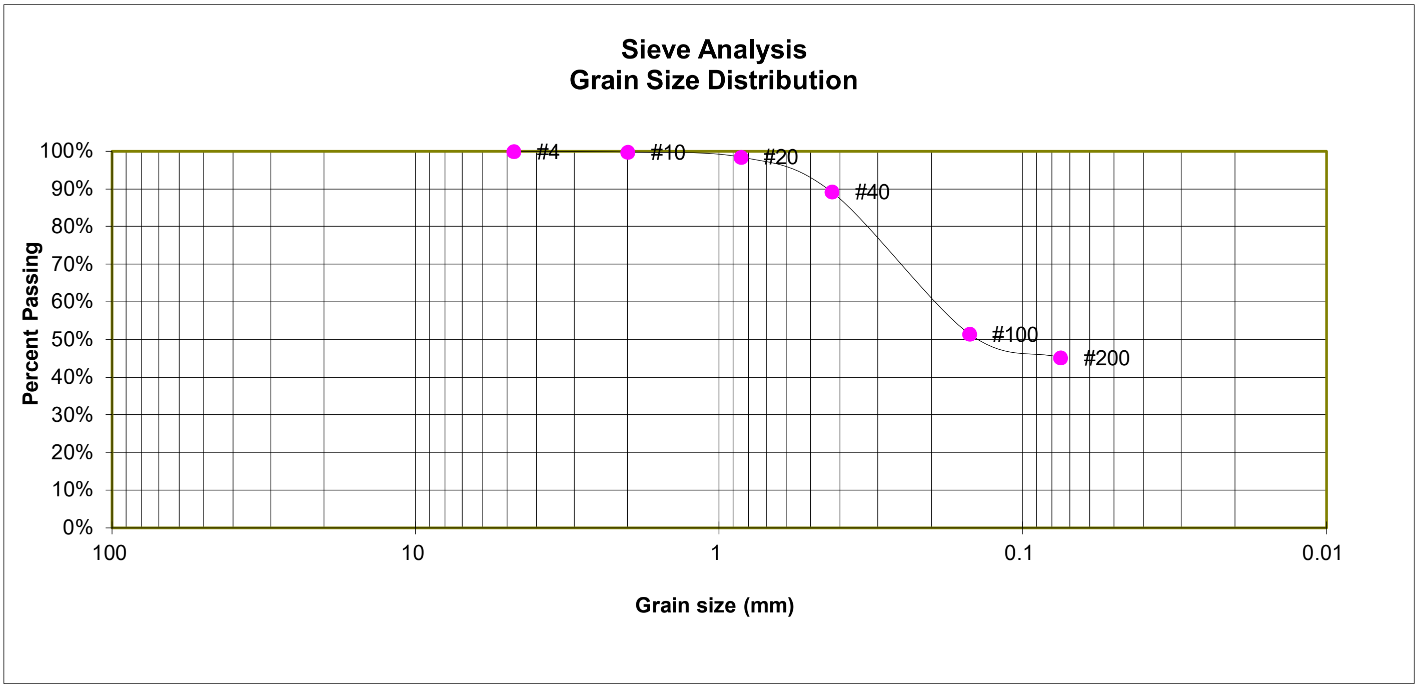
FIG. B-2

TEST BORING	2	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	2-3	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	99.9%
20	98.5%
40	89.2%
100	51.6%
200	45.2%

ATTERBERG LIMITS

Plastic Limit	24
Liquid Limit	32
Plastic Index	8

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-4
AASHTO GROUP INDEX:	1

ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

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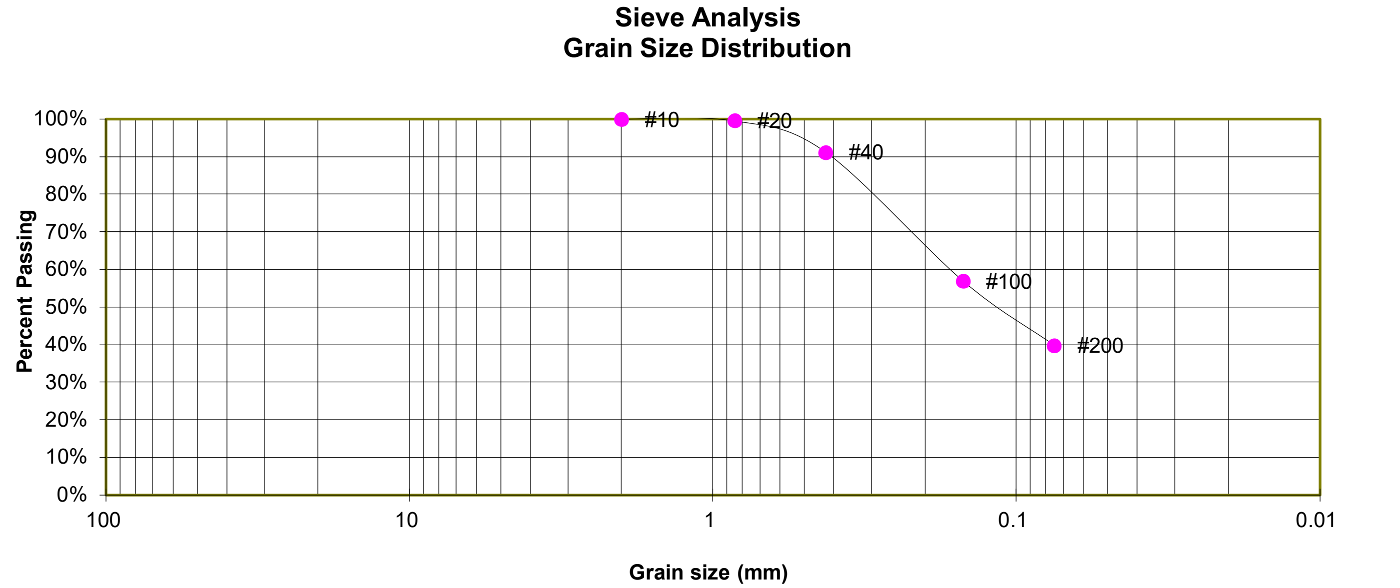
FIG. B-3

TEST BORING	3	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	10	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	100.0%
20	99.6%
40	91.2%
100	57.0%
200	39.8%

SOIL CLASSIFICATION

USCS CLASSIFICATION: SC
AASHTO CLASSIFICATION:
AASHTO GROUP INDEX:

ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

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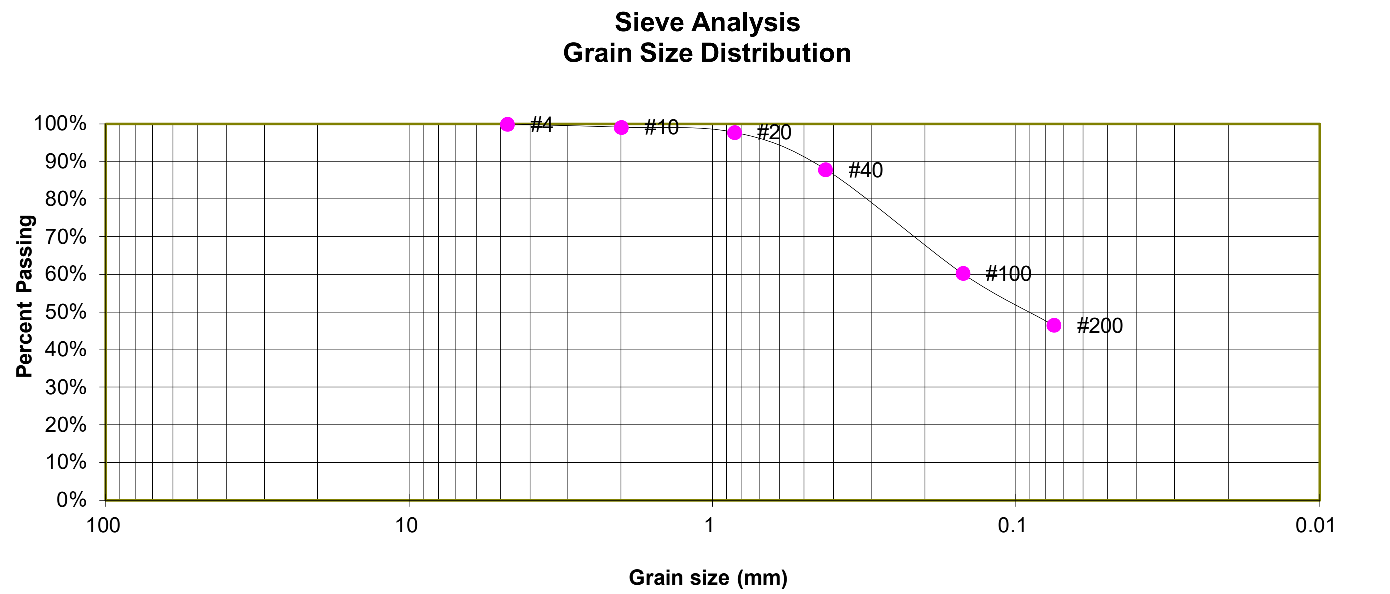
FIG. B-4

TEST BORING	5	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	5	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	97.8%
40	87.9%
100	60.3%
200	46.5%

SOIL CLASSIFICATION

USCS CLASSIFICATION: SC
AASHTO CLASSIFICATION:
AASHTO GROUP INDEX:

ENTECH ENGINEERING, INC.

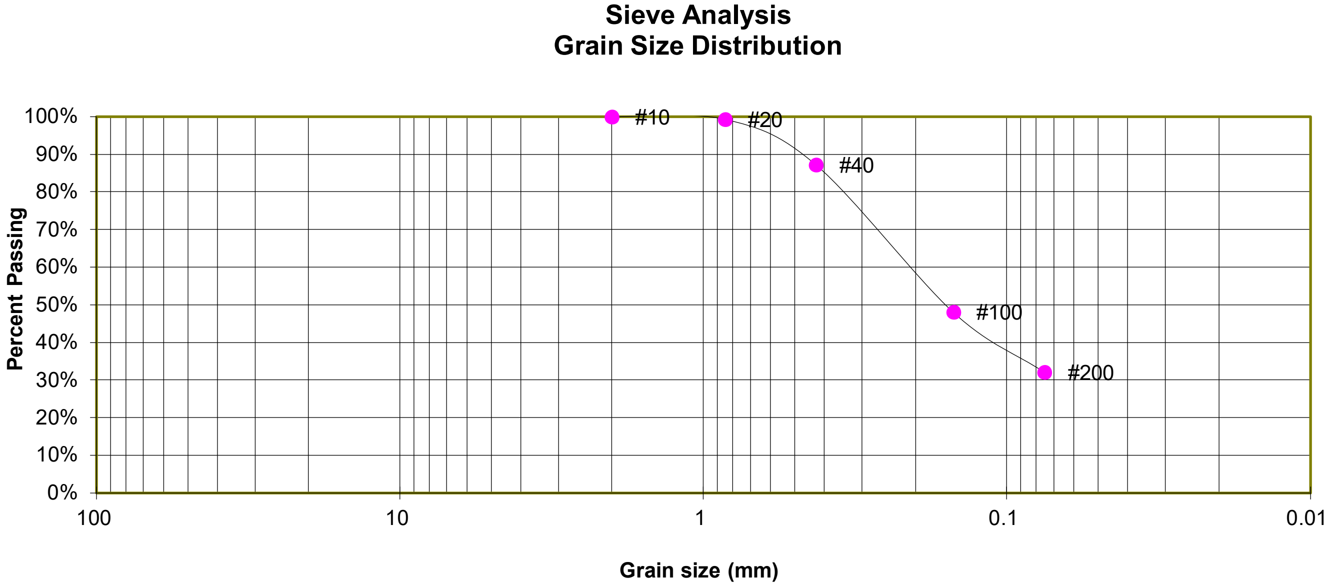
LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-5

TEST BORING	7	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	2-3	SOIL TYPE	1



GRAIN SIZE ANALYSIS

U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	100.0%
20	99.3%
40	87.2%
100	48.1%
200	32.1%

SOIL CLASSIFICATION

USCS CLASSIFICATION: SC

AASHTO CLASSIFICATION:

AASHTO GROUP INDEX:

ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

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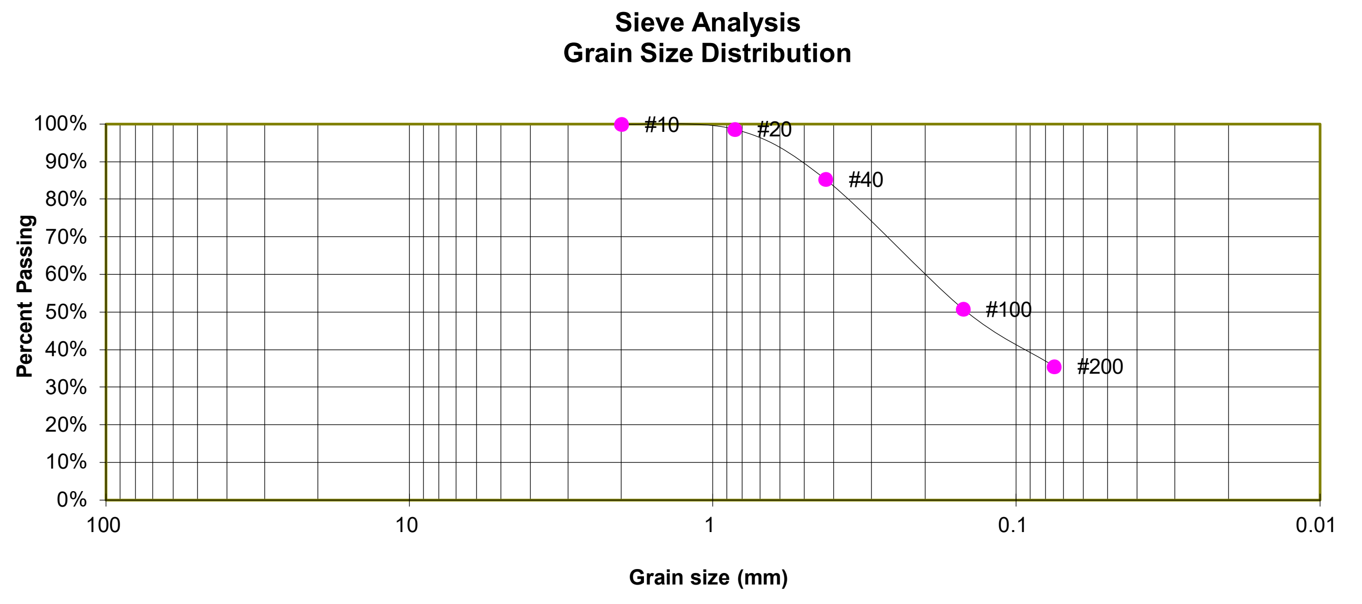
FIG. B-6

TEST BORING	8	SOIL DESCRIPTION	SAND, CLAYEY
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"	
4	
10	100.0%
20	98.7%
40	85.3%
100	50.9%
200	35.6%

ATTERBERG LIMITS

Plastic Limit	21
Liquid Limit	28
Plastic Index	7

SOIL CLASSIFICATION

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

ENTECH ENGINEERING, INC.

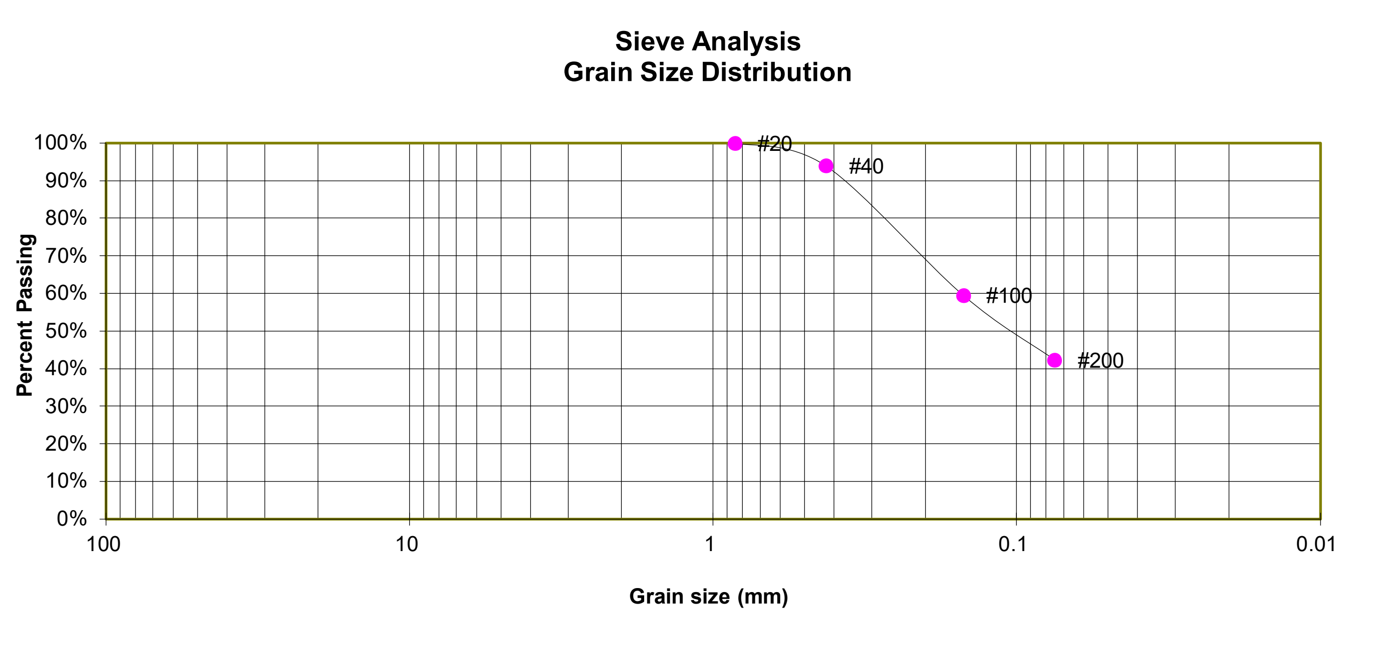
LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-7

TEST BORING	9	SOIL DESCRIPTION	SAND, CLAYEY
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"	
4	
10	
20	100.0%
40	93.9%
100	59.5%
200	42.4%

ATTERBERG LIMITS

Plastic Limit	22
Liquid Limit	33
Plastic Index	11

SOIL CLASSIFICATION

USCS CLASSIFICATION:	SC
AASHTO CLASSIFICATION:	A-6
AASHTO GROUP INDEX:	1

ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
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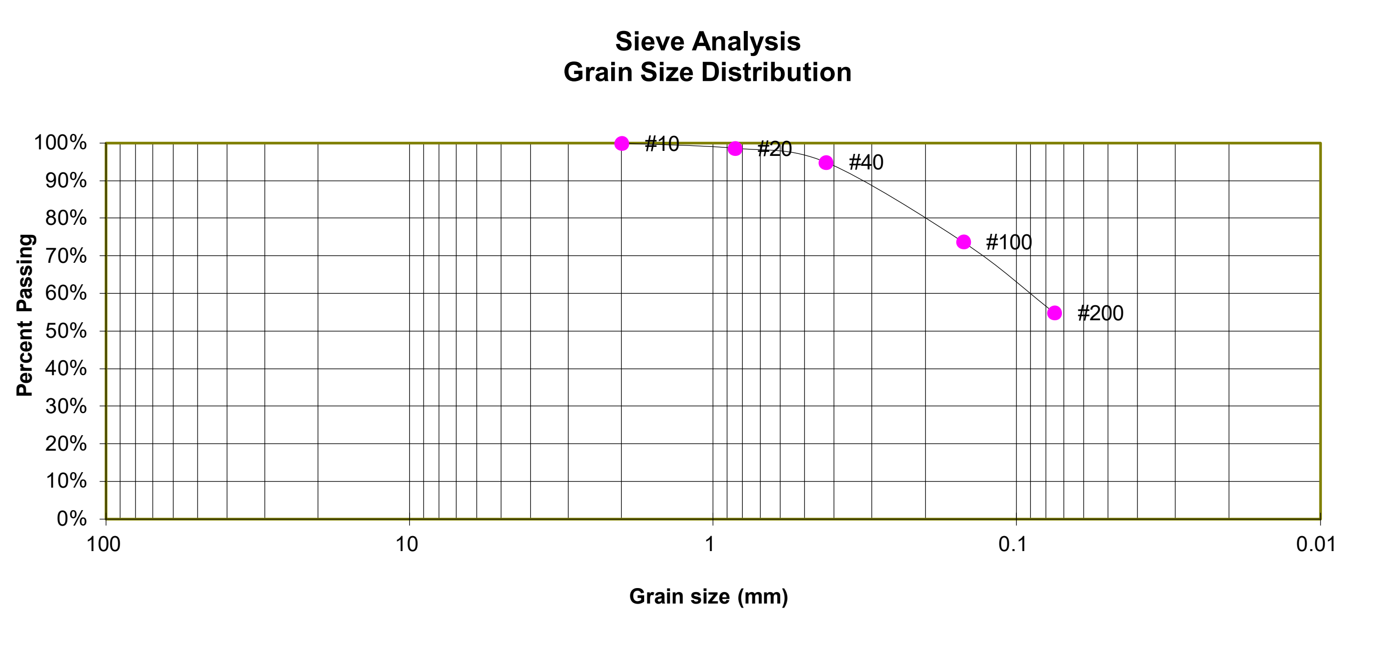
FIG. B-8

TEST BORING	4	SOIL DESCRIPTION	CLAY, SANDY
DEPTH (FT)	5	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	98.7%
40	94.9%
100	73.7%
200	54.9%

SOIL CLASSIFICATION

USCS CLASSIFICATION: CL
AASHTO CLASSIFICATION:
AASHTO GROUP INDEX:

ENTECH ENGINEERING, INC.

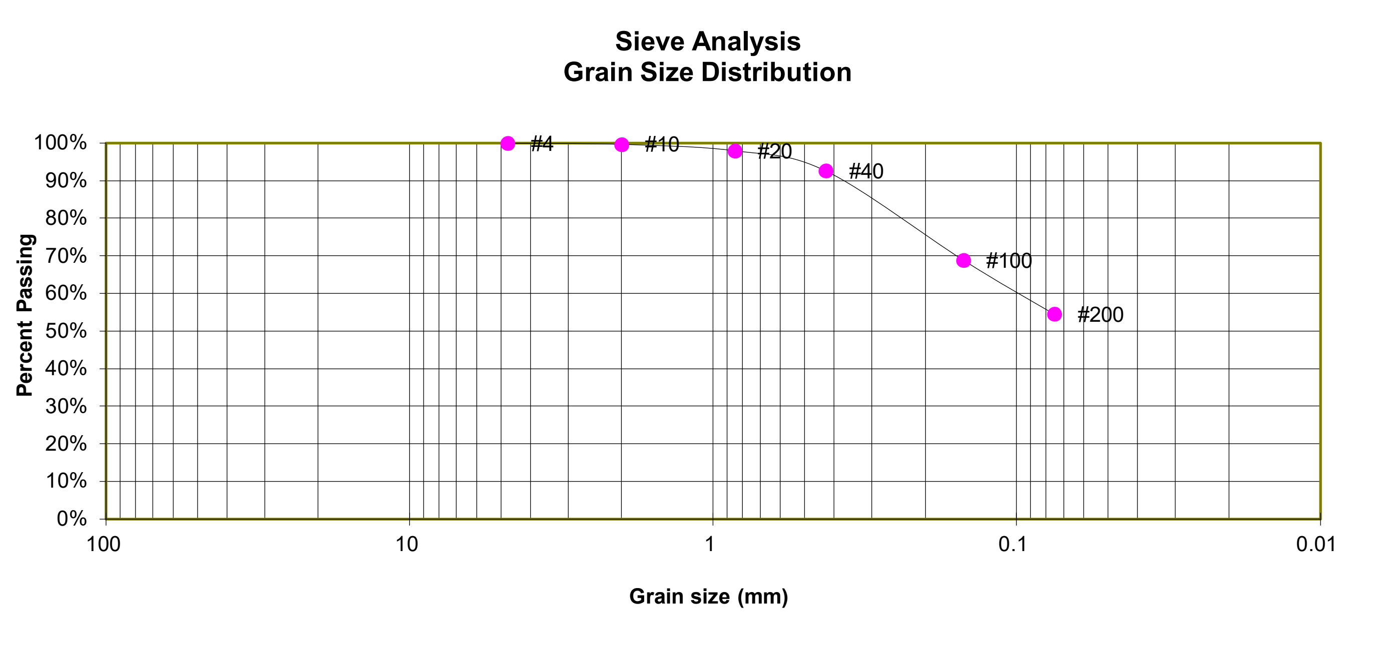
LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-9

TEST BORING	6	SOIL DESCRIPTION	CLAY, SANDY
DEPTH (FT)	10	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	99.7%
20	98.0%
40	92.6%
100	68.9%
200	54.5%

FHA SWELL

Moisture at start	12.3%
Moisture at finish	24.9%
Moisture increase	12.6%
Initial dry density (pcf)	95
Swell (psf)	450

SOIL CLASSIFICATION

USCS CLASSIFICATION: CL

AASHTO CLASSIFICATION:

AASHTO GROUP INDEX:

ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

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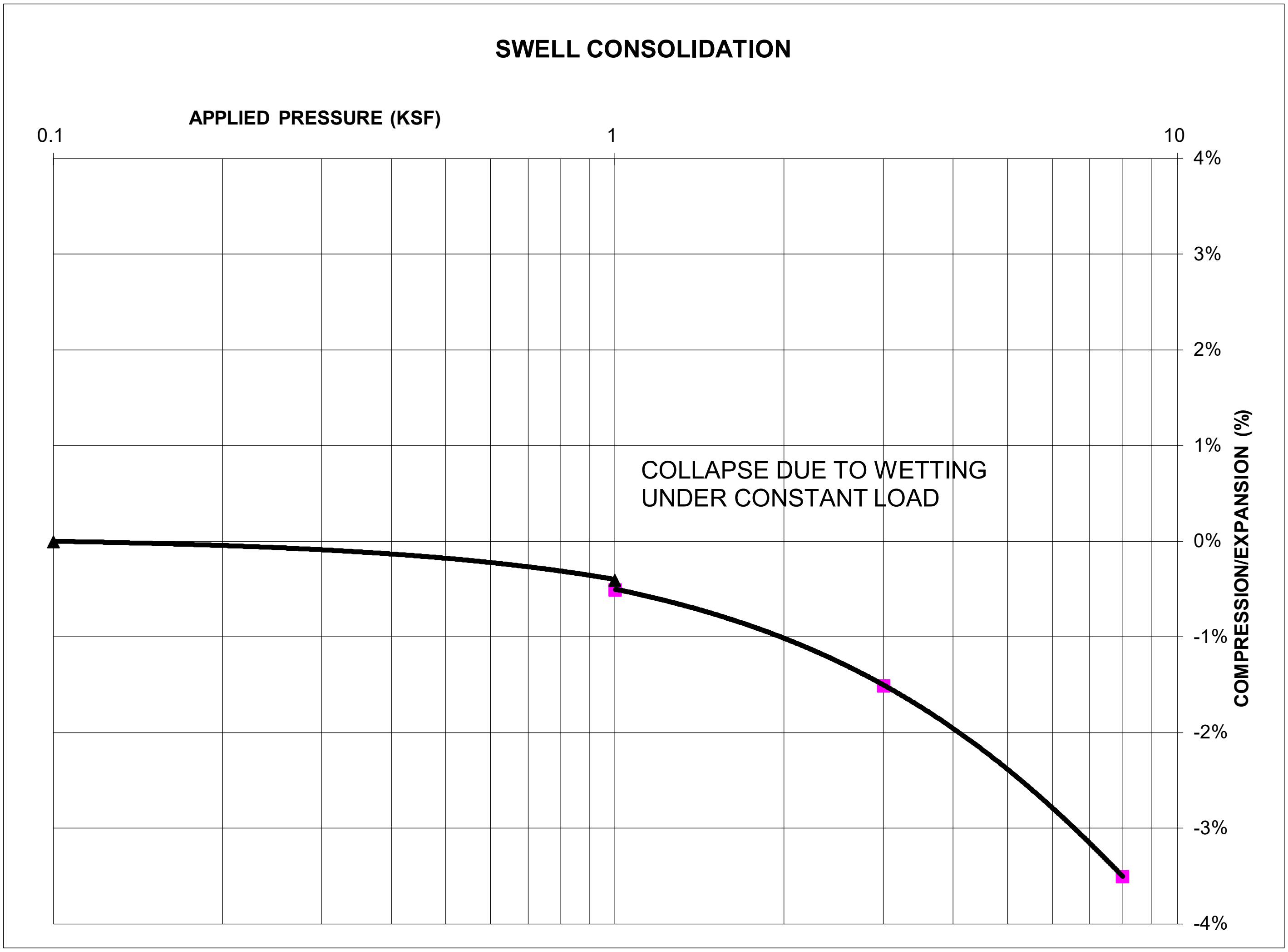
FIG. B-10

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



SWELL/COLLAPSE TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF):	109
NATURAL MOISTURE CONTENT:	14.8%
SWELL/COLLAPSE (%):	-0.1%

ENTECH ENGINEERING, INC.

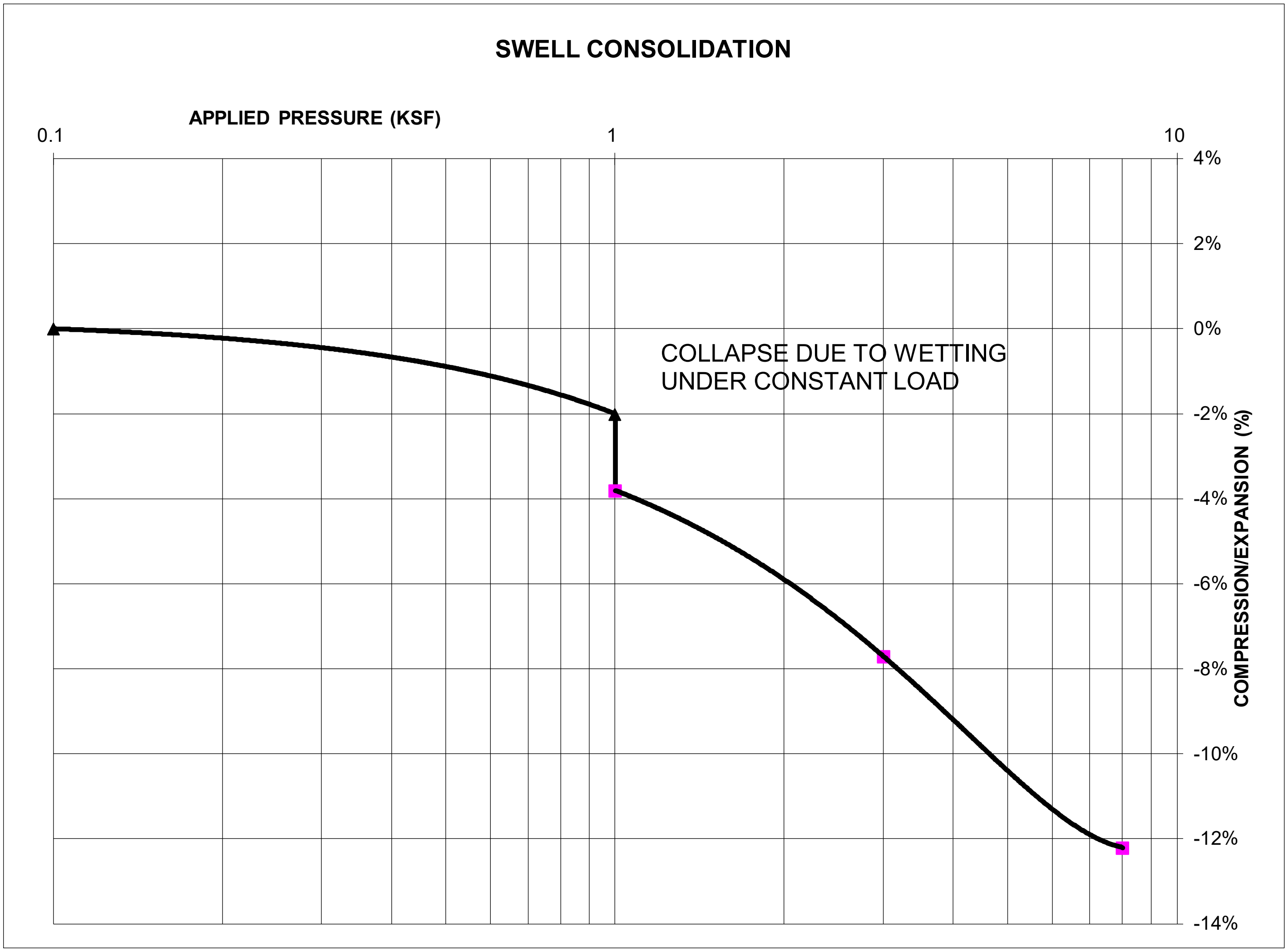
SWELL TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-11

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



SWELL/COLLAPSE TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF): 93
NATURAL MOISTURE CONTENT: 17.5%
SWELL/COLLAPSE (%): -1.8%

ENTECH ENGINEERING, INC.

SWELL TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
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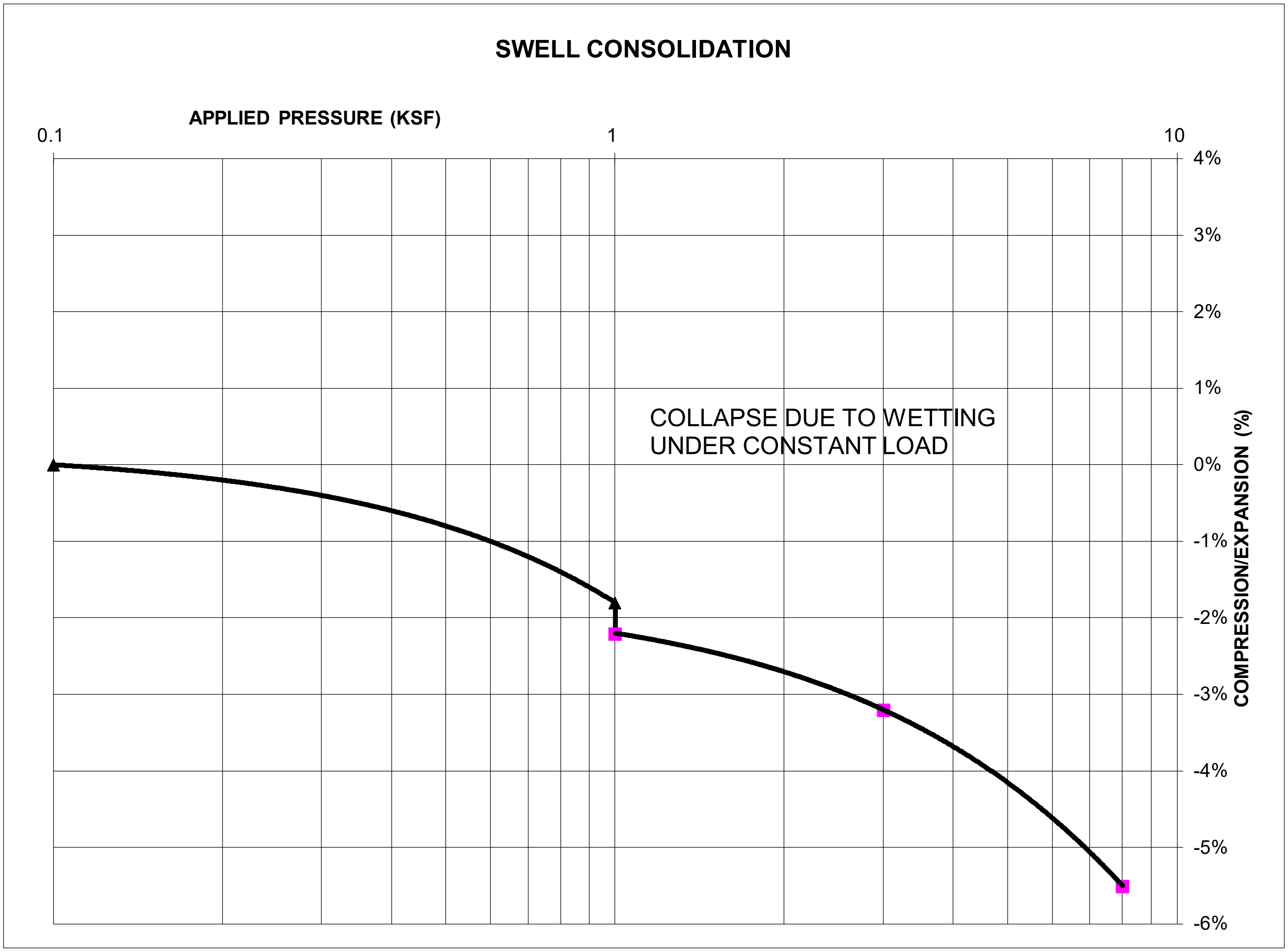
FIG. B-12

TEST BORING	5	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	5	SOIL TYPE	1



SWELL/COLLAPSE TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF):	103
NATURAL MOISTURE CONTENT:	14.7%
SWELL/COLLAPSE (%):	-0.4%

ENTECH ENGINEERING, INC.

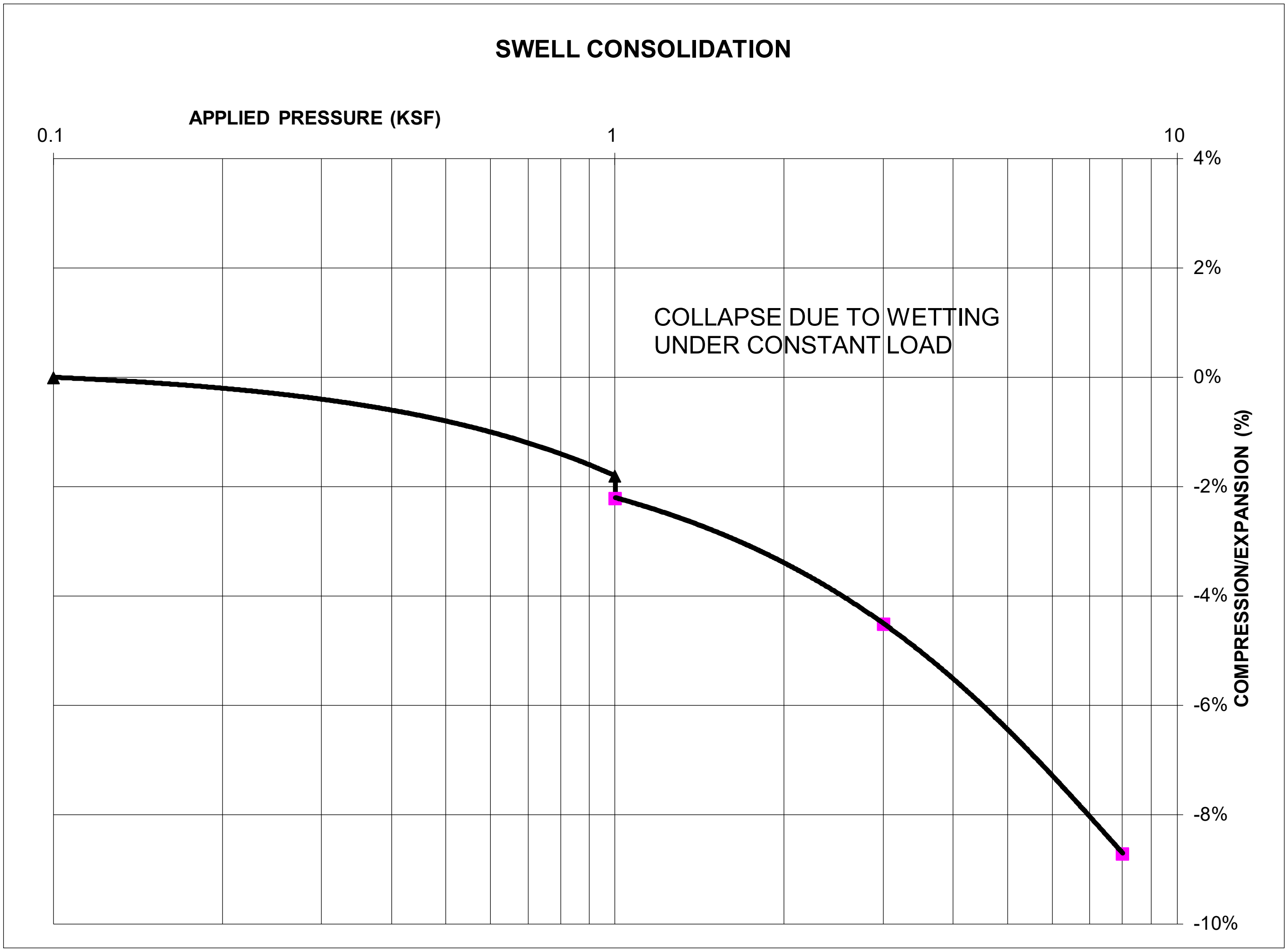
SWELL TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-13

TEST BORING	7	SOIL DESCRIPTION	SAND, CLAYEY
DEPTH (FT)	2-3	SOIL TYPE	1



SWELL/COLLAPSE TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF):	91
NATURAL MOISTURE CONTENT:	12.9%
SWELL/COLLAPSE (%):	-0.4%

ENTECH ENGINEERING, INC.

SWELL TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

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FIG. B-14

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

SWELL/COLLAPSE TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF):	102
NATURAL MOISTURE CONTENT:	14.5%
SWELL/COLLAPSE (%):	0.8%

ENTECH ENGINEERING, INC.

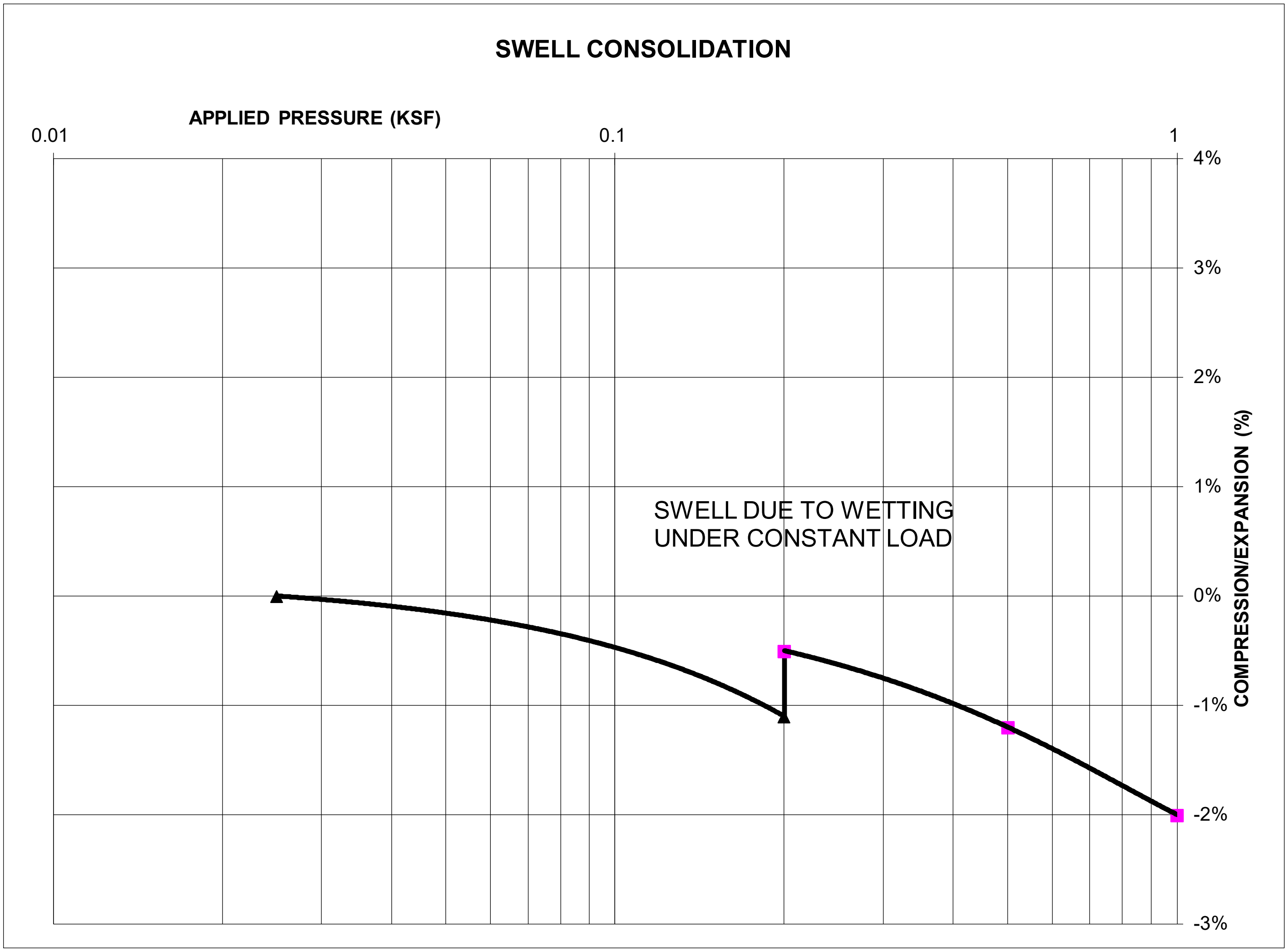
SWELL TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-15

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



SWELL/COLLAPSE TEST RESULTS

NATURAL UNIT DRY WEIGHT (PCF):	110
NATURAL MOISTURE CONTENT:	19.5%
SWELL/COLLAPSE (%):	0.6%

ENTECH ENGINEERING, INC.

SWELL TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

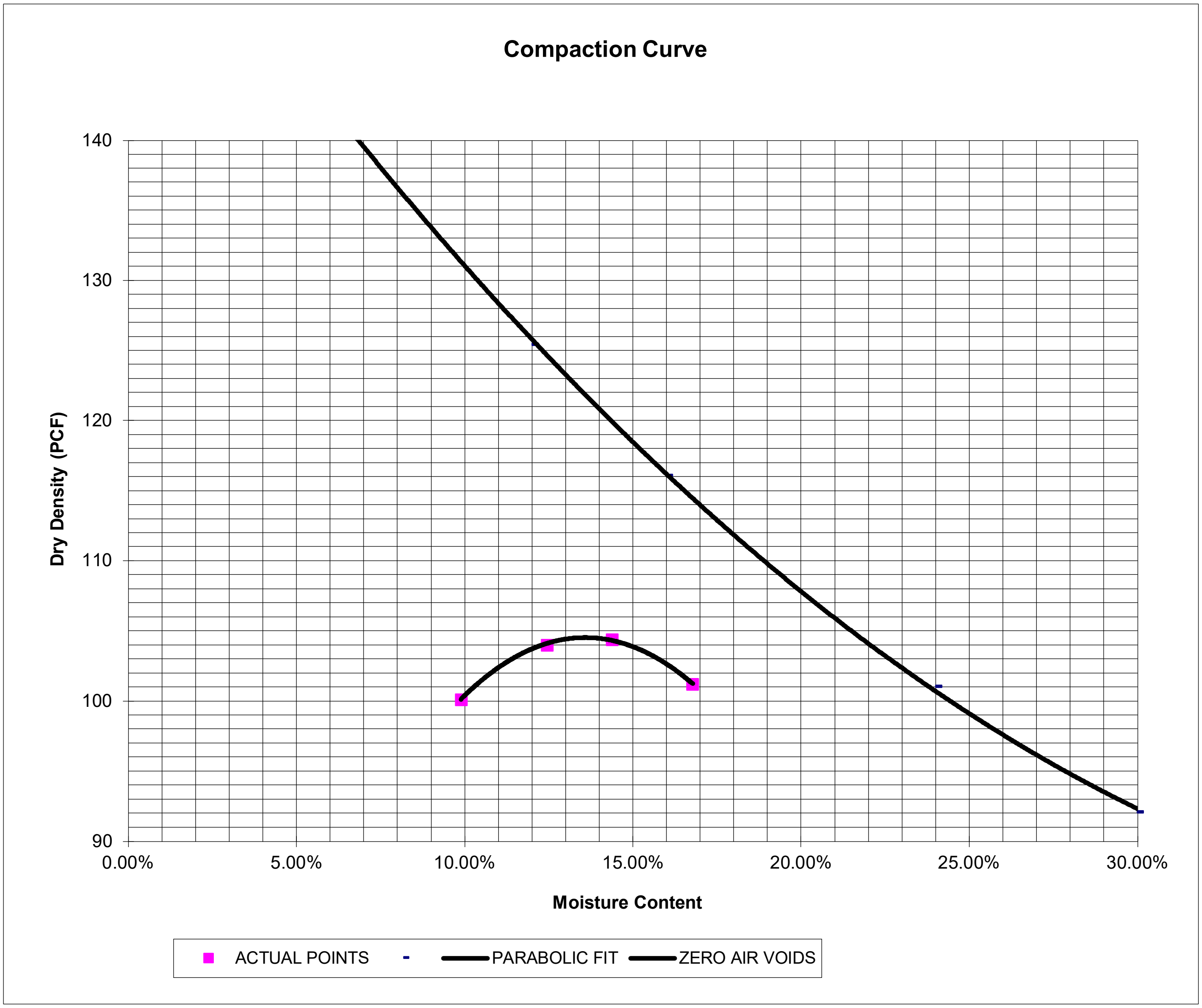
JOB NO.
242065

FIG. B-16

SAMPLE LOCATION TB-8 @ 1-3' | SOIL DESCRIPTION SAND, CLAYEY, BLACK
SOIL TYPE 1

PROCTOR DATA

IDENTIFICATION:	SC
PROCTOR TEST #:	1
TEST BY:	PH
TEST DESIGNATION:	ASTM-698-A
MAXIMUM DRY DENSITY (PCF):	104.8
OPTIMUM MOISTURE:	13.7



ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-17

SAMPLE LOCATION TB-8 @ 1-3'

SOIL DESCRIPTION SAND, CLAYEY, BLACK

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	49	16.37	99	33.08	171	57.14
0.050	63	21.05	126	42.11	267	89.22
0.075	75	25.06	149	49.79	339	113.28
0.100	81	27.07	161	53.80	395	132.00
0.125	91	30.41	182	60.82	453	151.38
0.150	103	34.42	206	68.84	507	169.42
0.175	113	37.76	226	75.52	542	181.12
0.200	118	39.43	236	78.86	580	193.82
0.300	133	44.44	266	88.89	721	240.93
0.400	155	51.80	310	103.59	817	273.02
0.500	176	58.81	352	117.63	920	307.43

MOISTURE AND DENSITY DATA

	Mold # 1	Mold # 2	Mold # 3
Can #	300	352	361
Wt. Can	8	8.16	8.58
Wt. Can+Wet	150	163.03	162.66
Wt. Can+Dry	130	133.86	139.89
Wt. H20	20	29.17	22.77
Wt. Dry Soil	122	125.7	131.31
Moisture Content	16.39%	23.21%	17.34%
Wet Density (PCF)	108.7	114.6	119.3
Dry Density (PCF)	95.6	100.8	105.0
% Compaction	91%	96%	100%
CBR	2.71	5.38	13.20

PROCTOR DATA

Maximum Dry Density (pcf)	104.8
Optimum Moisture	13.7
90% of Max. Dry Density (pcf)	94.3
95% of Max. Dry Density (pcf)	99.6

CBR at 90% of Max. Density = 2.0 ~ R VALUE 6

CBR at 95% of Max. Density = 4.7 ~ R VALUE 10

ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE

LANDSCAPE ENDEAVORS, INC.

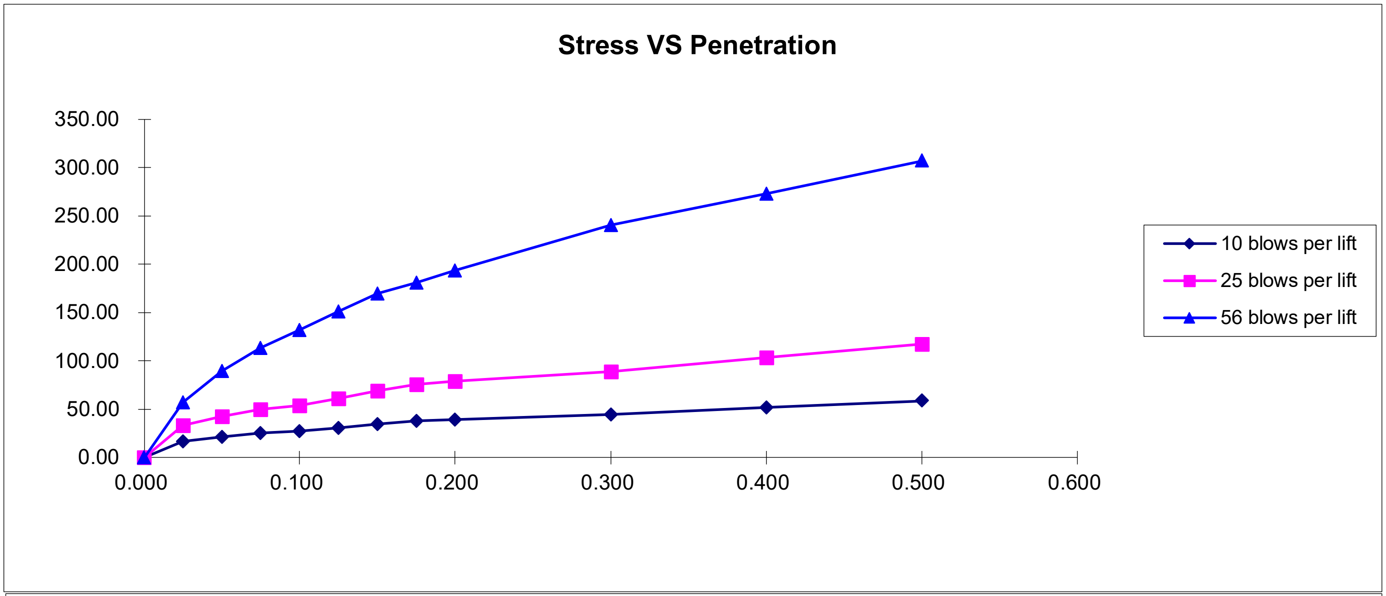
JOB NO. 242065

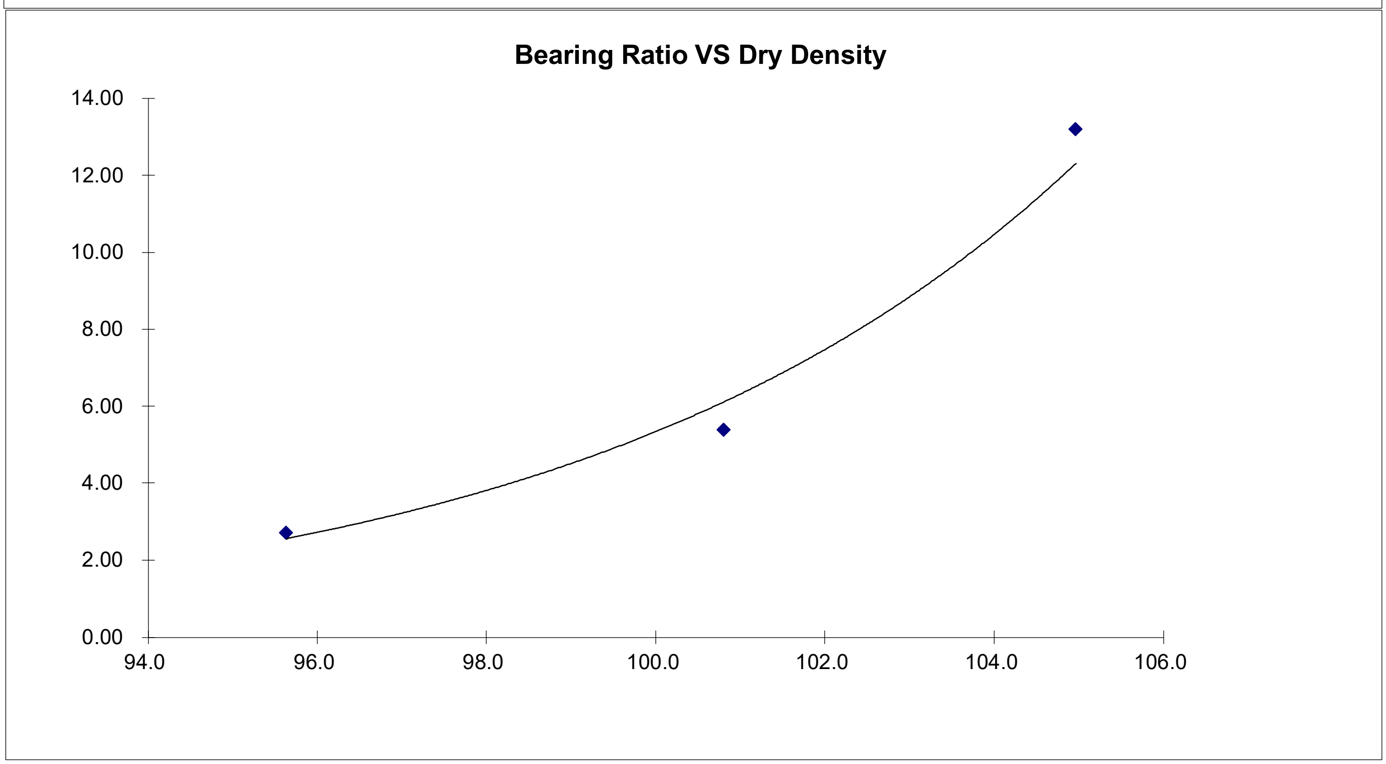
FIG. B-18

SAMPLE LOCATION TB-8 @ 1-3'

SOIL DESCRIPTION SAND, CLAYEY, BLACK

SOIL TYPE 1





ENTECH ENGINEERING, INC.

LABORATORY TEST RESULTS

2725 AKERS DRIVE
LANDSCAPE ENDEAVORS, INC.

JOB NO.
242065

FIG. B-19

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

PROJECT DATA

Project Location: 2725 Akers Drive - Addition and Retaining Walls

Job Number: 242065

DESIGN DATA

Equivalent (18-kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	50,000
Design CBR	CBR =	4.7
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.04
Soil Resilient Modulus	M_R =	7,050 psi

Required Structural Number (SN): → SN = 2.03

DESIGN EQUATIONS

Resilient Modulus

If using CBR:

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

If using R-Value:

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

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/RCB

D_1 = Depth of HMA (inches)

D_2 = Depth of ABC/RCB (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	ABC/RCB	C_2 = 0.12	4.0 inches	0.480	
				SN* = 2.240	2.03

Pavement SN > Required SN, Design is Acceptable

FIG. C-1