PRELIMINARY GEOTECHNICAL INVESTIGATION

RIDEGATE – MESA TOPS ROAD ALIGNMENT
LONE TREE, COLORADO

Prepared for:

JR ENGINEERING, LLC
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Attention:

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Client Manager

Project No. DN52,378.000-115-R1

March 12, 2025

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SCOPE

This report presents the results of our Prelimlinary Geotechnical Investigation for the proposed road alignment planned for Cabela Drive within the Ridgegate – Mesa Tops development in Lone Tree, Colorado. The purpose of our investigation was to determine the type of subgrade soils present at the site, evaluate pavement support characteristics, and provide preliminary design pavement alternatives. The Scope was described in a Proposal (No. DN-24-0331), dated July 26, 2024. We are concurrently preparing a Slope Stability and Geologic Hazard Evaluation for the proposed road development.

This report was prepared from data developed during field exploration, laboratory testing, engineering analysis and experience with similar conditions. The report includes a description of the subgrade soils found in exploratory borings, laboratory test results, alternative pavement sections, construction and materials recommendations, and recommendations for maintenance. The preliminary pavement alternatives presented in this report are based on Douglas County design criteria, which follows MGPEC and AASHTO methodology. It is also based on a Hillcamp (also known as Mesa Tops) Development Traffic Impact Study prepared by JR Engineering dated January 30, 2025. If plans change significantly or if our traffic assumptions are not valid, we should be contacted to review and revise our recommendations, as necessary A brief summary of our conclusions and recommendations is presented below, with more detailed criteria and recommendations contained in the report.

SUMMARY OF CONCLUSIONS

1. Subsoils found in our borings consisted of about 1 to 20 feet of sandy clay and/or clean to clayey sand underlain by weathered and comparatively unweathered claystone and sandstone bedrock to the total depth drilled of 20 feet. One sample of the onsite soils exhibited a compression of 2.1 percent and four samples had swells ranging from 0.1 to 2.4 percent under a confining pressure of 200 psf. The average swell was 1.4 percent.

2. Preliminary pavement alternatives include asphalt concrete over aggregate base course, asphalt concrete over chemically stabilized subgrade, and Portland cement concrete. Preliminary pavement alternatives are presented

in Table I and on Fig. 3. A design level pavement will be required by Douglas County prior to paving after grading is complete. New subgrade samples will need to be taken at 250-feet intervals and lab testing will be performed in conformance with Douglas County specifications.

SITE CONDITIONS

The proposed road segment will serve the Ridgegate Mesa Tops development located southwest of Ridgegate Parkway and Interstate 25 in Lone Tree, Colorado (Photo 1). The site is vegetated moderately with grasses throughout and dense shrubs and trees along slope faces and drainages. A residential development is located north of the road segment and the East-West Regional Trail and other smaller pedestrian trails are located south of the site. Historical aerial photos were reviewed to evaluate the site history and associated impacts on design and construction. Photos dating back to 1937 show the site has remained relatively unchanged until construction of the East-West Regional Trail between 2011 and 2012. Construction of the residential development began in 2017. The site generally slopes to the east. At the time of our investigation the site soils were natural, and no grading or utility installation had taken place. Several drainages and moderate to steep slopes are present throughout the site. Geologic maps indicate that portions of the site have potential risk for landslides and debris flow. We are concurrently preparing a Slope Stability and Geologic Hazard Evaluation for the proposed road development.

The proposed road segment will tie into existing Cabela Drive and provide access to the Ridgegate Mesa Tops development. A plan prepared by JR Engineering (Cabela Drive Exhibit) indicates the proposed street segment will be approximately 3,150 feet in length. The road will cross several drainages. We anticipate cuts of up to about 15 feet and fills of up to about 20 feet will be required to reach construction grades.

Photo 1: Google Earth© Aerial Site Photo, October 2023
Proposed street segment colored in red.

INVESTIGATION

Subsurface conditions at the site were investigated by drilling six exploratory borings along the proposed road segment to a depth of 20 feet at the approximate locations shown on Fig. 1. Subsoils found in the borings consisted of sandy clay or clean to clayey sand over weathered and comparatively unweathered claystone and sandstone bedrock to the maximum depth drilled. Groundwater was not encountered in the exploratory borings at the time of drilling. When checked several days after drilling, groundwater was measured in three borings at depths of about 14.5 to 28.5 feet below existing grades. Groundwater is not expected to influence construction. Groundwater levels may fluctuate seasonally, and develop and rise in response to development, precipitation, landscape irrigation, changes in land-use and flow in nearby drainages.

Laboratory testing was designed to provide index properties of the soils sampled and subgrade support values for those soil types which influence the pavement design. To evaluate potential heave, swell-consolidation testing was performed on five samples of the on-site soils under a confining pressure of 200 psf. One sample compressed 0.1 percent and four samples swelled 0.1 to 2.4 when wetted, with an average swell of 1.4 percent. . Results of laboratory tests are presented in Appendix A and summarized in Table A-I.

Classification testing indicates the pavement subgrade consists of AASHTO A-2-6, A-6, and A-7-6 soils with Group Indices ranging from 0 to 21, with an average of about 9. Based on the MGPEC Pavement Design Standards manual, both Hveem Stabilometer (R-Value) (ASTM D 2844, AASHTO T 190) and California Bearing Ratio (CBR) (ASTM D 1883, AASHTO T193) tests are suitable to determine subgrade support characteristics for soils. Based on our experience, clayey materials tend to “squeeze out” during R-Value testing and provide poor R-Value results. To obtain more accurate results for this preliminary design, we subjected a composite sample of Group III soils (A-7-6) was subjected to Standard Proctor (ASTM D 698, AASHTO T99) compaction test procedures and a CBR test to determine a design support value for the subgrade soils. The composite sample was comprised of the poorest site soils. Our results show a CBR subgrade support value of 4.0. Using Equation 4.2A-2 from the MGPEC manual, we calculated a subgrade resilient modulus of 6,205 psi. During final design, Douglas County will require R-Value testing to determine subgrade support values. We recommend using sandy A-2 to A-6 materials within the top three feet of pavement subgrade which will provide higher R-Value results and reduce the amount of additional mitigation required per Douglas County specifications.

Concrete in contact with soil can be subject to sulfate attack. We measured water-soluble sulfate concentrations of less than 0.01 to 0.02 percent in two samples. As indicated in our tests and ACI 332-20, the sulfate exposure class is *Not Applicable* or *RS0*. For this level of sulfate concentration, ACI 332-20 *Code Requirements for Residential Concrete* indicates there are no special cement restrictions for sulfate resistance. Additional sulfate testing is recommended during the design-level phase of the pavement design.

EXPANSIVE SOIL MITIGATION

Natural clay soils and bedrock at this site include expansive materials. The presence of expansive soils implies risk that pavements may heave and be damaged. The risks associated with swelling soils cannot be eliminated, but may be mitigated by careful design, construction, and maintenance procedures.

Based on our swell tests and Douglas County design criteria, mitigation of expansive subgrade will be required. Our measured swells on the natural soils ranged from 0.1 to 2.4 percent when wetted under a confining pressure of 200 psf. Three out of our five samples tested swelled more than 2 percent. We judge the soils to generally possess low to moderate potential for damaging differential heave of the subgrade. For subgrade material with swells of 2 percent or more, Douglas County requires additional mitigation, which is detailed below in the following section.

During grading, the subgrade soils below pavements should be moisture conditioned between optimum and four percent above optimum for clayey AASHTO A-6 soils or within two percent of optimum for sandy A-2 to A-4 soils, and compacted to at least 95 percent of maximum dry density (ASTM D698) prior to asphalt or base course placement to re-establish moisture in the subgrade prior to pavement. We recommend at least 36 inches of moisture treated fill or sub-excavation to help mitigate the swells prior to the final pavement subgrade investigation. Based on Douglas County requirements, and where possible, we do not recommend placing A-7-5 or A-7-6 soils within the top three feet of subgrade below the pavements.

Douglas County Requirements

Based on our investigation, we believe about 60 percent of the site will require expansive soil mitigation where clayey soils were encountered. Douglas County requires mitigation of expansive soils below pavements with measured swells of 2.0 percent or greater (under a confining pressure of 200 psf) or a R-Value of 5 or less. The County provides three options for mitigation: (1) over excavation of 3 feet of material, and replacement of the soils with an A-2 to A-6 soil group, per section 5.4.3.1.1, (2) Over excavation of 12 inches of subgrade soils directly below the bottom of the pavement section and replacing it with 12 inches of aggregate base. The subgrade soils must be scarified and reconditioned to a depth of 8 inches prior to placement of aggregate base course, per section 5.4.3.1.2, and (3) chemical stabilization using lime or cement to stabilize the subgrade, per section 5.4.3.1.3.

Douglas County requires that all new pavements constructed on A-6 and A-7 soils shall include trench drains. The trench drains shall be placed along both sides of the pavement and wherever else it is deemed to be necessary, per section 5.3.11.

We recommend using sandy A-2 to A-6 materials within the top three feet of pavement subgrade to reduce the amount of additional mitigation required. Generally, sandier materials tend to result in higher R-Value results and lower swell potential. If clayey soils need to be used, we recommend moisture treating or sub-excavating to help mitigate the swell potential as detailed in **EXPANSIVE SOIL MITIGATION**.

PAVEMENT DESIGN

We reviewed the Hillcamp (also referred to as Mesa Tops) Development Traffic Impact Study in preparation of this report. The primary access for the development is the existing Cabela Drive, which currently has a dead-end 2,000 feet south of Ridgegate Parkway. The proposed road will connect into the existing dead-end. Cabela Drive is a two-lane street that is classified as a residential collector. The study provides a projected peak average daily traffic volume of 3,136 with no growth factor. The report also indicates that 2 percent of the traffic will consist of heavy vehicles. The design 18-kip Equivalent Single Application Load (ESAL) was determined using criteria from the MGPEC Pavement Design Standards manual. For Cabela Drive, we calculated a design ESAL of 527,244.

We have provided preliminary pavement design alternatives, which include asphalt concrete over aggregate base course, asphalt concrete over chemically stabilized subgrade (using lime), and Portland Concrete Cement. Douglas County does not allow full-depth asphalt sections for Residential Collectors. These alternatives are preliminary, and a final design level investigation will be required after grading is complete. Our pavement thickness alternatives are presented on the table below. Additional discussion regarding advantages and disadvantages of the pavement alternatives and their expected performance is included in **Pavement Selection**. <u>A design level pavement design is required by Doulgas County after grading. New subgrade samples will need to be taken and lab testing performed to confirm preliminary recommendations are valid and in accordance with Douglas County specifications.</u>

PRELIMINARY PAVEMENT DESIGN THICKNESS ALTERNATIVES*

Roadway	Classification	Asphalt Concrete + Aggregate Base Course (AC + ABC)	Asphalt Concrete + Stabilized Subgrade (AC + SS)	Portland Cement Concrete (PCC)
Cabela Drive	Residential Collector (ESAL = 527,244)	5.0” AC + 10.0” ABC	5.0” AC + 9.0” SS	7” PCC

*Pavement sections do not include potential swell mitigation required by Douglas County as discussed in **EXPANSIVE SOIL MITIGATION**.

PAVEMENT SELECTION

Asphalt concrete over aggregate base course generally has good performance history in swelling soil environments. Some municipalities believe base course provides a flexible layer to help distribute swell of the subgrade and may reduce the likelihood of longitudinal cracks. Conversely, there have been problems where base course has “pushed” into wet clay subgrade. The base course may allow moisture to infiltrate under the pavement. Some aggregate base course that is available in the front range is highly sensitive to moisture and can lose a significant portion of its strength when wetted. An alternative to aggregate base course would be to use recycled concrete.

Asphalt concrete over stabilized subgrade can perform well in soils exhibiting low to moderate swell characteristics. Stabilizing agents approved by Douglas County include cement, lime, or a combination of cement and lime. The asphalt concrete pavement over stabilized subgrade has a higher fatigue resistance than the other alternatives and can effectively reduce potential heave related damage to the pavement. The choice of using stabilized subgrade will be influenced by higher first costs, and construction difficulties during winter months.

We recommend a laboratory mix design be performed using the stabilizing agent with on-site soils to assure proper strength. We recommend a lime stabilizer agent be used. Scheduling should allow at least three weeks for the mix design to be completed prior to construction. Should the mix design indicate sulfate concentrations above 0.3 percent, a double treatment method should be used.

We understand that some municipalities and developers prefer to pave the streets low allowing for a final overlay after the residential construction is completed. Construction traffic is the heaviest loading a residential pavement will handle during its life cycle, and we do not recommend placing a thinner section. If a final overlay is desired after construction is completed, we recommend the streets be constructed with the full design section, but with less crown in the center. This will provide better support for the construction traffic and will reduce the risk of water ponding along the curb face or gutter. When construction of the area is completed, the edges can be rotomilled and a final overlay placed, thus providing the smooth finish with a proper crown to facilitate drainage.

Garbage, drywall, sod, and concrete trucks are often over the legal weight limit. The driving and parking of these types of overweight trucks can cause pavement rutting and depressions in areas where the underlying subgrade is wet. We recommend these types of trucks be required to be beneath the legal load limit of 18,000 pounds per axle. Where possible, drivers should be instructed to avoid driving and/or parking near the curblines. These precautions should reduce the risk of additional pavement damage during construction.

PAVEMENT MATERIALS

Material properties and construction criteria for the pavement alternatives are provided below. These criteria were developed from analysis of the field and laboratory data, our experience, and Douglas County requirements. If the materials cannot meet these recommendations, then the pavement design should be reevaluated based upon available materials. Materials and construction requirements of Douglas County should be followed. Materials planned for construction should be submitted and the applicable laboratory tests performed to verify compliance with the specifications.

Asphalt Concrete (AC) or Hot Mix Asphalt (HMA)

1. HMA should be composed of a mixture of aggregate, filler, hydrated lime and asphalt cement. Some mixes may require polymer modified asphalt cement or make use of up to 20 percent reclaimed asphalt pavement (RAP). <u>A job mix design is recommended and periodic checks on the job site should be made to verify compliance with specifications</u>.

2. HMA should be relatively impermeable to moisture and should be designed with crushed aggregates that have a minimum of 80 percent of the aggregate retained on the No. 4 sieve with two mechanically fractured faces.

3. Gradations that approach the maximum density line (within 5 percent between the No. 4 and 50 sieve) should be avoided. A gradation with a nominal maximum size of one or two inches developed on the fine side of the maximum density line should be used.

4. Total void content, voids in the mineral aggregate (VMA) and voids filled should be considered in the selection of the optimum asphalt cement content. The optimum asphalt content should be selected at a total air void content of approximately four percent. The mixture should have a minimum VMA of 14 percent and between 65 percent and 80 percent of voids filled.

5. Asphalt cement should meet the requirements of the Superpave Performance Graded (PG) Binders. The minimum performing asphalt cement should be PG 58-28 for all local streets and PG 64-22 for all collector and arterial streets.

6. Hydrated lime should be added at the rate of one percent by dry weight of the aggregate and should be included in the amount passing the No. 200 sieve. Hydrated lime for aggregate pretreatment should conform to the requirements of ASTM C 207, Type N.

7. Paving should only be performed when subgrade temperatures are above 40°F and air temperature is at least 40°F and rising.

8. HMA should not be placed at a temperature lower than 245°F for mixes containing PG 58-28 or PG 64-22 asphalt, and 290°F for mixes containing polymer modified asphalt. The breakdown compaction should be completed before the mixture temperature drops 20°F.

9. The maximum compacted lift should be 3.0 inches and joints should be staggered. No joints should be placed within wheel paths.

10. HMA should be compacted to between 92 and 96 percent of Maximum Theoretical Density. The surface shall be sealed with a finish roller prior to the mix cooling to 185°F.

11. Placement and compaction of HMA should be observed and tested by a representative of our firm. Placement should not commence until the subgrade is properly prepared (or stabilized), tested and proof-rolled. Proof rolling should be performed with the heaviest machine available at the time. The proof roller should be selected from machines providing both mass and high contact pressure.

Aggregate Base Course (ABC)

1. A Class 5 or Class 6 Colorado Department of Transportation (CDOT) specified aggregate base course should be used. A recycled concrete alternative which meets the Class 5 or 6 designation is also acceptable.

2. Aggregate base course should have a minimum Hveem stabilometer value of 78. Aggregate base course or recycled concrete material must be moisture stable. The change in R-value from 300 psi to 100 psi exudation pressure should be 12 points or less.

3. Aggregate base course or recycled concrete should be laid in thin lifts not to exceed 8 inches, moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557, AASHTO T 180).

4. Placement and compaction of aggregate base course or recycled concrete should be observed and tested by a representative of our firm. Placement should not commence until the underlying subgrade is properly prepared and tested.

Stabilized Subgrade (SS)

1. The contractor should have a mix design performed using the actual site soils and the approved stabilizing agent. Scheduling should allow at least three weeks for the mix design to be completed prior to construction.

2. High calcium quicklime should conform to the requirements of ASTM C 977 and ASTM C 110. Dolomitic quicklime, magnesia quicklime with magnesium oxide contents in excess of 4 percent, or carbonated quicklime should not be used.

3. All stabilizing agents should come from the same source as used in the mix design. If the source is changed, a new mix design should be performed.

4. The subgrade should be mixed to the specified depth and at the specified concentration until a uniform blend of soil, stabilizing agent and water is obtained and the moisture content is at least 3 percent above the optimum moisture content of the design mixture.

5. If lime is used, a mellowing period of up to seven days may be required following initial mixing. Once the pH of the mixture is 12.3 or higher and the plasticity index is less than 6, the soils shall again be mixed and moisture conditioned to at least 3 percent over optimum moisture content and compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D 698). Up to seven additional days may be required for curing prior to paving. The treated surface shall be kept moist or sealed with emulsified asphalt. Traffic should not be allowed on the surface during the mellowing and curing periods.

6. Where sulfate concentrations in the subgrade are over 0.5 percent, a double treatment method should be performed. When a double treatment is required, the first half of the stabilizing agent should be placed, moisture treated and allowed to mellow or cure for at least two weeks. The remaining half of the stabilizing agent (plus an additional 0.5 percent) shall then be applied.

7. Mixing of the cement, lime or lime/fly ash treated subgrade should not occur if the temperature of the soil mixture is below 40ºF.

8. Placement, mixing and compaction of stabilized subgrade should be observed and tested by a representative of our firm.

Prepared Subgrade (PS)

1. Subgrade should be stripped of organic matter, scarified, moisture treated and compacted.

2. Cohesive soils (A-6) should be moisture conditioned to between optimum and 4 percent above optimum moisture content and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698, AASHTO T 99).

3. Granular soils (A-1 to A-5) should be moisture conditioned between 2 percent below and 2 percent above optimum moisture content and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557, AASHTO T 180).

4. Final grading of the subgrade should be carefully controlled so the design cross-slope is maintained and low spots in the subgrade that could trap water are eliminated.

5. Once final subgrade elevation has been reached and the subgrade compacted and tested, the area should be proof-rolled with the heaviest machine available at the time. The proof roller should be selected from machines providing both mass and high contact pressure.

6. The proof-roll should be performed while moisture contents of the subgrade are still within the recommended limits. Drying of the subgrade prior to proof-roll or paving should be avoided. Areas of soft or wet subgrade should be remedied.

CONSTRUCTION DETAILS

The design of a pavement system is as much a function of the quality of the paving materials and construction as the support characteristics of the subgrade. The construction materials are assumed to possess sufficient quality as reflected by the strength coefficients used in the flexible pavement design calculations. These strength coefficients were developed through research and experience to simulate expected material of good quality, as explained herein. During construction careful attention should be paid to the following details:

- Placement and compaction of trench backfill.
- Compaction at curblines and around manholes and water valves.
- Excavation of completed pavements for utility construction and repair.
- Moisture treating or stabilization of the subgrade to reduce swell potential.
- Design slopes of the adjacent ground and pavement to rapidly remove water from the pavement surface.

MAINTENANCE

Routine maintenance, such as sealing and repair of cracks, is necessary to achieve the long-term life of a pavement system. We recommend a preventive maintenance program be developed and followed for all pavement systems to assure the design life can be realized. Choosing to defer maintenance usually results in accelerated deterioration leading to higher future maintenance costs, and/or repair. A recommended maintenance program is outlined in Appendix C.

CONSTRUCTION OBSERVATIONS

This report has been prepared for the exclusive use of JR Engineering, LLC and your team for the purpose of providing preliminary geotechnical design and construction criteria for the proposed project. A design level pavement design is required by Douglas County after grading. New subgrade samples will need to be taken and lab testing performed to confirm preliminary recommendations are valid. The information, conclusions, and recommendations presented herein are based upon consideration of many factors including, but not limited to, the type of construction, geologic setting, and subsurface conditions encountered. The conclusions and recommendations contained in the report are not valid for use by others. Standards of practice change continuously in the area of geotechnical engineering. The conclusions contained within this report are preliminary.

We recommend that CTL|Thompson, Inc. provide construction observation services to allow us the opportunity to confirm whether soil conditions are consistent with those found during this investigation. If others perform these observations, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

GEOTECHNICAL RISK

The concept of risk is an important aspect with any geotechnical evaluation primarily because the methods used to develop geotechnical recommendations do not comprise an exact science. We never have complete knowledge of subsurface conditions. Our analysis must be tempered with engineering judgment and experience. Therefore, the recommendations presented in any geotechnical evaluation should not be considered risk-free. We cannot provide a guarantee that the interaction between the soils and pavements will be as desired or intended. Our recommendations represent our judgment of those measures that are necessary to increase the chances that the streets will perform satisfactorily. It is critical that all recommendations in this report are followed during construction. Jefferson County must assume responsibility for maintaining the streets and use appropriate practices regarding maintenance and repair.

LIMITATIONS

Our borings were widely spaced within the proposed street segment to obtain a reasonably accurate indication of preliminary pavement conditions for the proposed construction. The borings are representative of conditions encountered only at the exact boring locations. Variations in the subsoil conditions not indicated by our borings are possible. A representative of our firm should observe site grading and utility backfill.

We believe this investigation was conducted with a level of skill and care ordinarily used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the influence of subsoil conditions on design of the pavement, please call or email.

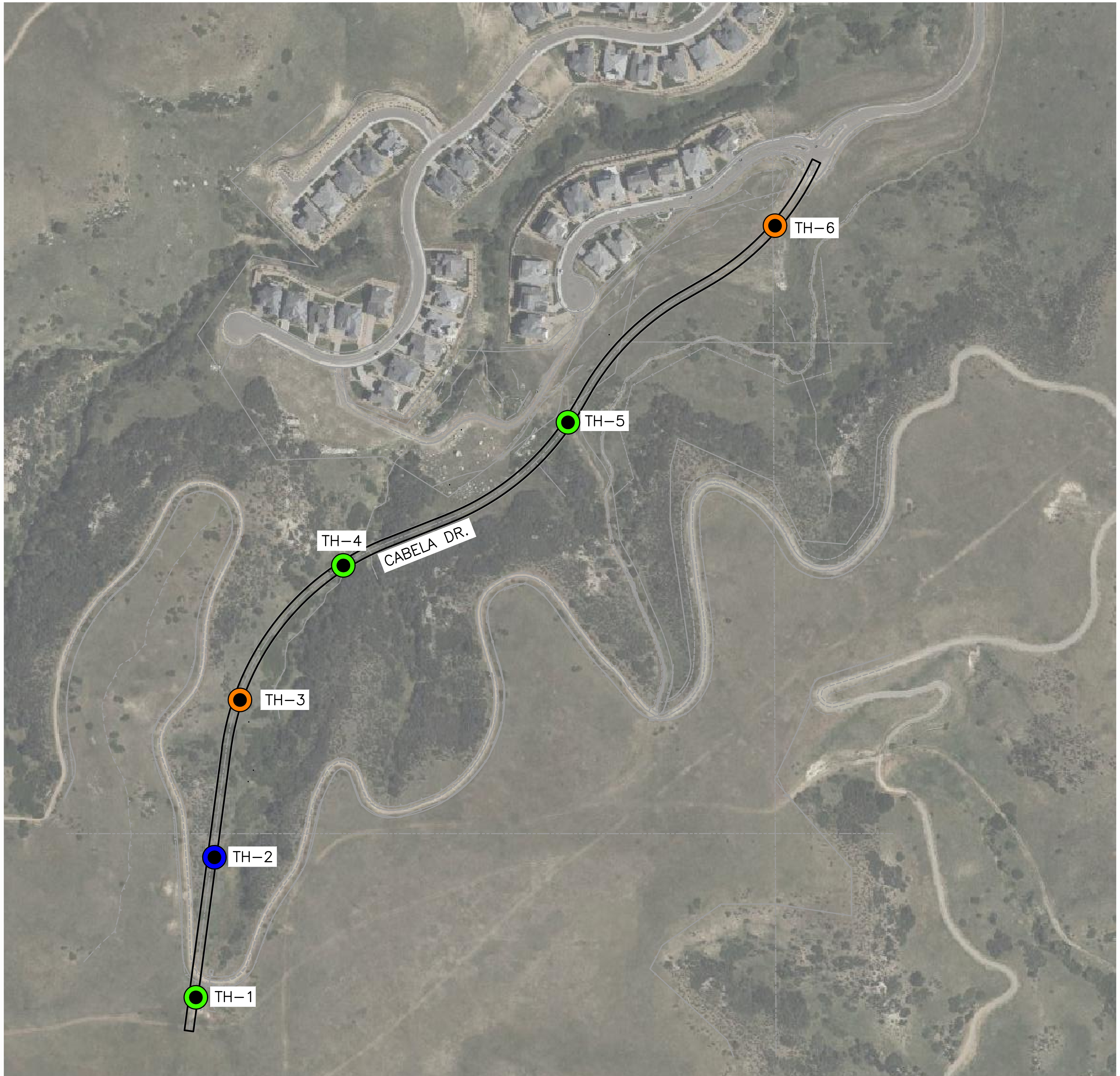
CTL|THOMPSON, INC.

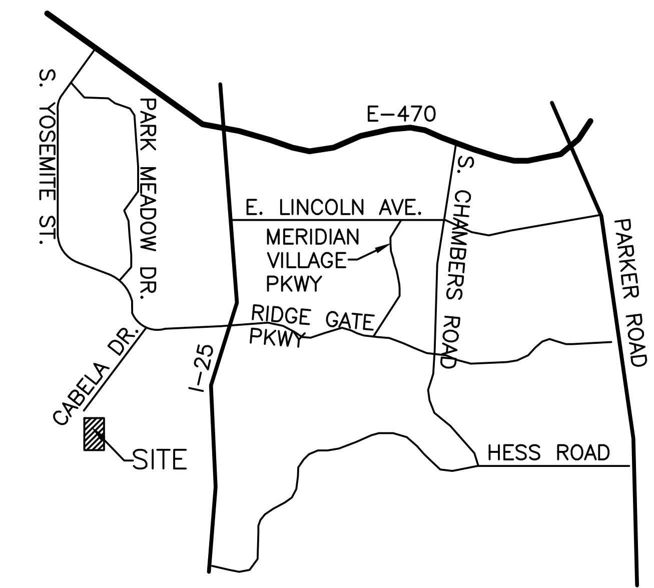
Javier Avitia-Herrera, E.I.T.
Staff Engineer

Reviewed by:

Alan Lisowy, P.E.
Principal

Via e-mail: krohrbough@jrengineering.com 3/12/2025





VICINITY MAP
NOT TO SCALE

LEGEND:

TH-1 ●	APPROXIMATE LOCATION OF EXPLORATORY BORING
● (blue)	GROUP I SOILS (A-2-6)
● (green)	GROUP II SOILS (A-6)
● (orange)	GROUP III SOILS (A-7-6)

0 150' 300'
SCALE: 1" = 300'

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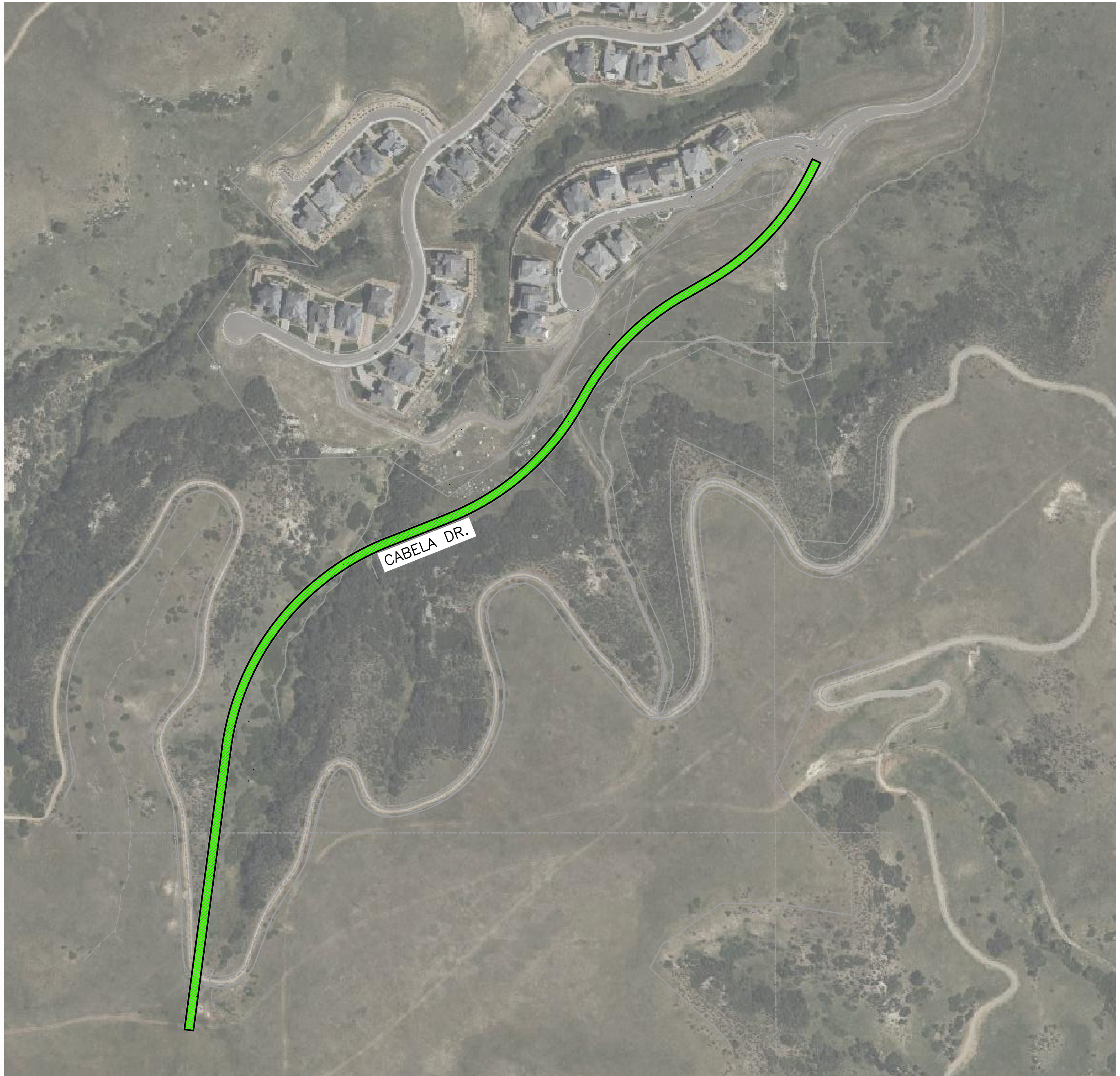
CTL|T Project No. DN52,378-115-R1

Locations of Exploratory Borings

Fig. 1



LEGEND:

RESIDENTIAL COLLECTOR
(ESAL=527,244)

N

0 150' 300'
SCALE: 1" = 300'

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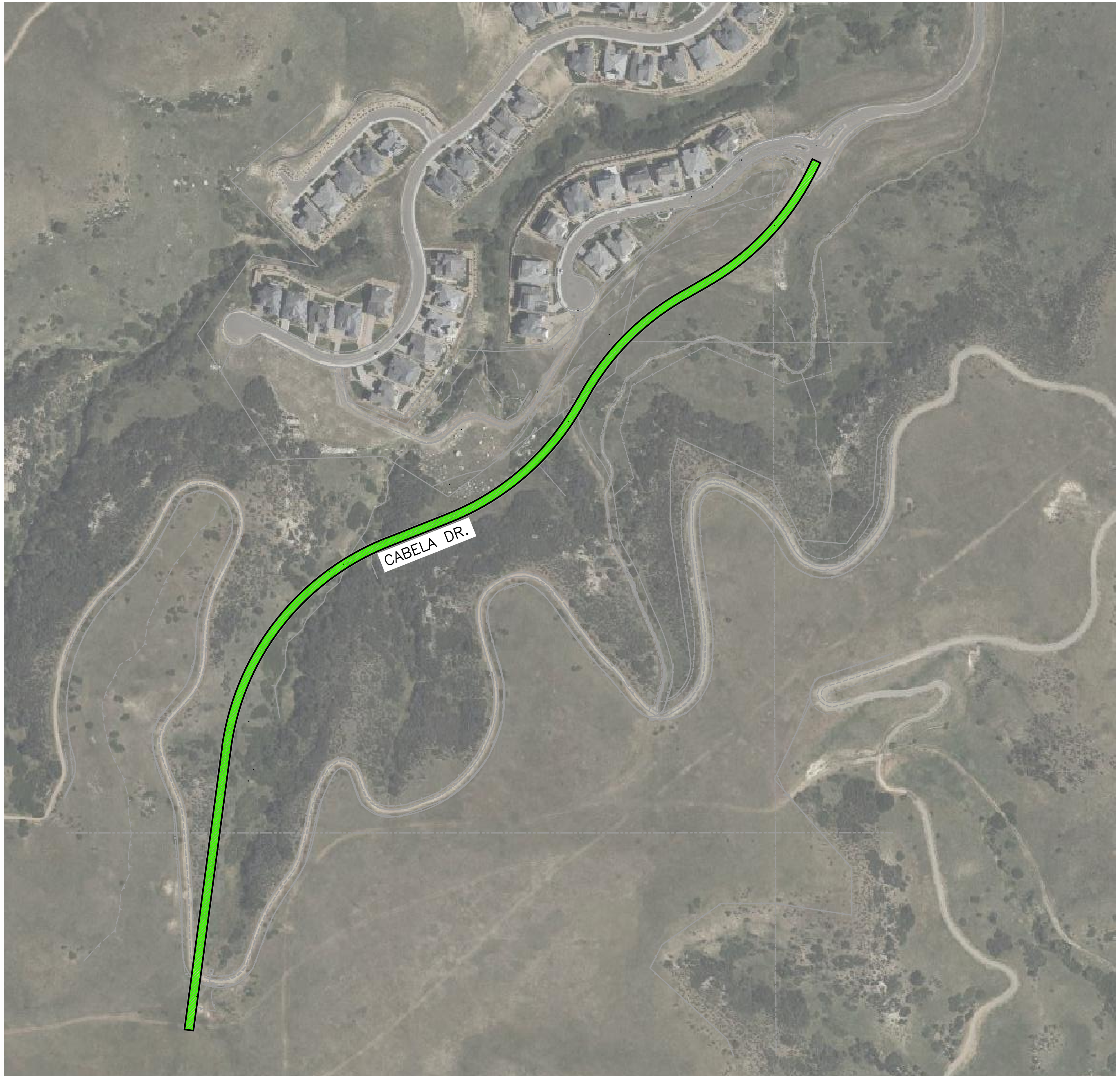
Design Traffic Values Fig. 2



LEGEND:

5.0 INCHES ASPHALT CONCRETE +
10.0 INCHES AGGREGATE BASE COURSE,

OR

5.0 INCHES ASPHALT CONCRETE +
9.0 INCHES CHEMICALLY STABILIZED SUBGRADE (LIME),

OR

7.0 INCHES PORTLAND CEMENT CONCRETE

N

0 150' 300'

SCALE: 1" = 300'

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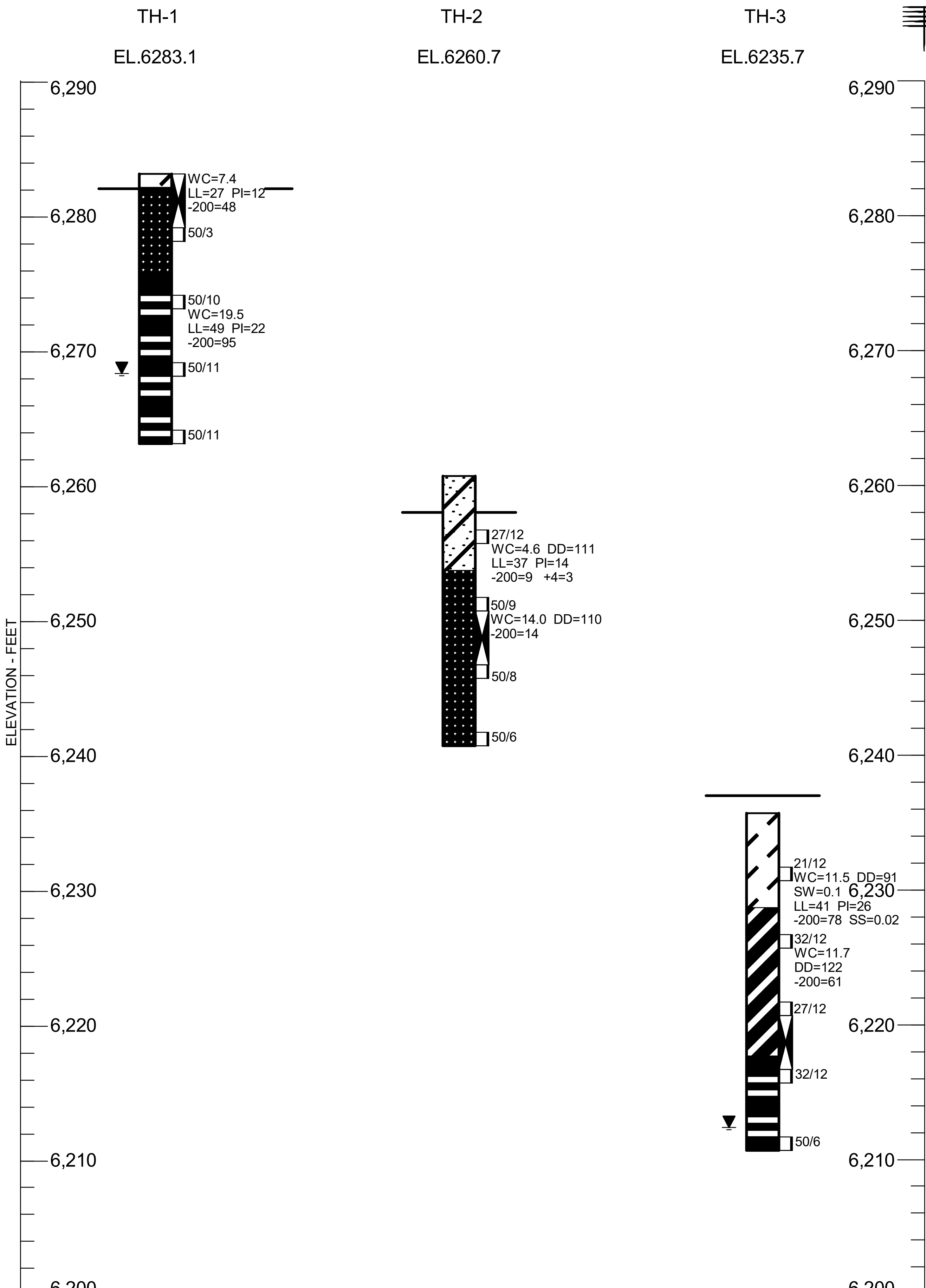
Recommended Preliminary Pavement Design Alternatives

Fig. 3



SUMMARY LOGS OF EXPLORATORY BORINGS

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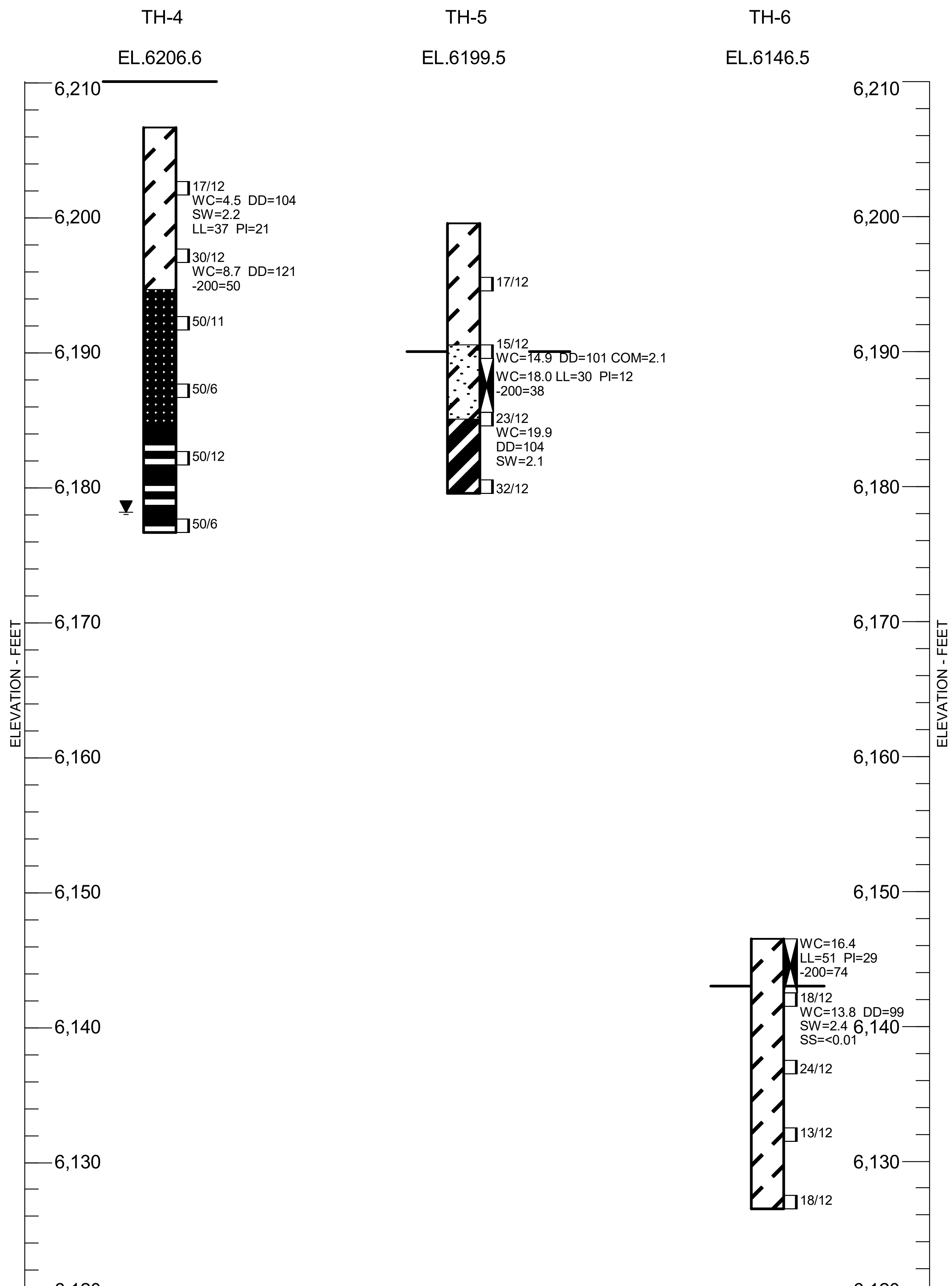
FIG. 4



SUMMARY LOGS OF EXPLORATORY BORINGS

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LEGEND:

- CLAY, SANDY, OCCASIONAL GRAVELS, STIFF TO VERY STIFF, SLIGHTLY MOIST TO MOIST, BROWN, TAN, OLIVE, GRAY, BLACK, WHITE (CL, CH).
- SAND, CLEAN TO SILTY, MEDIUM DENSE, SLIGHTLY MOIST TO MOIST, BROWN, TAN, GRAY, WHITE (SP-SM, SM, SP-SC).
- SAND, CLAYEY, MOIST, MEDIUM DENSE, BROWN, TAN (SC).
- WEATHERED CLAYSTONE, MOIST, BROWN, TAN, OLIVE, DARK BROWN, GRAY, WHITE.
- BEDROCK, SANDSTONE, HARD TO VERY HARD, SLIGHTLY MOIST TO MOIST, TAN, WHITE, OLIVE, BLACK, RUST.
- BEDROCK, CLAYSTONE, MEDIUM HARD TO VERY HARD, MOIST, BROWN, GRAY, TAN, OLIVE, DARK GRAY, BLUE, BLACK, RUST.
- DRIVE SAMPLE. THE SYMBOL 34/12 INDICATES 34 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.
- INDICATES BULK SAMPLE COLLECTED FROM AUGER CUTTINGS.
- WATER LEVEL MEASURED AFTER DRILLING ON SEPTEMBER 18, 2024.
- INDICATES PROPOSED GRADE.

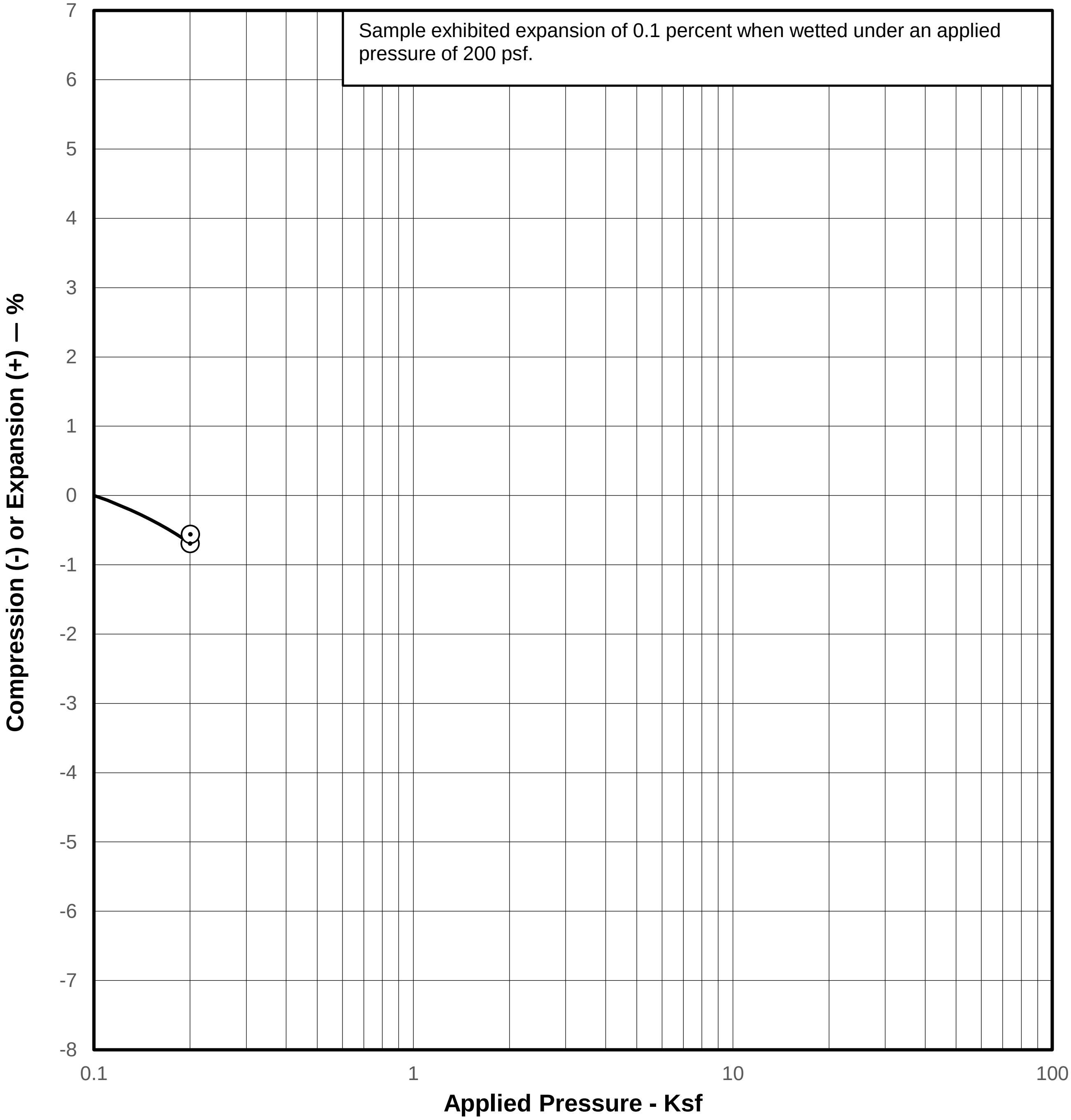
NOTES:

1. THE BORINGS WERE DRILLED ON SEPTEMBER 11 AND 12, 2024 USING A 4-INCH DIAMETER, CONTINUOUS-FLIGHT SOLID-STEM AUGER AND TRUCK-MOUNTED AND TRACK-MOUNTED CME-45 DRILL RIGS.
2. BORING LOCATIONS AND ELEVATIONS WERE STAKED AND SURVEYED BY OTHERS. SOME BORING LOCATIONS WERE MOVED DUE TO ACCESS ISSUES. THESE BORING LOCATIONS AND ELEVATIONS ARE APPROXIMATE AND WERE DETERMINED BY A REPRESENTATIVE OF OUR FIRM USING A LEICA GS18 GPS UNIT REFERENCING THE NORTH AMERICAN DATUM OF 1983 (NAD83).
3. WC - INDICATES MOISTURE CONTENT (%).
   DD - INDICATES DRY DENSITY (PCF).
   SW - INDICATES SWELL WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE (%).
   COM - INDICATES COMPRESSION WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE (%).
   LL - INDICATES LIQUID LIMIT.
   PI - INDICATES PLASTICITY INDEX.
   -200 - INDICATES PASSING NO. 200 SIEVE (%).
   +4 - INDICATES RETAINED ON NO. 4 SIEVE (%).
   SS - INDICATES WATER-SOLUBLE SULFATE CONTENT (%).
4. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS, AND CONCLUSIONS AS CONTAINED IN THIS REPORT.

FIG. 5

APPENDIX A

LABORATORY TEST RESULTS AND TABLE A-I



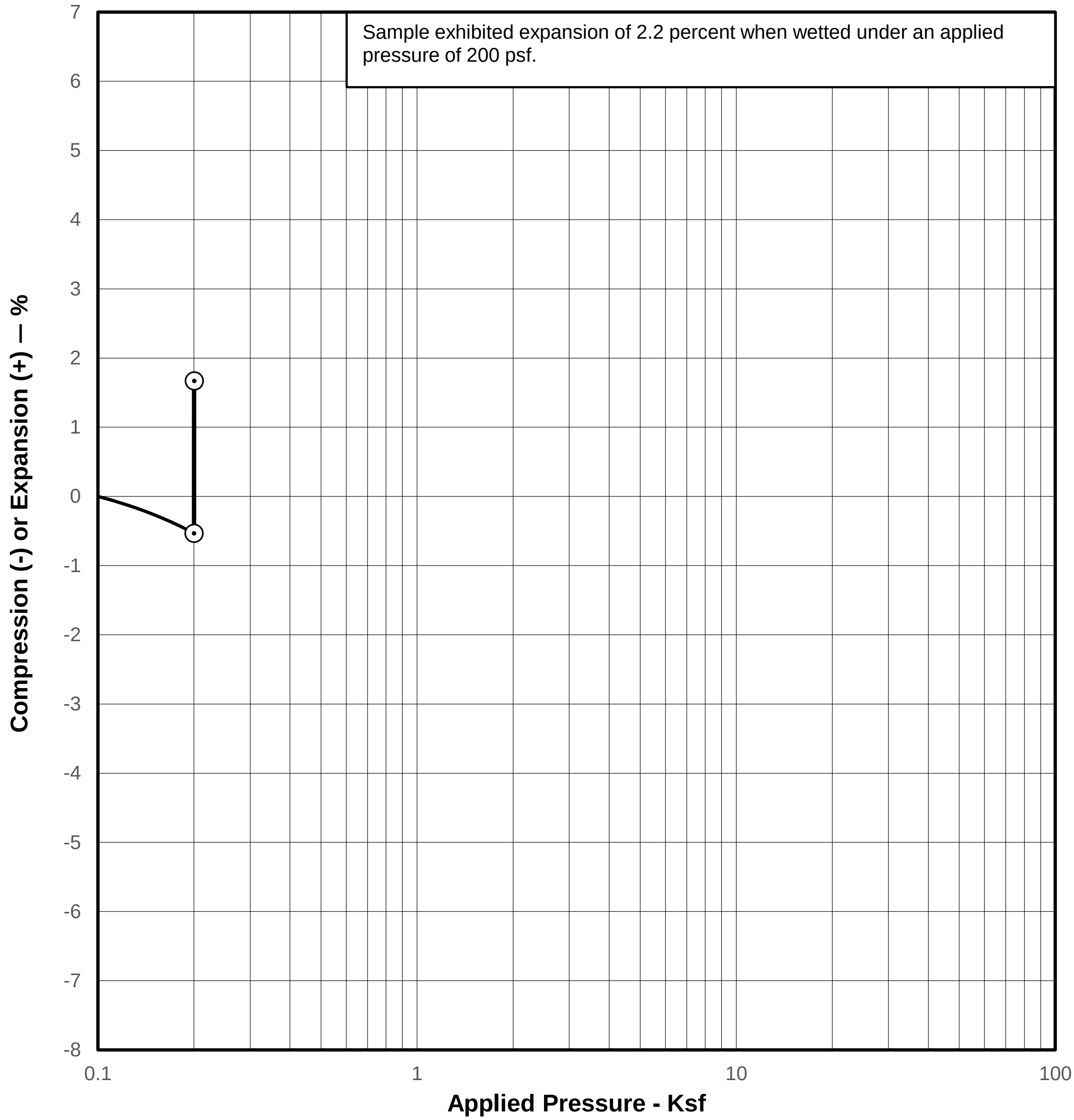
SAMPLE OF: CLAY, SANDY (CL)

FROM: TH-3 AT 4 FEET

MOISTURE CONTENT:	11.5 %	LIQUID LIMIT:	41	SILT AND CLAY:	78 %
DRY UNIT WEIGHT:	91 pcf	PLASTICITY INDEX:	26	SOIL SUCTION:	pf

JR ENGINEERING, LLC
RIDGEGATE MESA TOPS ROAD ALIGNMENT
CTL|T PROJECT NO. DN52378.000E-115-R1

Swell Consolidation Test Results

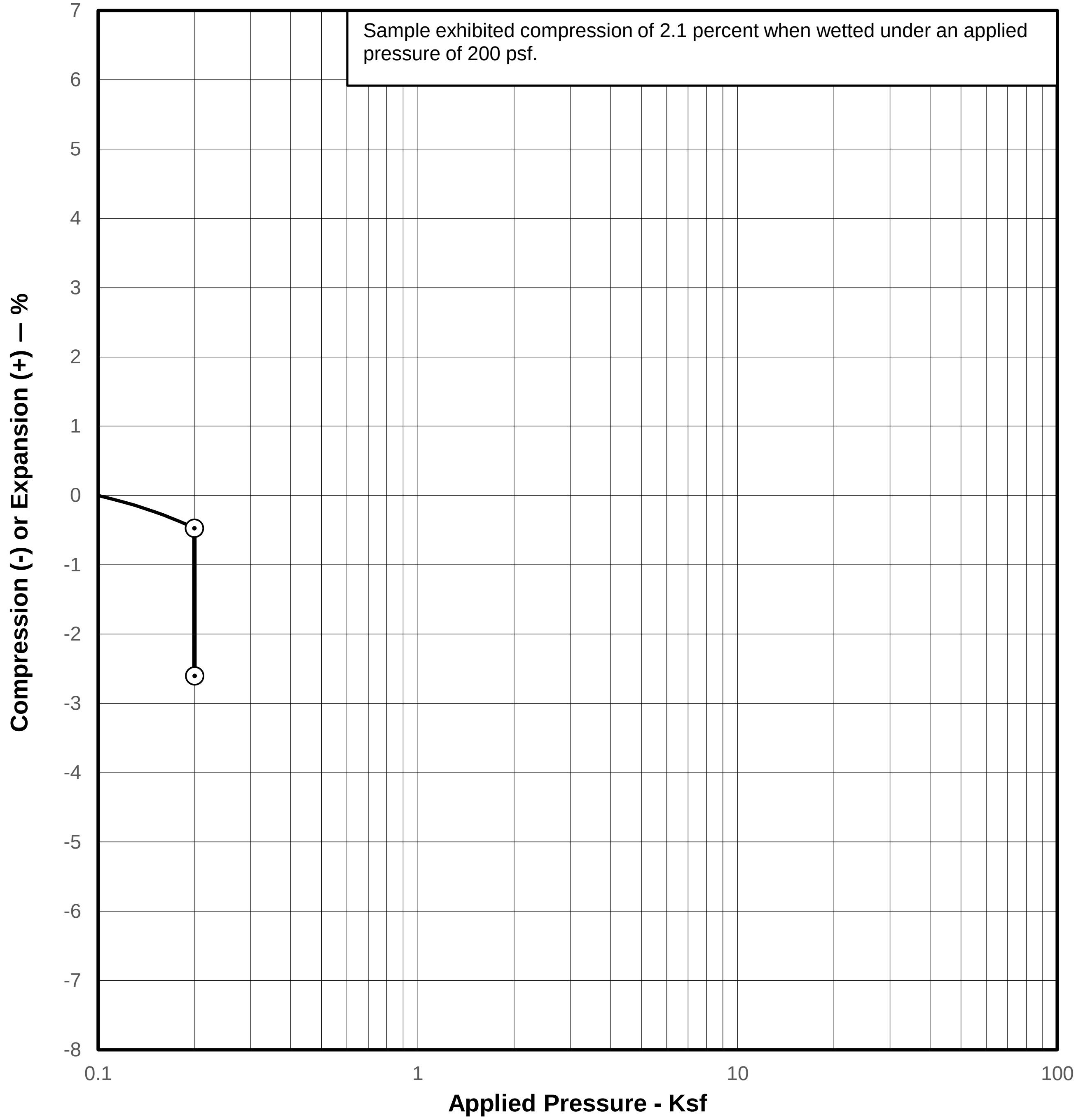


SAMPLE OF: CLAY, SANDY (CL)
FROM: TH-4 AT 4 FEET

MOISTURE CONTENT: 4.5 %
DRY UNIT WEIGHT: 104 pcf
LIQUID LIMIT: 37
PLASTICITY INDEX: 21
SILT AND CLAY: ___ %
SOIL SUCTION: ___ pf

JR ENGINEERING, LLC
RIDGEGATE MESA TOPS ROAD ALIGNMENT
CTL|T PROJECT NO. DN52378.000E-115-R1

Swell Consolidation Test Results



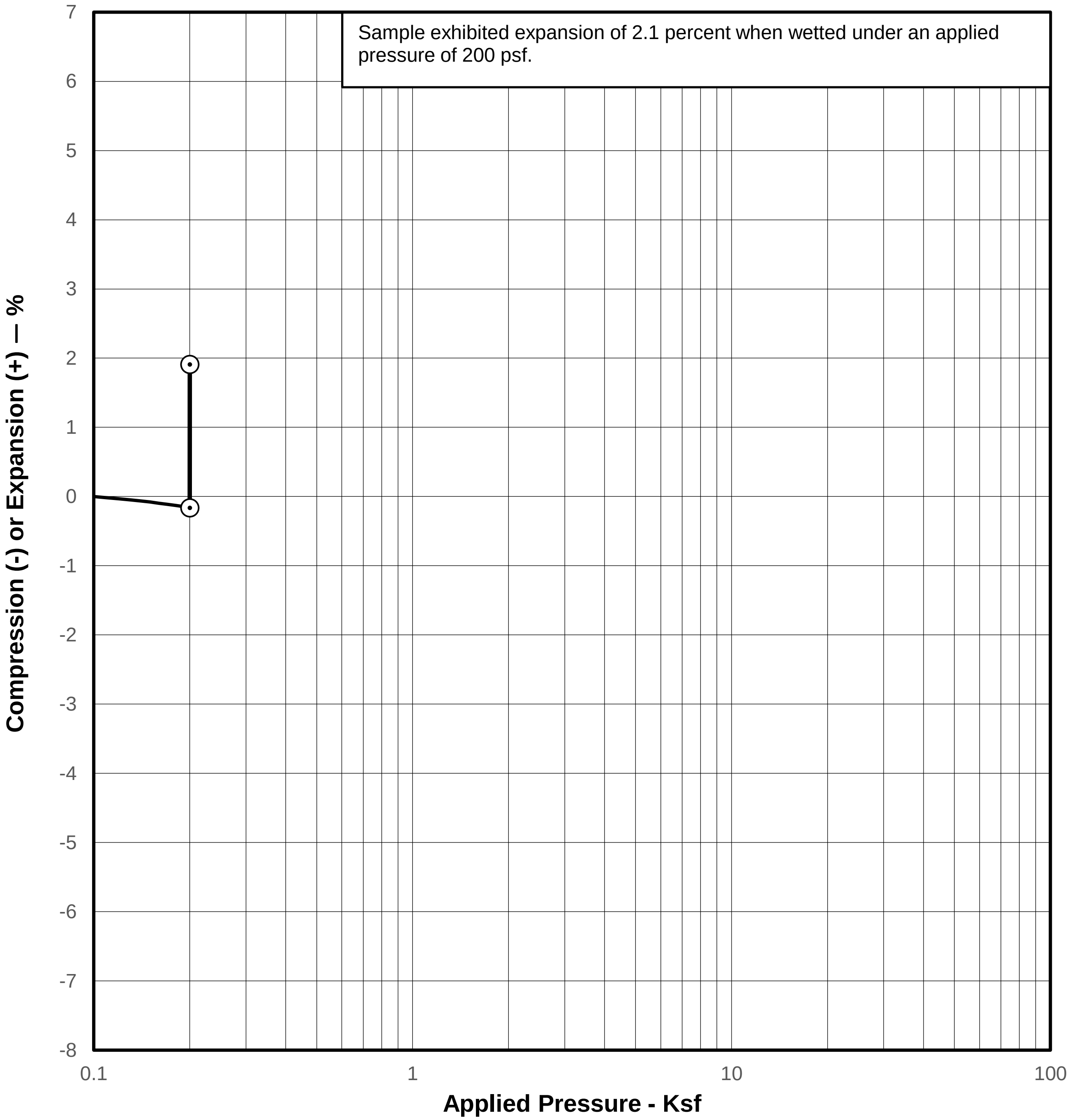
SAMPLE OF: SAND, CLAYEY (SC)

FROM: TH-5 AT 9 FEET

MOISTURE CONTENT:	14.9	%	LIQUID LIMIT:			SILT AND CLAY:		%
DRY UNIT WEIGHT:	101	pcf	PLASTICITY INDEX:			SOIL SUCTION:		pf

JR ENGINEERING, LLC
RIDGEGATE MESA TOPS ROAD ALIGNMENT
CTL|T PROJECT NO. DN52378.000E-115-R1

Swell Consolidation Test Results



SAMPLE OF: WEATHERED CLAYSTONE

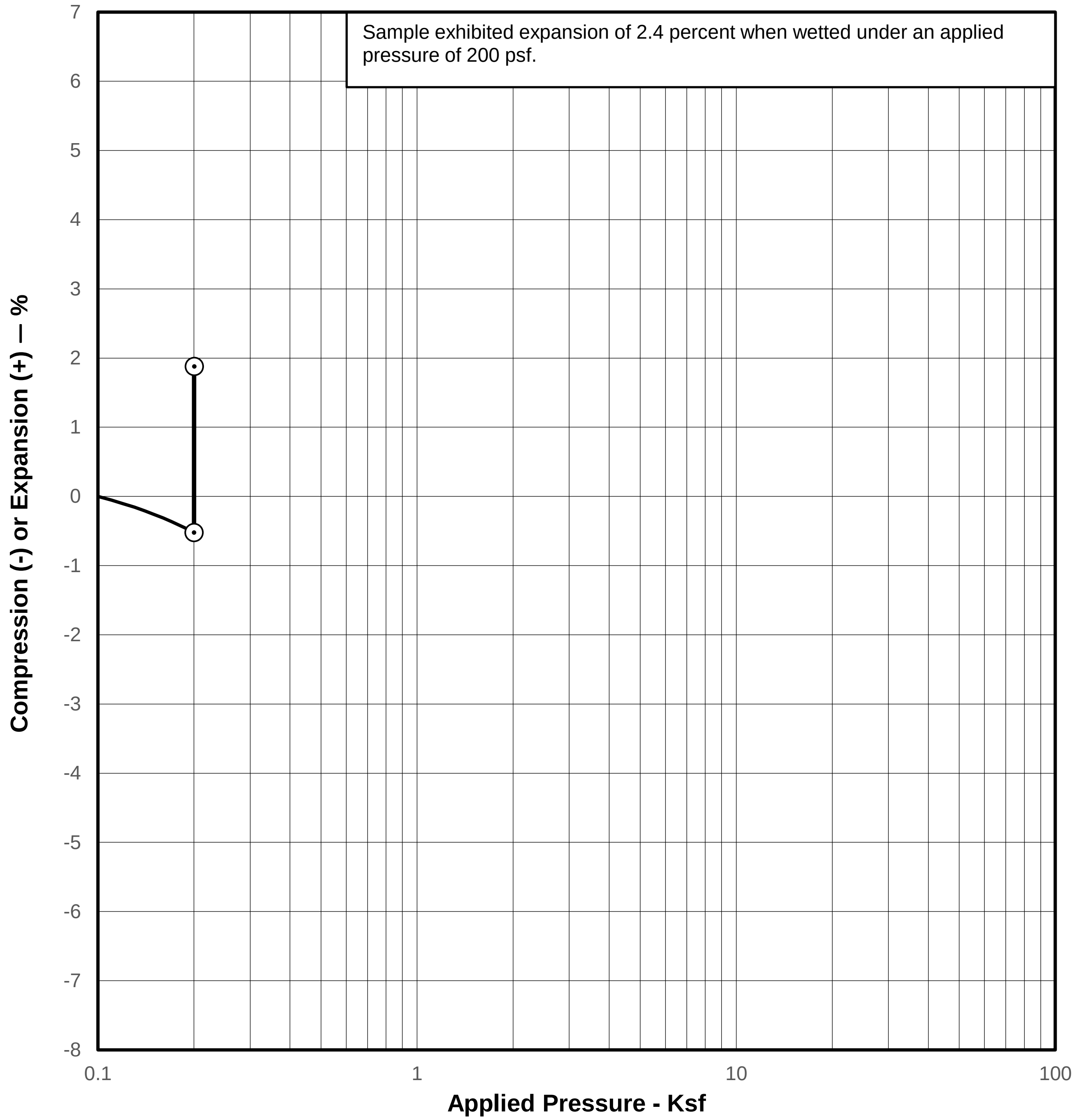
FROM: TH-5 AT 14 FEET

MOISTURE CONTENT: 19.9 % LIQUID LIMIT: ____ SILT AND CLAY: ____ %

DRY UNIT WEIGHT: 104 pcf PLASTICITY INDEX: ____ SOIL SUCTION: ____ pf

JR ENGINEERING, LLC
RIDGEGATE MESA TOPS ROAD ALIGNMENT
CTL|T PROJECT NO. DN52378.000E-115-R1

Swell Consolidation Test Results



SAMPLE OF: CLAY, SANDY (CH)

FROM: TH-6 AT 4 FEET

MOISTURE CONTENT: 13.8 % LIQUID LIMIT: ____ SILT AND CLAY: ____ %

DRY UNIT WEIGHT: 99 pcf PLASTICITY INDEX: ____ SOIL SUCTION: ____ pf

JR ENGINEERING, LLC
RIDGEGATE MESA TOPS ROAD ALIGNMENT
CTL|T PROJECT NO. DN52378.000E-115-R1

Swell Consolidation Test Results

CTL Thompson, Inc. - Denver
1971 West 12th Avenue
Denver, CO 80204
(303) 825-0777
denver@ctlthompson.com

CTL | THOMPSON
Founded in 1971

Proctor Report

Report ID: PTR:24-02929-01

Client: JR Engineering, LLC

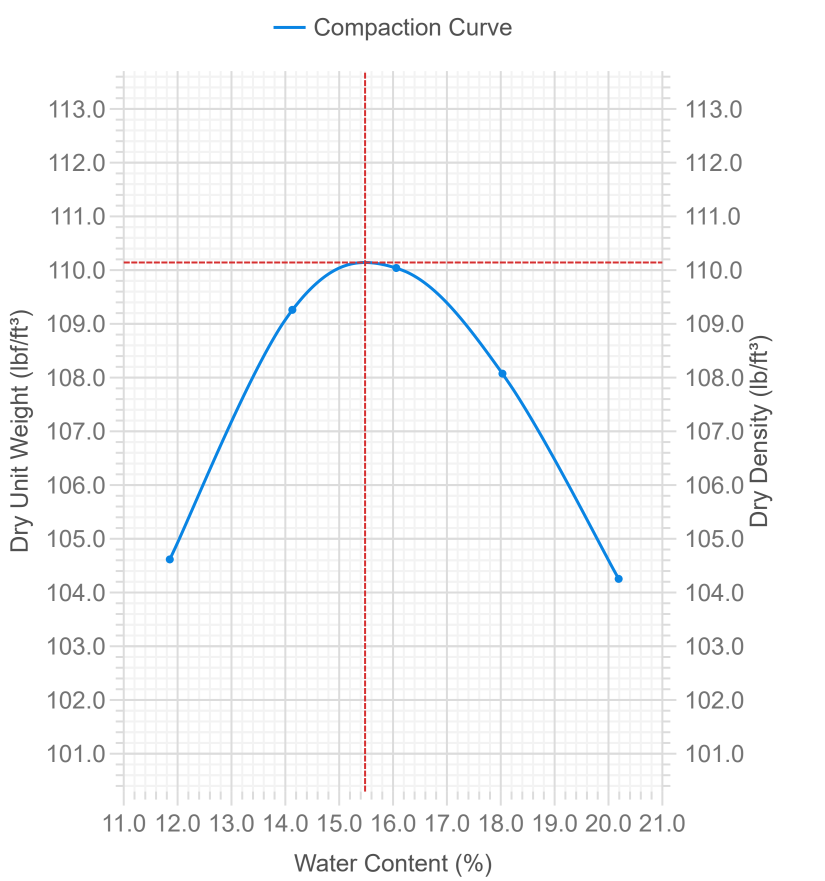
Project: Ridgegate Mesa Tops Road Alignment

Lone Tree CO
DN52378.000E-115

Sample Details

Sample ID:	24-02929-01	**Date Sampled:**	10/9/2024
Sampling Method:			
Source:			
Material:	CLAY, SANDY (CL)		
Specification:			
Location:			

Dry Unit Weight - Water Content Relationship



Test Results

ASTM D698

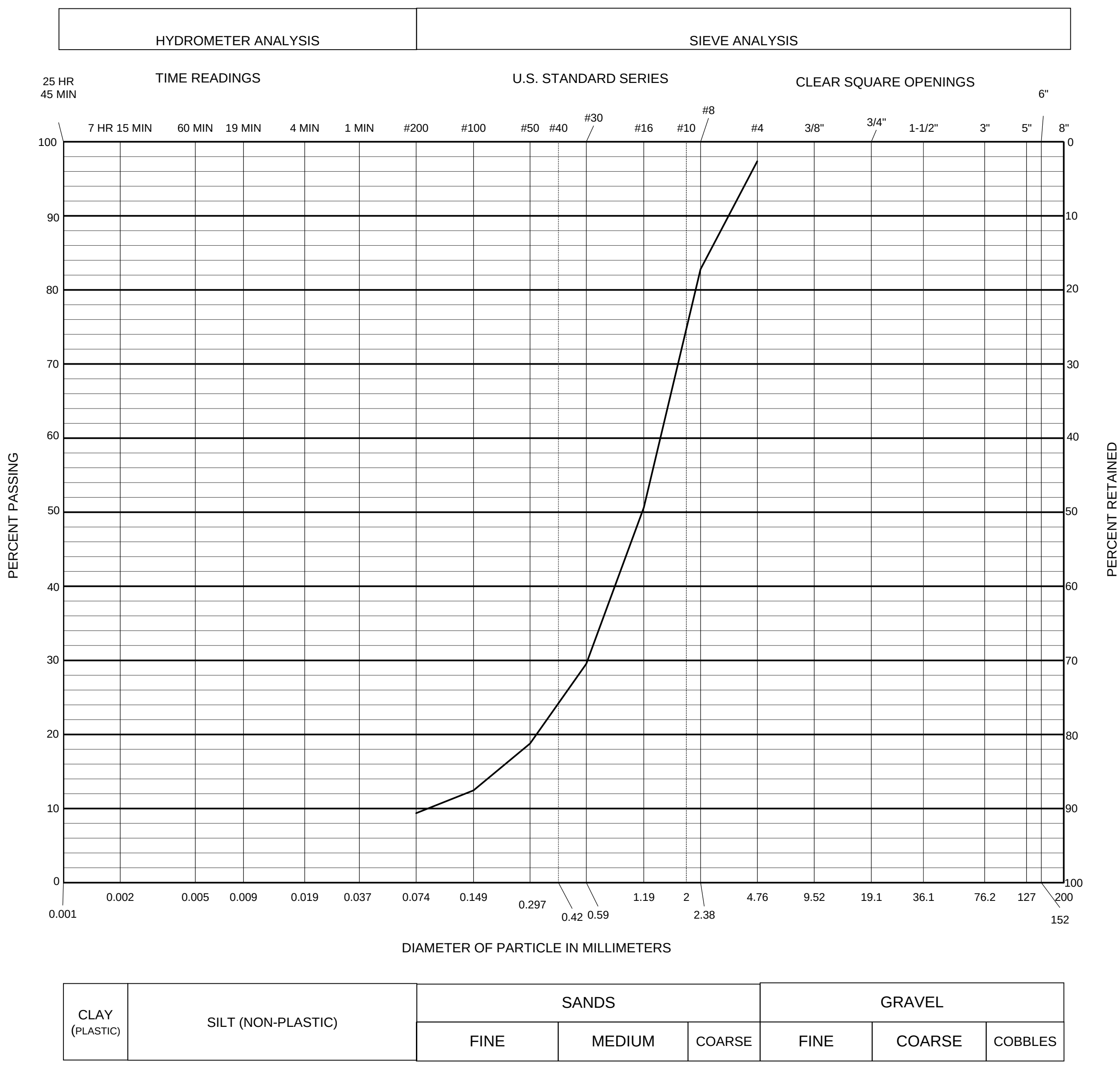
Std. Maximum Dry Unit Weight (lbf/ft³):	**110.0**
Std. Optimum Water Content (%):	**15.5**
Method:	
Preparation Method:	Moist
Determined By:	Estimated
Tested By:	Taqi Hossaini
Date Tested:	10/31/2024

ASTM D4318

Liquid Limit:	**41**
Plastic Limit:	**19**
Plasticity Index:	**22**
Tested By:	Jeffery Jones
Date Tested:	11/6/2024

Comments

FIG A-6



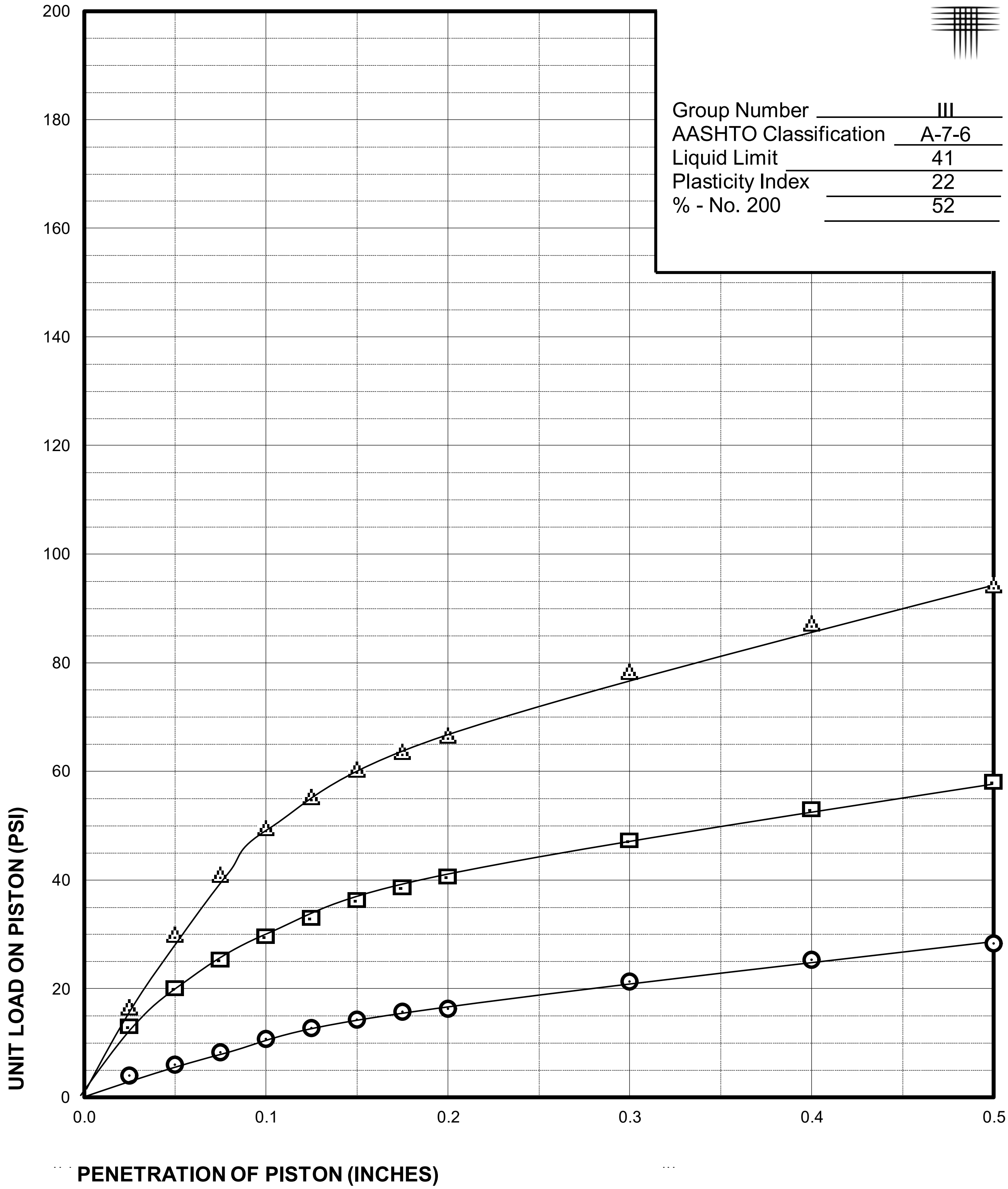
Sample of: SAND, CLEAN TO SILTY (SP-SM)
From: TH-2 AT 4 FEET

Sand & Gravel: 91 % Silt: - %
Clay: - % Liquid Limit: 37
Plasticity Index: 14

Size (mm)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4.75	#N/A	1.19	#N/A	0.297	0.149	0.074	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
% Passing	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	97.4	#N/A	50.6	#N/A	18.8	12.5	9	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

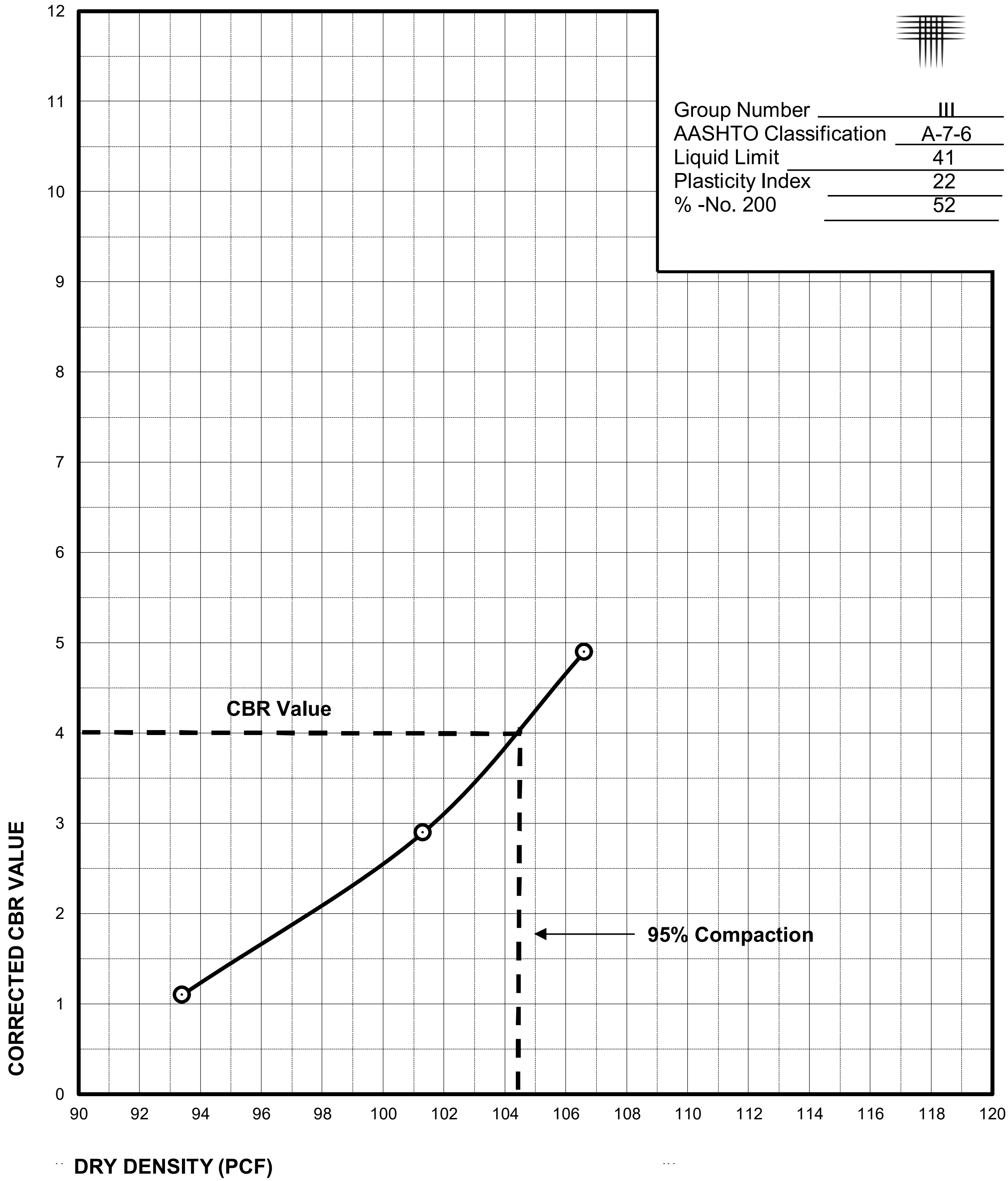
JR ENGINEERING, LLC
RIDGEGATE MESA TOPS ROAD ALIGNMENT
CTL|T PROJECT NO. DN52378.000E-115-R1

Gradation/ Hydrometer Test Results



	Group No.	III		Description:	Clay, Sandy (A-7-6)	
	Surcharge Load:	15 lbs.		Moisture Content:	16.9 %	
ʘ	Compaction	84.9 %	Swell	1.6 %	CBR Value	1.1
⊡	Compaction	92.1 %	Swell	1.9 %	CBR Value	2.9
△	Compaction	96.9 %	Swell	0.4 %	CBR Value	4.9

California Bearing Ratio



SYMBOL	GROUP NO.	95% COMPACTION	DESIGN CBR VALUE
⊙	III	104.5	4.0

California Bearing Ratio

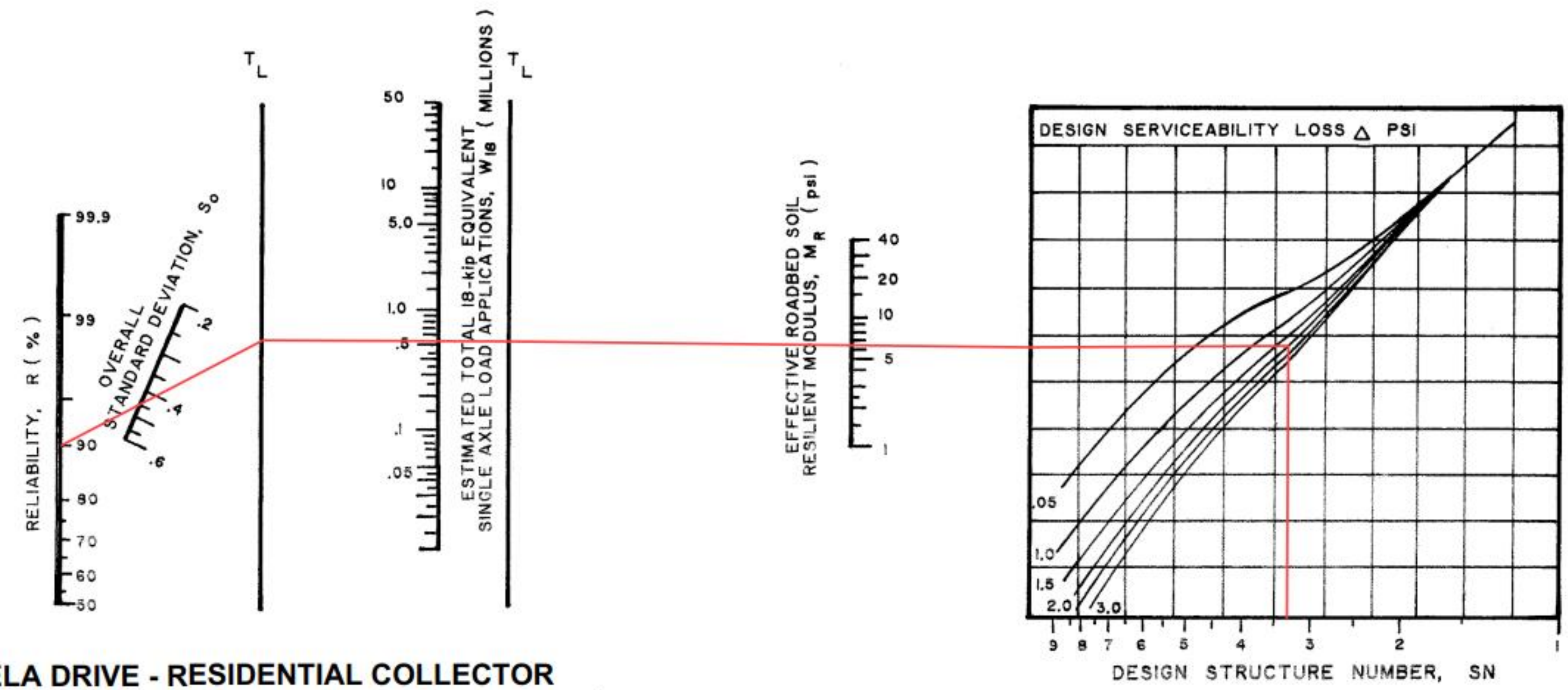
TABLE A-I

SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH (ft)	GROUP NO.	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	GROUP INDEX	CLASSIFICATION AASHTO	CLASSIFICATION UNIFIED	PERCENT SWELL @ 200 PSF (%)	PERCENT COMPRESSION @ 200 PSF (%)	SOLUBLE SULFATE CONTENT (%)	RETAINED NO. 4 SIEVE (%)	CBR VALUE	SOIL TYPE
TH-1,5,6	0-5, 10-15	III			52	41	22	8	A-7-6	CL					4	CLAY, SANDY (CL)
TH-1	0-5	II	7.4		48	27	12	3	A-6	SC						SANDSTONE
TH-1	9	III	19.5		95	49	22	24	A-7-6	CL						CLAYSTONE
TH-2	4	I	4.6	111	9	37	14	0	A-2-6	SP-SC				3		SAND, CLEAN TO SILTY (SP-SM)
TH-2	9	II	14.0	110	14					SM						SANDSTONE
TH-3	4	III	11.5	91	78	41	26	19	A-7-6	CL	0.1		0.02			CLAY, SANDY (CL)
TH-3	9	III	11.7	122	61					CL						WEATHERED CLAYSTONE
TH-4	4	II	4.5	104		37	21			CL	2.2					CLAY, SANDY (CL)
TH-4	9	II	8.7	121	50					CL						CLAY, SANDY (CL)
TH-5	9	II	14.9	101						SC		2.1				SAND, CLAYEY (SC)
TH-5	10-15	II	18.0		38	30	12	1	A-6	SC						SAND, CLAYEY (SC)
TH-5	14	III	19.9	104						CL	2.1					WEATHERED CLAYSTONE
TH-6	0-5	III	16.4		74	51	29	21	A-7-6	CH						CLAY, SANDY (CH)
TH-6	4	III	13.8	99						CH	2.4		<0.01			CLAY, SANDY (CH)

APPENDIX B

DESIGN CHARTS AND DESIGN CALCULATIONS



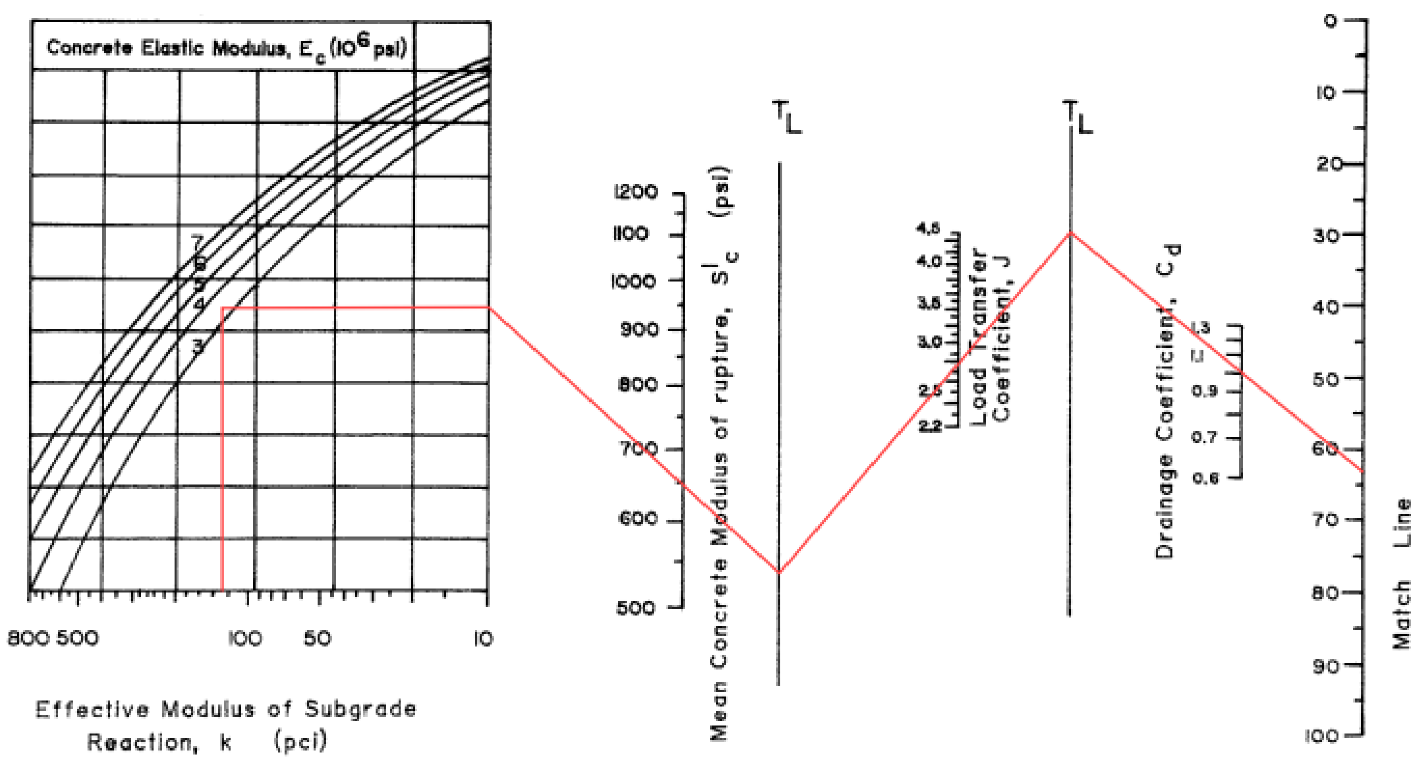
CABELA DRIVE - RESIDENTIAL COLLECTOR

Reliability, R (%) = 90 (From Douglas County Specs)
Overall Standard Deviation, S_o = 0.44 (From Douglas County Specs)
Equivalent Single Axle Loads, ESAL = 527,244 (Calculated from ADT provided in traffic study, using MGPEC Specs)
Resilient Modulus, Mr (psi) = 6,205 (Calculated from Lab Results, R-Value < 5)
Design Serviceability Loss, (psi) = 2.0 (From Douglas County Specs)
Design Structural Number, SN = 3.4

DESIGN CHART FOR FLEXIBLE PAVEMENT

DESIGN CHART FOR RIGID PAVEMENT

PART I



CABELA DRIVE - RESIDENTIAL COLLECTOR

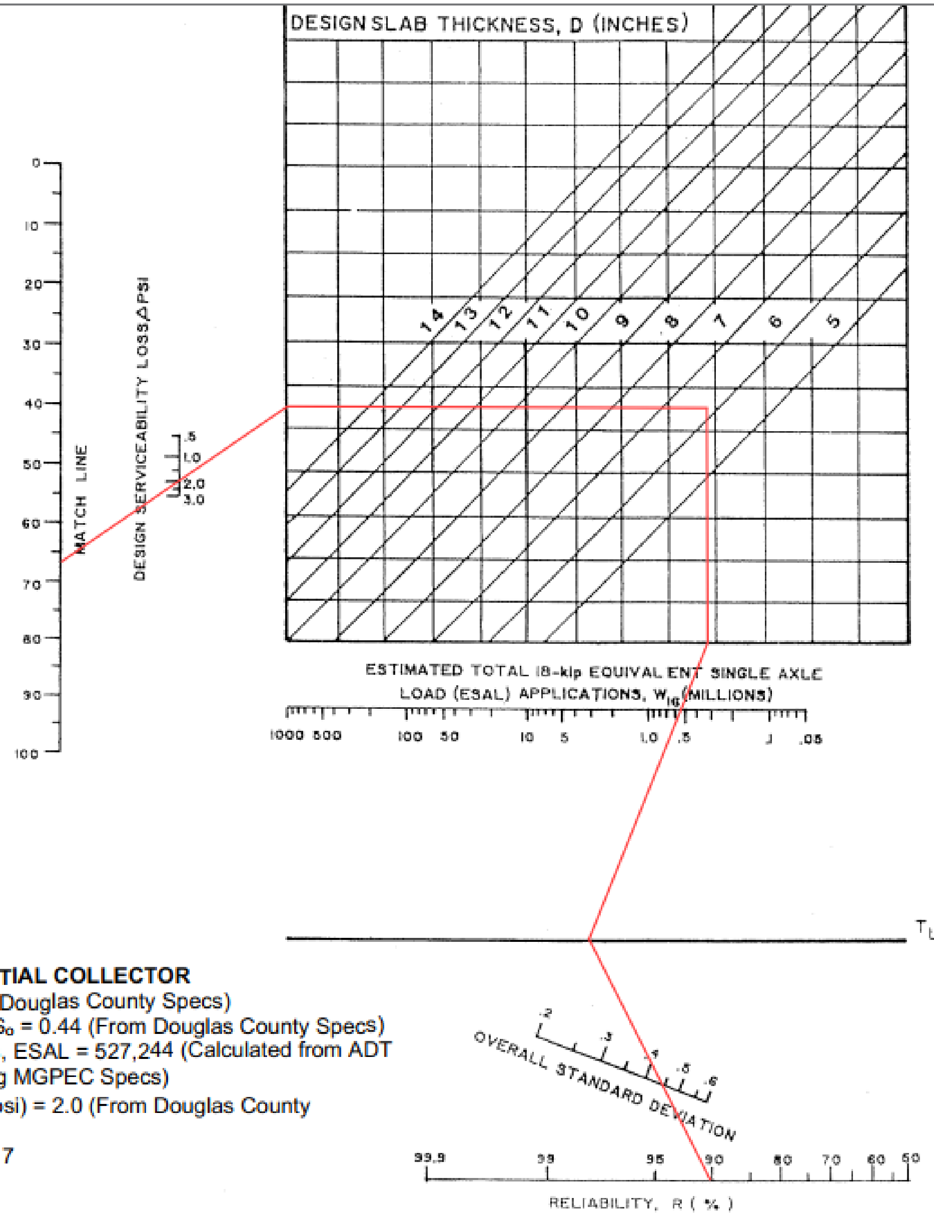
Modulus of Subgrade Reaction, k (pci) - 145 (from MGPEC, ACPA)

Modulus of Elasticity, E_c (psi) = 3,400,000 (From Douglas County Specs)

Modulus of Rupture S'_c (psi) = 650 (From Douglas County Specs)

Load Transfer Coefficient, J = 2.7 (From Douglas County Specs)

Drainage Coefficient, C_d = 1.0 (From Douglas County Specs)



CABELA DRIVE - RESIDENTIAL COLLECTOR

Reliability, R (%) = 90 (From Douglas County Specs)
Overall Standard Deviation, S_o = 0.44 (From Douglas County Specs)
Equivalent Single Axle Loads, ESAL = 527,244 (Calculated from ADT provided in traffic study, using MGPEC Specs)
Design Serviceability Loss, (psi) = 2.0 (From Douglas County Specs)
Design Slab Thickness (in) = 7

DESIGN CALCULATIONS
RESIDENTIAL COLLECTOR
(GROUP III SOILS: A-7-6)

DESIGN DATA

Equivalent Single Axle Loads (ESAL) = 527,244
California Bearing Ratio = 4.0
Subgrade Resilient Modulus (M_R) = 6,205 psi
Structural Number (SN) = 3.4

DESIGN EQUATION

$SN = (a_1D_1) + (a_2D_2)$

a_1 = 0.44 – Asphalt Concrete Strength Coefficient
a_2 = 0.12 – Aggregate Base Course Strength Coefficient
a_3 = 0.14 – Lime Treated Subgrade Strength Coefficient

D_1 = Depth of Asphalt Concrete (inches)
D_2 – Depth of Aggregate Base Course (inches)
D_3 – Depth of Stabilized Subgrade (inches)

ASPHALT CONCRETE + AGGREGATE BASE COURSE SECTION

$D_2 = ((3.4) - (5.0)(0.44)) / 0.12 = 10.0$ inches of Aggregate Base Course

ASPHALT + STABILIZED SUBGRADE SECTION

$D_3 = ((3.4) - (5.0)(0.44)) / 0.14 = 8.6$ inches of Stabilized Subgrade

RECOMMENDED SECTIONS

1. 5.0 inches of Asphalt Concrete + 10 inches Aggregate Base Course
2. 5.0 inches of Asphalt Concrete + 9.0 inches Stabilized Subgrade
3. 7.0 inches of Portland Concrete Cement

APPENDIX C

GUIDELINE MAINTENANCE RECOMMENDATIONS

MAINTENANCE RECOMMENDATIONS FOR FLEXIBLE PAVEMENTS

A primary cause for deterioration of pavements is oxidative aging resulting in brittle pavements. Tire loads from traffic are necessary to "work" or knead the asphalt concrete to keep it flexible and rejuvenated. Preventive maintenance treatments will typically preserve the original or existing pavement by providing a protective seal or rejuvenating the asphalt binder to extend pavement life.

1. Annual Preventive Maintenance

   a. Visual pavement evaluations should be performed each spring or fall.
   b. Reports documenting the progress of distress should be kept current to provide information on effective times to apply preventive maintenance treatments.
   c. Crack sealing should be performed annually as new cracks appear.

2. 3 to 5 Year Preventive Maintenance

   a. The owner should budget for a preventive treatment at approximate intervals of 3 to 5 years to reduce oxidative embrittlement problems.
   b. Typical preventive maintenance treatments include chip seals, fog seals, slurry seals and crack sealing.

3. 5 to 10 Year Corrective Maintenance

   a. Corrective maintenance may be necessary, as dictated by the pavement condition, to correct rutting, cracking and structurally failed areas.
   b. Corrective maintenance may include full-depth patching, milling and overlays.
   c. In order for the pavement to provide a 20-year service life, at least one major corrective overlay should be expected.

MAINTENANCE RECOMMENDATIONS FOR RIGID PAVEMENTS

High traffic volumes create pavement rutting and smooth, polished surfaces. Preventive maintenance treatments will typically preserve the original or existing pavement by providing a protective seal and improving skid resistance through a new wearing course.

1. Annual Preventive Maintenance

   a. Visual pavement evaluations should be performed each spring or fall.
   b. Reports documenting the progress of distress should be kept current to provide information of effective times to apply preventive maintenance.
   c. Crack sealing should be performed annually as new cracks appear.

2. 4 to 8 Year Preventive Maintenance

   a. The owner should budget for a preventive treatment at approximate intervals of 4 to 8 years to reduce joint deterioration.
   b. Typical preventive maintenance for rigid pavements include patching, crack sealing and joint cleaning and sealing.
   c. Where joint sealants are missing or distressed, resealing is mandatory.

3. 15 to 20 Year Corrective Maintenance

   a. Corrective maintenance for rigid pavements includes patching and slab replacement to correct subgrade failures, edge damage and material failure.
   b. Asphalt concrete overlays may be required at 15 to 20 year intervals to improve the structural capacity of the pavement.