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GEOTECHNICAL INVESTIGATION
PAVEMENT RECOMMENDATIONS

Ruby Ranch Pavement Repair
Buda, Texas

Report For:

Ruby Ranch Homeowners Association
P.O. Box 71
Buda, Texas 78610

July 2022

Engineer's Job # 22102100.003

MLA Geotechnical TBPE FIRM # F-2684
Geotechnical Engineering and
Construction Materials Testing
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BACKGROUND

The purpose of this investigation was to perform a pavement condition survey and to determine subsurface conditions relative to the establishment and design of pavement thickness sections for *Ruby Ranch* located in Buda, Texas. Authorization to perform this exploration and analysis was by Agreement for Engineering Services signed by Mr. Richard Spradley, president of Ruby Ranch Homeowners Association, on May 17, 2022.

More specifically, the purposes of this investigation were to determine the soil profile, the engineering characteristics of the foundation soil and to provide criteria for use by the design engineers in preparing the pavement thickness designs for the subdivision streets. The scope included a review of geologic literature, a reconnaissance of the immediate site, the subsurface exploration, field and laboratory testing, and an engineering analysis and evaluation of the foundation materials.

Index and engineering properties of the different soil types encountered on this project were determined and used as a basis for assigning parameters for pavement thickness designs. Pavement thicknesses were then designed using the computerized procedure adopted by the City of Austin, March 24, 1988, "Municipal Pavement Structural Design and Life Cycle Cost Analysis System" (1). Input data and assumptions as well as results are listed in later sections of this report. Output from the computer analysis is enclosed in ***Appendix C*** and ***Appendix D***.

The exploration and analysis of the subsurface conditions reported herein is considered in sufficient detail and scope to form a reasonable basis for the preliminary pavement thickness designs. The recommendations submitted are based on the available soil information and the assumed preliminary design for the proposed streets. Any revision in the plans for the proposed street system from those stated in this report should be brought to the attention of the geotechnical engineer so that he may determine if changes in the recommendations are required.

MLA Geotechnical should be retained to monitor site work and construction so that these preliminary recommendations may be finalized, and so that deviations from expected conditions can be properly evaluated.

This report has been prepared for the exclusive use of the client and their design professionals for specific application to the proposed project in accordance with generally accepted soils and pavement engineering practice. This report is not intended to be used as a specification or construction contract document, but as a guide and information source to those qualified professionals who prepare such documents.

FIELD AND LABORATORY INVESTIGATION

Twenty-five borings were drilled to various depths spaced at locations as shown on the enclosed Logs of Boring and Plan of Borings using a truck-mounted drilling rig. Water was not introduced into the borings. The field investigation included completing the soil borings, performing field tests, and recovering samples. Pocket penetrometer tests were performed on specimens during sampling. Representative soil samples were selected for laboratory index tests including Atterberg Limits and moisture content tests. The results of these tests and stratigraphy are presented on the Logs of Boring found in ***Appendix A***. A key to the Soil Classification and symbols is located behind the last Log of Boring. See ***Appendix B*** for details of field and laboratory procedures, as applicable.

SITE TOPOGRAPHY, DRAINAGE AND VEGETATION

The site is situated on variably sloping topography with natural slopes ranging from approximately 1 to 7 percent. The predeveloped vegetation at this site consists primarily of native grasses and mature trees. Regionally, the site drains towards Onion Creek.

SUBSURFACE CONDITIONS AND LOCAL GEOLOGY

Existing Pavement Sections

The existing pavement thicknesses for each boring are listed in the table below:

Boring	Street Name	Hot Mix Asphaltic Concrete, in	Crushed Limestone Base, in	Structural Number
B-1	Ruby Ranch Rd	1.75	12	2.5
B-2	Ruby Ranch Rd	2.5	2.5	1.5
B-3	Ruby Ranch Rd	3.0	13	3.2
B-4	Ruby Ranch Rd	2.5	14	3.1
B-5	Ruby Ranch Rd	1.5	10	2.1
B-6	Ruby Ranch Rd	1.75	8	1.9
B-7	Ruby Ranch Rd	1.0	18	3.0
B-8	Ruby Ranch Rd	1.5	8	1.8
B-9	Walter Cir	1.75	15	2.9
B-10	Matzig Cove	2.25	8	2.1
B-11	Matzig Cove	1.75	7	1.8
B-12	Armstrong Cove	2.75	5	1.9
B-13	Humphreys Drive	3.0	4	1.9
B-14	Humphreys Drive	3.25	4	2.0
B-15	McCoy Drive	1.25	6	1.4
B-16	Clark Cove Rd	1.75	4	1.3
B-17	Clark Cove Rd	2.0	7	1.9
B-18	Creekside Dr	3.0	7	2.3
B-19	E. Bartlett Dr	2.5	6	2.0
B-20	W. Bartlett Dr	1.0	6	1.3
B-21	W. Bartlett Dr	1.25	6	1.4

Boring	Street Name	Hot Mix Asphaltic Concrete, in	Crushed Limestone Base, in	Structural Number
B-22	Story Dr	0.75	2	0.62
B-23	Story Dr	1.25	2	0.84
B-24	Ware Dr	1.0	7	1.4
B-25	Richards Drive	3.5	2	1.9

Fill

The fill encountered in Borings B-2 and B-5 generally consists of brown and tan low plasticity clay (CL).

Soil Profiles

The soil profile revealed in the borings consists of dark grayish brown high plasticity clay (CH) underlain by reddish tan low plasticity clay (CL). These clay layers are underlain by severely weathered and intact limestone.

Geology

The proposed project site is underlain by an outcropping of the Fredericksburg Group, *Kfr* (2,3). This geologic unit is from the Lower Cretaceous Period and is composed of a series of limestone and marl formations. These include the Edwards Limestone, the Comanche Peak Limestone, the Cedar Park Limestone, the Bee Cave Marl, the Keys Valley Marl, and the Walnut Formation. Each of these geologic formations bears unique characteristics. Descriptions of these formations follows.

The Edwards Formation is the primary member of the Fredericksburg Group and forms a cap on most of the Edwards Plateau. Full sections of the Edwards in Central Texas are about 300 feet thick. Locally, the Edwards limestone is known to contain extremely hard strata, along with occasional marl or clay seams. In some zones, the limestone is dolomitic and contains some quartz and chert deposits. Soil weathering profiles are generally thin and usually include reddish brown high plasticity clay. Iron stained reddish earth is sometimes found throughout the section and is a result of solution weathering.

The Comanche Peak Formation is one of the youngest members of the Fredericksburg Group. It can range up to 80 feet thick in the Travis-Williamson County area, but the unit thins gradually to the south and east. The Comanche Peak Formation is fine to very fine grained, fairly hard and weathers white in color. This formation typically provides excellent support for residential foundations.

The Cedar Park Limestone is similar to the Comanche Peak but ranges up to 40 feet thick in the Travis-Williamson County area. South of the Travis-Williamson county line the upper portion of this limestone formation is blended with the Edward Limestone and the lower portion of the Cedar Park is mapped with the Bee Cave Marl. This formation is fine to very fine grained, fairly hard in the upper portion, and weathers white in color.

The Bee Cave Marl, the Keys Valley Marl, and the Walnut Formation are very similar. These marl are characteristically soft, white to pale yellow in color and outcrop locally in thicknesses up to 50 feet. Typical indicator fossils are the *Exogyra texana*, with a greater abundance of these occurring in the Bee Cave Marl. Excavations in these marl are often managed with ordinary power equipment. These marl provide generally acceptable support conditions for lightly loaded slabs on ground.

Faults

Geologic maps indicate the presence of a fault on the subject site; however, faulted conditions were not noted in the borings.

Ground Water

Ground water was not noted in any of the borings during this investigation. However, this formation is capable of producing varying quantities of ground water depending upon the antecedent rainfall conditions.

FLEXIBLE PAVEMENT VISUAL CONDITION SURVEY

Below is a brief description of the types of pavement distresses that were noted during this survey:

- **Longitudinal Cracking:** Longitudinal cracking consists of cracks or breaks that run parallel to the pavement centerline and may appear anywhere along the driving lane. Differential movement beneath the surface is the primary cause of longitudinal cracking outside of the wheel path. Cracks along the wheel path are typically associated with inadequate structural thickness for the traffic loads or a weakened subgrade. Environmentally-induced longitudinal cracking can occur from shrink/swell at the edges of the pavement or embankment consolidation/slope failures.
- **Transverse Cracking:** Transverse cracks travel at right angles to the pavement centerline. Transverse cracking is frequently associated with environmental surface shrinkage due to temperature changes, or may result from differential movement beneath the pavement surface.
- **Alligator Cracking:** Alligator cracking was the most noted distress observed during the visual survey. This distress is also known as fatigue cracking and is a traffic loading related distress typically initiated in the wheel paths. Alligator cracking consists of interconnected cracks that form irregularly-shaped blocks. Alligator cracking forms whenever the pavement surface is repeatedly flexed under traffic loads. Where alligator cracking occurs relatively early in the pavement's performance period, the distress can also be linked to inadequate structural thickness for the current traffic loads, surface layer delamination, poor construction practices, and/or a soft subgrade.
- **Rutting:** Rutting is longitudinal surface depressions typically in a wheel path that is a load-associated distress. Contributing factors to rutting may include:
    - Insufficient thickness of Hot Mixed Asphaltic Concrete (HMAC) or base for the traffic loading.

  - Compressive failure of the subgrade (soft subgrade).
  - Post-construction consolidation of HMAC or unbound layers under traffic loads (air void content too high).

CONCLUSIONS & RECOMMENDATIONS

Conclusions

Our investigation, as previously described, has reached the following conclusions.

1. Extremely variable subgrade conditions were encountered such that the pavement has been constructed on weathered limestone in some locations and highly expansive clay in other locations. See the enclosed Logs of Boring in ***Appendix A***.
2. Extremely variable thicknesses of pavement layers were encountered. See the enclosed Logs of Boring in ***Appendix A***.
3. The pavement layers are very thin in many locations. These thin areas are too thin for typical subdivision streets.
4. Based on the age of the pavement and the thicknesses of the pavement layers encountered, the pavement is likely beyond its design life.
5. The existing pavement sections are too thin and too variable for recycling of existing pavement layers to be considered as part of any rehabilitation or reconstruction recommendations.
6. Pavement damage is too widespread and pavement layers are too thin to consider simply overlaying the exiting asphalt with an additional thickness of asphalt as there is not enough underlying structure to prevent similar and significant damage to the newly laid asphalt overlay.

Likely Causes of the Current Pavement Conditions

The majority of the pavement distresses observed during the visual survey included longitudinal cracking and transverse cracking throughout the site. The distresses observed in the pavements are likely attributed to the age of the pavement and some areas of poor drainage adjacent to the pavement which has accelerated the aging process. Poor drainage away from the pavement structure allows water into the base and subgrade layers, thereby weakening these layers and also causing the soil beneath the pavement structure to shrink and swell. Inadequate structural thickness of the HMAC and base layers for the current traffic loads and subgrade stiffness could also be contributing factors in isolated areas. Typically, pavements should be constructed with a curb and gutter or bar ditch system on all sides such that water drains away from the pavement system and does not pond near the pavement system. Based on the visual survey, it appears that bar ditches were not installed in some areas or not constructed to be deep enough in others, allowing water to flow back into the pavement system.

Recommendations

Based on the pavement conditions previously described, the variable thicknesses of the pavement layers and the overall thin section of pavement, we are recommending the following options for the existing pavements at this site.

1. It is our professional opinion that a top-down approach, like placing an overlay, is not a viable long-term solution. See previous discussion.
2. In areas where pavement ride quality is acceptable, it is possible to extend the life of the pavement. To extend the life of the pavement in these areas, any cracks in the asphalt should be sealed to minimize water intrusion into the underlying layers. This may include an overall seal coat on the entire width of the road, as desired.
3. In areas where ride quality is unacceptable, the pavement should be removed and reconstructed in accordance with the pavement sections provided under the ***Recommendations – Pavement Thickness Sections*** portion of this report.

MFPS AND MRPS ANALYSIS AND DESIGN

Pavement thickness sections were developed using the computerized pavement analysis software programs called "*Municipal Flexible Pavement Design System*" (MFPS) and "*Municipal Rigid Pavement Design System*" (MRPS) (1). These programs accept a number of input variables and predict the performance of the pavement sections including the number and type of overlays required for the specified pavement design life. The different sections are ranked on total cost, overlay cost, user cost, routine maintenance cost, and salvage value.

In the absence of project specific data, the City of Austin guidelines for estimating material costs, civil design information and traffic data were used. An estimate of anticipated traffic usage was made from the street classification inferred from the subdivision plat. Minimum layer thicknesses used Table 3-11 of the City of Austin's *Transportation Criteria Manual* (4). Pavement layer properties and costs used are shown in the computer output contained in ***Appendix C*** and ***Appendix D***.

Pavement options for the expected subgrade conditions are presented in the following table. Final pavement sections should be evaluated in the field by the Geotechnical Engineer.

RECOMMENDATIONS - PAVEMENT THICKNESS SECTIONS

Street Classification	Road Name	Hot Mix Asphaltic Concrete, in	Crushed Limestone Base, in	Concrete Pavement (JRCP), in	Geogrid
Local Streets	All other roads	2.0	9	-	X*
		-	-	6	-
Minor Collector	Ruby Ranch Road	2.5	13	-	X*
		-	-	7	-

Notes:

1. *A single layer of Tensar TX-130S or equivalent to be approved by the geotechnical engineer should be placed below the crushed limestone base layer.
2. The subgrade improvement should be extended 2 feet beyond the back of the edge of pavement or curb line.
3. These pavement thickness designs are intended to transfer the load from the anticipated traffic conditions.
4. The responsibility of assigning street classification to the streets in this project is left to the civil engineer.
5. If pavement designs other than those listed above are desired, please contact MLA Geotechnical.
6. All pavements should be constructed with a curb and gutter or shoulder/bar ditch system on all sides such that water drains away from the pavement system and does not pond near the pavement system. A bar ditch typically includes a 5-to-6-foot shoulder past the ribbon curb with a bar ditch beginning past the shoulder. Water must not be allowed to pond adjacent to the pavement.
7. If positive drainage, similar to what is described in Item 6 cannot be established, a vertical moisture barrier is highly recommended. Moisture barriers should be installed to a depth of 4 feet below the current ground surface in order to prevent water from entering the pavement structure. The moisture barrier can be comprised of either deepened ribbon curb or 15-mil poly attached at the back of the ribbon curb.
8. MLA Geotechnical should review the final construction plans to determine if proper drainage has been established as well as the details for any moisture barriers if they will be utilized for this project.

CONSTRUCTION CONSIDERATIONS

Ground Water

Should ground water become a problem during excavation, or if surface water accumulates during a rainy period, saturated soil should be dried out and/or removed and replaced with crushed limestone base.

Pavement

1. Subgrade and Foundation Soil Preparation
   a. Strip and remove from construction area any top soil, organics and vegetation to a minimum depth of 6 inches below the existing natural ground surface.
   b. Fill sections may be composed of on-site material excluding topsoil, vegetation, and organics. Fills should be compacted in lifts not exceeding 8 inches after compaction and meet Hays County current "Specifications for Roadway Design, Paving and Drainage Improvements" (Specifications) Item No.'s 1.03 and 1.08 as applicable (5).
   c. Compaction of cut areas, on-grade areas, and fill sections should be to 95 percent of TxDOT TEX-114-E. Compaction should be performed with the moisture content of the soil adjusted to within 3 percent of optimum moisture content unless exposed limestone is encountered or suspected. If exposed limestone is suspected the geotechnical engineer should be notified to provide a field confirmation.
2. Base Course
   a. Base material shall meet the specifications outlined by Item 3.00 of Hays County Specifications.
   b. Thickness of the base course shall be as shown on the enclosed ***Recommendations - Pavement Thickness Sections***.

c. Base course compaction shall be 100 percent of TxDOT TEX-113-E using 13.26 ft. lbs./cu.in. compaction effort. The moisture content during compaction shall be maintained within 3 percent of optimum moisture content. Density control by means of field density determination shall be exercised.

d. After compaction, testing, and curing of the base material, the surface shall be primed using an Asphalt Emulsified Petroleum (AE-P) primer or other acceptable priming material as per Item 4.00 of the of the current Hays County Specifications.

e. A full thickness of the base course and subgrade improvement should be extended 2 feet beyond the back of curb line for expansive subgrades.

3. Surface Course Options

a. **Hot Mix Asphaltic Concrete** - This surfacing shall consist of a hot-mix asphaltic concrete (HMAC) meeting the requirement of Item 6.00, Type "D" of the current Hays County Specifications. Thickness should be as shown on the included ***Recommendations - Pavement Thickness Sections***.

b. **Concrete Pavement** - The concrete should develop a minimum 28-day flexural strength of 500 psi with 4 to 6 percent entrained air. This flexural strength equates to approximately 3,500 psi compressive strength. Minimum reinforcing should be No. 3 bars at 18 inches on center each way, centered in the slab. Contraction (saw cut) joint spacing should not exceed 15 feet on center without engineering consultation. Contraction joints should be saw cut as soon as the freshly poured concrete can support the weight of the saw cut machine. Waiting too long to saw cut the concrete can result in unwanted cracking. Full depth, full width isolation joints with bituminous fiber or preformed joint filler should be installed at no more than 125 feet on center and at all rigid structure interfaces such as older sections of pavement

4. General Conditions

   a. Should at any stage in the construction of the street pavements a non-stable or weaving condition of the subgrade or base course be noted under loads of construction equipment, such areas should be delineated and the Geotechnical Engineer consulted for remedial action before completing the pavement section.

   b. Seepage areas or unusual subgrade soil conditions should be similarly brought to the Geotechnical Engineer's attention before proceeding with pavement completion.

   c. Where completed pavements are trenched for utilities, a thickness of compacted flexible sub-base should be placed below the new crushed stone base. The sub-base should be meet the specifications outlined by Item 210 of the City of Austin's "Standard Specifications." This sub-base should be compacted in 8 inch lifts to 95 percent of TEX-113-E and be a minimum of 18 inches thick or twice the design base thickness (if greater).

   d. Trenches beneath structures should be strategically backfilled with borrow or suitable material excavated from the trench and free of stone or rock over 8 inches in diameter. The backfill should be compacted to 95 percent of the maximum dry density when determined by TxDOT test method Tex-114-E. The moisture content should be within 2 percent of the optimum moisture content at the time of compaction. If stormwater trenches are backfilled with freely draining materials such as crushed stone, pea gravel or sand, the trench must be sloped a minimum of 0.5 percent to provide positive drainage to daylight.

   e. If ground water or seepage is encountered at the time of construction, French drains may be required to drain or intercept the flow of water from the subsurface pavement materials. These drains should be sloped a minimum of 0.5 percent to provide positive drainage to daylight. French drains should be constructed in general accordance with ASTM D 2321 "Standard Practice for Underground Installation of Thermoplastic Pipe of Sewer and Other Gravity Flow Applications(6)." The French drain design should be reviewed by the geotechnical engineer prior to installation.

f. All pavements should be constructed with a curb and gutter or bar ditch system on all sides such that water drains away from the pavement system and does not pond near the pavement system. If ribbon curb is used, positive drainage should be maintained away from the edges of the pavement for a minimum of 5 feet. Water must not be allowed to pond adjacent to the pavement.

QUALITY ASSURANCE CONSIDERATIONS

Type of Work	Item	Sample Frequency	Sample Size	Minimum Testing
General Earthwork and Fill Material	Soil	1 per Soil Type	110 lbs.	♦ Sieve ♦ P.I. ♦ Moisture Density Relationship
Base Course	Compaction	1 per 5000 ft^2 per lift (min. of 3 per lift)	300 lbs.	♦ Field Density Test
Subgrade	Compaction	----------------		♦ Proof rolling w/25 ton pneumatic roller
Concrete or HMAC	Mix Design	1 per concrete class		♦ Review & approval with confirmatory cylinders/cores ♦ Plant & materials approval, testing, if questionable
	Aggregates (coarse & fine)	1 per 500 cu. Yd. Min. 1 per job	30 lbs.	Sieve, organic impurities, specific gravity
HMAC Surface Course	HMAC	1 per 500 tons or each days laydown		♦ 3 cores for density ♦ Extraction/gradation tests ♦ Stability tests ♦ Thickness ♦ Temperature

REFERENCES

1. "Municipal Pavement Structural Design and Life Cycle Cost Analysis", City of Austin, Austin, Texas, December 1992.

2. Local geologic maps published by The Bureau of Economic Geology. Austin, Texas including:
   "Geologic Atlas of Texas" 15-minute quadrangles. March 9, 2004 geospatial data.
   "Geologic Map of the Austin Area, Texas 1992" Geology of Austin Area Plate VII.
   "Geologic Map of the West Half of Taylor Texas, 30 x 60 min quad. 2005. misc. map 43
   "Geologic Map of the New Braunfels, Texas 30 x 60 min quad" 2000. misc. map 39

3. "The Geology of Texas, Volume I, Stratigraphy", The University of Texas Bulletin No. 3232: August 22, 1932, The University of Texas, Austin, Texas, 1981.

4. "Transportation Criteria Manual", City of Austin, January 1998.

5. "Specifications for Roadway Design, Paving and Drainage Improvements", Hays County, Latest Adopted Revision.

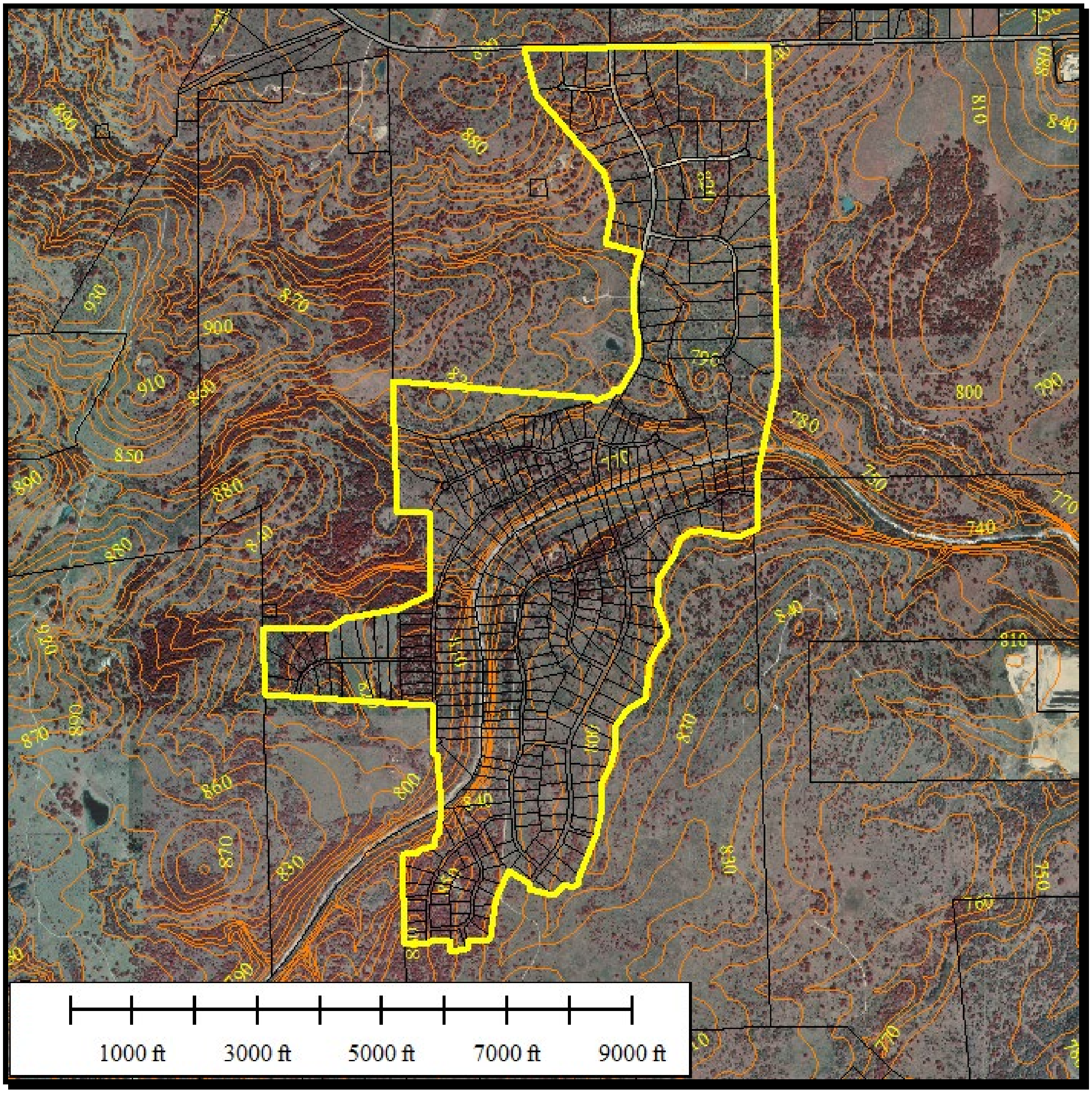
6. "ASTM D-2321-89 Standard Practice for Underground Installation of Thermoplastic Pipe Sewers and Other Gravity Flow Applications", ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania, USA 19428-2959.

LIMITATION OF REPORT

Conditions of the site at locations other than the boring locations are not expressed or implied, and conditions may be different at different times from the time of this investigation. Contractors or others desiring more complete information are advised to secure their own supplemental borings. The analysis and recommendations contained herein are based on the available data as shown in this report and the writer's professional expertise, experience and training, and no other warranty is expressed or implied concerning the satisfactory use of these recommendations or data.

APPENDIX A

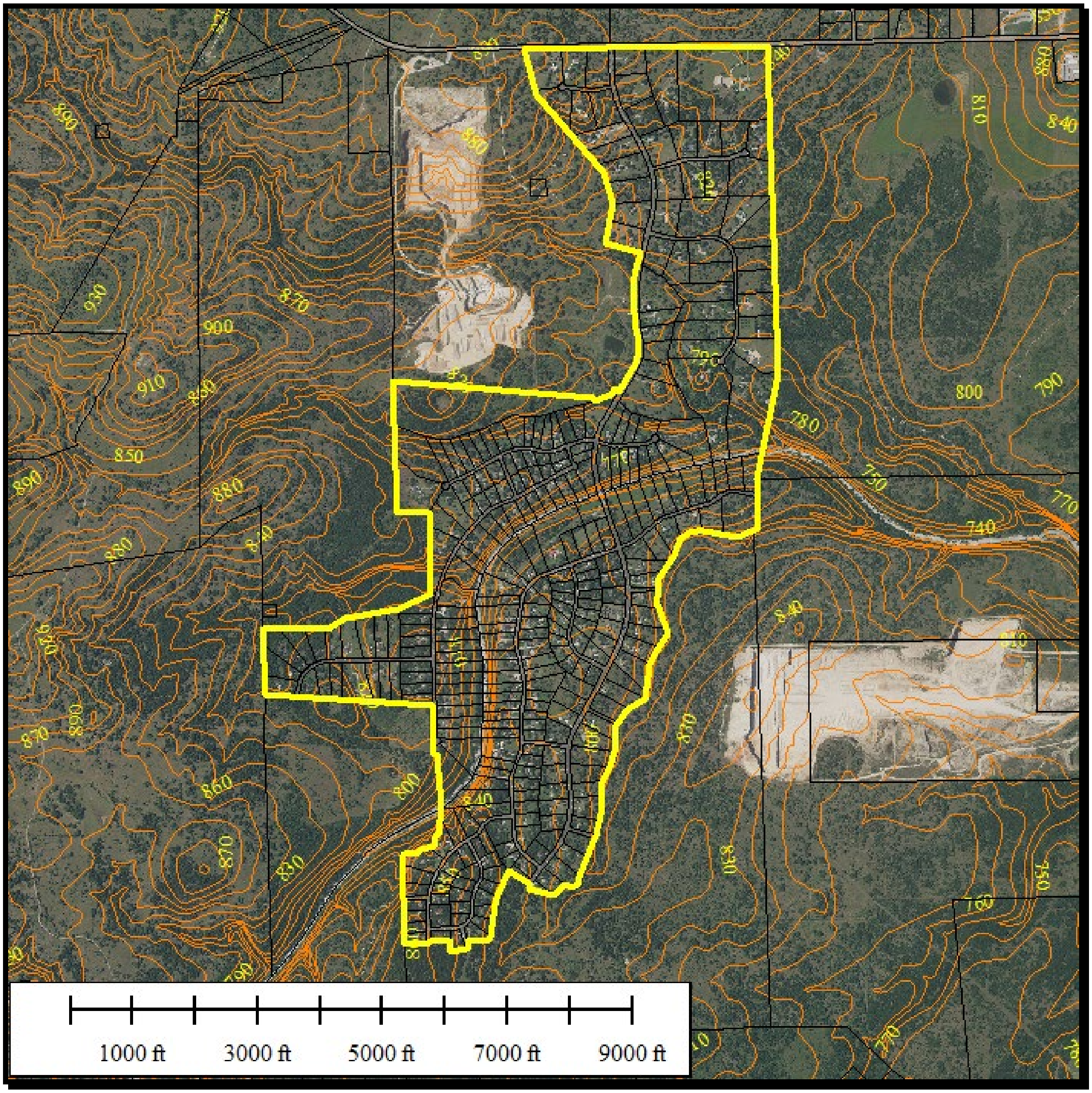
GEOTECHNICAL DATA



Approximate location of site in yellow
CAPCOG contours (2008) in orange
Hays County parcels (2021) in black

NAPP Aerial Photograph of Site – 1995

Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
3.75-minute DOQQ. 1-meter ground resolution. apx. date 1995-6
(http://www.tnris.state.tx.us/digital.htm)

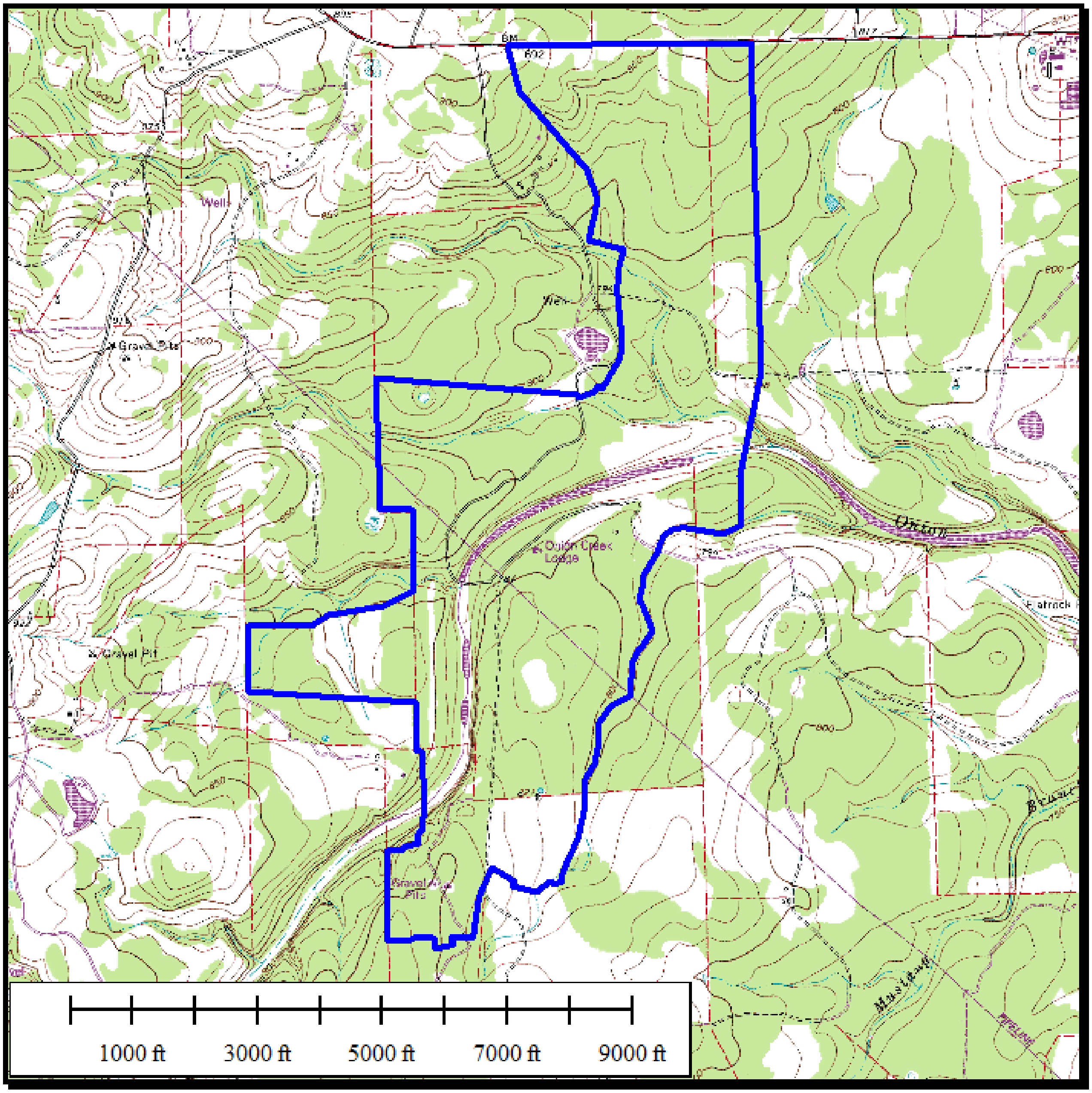


Approximate location of site in yellow
CAPCOG contours (2008) in orange
Hays County parcels (2021) in black

Aerial Photograph of Site – 2020

Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
Apx. Date - 2020
(https://tnris.org/)

N



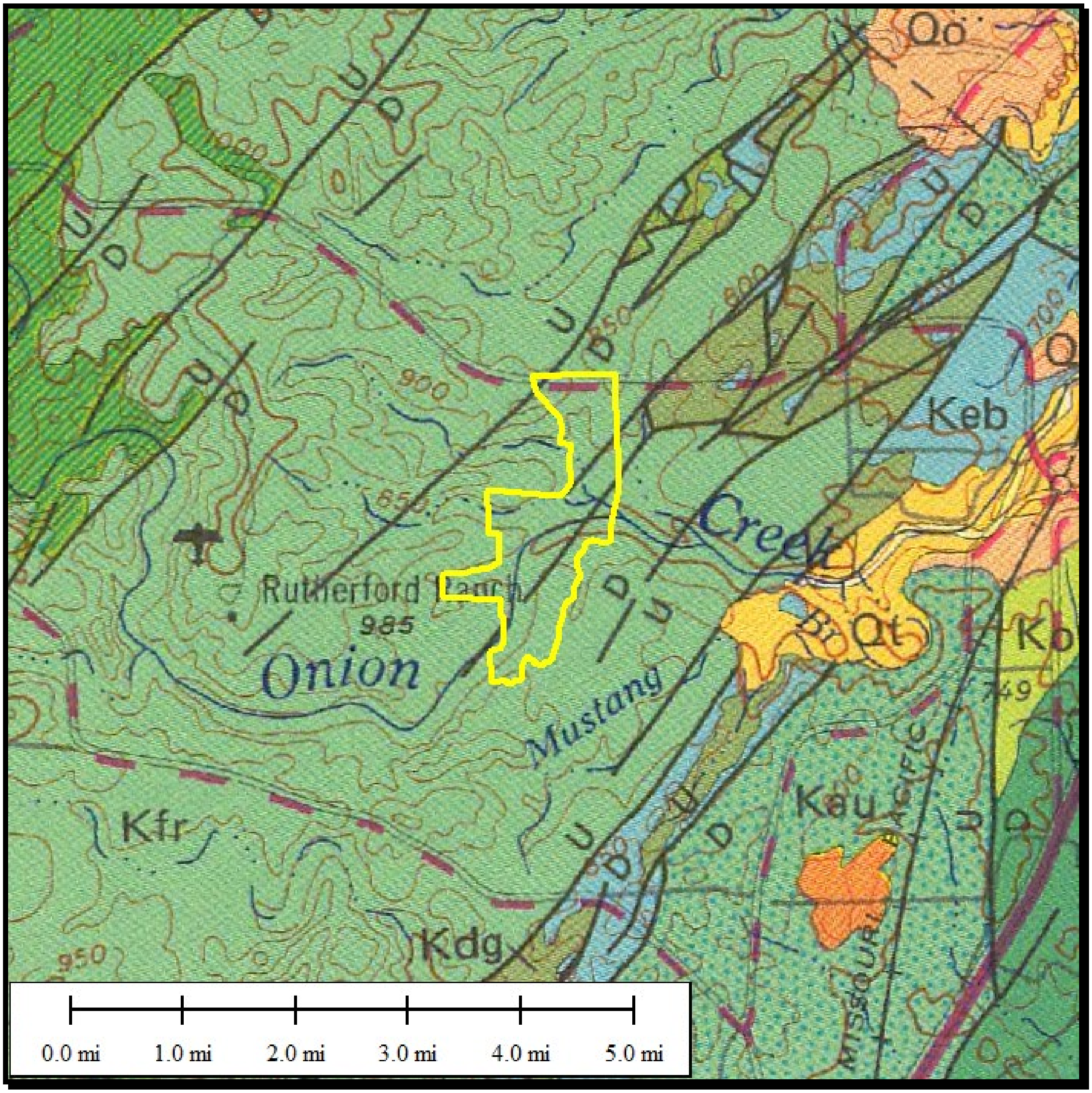
Approximate location of site in blue

U.S. 7.5 Minute Series Topographic Map
Mountain City Quadrangle, Texas

Contour Interval = 10 feet

Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
(http://www.tnris.state.tx.us/digital.htm)

N

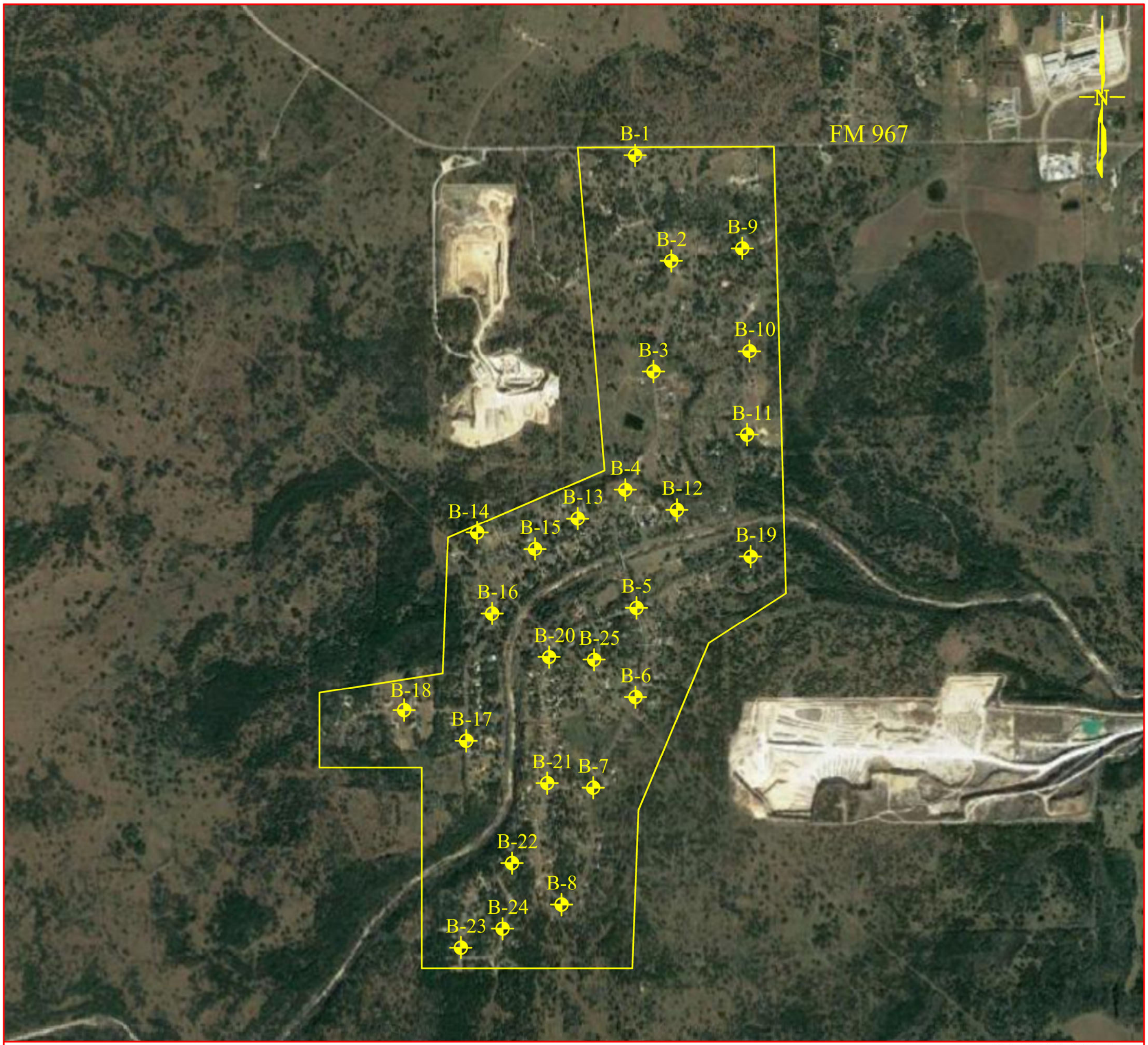


Approximate location of site in yellow

Geologic Setting of Site
Geologic Atlas of Texas

Contour Interval = 50 feet

Original Source: Bureau of Economic Geology, The University of Texas at Austin, latest version
Digital Source: 15-minute Digital GAT Quads. TCEQ March 9, 2004



SCALE = N.T.S.

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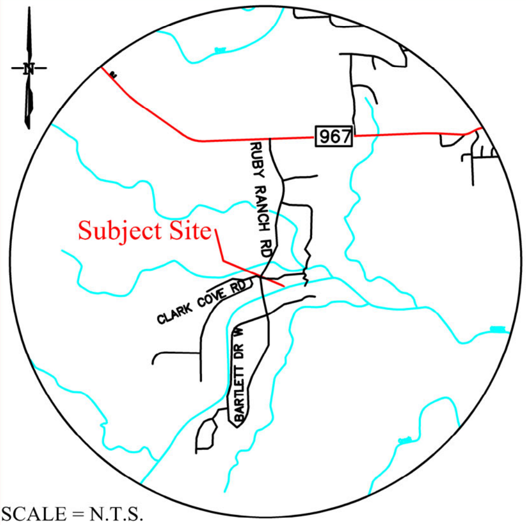
PLAN OF BORINGS

Ruby Ranch Pavement Repair
Buda, Texas
Job. No.: 22102100.003
Client: Ruby Ranch Homeowners Association

LEGEND

B-#	Boring Number
⊕	Approx. Boring Location

VICINITY MAP



SCALE = N.T.S.

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LOG OF BORING

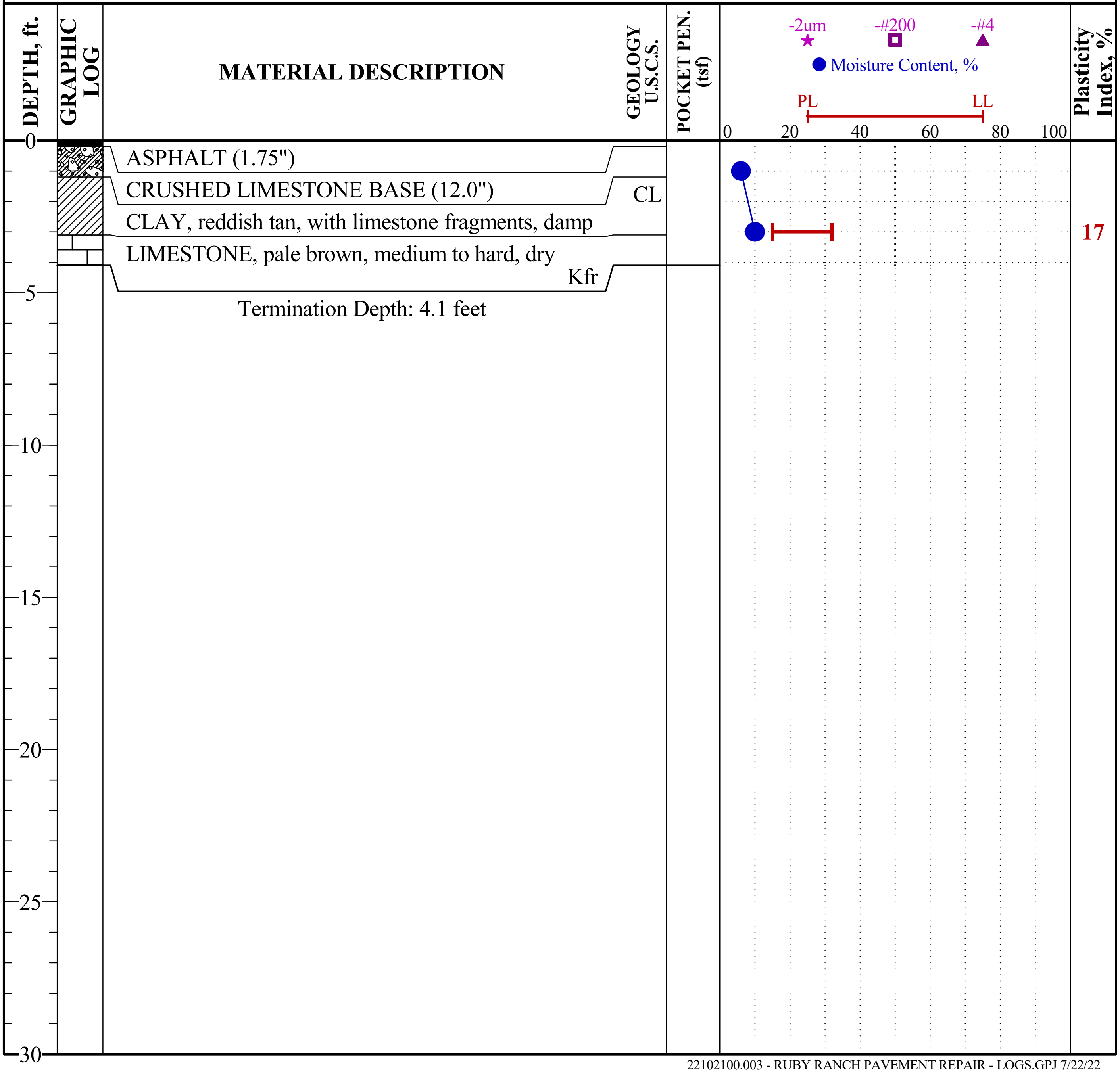
Boring B-1
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 7, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



ASPHALT (1.75")
CRUSHED LIMESTONE BASE (12.0")
CLAY, reddish tan, with limestone fragments, damp
LIMESTONE, pale brown, medium to hard, dry

Termination Depth: 4.1 feet

LOG OF BORING

Boring B-2

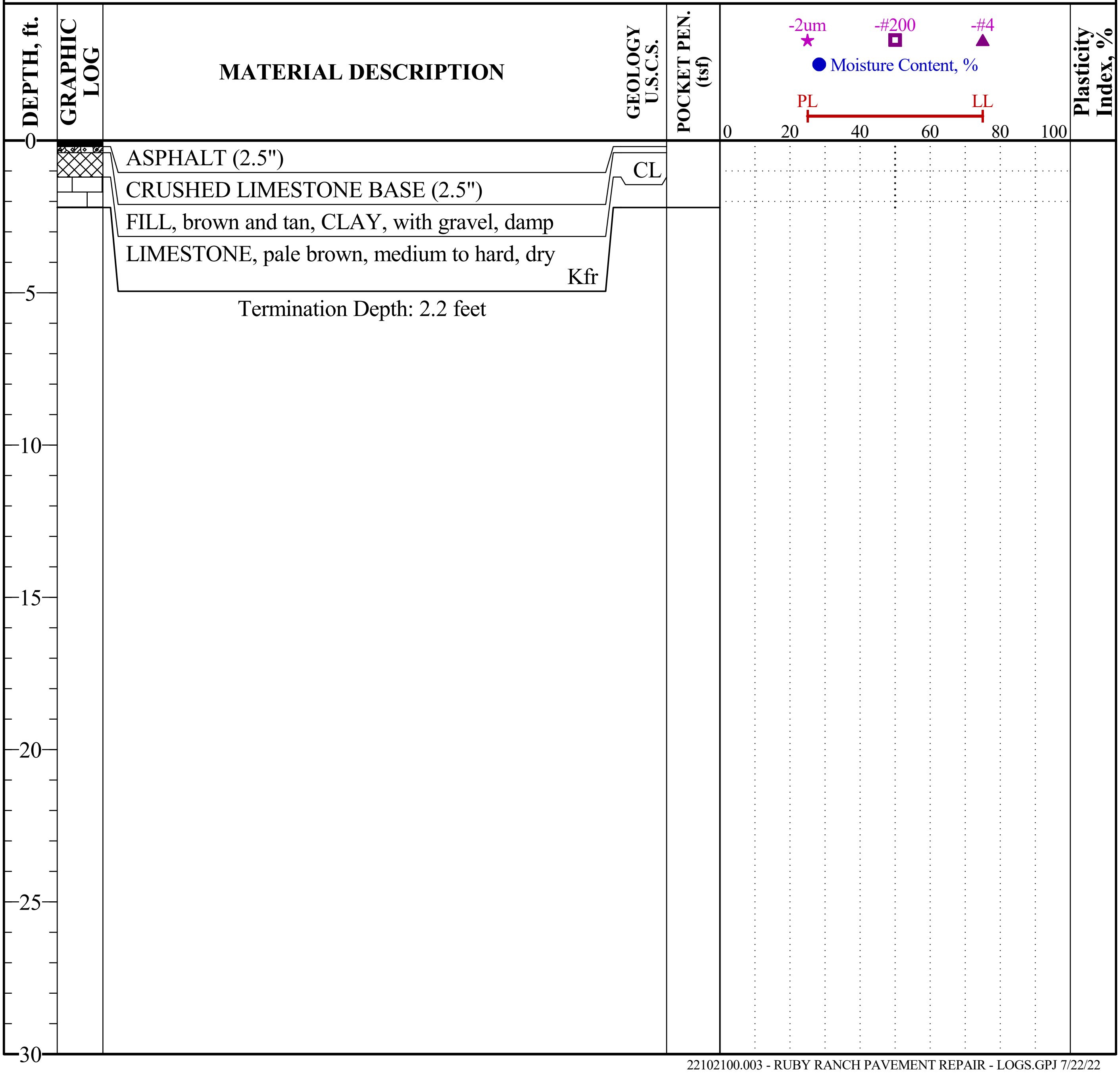
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 7, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



ASPHALT (2.5")

CRUSHED LIMESTONE BASE (2.5")

FILL, brown and tan, CLAY, with gravel, damp — CL

LIMESTONE, pale brown, medium to hard, dry — Kfr

Termination Depth: 2.2 feet

LOG OF BORING

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Boring B-3

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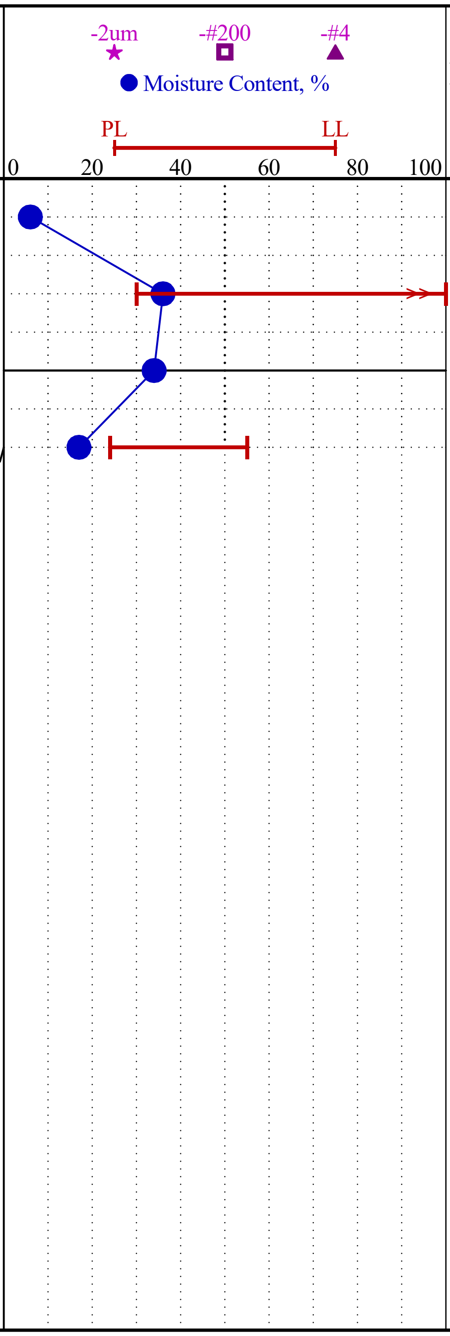
Drill Date: June 7, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:

AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0		ASPHALT (3.0")			
		CRUSHED LIMESTONE BASE (13.0")	CH		
		CLAY, reddish brown, with limestone fragments, damp		2.5	80
5				3.0	
			Kfr	2.5	31
		Termination Depth: 7.0 feet			
10					
15					
20					
25					
30					



LOG OF BORING

Boring B-4

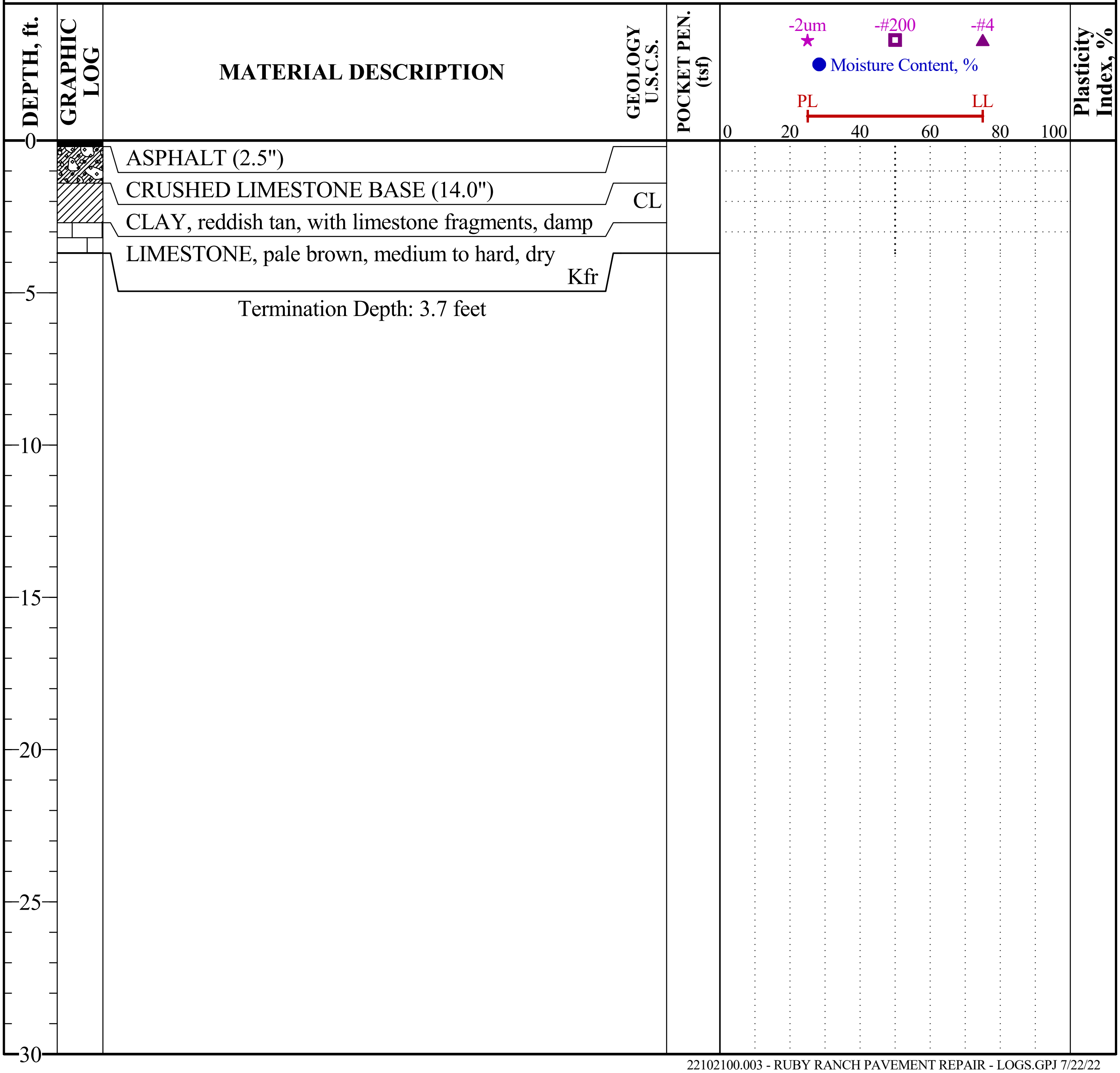
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 7, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



MATERIAL DESCRIPTION

ASPHALT (2.5")

CRUSHED LIMESTONE BASE (14.0")

CLAY, reddish tan, with limestone fragments, damp — CL

LIMESTONE, pale brown, medium to hard, dry — Kfr

Termination Depth: 3.7 feet

LOG OF BORING

Boring B-5
PAGE 1 OF 1

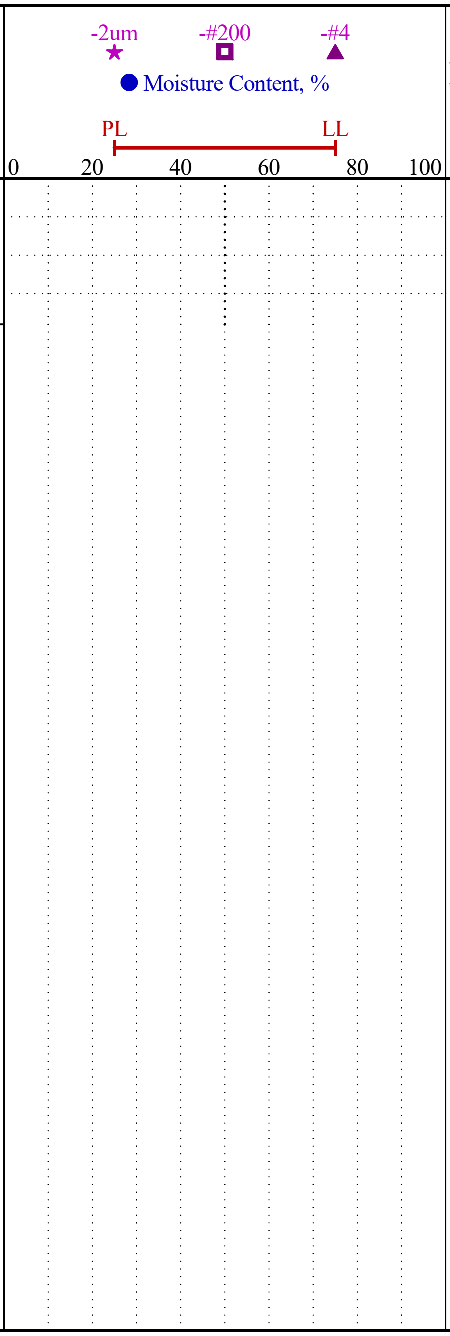
Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 7, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	ASPHALT (1.5")			
	CRUSHED LIMESTONE BASE (10.0")			
	FILL, brown and tan, CLAY, with gravel, damp	CL		
	LIMESTONE, pale brown, medium to hard, dry	Kfr		
5	Termination Depth: 3.8 feet			
10				
15				
20				
25				
30				



22102100.003 - RUBY RANCH PAVEMENT REPAIR - LOGS.GPJ 7/22/22

"put us to the test"

LOG OF BORING

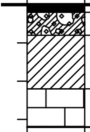
Boring B-6
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 7, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	-2um ★ / -#200 ◻ / -#4 ▲ / ● Moisture Content, % / PL–LL (0 20 40 60 80 100)	Plasticity Index, %
0	ASPHALT (1.75")				
	CRUSHED LIMESTONE BASE (8.0")				
	CLAY, reddish tan, with limestone fragments, damp	CL			
	LIMESTONE, pale brown, medium to hard, dry	Kfr			

Termination Depth: 3.2 feet

Depth scale: 0, 5, 10, 15, 20, 25, 30

22102100.003 - RUBY RANCH PAVEMENT REPAIR - LOGS.GPJ 7/22/22

LOG OF BORING

Boring B-7

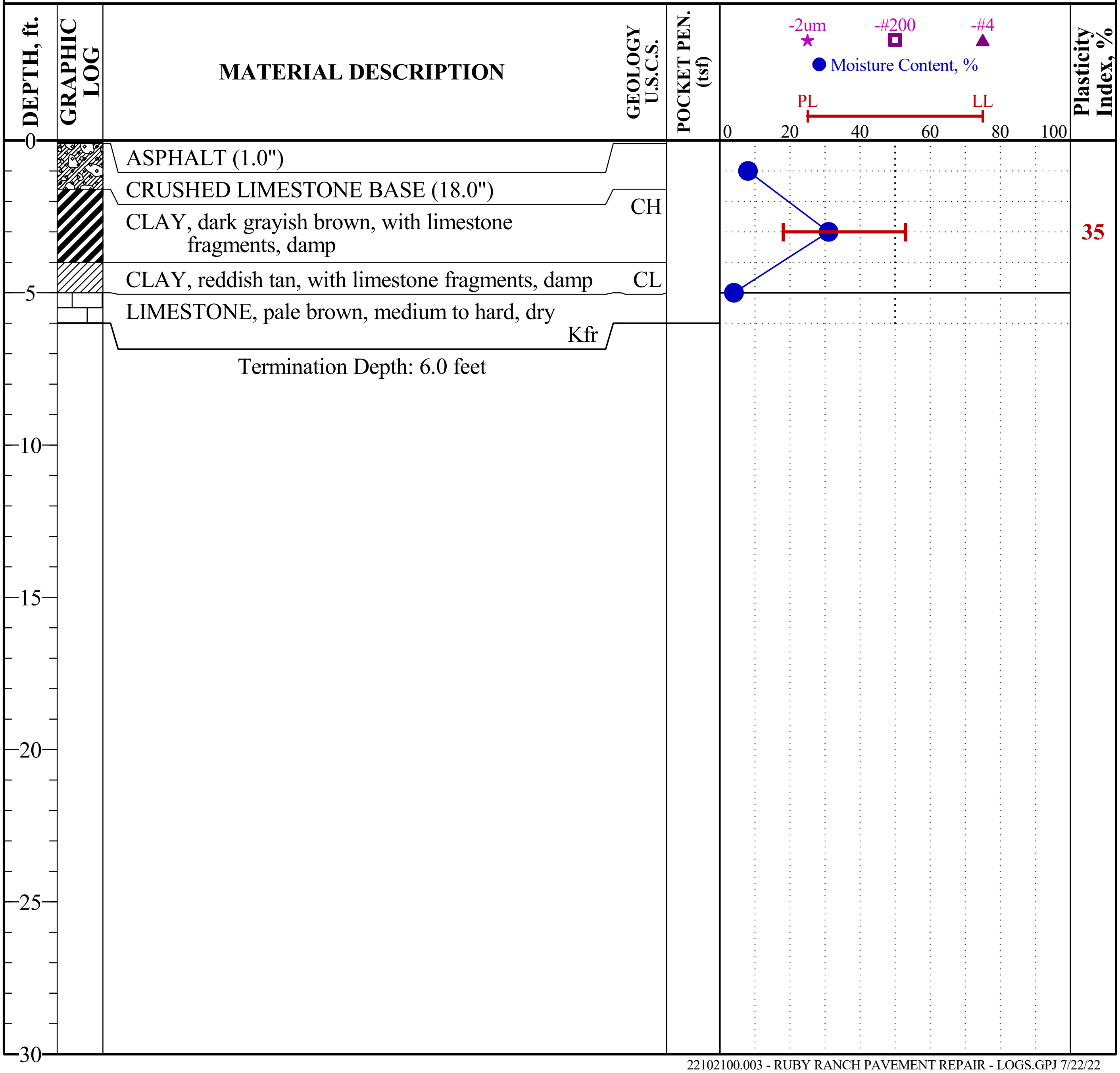
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 7, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	ASPHALT (1.0")			
	CRUSHED LIMESTONE BASE (18.0")			
	CLAY, dark grayish brown, with limestone fragments, damp	CH		35
	CLAY, reddish tan, with limestone fragments, damp	CL		
5	LIMESTONE, pale brown, medium to hard, dry	Kfr		

Termination Depth: 6.0 feet

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LOG OF BORING

Boring B-8
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

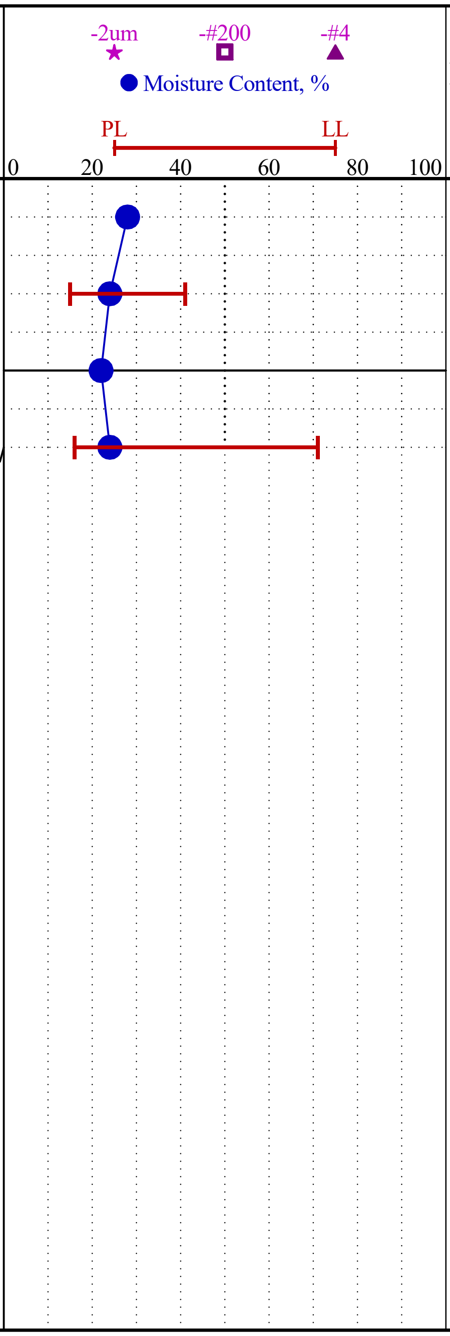
Drill Date: June 7, 2022
Hole Size: 4.5 in.

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0		ASPHALT (1.5")			
		CRUSHED LIMESTONE BASE (8.0")		1.5	
		CLAY, dark grayish brown, with limestone fragments, damp	CL	2.0	26
5		CLAY, dark grayish brown, with limestone fragments, damp	CH	2.0	
			Kfr	2.5	55
		Termination Depth: 7.0 feet			



LOG OF BORING

Boring B-9

PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair

Job Location: Buda, Texas

Engineer's Job #: 22102100.003

Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022

Ground Elevation: n/a

Hole Size: 4.5 in.

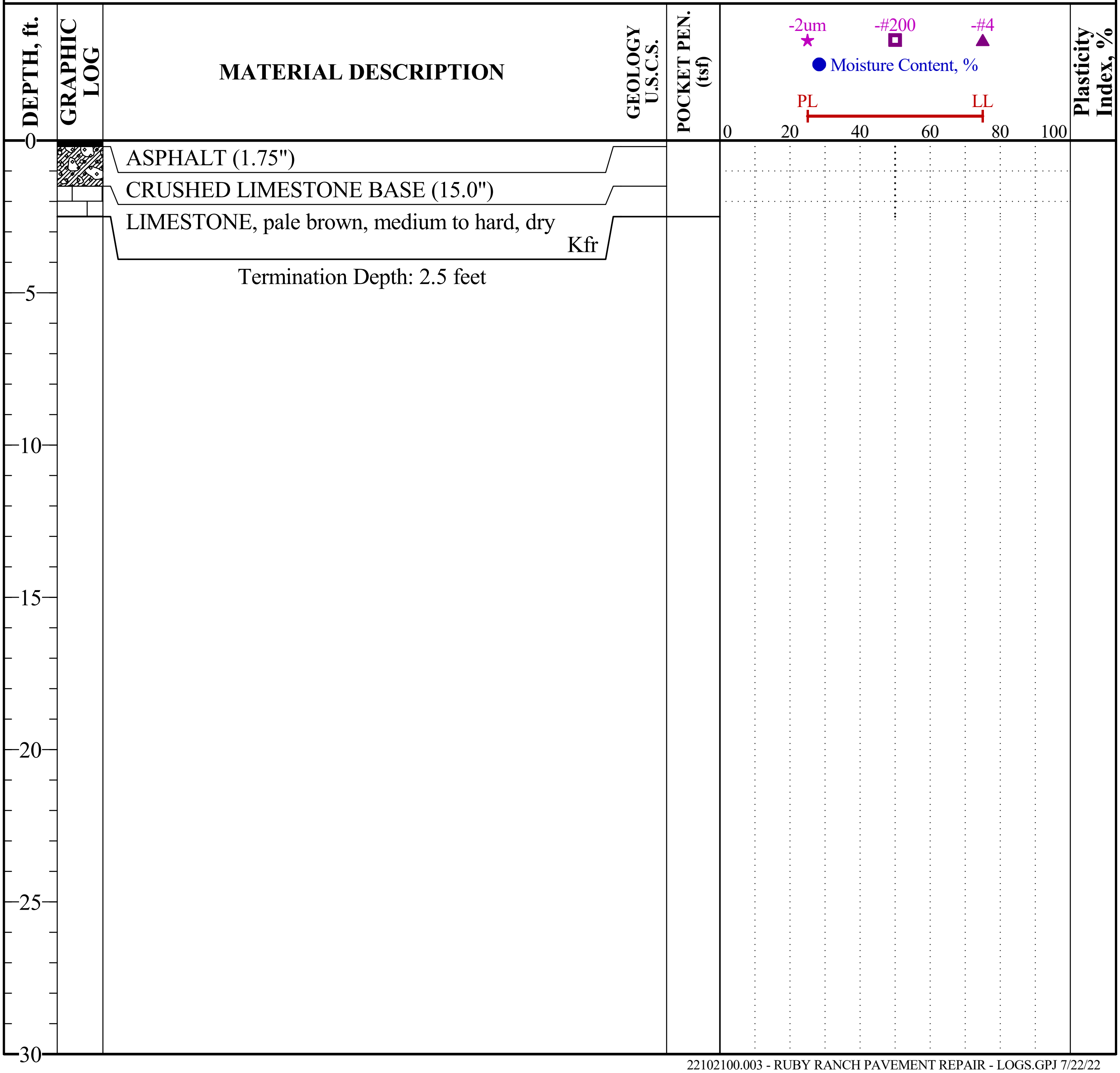
Notes:

Ground Water Levels:

AT TIME OF DRILLING: ---

AT END OF DRILLING: ---

AFTER DRILLING: ---



ASPHALT (1.75")

CRUSHED LIMESTONE BASE (15.0")

LIMESTONE, pale brown, medium to hard, dry — Kfr

Termination Depth: 2.5 feet

LOG OF BORING

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Boring B-10
PAGE 1 OF 1

Drill Date: June 7, 2022
Hole Size: 4.5 in.

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	-2um ★ -#200 ◻ -#4 ▲ ● Moisture Content, % PL LL 0 20 40 60 80 100	Plasticity Index, %
0		ASPHALT (2.25")				
		CRUSHED LIMESTONE BASE (8.0")	CH	4.5		
		CLAY, dark grayish brown, with limestone fragments, damp		4.0		
		LIMESTONE, pale brown, medium to hard, dry	Kfr			
5		Termination Depth: 5.0 feet				
10						
15						
20						
25						
30						

LOG OF BORING

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Boring B-11

PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 7, 2022
Hole Size: 4.5 in.

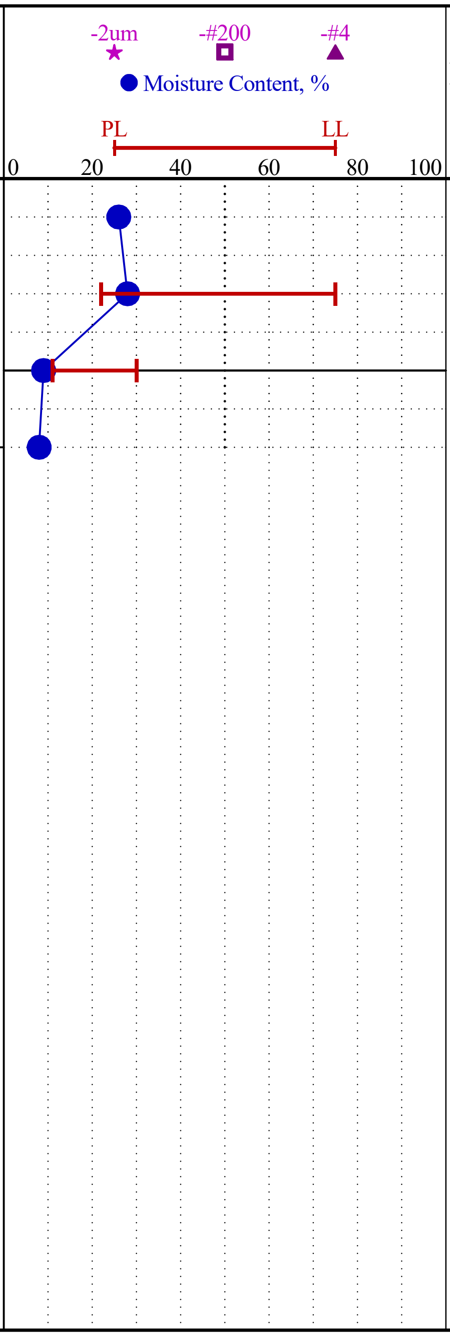
Ground Elevation: n/a

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

Notes:

MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
ASPHALT (1.75")			
CRUSHED LIMESTONE BASE (7.0")		2.5	
CLAY, dark grayish brown, with limestone fragments, damp	CH	3.0	53
CLAY, reddish tan, with limestone fragments, damp	CL		19
LIMESTONE, pale brown, severely weathered, dry			

Termination Depth: 7.0 feet



22102100.003 - RUBY RANCH PAVEMENT REPAIR - LOGS.GPJ 7/22/22

LOG OF BORING

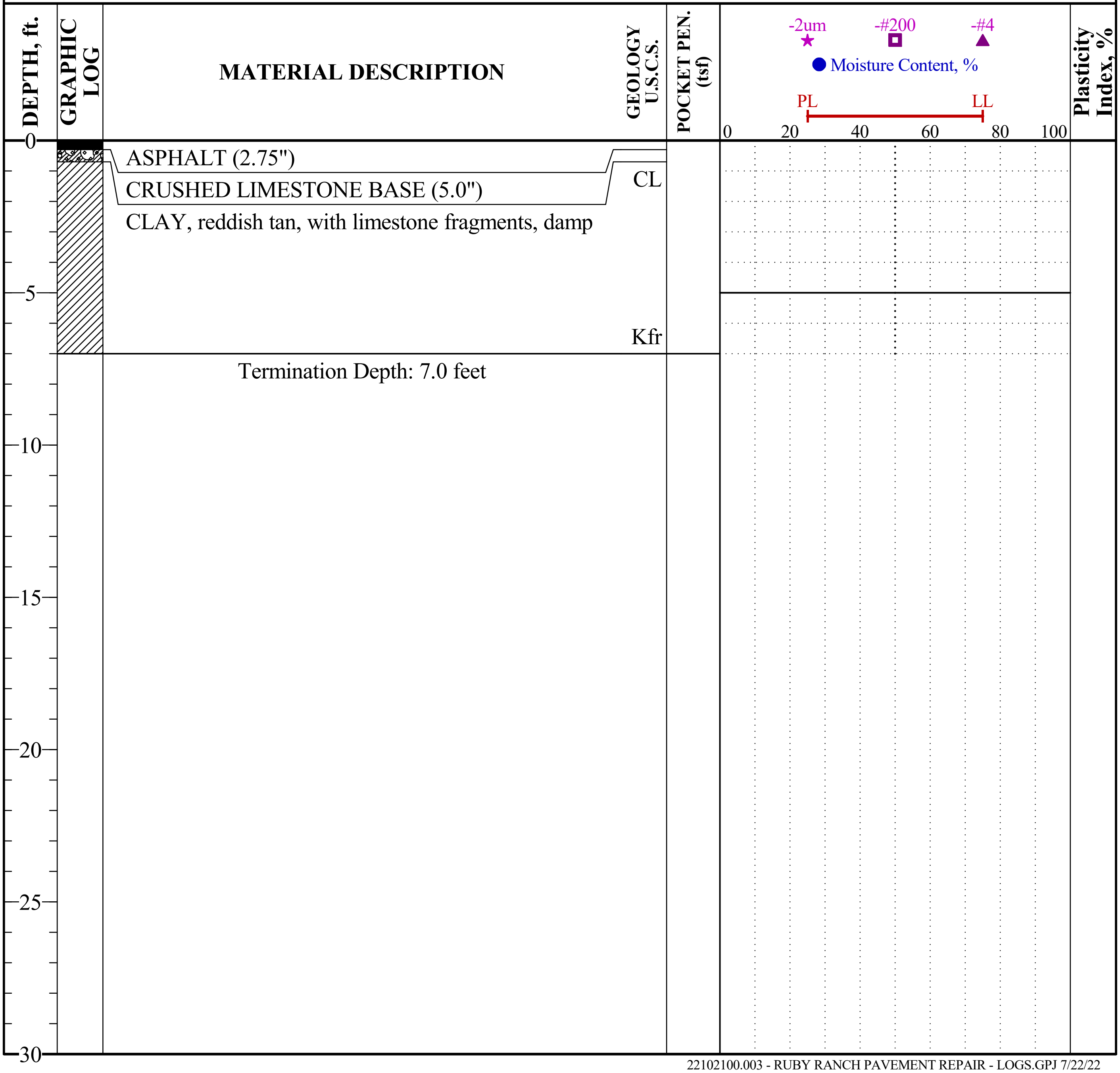
Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Boring B-12
PAGE 1 OF 1

Drill Date: June 7, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



ASPHALT (2.75")

CRUSHED LIMESTONE BASE (5.0")

CLAY, reddish tan, with limestone fragments, damp — CL — Kfr

Termination Depth: 7.0 feet

LOG OF BORING

Boring B-13

PAGE 1 OF 1

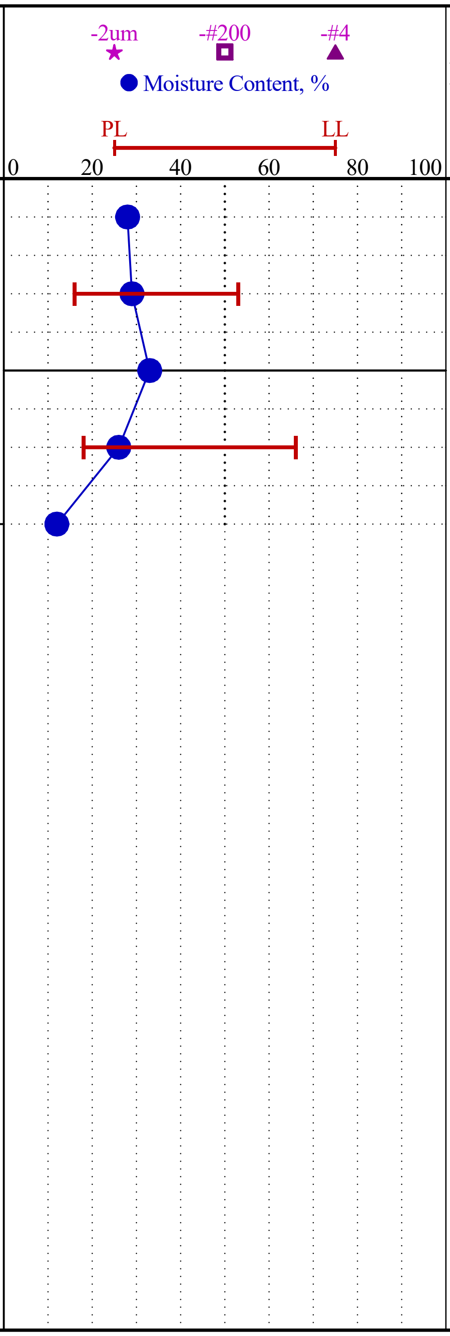
Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0		ASPHALT (3.0")			
		CRUSHED LIMESTONE BASE (4.0")	CH	1.5	
		CLAY, dark grayish brown, with limestone fragments, damp		1.0	37
5				1.5	
				1.5	48
			Kfr		
		Termination Depth: 9.0 feet			
10					
15					
20					
25					
30					



LOG OF BORING

Boring B-14

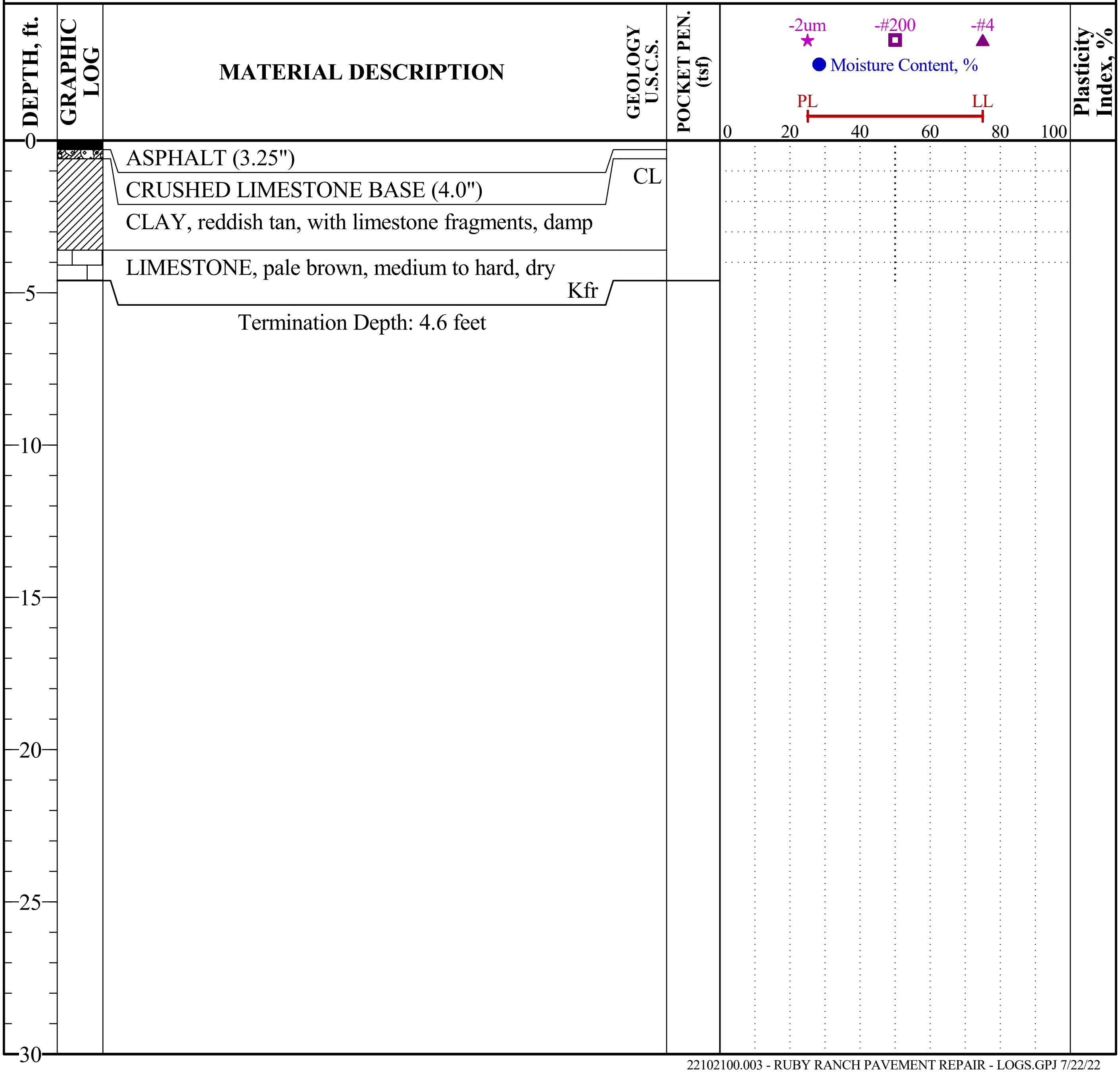
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



ASPHALT (3.25")

CRUSHED LIMESTONE BASE (4.0")

CLAY, reddish tan, with limestone fragments, damp

LIMESTONE, pale brown, medium to hard, dry

Termination Depth: 4.6 feet

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LOG OF BORING

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Boring B-15

PAGE 1 OF 1

Drill Date: June 8, 2022

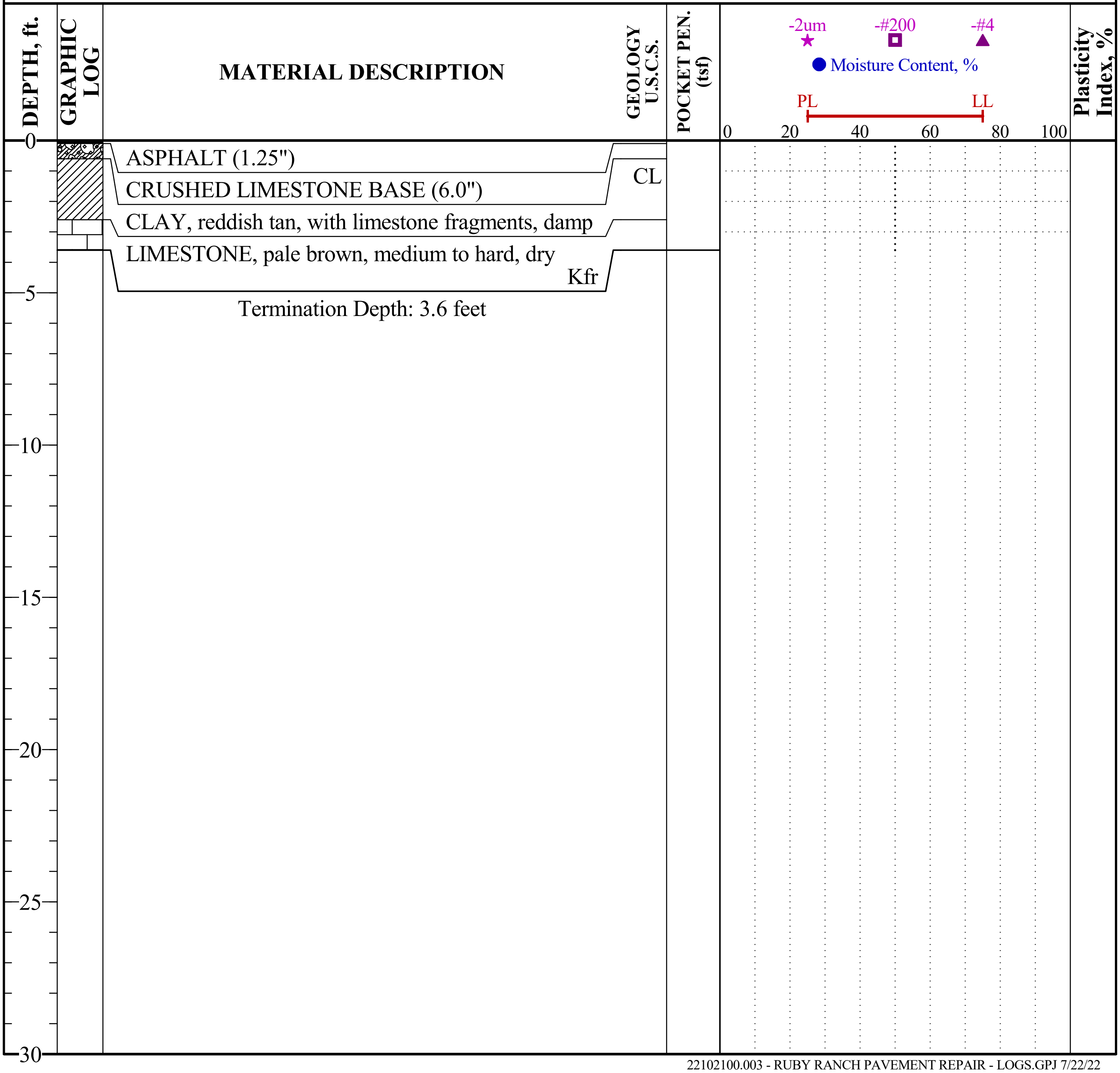
Hole Size: 4.5 in.

Ground Elevation: n/a

Ground Water Levels:

AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

Notes:



ASPHALT (1.25")		
CRUSHED LIMESTONE BASE (6.0")		
CLAY, reddish tan, with limestone fragments, damp		CL
LIMESTONE, pale brown, medium to hard, dry	Kfr	

Termination Depth: 3.6 feet

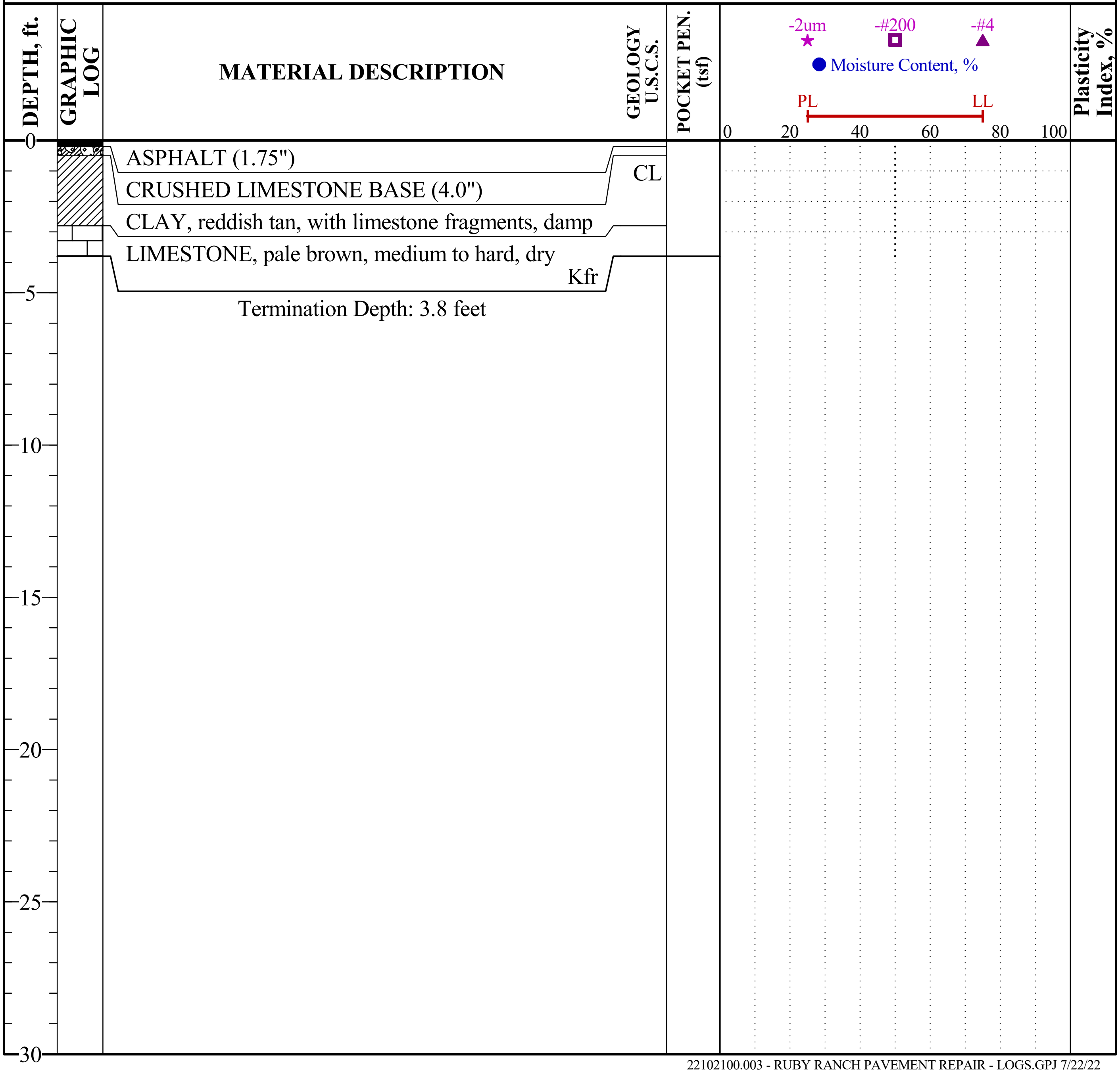
LOG OF BORING

Boring B-16
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.
Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)
0	ASPHALT (1.75")		
	CRUSHED LIMESTONE BASE (4.0")	CL	
	CLAY, reddish tan, with limestone fragments, damp		
	LIMESTONE, pale brown, medium to hard, dry	Kfr	

Termination Depth: 3.8 feet

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LOG OF BORING

Boring B-17

PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Hole Size: 4.5 in.

Ground Elevation: n/a

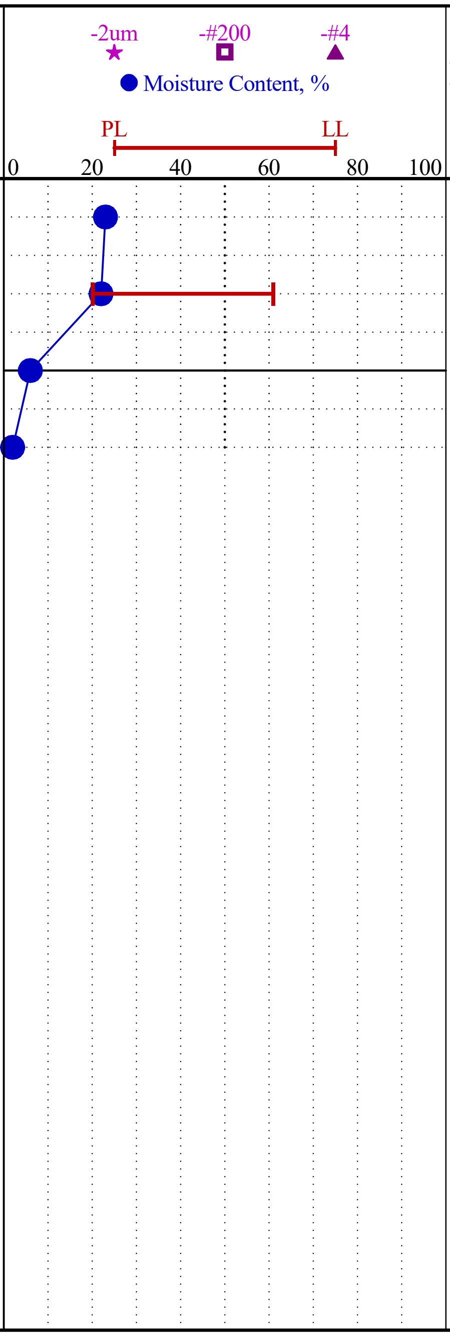
Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

Notes:

MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
ASPHALT (2.0")			
CRUSHED LIMESTONE BASE (7.0")	CH	3.5	
CLAY, dark grayish brown, with limestone fragments, damp		3.5	41
LIMESTONE, pale brown, severely weathered, dry	Kfr		

Termination Depth: 7.0 feet

DEPTH, ft.: 0, 5, 10, 15, 20, 25, 30



LOG OF BORING

Boring B-18
PAGE 1 OF 1

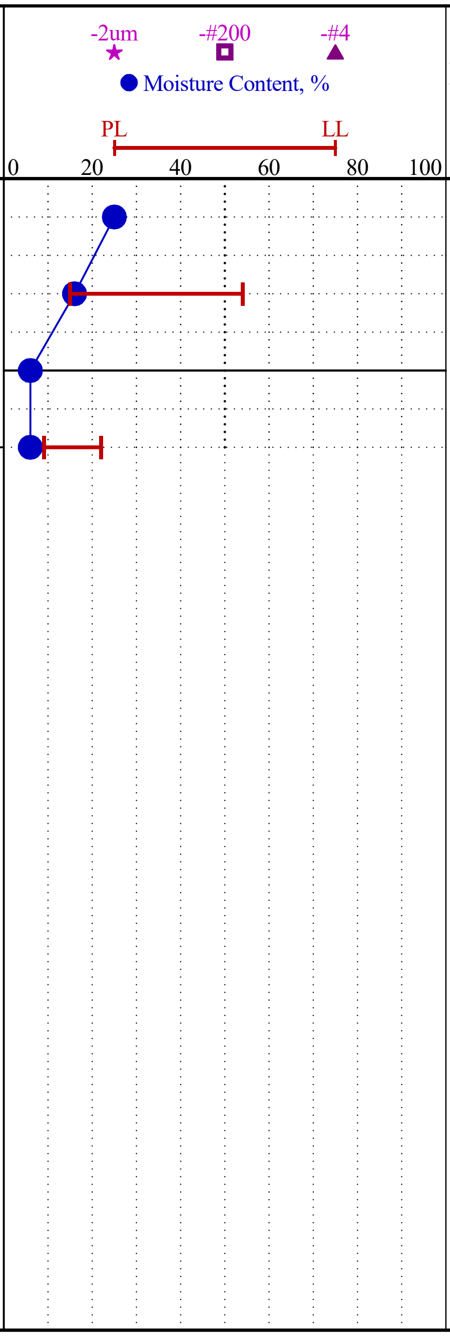
Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0		ASPHALT (3.0")			
		CRUSHED LIMESTONE BASE (7.0")			
		CLAY, dark grayish brown, with limestone fragments, damp	CH	3.0 0.5	39
5		CLAY, reddish tan, with limestone fragments, damp	CL Kfr		13
		Termination Depth: 7.0 feet			



LOG OF BORING

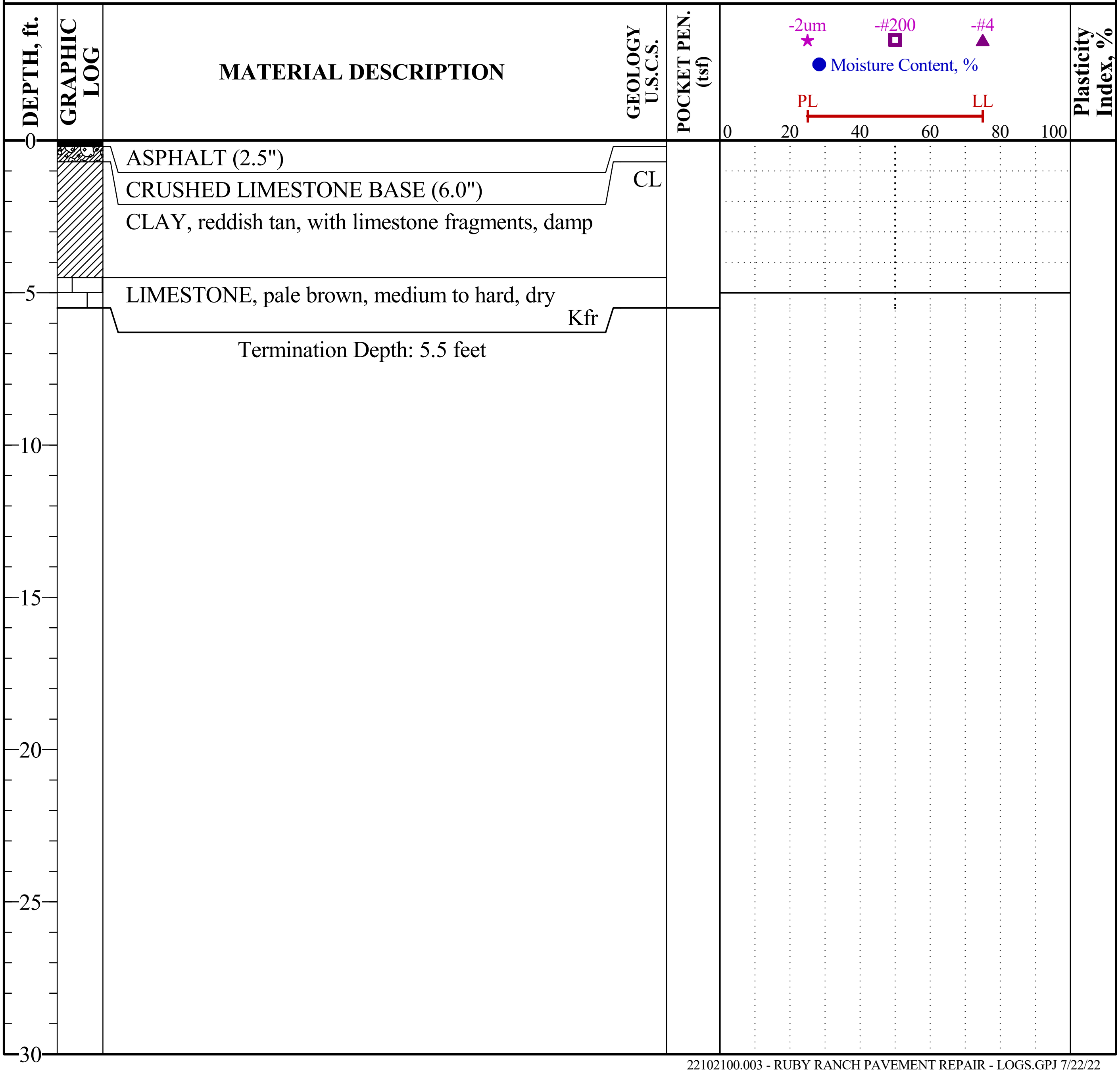
Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Boring B-19
PAGE 1 OF 1

Drill Date: June 8, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.
0	ASPHALT (2.5")	
	CRUSHED LIMESTONE BASE (6.0")	
	CLAY, reddish tan, with limestone fragments, damp	CL
	LIMESTONE, pale brown, medium to hard, dry	Kfr

Termination Depth: 5.5 feet

LOG OF BORING

Boring B-20

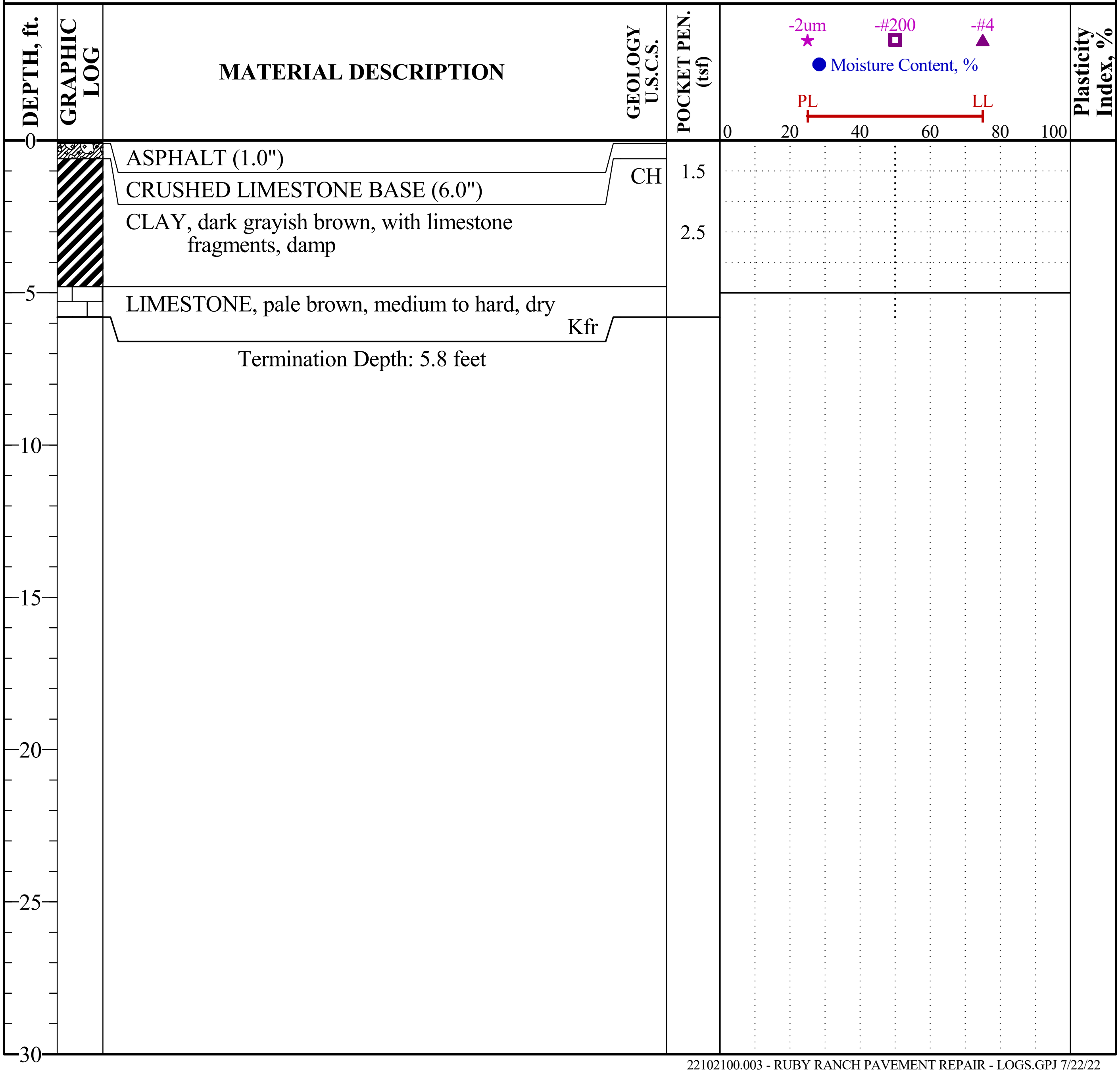
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)
0	ASPHALT (1.0")		
	CRUSHED LIMESTONE BASE (6.0")	CH	1.5
	CLAY, dark grayish brown, with limestone fragments, damp		2.5
5	LIMESTONE, pale brown, medium to hard, dry	Kfr	
	Termination Depth: 5.8 feet		

LOG OF BORING

Boring B-21

PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

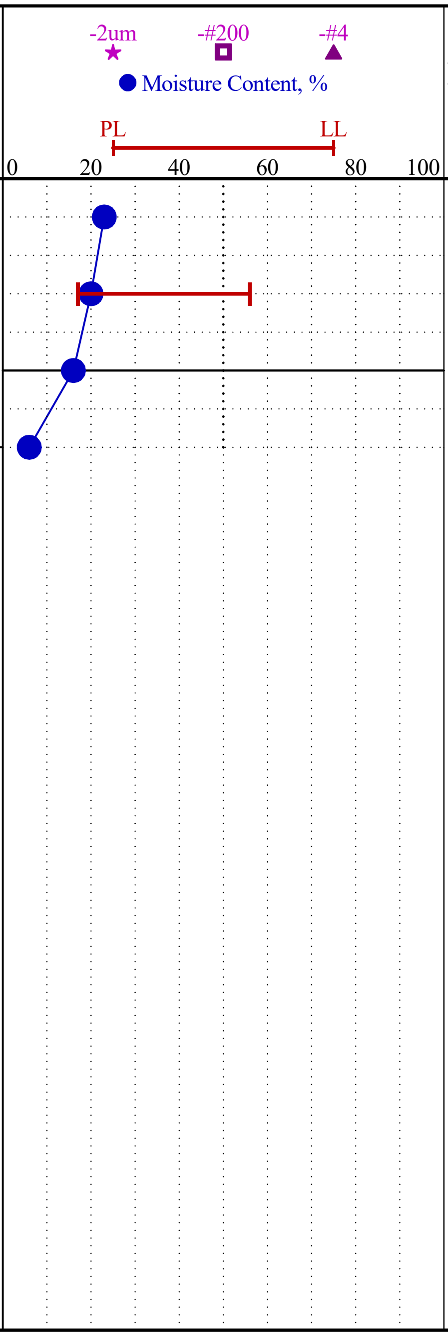
Drill Date: June 8, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	ASPHALT (1.25")			
	CRUSHED LIMESTONE BASE (6.0")	CH	1.0	
	CLAY, dark grayish brown, with limestone fragments, damp		1.0	39
5			1.5	
	LIMESTONE, pale brown, medium to hard, dry	Kfr		

Termination Depth: 7.0 feet



Depth scale: 0, 5, 10, 15, 20, 25, 30

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LOG OF BORING

Boring B-22

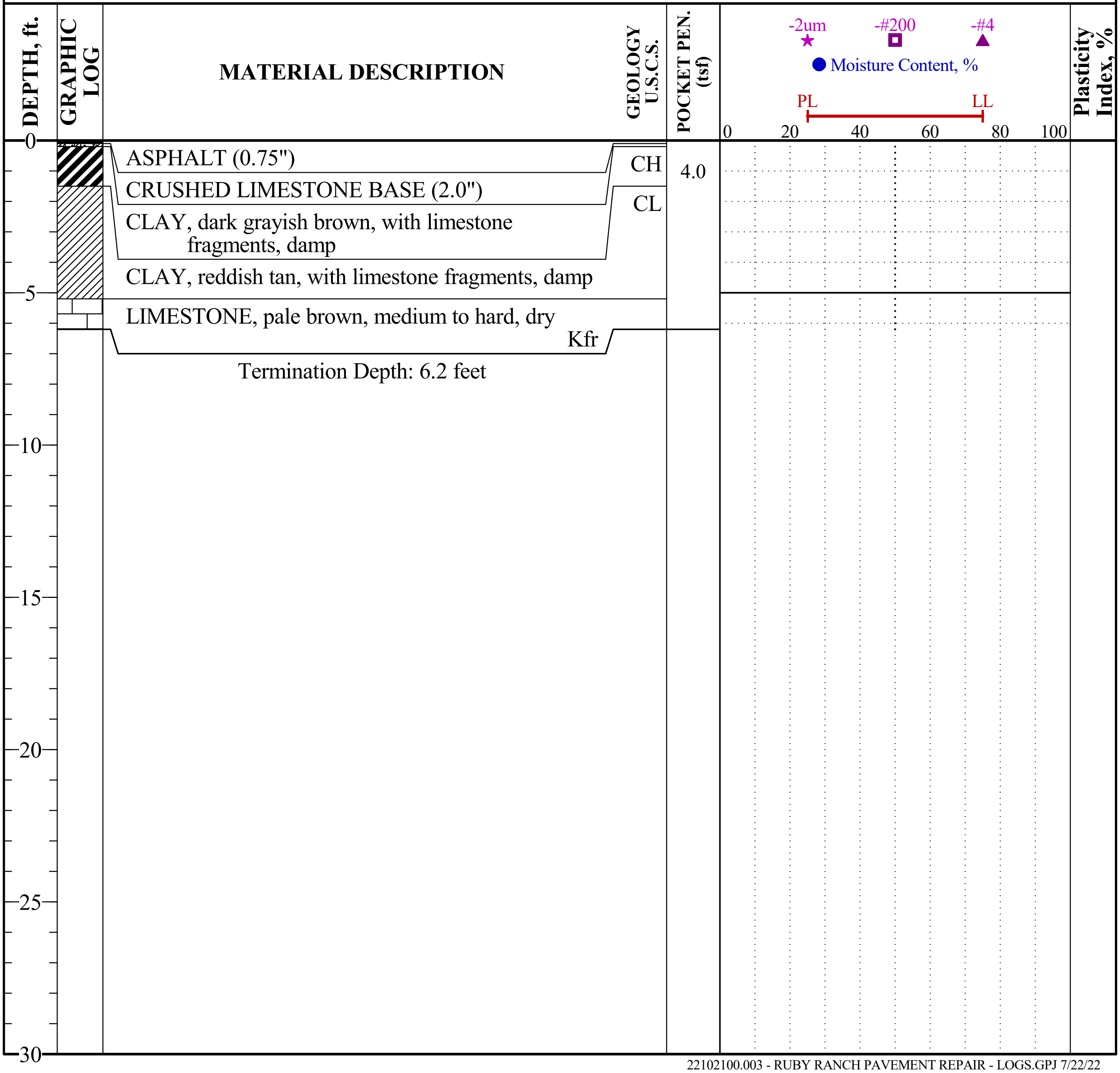
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



ASPHALT (0.75")

CRUSHED LIMESTONE BASE (2.0")

CLAY, dark grayish brown, with limestone fragments, damp

CLAY, reddish tan, with limestone fragments, damp

LIMESTONE, pale brown, medium to hard, dry

Termination Depth: 6.2 feet

LOG OF BORING

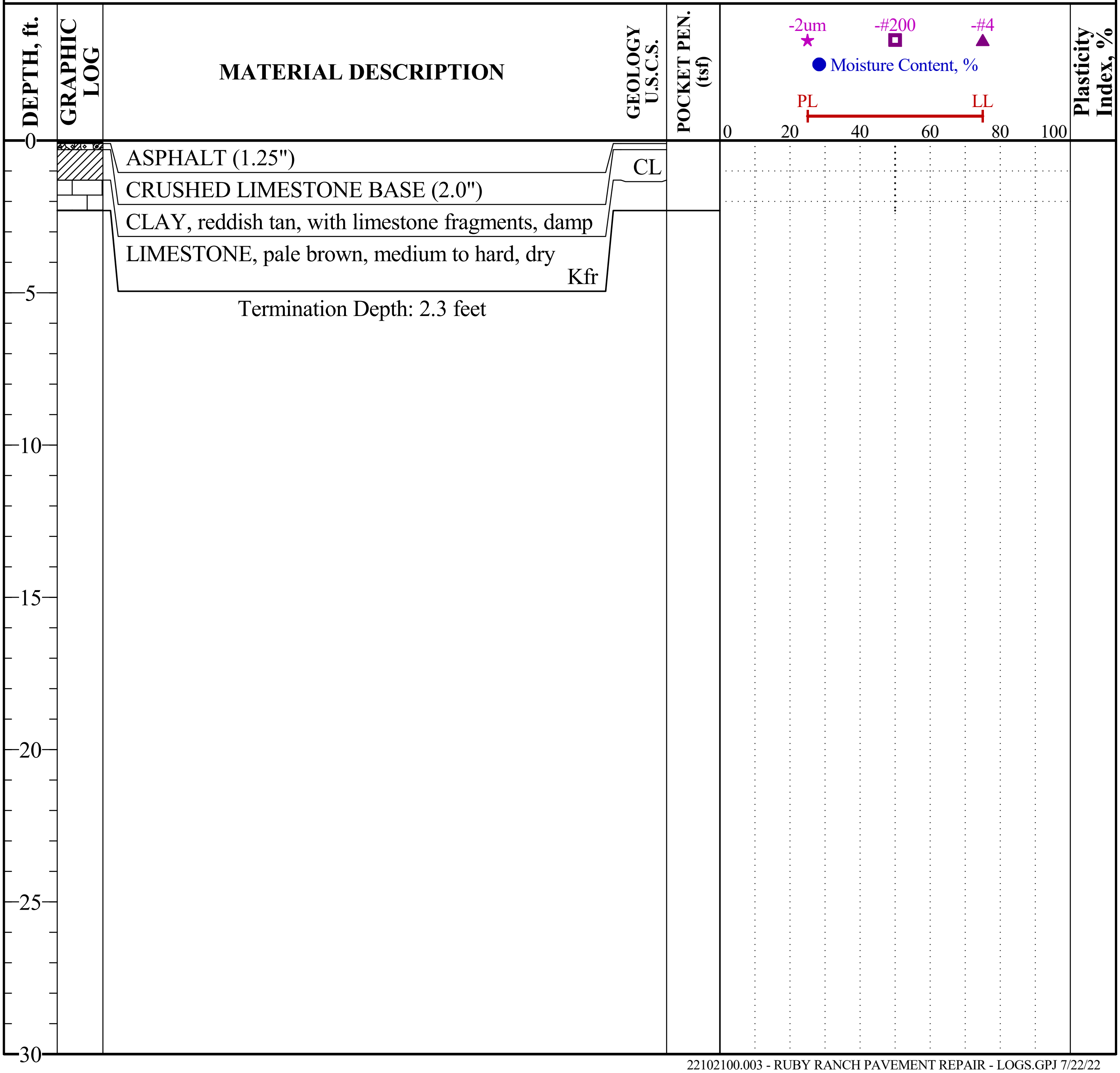
Boring B-23
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.
ASPHALT (1.25")	
CRUSHED LIMESTONE BASE (2.0")	
CLAY, reddish tan, with limestone fragments, damp	CL
LIMESTONE, pale brown, medium to hard, dry	Kfr

Termination Depth: 2.3 feet

22102100.003 - RUBY RANCH PAVEMENT REPAIR - LOGS.GPJ 7/22/22

LOG OF BORING

Boring B-24

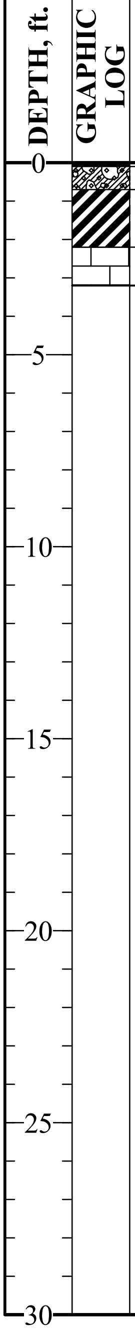
PAGE 1 OF 1

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Drill Date: June 8, 2022
Hole Size: 4.5 in.
Ground Elevation: n/a

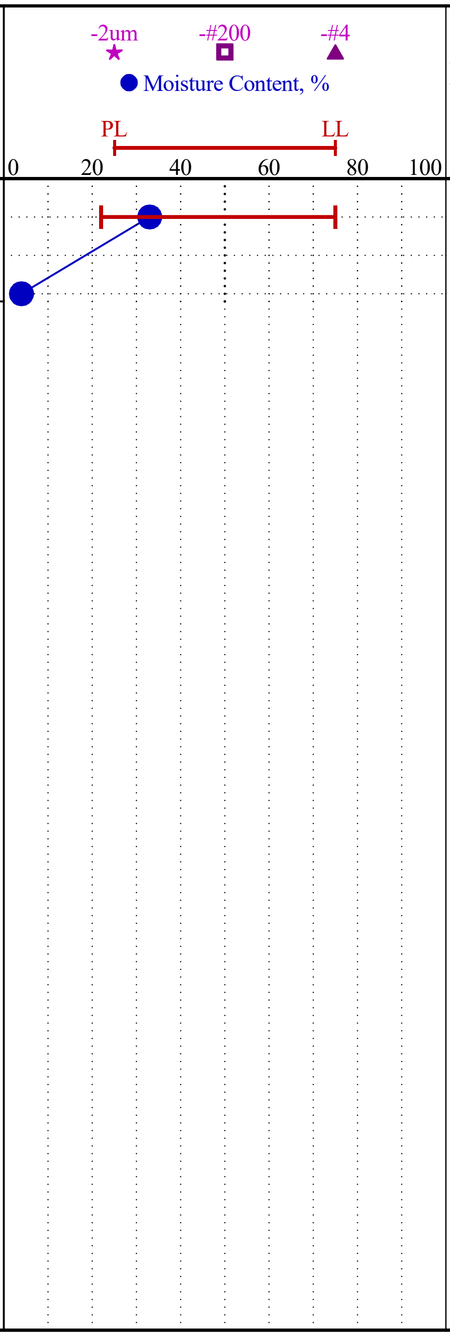
Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
ASPHALT (1.0")			
CRUSHED LIMESTONE BASE (7.0")	CH	3.5	53
CLAY, dark grayish brown, with limestone fragments, damp			
LIMESTONE, pale brown, medium to hard, dry	Kfr		

Termination Depth: 3.2 feet



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LOG OF BORING

Job Name: Ruby Ranch Pavement Repair
Job Location: Buda, Texas
Engineer's Job #: 22102100.003
Client: Ruby Ranch Homeowners Association

Boring B-25
PAGE 1 OF 1

Drill Date: June 8, 2022
Hole Size: 4.5 in.

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	-2um ★ -#200 ◻ -#4 ▲ ● Moisture Content, % PL LL 0 20 40 60 80 100	Plasticity Index, %
0		ASPHALT (3.5")				
		CRUSHED LIMESTONE BASE (2.0")				
		CLAY, dark grayish brown, with limestone fragments, damp	CH			
5		LIMESTONE, pale brown, medium to hard, dry	Kfr			
		Termination Depth: 1.8 feet				
10						
15						
20						
25						
30						

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	●	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			○	GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	○	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	⁘	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			⁘	SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	⁘	SM	SILTY SANDS, SAND - SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▤	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	CLAYS	LIQUID LIMIT GREATER THAN 50	▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY
SOILS OF MODERATE PLASTICITY			▧	CL-CH	LOW PI CLAYS WITH APPRECIABLE HIGH PI MOTTLING, CLAY WITH BORDERLINE CLASSIFICATION
OTHER MATERIALS			▩	FILL	MATERIAL NOT NATURALLY DEPOSITED
			▦	LS	WEATHERED LIMESTONE INTACT LIMESTONE

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Key to Terms and Abbreviations

Descriptive Terms Characterizing Soils and Rock	Standard Description Abbreviations and Terms	Symbols and Abbreviations for Test Data
Argillaceous – having appreciable amounts of clay in the soil or rock mass. Used most often in describing limestones, occasionally sandstones. **Calcareous** – containing appreciable quantities of calcium carbonate. Can be either nodular or "powder." **Crumbly** – cohesive soils which break into small blocks or crumbs on drying. **Evaporite** – deposits of salts and other soluble compounds. Most commonly calcium carbonate or gypsum. May be in either "powder" or visible crystal form. **Ferruginous** – having deposits of iron or nodules, typically oxidized and dark red in color. **Ferrous –** see Ferruginous **Fissured** – containing shrinkage cracks frequently filled with fine sand or silt, usually more or less vertical. **Fossiliferous –** containing appreciable quantities of fossils, fossil fragments, or traces of fossils **Laminated** – composed of thin layers of varying color or texture. Layers are typically distinct and varying in composition from sand to silt and clay. **Mottled** – characterized as having multiple colors organized in a marbled pattern. **Slickensided** – having inclined planes of weakness that are slick and glossy in appearance. **Varved** – see Laminated.	brn = brown dk = dark lt = light wx = weathered calc = calcareous sw = severely weathered cw = completely weathered n/a = not available b. = below **Engineering Units** pcf = pounds per cubic foot psf = pounds per square foot tsf = tons per square foot pF = picofarad psi = pounds per square inch kips = thousand pounds (force) ksf = kips per square foot	LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index (LL-PL) NP = non-plastic γ_d = dry unit weight q_u = unconfined compressive strength q_c = confined compressive strength SPT = standard penetration test TCP = Texas cone penetration test (Texas Highway Department) N or N_{SPT} = blows per foot from SPT N_{TCP} = blows per foot from TCP SCR = standard core recovery RQD = rock quality designation RQI = see RQD

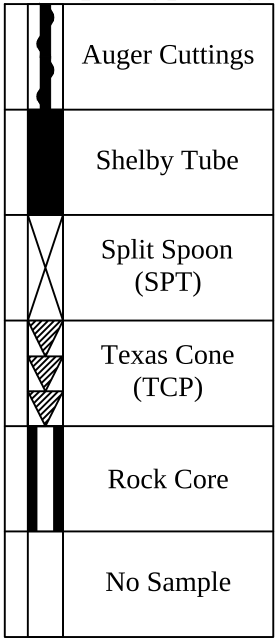
Terms Describing Consistency of Soil and Rock

COARSE GRAINED MATERIAL		SEDIMENTARY ROCK	
DESCRIPTIVE TERM	BLOWS/FT (SPT)	DESCRIPTIVE TERM	STRENGTH, TSF
very loose	0 – 4	soft	4 – 8
loose	4 – 10	medium	8 – 15
firm (medium)	10 – 30	hard	15 – 50
dense	30 – 50	very hard	over 50
very dense	over 50		

Describing Consistency of Fine Grained Soil

DESCRIPTIVE TERM	BLOWS/FT (SPT)	UNCONFINED COMPRESSION, TSF
very soft	< 2	< 0.25
soft	2 – 4	0.25 – 0.50
medium stiff	4 – 8	0.50 – 1.00
stiff	8 – 15	1.00 – 2.00
very stiff	15 – 30	2.00 – 4.00
hard	over 30	over 4.00

Sample Type Key



Revised: October 2018

APPENDIX B

STANDARD FIELD AND LABORATORY PROCEDURES

STANDARD FIELD AND LABORATORY PROCEDURES

STANDARD FIELD PROCEDURES

Drilling and Sampling

Borings and test pits are typically staked in the field by the drillers, using simple taping or pacing procedures and locations are assumed to be accurate to within several feet. Unless noted otherwise, ground surface elevations (GSE) when shown on logs are estimated from topographic maps and are assumed to be accurate to within a foot. A Plan of Borings or Plan of Test Pits showing the boring locations and the proposed structures is provided in the Appendix.

A log of each boring or pit is prepared as drilling and sampling progressed. In the laboratory, the driller's classification and description is reviewed by a Geotechnical Engineer. Individual logs of each boring or pit are provided in the Appendix. Descriptive terms and symbols used on the logs are in accordance with the Unified Soil Classification System (ASTM D-2487). A reference key is also provided. The stratification of the subsurface material represents the soil conditions at the actual boring locations, and variations may occur between borings. Lines of demarcation represent the approximate boundary between the different material types, but the transition may be gradual.

A truck-mounted rotary drill rig utilizing rotary wash drilling or continuous flight hollow or solid stem auger procedures is used to advance the borings, unless otherwise noted. A backhoe provided by others is used to place test pits. Test pits are advanced to the required depth, refusal (typically bedrock) or to the limits of the equipment. Samples of soil are obtained from the borings or test pit spoils for subsequent laboratory study. Samples are sealed in plastic bags and marked as to depth and boring/pit locations in the field. Cores are wrapped in a polyethylene wrap to preserve field moisture conditions, placed in core boxes and marked as to depth and core runs. Unless notified to the contrary, samples and cores will be stored for 90 days, then discarded.

Standard Penetration Test and Split-Barrel Sampling of Soils (ASTM D-1586) (SPT)

This sampling method consists of driving a 2 inch outside diameter split barrel sampler using a 140 pound hammer freely falling through a distance of 30 inches. The sampler is first seated 6 inches into the material to be sampled and then driven an additional 12 inches. The number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance. The results of the SPT is recorded on the boring logs as "N" values.

Thin-Walled Tube Sampling of Soils (ASTM D-1587) (Shelby Tube Sampling)

This method consists of pushing thin walled steel tubes, usually 3 inches in diameter, into the soils to be sampled using hydraulic pressure or other means. Cohesive soils are usually sampled in this manner and relatively undisturbed samples are recovered.

Soil Investigation and Sampling by Auger Borings (ASTM D-1452)

This method consists of auguring a hole and removing representative soil samples from the auger flight or bit at intervals or with each change in the substrata. Disturbed samples are obtained and this method is, therefore, limited to situations where it is satisfactory to determine the approximate subsurface profile and obtain samples suitable for Index Property testing.

Diamond Core Drilling for Site Investigation (ASTM D-2113)

This method consists of advancing a hole into hard strata by rotating a single or double tube core barrel equipped with a cutting bit. Diamond, tungsten carbide, or other cutting agents may be used for the bit. Wash water or air is used to remove the cuttings and to cool the bit. Normally, a 3 inch outside diameter by 2-1/8 inch inside diameter coring bit is used unless otherwise noted. The rock or hard material recovered within the core barrel is examined in the field and in the laboratory and the cores are stored in partitioned boxes. The intactness of all rock core specimens is evaluated in two ways. The first method is the Standard Core Recovery (SCR) expressed as the length of the total core recovered divided by the length of the core run, expressed as a percentage:

$$\text{SCR} = \frac{\text{total core length recovered}}{\text{length of core run}} \times 100\%$$

This value is exhibited on the boring logs as the Standard Core Recovery (SCR).

The second procedure for evaluating the intactness of the rock cores is by Rock Quality Designation (RQD). The RQD provides an additional qualitative measure of soundness of the rock. This index is determined by measuring the intact recovered core unit which exceed four inches in length divided by the total length of the core run:

$$\text{RQD} = \frac{\text{all core lengths greater than 4''}}{\text{length of core run}} \times 100\%$$

The RQD is also expressed as a percentage and is shown on the boring logs.

Vane Shear Tests

In-situ vane shear tests may be used to determine the shear strength of soft to medium cohesive soil. This test consists of placing a four-bladed vane in the undisturbed soil and determining the torsional force applied at the ground surface required to cause the cylindrical perimeter surface of the vane to be sheared. The torsional force sufficient to cause shearing is converted to a unit of shearing resistance or cohesion of the soil surrounding the cylindrical surface.

THD Cone Penetrometer Test

The THD Cone Penetrometer Test is a standard field test to determine the relative density or consistency and load carrying capacity of foundation soils. This test is performed in much the same manner as the Standard Penetration Test described above. In this test, a 3 inch diameter penetrometer cone is used in place of a split-spoon sampler. This test calls for a 170-pound weight falling 24 inches. The actual test in hard materials consists of driving the penetrometer cone and accurately recording the inches of penetration for the first and second 50 blows for a total of 100 blows. These results are then correlated using a table of load capacity vs. number of inches penetrated per 100 blows.

Pocket Penetrometer Test

A pocket penetrometer or hand penetrometer is a small device used to estimate the shear capacity or unconfined compressive strength of a soil sample. The device consists of a spring-loaded probe which measures the pressure required to penetrate the probe into a soil sample for specified depth. This test can only be performed on cohesive soil samples. This pressure is reported in tons per square foot (tsf) on the Logs of Boring. A hyphen (-) indicates that the soil sample was too loose or too soft to perform the test. This test is considered rudimentary and too inaccurate to be used for direct design parameters; however, this test is useful for correlations among soil strata and general stiffness descriptions.

Ground Water Observation

Ground moisture observations are made during the operations and are reported on the logs of boring or pit. Moisture condition of cuttings are noted, however, the use of water for circulation precludes direct observation of wet conditions. Water levels after completing the borings or pits are noted. Seasonal variations, temperatures and recent rainfall conditions may influence the levels of the ground water table and water may be present in excavations, even though not indicated on the logs.

STANDARD LABORATORY PROCEDURES

To adequately characterize the subsurface material at this site, some or all of the following laboratory tests are performed. The results of the actual tests performed are shown graphically on the Logs of Boring or Pit.

Moisture Content - ASTM D-2216

Natural moisture contents of the samples (based on dry weight of soil) are determined for selected samples at depths shown on the respective boring logs. These moisture contents are useful in delineating the depth of the zone of moisture change and as a gauge of correlation between the various index properties and the engineering properties of the soil. For example, the relationship between the plasticity index and moisture content is a source of information for the correlation of shear strength data.

Dry Density - ASTM D-7263

The dry density, γ_d, (bulk density or unit weight) of the samples is determined for selected samples at depths shown on the respective boring logs using Method B of the aforementioned ASTM standard. The in-situ density was determined from undisturbed SPT samples and the dry density was calculated using moisture content results. These dry density values are useful for calculating other characteristic values such as porosity, void ratio, and mass composition of soil. Additionally, these values can also be used to assess the degree of compaction or consolidation of fill materials.

Atterberg Limits - ASTM D-4318

The Atterberg Limits are the moisture contents at the time the soil meets certain arbitrarily defined tests. At the moisture content defined as the plastic limit, Pw, the soil is assumed to change from a semi-solid state to a plastic state. By the addition of more moisture, the soil may be brought up to the moisture content defined as the liquid limit, Lw, or that point where the soil changes from a plastic state to a liquid state. A soil existing at a moisture content between these two previously described states is said to be in a plastic state. The difference between the liquid limit, Lw, and the plastic limit, Pw, is termed the plasticity index, Iw. As the plasticity index increases, the ability of a soil to attract water and remain in a plastic state increases. The Atterberg Limits that were determined are plotted on the appropriate log.

The Atterberg Limits are quite useful in soil exploration as an indexing parameter. Using the Atterberg Limits and grain size analysis, A. Casagrande developed the Unified Soils Classification System (USCS) which is widely used in the geotechnical engineering field. This system related the liquid limit to the plasticity index by dividing a classification chart into various zones according to degrees of plasticity of clays and silts. Although the Atterberg Limits are an indexing parameter, K. Terzaghi has related these limits to various engineering properties of a soil. Some of these relationships are as follows:

1. As the grain size of the soil decreases, the Atterberg Limits increase.
2. As the percent clay in the soil increases, the Atterberg Limits increase.
3. As the shear strength increases, the Atterberg Limits decrease.
4. As the compressibility of a soil increases, the Atterberg Limits increase.

Free Swell Test - ASTM D-4546-96

The free swell test assesses the potential for swell of soil. This value is useful for the design of various structures such as slab-on-ground foundations, piers and piles, and underground utilities. Method B of the aforementioned ASTM standard determines the amount of swell (vertical heave) of a sample. This is done by placing the sample in a consolidometer under a seating load equal to the overburden pressure and giving the sample free access to water. The height is measured and the swell is calculated as the vertical displacement divided by the original height of the specimen. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Swell Pressure Test - ASTM D-4546-96

The swell pressure test assesses the potential for swell of soil. This value is useful for the design of various structures such as slab-on-ground foundations, piers and piles, and underground utilities. Method C of the aforementioned ASTM standard determines the pressure required to keep a soil sample at equilibrium under swelling conditions. This is done by placing the sample in a consolidometer under a seating load and giving the sample free access to water. A constant height of the sample is maintained and the vertical pressure on the sample is adjusted until equilibrium is reached. The vertical pressure on the sample at equilibrium is reported as the swell pressure. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Soil Suction Test - ASTM D-5298-94

Soil suction (potential) tests are performed to determine both the matric and total suction values for the samples tested. Soil suction measures the free energy of the pore water in a soil. In a practical sense, soil suction is an indication of the affinity of a given soil sample to retain water. Soil suction provides useful information on a variety of characteristics of the soil that are affected by the soil water including volume change, deformation, and strength.

Soil suction tests are performed using the filter paper method per ASTM D-5298. Results of these tests are shown graphically on the logs of boring and tabulated in summary sheet of laboratory data.

For matric suction values found using this method, it should be noted that when the soil is in a dry state adequate contact between the filter paper and the soil may not be possible. This lack of contact may result in the determination of total suction instead of matric suction.

Triaxial Shear Test - ASTM D-2850-70

Triaxial tests may be performed on samples that are approximately 2.83 inches in diameter, unless a smaller diameter sample was necessary to achieve a more favorable length:diameter (L:D) ratio. A minimum length to diameter ratio (L:D) of 2.0 is maintained to reduce end effects.

The triaxial tests are typically unconsolidated-undrained using nitrogen gas for chamber confining pressure. Confining pressures are selected to conform to in-situ hydrostatic pressure considering the earth to be a fluid of 120 pcf. In this test, undisturbed Shelby tube samples are trimmed so that their ends are square and then pressed in a triaxial compression machine. The load at which failure occurs is the compressive strength. The results of the triaxial tests and the correlated hand penetrometer strengths can be utilized to develop soil shear strength values. These test provide the confined compressive strength, q_c, which are presented on the Logs of Boring at the depth of the samples tested.

Unconfined Compressive Strength of Rock Cores - ASTM D-2938

The unconfined compressive strength, q_u, is a valuable parameter useful in the design of foundation footings. This value, qu, is related to the shearing resistance of the rock and thus to the capacity of the rock to support a load. In completing this test it is imperative that the length:diameter ratio of the core specimens are maintained at a minimum of 2:1. This ratio is set so that the shear plane will not extend through either of the end caps. If the ratio is less than 2.0 a correction is applied to the result.

Grain Size Analysis - ASTM D-421 and D-422

Grain size analysis tests are performed to determine the particle size and distribution of the samples tested. The grain size distribution of the soils coarser than the Standard Number 200 sieve is determined by passing the sample through a standard set of nested sieves, and the distribution of sizes smaller than the No. 200 sieve is determined by a sedimentation process, using a hydrometer. The results are given on the log of Boring/Pit or on Grain Size Distribution semi-log graphs within the report.

Slake Durability Test - ASTM D-4644

The slake durability test provides an index for the durability of a shale, or similar rock, considering the effects of wetting, drying, and abrasion. This index is used to quantify the strength of weak rock formations when exposed to natural wetting and drying cycles, especially in the context of underground tunneling and excavation. The index, $I_d(2)$, represents the percentage, by mass, of rock material retained after two wetting and drying cycles. These cycles are simulated by oven drying the sample followed by ten minutes of tumbling and soaking in water within a drum and trough apparatus. After tumbling and soaking, the sample is oven-dried and the mass of the sample is recorded. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Brazilian Tensile Strength - ASTM D-3967

The Brazilian (splitting) tensile strength, σ_t, is useful in rock mechanics design, especially in regard to tunneling. This value is an indirect representation of the true uniaxial tensile strength. The Brazilian test is typically used more commonly than direct tensile strength tests because it is less difficult, more cost effective, and more represented of in-situ conditions. The test is conducted by mechanically compressing a rock core sample along its vertical diameter, causing the sample to fail due to tension along the horizontal diameter caused by the Poisson effect.

CERCHAR Abrasivity Index (CAI) Test - ASTM D-7625

The CERCHAR Abrasivity Index (CAI) is used to determine the abrasivity of rocks. This is particularly useful in assessing the potential wearing on cutting tools during excavation. The CAI of a rock is determined by the CERCHAR test, which consists of scraping steel pins across a rock surface and measuring the wear of each pin. The rock specimen is held in a mechanical vice, while a conical steel pin fastened to a 15-pound head is drug across the face of the specimen using a lever being pulled 1 centimeter in 1 second. The CAI is calculated based on the resultant diameter on the end of the pin.

APPENDIX C

MFPS COMPUTER OUTPUT

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MM     MM  FFFFFFFFF  PPPPPPPP     SSSSS      11
MMM   MMM  FFFFFFFFF  PPPPPPPPP   SSSSSSS    111
MMMM MMMM  FF         PP     PP  SS     SS  1111
MMMMMMMMM  FF         PP     PP  SS           11
MM MMM MM  FFFFFFF    PPPPPPPPP   SSSSSS      11
MM  M  MM  FFFFFFF    PPPPPPPP     SSSSSS     11
MM     MM  FF         PP                SS    11
MM     MM  FF         PP         SS     SS    11
MM     MM  FF         PP          SSSSSSS   111111
MM     MM  FF         PP           SSSSS    111111



MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM
VERSION 1.0, SEPTEMBER 1983
MOVED TO MICROCOMPUTER OCTOBER 1985 (P.J.- BRE)

NOTICE --

THIS COMPUTER PROGRAM REPRESENTS AN ADAPTATION
OF THE ORIGINAL TEXAS STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION FLEXIBLE PAVEMENT DESIGN
SYSTEM (FPS-11) FOR THE DESIGN AND CONSIDERATION
OF LIFE-CYCLE COSTS OF MUNICIPAL STREETS AND
THOROUGHFARES IN AUSTIN, TEXAS.  THIS PROGRAM WAS
DEVELOPED BY ARE, INC (512/327-3520) FOR SOLE USE
BY THE CITY OF AUSTIN.  BECAUSE OF THE NATURE OF THE
DEVELOPMENT OF THE MFPS-1 PROGRAM AND CERTAIN BUILT-IN
REGIONAL FACTORS, USE BY ANY OTHER CITY OR AGENCY
REQUIRES A THOROUGH UNDESTANDING OF THE PROGRAM
OPERATION AND ITS INHERENT ASSUMPTIONS.

CAUTION IS RECOMMENDED IN APPLYING THIS FIRST VERSION
OF THE MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM.
THE USER SHOULD ACCEPT ULTIMATE RESPONSIBILITY FOR
THE ACCURACY OF THE INPUTS AND THE VALIDITY OF THE
RESULTS.
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MFPS-1  MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT FPS-11 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM        TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets


      *****  PAVEMENT  *****

      TOTAL NUMBER OF LANES IN FACILITY . . . . . . . .  2
      TOTAL NUMBER OF CURBS IN FACILITY . . . . . . . .  2
      NUMBER OF LAYERS CONSIDERED IN THIS PROBLEM . . .  2
      LANE WIDTH (FEET) . . . . . . . . . . . . . . . .  13.50
      CURB HEIGHT (INCHES). . . . . . . . . . . . . . .   6.00
      CONCRETE CURB CONSTRUCTION COST ($/LF). . . . . .   5.50
      THICKENED EDGE FIXED COST ($/LF). . . . . . . . .    .00
      THICKENED EDGE INCREMENTAL COST ($/IN/LF) . . . .    .00


      *****  LAYER  *****

                             MIN.  MAX.  THICK.               SALV.
LAYER LAYER      LAYER      DEPTH  DEPTH  INCR.  COST   COST  VALUE STIFF.
 NO.   CODE   DESCRIPTION   (IN.)  (IN.)  (IN.) ($/CY) ($/SY)  (%)   COEF.
----- ----- --------------- -----  ----- ------ ------ ------ ----- ------
  1     H              HMAC  2.00   4.00    .50  84.00    .00  30.0   .960
  2     F        FLEX. BASE  8.00  18.00   1.00  20.00    .00  20.0   .500


      *****  SUBGRADE  *****

      SWELLING PROBABILITY. . . . . . . . . . . . . . .   1.00
      SWELLING RATE CONSTANT. . . . . . . . . . . . . .    .12
      POTENTIAL VERTICAL RISE (INCHES). . . . . . . . .   3.00
      SUBGRADE EXCAVATION COST ($/CY) . . . . . . . . .   7.50
      SUBGRADE COST ($/SY). . . . . . . . . . . . . . .    .00
      SUBGRADE STIFFNESS COEFFICIENT. . . . . . . . . .    .190


      *****  AC OVERLAY  *****

      MINIMUM AC OVERLAY THICKNESS (INCHES) . . . . . .   1.50
      MAXIMUM ACCUMULATED OVERLAY THICKNESS (INCHES). .   3.00
      AVERAGE LEVEL-UP THICKNESS (INCHES) . . . . . . .    .50
      OVERLAY COST ($/CY) . . . . . . . . . . . . . . .  55.00
      OVERLAY COST ($/SY) . . . . . . . . . . . . . . .    .00
      OVERLAY SALVAGE VALUE (%) . . . . . . . . . . . .  30.00
      AC OVERLAY STIFFNESS COEFFICIENT. . . . . . . . .    .960
      OVERLAY EDGE TAPERING COST ($/LF) . . . . . . . .    .00
      OVERLAY EDGE MILLING COST ($/LF). . . . . . . . .   3.25
      AC OVERLAY PRODUCTION RATE (CY/HR). . . . . . .  40.0
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MFPS-1  MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT FPS-11 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM        TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets


      *****  DESIGN CONSTRAINTS  *****

      CONFIDENCE LEVEL (%). . . . . . . . . . . . . . . .  90.00
      LENGTH OF ANALYSIS PERIOD (YEARS) . . . . . . . . .  20.0
      MINIMUM TIME TO FIRST OVERLAY (YEARS) . . . . . . .  20.0
      MINIMUM TIME BETWEEN OVERLAYS (YEARS) . . . . . . .   5.0
      MAXIMUM THICKNESS OF INITIAL CONSTR. (INCHES) . .  22.00
      MAXIMUM FUNDS AVAILABLE FOR INITIAL CONSTR. ($) .  50.00
      DISCOUNT RATE (%) . . . . . . . . . . . . . . . . .   5.00


      *****  PERFORMANCE  *****

      SERVICEABILITY INDEX AFTER INITIAL CONSTRUCTION .   4.20
      TERMINAL SERVICEABILITY INDEX . . . . . . . . . .   1.50
      SERVICEABILITY INDEX AFTER OVERLAY CONSTRUCTION .   4.00


      *****  MAINTENANCE  *****

      FIRST YEAR COST OF ROUTINE MAINTENANCE. . . . . .    .00
      ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST . 150.00


      *****  TRAFFIC  *****

      AVERAGE DAILY TRAFFIC GROWTH RATE (%) . . . . . .   3.50
      DIRECTIONAL DISTRIBUTION FACTOR (%) . . . . . . .  50.00
      LANE DISTRIBUTION FACTOR (%). . . . . . . . . . . 100.00
      PERCENT TRUCKS IN AVERAGE DAILY TRAFFIC . . . . .   2.00
      18-KIP EQUIVALENCY FACTOR FOR STD. CITY TRUCK . .    .40
      INITIAL ADT ON FACILITY (VPD) . . . . . . . . . .   1000.


      *****  TRAFFIC DELAY  *****

      INDEX TO DETOUR MODEL . . . . . . . . . . . . . .  2
      NO. OF OPEN LANES THROUGH OVERLAY ZONE
           IN OVERLAY DIRECTION . . . . . . . . . . . .  1
           IN NON-OVERLAY DIRECTION . . . . . . . . . .  1
      AVERAGE APPROACH SPEED TO OVERLAY ZONE (MPH). . .    15.
      AVERAGE SPEED THROUGH OVERLAY ZONE (MPH)
           IN OVERLAY DIRECTION . . . . . . . . . . . .    15.
           IN NON-OVERLAY DIRECTION . . . . . . . . . .    15.
      DISTANCE OVER WHICH TRAFFIC IS SLOWED (MILES)
           IN OVERLAY DIRECTION . . . . . . . . . . . .    .20
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          IN NON-OVERLAY DIRECTION . . . . . . . . . .    .20
     DETOUR DISTANCE (MILES) . . . . . . . . . . . . .   1.00
     NO. OF HOURS PER DAY OVERLAY CONSTRUCTION OCCURS.   7.00
     ADT ARRIVING EACH HOUR OF CONSTRUCTION (%). . . .  14.00


MFPS-1  MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT FPS-11 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM        TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets


SUMMARY OF THE BEST DESIGN STRATEGIES
IN ORDER OF INCREASING TOTAL COST

                         1      2
************************************
MATERIAL ARRANGEMENT    HF     HF
************************************
SUBGRADE EXC. COST     2.29   2.19
CURB CONSTR. COST      3.67   3.67
THICKENED EDGE COST     .00    .00
************************************
TAPERING COSTS          .00    .00
MILLING COSTS           .00    .00
************************************
INIT. CONST. COST     15.63  16.13
OVERLAY CONST. COST     .00    .00
USER COST               .00    .00
ROUTINE MAINT. COST    1.96   1.96
SALVAGE VALUE          -.90   -.99
************************************
TOTAL COST            16.68  17.10
************************************
LAYER DEPTH (INCHES)
    D(1)              2.00   2.50
    D(2)              9.00   8.00
************************************
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
************************************
PERF. TIME (YEARS)
    T(1)             24.01  24.06
************************************
SWELLING CLAY LOSS
 (SERVICEABILITY)
   SC(1)               .95    .95
************************************

THE TOTAL NUMBER OF FEASIBLE DESIGNS ENCOUNTERED WAS        54
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MM     MM  FFFFFFFFF  PPPPPPPP     SSSSS      11
MMM   MMM  FFFFFFFFF  PPPPPPPPP   SSSSSSS    111
MMMM MMMM  FF         PP     PP  SS     SS  1111
MMMMMMMMM  FF         PP     PP  SS           11
MM MMM MM  FFFFFFF    PPPPPPPPP   SSSSSS      11
MM  M  MM  FFFFFFF    PPPPPPPP     SSSSSS     11
MM     MM  FF         PP               SS    11
MM     MM  FF         PP         SS     SS    11
MM     MM  FF         PP          SSSSSSS   111111
MM     MM  FF         PP           SSSSS    111111



MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM
VERSION 1.0, SEPTEMBER 1983
MOVED TO MICROCOMPUTER OCTOBER 1985 (P.J.- BRE)

NOTICE --

THIS COMPUTER PROGRAM REPRESENTS AN ADAPTATION
OF THE ORIGINAL TEXAS STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION FLEXIBLE PAVEMENT DESIGN
SYSTEM (FPS-11) FOR THE DESIGN AND CONSIDERATION
OF LIFE-CYCLE COSTS OF MUNICIPAL STREETS AND
THOROUGHFARES IN AUSTIN, TEXAS.  THIS PROGRAM WAS
DEVELOPED BY ARE, INC (512/327-3520) FOR SOLE USE
BY THE CITY OF AUSTIN.  BECAUSE OF THE NATURE OF THE
DEVELOPMENT OF THE MFPS-1 PROGRAM AND CERTAIN BUILT-IN
REGIONAL FACTORS, USE BY ANY OTHER CITY OR AGENCY
REQUIRES A THOROUGH UNDESTANDING OF THE PROGRAM
OPERATION AND ITS INHERENT ASSUMPTIONS.

CAUTION IS RECOMMENDED IN APPLYING THIS FIRST VERSION
OF THE MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM.
THE USER SHOULD ACCEPT ULTIMATE RESPONSIBILITY FOR
THE ACCURACY OF THE INPUTS AND THE VALIDITY OF THE
RESULTS.
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MFPS-1  MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT FPS-11 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM        TITLE (DESCRIPTION)
 22102100.003 - Ruby Ranch Pavement Repair, Minor Collectors


      *****  PAVEMENT  *****

      TOTAL NUMBER OF LANES IN FACILITY . . . . . . . .  2
      TOTAL NUMBER OF CURBS IN FACILITY . . . . . . . .  2
      NUMBER OF LAYERS CONSIDERED IN THIS PROBLEM . . .  2
      LANE WIDTH (FEET) . . . . . . . . . . . . . . . .  18.50
      CURB HEIGHT (INCHES). . . . . . . . . . . . . . .   6.00
      CONCRETE CURB CONSTRUCTION COST ($/LF). . . . . .   5.50
      THICKENED EDGE FIXED COST ($/LF). . . . . . . . .    .00
      THICKENED EDGE INCREMENTAL COST ($/IN/LF) . . . .    .00


      *****  LAYER  *****

                              MIN.  MAX.  THICK.               SALV.
LAYER LAYER      LAYER       DEPTH  DEPTH  INCR.  COST   COST  VALUE STIFF.
 NO.   CODE   DESCRIPTION    (IN.)  (IN.)  (IN.) ($/CY) ($/SY)  (%)   COEF.
----- ----- --------------- -----  ----- ------ ------ ------ ----- ------
  1     H             HMAC  2.50   4.00    .50  84.00    .00  30.0   .960
  2     F       FLEX. BASE 10.00  18.00   1.00  20.00    .00  20.0   .500


      *****  SUBGRADE  *****

      SWELLING PROBABILITY. . . . . . . . . . . . . . .   1.00
      SWELLING RATE CONSTANT. . . . . . . . . . . . . .    .12
      POTENTIAL VERTICAL RISE (INCHES). . . . . . . . .   3.00
      SUBGRADE EXCAVATION COST ($/CY) . . . . . . . . .   7.50
      SUBGRADE COST ($/SY). . . . . . . . . . . . . . .    .00
      SUBGRADE STIFFNESS COEFFICIENT. . . . . . . . . .    .190


      *****  AC OVERLAY  *****

      MINIMUM AC OVERLAY THICKNESS (INCHES) . . . . . .   1.50
      MAXIMUM ACCUMULATED OVERLAY THICKNESS (INCHES). .   3.00
      AVERAGE LEVEL-UP THICKNESS (INCHES) . . . . . . .    .50
      OVERLAY COST ($/CY) . . . . . . . . . . . . . . .  55.00
      OVERLAY COST ($/SY) . . . . . . . . . . . . . . .    .00
      OVERLAY SALVAGE VALUE (%) . . . . . . . . . . . .  30.00
      AC OVERLAY STIFFNESS COEFFICIENT. . . . . . . . .    .960
      OVERLAY EDGE TAPERING COST ($/LF) . . . . . . . .    .00
      OVERLAY EDGE MILLING COST ($/LF). . . . . . . . .   3.25
      AC OVERLAY PRODUCTION RATE (CY/HR). . . . . . . .  40.0
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MFPS-1  MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT FPS-11 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM        TITLE (DESCRIPTION)
 22102100.003 - Ruby Ranch Pavement Repair, Minor Collectors


      *****  DESIGN CONSTRAINTS  *****

      CONFIDENCE LEVEL (%). . . . . . . . . . . . . . . .  90.00
      LENGTH OF ANALYSIS PERIOD (YEARS) . . . . . . . . .  20.0
      MINIMUM TIME TO FIRST OVERLAY (YEARS) . . . . . . .  20.0
      MINIMUM TIME BETWEEN OVERLAYS (YEARS) . . . . . . .   5.0
      MAXIMUM THICKNESS OF INITIAL CONSTR. (INCHES) . .  22.00
      MAXIMUM FUNDS AVAILABLE FOR INITIAL CONSTR. ($) .  50.00
      DISCOUNT RATE (%) . . . . . . . . . . . . . . . .   5.00


      *****  PERFORMANCE  *****

      SERVICEABILITY INDEX AFTER INITIAL CONSTRUCTION .   4.20
      TERMINAL SERVICEABILITY INDEX . . . . . . . . . .   1.50
      SERVICEABILITY INDEX AFTER OVERLAY CONSTRUCTION .   4.00


      *****  MAINTENANCE  *****

      FIRST YEAR COST OF ROUTINE MAINTENANCE. . . . . .    .00
      ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST . 150.00


      *****  TRAFFIC  *****

      AVERAGE DAILY TRAFFIC GROWTH RATE (%) . . . . . .   4.00
      DIRECTIONAL DISTRIBUTION FACTOR (%) . . . . . . .  50.00
      LANE DISTRIBUTION FACTOR (%). . . . . . . . . . . 100.00
      PERCENT TRUCKS IN AVERAGE DAILY TRAFFIC . . . . .   4.90
      18-KIP EQUIVALENCY FACTOR FOR STD. CITY TRUCK . .    .53
      INITIAL ADT ON FACILITY (VPD) . . . . . . . . . .   2000.


      *****  TRAFFIC DELAY  *****

      INDEX TO DETOUR MODEL . . . . . . . . . . . . . .  2
      NO. OF OPEN LANES THROUGH OVERLAY ZONE
           IN OVERLAY DIRECTION . . . . . . . . . . . .  1
           IN NON-OVERLAY DIRECTION . . . . . . . . . .  1
      AVERAGE APPROACH SPEED TO OVERLAY ZONE (MPH). . .    15.
      AVERAGE SPEED THROUGH OVERLAY ZONE (MPH)
           IN OVERLAY DIRECTION . . . . . . . . . . . .    15.
           IN NON-OVERLAY DIRECTION . . . . . . . . . .    15.
      DISTANCE OVER WHICH TRAFFIC IS SLOWED (MILES)
           IN OVERLAY DIRECTION . . . . . . . . . . . .    .20
```

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           IN NON-OVERLAY DIRECTION . . . . . . . . . .    .20
      DETOUR DISTANCE (MILES) . . . . . . . . . . . . .   1.00
      NO. OF HOURS PER DAY OVERLAY CONSTRUCTION OCCURS.   7.00
      ADT ARRIVING EACH HOUR OF CONSTRUCTION (%). . . .  14.00



MFPS-1  MUNICIPAL FLEXIBLE PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
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        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM        TITLE (DESCRIPTION)
 22102100.003 - Ruby Ranch Pavement Repair, Minor Collectors


SUMMARY OF THE BEST DESIGN STRATEGIES
IN ORDER OF INCREASING TOTAL COST

                         1      2      3      4
****************************************************
MATERIAL ARRANGEMENT    HF     HF     HF     HF
****************************************************
SUBGRADE EXC. COST     3.23   3.13   3.02   2.92
CURB CONSTR. COST      2.68   2.68   2.68   2.68
THICKENED EDGE COST     .00    .00    .00    .00
****************************************************
TAPERING COSTS          .00    .00    .00    .00
MILLING COSTS           .00    .00    .00    .00
****************************************************
INIT. CONST. COST     18.96  19.47  19.97  20.48
OVERLAY CONST. COST     .00    .00    .00    .00
USER COST               .00    .00    .00    .00
ROUTINE MAINT. COST    1.43   1.43   1.43   1.43
SALVAGE VALUE         -1.20  -1.29  -1.38  -1.47
****************************************************
TOTAL COST            19.19  19.60  20.02  20.44
****************************************************
LAYER DEPTH (INCHES)
    D(1)              2.50   3.00   3.50   4.00
    D(2)             13.00  12.00  11.00  10.00
****************************************************
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
****************************************************
PERF. TIME (YEARS)
    T(1)             20.00  20.30  20.60  20.86
****************************************************
SWELLING CLAY LOSS
 (SERVICEABILITY)
   SC(1)               .91    .92    .92    .92
****************************************************

THE TOTAL NUMBER OF FEASIBLE DESIGNS ENCOUNTERED WAS        30
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APPENDIX D

MFPS COMPUTER OUTPUT

```
MM     MM  RRRRRRRR   PPPPPPPP     SSSSS      11
MMM   MMM  RRRRRRRRR  PPPPPPPPP   SSSSSSS    111
MMMM MMMM  RR     RR  PP     PP  SS     SS  1111
MMMMMMMMM  RR     RR  PP     PP  SS           11
MM MMM MM  RRRRRRRRR  PPPPPPPPP   SSSSSS      11
MM  M  MM  RRRRRRRR   PPPPPPPP     SSSSSS     11
MM     MM  RR     RR  PP               SS    11
MM     MM  RR     RR  PP         SS     SS    11
MM     MM  RR     RR  PP          SSSSSSS   111111
MM     MM  RR     RR  PP           SSSSS    111111



MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM
VERSION 1.0, SEPTEMBER 1983

NOTICE --

THIS COMPUTER PROGRAM REPRESENTS AN ADAPTATION
OF THE ORIGINAL TEXAS STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION RIGID PAVEMENT DESIGN
SYSTEM (RPS-3) FOR THE DESIGN AND CONSIDERATION
OF LIFE-CYCLE COSTS OF MUNICIPAL STREETS AND
THOROUGHFARES IN AUSTIN, TEXAS.  THIS PROGRAM WAS
DEVELOPED BY ARE, INC (512/327-3520) FOR SOLE USE
BY THE CITY OF AUSTIN.  BECAUSE OF THE NATURE OF THE
DEVELOPMENT OF THE MRPS-1 PROGRAM AND CERTAIN BUILT-IN
REGIONAL FACTORS, USE BY ANY OTHER CITY OR AGENCY
REQUIRES A THOROUGH UNDERSTANDING OF THE PROGRAM
OPERATION AND ITS INHERENT ASSUMPTIONS.

CAUTION IS RECOMMENDED IN APPLYING THIS FIRST VERSION
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THE USER SHOULD ACCEPT ULTIMATE RESPONSIBILITY FOR
THE ACCURACY OF THE INPUTS AND THE VALIDITY OF THE
RESULTS.
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MRPS-1  MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT RPS-3 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM       TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets



      *****  NEW PAVEMENT  *****

      TOTAL NUMBER OF LANES IN THE FACILITY . . . . . .  2
      TOTAL NUMBER OF CONCRETE CURBS. . . . . . . . . .  2
      NUMBER OF SUBBASE TYPES . . . . . . . . . . . . .  1
      PROJECT LENGTH (MILES). . . . . . . . . . . . . .    .30
      LANE WIDTH (FEET) . . . . . . . . . . . . . . . .  13.50
      CURB HEIGHT (INCHES). . . . . . . . . . . . . . .   6.00
      CONCRETE CURB CONSTRUCTION COST ($/LF). . . . . .   2.00



      *****  CONCRETE SLAB  *****

      MINIMUM SLAB THICKNESS (INCHES) . . . . . . . . .   6.00
      MAXIMUM SLAB THICKNESS (INCHES) . . . . . . . . .  12.00
      SLAB THICKNESS INCREMENT (INCHES) . . . . . . . .    .50
      CONCRETE PLACEMENT COST ($/CY). . . . . . . . . .  98.00
      ADDITIONAL CONCRETE PAVEMENT COST ($/SY). . . . .    .00
      CONCRETE SALVAGE VALUE (PERCENT). . . . . . . . .  30.00
      CONCRETE FLEXURAL STRENGTH (PSI). . . . . . . . .  530.0
      CONCRETE TENSILE STRENGTH (PSI) . . . . . . . . .  375.0
      CONCRETE ELASTIC MODULUS (PSI). . . . . . . . . . 3580000.
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MRPS-1  MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT RPS-3 PROGRAM FOR CITY OF AUSTIN
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PROBLEM       TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets



      *****  SUBGRADE  *****

      SWELLING PROBABILITY. . . . . . . . . . . . . . . .   1.00
      SWELLING RATE CONSTANT. . . . . . . . . . . . . . .    .12
      POTENTIAL VERTICAL RISE (INCHES). . . . . . . . . .   3.00
      SUBGRADE EXCAVATION COST ($/CY) . . . . . . . . . .   7.50
      ADDITIONAL SUBGRADE COST ($/SY) . . . . . . . . . .    .00
      SUBGRADE ERODABILITY FACTOR . . . . . . . . . . . .   3.00
      FRICTION FACTOR BETWEEN SLAB AND SUBGRADE . . . . .    .90
      SUBGRADE K-VALUE (PCI). . . . . . . . . . . . . . .   50.0



      *****  ASPHALT CONCRETE OVERLAY  *****

      MINIMUM AC OVERLAY THICKNESS (INCHES) . . . . . . .   1.50
      MAXIMUM TOTAL AC OVERLAY THICKNESS (INCHES) . . . .   3.00
      AVERAGE AC OVERLAY LEVEL-UP THICKNESS (INCHES). . .    .50
      AC OVERLAY CONSTRUCTION COST ($/CY) . . . . . . . .  55.00
      ADDITIONAL OVERLAY COST ($/SY). . . . . . . . . . .    .00
      AC OVERLAY SALVAGE VALUE (PERCENT). . . . . . . . .  30.0
      TAPERING COST FOR FIRST OVERLAY ($/LF). . . . . . .    .00
      EDGE MILLING COST ($/LF). . . . . . . . . . . . . .    .00
      AC OVERLAY ELASTIC MODULUS (PSI). . . . . . . . . .  40000.
      AC PRODUCTION RATE (CY/HOUR). . . . . . . . . . . .  40.0



      *****  DESIGN CONSTRAINTS  *****

      CONFIDENCE LEVEL (PERCENT). . . . . . . . . . . . .  90.00
      ANALYSIS PERIOD (YEARS) . . . . . . . . . . . . . .  20.0
      MINIMUM TIME TO FIRST OVERLAY (YEARS) . . . . . . .  10.0
      MINIMUM TIME BETWEEN OVERLAYS (YEARS) . . . . . . .   5.0
      MAXIMUM THICKNESS OF SLAB AND SUBBASE (INCHES). . .  30.00
      MAX. FUNDS AVAILABLE FOR INITIAL CONST. ($/SY). . .  50.00
      DISCOUNT RATE (%) . . . . . . . . . . . . . . . . .   5.00



      *****  PERFORMANCE  *****

      SERVICABILITY AFTER INITIAL CONSTRUCTION. . . . . .   4.20
      TERMINAL SERVICABILITY. . . . . . . . . . . . . . .   1.50
      SERVICABILITY AFTER AC OVERLAY. . . . . . . . . . .   4.00
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MRPS-1  MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT RPS-3 PROGRAM FOR CITY OF AUSTIN
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PROBLEM       TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets



      *****  MAINTENANCE  *****

      COMPOSITE LABOR WAGE ($/HOUR) . . . . . . . . . .   9.00
      COMPOSITE EQUIPMENT RENTAL RATE ($/HOUR). . . . .   6.00
      COST OF MATERIALS ($/UNIT OPERATION). . . . . . .   4.00



      *****  TRAFFIC  *****

      AVERAGE DAILY TRAFFIC GROWTH RATE (% / YEAR). . .   3.50
      DIRECTIONAL DISTRIBUTION FACTOR (%) . . . . . . .  50.00
      LANE DISTRIBUTION FACTOR (%). . . . . . . . . . . 100.00
      PERCENT TRUCKS IN INITIAL AVERAGE DAILY TRAFFIC .   2.00
      18-KIP EQUIVALENCY FACTOR FOR AVERAGE CITY TRUCK.    .400
      INITIAL AVERAGE DAILY TRAFFIC (VEHICLES/DAY). . .   1000.



      *****  TRAFFIC DELAY  *****

      DETOUR MODEL NUMBER . . . . . . . . . . . . . . .  3
      NUMBER OF OPEN LANES THROUGH RESTRICTED ZONE:
           IN OVERLAY DIRECTION . . . . . . . . . . . .  1
           IN NON-OVERLAY DIRECTION . . . . . . . . . .  2
      AVERAGE APPROACH SPEED TO OVERLAY ZONE (MPH). . .    40.
      AVERAGE SPEED THROUGH RESTRICTED ZONE:
           IN OVERLAY DIRECTION . . . . . . . . . . . .    15.
           IN NON-OVERLAY DIRECTION . . . . . . . . . .    40.
      DISTANCE TRAFFIC IS SLOWED (MILES):
           OVERLAY DIRECTION. . . . . . . . . . . . . .   1.00
           NON-OVERLAY DIRECTION. . . . . . . . . . . .    .00
      DETOUR DISTANCE AROUND OVERLAY ZONE (MILES) . . .    .00
      NO. OF HOURS PER DAY OVERLAY CONSTRUCTION OCCURS.   7.00
      BEGINNING TIME OF OVERLAY CONSTRUCTION. . . . . .   800.
      ENDING TIME OF OVERLAY CONSTRUCTION . . . . . . .   500.
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MRPS-1  MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT RPS-3 PROGRAM FOR CITY OF AUSTIN
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PROBLEM       TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets



               *********************************************
               *                                           *
               *     OUT OF ALL OVERLAY STRATEGIES         *
               *            THAT WERE TRIED                *
               *        NO  OVERLAY  STRATEGY              *
               *        MEETS THE REQUIREMENTS             *
               *                                           *
               *    PROGRAM PARTIALLY CONTINUED            *
               *********************************************
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MRPS-1  MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT RPS-3 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM       TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Local Streets



       SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

       DESIGN NUMBER                   1
       *********************************
       PAVEMENT TYPE                 JCP
       SUBBASE  TYPE                   1
       *********************************

       SLAB THICKNESS               6.00
       SUBBASE THICKNESS             .00


       INITIAL LIFE                43.23


       TOTAL PERFORMANCE LIFE      43.23

       SPACING TRANS. JOINTS       40.00
       SPACING LONG. JOINTS        13.50
       *********************************

       COST OF SUBG. PREPARATION   1.250
       COST OF CONCRETE           16.333
       COST OF CURB AND GUTTER     1.333
       COST OF SUBBASE              .000
       COST OF JOINTS               .000

       INITIAL CONST. COST        18.917

       COST OF EDGE TAPERING        .000
       COST OF EDGE MILLING         .000
       OVERLAY CONST. COST          .000
       TRAFFIC DELAY COST           .000
       MAINTENANCE COST            6.682
       SALVAGE RETURNS            -1.847

       *********************************
       TOTAL COST PER SQ YARD     23.752
       *********************************
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     MRPS-1  MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
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     PROBLEM       TITLE (DESCRIPTION)
     22102100.003 - Ruby Ranch Pavement Repair, Local Streets




                                 INITIAL DESIGN ANALYSIS

                 OUT OF A TOTAL OF   13 INITIAL POSSIBLE DESIGNS,
                          0 WERE REJECTED DUE TO MAX. INITIAL THICKNESS
RESTRAINT
                 OUT OF  13 DESIGNS THUS LEFT
                         12 DESIGNS WERE REJECTED SINCE THEY ARE OVERDESIGNS OF
                           INITIAL DESIGNS WHICH LAST THE ANALYSIS PERIOD
                 OUT OF   1 DESIGNS THUS LEFT,
                          0 DESIGNS WERE REJECTED DUE  TO THEIR LIVES BEING LESS
                           THAN THE MINIMUM ALLOWABLE TIME  TO THE FIRST OVERLAY
                 OUT OF   1 DESIGNS THUS LEFT,
                          0 DESIGNS WERE REJECTED DUE TO THE RESTRAINT OF
MAXIMUM
                           INITIAL FUNDS AVAILABLE
                 OUT OF   1 DESIGNS THUS LEFT,
                          1 DESIGNS WERE ACCEPTABLE  INITIAL DESIGNS WITH LIVES
                           MORE THAN THE ANALYSIS PERIOD
                 AND THUS      0 DESIGNS WERE PASSED TO THE OVERLAY SUBSYSTEM
TO
                                FORMULATE THE POSSIBLE OVERLAY STRATEGIES
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MM     MM  RRRRRRRR   PPPPPPPP     SSSSS      11
MMM   MMM  RRRRRRRRR  PPPPPPPPP   SSSSSSS    111
MMMM MMMM  RR     RR  PP     PP  SS     SS  1111
MMMMMMMMM  RR     RR  PP     PP  SS          11
MM MMM MM  RRRRRRRRR  PPPPPPPPP   SSSSSS      11
MM  M  MM  RRRRRRRR   PPPPPPPP     SSSSSS     11
MM     MM  RR     RR  PP                SS    11
MM     MM  RR     RR  PP         SS     SS    11
MM     MM  RR     RR  PP          SSSSSSS   111111
MM     MM  RR     RR  PP           SSSSS    111111



MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM
VERSION 1.0, SEPTEMBER 1983

NOTICE --

THIS COMPUTER PROGRAM REPRESENTS AN ADAPTATION
OF THE ORIGINAL TEXAS STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION RIGID PAVEMENT DESIGN
SYSTEM (RPS-3) FOR THE DESIGN AND CONSIDERATION
OF LIFE-CYCLE COSTS OF MUNICIPAL STREETS AND
THOROUGHFARES IN AUSTIN, TEXAS.  THIS PROGRAM WAS
DEVELOPED BY ARE, INC (512/327-3520) FOR SOLE USE
BY THE CITY OF AUSTIN.  BECAUSE OF THE NATURE OF THE
DEVELOPMENT OF THE MRPS-1 PROGRAM AND CERTAIN BUILT-IN
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OPERATION AND ITS INHERENT ASSUMPTIONS.

CAUTION IS RECOMMENDED IN APPLYING THIS FIRST VERSION
OF THE MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM.
THE USER SHOULD ACCEPT ULTIMATE RESPONSIBILITY FOR
THE ACCURACY OF THE INPUTS AND THE VALIDITY OF THE
RESULTS.
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MRPS-1  MUNICIPAL RIGID PAVEMENT DESIGN SYSTEM, VERSION 1.0, 8/83
        ADAPTED FROM TEXAS SDHPT RPS-3 PROGRAM FOR CITY OF AUSTIN
        BY ARE INC, CONSULTING ENGINEERS, AUSTIN, TEXAS

PROBLEM       TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Minor Collectors



      *****  NEW PAVEMENT  *****

      TOTAL NUMBER OF LANES IN THE FACILITY . . . . . .  2
      TOTAL NUMBER OF CONCRETE CURBS. . . . . . . . . .  2
      NUMBER OF SUBBASE TYPES . . . . . . . . . . . . .  1
      PROJECT LENGTH (MILES). . . . . . . . . . . . . .    .30
      LANE WIDTH (FEET) . . . . . . . . . . . . . . . .  13.50
      CURB HEIGHT (INCHES). . . . . . . . . . . . . . .   6.00
      CONCRETE CURB CONSTRUCTION COST ($/LF). . . . . .   2.00



      *****  CONCRETE SLAB  *****

      MINIMUM SLAB THICKNESS (INCHES) . . . . . . . . .   6.00
      MAXIMUM SLAB THICKNESS (INCHES) . . . . . . . . .  10.00
      SLAB THICKNESS INCREMENT (INCHES) . . . . . . . .   1.00
      CONCRETE PLACEMENT COST ($/CY). . . . . . . . . .  98.00
      ADDITIONAL CONCRETE PAVEMENT COST ($/SY). . . . .    .00
      CONCRETE SALVAGE VALUE (PERCENT). . . . . . . . .  30.00
      CONCRETE FLEXURAL STRENGTH (PSI). . . . . . . . .  530.0
      CONCRETE TENSILE STRENGTH (PSI) . . . . . . . . .  375.0
      CONCRETE ELASTIC MODULUS (PSI). . . . . . . . . . 3580000.
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PROBLEM       TITLE (DESCRIPTION)
22102100.003 - Ruby Ranch Pavement Repair, Minor Collectors



      *****  SUBGRADE  *****

      SWELLING PROBABILITY. . . . . . . . . . . . . . . .   1.00
      SWELLING RATE CONSTANT. . . . . . . . . . . . . . .    .12
      POTENTIAL VERTICAL RISE (INCHES). . . . . . . . . .   3.00
      SUBGRADE EXCAVATION COST ($/CY) . . . . . . . . . .   4.50
      ADDITIONAL SUBGRADE COST ($/SY) . . . . . . . . . .    .00
      SUBGRADE ERODABILITY FACTOR . . . . . . . . . . . .   3.00
      FRICTION FACTOR BETWEEN SLAB AND SUBGRADE . . . . .    .90
      SUBGRADE K-VALUE (PCI). . . . . . . . . . . . . . .   50.0



      *****  ASPHALT CONCRETE OVERLAY  *****

      MINIMUM AC OVERLAY THICKNESS (INCHES) . . . . . . .   1.50
      MAXIMUM TOTAL AC OVERLAY THICKNESS (INCHES) . . . .   3.00
      AVERAGE AC OVERLAY LEVEL-UP THICKNESS (INCHES). . .    .50
      AC OVERLAY CONSTRUCTION COST ($/CY) . . . . . . . .  55.00
      ADDITIONAL OVERLAY COST ($/SY). . . . . . . . . . .    .00
      AC OVERLAY SALVAGE VALUE (PERCENT). . . . . . . . .  30.0
      TAPERING COST FOR FIRST OVERLAY ($/LF). . . . . . .    .00
      EDGE MILLING COST ($/LF). . . . . . . . . . . . . .    .00
      AC OVERLAY ELASTIC MODULUS (PSI). . . . . . . . . .  40000.
      AC PRODUCTION RATE (CY/HOUR). . . . . . . . . . . .  40.0



      *****  DESIGN CONSTRAINTS  *****

      CONFIDENCE LEVEL (PERCENT). . . . . . . . . . . . .  90.00
      ANALYSIS PERIOD (YEARS) . . . . . . . . . . . . . .  20.0
      MINIMUM TIME TO FIRST OVERLAY (YEARS) . . . . . . .  10.0
      MINIMUM TIME BETWEEN OVERLAYS (YEARS) . . . . . . .   5.0
      MAXIMUM THICKNESS OF SLAB AND SUBBASE (INCHES). . .  30.00
      MAX. FUNDS AVAILABLE FOR INITIAL CONST. ($/SY). . .  50.00
      DISCOUNT RATE (%) . . . . . . . . . . . . . . . . .   5.00



      *****  PERFORMANCE  *****

      SERVICABILITY AFTER INITIAL CONSTRUCTION. . . . . .   4.20
      TERMINAL SERVICABILITY. . . . . . . . . . . . . . .   1.50
      SERVICABILITY AFTER AC OVERLAY. . . . . . . . . . .   4.00
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      *****  MAINTENANCE  *****

      COMPOSITE LABOR WAGE ($/HOUR) . . . . . . . . . .   6.00
      COMPOSITE EQUIPMENT RENTAL RATE ($/HOUR). . . . .   5.00
      COST OF MATERIALS ($/UNIT OPERATION). . . . . . .   2.00



      *****  TRAFFIC  *****

      AVERAGE DAILY TRAFFIC GROWTH RATE (% / YEAR). . .   4.00
      DIRECTIONAL DISTRIBUTION FACTOR (%) . . . . . . .  50.00
      LANE DISTRIBUTION FACTOR (%). . . . . . . . . . . 100.00
      PERCENT TRUCKS IN INITIAL AVERAGE DAILY TRAFFIC .   4.90
      18-KIP EQUIVALENCY FACTOR FOR AVERAGE CITY TRUCK.    .530
      INITIAL AVERAGE DAILY TRAFFIC (VEHICLES/DAY). . .   2000.



      *****  TRAFFIC DELAY  *****

      DETOUR MODEL NUMBER . . . . . . . . . . . . . . . . 3
      NUMBER OF OPEN LANES THROUGH RESTRICTED ZONE:
           IN OVERLAY DIRECTION . . . . . . . . . . . . 1
           IN NON-OVERLAY DIRECTION . . . . . . . . . . 2
      AVERAGE APPROACH SPEED TO OVERLAY ZONE (MPH). . .    40.
      AVERAGE SPEED THROUGH RESTRICTED ZONE:
           IN OVERLAY DIRECTION . . . . . . . . . . . .    15.
           IN NON-OVERLAY DIRECTION . . . . . . . . . .    40.
      DISTANCE TRAFFIC IS SLOWED (MILES):
           OVERLAY DIRECTION. . . . . . . . . . . . . .   1.00
           NON-OVERLAY DIRECTION. . . . . . . . . . . .    .00
      DETOUR DISTANCE AROUND OVERLAY ZONE (MILES) . . .    .00
      NO. OF HOURS PER DAY OVERLAY CONSTRUCTION OCCURS.   7.00
      BEGINNING TIME OF OVERLAY CONSTRUCTION. . . . . .   800.
      ENDING TIME OF OVERLAY CONSTRUCTION . . . . . . .  1600.
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       SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

       DESIGN NUMBER                   1       2
       *****************************************
       PAVEMENT TYPE                 JCP     JCP
       SUBBASE  TYPE                   1       1
       *****************************************

       SLAB THICKNESS               6.00    7.00
       SUBBASE THICKNESS             .00     .00

       1ST OVERLAY + LEVEL UP       2.00     .50

       INITIAL LIFE                12.17   25.17

       PERFORMANCE LIFE 1          30.75     .00

       TOTAL PERFORMANCE LIFE      30.75   25.17

       SPACING TRANS. JOINTS       40.00   40.00
       SPACING LONG. JOINTS        13.50   13.50
       *****************************************

       COST OF SUBG. PREPARATION    .750    .875
       COST OF CONCRETE           16.333  19.056
       COST OF CURB AND GUTTER     1.333   1.333
       COST OF SUBBASE              .000    .000
       COST OF JOINTS               .000    .000

       INITIAL CONST. COST        18.417  21.264

       COST OF EDGE TAPERING        .000    .000
       COST OF EDGE MILLING         .000    .000
       OVERLAY CONST. COST         1.688    .000
       TRAFFIC DELAY COST           .017    .000
       MAINTENANCE COST            1.616   4.500
       SALVAGE RETURNS            -2.106  -2.155

       *****************************************
       TOTAL COST PER SQ YARD     19.631  23.610
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                                INITIAL DESIGN ANALYSIS

                 OUT OF A TOTAL OF    5 INITIAL POSSIBLE DESIGNS,
                          0 WERE REJECTED DUE TO MAX. INITIAL THICKNESS
RESTRAINT
                 OUT OF   5 DESIGNS THUS LEFT
                          3 DESIGNS WERE REJECTED SINCE THEY ARE OVERDESIGNS OF
                           INITIAL DESIGNS WHICH LAST THE ANALYSIS PERIOD
                 OUT OF   2 DESIGNS THUS LEFT,
                          0 DESIGNS WERE REJECTED DUE  TO THEIR LIVES BEING LESS
                           THAN THE MINIMUM ALLOWABLE TIME  TO THE FIRST OVERLAY
                 OUT OF   2 DESIGNS THUS LEFT,
                          0 DESIGNS WERE REJECTED DUE TO THE RESTRAINT OF
MAXIMUM
                           INITIAL FUNDS AVAILABLE
                 OUT OF   2 DESIGNS THUS LEFT,
                          1 DESIGNS WERE ACCEPTABLE  INITIAL DESIGNS WITH LIVES
                           MORE THAN THE ANALYSIS PERIOD
                 AND THUS      1 DESIGNS WERE PASSED TO THE OVERLAY SUBSYSTEM
TO
                               FORMULATE THE POSSIBLE OVERLAY STRATEGIES
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