Geotechnical Engineering Report

Bacliff Drainage Improvements
Bacliff, Texas
June 21, 2022
Terracon Project No. 91225002

Prepared for:
DEC, Inc.
Houston, Texas

Prepared by:
Terracon Consultants, Inc.
League City, Texas

June 21, 2022

DEC, Inc.
3100 W. Alabama
Houston, Texas 77098

Attn: Mr. Ashish Waghray, P.E., CFM

Re: Geotechnical Engineering Report
Bacliff Drainage Improvements
10th Street and 15th Street
Bacliff, Texas
Terracon Project No. 91225002

Dear Mr. Waghray:

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the project referenced above in Bacliff, Texas. We trust that this report is responsive to your project needs. We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.
(Texas Firm Registration No.: F-3272)

Ruofan Chu, P.E.
Project Manager

Joshua C. Miles, P.E.
Department Manager

Patrick M. Beecher, P.E.
Senior Principal

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REPORT TOPICS

Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

Bacliff Drainage Improvements
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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed improvements to be located at 10th Street and 15th Street in Bacliff, Texas. This project was authorized by Mr. Christopher W. Sallese, PMP, Executive V.P. with DEC, Inc. through signature of Subcontractor for Professional Services. This project was performed in general accordance with Terracon Proposal No. P91225005.Revision1 dated January 19, 2022.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Site and subgrade preparation
- Drainage improvement construction considerations:
    - Slope stability analysis
    - Temporary groundwater control and excavation considerations,
    - Erosion control, and
    - Bedding requirements for culvert replacement.

The geotechnical engineering Scope of Services for this project included the advancement of nine test borings to depths of approximately 15 feet below existing grade.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration.

Item	Description
Site location	The project site is located along the existing drainage areas along 10th Street and 15th Street in Bacliff, Texas.
Existing improvements	Existing drainage features are located within the right-of-ways.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated and our final understanding of the project conditions is as follows:

Item	Description
Proposed improvements	■ Approximately 3,800 linear feet of drainage channel is planned to be deepened to a maximum depth of 8 feet (N-16 ditch). The sideslopes of the canals are planned to be 3H:1V. ■ Replacement of the 15th Street culvert. ■ Removal and replacement of existing culvert crossing at 10th Street - erosion recommendations, bedding recommendations for new low water crossing, rehabilitation of existing low water crossing, and articulated blocks.

GEOTECHNICAL CHARACTERIZATION

Geology

Based on the geologic maps published by the Bureau of Economic Geology, the site for the proposed construction is located on the Beaumont formation, a deltaic nonmarine Pleistocene deposit. The Beaumont formation is heterogeneous containing thick interbedded layers of clay, fine sand, and silt.

The clay fraction is primarily composed of montmorillonite, illite, kaolinite, and finely ground quartz. The clay present in the formation has been preconsolidated by a process of desiccation. Numerous wetting and drying cycles have produced a network of small randomly oriented, closely-spaced joints within some depth zones. These small joints frequently have a shiny appearance and the clays are called slickensided in these cases. The joint pattern may have an influence on the construction and engineering behavior of the soil.

The coastal plain in this region has a complex tectonic geology, several major features of which are: Gulf Coastal geosyncline, salt domes, and major sea level fluctuations during the glacial stages, subsidence and geologic faulting activities. Most of these geologic faulting activities have ceased for millions of years, but some are still active. A detailed geologic fault investigation and study of the site geology are beyond the scope of this report.

Subsurface Profile

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Fill - Crushed Aggregate**	approximately 6 inches of crushed aggregate with sand and fines
2	**Lean Clay, Lean Clay with Sand, and Sandy Lean Clay**	reddish brown, tan, and gray, soft to hard, with ferrous and calcareous nodules, scattered roots, gravels, sand pockets, silt pockets and slickensides
3	**Fat Clay and Fat Clay with Sand**	reddish brown, tan, and gray, medium stiff to hard with ferrous and calcareous nodules and slickensides
4	**Clayey Sand and Poorly Graded Sand with Silt**	reddish brown, tan and gray, loose to medium dense, with clay pockets

Dispersion Potential

Five crumb tests and nine double hydrometer tests were performed for evaluation of the dispersive nature of the on-site soils at the location of the channel. The results are summarized below

Crumb Test and Double Hydrometer Test Results				
Boring No.	**Sample Depth (feet)**	**Soil Description**	**Crumb Test Grade**	**Double Hydrometer Test Results (% Dispersion)**
B-1	6 to 8	Fat Clay (CH)	--	11
B-2	4 to 6	Fat Clay (CH)	1	16
B-3	2 to 4	Lean Clay (CL)	--	55
B-3	8 to 10	Lean Clay (CL)	--	61
B-4	0 to 2	Lean Clay (CL)	1	13
B-5	2 to 4	Lean Clay (CL)	--	10
B-6	4 to 6	Lean Clay (CL)	1	21
B-7	0 to 2	Lean Clay (CL)	--	10
B-8	8 to 10	Fat Clay (CH)	2	17
B-9	10 to 12	Fat Clay (CH)	2	14

The crumb test may be used as an indicator of field performance of dispersive soils using the following evaluation of soil crumb reaction:

Grade 1: No dispersion problem.
Grade 2: Possible dispersion problem.
Grade 3 or 4: Definite dispersion problem.

The double hydrometer test may also be used as an indicator of the dispersive characteristics of clay soils. According to ASTM D4221-18, percent dispersion less than 30 percent indicates a nondispersive clay. When the percent dispersion ranges from 30 to 50 percent, it indicates an intermediate dispersive clay. If the percent dispersion is greater than 50 percent, it indicates a dispersive clay. The double hydrometer test results can be found in **Exploration Results**.

Based on the results of our dispersive potential testing, the soils in the location of the channel, culvert and crossing are typically non-dispersive in nature except at location B-3 which indicated to be dispersive. Dispersive soils are soils that easily erode by the individual soil particles going into suspension. The suspended soil particles are then carried away through cracks in soil fabric or washed away during rain events. This type of soil is often heterogeneously distributed within the subgrade. The presence of dispersive soil can result in significant erosion and piping/washout of the sideslopes. The application of lime to dispersive soils along the sideslopes and at the top of bank will help reduce erosion of the sideslopes due to dispersion. Terracon should be contacted for additional recommendations if lime treatment of the sideslopes and top of bank is desired to address dispersive soils.

Groundwater Conditions

Borings B-1 through B-9 were advanced using dry drilling techniques to their termination depths (approximately 15 feet) in an effort to evaluate groundwater conditions at the time of the field program. Upon reaching groundwater, drilling was suspended for a period of about 15 minutes to allow the groundwater to rise and the groundwater levels to be recorded. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results**.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the proposed improvements may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project and should be evaluated prior to construction.

GEOTECHNICAL OVERVIEW

- Fill soils were observed at the ground surface at boring B-9 and extended to a depth of approximately 6 inches below existing grade. Fill soils may be observed at varying depths at other locations within the site not explored during our field program. Support of the foundation elements, floor slabs, and pavements on or above existing fill materials is discussed in this report. However, even with the recommended construction procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill.

- Groundwater was initially observed at depths that ranged from about 10 to 13 feet during dry drilling. After a monitored period of about 15 minutes, groundwater was observed at depths that ranged from about 7 to 11½ feet below existing grade.
- Based on the soil and groundwater conditions observed, we anticipate that excavations will likely experience seepage. Seepage volume will be reduced in excavations extending into clays and increased if sands are encountered such as observed in Borings B-4 and B-5.

- Based on the crumb tests and double hydrometers tests results, the on-site clay soils are typically non-dispersive to in nature except in the area of B-3 which is dispersive in nature.

- Construction operations may encounter difficulties due to the wet or soft surface soils including rutting and pumping. If wet and/or soft conditions are present at the time of construction, remedial efforts may be necessary for preparation of the surficial soils. Tracked equipment operating above the level of the final excavation grade will reduce the disturbance and the need for subsequent remedial measures to the channel bottom and sideslopes.

- Terracon evaluated the soil and groundwater conditions and performed slope stability analyses of a proposed drainage channel with a depth of 8 feet and maximum sideslope declinations of about 3H:1V. The stability analyses were performed based on the cross-section information provided by Client. The slope stability analyses performed included short-term, long-term, and rapid-drawdown conditions. Based on the results from our slope stability analyses, the evaluated drainage channel configuration met the minimum safety factor requirements.

This summary should be used in conjunction with the entire report for design purposes. Details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The **General Comments** section provides an understanding of the report limitations.

WET WEATHER/SOFT SUBGRADE CONSIDERATIONS

Construction operations may encounter difficulties due to wet or soft surface soils becoming a general hindrance to equipment, especially following periods of wet weather. If the subgrade cannot be adequately compacted to the minimum densities as described previously, one of the following measures will be required: 1) removal and replacement with select fill, 2) chemical treatment of the soil to dry and improve the condition of the subgrade, or 3) drying by natural means if the schedule allows. Based on our experience with similar soils in this area, chemical treatment is generally an efficient and effective method to improve the condition of wet and weak subgrade. Terracon should be contacted for additional recommendations if chemical treatment is needed due to soft and wet subgrade.

RECOMMENDATION FOR DRAINAGE CHANNEL

Drainage Channel

As mentioned previously, the proposed drainage channel is planned to have a depth of 8 feet with a sideslope configuration on the order of about 3H:1V. If the sideslopes or depth of the proposed channel differ from what is stated in this report, Terracon should be contacted to reevaluate the stability of the proposed channel. The following paragraphs present our recommendations regarding the excavation of the channel and sideslopes, and discussion of groundwater control.

Slope Stability Analysis

Slope stability analyses were performed utilizing a commercial slope stability software program, SLIDE. This software calculates the factor of safety against slope failure using a two-dimensional limiting equilibrium method. The factors of safety for analyzing slope stability were computed utilizing the Bishop (simplified) method. The slope stability analyses for the short-term, long-term, and rapid drawdown conditions were performed considering cross-sections provided by DEC, Inc. Our stability analysis included the following conditions:

- Short-Term – This condition was analyzed to evaluate the overall stability of the slopes after construction is complete. Short term (total stress) soil parameters were utilized because the soil is not anticipated to have had time to drain since completion of construction. A surcharge of 250 psf was also imposed at the top of the drainage channel's bank to account for the presence of construction equipment. This surcharge load does not include excavation spoils; excavated materials should not be stockpiled within 20 feet of the slope crest.

- Long-Term – The long-term case represents steady state piezometric and stress conditions. When a slope is excavated, altered stress conditions create pore pressure changes within the slope and the undrained strength of the bank soils is mobilized. With time, the soil pore pressures adjust to the imposed stress and piezometric conditions, and the bank soils rely on their available strength for long-term stability. Therefore, effective stress soil parameters were used in these analyses. Weathered parameters were also considered in our analyses for cross sections with unprotected slopes. The water level inside the channel was assumed be at the bottom of the channel or at the groundwater level observed in our field program, whichever was lower. A surcharge of 150 psf was also imposed at the top of the drainage channel's bank to account for traffic and occasional maintenance vehicles.

- Rapid Drawdown – A rapid drawdown condition is considered to occur when the drainage channel contains water for a time sufficient to allow saturation of the soils near the surface of the embankment. The channel then drains completely within a short time frame such that the water that has infiltrated the embankment soils does not dissipate, thereby imposing additional driving loads on the channel sideslopes. The rapid drawdown condition was evaluated utilizing effective stress soil parameters. Weathered parameters were also considered in our analyses for cross sections with unprotected slopes. The water level behind the bank was assumed at top of the bank and the water level inside the channel was assumed at the surface of the sideslopes and at the bottom of the channel.

Soil Profile

Based on the field and laboratory test results and our experience with similar subsurface soil conditions, the strength parameters in the following table were used in the stability analyses.

Soil Description	Depth (feet)	Total Unit Weight (pcf)	Short-Term		Long-Term/ Rapid Drawdown		Weathered Parameters	
			c_u (psf)	ϕ_u (deg)	c' (psf)	ϕ' (deg)	c' (psf)	ϕ' (deg)
Lean Clay	6	130	1,500	0	150	15	80	15
Lean Clay and Fat Clay	10	125	1,000	0	100	15	80	15
Sand	15	125	0	23	0	23	--	--

Where,

c_u Undrained Cohesion
ϕ_u Angle of Internal Friction
c' Consolidated-Drained Cohesion
ϕ' Consolidated-Drained Friction Angle
c_r' Consolidated-Drained Residual Cohesion
ϕ_r' Consolidated-Drained Residual Friction Angle

Results of Stability Analyses

The results of the analyses are summarized in the following table and are also presented in **FIGURES.**

Location	Computed Factor of Safety		
	Short-Term	Long-Term	Rapid Drawdown
3 Horizontal to 1 Vertical Slope	2.9	1.5	1.3
Minimum Acceptable Factor of Safety	1.3	1.5	1.25

The preceding table indicates the slope stability factors of safety for the configurations analyzed exceed the minimum safety factor requirements for the short-term, long-term, and rapid drawdown conditions. If the final geometric configurations are different from those analyzed, Terracon should be contacted to review and revise our analyses, if necessary.

Temporary Groundwater Control

Based on the soil and groundwater information obtained during our field activities, we anticipate that excavations for the channel that extend into the clay soils may occur without advance dewatering. Seepage from the clay soils is expected to be minor and can be managed by pumping water collected within sumps positioned in the bottom of the excavation.

However, excavations that extend into or through zones of sandy soils, which were observed at B-4 and B-5 as shallow as about 8 feet, may require some form of advance dewatering, such as vacuum well points, depending on the groundwater conditions at the time of construction. However, vacuum well points are generally less effective below a depth of about 15 feet beneath the top of the well point. In addition, dewatering with well points may not be effective in zones containing significant amounts of fine-grained soils. Deeper dewatering typically requires eductors or deep wells with submersible pumps or multiple-stage well point systems depending on the groundwater conditions at the time of construction.

The suggested method given above serves as a guideline for groundwater control. Other appropriate means may be required for groundwater control during construction. Control of groundwater should be accomplished in a manner that will preserve the strength of the soils, will not cause instability of the excavation, and will not result in damage to existing structures, if any. If necessary, the water should be lowered in advance of excavation by well points, deep wells, eductors, or similar methods. Open pumping should not be permitted if it results in boils, loss of fines, softening of the subgrade, or excavation instability. Well points, deep wells, and eductors should be installed with suitable screen and filter so that pumping of fines does not occur.

If advance dewatering is needed, the dewatering system should be in operations for at least several days prior to excavating to the design depths. We recommend that the groundwater head be lowered at least 3 feet below the bottom of the excavation to provide a working area with increased stability. The dewatering should continue until construction has been completed.

Dewatering of loose to medium dense sands might cause subsidence or compression of adjacent soils, in spite of safeguards and methodology selected and used. For this reason, the dewatering operations must be performed and provided with great care to ensure caution and control of the potential subsidence resulting from the dewatering operations.

As stated previously, the groundwater levels will fluctuate with seasonal and climatic changes and should be evaluated just prior to construction. To further evaluate groundwater at the time of construction, piezometers can be set just prior to construction. As an alternative, test pits may be excavated to the planned channel depth. Based on the results, the contractor should determine effective methods of groundwater management prior to starting excavation operations.

Erosion Control

If water flow is permitted along the sideslopes of the channel, the near-surface soils will likely erode, causing gradual steepening and subsequent sloughing of the sideslopes. Therefore, the sideslopes should be protected against sheet flow down the banks or concentrated high velocity water flow. Measures to protect the sideslopes may include slope paving, rip-rap, geofabrics, or even vegetation with an aggressive root system. Routine maintenance of the sideslopes should be performed to reconstruct areas where sloughing and/or erosion have occurred.

RECOMMENDATION FOR CULVERT AND CROSSING

Allowable Bearing Capacity

As stated previously, we understand that the proposed culvert is planned to be installed at a maximum depth of 8 feet below existing grade. Based on the subsurface soil conditions, the bottom of the culvert should be placed to bear in the native clay soils. If the culvert is constructed upon the native clay soils at a depth of 8 feet below existing grade, the foundations may be sized utilizing a net allowable bearing pressure of 1,500 psf. This allowable bearing pressure is based on the assumption that the base of the foundation excavation is relatively dry, undisturbed, and clean of loose soil. The bearing surface should be evaluated immediately prior to placing concrete.

Lateral Earth Pressure

The backfill soils adjacent to the culvert will impose active to at-rest earth pressures against the wall. The backfill should be compacted to 95 percent of the Standard Effort (ASTM D698) maximum dry density. Design lateral earth pressures may be computed using an equivalent fluid weight of 90 pounds per cubic foot (pcf) for clean sand backfill and 110 pcf for on-site clay soils or select fill soils. This pressure includes hydrostatic pressures but does not include surcharge forces imposed by construction or vehicular loading. The lateral pressure produced by surcharge may be computed as 50 percent of the vertical surcharge pressure applied as a constant pressure over the full depth of the wall. A 2-foot layer of compacted clay soil should be placed at the top of sand backfill to reduce the amount of infiltration of surface water.

Excavation Considerations

The sides may either be sloped or formed with vertical cuts. For vertical sided excavations greater than 5 feet in depth, the excavations will require the use of shoring, bracing or some form of retention to prevent sloughing and caving of the soil into the excavation.

OSHA standards provide recommendations for the design of temporary sloped excavations with a depth more than 5 feet and less than 20 feet. The OSHA standards provide maximum allowable slopes contingent on three designated soil types: Type A, Type B, and Type C. According to OSHA standards, temporary sloped excavations should be no steeper than 0.75-horizontal on 1-vertical (0.75H:1V) for Type A soils, 1H:1V for Type B soils, and 1.5H:1V for Type C soils. The soils type should be evaluated by a contractor designated Competent Person at the time of construction. The surface soils should be protected from deterioration and weathering if they are left open for significant periods of time.

As a safety measure, no equipment should be operated within 5 feet of the edge of the underground excavation and no materials should be stockpiled within 10 feet of the excavation.

Excavations should not approach closer than 10 feet from existing structures/facilities without some form of protection for the facilities.

Excavations must be performed and inspected under the supervision of a contractor designated Competent Person. The Competent Person, as defined by the OSHA Standard, 29 CFR Part 1926.650 to .652, Subpart P – Excavations, must evaluate the excavations at the time of construction activity to safeguard workers.

Excavations should be performed with equipment capable of providing a relatively clean bearing area. Excavating equipment should not disturb the soil beneath the design excavation bottom and should not leave large amounts of loose soil in the excavation. The excavation bottom should be properly sloped to allow any water infiltrating into the excavation to be collected at a convenient location along the edge of the excavation. Water should not be allowed to stand on the bearing area.

Temporary Groundwater Control

The groundwater control should be operated as discussed in the **RECOMMENDATION FOR DRAINAGE CHANNEL - Temporary Groundwater Control** section of this report.

Culvert Bedding

The subgrade and bedding for the box culvert should conform to the Harris County standards on bedding details. Standard bedding details for box culverts in dry stable trench conditions are outlined on Harris County Public Infrastructure Department, Architecture and Engineering Division (HCPID, AED) Drawing No. HC480-1. For excavations that penetrate into the silty/sandy soils or terminate below groundwater, bedding details for unsatisfactory soil conditions should be used as shown on HCPID, AED Drawing No. HC480-2. Since groundwater levels and subsurface conditions can vary, the decision should be made at the time of construction, based on actual observations and the response of the soil and water to open trenching and dewatering. The excavations should be monitored to detect any variation in soil conditions from those found in the borings drilled for this report. Any changes noted in the soil stratigraphy should be brought to the attention of Terracon so that the conditions may be assessed and changes to the required bedding details and/or recommendations made, as necessary.

Culvert Backfill

As previously discussed, the surface above the culvert is planned to be paved. The backfill within pavement areas and within 3 horizontal feet of pavement should consist of cement stabilized sand to within 12 inches of the top of the subgrade compacted to at least 95 percent of the Standard Effort (ASTM D558) maximum dry density. On-site clean soils compacted to at least 95 percent of the Standard Effort (ASTM D698) maximum dry density should be placed above the cement stabilized sand. The subgrade soils immediately below the pavement may require chemical treatment as part of the pavement design. Prior to any filling operations, samples of the proposed borrow materials should be obtained for laboratory moisture-density testing. The tests will provide a basis for evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to verify that proper levels of compaction are being attained. We understand that pavement designs will be provided by others.

GENERAL COMMENTS

Our work is conducted with the understanding of the project as described in the proposal, and incorporated collaboration with the design team as we completed our services to verify assumptions. Revision of our understanding to reflect actual conditions important to our work was based on these verifications and it is reflected in this report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from our site exploration and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other services should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third party beneficiaries intended. Any third party access to services or correspondence is solely for information purposes only. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing.

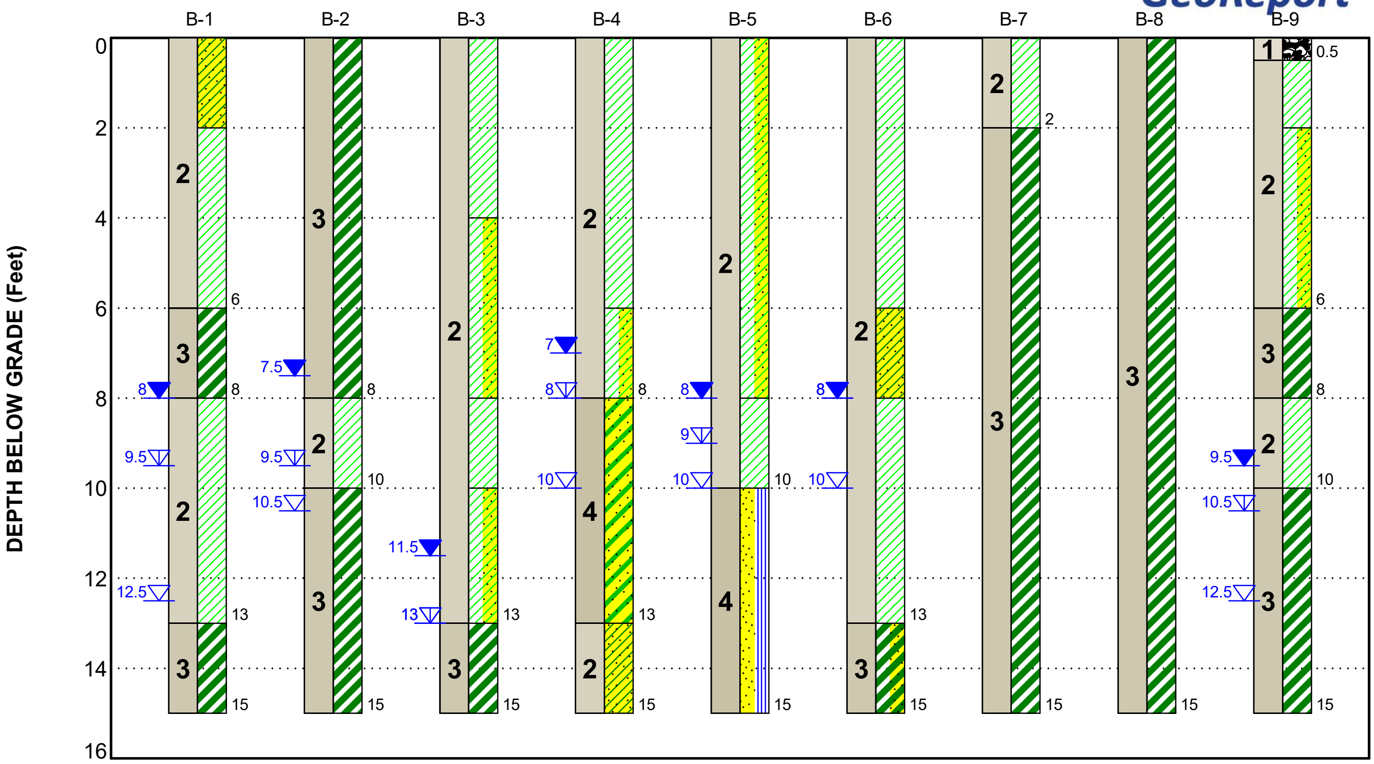
FIGURES

Contents:

GeoModel
Slope Stability Analysis (Short Term, Long Term and Rapid Drawdown)

GEOMODEL

Bacliff Drainage Improvements ■ Bacliff, Texas
Terracon Project No. 91225002



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Fill - Crushed Aggregate	approximately 6 inches of crushed aggregate with sand and fines
2	Lean Clay, Lean Clay with sand, and Sandy Lean Clay	reddish brown, tan, and gray, soft to hard, with ferrous and calcareous nodules, scattered roots, gravels, sand pockets, silt pockets and slickensides
3	Fat Clay and Fat Clay with Sand	reddish brown, tan, and gray, medium stiff to hard with ferrous and calcareous nodules and slickensides
4	Clayey Sand and Poorly Graded Sand with Silt	reddish brown, tan and gray, loose to medium dense, with clay pockets

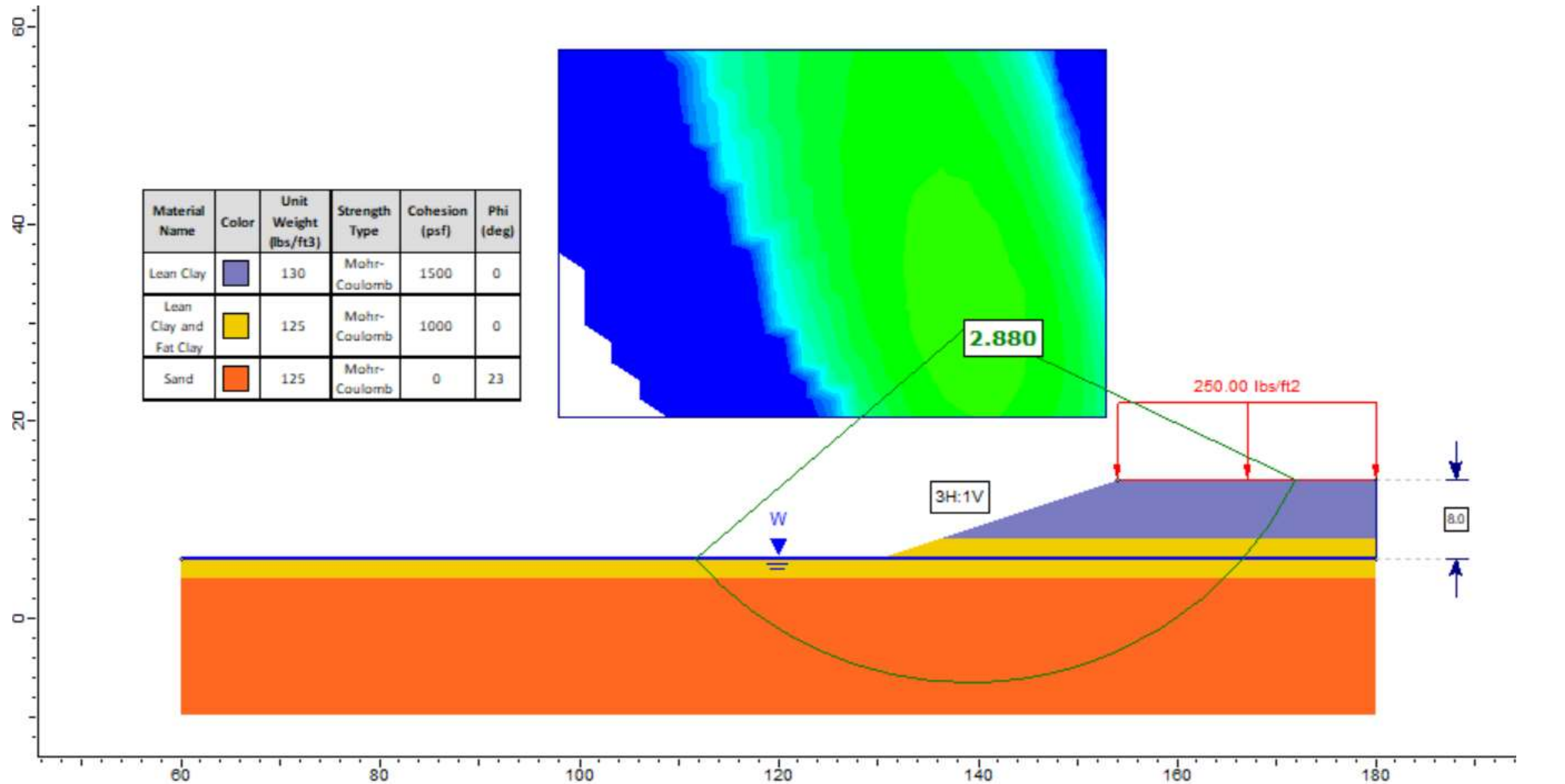
LEGEND

- Sandy Lean Clay
- Lean Clay
- Fat Clay
- Lean Clay with Sand
- Clayey Sand
- Poorly-graded Sand with Silt
- Fat Clay with Sand
- Fill

- First Water Observation
- Second Water Observation
- Third Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Lean Clay		130	Mohr-Coulomb	1500	0
Lean Clay and Fat Clay		125	Mohr-Coulomb	1000	0
Sand		125	Mohr-Coulomb	0	23

Terracon

Consultants Inc.

Texas Registration 3272

551 League City Parkway, Suite F

League City, Texas 77573

Drainage Channel

Short Term Analysis (Simplified Bishop's Method)

Drawn by: RC

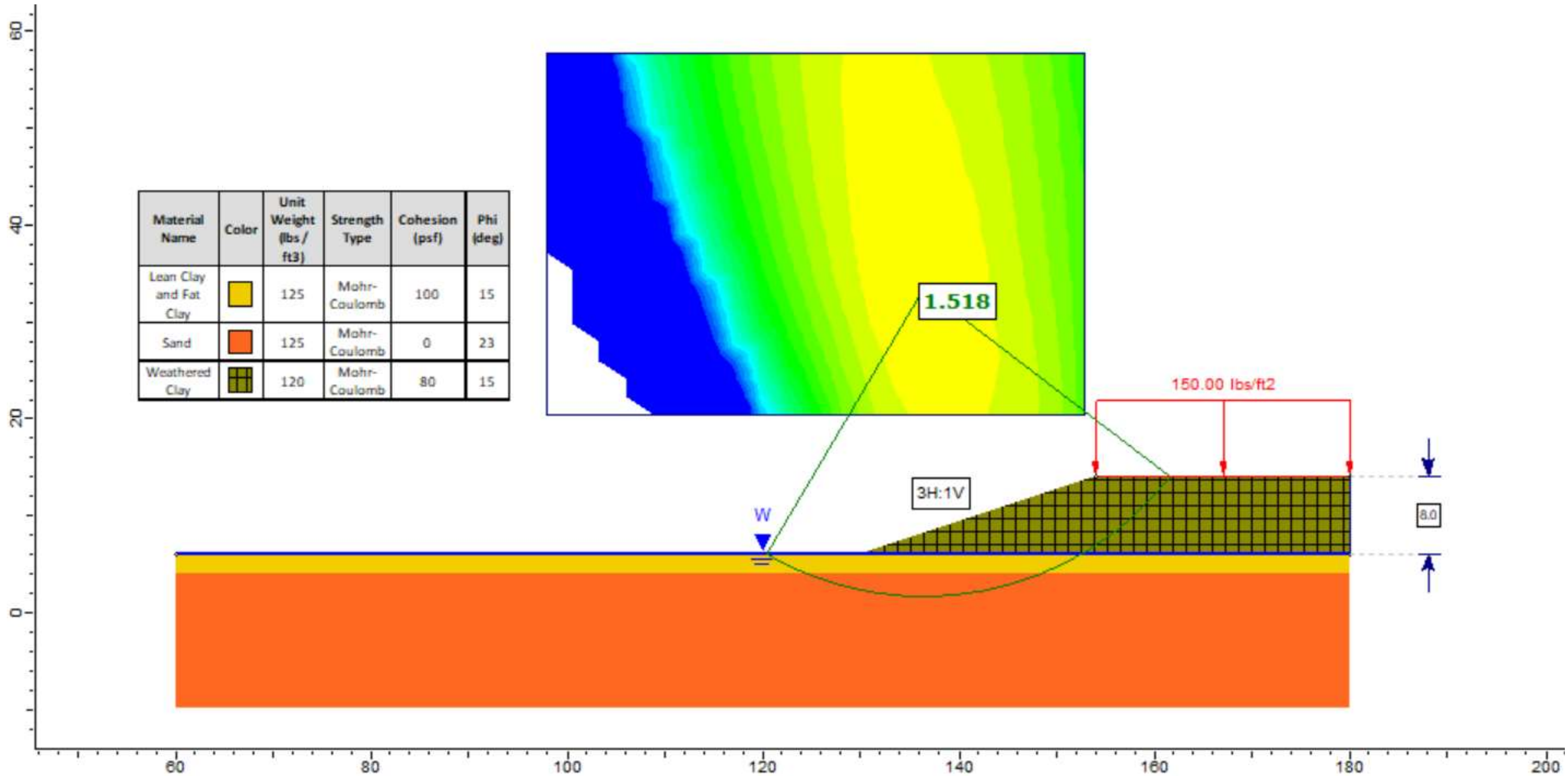
Reviewed by: JCM

Approved by: PMB

Bacliff Drainage Improvements

Terracon Project Number 91225002

Stability Figure 1



Material Name	Color	Unit Weight (lbs / ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Lean Clay and Fat Clay		125	Mohr-Coulomb	100	15
Sand		125	Mohr-Coulomb	0	23
Weathered Clay		120	Mohr-Coulomb	80	15

Terracon

Consultants Inc.

Texas Registration 3272

551 League City Parkway, Suite F

League City, Texas 77573

Drainage Channel

Long Term Analysis (Simplified Bishop's Method)

Drawn by: RC

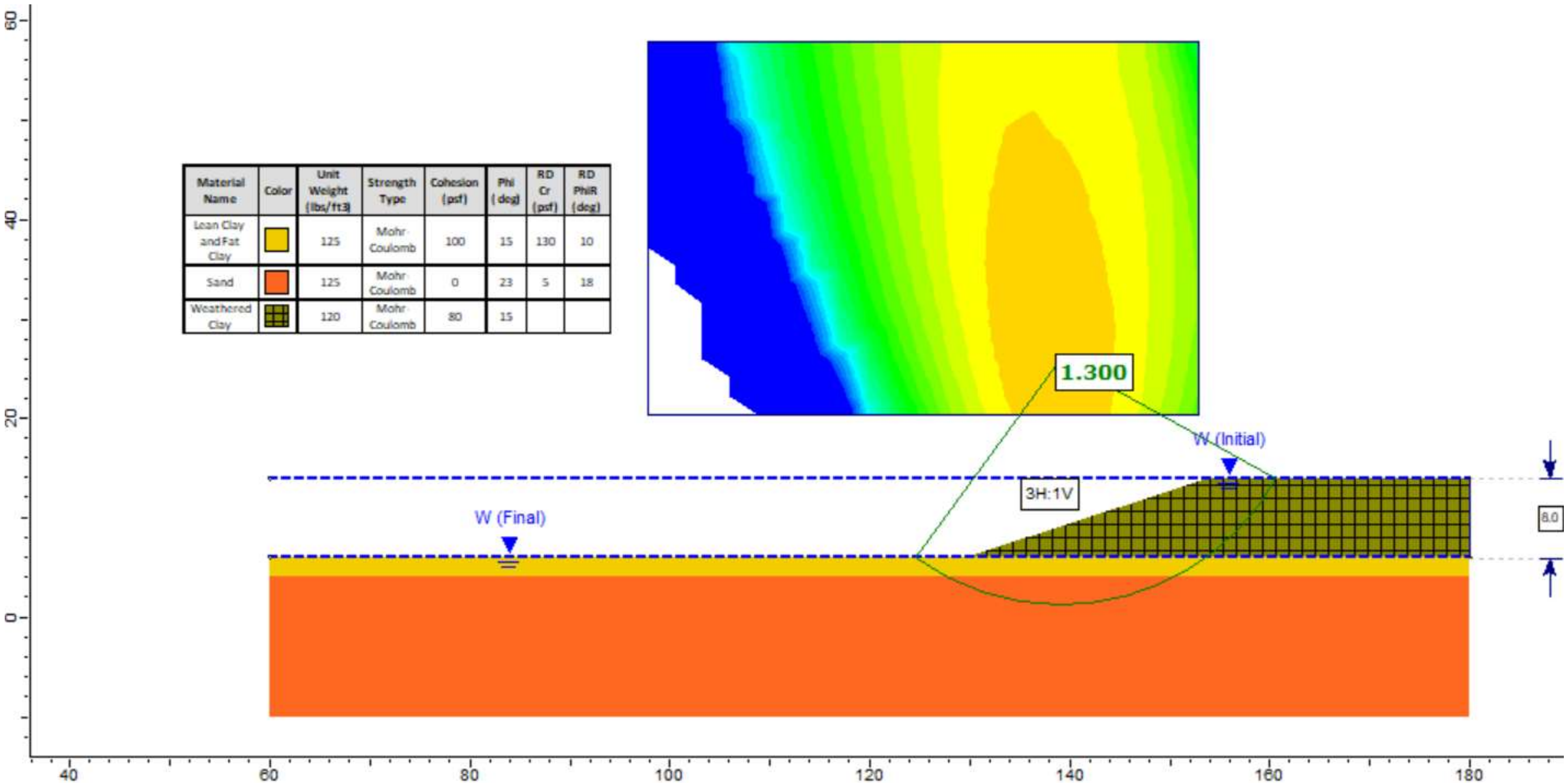
Reviewed by: JCM

Approved by: PMB

Bacliff Drainage Improvements

Terracon Project Number 91225002

Stability Figure 2



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	RD Cr (psf)	RD PhiR (deg)
Lean Clay and Fat Clay		125	Mohr-Coulomb	100	15	130	10
Sand		125	Mohr-Coulomb	0	23	5	18
Weathered Clay		120	Mohr-Coulomb	80	15		

Terracon

Consultants Inc.

Texas Registration 3272

551 League City Parkway, Suite F

League City, Texas 77573

Drainage Channel

Rapid Drawdown Analysis (Simplified Bishop's Method)

Drawn by: RC

Reviewed by: JCM

Approved by: PMB

Bacliff Drainage Improvements

Terracon Project Number 91225002

Stability Figure 3

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Boring Location
6 (B-1 through B-6)	15	East of 10th Street
2 (B-7 and B-8)	15	Along 10th Street
1 (B-9)	15	15th Street

Boring Layout and Elevations: We used handheld Global Positioning System (GPS) equipment to locate the approximate latitude and longitude of the borings with an accuracy of +/-25 feet. The boring depths were measured from the existing ground surface at the time of our field activities.

Subsurface Exploration Procedures: We advanced soil borings with an all-terrain vehicle (ATV) mounted drill rig using solid stem auger and wet rotary drilling techniques. Samples were obtained at 2-foot intervals in the upper 12 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was typically performed using open-tube and/or split-barrel sampling procedures.

Cohesive soil samples were generally recovered using open-tube samplers. Hand penetrometer tests were performed on samples of cohesive soils in the field to serve as a general measure of consistency.

Granular soils and soils for which good quality open-tube samples could not be recovered were sampled by means of the Standard Penetration Test (SPT). This test consists of measuring the number of blows (N) required for a 140-pound hammer free falling 30 inches to drive a standard split-spoon sampler 12 inches into the subsurface material after being seated six inches. This blow count or SPT "N" value is used to evaluate the stratum. An automatic SPT hammer was used in advancing the split-spoon sampler at the borings. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT N-values and soil properties are based on the lower efficiency cathead and rope method. The higher efficiency of an automatic SPT hammer affects the SPT N-value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method.

The samples were placed in appropriate containers, taken to our soil laboratory for testing, and classified by a geotechnical engineer. In addition, we observed and recorded groundwater levels during drilling and sampling. We backfilled the borings with auger We backfilled the borings with auger cuttings after completion.

Our exploration team prepared field boring logs as part of standard drilling operations including sampling depths, penetration distances, and other relevant sampling information. Field logs include visual classifications of materials observed during drilling, and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent an interpretation of the field logs by a geotechnical engineer and include modifications based on laboratory observation and tests on select samples.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. The laboratory testing performed included the following tests:

- Moisture content
- Unit weight
- Atterberg limits
- Percent finer than No. 200 sieve
- Unconfined compressive strength
- Crumb tests
- Double hydrometer tests

Our laboratory testing program included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System (USCS).

Samples not tested in the laboratory will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless we are notified otherwise.

SITE LOCATION AND EXPLORATION PLAN

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Bacliff Drainage Improvements ■ Bacliff, Texas

June 21, 2022 ■ Terracon Project No. 91225002

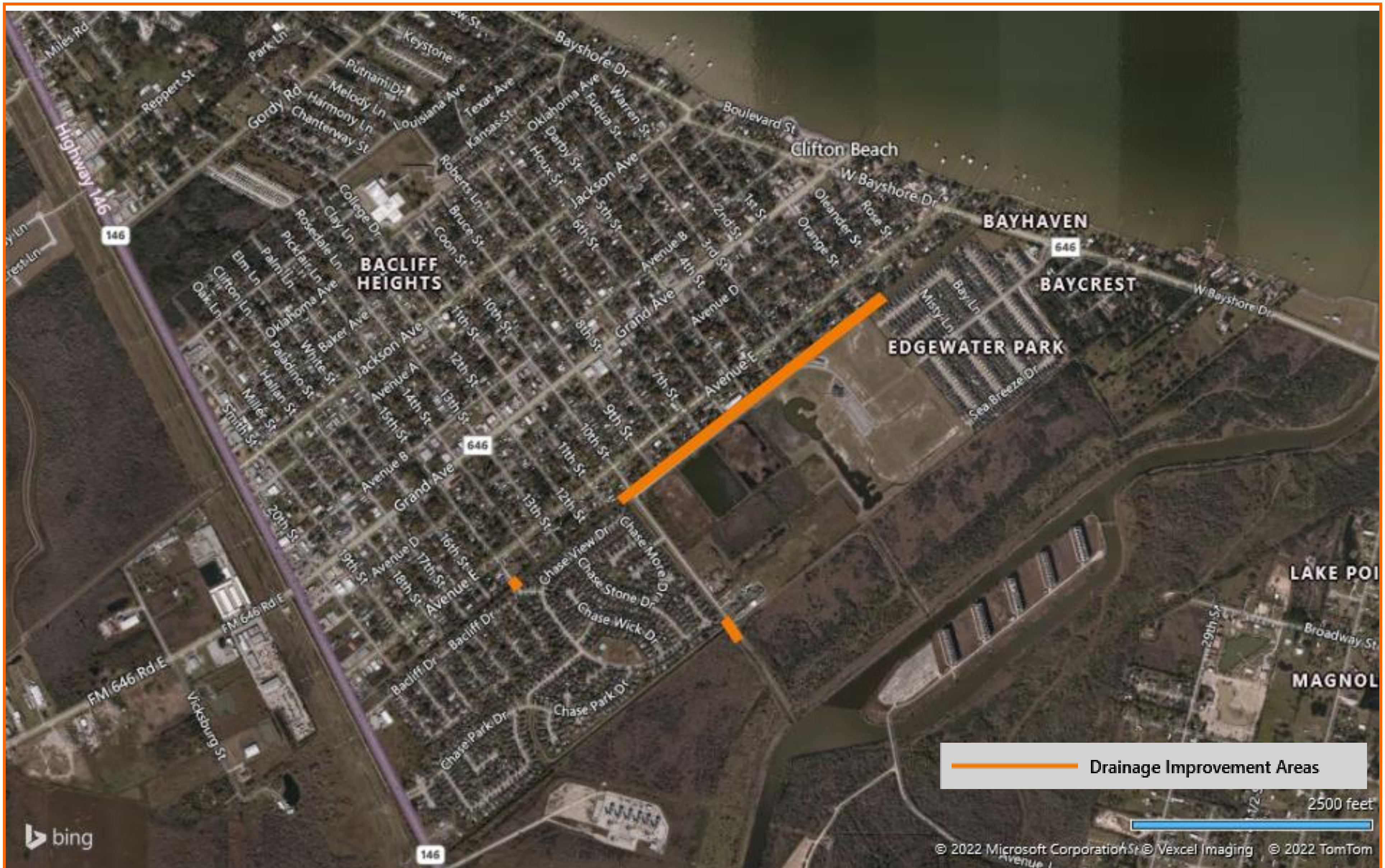


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Bacliff Drainage Improvements ■ Bacliff, Texas
June 21, 2022 ■ Terracon Project No. 91225002

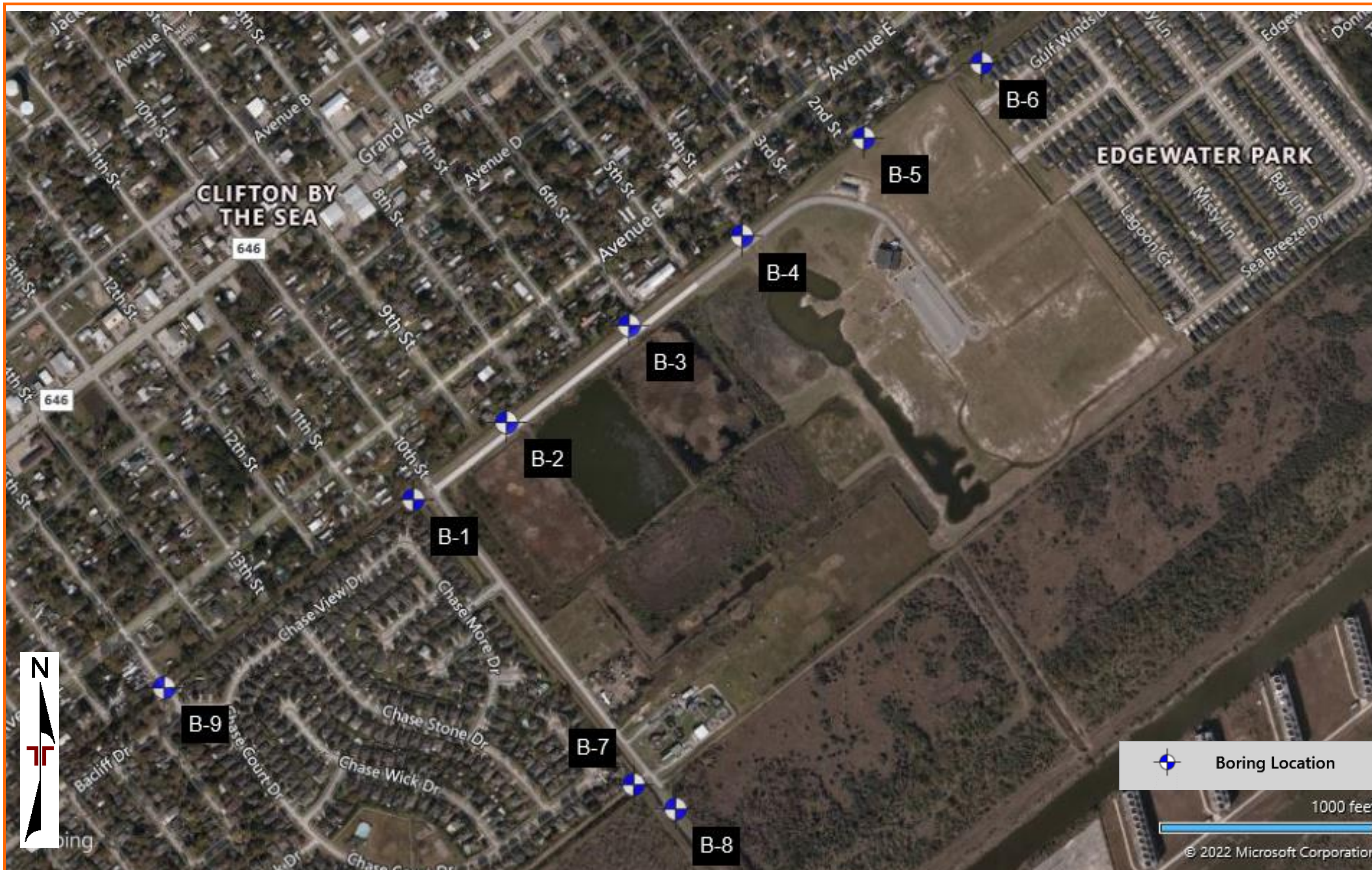


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc Houston, Texas

SITE: 10th Street and 15th Street Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.5013° Longitude: -94.9843°

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		2.0	**SANDY LEAN CLAY (CL)**, tan and gray, very stiff, with calcareous nodules, scattered roots and gravel				4.5+ (HP)	UC	4.34	6.5	9.5	122	41-15-26	66
2			**LEAN CLAY (CL)**, tan and gray, stiff to very stiff, with calcareous nodules				4.0 (HP)				21.0			
		6.0	- with ferrous nodules 4 to 6 feet	5			1.75 (HP)	UC	1.55	13.7	15.6	112	48-20-28	
3		8.0	**FAT CLAY WITH SAND (CH)**, reddish brown and light gray, very stiff, with calcareous nodules		After 15 minutes		4.25 (HP)				21.3		55-17-38	84
2			**LEAN CLAY (CL)**, reddish brown and light gray, soft to very stiff		After 5 minutes		2.25 (HP)				23.8			
				10			0.75 (HP)	UC	0.47	3.1	21.2	105	30-23-7	90
		13.0			While drilling									
3		15.0	**FAT CLAY (CH)**, reddish brown and light gray, very stiff	15			4.0 (HP)				27.5			

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

While drilling

After 5 minutes

After 15 minutes

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-12-2022	Boring Completed: 04-12-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

BORING LOG NO. B-2

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc
Houston, Texas

SITE: 10th Street and 15th Street
Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.5023° Longitude: -94.9830°

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
3		**FAT CLAY (CH)**, tan and gray, stiff to very stiff - with calcareous nodules 0 to 2 feet				4.5 (HP)					13.4			
						2.0 (HP)	UC	1.54	14.9		19.9	107	53-20-33	
		- tan and light gray 4 to 8 feet - with calcareous nodules 4 to 6 feet	5			1.5 (HP)					22.0		57-16-41	77
		- with ferrous nodules 6 to 8 feet 8.0		▼		1.75 (HP)					19.5		50-23-27	84
2		**LEAN CLAY (CL)**, tan and light gray, medium stiff, with sand pockets 10.0		▽		1.0 (HP)					20.7			
3		**FAT CLAY (CH)**, reddish brown and light gray, medium stiff to very stiff - with calcareous nodules 10 to 13 feet	10	▽		0.75 (HP)					23.4			
		15.0	15			3.0 (HP)	UU	2.00	3.9	12	24.2	100	67-22-45	98

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *While drilling*
- ▽ *After 5 minutes*
- ▼ *After 15 minutes*

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-12-2022	Boring Completed: 04-12-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

BORING LOG NO. B-3

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc
Houston, Texas

SITE: 10th Street and 15th Street
Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.5035° Longitude: -94.9812°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2		**LEAN CLAY (CL)**, tan and gray, stiff to hard - with calcareous nodules and scattered roots 0 to 2 feet				4.5 (HP)	UC	4.22	4.4	13.4	105	39-18-21	
		- with silt pockets 2 to 4 feet 4.0				1.75 (HP)				23.8		45-16-29	87
		LEAN CLAY WITH SAND (CL), tan and gray, stiff to very stiff - with silt pockets 4 to 6 feet	5			1.25 (HP)	UC	1.14	12.5	19.3	107	49-20-29	72
		- with ferrous nodules 6 to 8 feet 8.0				2.25 (HP)				19.0			
		LEAN CLAY (CL), reddish brown and light gray, stiff, with ferrous nodules 10.0				1.75 (HP)				25.4		42-16-26	92
		LEAN CLAY WITH SAND (CL), reddish brown and light gray, medium stiff	10	▼ (After 15 minutes)		1.0 (HP)	UC	0.88	7.1	22.2	102	43-24-19	84
		13.0		▽ (While drilling)									
3		**FAT CLAY (CH)**, reddish brown and light gray, very stiff 15.0				3.75 (HP)				23.4			
		Boring Terminated at 15 Feet	15										

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *While drilling*
- ▽ *After 5 minutes*
- ▼ *After 15 minutes*

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-12-2022	Boring Completed: 04-12-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

BORING LOG NO. B-4

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc Houston, Texas

SITE: 10th Street and 15th Street Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.5047° Longitude: -94.9795°

Model Layer	Depth	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**LEAN CLAY (CL)**, tan and gray, very stiff - with scattered roots 0 to 2 feet				4.5+ (HP)				10.6		40-15-25	
		- with silt pockets 2 to 6 feet.				3.5 (HP)	UC	2.01	5.4	11.2	120	45-18-27	
	6.0		5			3.75 (HP)				13.2			
	8.0	**LEAN CLAY WITH SAND (CL)**, reddish brown and light gray, very stiff		After 15 minutes; After 5 minutes		2.5 (HP)				18.9			
4		**CLAYEY SAND (SC)**, tan and reddish brown, loose		While drilling		2-3-3 N=6				24.0		28-19-9	24
	13.0		10			2-2-2 N=4				27.0			
2	15.0	**SANDY LEAN CLAY (CL)**, tan and reddish brown, medium stiff	15			2-3-3 N=6				28.1		27-19-8	65
		Boring Terminated at 15 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
- *While drilling*
- *After 5 minutes*
- *After 15 minutes*

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-12-2022	Boring Completed: 04-12-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

BORING LOG NO. B-5

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc Houston, Texas

SITE: 10th Street and 15th Street Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.5059° Longitude: -94.9778°

MODEL LAYER	DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2		**LEAN CLAY WITH SAND (CL)**, tan and gray, stiff to hard - with calcareous nodules and scattered roots 0 to 2 feet				4.5+ (HP)	UC	5.36	4.9		14.1	111	37-19-18	
						3.0 (HP)					16.7		36-15-21	80
		- with ferrous nodules 2 to 8 feet	5			1.5 (HP)	UC	1.59	14.5		17.8	110	41-19-22	79
	8.0	- with calcareous nodules 6 to 8 feet				1.25 (HP)					20.3			
	10.0	**LEAN CLAY (CL)**, tan and light gray, stiff	10			1.75 (HP)	UU	1.04	9	8	19.0	113		
4		**POORLY GRADED SAND WITH SILT (SP-SM)**, light gray, loose to medium dense - with clay pockets 10 to 13 feet				2-6-7 N=13					24.1			
	15.0		15			1-2-2 N=4					26.7		25-22-3	8
		Boring Terminated at 15 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- *While drilling*
- *After 5 minutes*
- *After 15 minutes*

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-12-2022	Boring Completed: 04-12-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

BORING LOG NO. B-6

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc
Houston, Texas

SITE: 10th Street and 15th Street
Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.5069° Longitude: -94.9760°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2		**LEAN CLAY (CL)**, tan and gray, very stiff to hard				4.5+ (HP)					11.2			
		- with scattered roots 0 to 2 feet - with ferrous nodules 2 to 4 feet				4.5+ (HP)	UC	4.94	10.8		15.5	113	55-18-37	
		6.0	5			4.5+ (HP)					16.3		55-16-39	86
		SANDY LEAN CLAY (CL), tan and light gray, soft 8.0		After 15 minutes		0.5 (HP)					25.9			
		LEAN CLAY (CL), reddish brown and light gray, soft - with calcareous nodules 8 to 10 feet		After 5 minutes		2-2-2 N=4					22.8		32-17-15	86
			10			0.5 (HP)	UU	0.40	7	9	24.4	125		
		13.0												
3		**FAT CLAY WITH SAND (CH)**, reddish brown and light gray, medium stiff 15.0	15			3-3-5 N=8					26.2		64-29-35	84
		Boring Terminated at 15 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
- *While drilling*
- *After 5 minutes*
- *After 15 minutes*

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-13-2022	Boring Completed: 04-13-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

BORING LOG NO. B-7

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc Houston, Texas

SITE: 10th Street and 15th Street Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.4977° Longitude: -94.9811°

MODEL LAYER	GRAPHIC LOG	DEPTH / Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
2		**LEAN CLAY (CL)**, dark gray, very stiff, with slickensides				4.5+ (HP)					15.4		49-16-33	88
		2.0												
3		**FAT CLAY (CH)**, tan and gray, stiff to very stiff - with slickensides 2 to 4 feet				4.0 (HP)	UC	2.16	6.6		21.0	106	60-21-39	
		- with ferrous nodules 4 to 8 feet	5			1.5 (HP)					26.5			
		- tan and light gray 6 to 8 feet - with calcareous nodules 6 to 10 feet				1.5 (HP)	UC	1.04	15		22.5	103	59-24-35	86
		- reddish brown and light gray below 8 feet				2.25 (HP)					22.5			
		- with slickensides 10 to 13 feet	10			2.25 (HP)	UU	1.59	4.7	8	26.4	101		87
						2.5 (HP)					22.3			
		15.0	15											
		Boring Terminated at 15 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-13-2022 | Boring Completed: 04-13-2022
Drill Rig: Geoprobe | Driller: R.Bauer
Project No.: 91225002

BORING LOG NO. B-8

PROJECT: Bacliff Drainage Improvements

CLIENT: DEC, Inc
Houston, Texas

SITE: 10th Street and 15th Street
Bacliff, Texas

LOCATION See Exploration Plan

Latitude: 29.4974° Longitude: -94.9805°

MODEL LAYER	DEPTH	Description	DEPTH (Ft.)	FIELD TEST RESULTS	TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
3		**FAT CLAY (CH)**, tan and gray, stiff to hard - with scattered roots 0 to 2 feet		4.5+ (HP)	UC	4.18	7.2	23.9	102	52-16-36	
		- with ferrous nodules 2 to 10 feet		2.5 (HP)				22.4			
			5	1.75 (HP)	UC	1.44	15	24.4	101	57-21-36	91
	8.0	- tan and light gray, with calcareous nodules 6 to 8 feet		1.75 (HP)				25.1			
	10.0	**FAT CLAY WITH SAND (CH)**, reddish brown and light gray, very stiff		2.5 (HP)				23.7		61-17-44	82
		FAT CLAY (CH), reddish brown and light gray, stiff, with slickensides 10 to 12 feet	10	1.75 (HP)	UC	1.05	3.6	29.5	101		
	15.0			3.75 (HP)				20.0			
		Boring Terminated at 15 Feet	15								

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-12-2022	Boring Completed: 04-12-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

BORING LOG NO. B-9

PROJECT: Bacliff Drainage Improvements

**CLIENT: DEC, Inc
Houston, Texas**

**SITE: 10th Street and 15th Street
Bacliff, Texas**

LOCATION See Exploration Plan

Latitude: 29.4989° Longitude: -94.9880°

MODEL LAYER	DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	FIELD TEST RESULTS	TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	0.5	**FILL - CRUSHED AGGREGATE**, apporximately 6 inches of crushed aggregate with sand and fines											
2	2.0	**LEAN CLAY (CL)**, tan and gray, with scattered gravel and roots											
2	6.0	**LEAN CLAY WITH SAND (CL)**, tan and gray, very stiff, with ferrous and calcareous nodules			4.5 (HP)					16.9			
			5		2.75 (HP)	UC	2.69	14.3		15.8	112	48-20-28	76
3	8.0	**FAT CLAY (CH)**, reddish brown and light gray, stiff			2.25 (HP)	UU	1.88	11.1	6	18.8	114	55-15-40	
2	10.0	**LEAN CLAY (CL)**, reddish brown and light gray, medium stiff		After 15 minutes	0.75 (HP)	UC	0.62	6		21.1	104	36-21-15	
3	15.0	**FAT CLAY (CH)**, reddish brwon and light gray, medium stiff to stiff	10	After 5 minutes	1.5 (HP)					27.0		61-20-41	92
				While drilling									
		- with slickensides below 13 feet			2.75 (HP)	UC	1.00	4.7		29.3	92	76-32-44	
		Boring Terminated at 15 Feet	15										

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to a depth of about 15 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

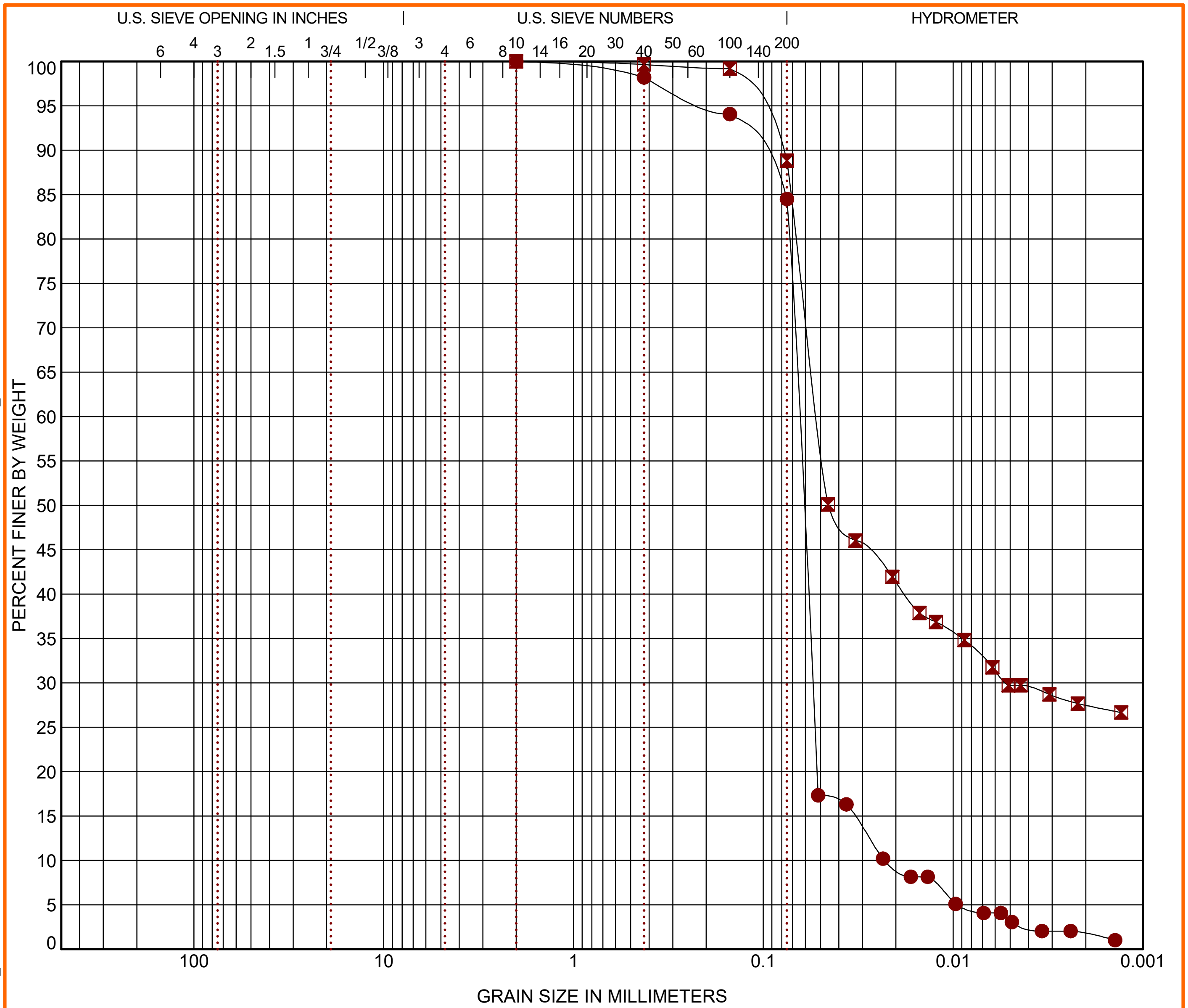
WATER LEVEL OBSERVATIONS
- *While drilling*
- *After 5 minutes*
- *After 15 minutes*

Terracon
551 W League City Pkwy Ste F
League City, TX

Boring Started: 04-13-2022	Boring Completed: 04-13-2022
Drill Rig: Geoprobe	Driller: R.Bauer
Project No.: 91225002	

DOUBLE HYDROMETER

ASTM D4221



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
● B-1	6 - 8	FAT CLAY - NATURAL (CH)	21.3	55	17	38	2.06	2.89
☒ B-1	6 - 8	FAT CLAY (CH)						

Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
● B-1	6 - 8	0.112	0.062	0.055	0.023	0.0	15.5	81.3		3.2
☒ B-1	6 - 8	0.081	0.045	0.005		0.0	11.2	59.1		29.7

PROJECT: Bacliff Drainage Improvements

SITE: 10th Street and 15th Street
Bacliff, Texas

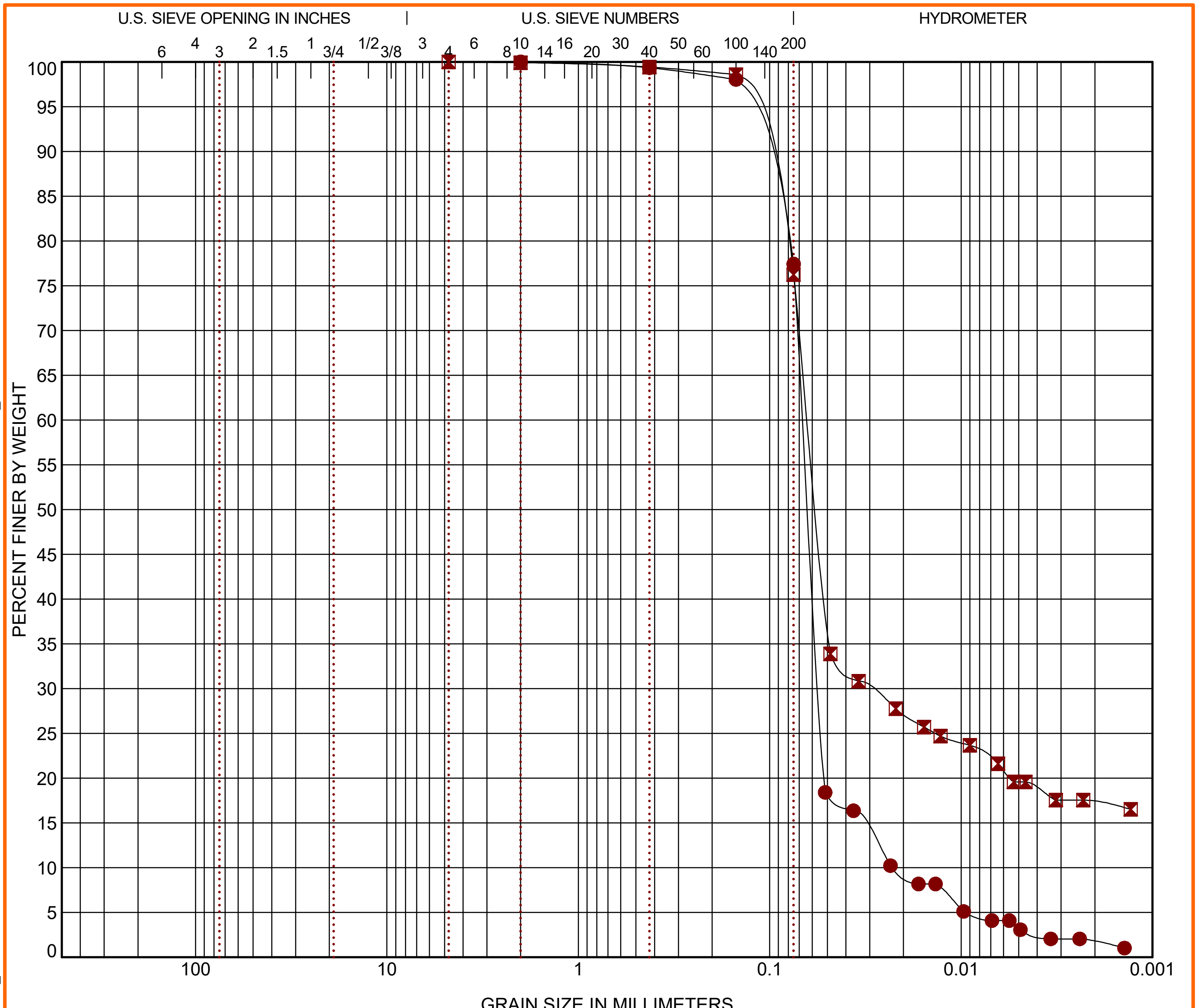
Terracon
551 W League City Pkwy Ste F
League City, TX

PROJECT NUMBER: 91225002

CLIENT: DEC, Inc
Houston, Texas

DOUBLE HYDROMETER

ASTM D4221



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-2	4 - 6	FAT CLAY - NATURAL (CH)	22.0	57	16	41	2.02	2.97
⊠	B-2	4 - 6	FAT CLAY (CH)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-2	4 - 6	0.114	0.063	0.055	0.023	0.0	22.6	74.2		3.2
⊠	B-2	4 - 6	0.115	0.057	0.03		0.0	23.8	56.7		19.6

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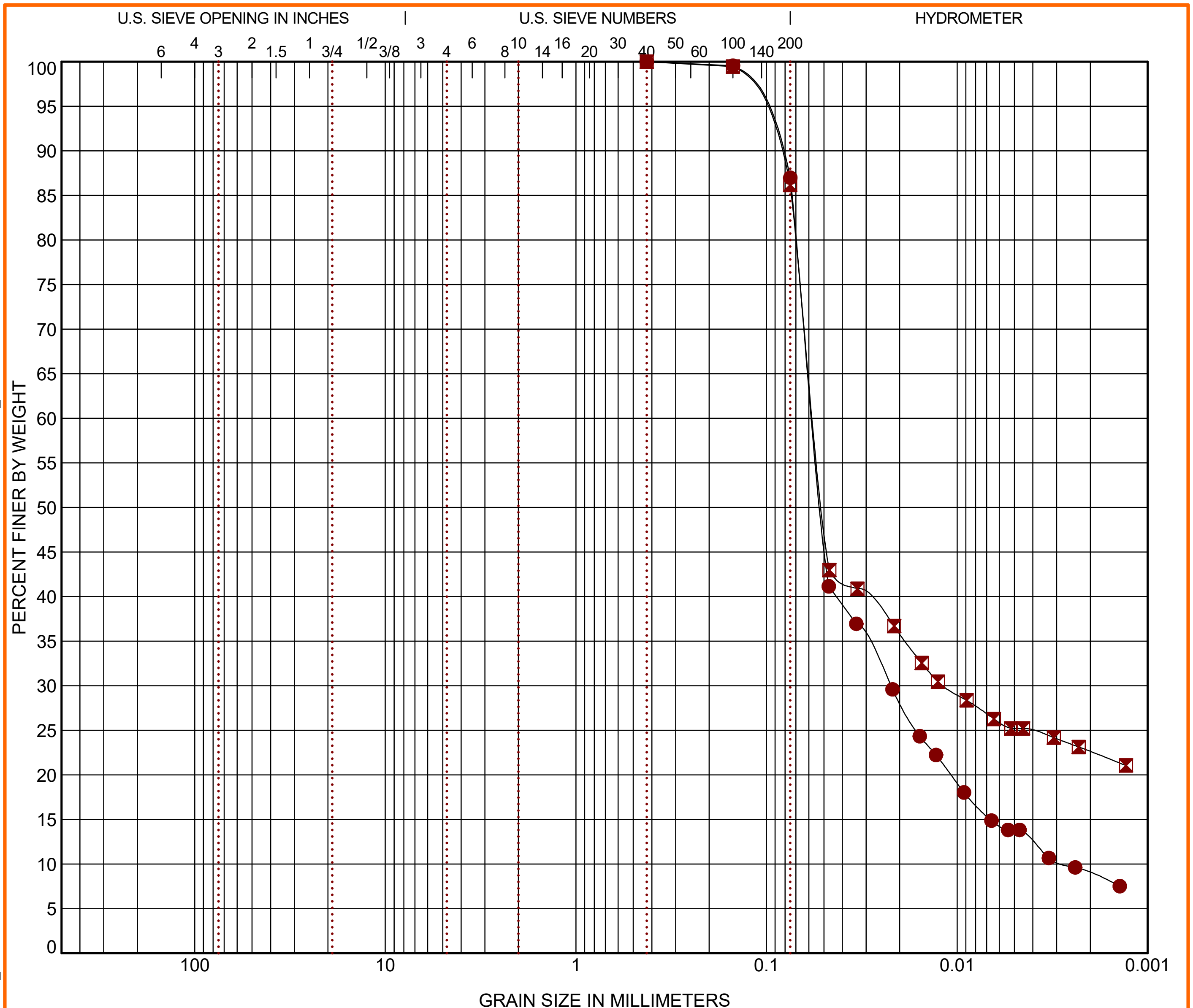

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-3	2 - 4	LEAN CLAY - NATURAL (CL)	23.8	45	16	29	3.25	21.18
⊠	B-3	2 - 4	LEAN CLAY (CL)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-3	2 - 4	0.089	0.052	0.022	0.003	0.0	13.0	73.2		13.8
⊠	B-3	2 - 4	0.092	0.051	0.012		0.0	13.8	61.0		25.2

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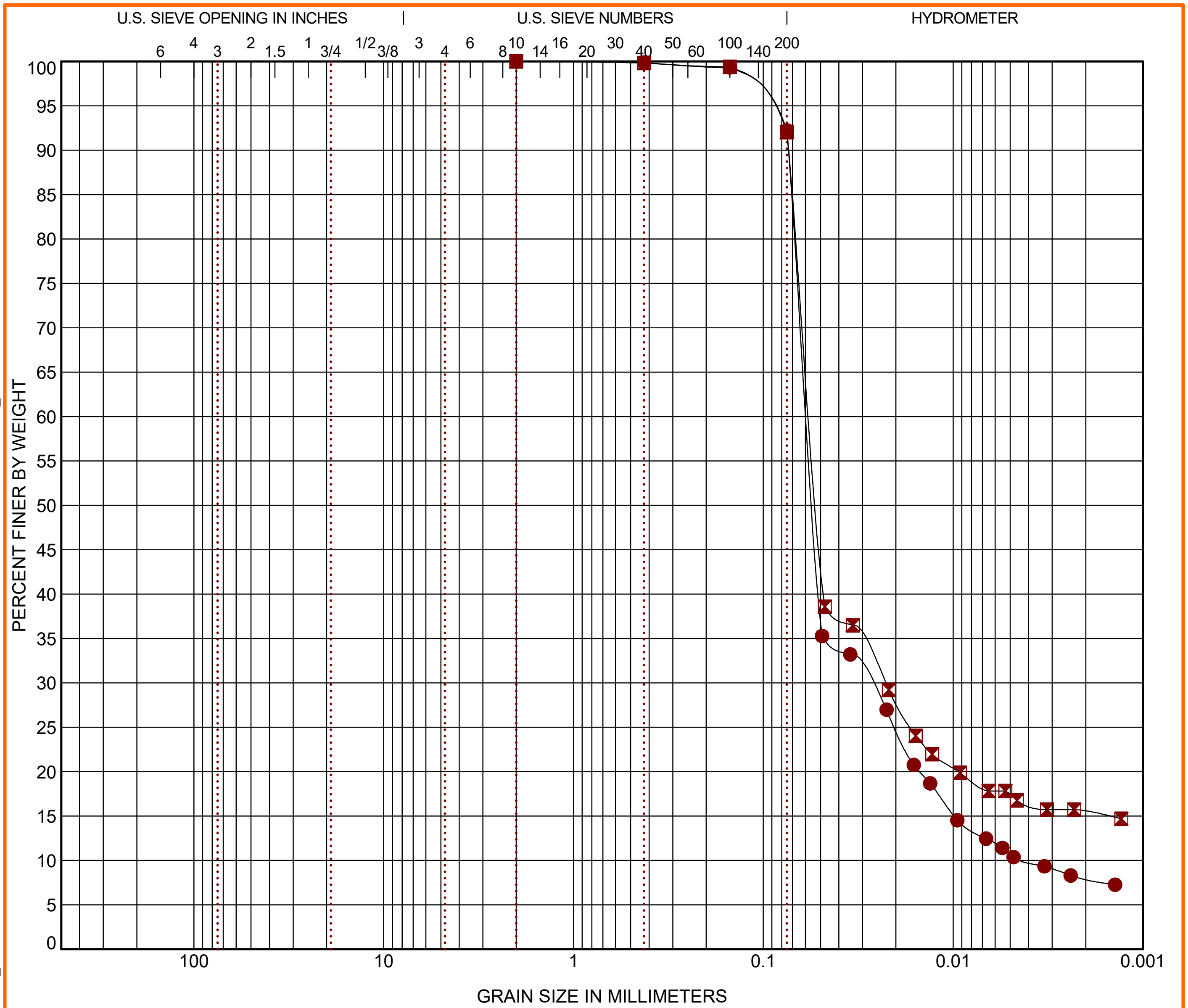

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-3	8 - 10	LEAN CLAY - NATURAL (CL)	25.4	42	16	26	3.12	14.07
⊠	B-3	8 - 10	LEAN CLAY (CL)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-3	8 - 10	0.074	0.055	0.028	0.004	0.0	7.8	81.5		10.7
⊠	B-3	8 - 10	0.074	0.052	0.023		0.0	8.0	74.7		17.4

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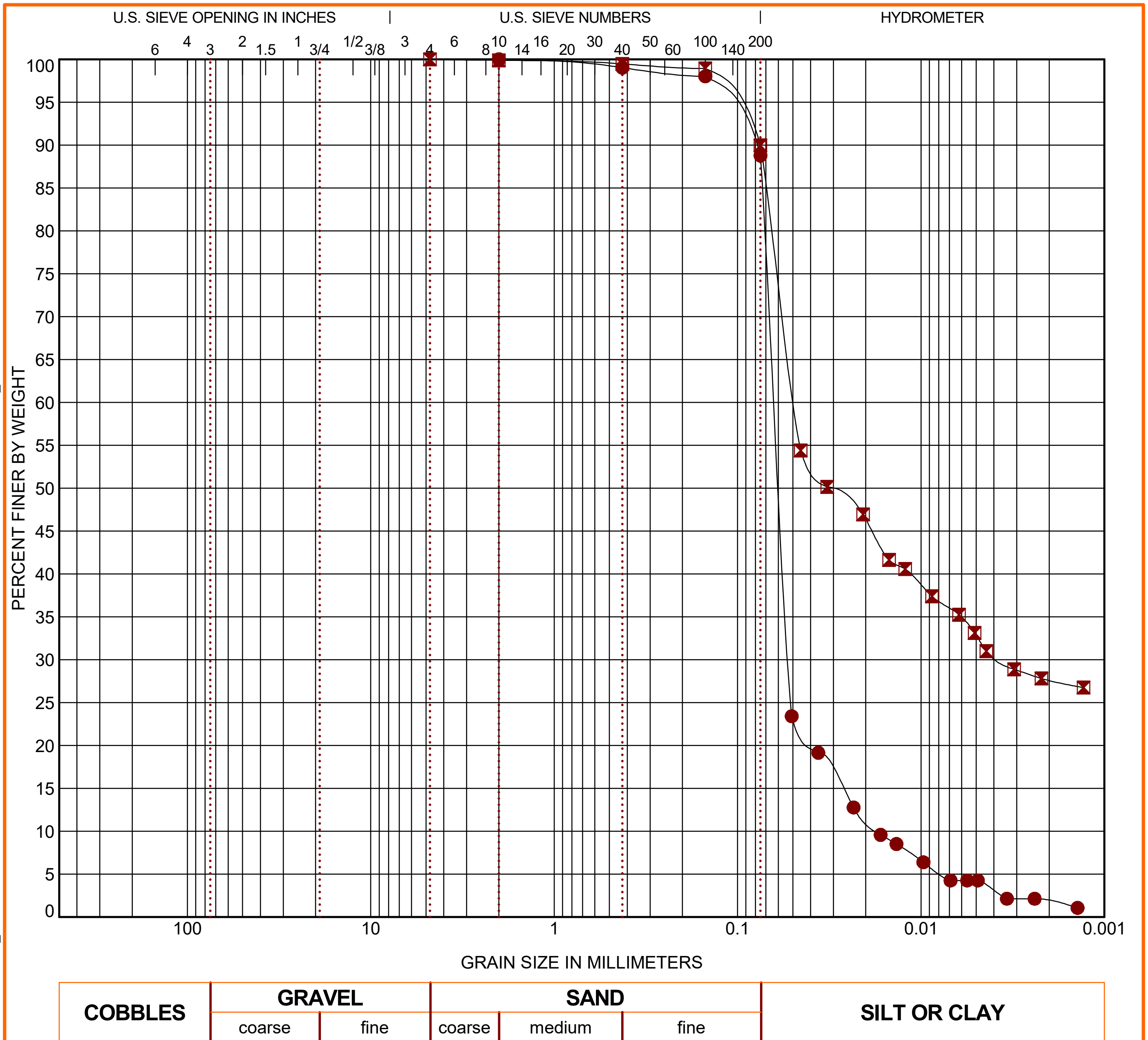

Boring ID		Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-4	0 - 2	LEAN CLAY- Natural (CL)	10.6	40	15	25	2.54	3.64
⊠	B-4	0 - 2	LEAN CLAY (CL)						

Boring ID		Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-4	0 - 2	0.082	0.059	0.053	0.017	0.0	11.2	84.5		4.3
⊠	B-4	0 - 2	0.075	0.032	0.004		0.0	10.0	57.1		32.8

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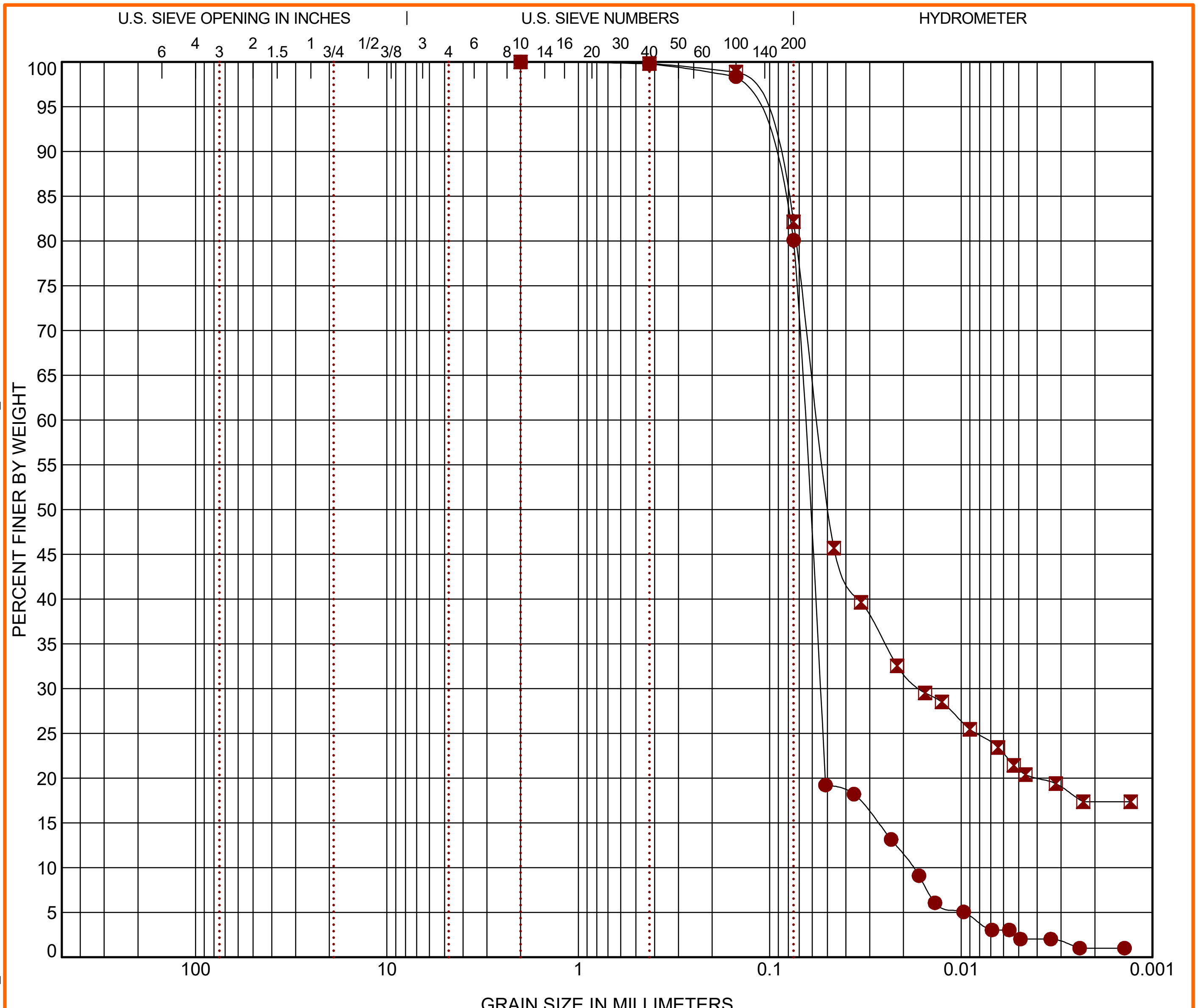

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-5	2 - 4	LEAN CLAY WITH SAND - NATURAL (CL)	16.7	36	15	21	2.53	3.70
⊠	B-5	2 - 4	LEAN CLAY WITH SAND (CL)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-5	2 - 4	0.109	0.062	0.055	0.018	0.0	19.9	77.9		2.2
⊠	B-5	2 - 4	0.104	0.049	0.016		0.0	17.8	61.2		21.0

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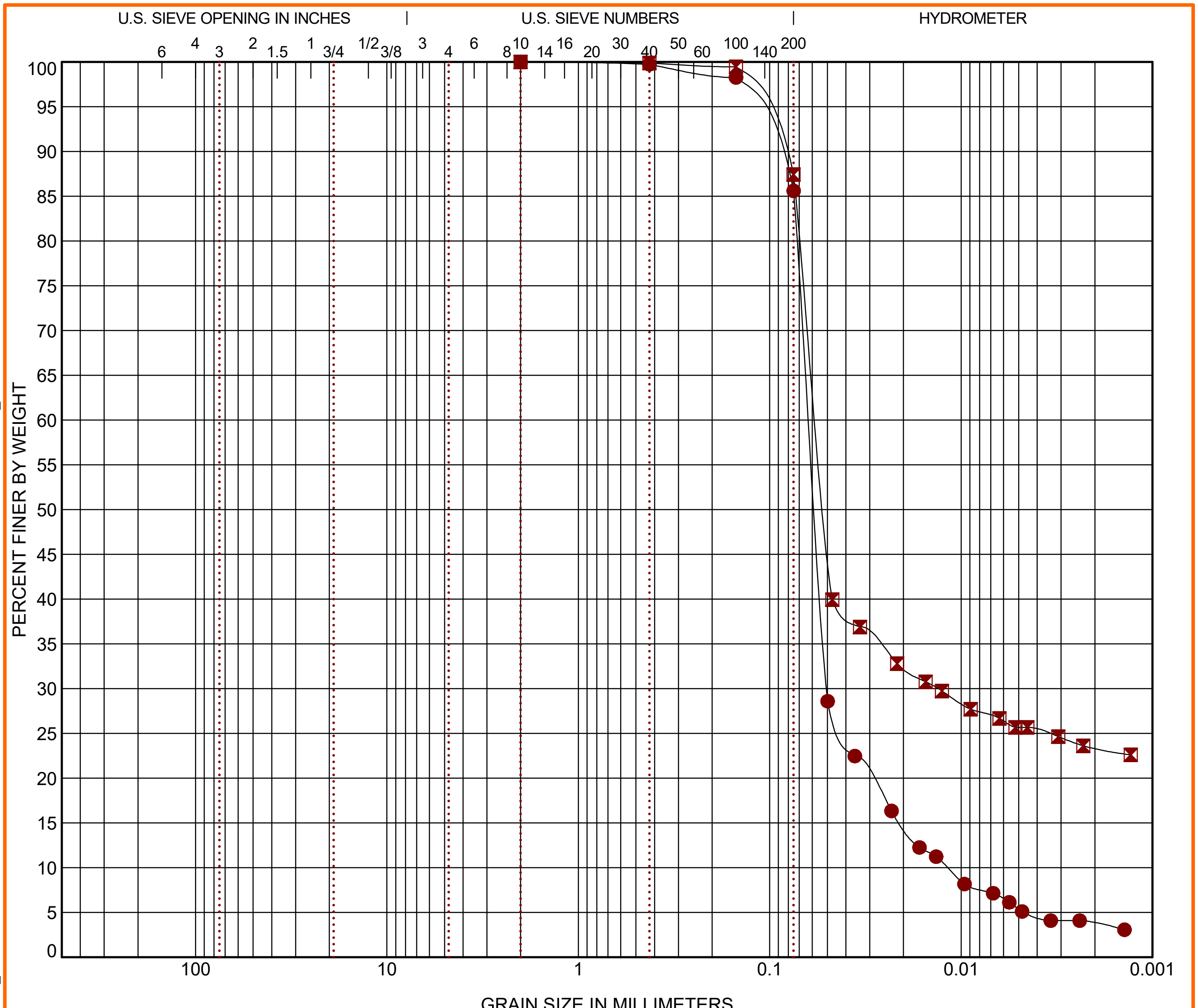

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-6	4 - 6	LEAN CLAY - NATURAL (CH)	16.3	55	16	39	3.45	5.30
⊠	B-6	4 - 6	LEAN CLAY (CL)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-6	4 - 6	0.095	0.058	0.05	0.012	0.0	14.4	80.2		5.4
⊠	B-6	4 - 6	0.087	0.052	0.013		0.0	12.6	61.7		25.7

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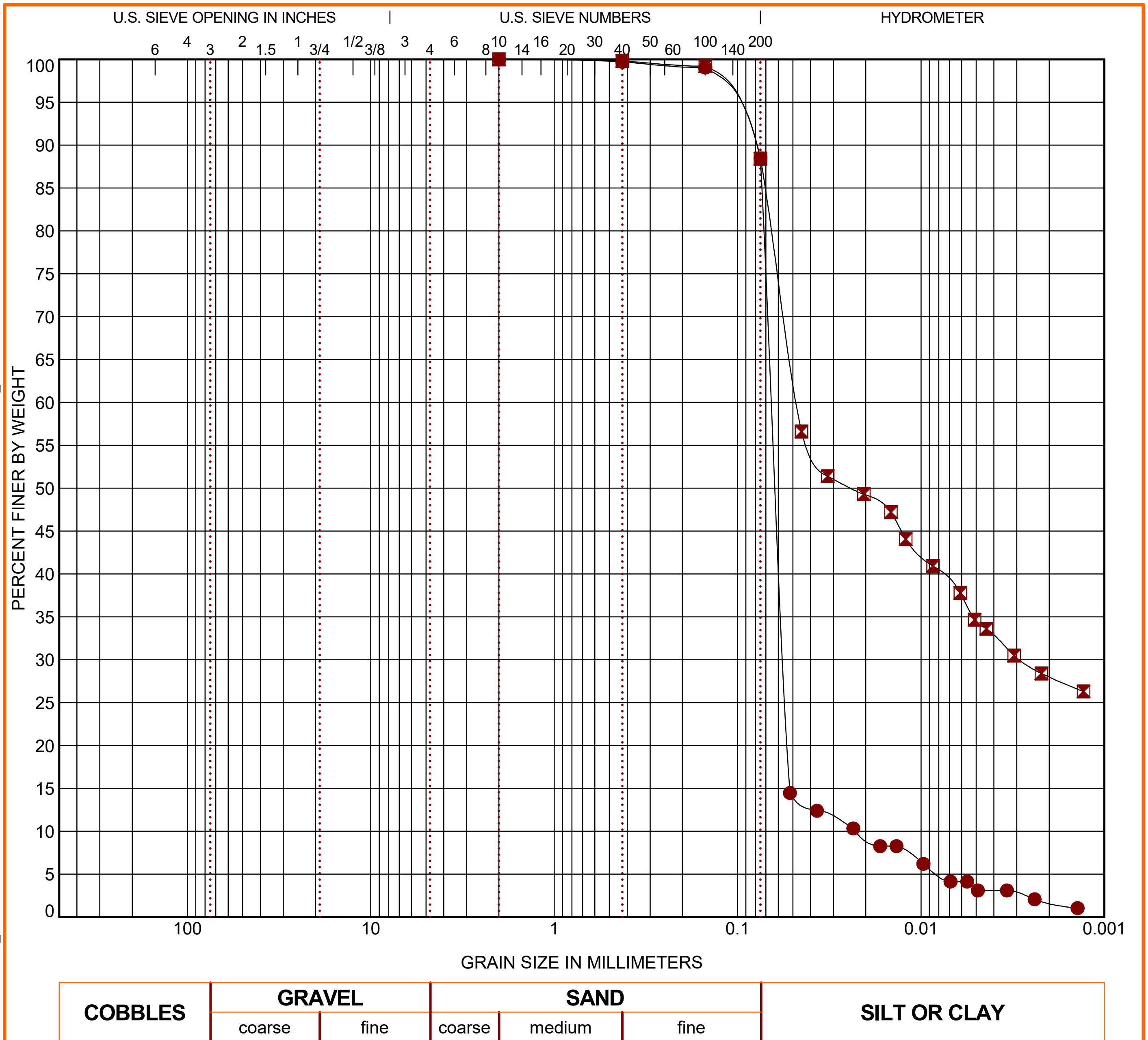

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-7	0 - 2	LEAN CLAY - NATURAL (CL)	15.4	49	16	33	2.17	2.93
⊠	B-7	0 - 2	LEAN CLAY (CL)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-7	0 - 2	0.083	0.062	0.056	0.022	0.0	11.5	85.2		3.3
⊠	B-7	0 - 2	0.083	0.024	0.003		0.0	11.6	53.9		34.5

PROJECT: Bacliff Drainage Improvements

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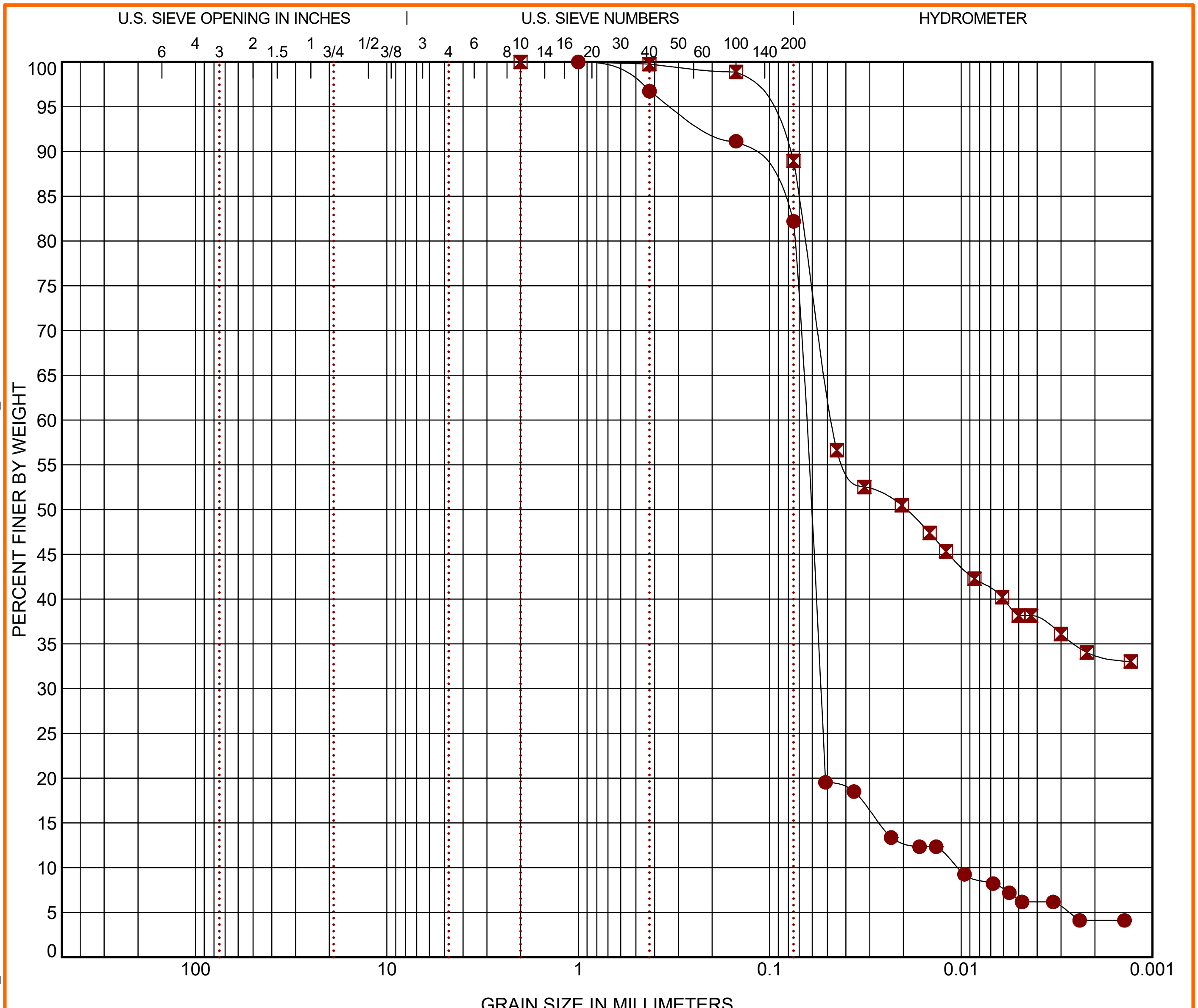

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-8	8 - 10	FAT CLAY - NATURAL (CH)	23.7	61	17	44	4.35	6.28
⊠	B-8	8 - 10	FAT CLAY (CH)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-8	8 - 10	0.137	0.062	0.054	0.01	0.0	17.8	75.8		6.4
⊠	B-8	8 - 10	0.081	0.019			0.0	11.0	50.8		38.2

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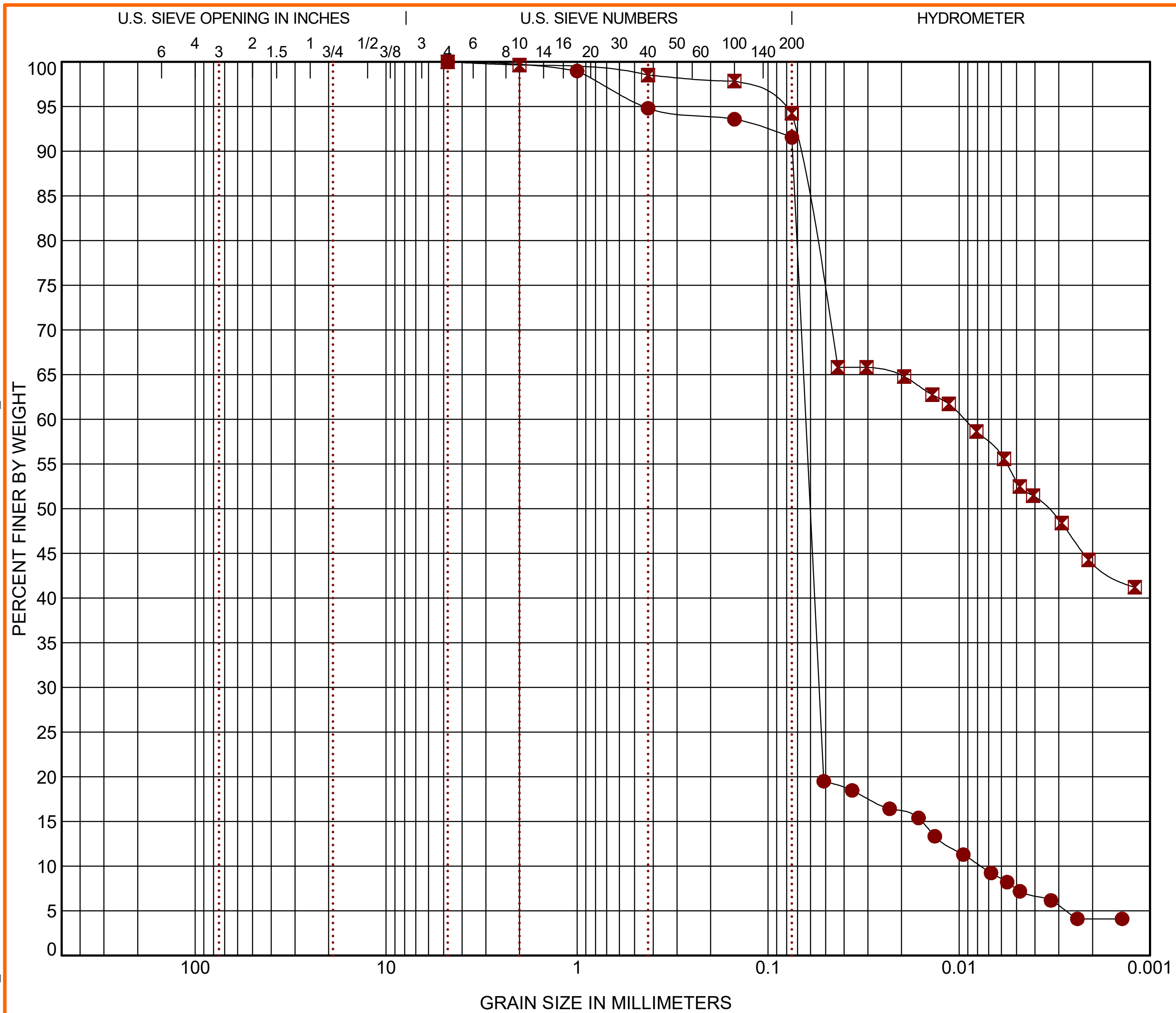

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-9	10 - 12	FAT CLAY - NATURAL (CH)	27.0	61	20	41	5.98	8.23
⊠	B-9	10 - 12	FAT CLAY (CH)						

	Boring ID	Depth	D_{90}	D_{50}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-9	10 - 12	0.074	0.06	0.054	0.008	0.0	8.5	84.1		7.5
⊠	B-9	10 - 12	0.069	0.003			0.0	5.8	41.1		53.2

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CLIENT: DEC, Inc
Houston, Texas

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Bacliff Drainage Improvements ■ Bacliff, Texas

Terracon Project No. 91225002

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Auger Cuttings; Shelby Tube; Standard Penetration Test	**Water Initially Encountered** **Water Level After a Specified Period of Time** **Water Level After a Specified Period of Time** **Cave In Encountered** Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	**N** Standard Penetration Test Resistance (Blows/Ft.) **(HP)** Hand Penetrometer **(T)** Torvane **(DCP)** Dynamic Cone Penetrometer **UC** Unconfined Compressive Strength **(PID)** Photo-Ionization Detector **(OVA)** Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A” line	CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line	CH	Fat clay [K, L, M]
			PI plots below “A” line	MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\qquad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ≥ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

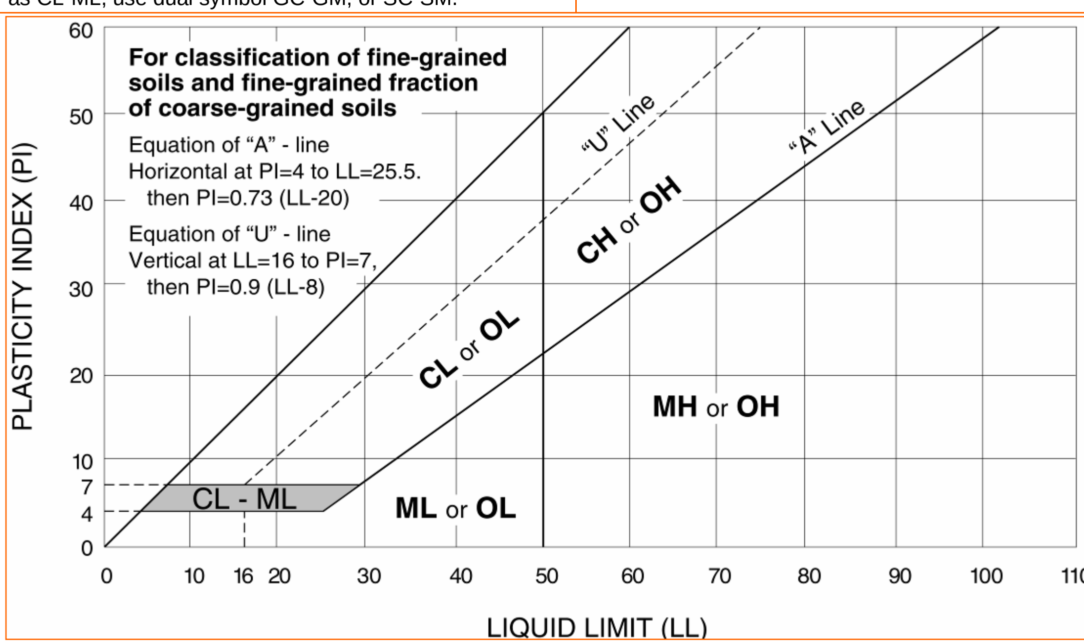
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ≥ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



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August 29, 2023

DEC, Inc.
3100 W. Alabama
Houston, Texas 77098

Attn: Ms. Mounika Jella, P.E., CFM, ENV SP

Re: Additional Geotechnical Engineering Recommendations
Bacliff Drainage Additional Improvements
10th Street and 15th Street
Bacliff, Texas
Terracon Project No. 91225147.Supplement1

Dear Ms. Mounika:

This letter should be considered supplemental to our original Geotechnical Engineering Report (Terracon Report No.912215147 dated June 9, 2023) and was prepared as requested by the project team to provide additional laboratory testing and slope stability analysis for the proposed drainage channel along N-16 West Sections 33+00 to 63+00 and 10th Street Sections 63+00 to 80+00. Project information and drawings, including drainage plan and profile drawings and N-16 west cross sections were received on July 10, 2023 and are attached.

Slope stability analysis in our original report was based on previous collected data and correlations. We could not achieve an acceptable factor of safety for sideslopes of 2 Horizontal to 1 Vertical (2H:1V) under rapid draw-down conditions by utilizing the previous data. Therefore, Consolidated Undrained (CU) triaxial tests were performed on the site-specific soils. The test results are present below.

We consider 10th Street Section 64+14 (located at borings B-04 and B-05) to be the most critical cross section along the Bacliff drainage channel. Slope stability analysis was performed for this cross section with sideslopes of 2H:1V, a maximum height of 8 feet, a maximum bottom width of 10 feet, with concrete lining along the sideslopes. Results of our analyses are provided below. Please refer to the original report for any recommendations not contained within this letter. This supplemental report should be used in conjunction with the original report and not serve as a stand-alone document.

Soil Profile

Results from the Consolidated Undrained (CU) Triaxial Tests are attached and incorporated into the results presented. Based on the field and laboratory test results and our experience with similar subsurface soil conditions, the strength parameters in the following table were used in the stability analyses.

Soil Description	Depth (feet)	Total Unit Weight (pcf)	Short-Term		Long-Term/ Rapid Drawdown			
			c_u (psf)	ϕ_u (deg)	c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)
Clay 1	6	130	1,400	0	250	10	200	17
Clay 2	13	125	1,000	0	130	10	100	17
Clay 3	15	125	1,600	0	200	10	160	17

Where,

c_u Undrained Cohesion
ϕ_u Angle of Internal Friction
c Total Consolidated-Drained Cohesion
ϕ Total Consolidated-Drained Friction Angle
c' Effective Consolidated-Drained Cohesion
ϕ' Effective Consolidated-Drained Friction Angle

Results of Stability Analyses

The results of the analyses are summarized in the following table and are attached to this letter.

Cross Section	Computed Factor of Safety		
	Short-Term	Long-Term	Rapid Drawdown
10th Street Section 64+14	4.9	1.7	1.34
Minimum Acceptable Factor of Safety	1.3	1.5	1.25

The preceding table indicates the slope stability factors of safety for the cross-section configurations analyzed exceed the minimum safety factor requirements for the short-term, long-term, and rapid drawdown conditions. If the final geometric configurations are different from those analyzed, Terracon should be contacted to review and revise our analyses, if necessary.

We trust that the recommendations contained herein meet your needs at this time. Please refer to the original report for any recommendations not contained within this letter. If you have any questions regarding this letter or require additional services, please do not hesitate to contact us.

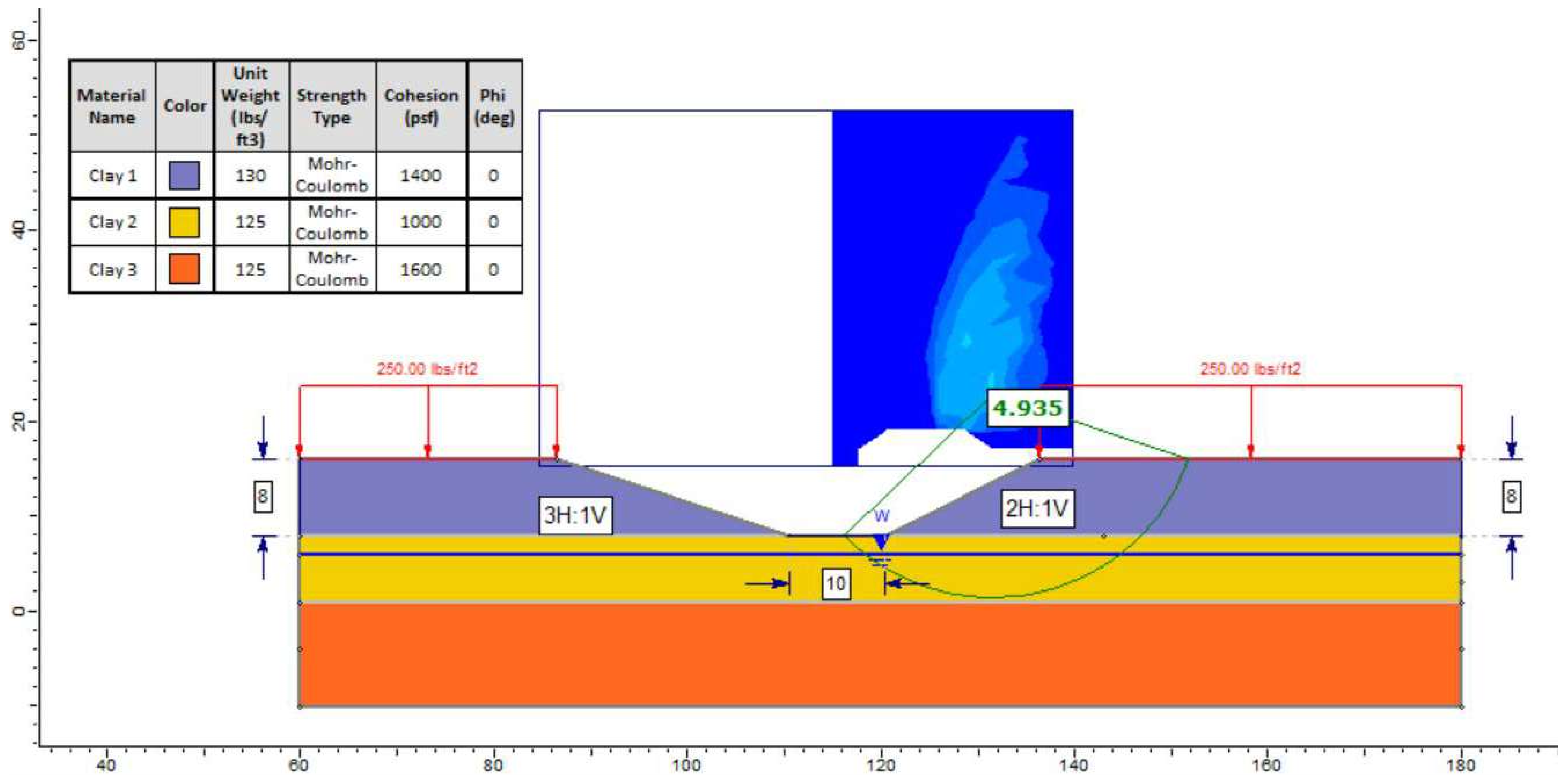
Sincerely,
Terracon Consultants, Inc.
(Texas Firm Registration No.: F-3272)

Ruofan Chu, P.E.
Project Manager

Joshua C. Miles, P.E.
Department Manager

Bobbie Sue Hood, P.E.
Principal

Attachments:
Slope Stability Analysis
Consolidated Undrained (CU) Triaxial Test Results
Drainage Plan & Profile N-16 West Ditch
Drainage Plan & Profile 10th Street Channel
N-16 West Ditch Cross Sections



Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay 1		130	Mohr-Coulomb	1400	0
Clay 2		125	Mohr-Coulomb	1000	0
Clay 3		125	Mohr-Coulomb	1600	0

Terracon
Consultants Inc.
Texas Registration 3272
551 League City Parkway, Suite F
League City, Texas 77573

Cross Section: 10th Street Section 64+14

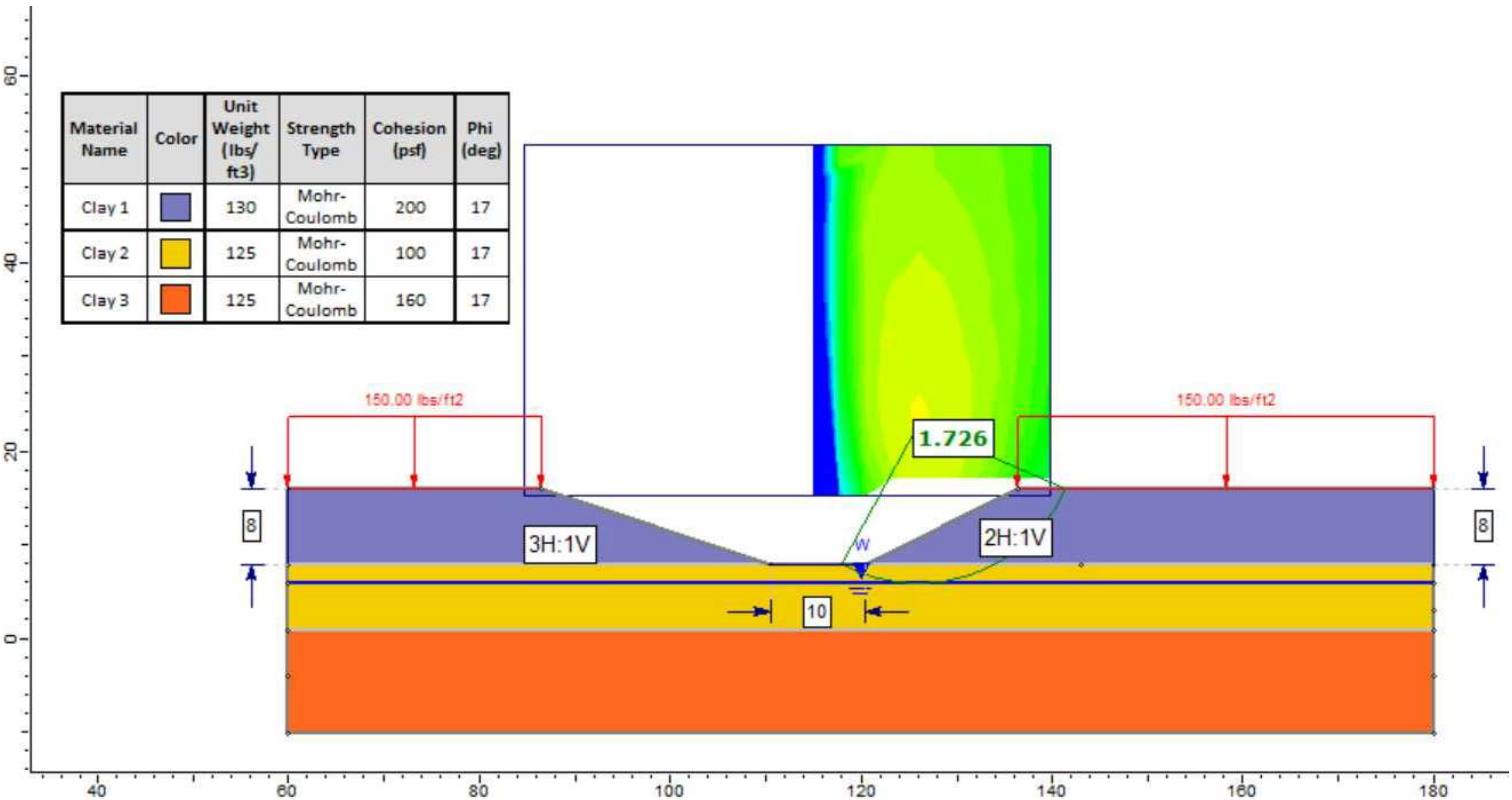
Short Term Analysis (Simplified Bishop's Method)

Drawn by: RC
Reviewed by: JCM
Approved by: BSH

Bacliff Drainage Additional Improvements

Terracon Project Number 91225147

Stability Figure 1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay 1	(purple)	130	Mohr-Coulomb	200	17
Clay 2	(yellow)	125	Mohr-Coulomb	100	17
Clay 3	(orange)	125	Mohr-Coulomb	160	17

Terracon
Consultants Inc.
Texas Registration 3272
551 League City Parkway, Suite F
League City, Texas 77573

Cross Section: 10th Street Section 64+14

Long Term Analysis (Simplified Bishop's Method)

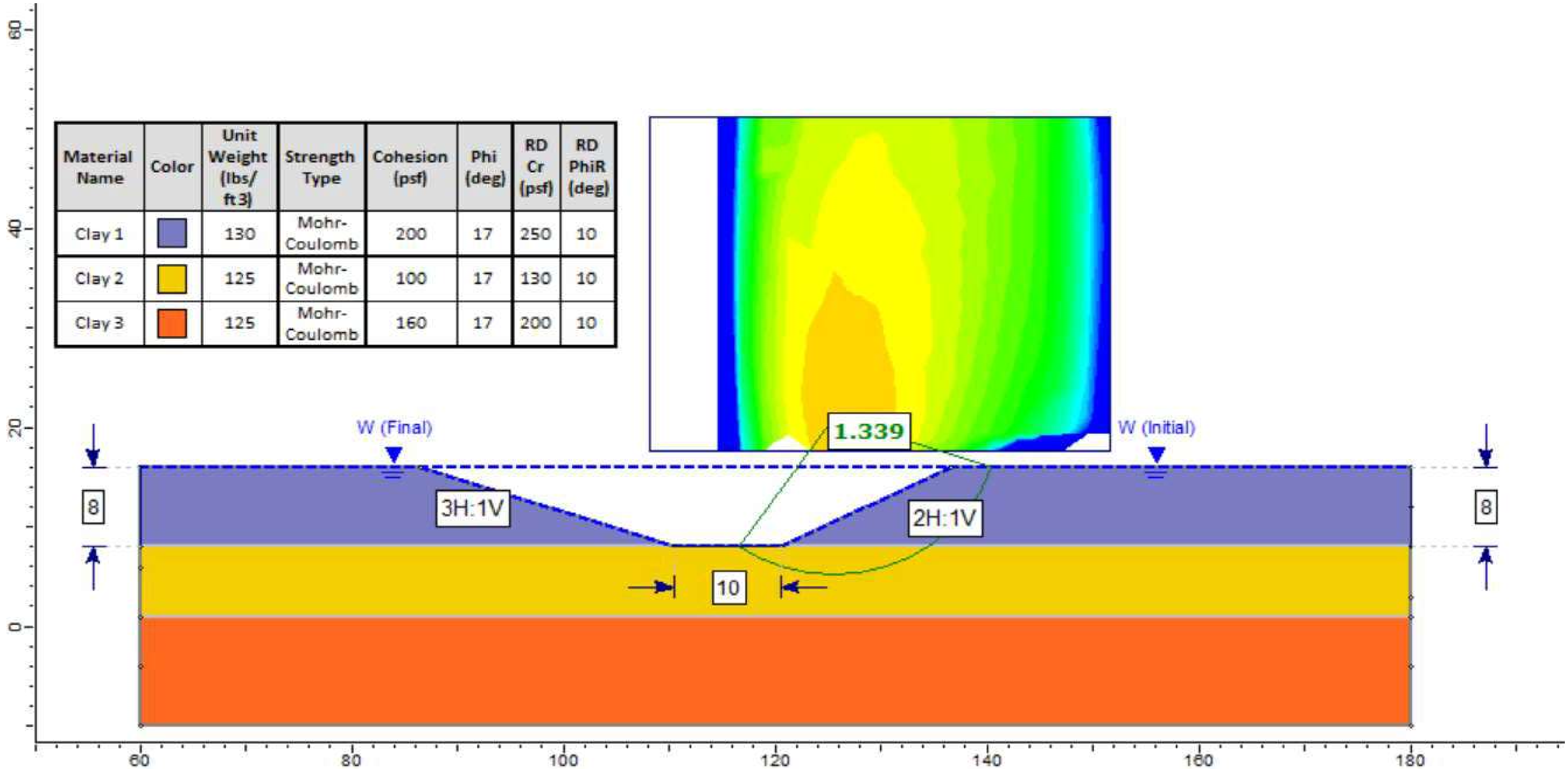
Drawn by: RC
Reviewed by: JCM
Approved by: BSH

Bacliff Drainage Additional Improvements

Terracon Project Number 91225147

Stability Figure 2

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	RD Cr (psf)	RD PhiR (deg)
Clay 1		130	Mohr-Coulomb	200	17	250	10
Clay 2		125	Mohr-Coulomb	100	17	130	10
Clay 3		125	Mohr-Coulomb	160	17	200	10



Terracon
Consultants Inc.
Texas Registration 3272
551 League City Parkway, Suite F
League City, Texas 77573

Cross Section: 10th Street Section 64+14

Rapid Drawdown Analysis (Simplified Bishop's Method)

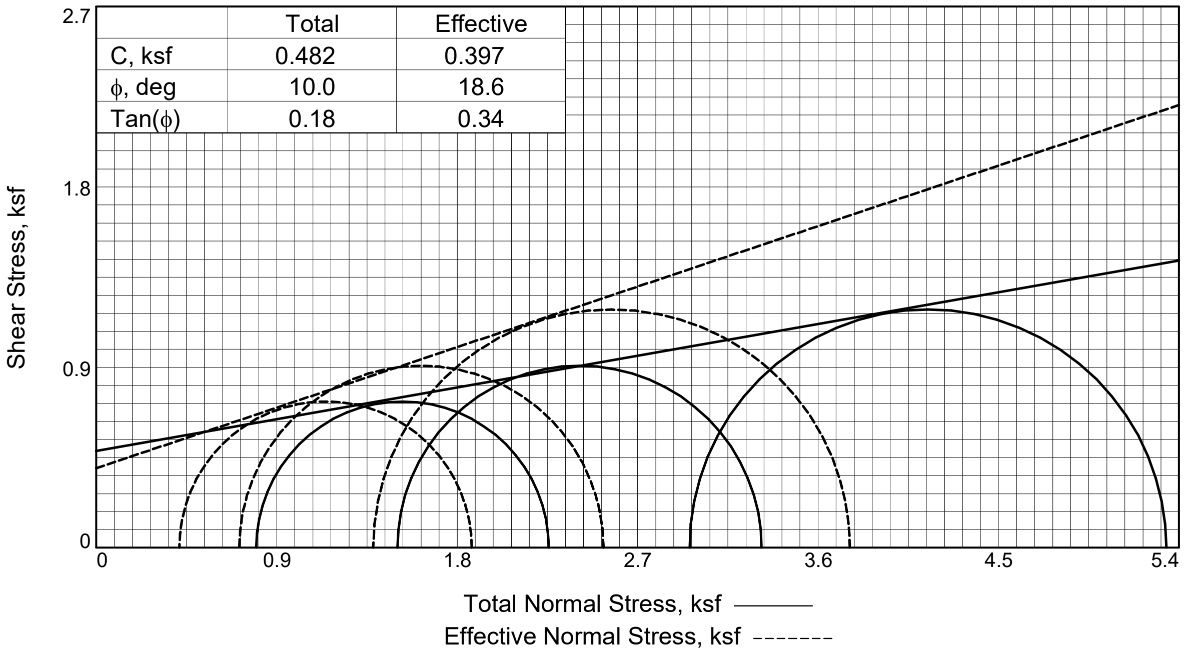
Drawn by: RC
Reviewed by: JCM
Approved by: BSH

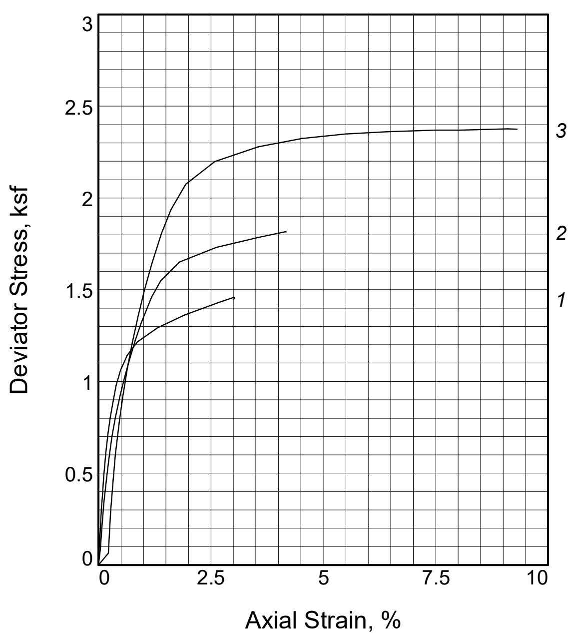
Bacliff Drainage Additional Improvements

Terracon Project Number 91225147

Stability Figure 3

	Total	Effective
C, ksf	0.482	0.397
ϕ, deg	10.0	18.6
Tan(ϕ)	0.18	0.34





	Sample No.	1	2	3
Initial	Water Content, %	20.3	20.3	20.3
	Dry Density, pcf	105.2	105.2	105.2
	Saturation, %	91.2	91.2	91.2
	Void Ratio	0.6017	0.6017	0.6017
	Diameter, in.	2.790	2.790	2.790
	Height, in.	6.030	6.030	6.030
At Test	Water Content, %	22.2	22.1	21.9
	Dry Density, pcf	105.4	105.5	105.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5992	0.5976	0.5923
	Diameter, in.	2.789	2.831	2.888
	Height, in.	6.027	5.843	5.593
	Strain rate, %/min.	0.0040	0.0040	0.0040
	Back Pressure, psi	60.000	60.000	60.000
	Cell Pressure, psi	65.540	70.430	80.550
	Fail. Stress, ksf	1.459	1.816	2.377
	Excess Pore Pr., ksf	0.384	0.789	1.578
	Ult. Stress, ksf			
	Excess Pore Pr., ksf			
	$\overline{\sigma}_1$ Failure, ksf	1.873	2.529	3.759
	$\overline{\sigma}_3$ Failure, ksf	0.414	0.713	1.382

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed

Description: Dark gray and light gray Fat Clay

Assumed Specific Gravity= 2.70

Remarks:

Client: Dannenbaum Engineering Corp.

Project: Bacliff Drainage Additional Improvements

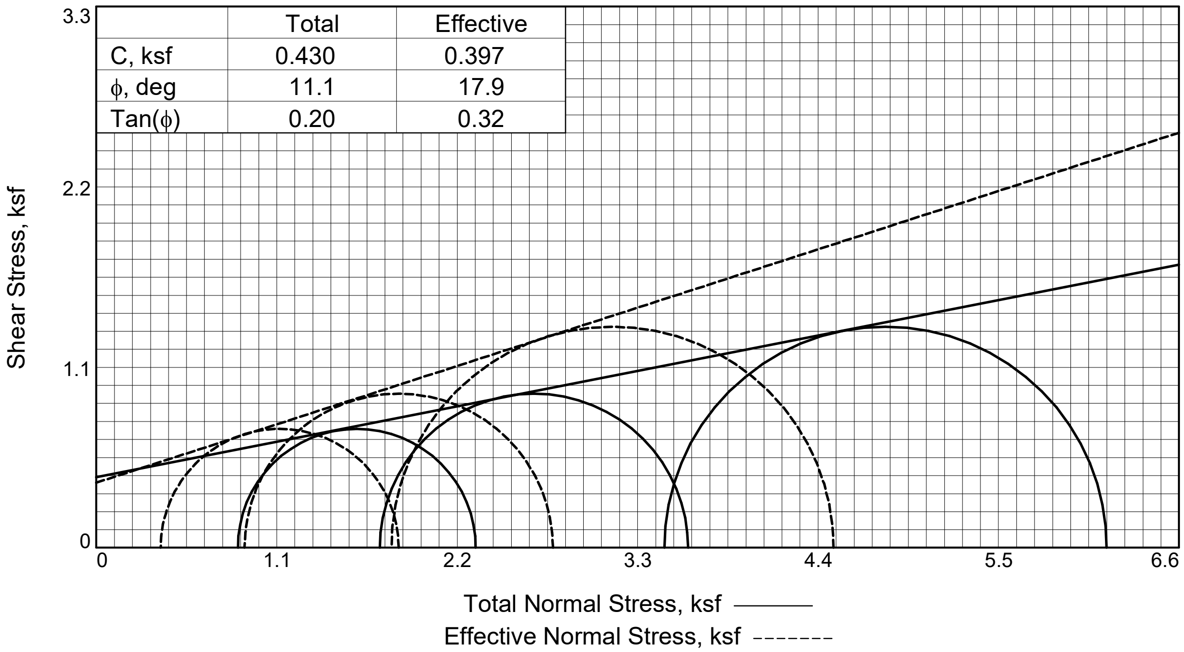
Location: B-04

Depth: 4-6 ft.

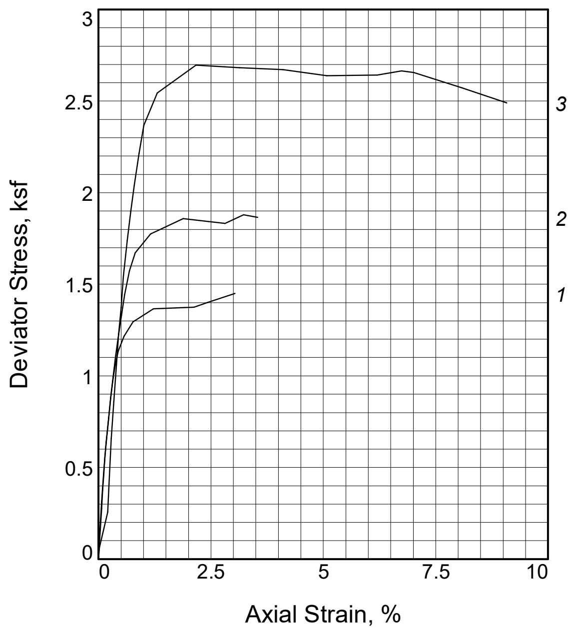
Proj. No.: 91225147

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.
Houston, TX



	Total	Effective
C, ksf	0.430	0.397
ϕ, deg	11.1	17.9
Tan(ϕ)	0.20	0.32



Sample No.		1	2	3
Initial	Water Content, %	27.7	27.7	27.7
	Dry Density, pcf	96.2	96.2	96.2
	Saturation, %	99.5	99.5	99.5
	Void Ratio	0.7516	0.7516	0.7516
	Diameter, in.	2.770	2.770	2.770
	Height, in.	6.000	6.000	6.000
At Test	Water Content, %	27.7	27.6	27.5
	Dry Density, pcf	96.4	96.5	96.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.7480	0.7463	0.7426
	Diameter, in.	2.768	2.810	2.859
	Height, in.	5.996	5.812	5.602
Strain rate, %/min.		0.0040	0.0040	0.0040
Back Pressure, psi		60.000	60.000	60.000
Cell Pressure, psi		65.990	72.000	84.050
Fail. Stress, ksf		1.450	1.879	2.696
Excess Pore Pr., ksf		0.470	0.824	1.665
Ult. Stress, ksf				
Excess Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		1.843	2.783	4.494
$\bar{\sigma}_3$ Failure, ksf		0.392	0.904	1.799

Type of Test:
CU with Pore Pressures
Sample Type: Undisturbed
Description: Tan and light gray Fat Clay

Assumed Specific Gravity= 2.70
Remarks:

Client: Dannenbaum Engineering Corp.

Project: Bacliff Drainage Additional Improvements

Location: B-05

Depth: 8-10 ft.

Proj. No.: 91225147

TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Houston, TX

EXPLORATION PLAN

Bacliff Drainage Additional Improvements ■ Bacliff, Texas

June 9, 2023 ■ Terracon Project No. 91225147

Terracon GeoReport

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

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GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

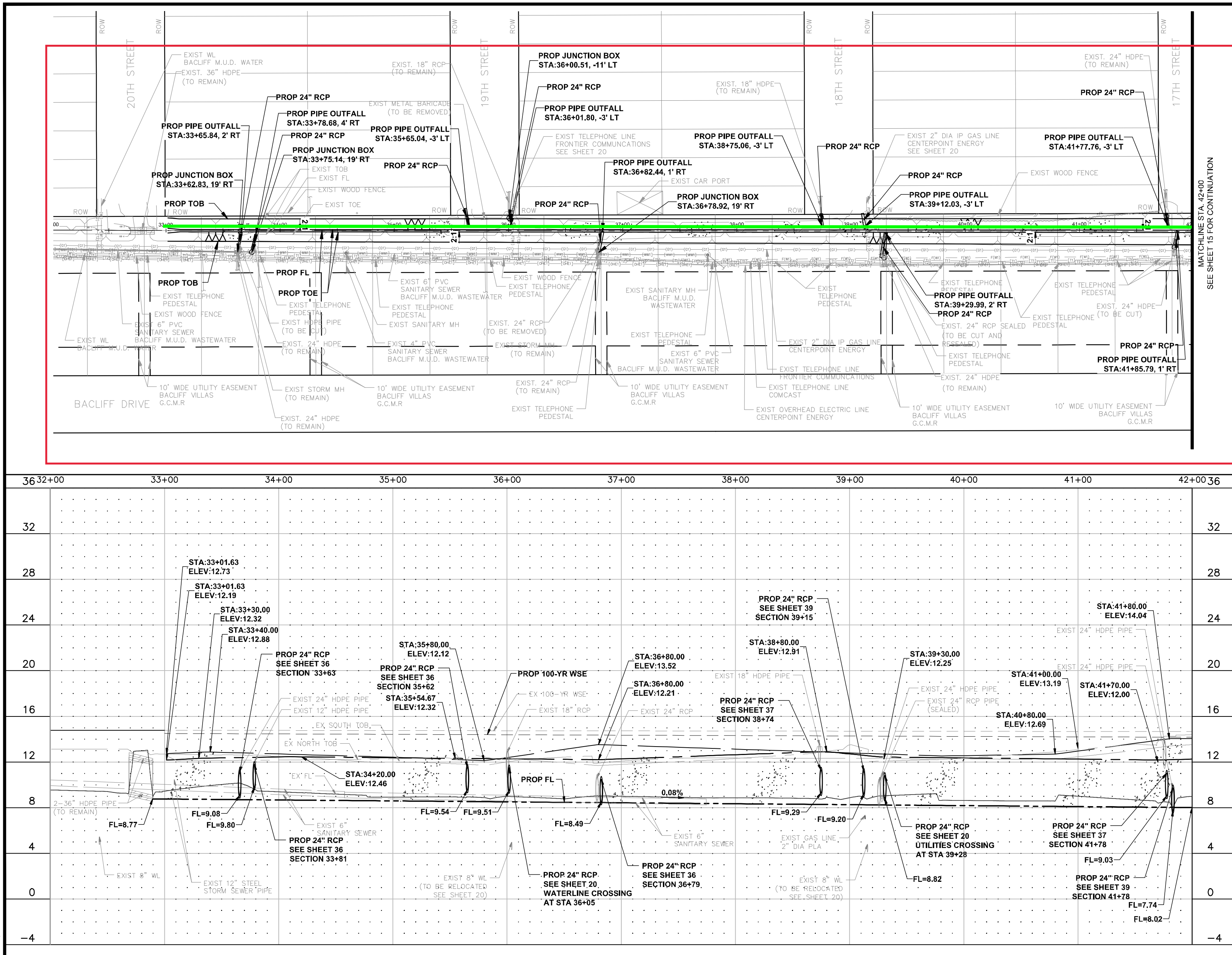
BORING LOGS
(SHEET 1 OF 4)

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 70 OF 73
DRAWN BY: JKC	SCALE: HORZ: NO SCALE VERT:	JOB No. 5370-01
APPROVED: AF		

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

G:\1180\5370-01 GALVESTON COUNTY ARPA - BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\070-073-BORING LOG SHEETS.DWG

Thursday, June 29, 2023 8:03:54 AM



HORZ. SCALE: 1" = 40'

VERT. SCALE: 1" = 4'

APPROXIMATE LOCATIONS ARE SHOWN FOR UTILITIES, CONTRACTOR TO VERIFY LOCATIONS OF ALL EXISTING UTILITIES AND TO COORDINATE RELOCATION OF ANY EXISTING UTILITIES THAT CONFLICT WITH CONSTRUCTION. NOTIFY GALVESTON COUNTY ENGINEER'S OFFICE OF ALL CONFLICTS.

NOTES:

1. FOR CHANNEL IMPROVEMENT COORDINATES AND ELEVATIONS SEE SHEETS 26 AND 29
2. FOR MH DETAILS SEE SHEET 50
3. FOR CONC CHANNEL LINING DETAILS SEE SHEETS 64

CAUTION! UNDER GROUND POWER LINES IN THE AREA

CAUTION! UNDER GROUND TELEPHONE LINES IN THE AREA

CAUTION! OVERHEAD POWER LINES IN THE AREA

CAUTION! GAS LINES IN THE AREA

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THE STATE OF TEXAS — COUNTY OF GALVESTON

GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

DRAINAGE
PLAN & PROFILE
N-16 WEST DITCH (SHEET 1 OF 3)
BEGIN TO STA 42+00

DESIGN BY: GWT | DATE: 6/29/2023 | SHEET No. 14 OF 73
DRAWN BY: JKC
APPROVED: AF | SCALE: HORZ: 1" = 40', VERT: 1" = 4' | JOB No. 5370-01

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

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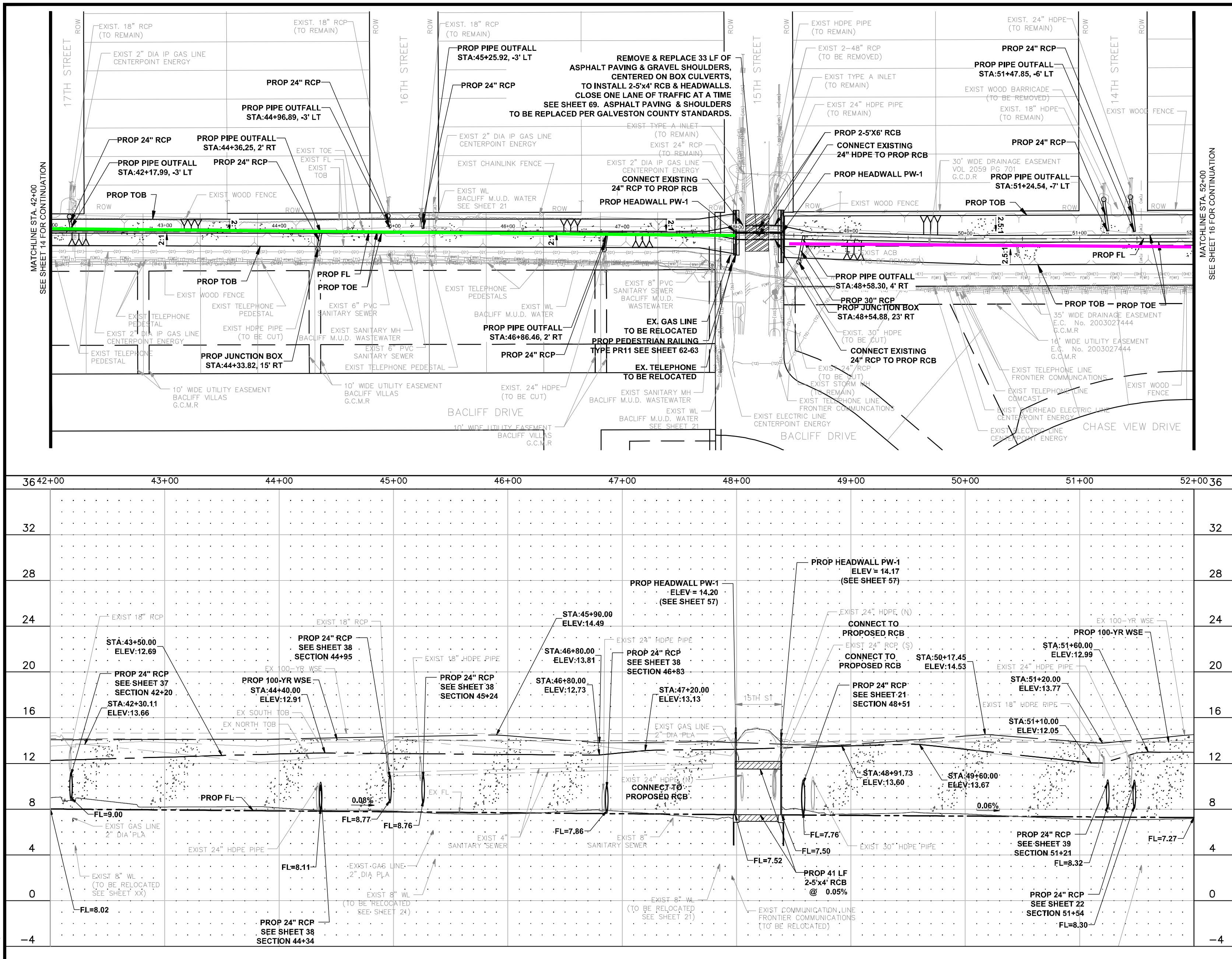

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GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

DRAINAGE
PLAN & PROFILE
N-16 WEST DITCH (SHEET 2 OF 3)
STA 42+00 TO STA 52+00

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 15 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 40' VERT: 1" = 4'	JOB No. 5370-01
APPROVED: AF		

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

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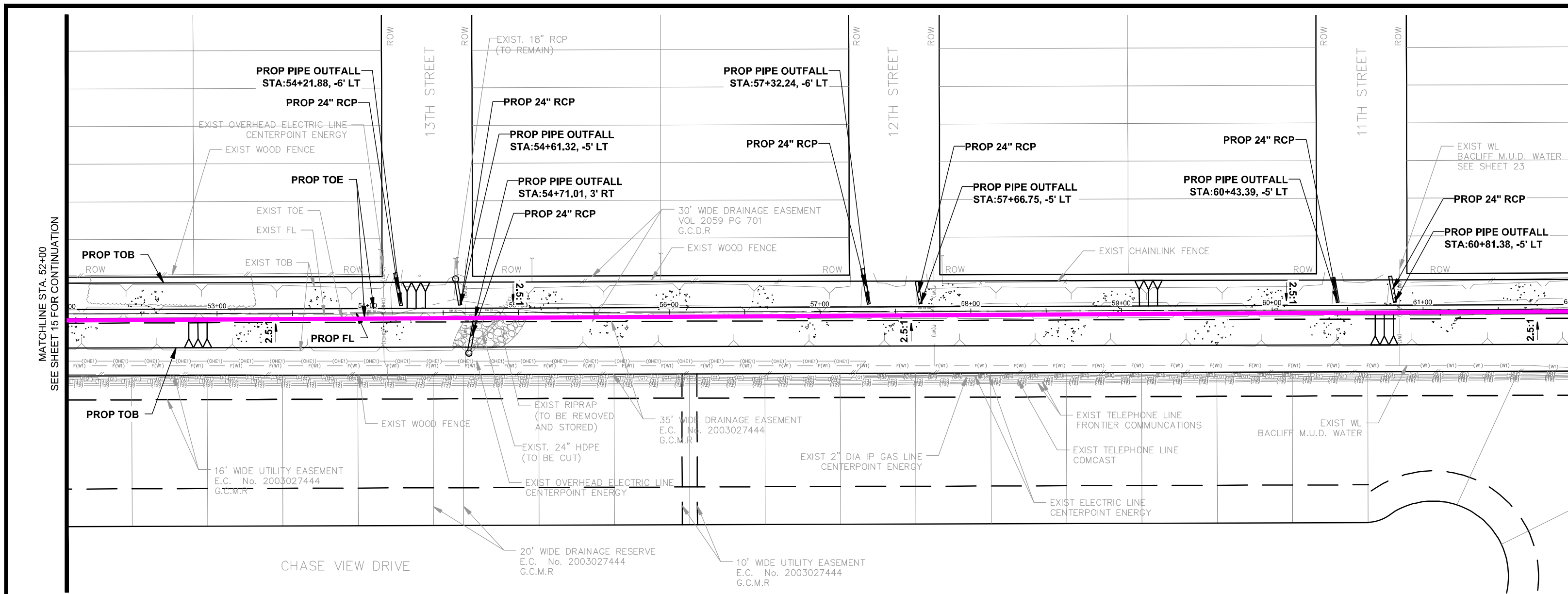

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NOTES:
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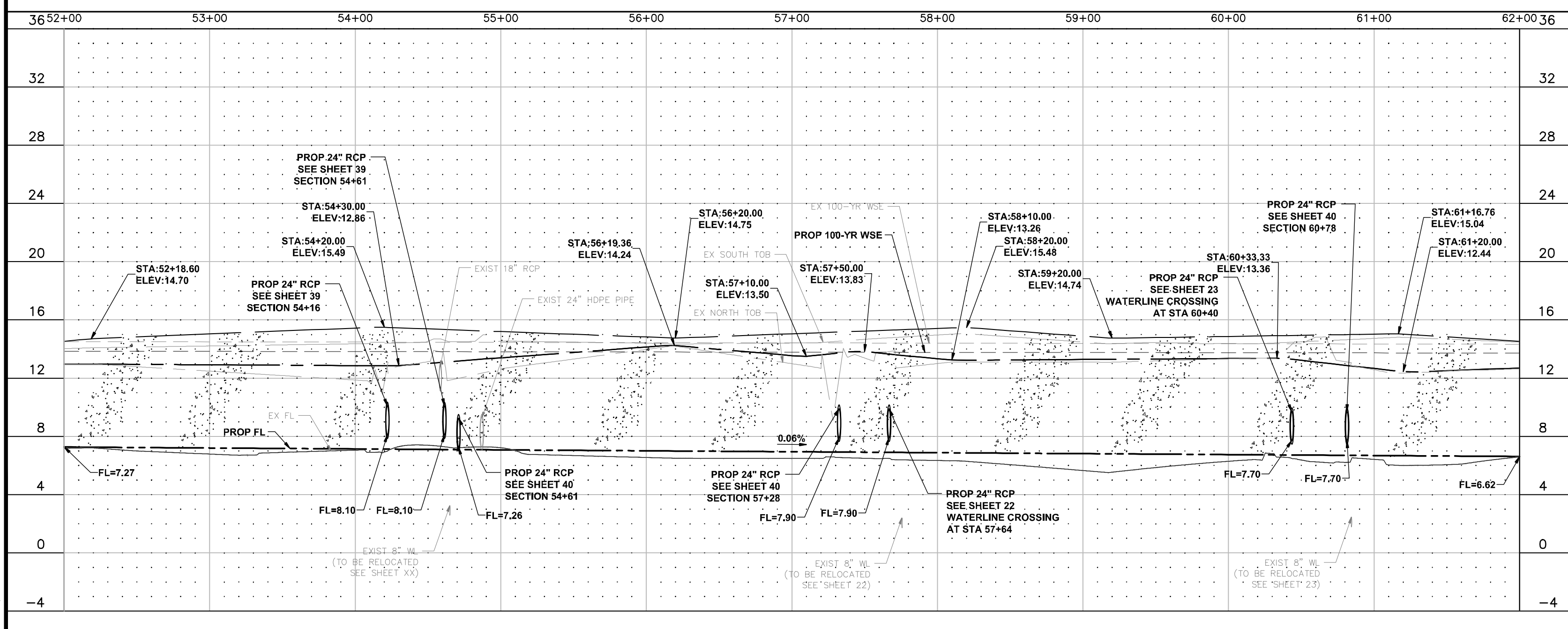
2. FOR MH DETAILS SEE SHEET 50
3. FOR CONC CHANNEL LINING DETAILS SEE SHEETS 64

CAUTION! UNDER GROUND POWER LINES IN THE AREA

CAUTION! UNDER GROUND TELEPHONE LINES IN THE AREA

CAUTION! OVERHEAD POWER LINES IN THE AREA

CAUTION! GAS LINES IN THE AREA



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GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

DRAINAGE
PLAN & PROFILE
N-16 WEST DITCH (SHEET 3 OF 3)
STA 52+00 TO END

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 16 OF 73
DRAWN BY: JKC		
APPROVED: AF	SCALE: HORZ: 1" = 40' VERT: 1" = 4'	JOB No. 5370-01

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

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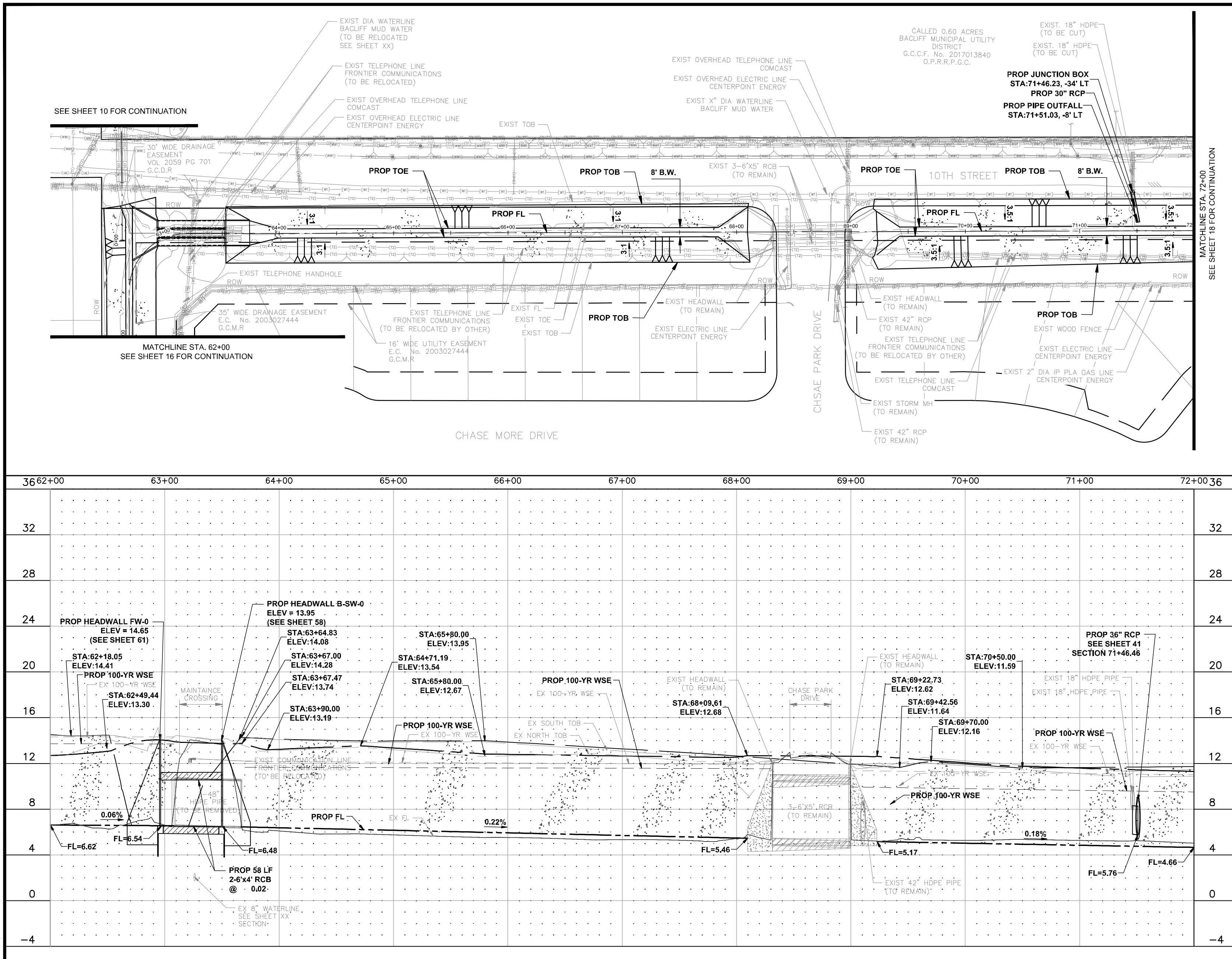

HORZ. SCALE: 1" = 40'

VERT. SCALE: 1" = 4'

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NOTES:

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2. FOR MH DETAILS SEE SHEET 50
3. FOR CONC CHANNEL LINING DETAILS SEE SHEETS 64 AND 65

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CAUTION! UNDER GROUND TELEPHONE LINES IN THE AREA

CAUTION! OVERHEAD POWER LINES IN THE AREA

CAUTION! GAS LINES IN THE AREA

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GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

DRAINAGE
PLAN & PROFILE
10TH STREET CHANNEL (SHEET 1 OF 2)
BEGIN TO STA 72+00

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 17 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 40' VERT: 1" = 4'	JOB No. 5370-01
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ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

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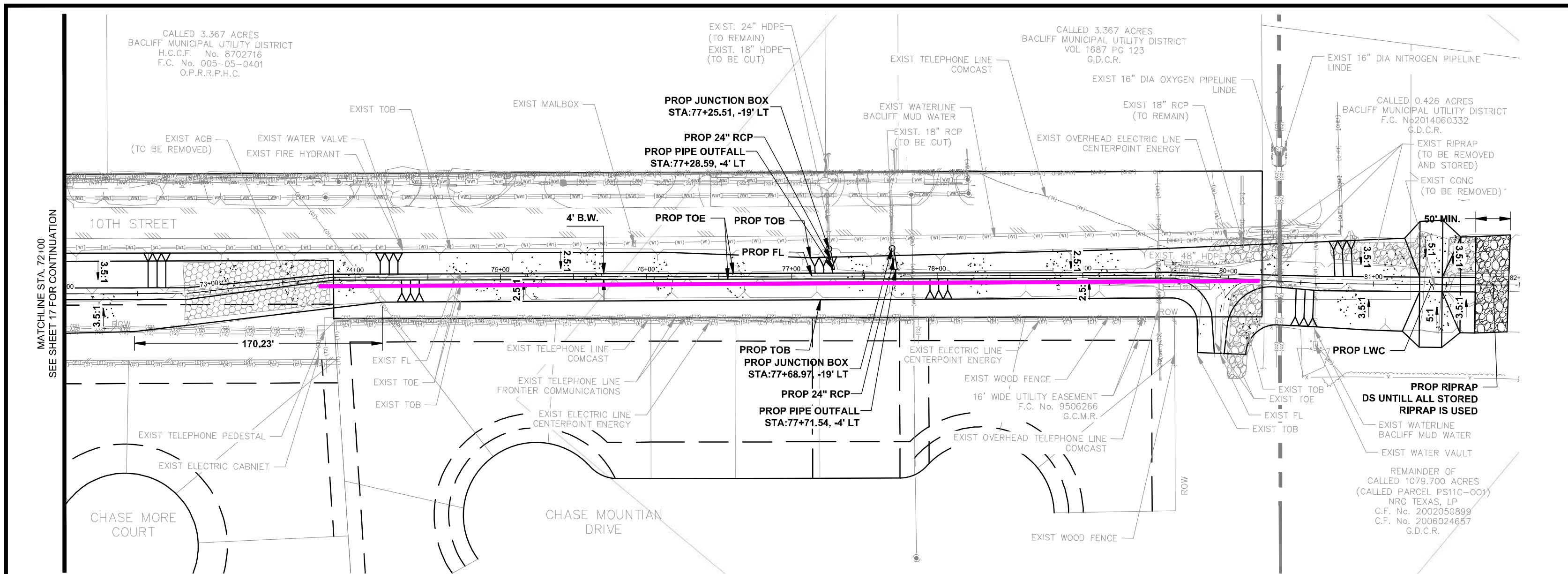

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NOTES:

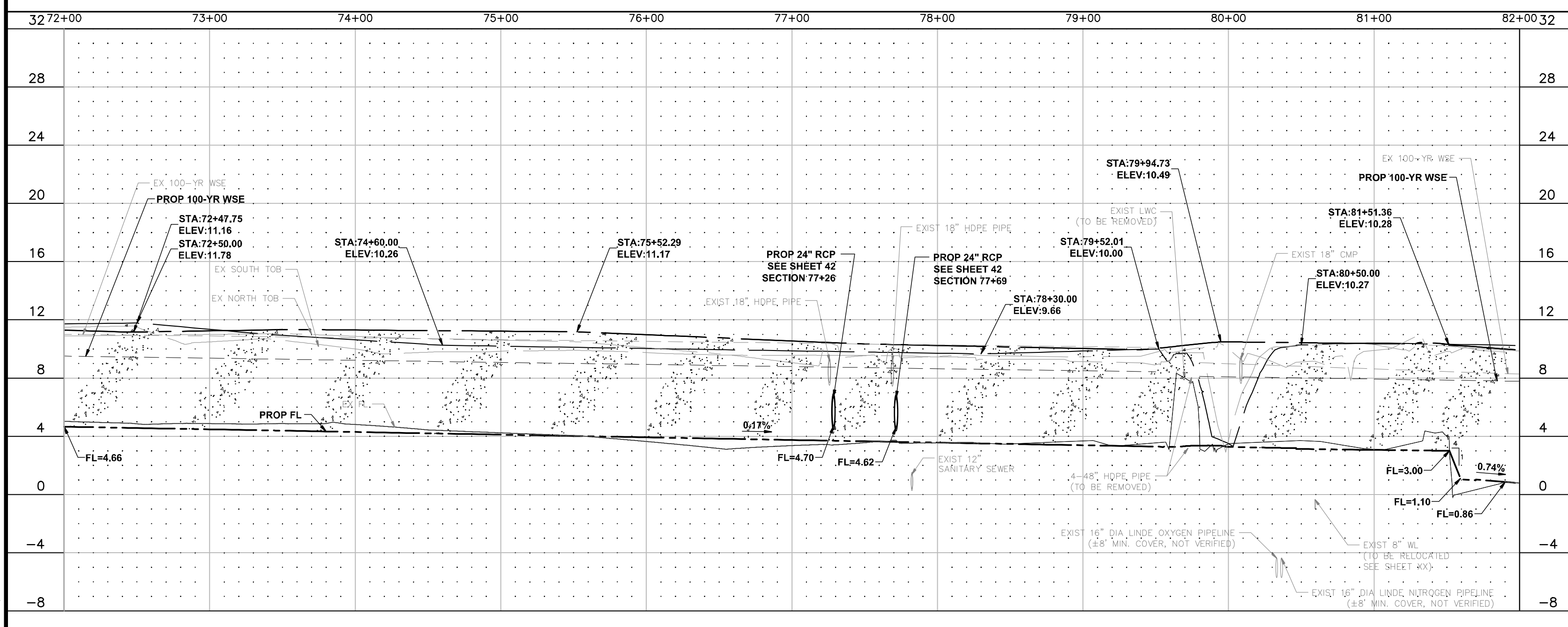
1. FOR CHANNEL IMPROVEMENT COORDINATES AND ELEVATIONS SEE SHEETS 28 AND 29
2. FOR MH DETAILS SEE SHEET 50
3. FOR CONC CHANNEL LINING DETAILS SEE SHEETS 64 AND 65

CAUTION! UNDER GROUND POWER LINES IN THE AREA

CAUTION! UNDER GROUND TELEPHONE LINES IN THE AREA

CAUTION! OVERHEAD POWER LINES IN THE AREA

CAUTION! GAS LINES IN THE AREA



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3100 WEST ALABAMA HOUSTON, TEXAS 77098 (713) 520-9570

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THE STATE OF TEXAS — COUNTY OF GALVESTON

GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

DRAINAGE
PLAN & PROFILE
10TH STREET CHANNEL (SHEET 2 OF 2)
STA 72+00 TO END

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 18 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 40' VERT: 1" = 4'	JOB No. 5370-01
APPROVED: AF		

0 1 2 3 ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

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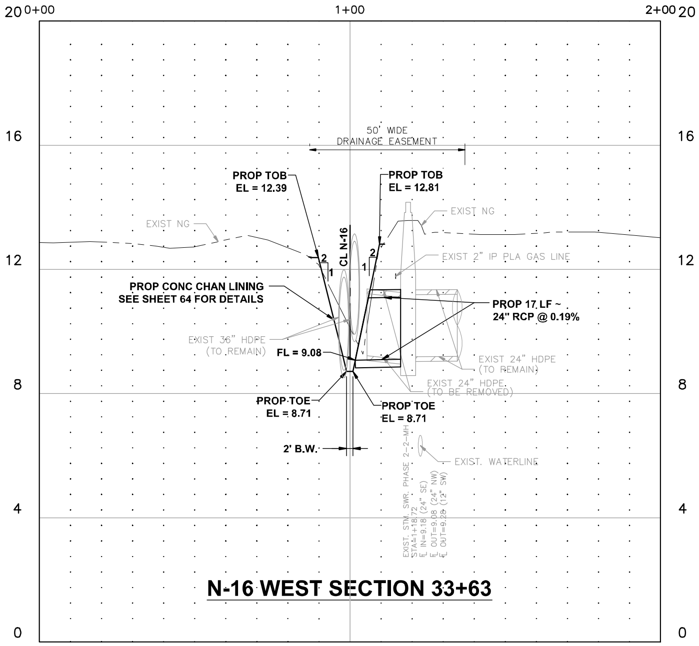
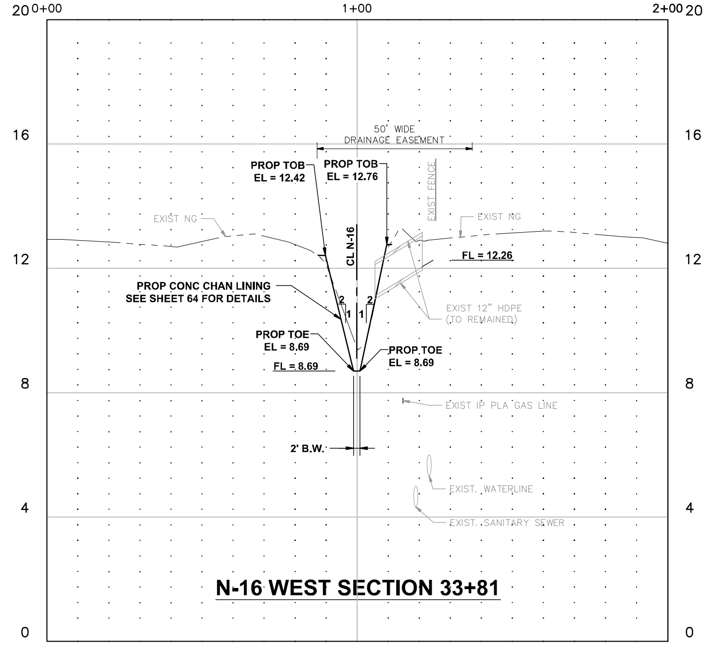
Thursday, June 29, 2023 7:55:58 AM





HORZ. SCALE: 1" = 20'

VERT. SCALE: 1" = 2'

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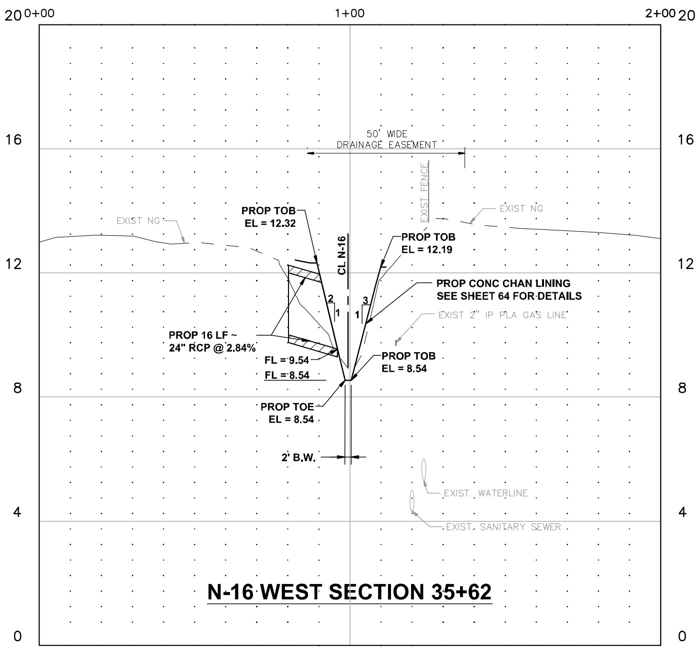
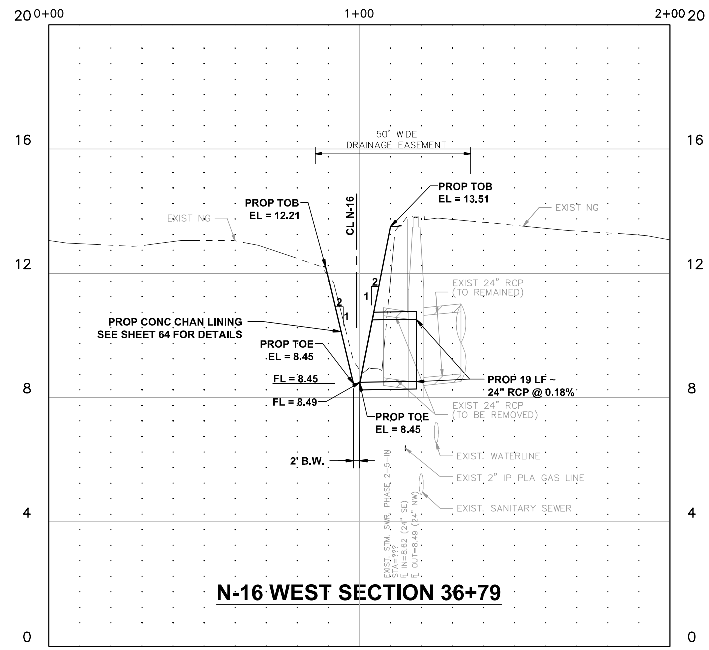
NOTES:
1. FOR MH DETAILS SEE SHEET 50





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GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

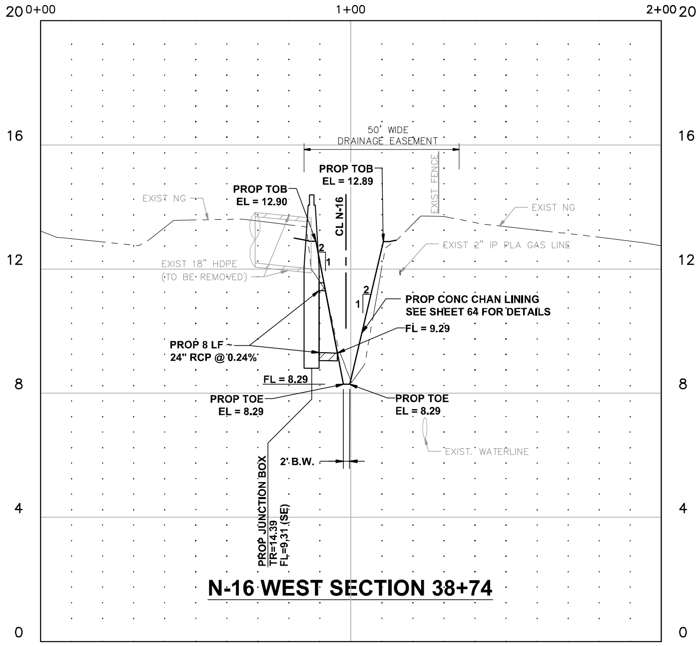
N-16 WEST
CROSS-SECTIONS
(SHEET 1 OF 8)

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 36 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01
APPROVED: AF		

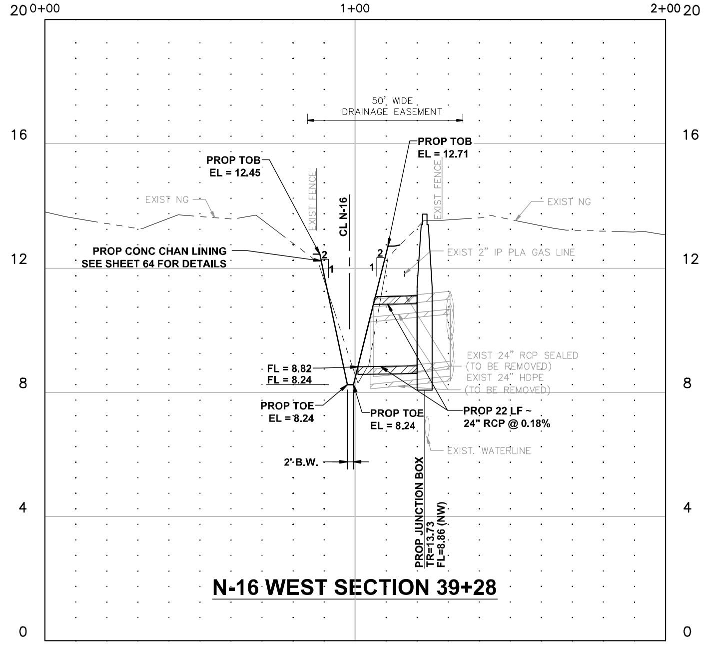
ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

G:\1180\5370-01 GALVESTON COUNTY ARPA - BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG

Thursday, June 29, 2023 7:59:39 AM



N-16 WEST SECTION 38+74



N-16 WEST SECTION 39+28

20' 0 20' 40'
HORZ. SCALE: 1" = 20'

2' 0 2' 4'
VERT. SCALE: 1" = 2'

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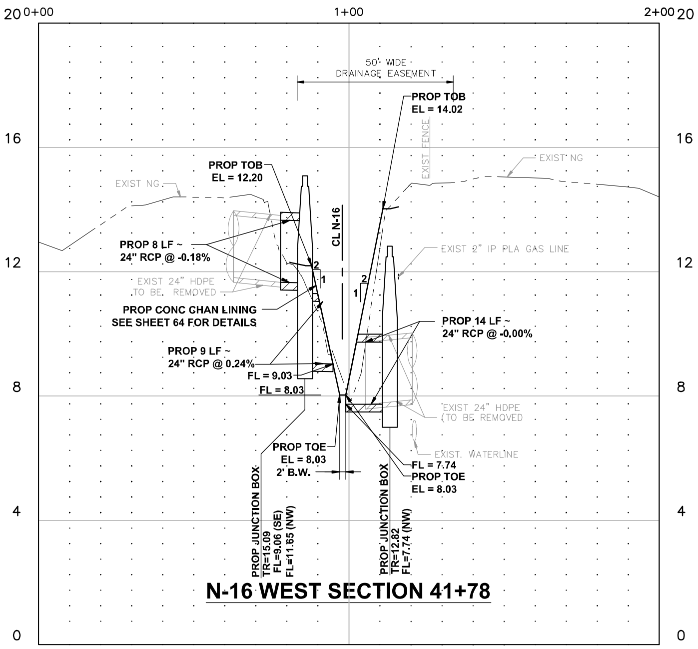
NOTES:

1. FOR MH DETAILS SEE SHEET 50



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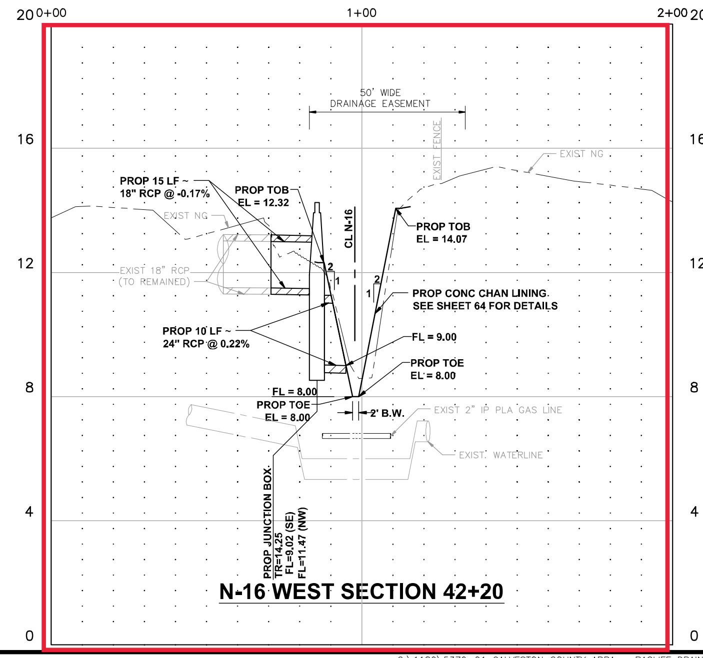

N-16 WEST SECTION 42+20

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GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

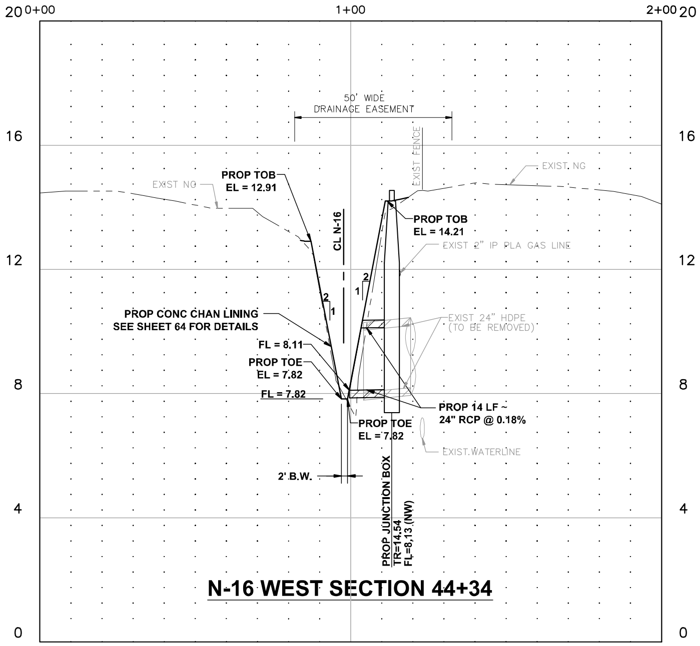
N-16 WEST
CROSS-SECTIONS
(SHEET 2 OF 8)

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 37 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01
APPROVED: AF		

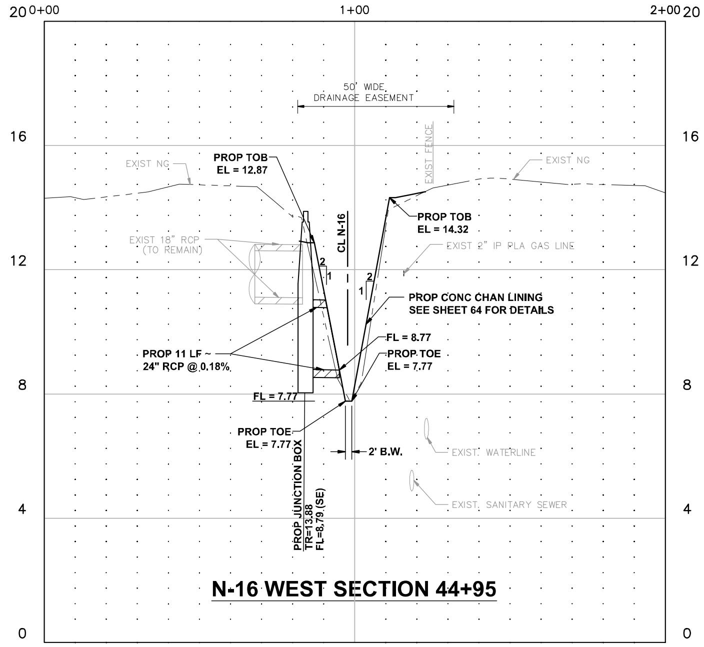
0 1 2 3 ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

G:\1180\5370-01 GALVESTON COUNTY ARPA - BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG

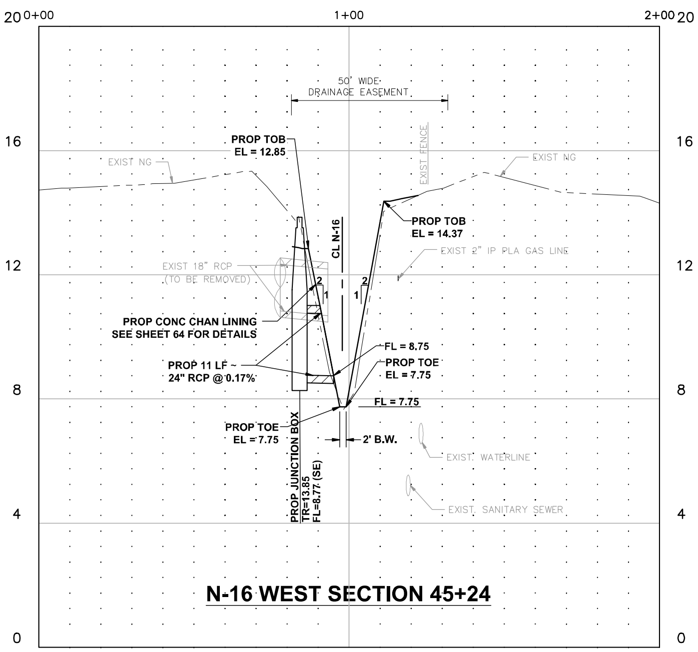
Thursday, June 29, 2023 7:59:52 AM



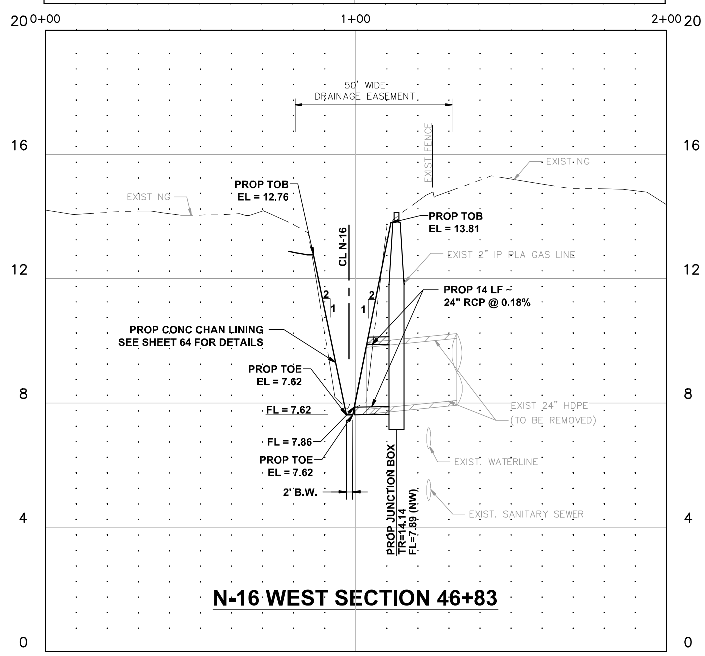
N-16 WEST SECTION 44+34



N-16 WEST SECTION 44+95



N-16 WEST SECTION 45+24



N-16 WEST SECTION 46+83

20' 0 20' 40'
HORZ. SCALE: 1" = 20'

2' 0 2' 4'
VERT. SCALE: 1" = 2'

APPROXIMATE LOCATIONS ARE SHOWN FOR UTILITIES, CONTRACTOR TO VERIFY LOCATIONS OF ALL EXISTING UTILITIES AND TO COORDINATE RELOCATION OF ANY EXISTING UTILITIES THAT CONFLICT WITH CONSTRUCTION. NOTIFY GALVESTON COUNTY ENGINEER'S OFFICE OF ALL CONFLICTS.

NOTES:
1. FOR MH DETAILS SEE SHEET 50

DEC ENGINEERING EXCELLENCE
T.B.P.E.L.S. FIRM REGISTRATION #3092
3100 WEST ALABAMA HOUSTON, TEXAS 77098 (713) 520-9570

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A. C FLORES VARELA P.E.
TEXAS P.E. No. 56939
DATE: 6/29/2023

REVISION No.	DATE	REVISION DESCRIPTION	MADE	CHECKED	APPROVED

THE STATE OF TEXAS — COUNTY OF GALVESTON

GALVESTON COUNTY
ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

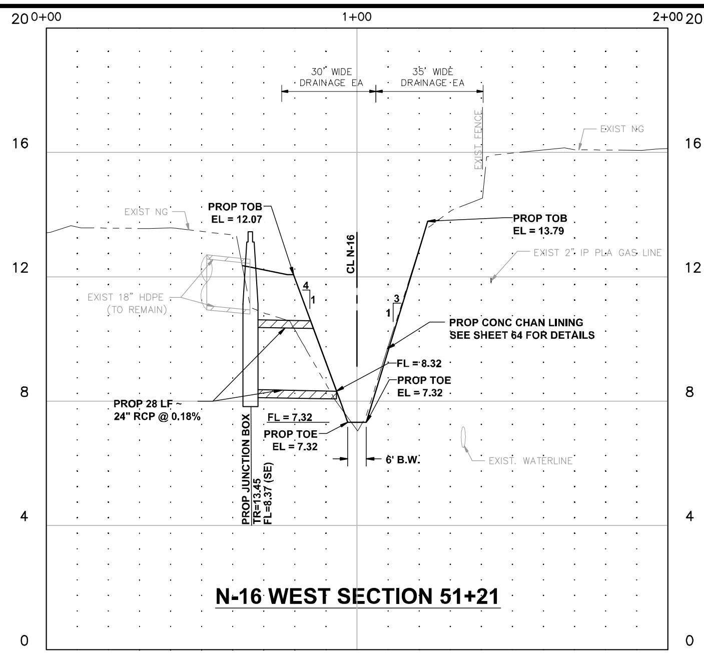
N–16 WEST
CROSS–SECTIONS
(SHEET 3 OF 8)

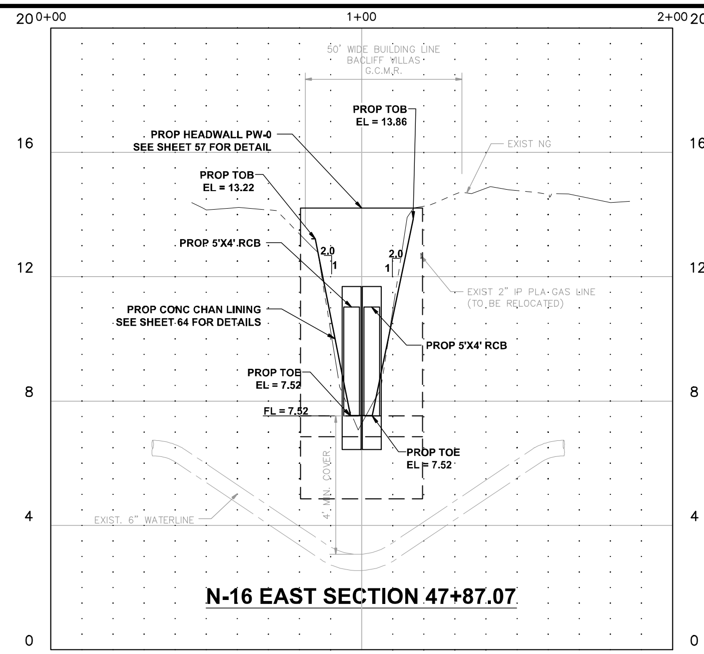
DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 38 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01
APPROVED: AF		

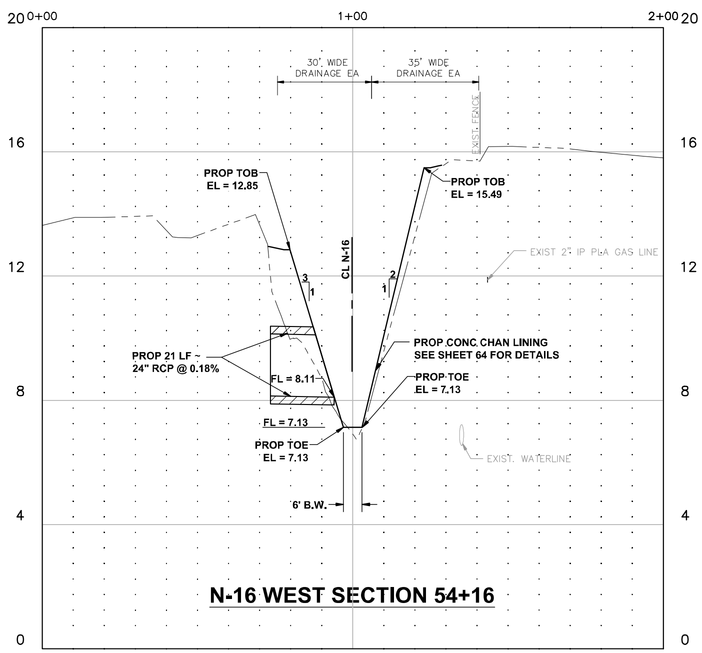
0 1 2 3 ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

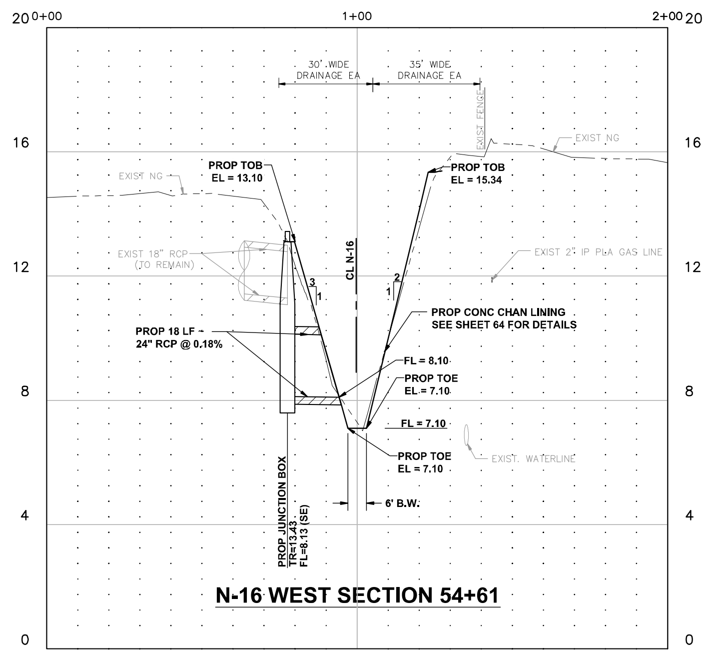
G:\1180\5370-01 GALVESTON COUNTY ARPA – BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG

Thursday, June 29, 2023 8:00:13 AM









HORZ. SCALE: 1" = 20'

VERT. SCALE: 1" = 2'

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NOTES:

1. FOR MH DETAILS SEE SHEET 50

DEC ENGINEERING EXCELLENCE
T.B.P.E.L.S. FIRM REGISTRATION #092

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A. C FLORES VARELA P.E.
TEXAS P.E. No. 56939
DATE: 6/29/2023

REVISION No.	DATE	REVISION DESCRIPTION	MADE	CHECKED	APPROVED

GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

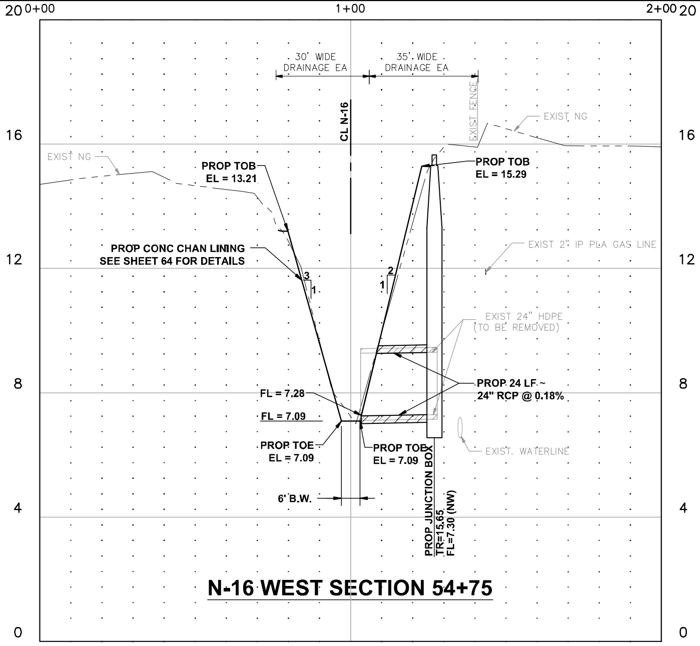
N-16 WEST CROSS-SECTIONS (SHEET 4 OF 8)

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 39 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01
APPROVED: AF		

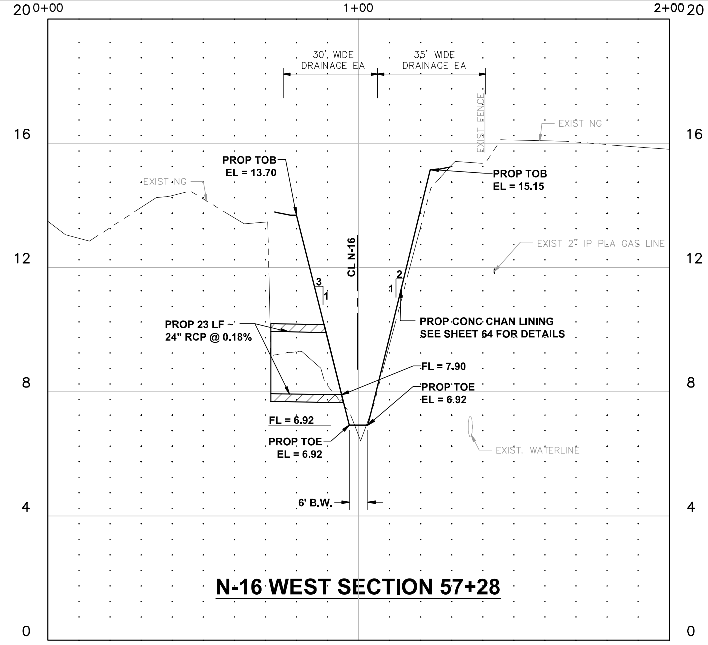
ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

G:\1180\5370-01 GALVESTON COUNTY ARPA - BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG

Thursday, June 29, 2023 8:00:35 AM



N-16 WEST SECTION 54+75



N-16 WEST SECTION 57+28

HORZ. SCALE: 1" = 20'

VERT. SCALE: 1" = 2'

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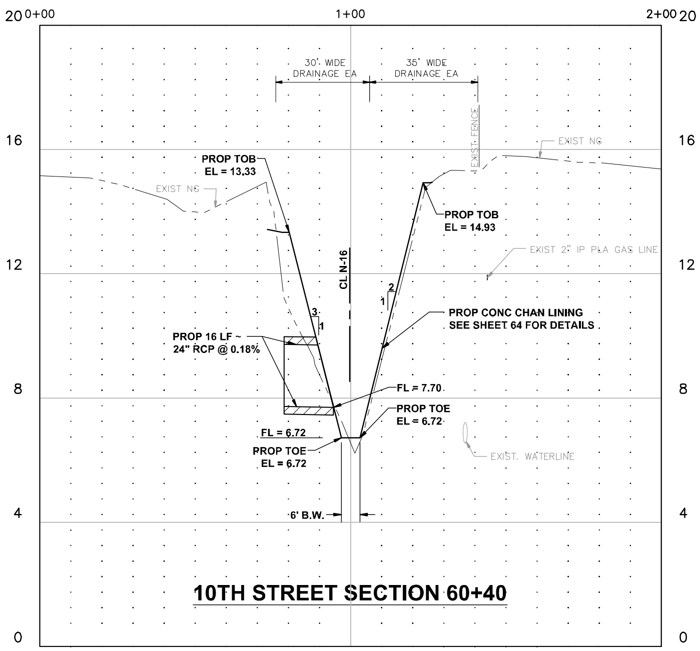
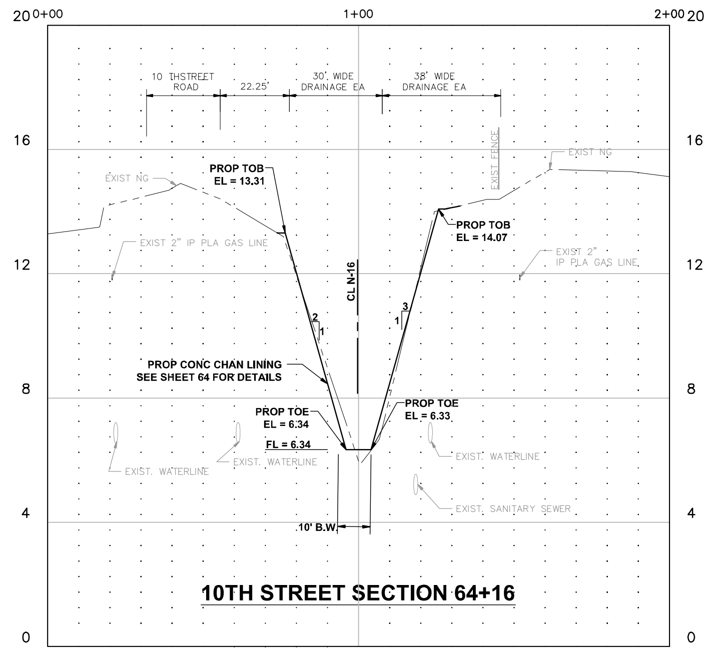
NOTES:

1. FOR MH DETAILS SEE SHEET 50



10TH STREET SECTION 60+40



10TH STREET SECTION 64+16

DEC ENGINEERING EXCELLENCE
T.B.P.E.L.S. FIRM REGISTRATION #092
3100 WEST ALABAMA HOUSTON, TEXAS 77098 (713) 520-9570

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A. C FLORES VARELA P.E.
TEXAS P.E. No. 56939
DATE: 6/29/2023

REVISION No.	DATE	REVISION DESCRIPTION	MADE	CHECKED	APPROVED

GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

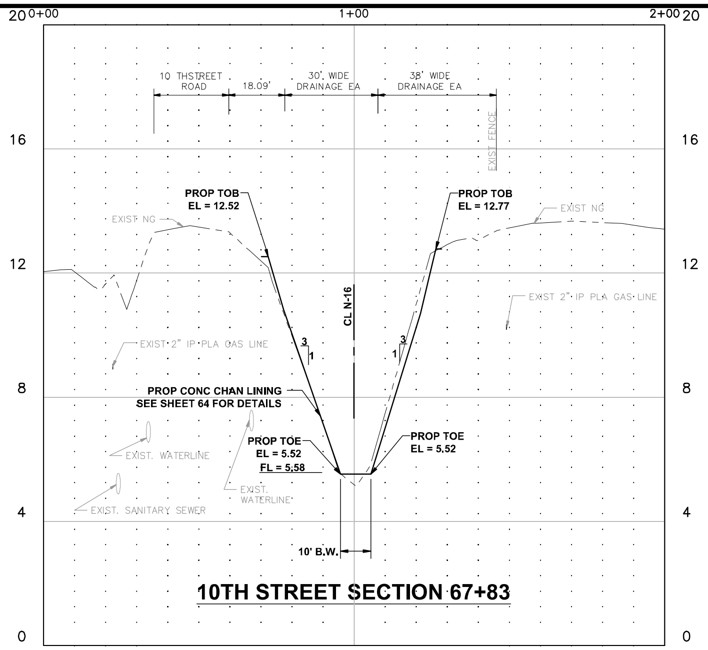
N-16 WEST
CROSS-SECTIONS
(SHEET 5 OF 8)

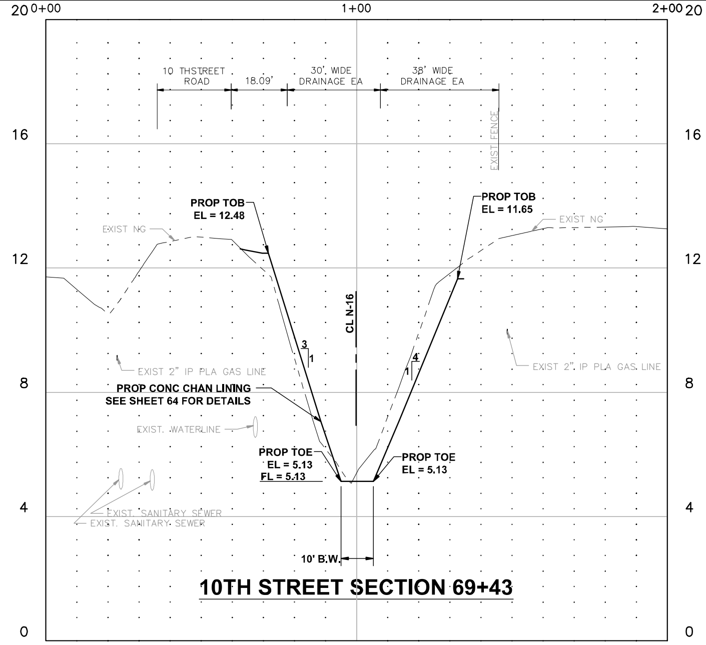
DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 40 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01
APPROVED: AF		

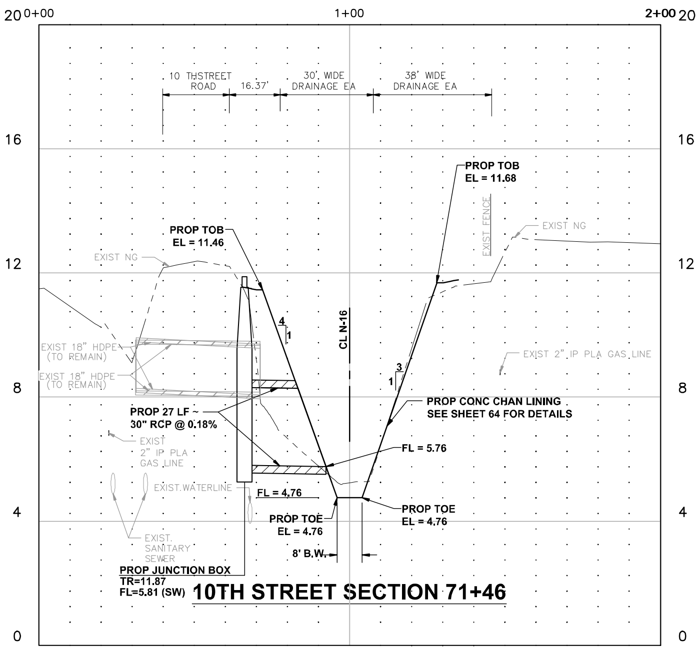
Thursday, June 29, 2023 8:00:56 AM

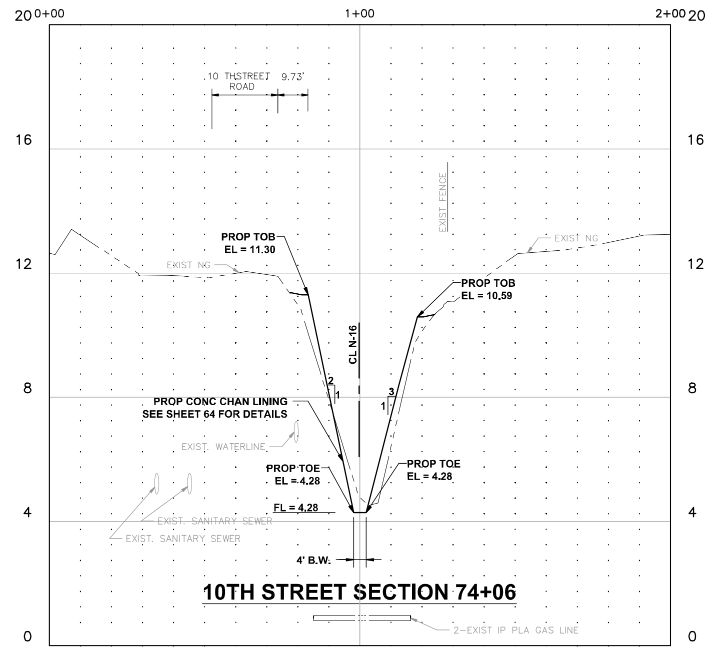
0 1 2 3 ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

G:\1180\5370-01 GALVESTON COUNTY ARPA - BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG









HORZ. SCALE: 1" = 20'

VERT. SCALE: 1" = 2'

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NOTES:

1. FOR RCB DETAILS SEE SHEETS 54 AND 56
2. FOR MH DETAILS SEE SHEET 50

DEC ENGINEERING EXCELLENCE
T.B.P.E.L.S. FIRM REGISTRATION #092

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TEXAS P.E. No. 56939
DATE: 6/29/2023

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GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

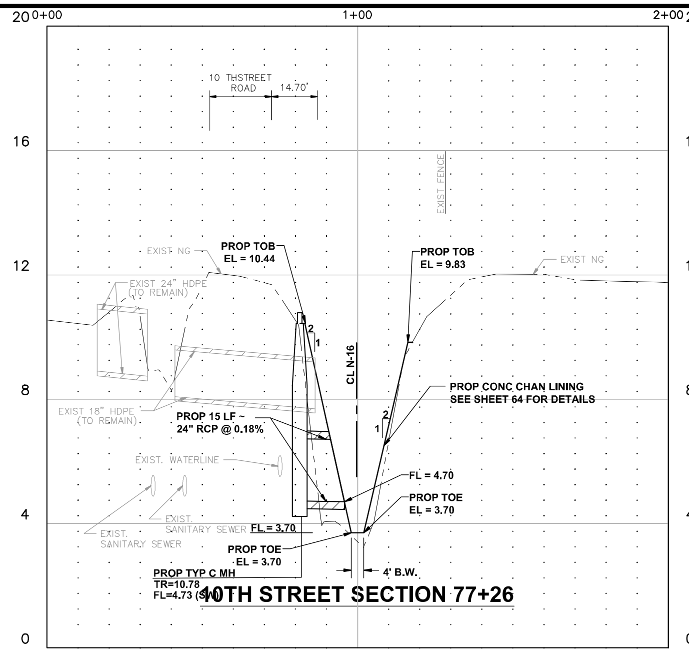
N-16 WEST
CROSS-SECTIONS
(SHEET 6 OF 8)

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 41 OF 73
DRAWN BY: JKC	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01
APPROVED: AF		

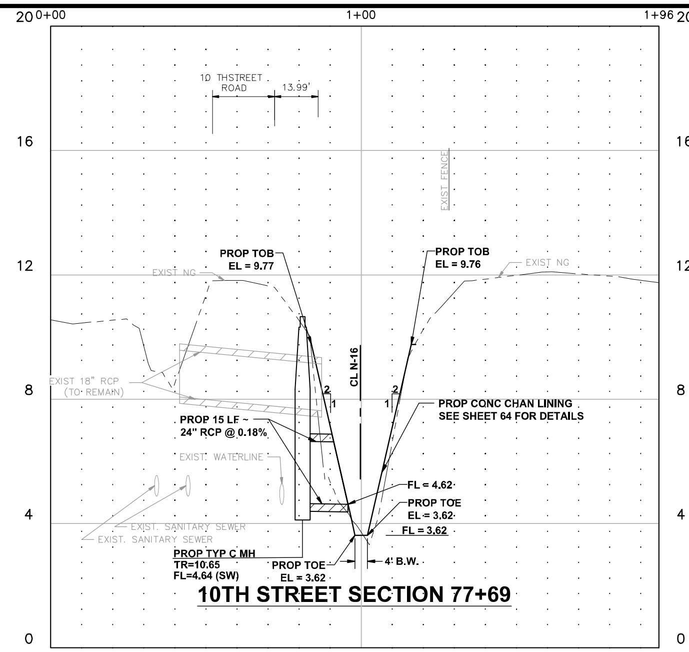
Thursday, June 29, 2023 8:01:17 AM

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

G:\1180\5370-01 GALVESTON COUNTY ARPA - BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG



10TH STREET SECTION 77+26



10TH STREET SECTION 77+69

HORZ. SCALE: 1" = 20'

VERT. SCALE: 1" = 2'

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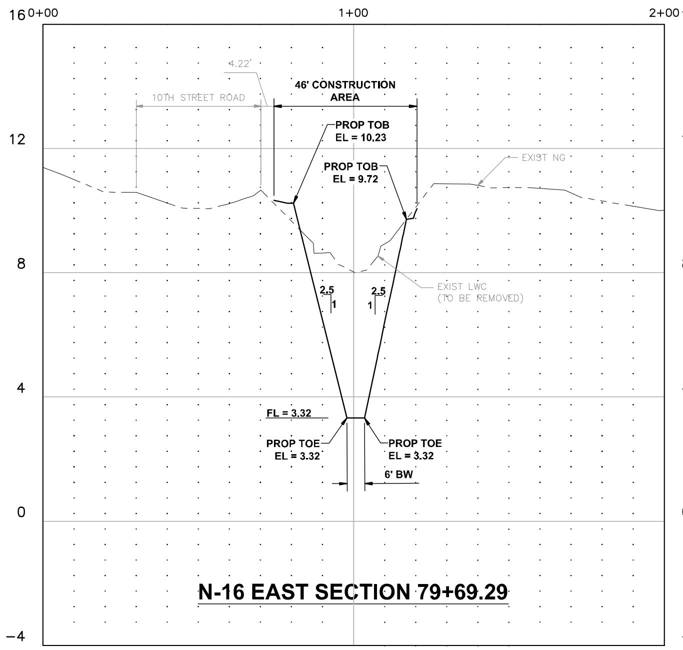
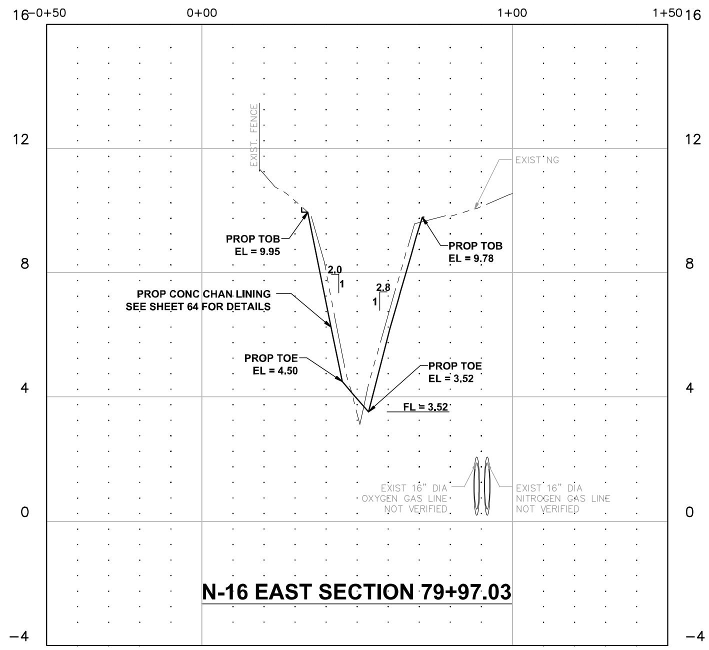
NOTES:

1. FOR RCB DETAILS SEE SHEETS ## AND 56
2. FOR MH DETAILS SEE SHEET 50



N-16 EAST SECTION 79+69.29



N-16 EAST SECTION 79+97.03

DEC ENGINEERING EXCELLENCE
T.B.P.E.L.S. FIRM REGISTRATION #392

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A. C FLORES VARELA P.E.
TEXAS P.E. No. 56939
DATE: 6/29/2023

REVISION No.	DATE	REVISION DESCRIPTION	MADE	CHECKED	APPROVED

GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

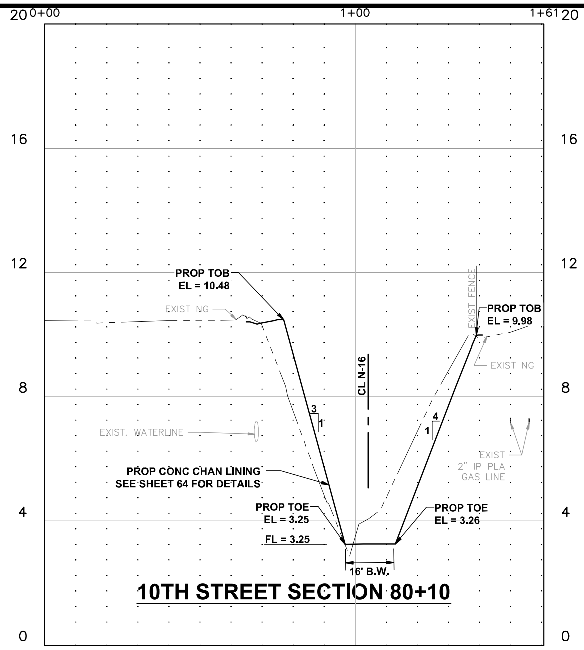
N–16 WEST
CROSS–SECTIONS
(SHEET 7 OF 8)

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 42 OF 73
DRAWN BY: JKC		
APPROVED: AF	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01

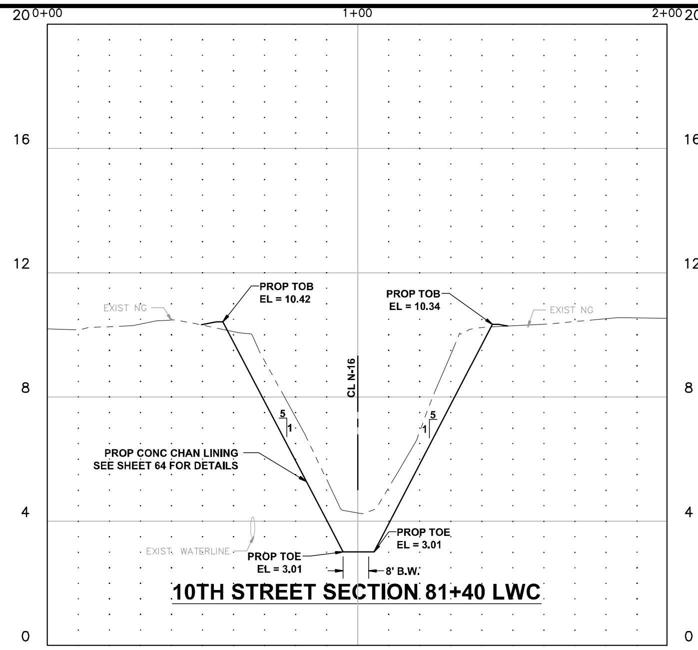
Thursday, June 29, 2023 8:01:42 AM

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

G:\1180\5370-01 GALVESTON COUNTY ARPA – BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG



10TH STREET SECTION 80+10



10TH STREET SECTION 81+40 LWC

HORZ. SCALE: 1" = 20'

VERT. SCALE: 1" = 2'

APPROXIMATE LOCATIONS ARE SHOWN FOR UTILITIES, CONTRACTOR TO VERIFY LOCATIONS OF ALL EXISTING UTILITIES AND TO COORDINATE RELOCATION OF ANY EXISTING UTILITIES THAT CONFLICT WITH CONSTRUCTION. NOTIFY GALVESTON COUNTY ENGINEER'S OFFICE OF ALL CONFLICTS.

NOTES:

1. FOR RCB DETAILS SEE SHEETS ## AND 56
2. FOR MH DETAILS SEE SHEET 50

DEC ENGINEERING EXCELLENCE
T.B.P.E.L.S. FIRM REGISTRATION 4092

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A. C FLORES VARELA P.E.
TEXAS P.E. No. 56939
DATE: 6/29/2023

REVISION No.	DATE	REVISION DESCRIPTION	MADE	CHECKED	APPROVED

GALVESTON COUNTY ENGINEERING DEPARTMENT

GALVESTON COUNTY ARPA
BACLIFF DRAINAGE IMPROVEMENTS

N-16 WEST
CROSS-SECTIONS
(SHEET 8 OF 8)

DESIGN BY: GWT	DATE: 6/29/2023	SHEET No. 43 OF 73
DRAWN BY: JKC		
APPROVED: AF	SCALE: HORZ: 1" = 20' VERT: 1" = 2'	JOB No. 5370-01

Thursday, June 29, 2023 8:01:50 AM

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

G:\1180\5370-01 GALVESTON COUNTY ARPA - BACLIFF DRAINAGE IMPROVEMENTS\CAD\SHEETS\036-043-N-16 WEST CROSS-SECTIONS.DWG